Cisco IP Video Surveillance Design Guide

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CHAPTER 1

Overview

This document summarizes high-level design recommendations and best practices for implementing IP Video Surveillance on the enterprise network infrastructure. In some instances, existing network equipment and topologies have the necessary configuration and performance characteristics to support high-quality IP Video Surveillance. In other instances, network hardware might require upgrading or reconfiguration to support increased bandwidth needed to support video. Quality-of-service (QoS) techniques are important for any design because video has similar—in some instances, more stringent—requirements than VoIP for loss, latency, and jitter.

IP Video Surveillance is a part of the Media Ready Network—a network initiative to incorporate all forms of video on the enterprise network. IP-based Video Surveillance is one of the four components of the Media Ready Network. These components consist of the following:

- TelePresence Network System
- Desktop Video
- Digital Media Systems
- IP Video Surveillance

This solution overview focuses on IP Video Surveillance while other overviews focus on the other three solutions. Not all forms of video on the enterprise network have the same requirements, given the diversity of transport techniques and user interfaces to the video feeds.

IP Video Surveillance Components

There are five components of IP-based video surveillance solution. These are as follows:

- **Cameras**—This is addressed by the Cisco Video Surveillance IP Camera, analog cameras attached to encoders, analog gateway network modules for the integrated services router, or third-party IP surveillance cameras.
- **Video management software**—This is addressed by the Cisco Video Surveillance Manager (VSM) suite of software. This software runs on one or more standalone, Linux-based servers or on a Cisco Integrated Services Router (ISR) Series Video Management and Storage System network module.
- **Servers**- Cisco Physical Security Multi Services Platforms are servers for network digital recording and playback.
- **Storage**—This is aligned with either the Data Center Architecture and the Cisco Video Surveillance Storage System, or with off-the-shelf iSCSI servers for archiving and storage of video feeds

- **Network**—This component is the enterprise network—the Media Ready Network. The primary focus of this document is to reference the existing design baselines of branch office, campus, WAN, and Metro Area Networks (MANs) while building on this base of knowledge with IP Video Surveillance requirements, best practices, and design recommendations.

The IP Video Surveillance component of the Media Ready Network is integrated with the *Places in the Network* (PIN) architecture along with the companion video components of the Media Ready Network.

Supporting Designs

Implementing IP Video Surveillance on an existing network is designed to overlay non-disruptively on other core Cisco PIN architecture design elements. These include the following:

- Quality of Service Design Considerations, page 1-2
- Branch PIN Design Considerations, page 1-2
- WAN/MAN PIN Design Considerations, page 1-3
- Campus PIN Design Considerations, page 1-4
- Data Center PIN Architecture, page 1-4

Each is summarized in the following subsections.

Quality of Service Design Considerations

QoS design is addressed in the *Enterprise QoS Solution Reference Network Design Guide Version 3.3* available at the following URL:

http://www.cisco.com/en/US/docs/solutions/Enterprise/WAN_and_MAN/QoS_SRND/QoS-SRND-Book.html

and should be considered a fundamental consideration for implementing video on any corporate network. Both voice and video are tolerant of some packet loss, latency, and jitter between the video end points; however, video is typically less tolerant to loss than voice over IP (VoIP). Depending on the type of video feed, the disruption of video quality might be evident for much longer periods of time than with VoIP.

Branch PIN Design Considerations

The branch architecture design collateral is organized under the Design Zone for Branch, which can be found at the following URL:

http://www.cisco.com/en/US/netsol/ns816/networking_solutions_program_home.html

From this website, there are a number of branch-related PIN design guides that are applicable to implementing a branch router deployment. They include the following:

- *Enterprise Branch Architecture Design Overview*
- *Enterprise Branch Security Design Guide*
- *Enterprise Branch Wide Area Application Services Design Guide (Version 1.1)*

The integration between IP Video Surveillance and the enterprise branch architecture is targeted at integration of the Cisco ISR VS network modules. Enabling branch architecture services along with the Cisco ISR VS network modules is a key element of IP Video Surveillance 1.0.

The Cisco Empowered Branch 4 marketing launch included the Cisco Video EVM-IPS-16A EVM Module featuring analog-to-IP encoding capabilities for existing analog cameras and the Cisco NME-VMSS Module that supports the Cisco Video Surveillance Manager (VSM) suite of software on the network module. The EVM-IPS-16A module is not required if the deployment is with all IP surveillance cameras.

Empowered Branch 4 also includes the Cisco 880 ISRs, which have sufficient performance characteristics to support the various forms of video at a Small Office/Home Office (SOHO) location. Many of the foundation architecture concepts are from the *Business Ready Teleworker.*

http://www.cisco.com/application/pdf/en/us/guest/netsol/ns171/c649/ccmigration_09186a008074f24a.pdf

The teleworker or SOHO deployment is applicable for addressing remotely located or isolated wired-IP cameras that in turn can be managed by a central or branch Video Surveillance Manager deployment. Video Surveillance Operations Manager viewing stations—PCs running an Active-X-enabled web browser—may also be located at extranet or remote locations to allow physical security staff or law enforcement agencies to view live or archived video.

The Cisco Application Networking Services (ANS), such as Wide Area Application Services (WAAS), are key elements given that the transport for IP Video Surveillance viewing stations is TCP-based.

WAN/MAN PIN Design Considerations

The WAN/MAN PIN architecture reference is found at the following URL:

http://www.cisco.com/en/US/netsol/ns817/networking_solutions_program_home.html

There are several design guides within the Design Zone for WAN/MAN that describe foundation architectures for deploying IP Video Surveillance. The integration between IP Video Surveillance and the WAN/MAN architecture is targeted at QoS, NetFlow, Network-Based Application Recognition (NBAR), Ethernet access, Performance Routing (PfR), and implementing IP Security (IPSec) technologies to enable privacy, integrity, and authenticity of IP Video Surveillance data through encryption. Because of the focus on the Cisco ISR VS network modules in branch routers, the design guidance provided here relies heavily on integration of the WAN/MAN PIN.

If the branch office locations are implemented over a public network, the *Dynamic Multipoint VPN (DMVPN) Design Guide* provides important information on encrypting data between branch, SOHO, and central office locations. Because of the requirements for availability and selecting the optimal path among redundant links, the *Transport Diversity: Performance Routing (PfR) Design Guide* is also a key element in a successful deployment. Video requires much higher bandwidth than is required for a VoIP and data enabled branch location and the *Ethernet Access for Next Gen Metro and Wide Area Networks* might be applicable when implementing the branch office over a Metro Ethernet deployment or an Multiprotocol Label Switching (MPLS) Layer-2 pseudowire. Also applicable is the *Next Generation Enterprise MPLS VPN-Based MAN Design and Implementation Guide*.

Campus PIN Design Considerations

The campus PIN architecture reference is found at the following URL:

http://www.cisco.com/en/US/netsol/ns815/networking_solutions_program_home.html

There are several design guides within this Design Zone for Campus that can provide guidance to the network manager in designing a Media Ready campus. These include the following:

- *Network Virtualization—Path Isolation Design Guide*
- *Network Virtualization—Services Edge Design Guide*
- *Campus Network for High Availability Design Guide*
- *Campus Design: Analyzing the Impact of Emerging Technologies on Campus Design*

The integration between IP Video Surveillance and campus PIN architecture is a requirement because most IP network cameras support Power-over-Ethernet (PoE). PoE is important to facilitate installation of these cameras as a single Category 5 Ethernet cable can provide both Ethernet connectivity and power-reducing installation costs. The Cisco IP cameras support Cisco Discovery Protocol (CDP) and Simple Network Management Protocol (SNMP), which together help to simplify provisioning and device management.

In the campus, QoS marking at both Layer 2—class-of-service (CoS) and Layer 3—Differentiated Services Code Point (DSCP)—can be enabled in the switching infrastructure to enhance the usability and quality of the video feeds.

The cameras, servers, and encoders can be deployed on separate VLANs to provide isolation at Layer 2 and transported over the WAN with Layer-3 isolation over an MPLS virtual private network (VPN).

Data Center PIN Architecture

The data center PIN architecture reference links can be found within the Design Zone for Data Center at the following URL:

http://www.cisco.com/en/US/netsol/ns743/networking_solutions_program_home.html

The integration between IP Video Surveillance and the Data Center PIN Architecture intersects notably at the storage requirements of an IP Video Surveillance system. An archive is a collection of video data. The video source, a feed from a camera or encoder, can be stored in multiple locations and viewed at a later time. Archives are either *one-time* (where the archive recording stops at a specified date and time) or *continuous loop* (where the archive continuously records). Loop archives reuse the disk space. Archives may also be scheduled to begin at a certain date and time and run using a recurring schedule.

The storage requirements for video archives can be substantial. For example, a high definition (HD) surveillance camera recording at a rate of 10-motion JPEG frames per second with a resolution of 1600 x 1200 pixels can require up to 1GB of disk storage *per hour*. Retention of this archive for days or weeks, combined with a deployment of a hundred cameras will consume vast amounts of storage.

The *Cisco Video Surveillance Manager Solutions Reference Guide* addresses at a functional level the way in which the storage subsystem of the Cisco Video Surveillance Media Server can augment internal storage with direct-attached storage and storage area networks (SANs). Additionally, the Cisco ISR Series Video Management and Storage System network module supports an iSCSI interface for local storage in the branch office.

Technical Assistance Center (TAC

Technical Assistance Center (TAC) Technical Tips are a valuable sources of configuration examples for the technologies deployed in this design guide. Refer to the Technical Tip section after logging on the Cisco TAC website at http://www.cisco.com/tac.

Solution Description

In this section the, Cisco Video Surveillance solution is described at a functional-level given a deployment of the components on standalone workstations and appliances. In addition, the functional components are mapped to an implementation using the Cisco 2800/3800 ISR IP Video Surveillance Network Modules. The Cisco Video Surveillance Manager software is a common code base that is ported to run on the network module.

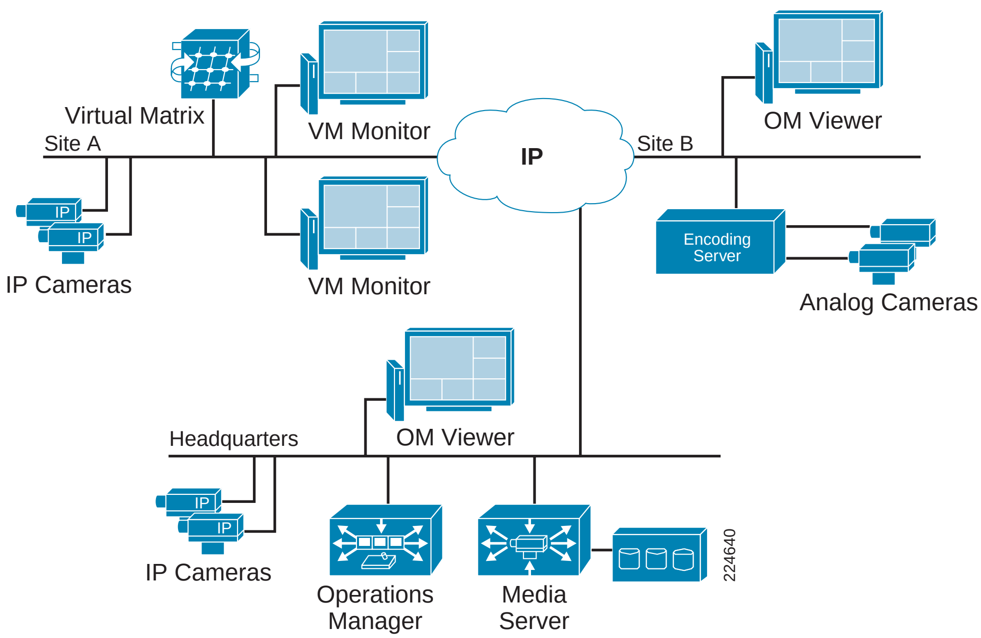
Cisco Video Surveillance Solution

The Cisco Video Surveillance solution relies on an IP network infrastructure to link all components. The designs of a highly available hierarchical network have been proven and tested for many years and allow applications to converge on an intelligent and resilient infrastructure.

Cisco offers a unique approach to moving different proprietary systems to a common IP backbone. This approach uses other Cisco technologies, such as network security, routing, switching, network management, and wireless. Video from IP cameras can now be truly converged into a robust network environment with the intelligence and flexibility provided by the Cisco infrastructure.

Figure 1-1 shows the Cisco Video Surveillance Manager solution using an Intelligent IP infrastructure as a transport.

Figure 1-1 Cisco Video Surveillance Solution



Solution Components

The Cisco Video Surveillance solution components are as follows:

- *Cisco Video Surveillance Media Server*—As the core component of the network-centric VSM, this software manages, stores, and delivers video for the network-centric video surveillance product portfolio.
- *Cisco Video Surveillance Operations Manager*—The Operations Manager authenticates and manages access to video feeds. It is a centralized administration tool for management of Media Servers, Virtual Matrixes, cameras, encoders, and viewers—and for viewing network-based video.
- *Cisco Video Surveillance Virtual Matrix*—The Virtual Matrix monitors video feeds in command center and other 24-hour monitoring environments. It allows operators to control the video being displayed on multiple local and remote monitors.
- *Cisco Video Surveillance Encoding Server*—This single-box solution encodes, distributes, manages, and archives digital video feeds. Each server encodes up to 64 channels and provides up to 12 TB of storage.
- *Cisco Video Surveillance Storage System*—This complementary component allows the Media Server's internal storage to be combined with direct-attached storage (DAS) and storage area networks (SANs). The storage system allows video to be secured and accessed locally or remotely.

Cisco 2800/3800 ISR IP Video Surveillance Network Modules

In addition to the standalone dedicated implementation of the Cisco Video Surveillance solution on Linux servers, the Cisco 2800 and Cisco 3800 ISRs support the necessary components of the solution to implement a self-contained instance at the branch location.

The Cisco Video Management and Storage System (VMSS) Network Module implements the Operations Manager and Media Server functions for the branch. It supports IP-based video cameras as well as analog cameras attached to the Analog Video Gateway Module.

The Analog Video Gateway Module installed in the Cisco ISR branch router provides support for analog cameras, analog Pan Tilt Zoom (PTZ), alarm input and control relay output. It supports up to 16 analog cameras. This module supports RS-485 on two serial interfaces, which controls analog Pan Tilt Zoom (PTZ). The module also supports event alerts by way of alarm input and control-relay output serial connections. The Analog Video Gateway Module is optional if these functions are not required.

A branch with all IP cameras and no analog requirements need only the VMSS network module. The NME-VMSS-16 and NME-VMSS-HP16 support up to 16 cameras, the NME-VMSS-HP32 is licensed to support up to 32 cameras.

The Virtual Matrix component is not supported on the Cisco ISR Video Surveillance Modules.

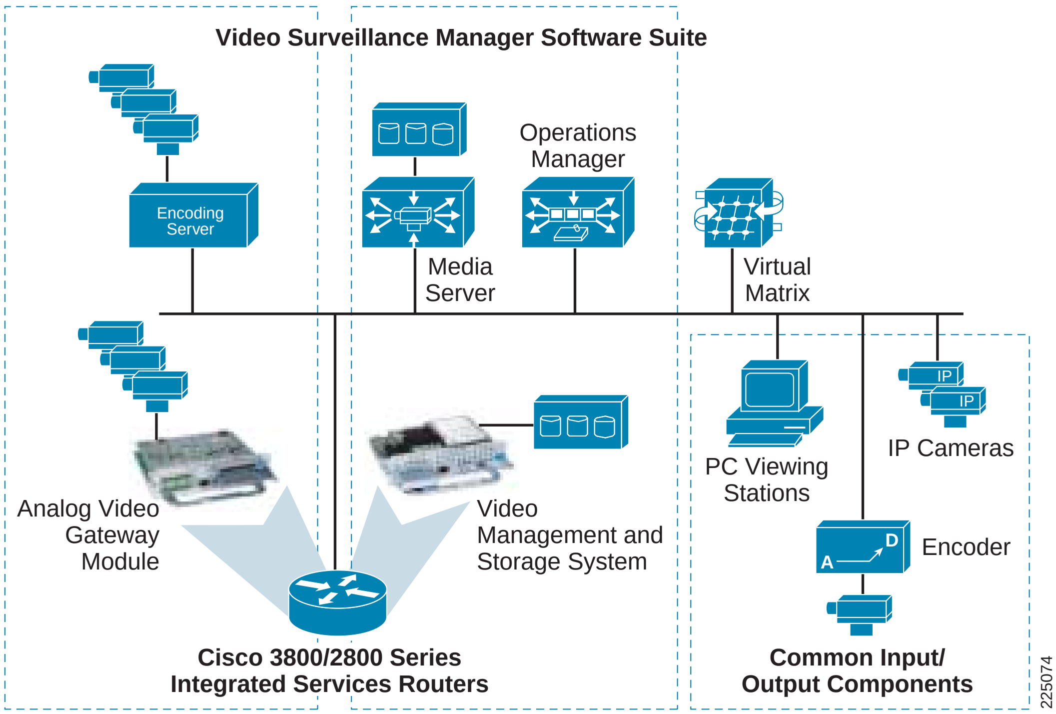
The Operations Manager provides a web-based browser console to configure, manage, display, and control video supported at the branch location. The Operations Manager and the Media Server share the same IP address configured on the logical interface of the Integrated Services Network Module. One or more Cisco Video Surveillance Media Servers are managed through this interface. The Operations Manager web interface is where the physical security administrator configures IP and analog cameras and where video feed archives are scheduled and managed.

In this remote branch location deployment, use of the Cisco VMSS provides efficiency. Traffic only needs to traverse the network when requested by remote viewers. Branch office video remains localized and does not have to traverse wide-area connections unless requested by users. An external iSCSI device is attached to the GigabitEthernet port on the network module in order to supplement the disk storage on the VMSS module.

In this topology, physical security staff at the campus location, a third-party location at an Extranet site, a separate branch, or even a remote teleworker location can configure, manage, and display the VMSS at the branch location. Video requests and video streams are delivered to the viewer through Hypertext Transfer Protocol (HTTP), which uses Transmission Control Protocol (TCP) port 80.

In Figure 1-2, the Video Surveillance Manager Software Suite components for both the Linux deployment and the Cisco ISR IP Video Surveillance Network Module deployment are shown.

Figure 1-2 Video Surveillance Manager Software Suite Components



At the branch location, the Analog Video Gateway Module provides a similar function to the encoding server. The Media Server and Operations Manager, along with storage, are supported on the VMSS network module. The Virtual Matrix function is not supported on the Cisco ISR Video Surveillance Modules. The IP cameras, analog cameras attached to dedicated IP encoders, and the PCs used as viewing stations are common to both implementations.

Solution Benefits

Video surveillance is a key component of the safety and security procedures of many organizations. It provides real-time monitoring of the environment, people, and assets, and provides a recorded archive for investigative purposes. The benefits of Cisco's Video Surveillance solution include the following:

- Provides access to video at any time from any network location within the constraints of available bandwidth, allowing remote monitoring, investigation, and incident response through remote physical security staff or law enforcement personnel.
- Uses existing investment in video surveillance and physical security equipment and technology.
- *Network-wide Management*—IP cameras and servers are monitored and managed over a single network for fault, configuration, and centralized logging.

- *Increased Availability*—IP networks offer a high level of redundancy that can extend to different physical locations.
- *Scalability*—The system can be expanded to new locations as business needs change.
- Digitized images can be transported and duplicated worldwide with no reduction in quality, economically stored, and efficiently indexed and retrieved.
- Employs an open, standards-based infrastructure that enables the deployment and control of new security applications from a variety of vendors.
- The Cisco Video Surveillance Solution relies on an IP network infrastructure to link all components, providing high availability, QoS, performance routing, WAN optimization, and privacy of data through IPSec encryption.

CHAPTER 2

Solution Overview and Best Practices

This chapter presents a high-level overview of an IP Video Surveillance deployment to give the reader a quick reference as to the capabilities of this solution. The associated design guide will then go into detail on planning, design, product selection, and implementation of an IP Video Surveillance deployment.

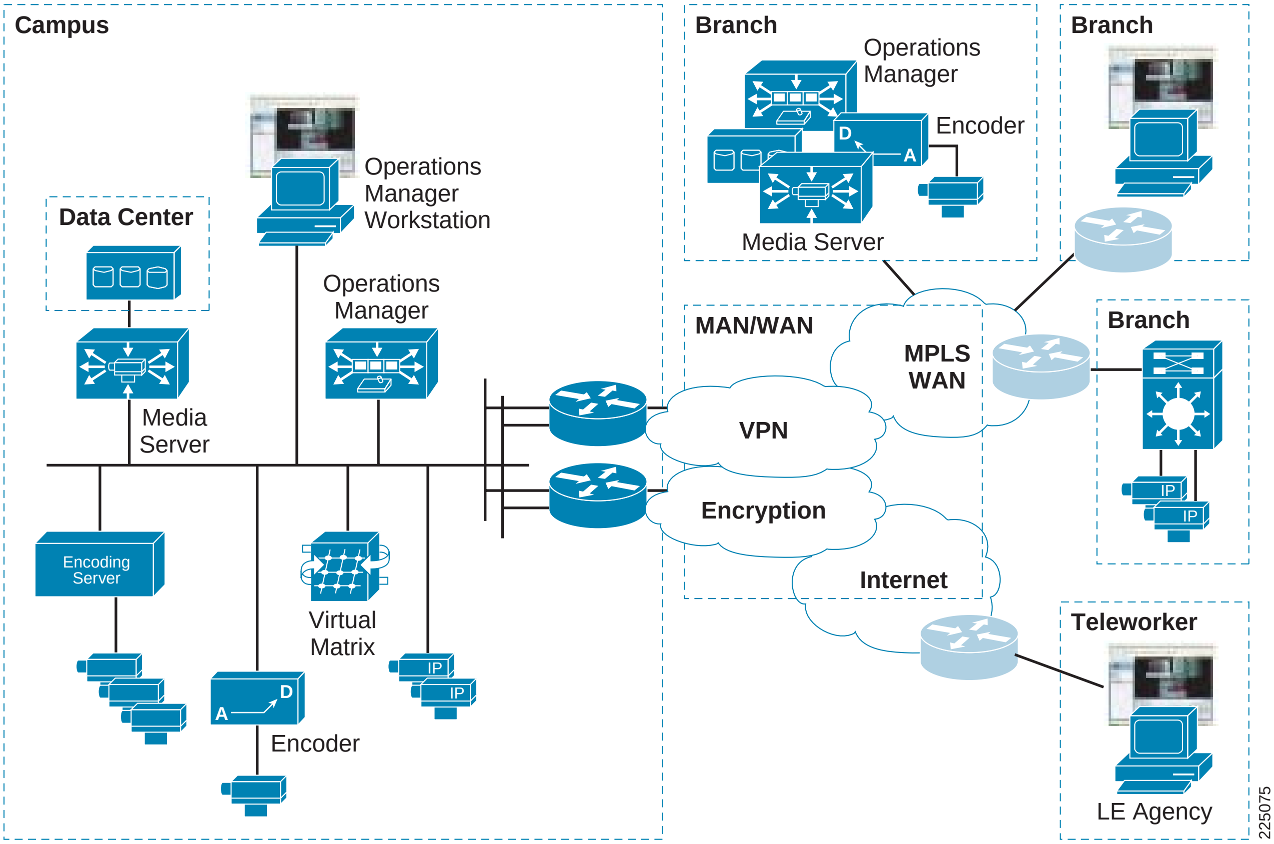
Deployment Model

A typical IP Video Surveillance deployment in an enterprise network consists of one or more campus locations running Cisco Video Surveillance Media Server, Video Surveillance Operations Manager, and Video Surveillance Virtual Matrix on an Intel-based Linux Enterprise Server operating system (Cisco Physical Security Multi Services Platform or third party server). Deployment on a standalone hardware is targeted at locations with more than 32 video surveillance cameras.

Branches that have a requirement for 1-to-32 video surveillance cameras can incorporate the Cisco ISR Video Surveillance Modules to provide the Media Server and Operations Manager functionality in a network module form factor. Optionally, an Analog Video Gateway Module can be installed to support legacy analog cameras.

Branch offices and teleworker locations may view and administer the video surveillance system—as may external organizations connected either through an Extranet or the public Internet through a global IP connectivity and a web browser. Figure 2-1 illustrates the topology and application services deployed in an enterprise-wide implementation of IP-based video surveillance.

Figure 2-1 Video Surveillance Solution Master Architecture Diagram



The branch locations are connected to the enterprise campus by WAN technologies, including Metro Ethernet, private line, the public Internet, or a Layer-2 or Layer-3 MPLS VPN deployment. With a Layer-2 MPLS deployments (*Pseudowire*), IP cameras may be Ethernet-attached to a remote switch and have images transported through the carrier network and provisioned and managed by the Operations Manager at either a branch location or a central location. Branches attached through a Layer-3 MPLS network, leased line, or over the Internet can support viewing stations and IP cameras that can be managed by either the campus or branch deployment.

Cisco technologies such as DMVPN can be overlaid onto the WAN transport to provide data privacy and authentication by way of IPSec encryption. To ensure prioritization of voice, video, and mission critical applications over the WAN, QoS is deployed on the WAN. Where multiple WAN links exist, PfR can be enabled to provide intelligent path selection and the ability to route around brownouts and transient failures, thereby enhancing what can be provided by traditional routing protocols such as Enhanced Internal Gateway Routing Protocol (EIGRP).

The decision as to whether a specific environment should implement the Cisco ISR Video Surveillance Modules at a branch location and archive data at the branch—or provision cameras off the campus implementation of the Cisco Video Surveillance Manager—depends on the number of cameras, the resolution, frame or bit rate of the camera, quality factors of the cameras, and the cost and availability of bandwidth at the remote locations. In cases where implementing cameras is the only requirement, it may be practical to transport the camera feeds across the WAN for archiving. However, in most deployments, local storage is necessary due to the bandwidth required and the costs associated with this bandwidth.

Solution Characteristics

Table 2-1 represents the general solution characteristics for an IP Video Surveillance deployment.

Table 2-1 Solution Characteristics Summary

Solution Characteristics
An IP network infrastructure is required to link all components.
IP cameras are under the control of and feed Media Servers. The VSOM interface is the viewing station portal into the video archives and live feeds.
The amount of disk storage for archiving camera feeds depends on factors that include the retention period requirements, image resolution, image quality, format , and encoding. Storage requirements might be difficult to plan and predict.
Encryption through IPSec may be implemented between video endpoints to ensure data privacy, integrity, and authentication.
VRF-lite, VLANs, and other network virtualization techniques may be used to segment the video endpoints and servers.
Viewing stations are PCs running Internet Explorer (IE) with Active-X controls. The PC must have a sufficient CPU clock rate to decode the video feeds.
Camera feeds traverse the IP network from the camera source to the Media Server either as Motion JPEG (MJPEG) or MPEG-4.
MJPEG is typically transported via the TCP protocol. TCP provides guaranteed delivery of packets by requiring acknowledgement by the receiver. Packets that are not acknowledged are retransmitted.
With MJPEG, each image standalone, so the images that are displayed are of good quality.
MPEG-4 video is typically transmitted over the User Datagram Protocol (UDP), Real-time Transport Protocol (RTP), or Real Time Streaming Protocol (RTSP). UDP does not guarantee delivery and provides no facility for retransmission of lost packets.
UDP transport provides the option of IP Multicast (IPmc) delivery, however is not universally supported.
Deploying a video surveillance solution through a WAN environment presents challenges that are not typically seen in a LAN. WAN bandwidth is most costly and the available transport types are dependent on the service provider offering available in the geographic area.

General Best Practices Guidelines

Table 2-2 presents a list of best practices that have been established through a combination of design experience, scalability and performance evaluation, and internal Cisco trials.

Table 2-2 IP Video Surveillance Best Practices Guidelines Summary

Best Practices Guidelines
Network Time Protocol (NTP) must be configured for an accurate and consistent time source for all video surveillance devices in the network.
Camera feeds for MJPEG can be reduced to save bandwidth and disk storage. For example, 30 frames per second (fps) can be configured from camera to Media Server, while two archives for this feed can be configured; one at 10 fps and a second at 1 fps. These archives can have different retention periods.
Access control techniques to limit the workstations that are allowed to configure and view an IP camera directly should be implemented.
Where possible, use PoE for IP cameras. It simplifies installation.

Table 2-2 IP Video Surveillance Best Practices Guidelines Summary (continued)

Best Practices Guidelines
IP Video Surveillance traffic is to be marked with the QoS DSCP value of CS5 and provisioned in either a priority or bandwidth queue.
Cisco IP Video Surveillance (IPVS) Utilities for the Cisco ISR Analog Gateway Module can be accessed with the following URL: http://*ipaddress*/ipvs/login.html, where *ipaddress* is the IP address of the analog network module. This utility facilitates implementation of analog cameras, RS-485 devices, alarms, and contract relays.
In most instances, configuring a camera feed constant bit-rate (CBR) value of 1024Kbps is an acceptable starting value for reasonable video quality.
Most implementations will require at least 4CIF or D1 video resolution for reasonable video quality.
MPEG-4 over RTP/UDP is relatively intolerant to packet loss; however, latency and jitter cause less degradation because the Media Server functions as a dejitter buffer (due to the storage and replication of the camera feed to the viewing station). Manage WAN links to minimize loss, even at the expense of latency and jitter. Round Trip Times (RTT) of 300 msec might be acceptable.
Latency between client viewing station and VSOM should be less than 80 msec RTT for best results.
Many IP cameras can be configured as both MJPEG or MPEG-4 codec technology. Both have advantages and disadvantages. A mixture of these codecs on certain cameras might be desirable.
In most instances, the only manual CLI configuration required on the Cisco ISR Analog Gateway Module would be text descriptions of the physical ports. VSOM will provide all the configuration necessary for operation of this module when adding cameras or alarm events.

General Solution Caveats

Table 2-3 presents a list of caveats for the solution described in this solution overview.

Table 2-3 IP Video Surveillance Solution Implementation Caveats

Solution Implementation Caveats
The available disk storage for video archives on the Cisco ISR Video Surveillance Modules is approximately 100 GB. In most deployments, external disk archives storage is required.
Not all features of the Cisco 2500 Series Video Surveillance IP camera are supported by Cisco VSM .For example, the IP camera supports IP multicast, but VSM does not. QoS can be enabled on the IP camera by configuring the camera directly through a supported web browser, but the QoS parameters cannot be configured from VSM.
Some HD cameras only support the higher definition resolution on MJPEG.
The latency of video encoders used in some IP cameras might exceed 500 msec, and values of 2,000 to 3,000 msec have been observed. This presents usability issues when using the audio and speaker jacks of the camera or with PTZ controls.
When defining analog cameras under VSOM using the Cisco ISR Analog Gateway Module, the Encoder Channel field is not zero relative. In other words, Encoder Channel 1 is coax cable 0 on the CAB-EVM-IPVS-16A.
When defining alarms/control relay events in the Cisco ISR Analog Gateway Module, VSOM port COM1 equates to S0, while COM2 equates to S1. Contact closure port 0 equates to Channel 1in VSOM.
When defining PTZ analog cameras in VSOM, *Chain Number* equates to the RS-485 address switch value on the camera.
When defining Bosch Autodome analog cameras with PTZ on the Cisco ISR Analog Gateway Module, use *Pelco Analog Camera (D protocol)* rather than selecting *Autodome Analog Camera*.

Table 2-3 IP Video Surveillance Solution Implementation Caveats (continued)

Solution Implementation Caveats
The PTZ analog device is intermittently unresponsive to joystick movements from the Video Surveillance Operations Manager (VSOM). See CSCsk21927.
Symptom—Video image does not load on the upper first pane on various layouts with VMR enabled. *Workaround*—Disable VMR mode in the VSOM under *Settings* if this problem occurs.
In some instances, there may be a delay of several seconds, up to a minute, from the time an operator selects a camera feed to view, until the video feed is displayed. It may require several mouse clicks on the camera feed to initiate viewing.
Cannot configure VSVM on the Cisco ISR Video Surveillance Modules. Error "Cannot connect to server at 192.0.2.2:8086" is displayed. VSVM is not supported on the network module implementation.
There are incompatibility issues when a NAT/pNAT device is located between the client viewing station and the VSOM.
In VSOM, previews are displayed when you configure JPEG but not with MPEG-4.
Recurring archives might stop initiating if the disk media becomes full.

CHAPTER 3

Solution Components

This guide is published at a point in time where video surveillance systems are no longer solely standalone, isolated, totally analog-based systems, nor fully integrated into the IP network and converged with other enterprise subsystems. The long-term goal of the industry is to move out of the targeted role of addressing the areas of loss prevention, regulatory compliance, and personal safety to providing a business value to the enterprise.

To increase sales and deployments of IP video surveillance equipment, the goal must be to move from targeting the physical security manager as the primary decision maker in the organization to the chief financial office and IT/technology officer.

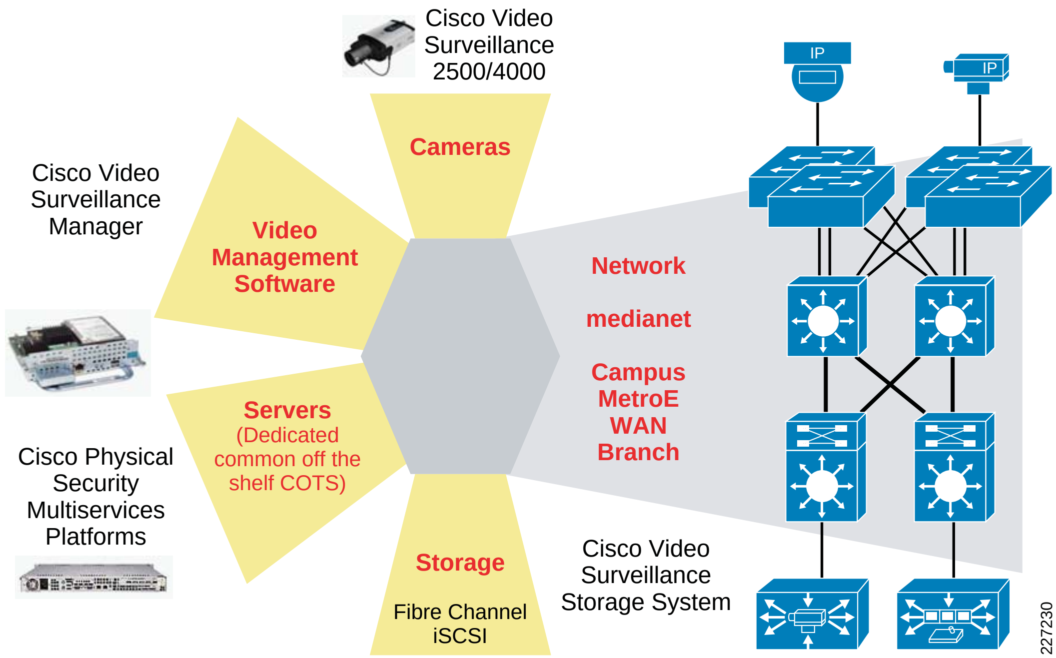
The true value in a converged physical security deployment is when the video data can be analyzed and the result of that analysis provides actionable information on increasing sales or reducing costs or legal liabilities to the enterprise. Increasing the return on investment (ROI) by lowering the costs of the video surveillance infrastructure through IP-enabling video surveillance is an initial goal. The goal is to reach the point where all aspects of the video surveillance system are IP-enabled and integrated on the IP network before moving on to subsequent objectives.

This guide addresses how to integrate a video surveillance onto the enterprise IP network. This is not the end goal, it is the first step. In this chapter, the various components and functions of an IP video surveillance deployment is discussed. Then, at an overview level, the IP network infrastructure key points of bandwidth, quality-of-service (QoS), security, network services, and virtualization are reviewed. The chapter concludes with the prospects of network management, integration with ancillary subsystems, and video data-mining and analytics.

Video Surveillance

Every video surveillance deployment is made up of cameras, video management software, servers, and storage. The IP network is then the fifth element that ties all these components into a converged network infrastructure. The relationship is shown in Figure 3-1.

Figure 3-1 Components of IP Video Surveillance Deployments



In very small deployments, the video management software, server, and storage components can be as simple as a single PC, an IP camera, and a simple Ethernet hub. Very large deployments may encompass thousands of IP cameras, hundreds of servers, and a storage subsystem capable of hundreds of terabytes to a 1-petabyte (1024 TB). In the first case, the network requirements are trivial, in the second, substantial.

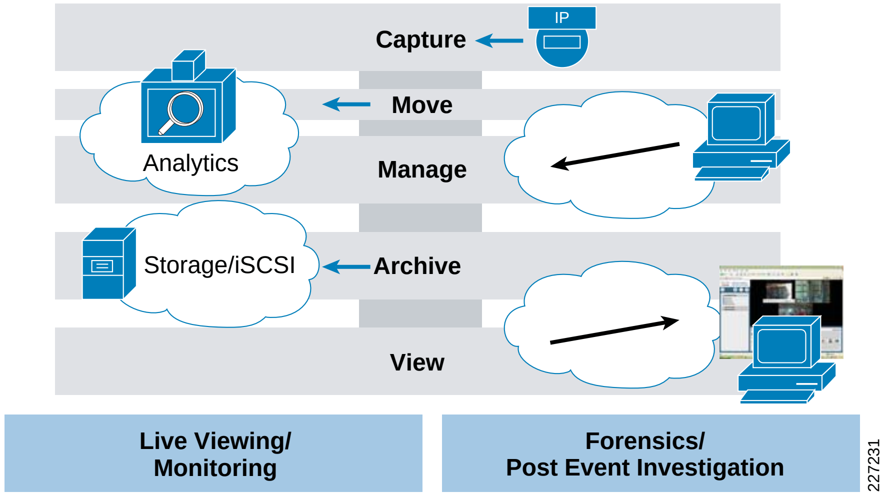
The IP video surveillance application intersects with the network infrastructure by connecting endpoints, IP cameras, workstations, servers and storage physically to the network. From a network planning and design standpoint, it is important to understand the flow of both media and command and control functions between the components. Video surveillance has two main baseline functions: live viewing and real-time monitoring of video feeds, and retrieval and viewing of video as a post-event investigation. Forensic video analysis is used to examine and analyze video for use in legal proceedings. Some video may require one type or the other, or both. Traffic cameras may have the sole purpose of identifying congestion and have no need for archive or retention of the video data. An enterprise video deployment may have both live viewing of selected cameras with all cameras being archived. Other deployments may be "*headless*," meaning there is only archiving, but no living viewing.

The primary video surveillance functions are:

- *Capture*—Encoding video feeds for network transport
- *Move*—Camera feeds are moved from camera to one or more servers for processing
- *Manage*—Administration of cameras, setting up archives, configuring operator views, etc
- *Archive*—Storing real-time camera feeds to disk for later retrieval
- *View*—Viewing either live or archived feeds

These functions are shown in Figure 3-2.

Figure 3-2 LAN/ WAN/MAN Intersections to IP Video Surveillance Functions



Each of the above functions can intersect with the underlying IP network and, to properly design and implement the network, the requirements of the video surveillance application must be understood. To capture a video feed, the IP camera must be configured for resolution, frame rate, and server IP address; at least the frame rate and resolution could change at times throughout the day. Therefore, simply capturing data requires some control plane network traffic as well as keeping the clock of the camera in synch with a universal clock through protocols such as Network Time Protocol (NTP). While the bandwidth requirements of the function is small, the reliability and availability requirement is high.

Moving video feeds introduce a bandwidth load on the network. The cameras may be LAN- or WAN-attached. Understanding the collective bandwidth from a deployment of hundreds or thousands of cameras requires an understanding of the load placed upon the network. These media streams must also be protected against packet loss.

Managing the system also influences the network bandwidth requirements. If there is a requirement to schedule a backup of an archive, sufficient bandwidth must be available for this function to complete. The archive backup process is typically between a remote Media Server and a central Media Server and the limited bandwidth of the WAN must be considered.

Archiving the data through a directly attached point-to-point Fibre Channel between server and storage unit is very straight forward, but what if Fibre Channel switches are deployed or iSCSI?

The viewing function shares similar network requirements as the move function, because the client workstation is retrieving the same video feed from the server as was transported from the camera to the server originally.

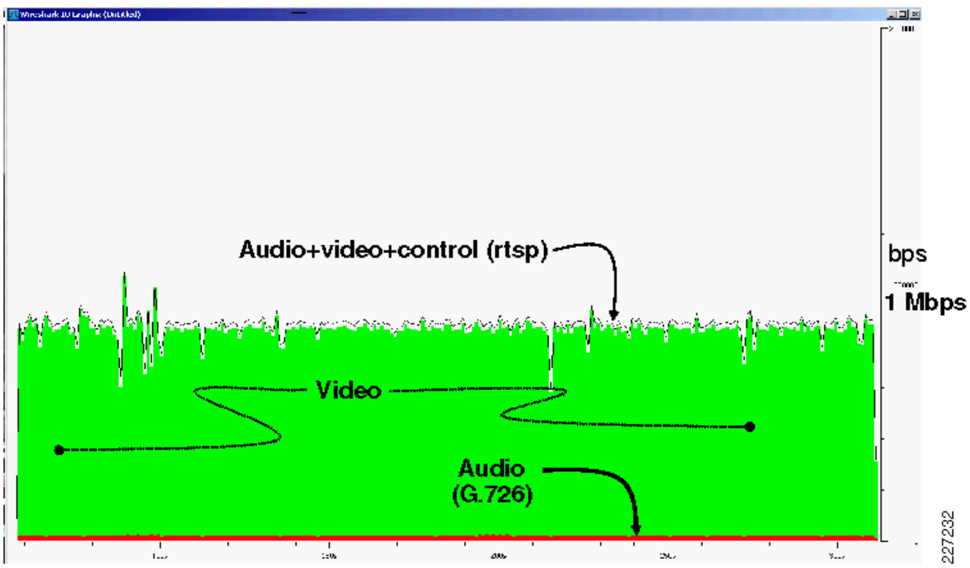
IP Network Infrastructure

The areas of bandwidth, QoS, security, network services, and virtualization are key elements of provisioning the enterprise IP network to support video.

Bandwidth

The bandwidth requirements for all video, but video surveillance in particular, is substantial compared to VoIP. Common codecs used in VoIP deployments, (G.711, G.729,G.726) use between 8 and 64Kbps for the voice encoding. A packet capture from a Cisco 2500 Series IP Camera configured at a CBR target of 1M for the MPEG4 feed with audio-enabled on the camera. Control traffic (HTTP/RTSP) is also captured. The relationship between the amount of audio, video, and control plane is obvious. See Figure 3-3.

Figure 3-3 Audio and Video Network Load



The bandwidth requirement for the video media stream is orders of magnitude higher than Audio (VoIP) and Signaling (RTSP) for video in the enterprise network.

While provisioning for this bandwidth requirement is a key element in planning for video in the enterprise network, there are other network requirements to be considered. For example, will the video traffic be segmented on both the LAN and WAN from other user traffic either logically or physically? Is the video deployment an overlay on an existing network infrastructure or is a entirely new deployment? Is IPSec encryption currently implemented? These factors must also be taken into consideration along with the bandwidth requirements.

QoS

QoS is a key element to managing network congestion during periods where bandwidth is constrained. QoS, however, does not eliminate bandwidth constraints; it manages the access to bandwidth by competing applications through prioritizing one application over another. QoS manages unfairness. Because the video quality for MPEG-4 and H.264 is highly dependent on little or no packet loss, IP video surveillance traffic must not be dropped by the enterprise QoS policy. Motion JPEG-based video does not suffer a degradation in the image with packet loss due to lack of bandwidth, but the smoothness of motion is compromised. Several frames or even several seconds of video may be missing with no indication of the loss. Because many video surveillance deployments are 'headless', and first time the video is viewed may be days or weeks after capture. If the quality is poor due to packet loss in the network, there is no recourse and the video data is worthless.

Security

Security focuses on controlling what users have access to a resource while in transit, at the originating node, or when it is processed or stored on a server. One aspect of IP networking is the any-to-any connectivity between networks and users. This strength is also a flaw. There is a certain population of users on the network that must have access to the video surveillance system, but many cannot be trusted to access this data. Video surveillance data is particularly sensitive because access to the system by unscrupulous individuals may expose the enterprise to financial loss and compromise personal safety. This guide illustrates transporting video traffic over LAN and WAN with IP security encryption and also implements administrative controls on who has access to the network.

Network Services

One advantage of the any-to-any aspect of IP networks is access to resources and systems. NTP and Syslog messages are examples of network services that IP cameras can request data from and send data to, which are either not available with analog-based systems or are more costly to implement. Additionally, local utilities like Power-over-Ethernet (PoE) and Cisco Discovery Protocol (CDP) both lower the cost of installation and facilitate troubleshooting.

Virtualization

Through virtualization techniques, the routers and switches can be configured to provide access to a common network infrastructure while maintaining a separate address space, broadcast domain, and separation of one user group from another. IP video surveillance is one application that is a prime candidate for virtualization as the end-user population is very small, the endpoints (IP cameras) may be distributed on a large number of routers and switches in the enterprise, and the data (video feeds) contain information that may be sensitive. This guide provides a detailed discussion of implementing virtualization of both routers and switches.

Network Management

Network management applications and protocols are discussed under the section on network services where IP service level agreements (IP SLAs), Syslog, CDP, and Simple Network Management Protocol (SNMP) are shown in relation to video surveillance deployments. Enterprise networks vary in degree of sophistication and maturity of network management. IP video surveillance, however, is one application that can greatly benefit from a proactive approach to the Fault, Configuration, Administration, Performance, and Security (FCAPS) model. For example, in headless deployments (video feeds that are not actively monitored by a person), the availability and network performance is critical to ensuring quality video recordings. The network management platforms and processes of the enterprise can help the physical security manager in detecting and reacting to an endpoint or network transport issues that could impact video quality.

Integration with Ancillary Subsystems

Physical security is one component of facilities management in many large organizations. Other components include door access control, which is often closely linked with video surveillance as a key component to the safety and security missions. In order to realize the goal of a fully-converged network, the other building management systems (BMS) such as fire alarms, elevator control (to park elevators in the event of a fire), air quality monitoring (carbon monoxide and smoke detection), and lighting and heating/cooling must be able to communicate with the video surveillance systems.

The first step in realizing this goal is to IP-enable these devices and provide the network infrastructure to support their effective communication between systems. For example, if virtualization is enabled on the IP network to support video surveillance, a practical approach is to also include the BMS devices on the same address space, and in the same network segments, as the video surveillance devices. Typically, the bandwidth requirements of BMS systems are very trivial to that of video surveillance, the end-users of the data are often report to the same organization heads and the likelihood of system integration now or in the future is high.

Video Data-Mining and Analytics

The end-goal of migrating from analog-based systems to IP-enabled video surveillance is to move the application from targeting loss prevention, compliance, safety, and security to obtain a greater business value by increasing sales and reducing expenses and exposure to liability. Data-mining is the process of detecting some pattern in data. One application to video surveillance may be to analyze video feeds to detect certain colors or articles of clothing to identify groups of gang members among patrons at a shopping mall. Video analytics uses data mining techniques to detect patterns in data. Video analytics may be preformed at the endpoint (IP camera) on specialized digital signal processors (DSPs) by a third-party analytics vendor or by servers within the enterprise data center. One application of video analytics is to detect the queue length of checkout lines and inform management to increase or decrease the staffing at cash registers to more fully use staff.

In the future, the output of the analysis of video data may be more economically valuable than the loss prevention role of video surveillance to many retail organizations.

CHAPTER 4

Planning and Design

This chapter introduces the concepts of why an enterprise network should consider migrating from a standalone analog network to a converged IP network supporting voice, video, and data. The following topics are addressed:

- Introduction to the concepts of video resolutions, codecs, aspect ratios, frame rates and requirements for camera placement to achieve the required number of pixels per-foot to provide sufficient video quality to meet the needs of the physical security manager.
- Network deployment models and the IP transports used by IP video surveillance cameras.
- The network requirements, video traffic flows between endpoints, bandwidth requirements are discussed.
- A design checklist to help the physical security and network manager achieve the goal of integrating IP video surveillance on the IP network.
- A case study for implementing IP video surveillance on a campus deployment.

IP Video Surveillance Fundamentals Overview

This section provides an overview of why video surveillance deployments are migrating from analog-based systems to IP-based systems. The time between 2007 and 2010 represents a market transition in the industry where sales of IP-based components began out-selling analog-based systems. While analog systems have a cost advantage in small deployments (sixteen cameras or less), when larger number of cameras are deployed, IP-based systems may be more cost-effective initially and have a lower ongoing total cost of ownership. IP-based video surveillance systems, especially the end-node (the IP camera), have several operational and technological advantages. Why implement IP video surveillance over analog-based systems? The following subsections provide the answer.

Leveraging VoIP Adoption

Many of the advantages of implementing IP video surveillance are similar to those of VoIP adoption. The fundamental reason is the cost savings of using the IP network for both voice and data. By adding the transport of video surveillance on the existing highly-available IP network, the cost savings realized from eliminating the separate cable plant for voice extends as well to the elimination of the separate cable plant for video.

Not only the wiring for media transport can be eliminated, but also the cabling for electrical power. As is the case with VoIP in the enterprise space, where the IP phone uses PoE, so does many fixed installation IP cameras. While power to some camera deployments continue to be a requirement (Pan-Tilt-Zoom housings, wireless cameras and cameras that require fibre connectivity due to distance), PoE is a substantial cost savings.

IP video surveillance cameras, once connected to the network, may be remotely configured and managed from a central command center. The installing technician must have a laptop to focus the lens and adjust the viewpoint of the camera, but following this initial installation, the camera configuration may be completed by a technician in a central, rather than local, facility.

Access Video Any Time, Any Place

With IP-based systems, video feeds are encoded into Motion JPEG or MPEG-4/H.264 formats and stored as a digital image on a computer disk array. This provides the ability to access the video, by way of the networked digital video recorder, through the IP network at any time, from any place. These digital images do not degrade in quality from duplication like analog recordings on magnetic tape. They can be replicated and posted on web servers, distributed to law enforcement as E-mail attachments, and sent to news outlets. When analog-based systems were the norm, loss prevention/investigations staff may have to visit the location of the incident to view the video or a tape or DVD would need to be shipped by overnight courier. These inefficiencies no longer exist with IP-based systems and WAN connectivity to the physical location.

Intelligence at the Camera

With IP cameras, local processing of the video image may be done during capture and analysis like motion detection and tampering detection logic may raise alerts by communicating with a central server. The alert may use a variety of IP protocols, SMTP (E-mail), Syslog, File Transfer (FTP), or a TCP socket connection with a small keyword in the payload. The Cisco 4500 IP Cameras have an additional DSP capabilities specifically designed to support real-time video analytics on the camera. This option is to allow analytic vendors to develop firmware in the future to run on these resources.

Barriers to Success

While the advantages of an IP-based system are considerable, there are some barriers to success. They mainly revolve around the human element—job responsibilities, training, and education. Typically, the physical security manager and the network manager have no overlapping job responsibilities and therefore have little need to interact with each other. The physical security manager has job responsibilities targeted at loss prevention, employee and customer/visitor safety, security and crime prevention. Because of this, the physical security manager is more confident with a dedicated, reliable, physically separate cable plant.

Many installations of physical security cameras and the accompanying components are solely or partially implemented by value added resellers (VARs) who are specialists in their field, but not yet experts in IP networking. The VAR must become more fluent in internetworking and the network manager must understand the requirements of the physical security processes and applications.

The key elements of video surveillance is the three *Rs*: resolution, retention, and reliability. For an IP video surveillance deployment to be a success on the IP network, the *reliability* element must have careful attention by the network manager for the physical security manager to be successful.

Video Resolutions

Resolution, one of the three *Rs* of video surveillance, directly influences the amount of bandwidth consumed by the video surveillance traffic. Image quality (a function of the resolution) and frame rate are functions of the amount of bandwidth required. As image quality and frame rate increase, so does bandwidth requirements.

Analog Video Resolutions

Video surveillance solutions use a set of standard resolutions. National Television System Committee (NTSC) and Phase Alternating Line (PAL) are the two prevalent analog video standards. PAL is used mostly in Europe, China, and Australia and specifies 625 lines per-frame with a 50-Hz refresh rate. NTSC is used mostly in the United States, Canada, and portions of South America and specifies 525 lines per-frame with a 59.94-Hz refresh rate.

These video standards are displayed in interlaced mode, which means that only half of the lines are refreshed in each cycle. Therefore, the refresh rate of PAL translates into 25 complete frames per second and NTSC translates into 30 (29.97) frames per second. Table 4-1 shows resolutions for common video formats.

Table 4-1 Analog Video Resolutions (in pixels)

Format	NTSC-Based	PAL-Based
QCIF	176 × 120	176 × 144
CIF	352 × 240	352 × 288
2CIF	704 x 240	704 x 288
4CIF	704 × 480	704 × 576
D1	720 × 480	720 × 576

Note that the linear dimensions of 4CIF are twice as big as CIF. As a result, the screen area for 4CIF is four times that of CIF with higher bandwidth and storage requirements. The 4CIF and D1 resolutions are almost identical and sometimes the terms are used interchangeably.

Note IP camera vendors may use different video resolutions. The Cisco Video Surveillance Manager solution supports the format delivered by the camera.

Digital Video Resolutions

User expectations for resolution of video surveillance feeds are increasing partially due to the introduction and adoption of high-definition television (HDTV) for broadcast television. A 4CIF resolution, which is commonly deployed in video surveillance, is a 4/10th megapixel resolution. The HDTV formats are megapixel or higher. Table 4-2 lists the typical resolutions available in the industry.

Table 4-2 Digital Video Surveillance Resolutions (in pixels)

Size/ Format	Pixels
QQVGA	160x120
QVGA	320x240

Size/ Format	Pixels
VGA	640x480
HDTV	1280x720
1M	1280x960
1M	1280x1024
2M	1600x1200
HDTV	1920x1080
3M	2048x1536

While image quality is influenced by the resolution configured on the camera, the quality of the lens, sharpness of focus, and lighting conditions also come into play. For example, harshly lighted areas may not offer a well-defined image, even if the resolution is very high. Bright areas may be washed out and shadows may offer little detail. Cameras that offer wide dynamic range processing, an algorithm that samples the image several times with differing exposure settings and provides more detail to the very bright and dark areas, can offer a more detailed image.

As a best practice, do not assume the camera resolution is everything in regards to image quality. For a camera to operate in a day-night environment, (the absence of light is zero lux), the night mode must be sensitive to the infrared spectrum. It is highly recommended to conduct tests or pilot installations before buying large quantities of any model of camera.

Tip Some cameras rated as megapixel cameras in Motion JPEG only offer 4CIF resolution when configured for MPEG-4.

Video Compression CODECS

The Cisco Video Surveillance Media Server supports IP endpoints that use Motion JPEG (MJPEG) or MPEG-4 codec technology. Both types of codecs have advantages and disadvantages when implemented in a video surveillance system. A system administrator may choose to use MJPEG on certain cameras and MPEG-4 or H.264 on others, depending on system goals and requirements.

A *codec* is a device or program that performs encoding and decoding on a digital video stream. In IP networking, the term frame refers to a single unit of traffic across an Ethernet or other Layer-2 network. In this guide, *frame* primarily refers to one image within a video stream. A video frame can consist of multiple IP packets or Ethernet frames.

A video stream is fundamentally a sequence of still images. In a video stream with fewer images per second, or a lower frame rate, motion is normally perceived as choppy or broken. At higher frame rates up to 30 frames per second, the video motion appears smoother; however, 15 frames per second video may be adequate for viewing and recording purposes.

Some of the most common digital video formats include the following:

- **Motion JPEG (MJPEG)** is a format consisting of a sequence of compressed Joint Photographic Experts Group (JPEG) images. These images only benefit from spatial compression within the frame; there is no temporal compression leveraging change between frames. For this reason, the level of compression reached cannot compare to codecs that use a predictive frame approach.

- **MPEG-1 and MPEG-2** formats are Discrete Cosine Transform-based with predictive frames and scalar quantization for additional compression. They are widely implemented, and MPEG-2 is still in common use on DVD and in most digital video broadcasting systems. Both formats consume a higher level of bandwidth for a comparable quality level than MPEG-4. These formats are not typically used in IP video surveillance camera deployments.
- **MPEG-4** introduced object-based encoding, which handles motion prediction by defining objects within the field of view. MPEG-4 offers an excellent quality level relative to network bandwidth and storage requirements. MPEG-4 is commonly deployed in IP video surveillance but will be replaced by H.264 as it becomes available. MPEG-4 may continue to be used for standard definition cameras.
- **H.264** is a technically equivalent standard to MPEG-4 part 10, and is also referred to as Advanced Video Codec (AVC). This emerging new standard offers the potential for greater compression and higher quality than existing compression technologies. It is estimated that the bandwidth savings when using H.264 is at least 25 percent over the same configuration with MPEG-4. The bandwidth savings associated with H.264 is important for high definition and megapixel camera deployments.

MJPEG

An MJPEG codec transmits video as a sequence of Joint Photographic Experts Group (JPEG) encoded images. Each image stands alone without the use of any predictive compression between frames. MJPEG is less computation-intensive than predictive codecs such as MPEG-4, so can be implemented with good performance on less expensive hardware. MJPEG can easily be recorded at a reduced frame rate by only sampling a subset of a live stream. For example, storing every third frame of a 30-frame per second video stream will result in a recorded archive at 10 frames per second.

MJPEG has a relatively high bandwidth requirement compared to MPEG-4. A 640x480 VGA resolution stream running at 30 frames per second can easily consume 5 to 10 Mbps. The bandwidth required is a function of the complexity of the image, in conjunction with tuning parameters that control the level of compression. Higher levels of compression reduce the bandwidth requirement but also reduce the quality of the decoded image. Since there is no predictive encoding between frames, the amount of motion or change in the image over time has no impact on bandwidth consumption.

MPEG-4/H.264

An MPEG-4 codec uses prediction algorithms to achieve higher levels of compression than MJPEG while preserving image quality. Periodic video frames called I-frames are transmitted as complete, standalone JPEG images similar to an MJPEG frame and are used as a reference point for the predictive frames. The remaining video frames (P-frames) contain only information that has changed since the previous frame.

To achieve compression, MPEG-4 relies on the following types of video frames:

- **I-frames** (intraframes, independently decodable)—These frames are also referred to as *key* frames and contain all of the data that is required to display an image in a single frame.
- **P-frames** (predictive or predicted frames)—This frame type contains only image data that has changed from the previous frame.
- **B-frames** (bi-directional predictive frames)—This frame type can reference data from both preceding frames and future frames. Referencing of future frames requires frame reordering within the codec.

The use of P-frames and B-frames within a video stream can drastically reduce the consumption of bandwidth compared to sending full image information in each frame. However, the resulting variance of the video frames' size contributes to the fluctuation in the bandwidth that a given stream uses. This is the nature of most codecs because the amount of compression that can be achieved varies greatly with the nature of the video source.

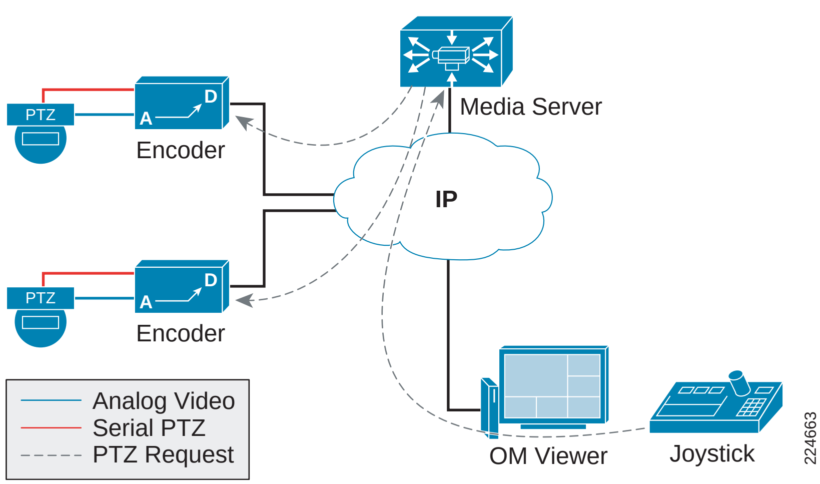
Pan-Tilt-Zoom (PTZ)

The Cisco Video Surveillance Manager solution supports the configuration of PTZ cameras connected to encoders or as IP cameras. In order to support PTZ connectivity, the encoder should be able to connect to the camera through a serial interface. The Video Surveillance Manager solution supports the following PTZ protocols:

- Bosch
- Cohu
- J2 Vision
- Pelco D
- Pelco P

Figure 4-1 shows how an analog camera can be connected to an IP encoder to convert its video feed to an IP video format. The encoder also connects through a serial cable to the analog camera. When the OM viewer requests PTZ control through the joystick, the Media Server intercepts the request and communicates the request to the encoder. Once the request is received by the encoder, a serial communication takes place between the encoder and the analog camera.

Figure 4-1 Pan-Tilt-Zoom Via Encoders



Aspect Ratio

The aspect ratio is the relationship between the number of pixels in the horizontal and vertical image dimensions. A 4:3 (1.33:1) aspect ratio is universal for standard definition cameras. For HDTV formats, 16:9 (1.78:1) is universal. In video surveillance deployments, the HDTV aspect ratio is more advantageous because the pixels at the top and bottom of the image are generally of less importance than having a wide field of view. In other words, the width of the image is more important than the height of the image. Capturing, encoding, and transporting bits that are of little value is a waste of bandwidth and disk space. In some instances, a single HDTV format video camera may be able to replace two standard definition cameras.

Camera Placement

Camera placement can be characterized by either overview or detail view. The camera placement influences the resolution, frame rate and codec in use.

Overview

A camera with an overview scene is monitoring a large area such as a parking lot or a traffic camera that is viewing vehicle congestion or the number of cars parked in the lot. Because details are not important, standard definition cameras using a wide-angle lens may be sufficient. The preferred codec may be MPEG-4 with a relatively low frame rate, 1-5 frames per second. Figure 4-2 shows an example of an overview scene.

Figure 4-2 Overview Scene

227233

AbbeyCam is a streaming video of the Iowa side of the I-74 bridge as seen from the Abbey Hotel in Bettendorf

Overview cameras may be supplemented with a detail view camera focused on a key area of interest or by a PTZ camera to provide real-time analysis of areas of interest at a higher resolution.

Detail View

The detail view placement is targeted at observing a specific area of interest at a higher resolution than the overview. Detail view is used for Point-of-sale transactions and face or license plate recognition. The detail view may have a PTZ capability, or the camera may be close to the subject area or have a long focal length lens. Megapixel or HD cameras may be deployed to provide a sufficient number of pixels per-foot to accurately represent the subject. Figure 4-3 is an example of a detail view, the camera positioned to identify a subject passing through a confined area.

Figure 4-3 Detail View Placement

The positioning of a camera for detail view is a function of the number of pixels per-foot required for the application.

Detection, Recognition, Identification

Detection, recognition, and identification are visual processes associated with the amount of detail discernable to the human eye. We detect an object when it enters the field of view. Detection means we are aware that an object (or person) now exists where previously it was not seen. Usually, this is due to movement of the object into the field of view of the surveillance camera. Detection simply means we are aware of the object, but have too little details to recognize or identify the object.

As the object moves closer, we may recognize the object from characteristics previously encountered. For example, aircraft recognition is taught to military ground troops and airmen. All aircraft have wings, engines, a fuselage, and tail assembly. They differ in size, shape, number, and position to each other. A particular model of aircraft can be recognized by recalling these characteristics from pictures, drawings or past detailed observations.

Identification is the process where sufficient details are available to uniquely discern a person or object that is previously unknown. Identification requires sufficient detail to accurately describe or recall the characteristics of the subject at a later time. For example, a mug shot (booking photograph) is taken following the arrest of a subject as a means of photographing (recording) sufficient details for later identification by a victim or witness. In video surveillance terms, sufficient detail is calibrated in pixels per foot of the area recorded by the camera.

The number of pixels per-foot to identify a subject may, at a minimum, range from 40 to over 150. If the goal, therefore, is to identify a person entering through a standard 7-foot high doorway, the camera would need to be positioned so that the pixel per-foot requirement covering the door is met. The door would then need to be covered by 1050 pixels, if the goal is to have 150 pixels per foot; *7 feet x 150* pixels per foot. Figure 4-4 provides an example of an image with approximately 100 pixels per foot for reference.

Figure 4-4 Pixels Per Foot

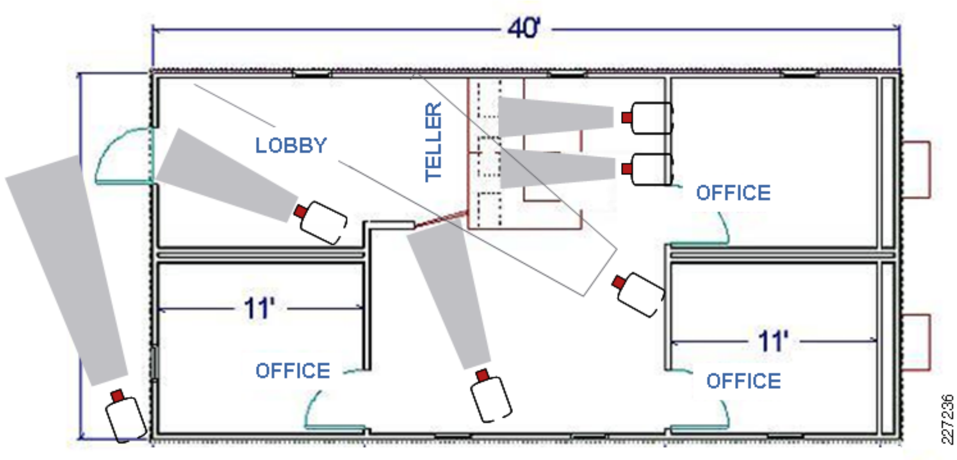
As shown in Figure 4-4, the video surveillance image is subject to uneven lighting, the subject is standing near a large window of a lab environment. There is little light from the internal space with the natural light entering from the side and rear in this scene. This image is from an analog camera that does not include a wide-dynamic range processing that would improve the image quality in this deployment. This illustrates the point that the number of pixels alone does not guarantee a high quality image.

Number of Cameras per Location

The number of cameras at any one building or facility may vary greatly depending on the coverage requirements and the nature of the business. While there are some small office deployment scenarios where only a single IP camera is needed, in most cases even a small office will require more cameras that one might initially expect.

Using a small, two teller bank branch as an example, consider the number and placement of cameras in the example shown in Figure 4-5.

Figure 4-5 Camera Deployment Floor Plan



There is a camera behind each teller station, a camera on the main entrance (both inside and outside), and two cameras in the inner office area focused on the lobby and half doorway leading into the manager office areas. Additionally, the parking lot area, side, front, and rear of the branch as well as any exterior

ATM would need be covered. This small location may easily require 10 to 16 IP cameras. The Cisco Video Management and Storage System (VMSS) Network Module for the ISR router is targeted at a 16 to 32 camera deployment any may be implemented in this branch location.

Larger facilities require more cameras per location. It is not uncommon for a large retail store, home center, or warehouse retailer to need 100 to 200 IP cameras per location. Public school deployments may need 80 to 100 cameras per building.

Tip One advantage of deploying high definition cameras over standard definition is fewer cameras may be required to cover an area of interest with a similar number of pixels per foot.

Frame Rates

As image quality and frame rate increase, so does bandwidth requirements. The frame rate selected must meet the business requirements, but it does not need to be higher than what is required and should be considered carefully as frame rate influences both bandwidth and storage requirements.

Motion pictures are captured at 24 frames per second (fps). The human eye/brain sees images captured at 24 fps as fluid motion. Televisions use 25 fps (PAL) or 30 fps (NTSC) as does analog video cameras. These full motion rates are not needed for all video surveillance applications and in most applications less than 12 to 15 fps is sufficient.

The following are some industry guidelines:

- Nevada Gaming Commission (NGC) standards for casinos—30 fps
- Cash register, teller stations—12 to 15 fps
- School or office hallways —5 fps
- Parking lots, traffic cameras, overview scenes —1 to 3 fps
- Sports Stadiums on non-event days, less than 1 fps

Movement in Relation to Camera Placement

If the camera is placed where the subject moves toward the camera or vertically, the number of frames per second can be less than if the subject moves from side to side or horizontally within the field of view. The velocity of the subject is also a consideration. A cameras observing persons jogging or riding a bicycle may require higher frame rates than a person walking.

Progressive Scanning

Analog cameras capture images using an interlaced scanning method, odd and even scan lines are done alternately. There is approximately 17 ms delay between the scanning of the odd and even lines making up the entire image. Because of this slight delay between scan passes, objects that are moving in the frame may appear blurred while stationary objects are sharp. Most IP cameras use a progressive scan that is not subject to this problem. Everything being equal, a progressive scan image has less motion blurring than an interlace scanned image.

Wide Dynamic Range Imaging

The Cisco 2500 Series Video Surveillance IP Camera offer wide dynamic range imaging. This technology increases the image quality in harsh lighting conditions, including back lighted scenes or indoor/outdoor areas such as loading docks or stadiums.

IP Transport

IP cameras and encoders communicate with the Media Server in different ways, depending on the manufacturer. Some edge devices may support only MJPEG over TCP, while others may also support MPEG-4 over UDP.

TCP

MJPEG is typically transported through TCP. TCP provides guaranteed delivery of packets by requiring acknowledgement by the receiver. Packets that are not acknowledged will be retransmitted. The retransmission of TCP can be beneficial for slightly congested network or networks with some level of inherent packet loss such as a wireless transport. Live video rendering at the receiving end may appear to stall or be choppy when packets are retransmitted, but with the use of MJPEG each image stands alone so the images that are displayed are typically of good quality.

UDP/RTP

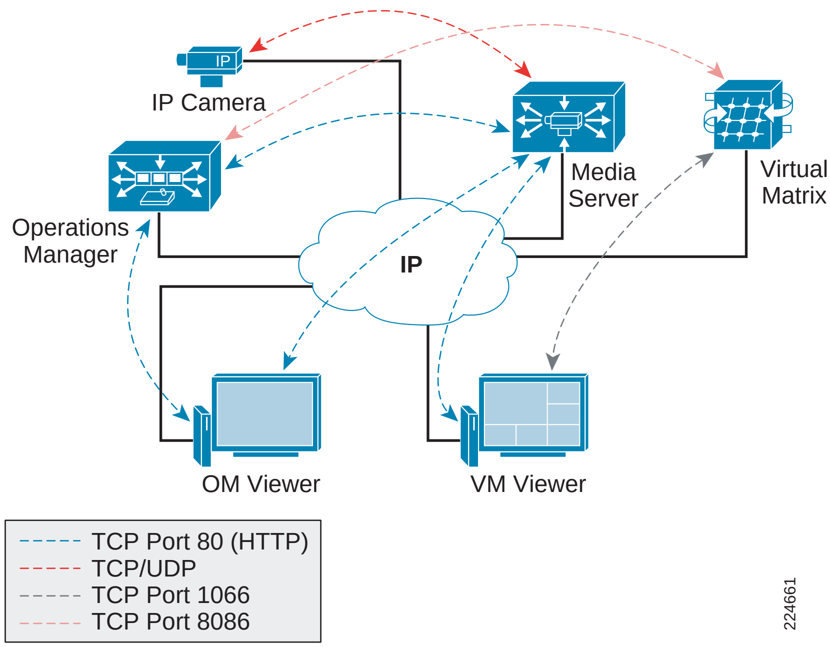
MPEG-4/H.264 video is typically transmitted over UDP or Real-time Transport Protocol (RTP). UDP does not guarantee delivery and provides no facility for retransmission of lost packets. RTP/UDP transport is most suitable for networks with very little packet loss and bandwidth that is guaranteed through QoS mechanisms. MPEG-4 over RTP/UDP is relatively intolerant to packet loss; if there is loss in the stream, there will typically be visible artifacts and degradation of quality in the decoded images. UDP transport does provide the option of IP multicast delivery, where a single stream may be received by multiple endpoints. In an IP multicast configuration, the internetworking devices handle replication of packets for multiple recipients. This reduces the processing load on the video encoder or IP camera and can also reduce bandwidth consumption on the network.

Some IP cameras and encoders also provide for TCP transport of MPEG-4. TCP encapsulation can be beneficial for networks with inherent packet loss. TCP may be useful especially for fixed cameras and streams that are only being recorded and not typically viewed live. TCP transport induces a little more latency in the transport due to the required packet acknowledgements, so may not be a desirable configuration for use with a PTZ controlled camera.

Required TCP/UDP Ports

The example in Figure 4-6 shows that the communication between the Media Server and viewers relies on TCP port 80 (HTTP), while the communication between edge devices and the Media Server may vary. The communication between the Virtual Matrix Server and the VM monitor is typically over TCP port 1066 while the communication between the Virtual Matrix Server and the Operations Manager is typically over TCP port 8086.

Figure 4-6 TCP/UDP Ports

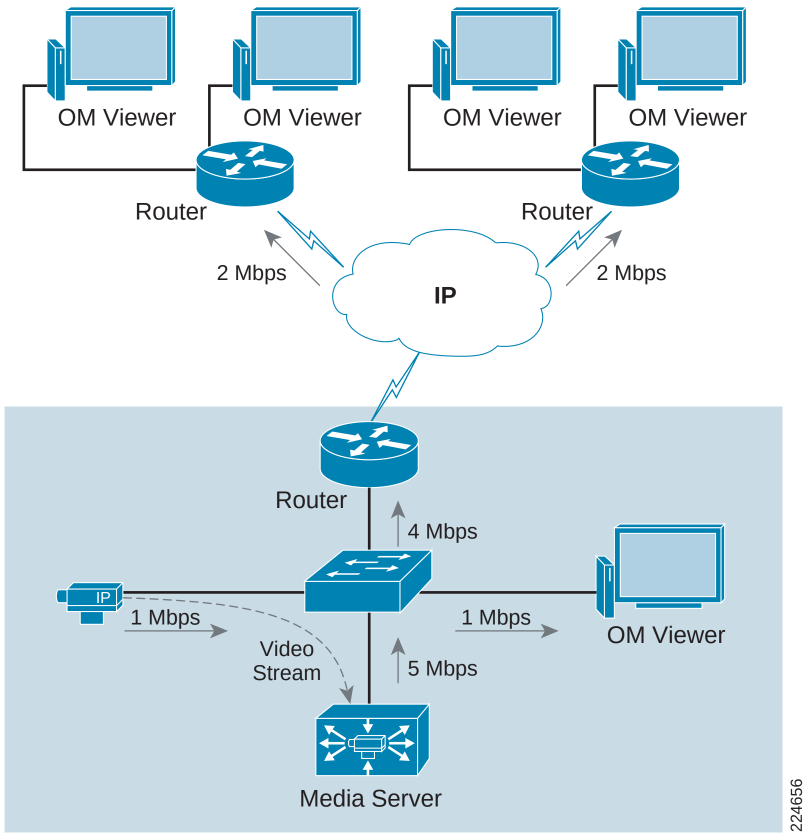


IP Unicast

Applications that rely on unicast transmissions send a copy of each packet between one source address and one destination host address. Unicast is simple to implement but hard to scale if the number of sessions is large. Since the same information has to be carried multiple times, the impact on network bandwidth requirements may be significant.

The communication between the Media Server and the viewers is always through IP unicast, making the Media Server responsible for sending a single stream to each viewer. The example in Figure 4-7 shows five viewers requesting a single video stream from the Media Server. Assuming a single 1Mbps video feed, the bandwidth requirements are noted throughout each network link.

Figure 4-7 IP Unicast Traffic



Note The Media Server only supports IP unicast between the Media Server and the viewers.

Network Deployment Models

This chapter provides a high-level overview of different deployment models and highlights the typical requirements of campus and wide area networks. Cisco's Enterprise Systems Engineering team offers detailed network designs that have been deployed by enterprise customers to provide enhanced availability and performance. These designs may be found at the Cisco Validated Design Program site at: http://www.cisco.com/go/cvd.

Campus Networks

An infrastructure that supports physical security applications requires several features from a traditional campus design. A hierarchical campus design approach has been widely tested, deployed, and documented. This section provides a high-level overview and highlights some of the design requirements that may apply to a video surveillance solution. For a more detailed review of Campus designs refer to the Campus Design documents in References, page A-18.

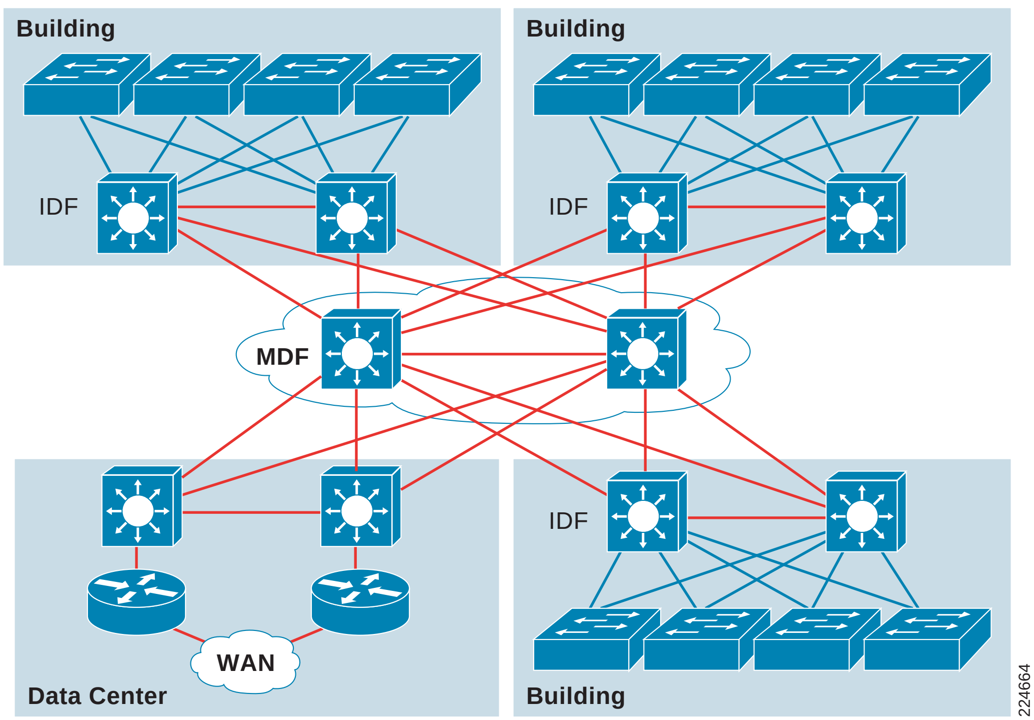
A traditional campus design should provide the following:

- **High availability**—Avoid single points of failure and provide fast and predictable convergence times.
- **Scalability**—Support the addition of new services without major infrastructure changes.
- **Simplicity**—Ease of management with predictable failover and traffic paths.

A highly available network is a network that provides connectivity at all times. As applications have become more critical, the network has become significantly more important to businesses. A network design should provide a level of redundancy where no points of failure exist in critical hardware components. This design can be achieved by deploying redundant hardware (processors, line cards, and links) and by allowing hardware to be swapped without interrupting the operation of devices.

The enterprise campus network shown in Figure 4-8 is a typical campus network. It provides connectivity to several environments such as IDFs, secondary buildings, data centers, and wide area sites. An Intermediate Distribution Frame (IDF) is the cable infrastructure used for interconnecting end user devices to the Main Distribution Frame (MDF) or other buildings and is typically located at a building wiring closet.

Figure 4-8 Campus Network



Quality-of-service (QoS) is critical in a converged environment where voice, video, and data traverse the same network infrastructure. Video surveillance traffic is sensitive to packet loss, delay, and delay variation (jitter) in the network. Cisco switches and routers provide the QoS features that are required to protect critical network applications from these effects.

Hierarchical Design

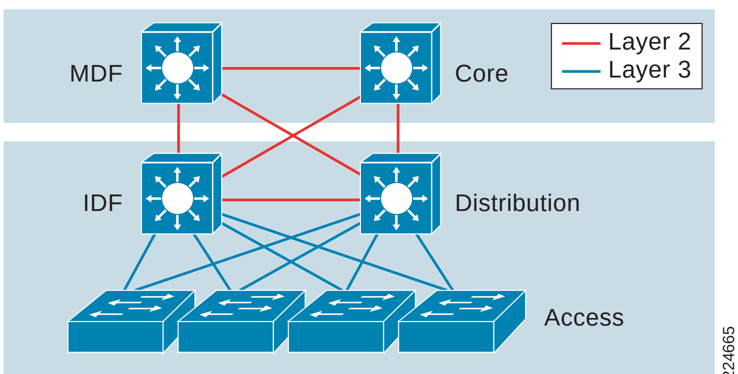
The goal of a campus design is to provide highly available and modular connectivity by separating buildings, floors, and servers into smaller groups. This multilayer approach combines Layer 2 switching (based on MAC addresses) and Layer 3 switching or routing (based on IP address) capabilities to achieve a robust, highly available campus network. This design helps reduce failure domains by providing appropriate redundancy and reducing possible loops or broadcast storms.

With its modular approach, the hierarchical design has proven to be the most effective in a campus environment. The following are the primary layers of a hierarchical campus design:

- **Core layer**—Provides high-speed transport between distribution-layer devices and core resources. The network's backbone.
- **Distribution layer**—Implements policies and provides connectivity to wiring closets. This layer provides first-hop redundancy such as Hot Standby Router Protocol (HSRP) and Gateway Load Balancing Protocol (GLBP).
- **Access layer**—User and workgroup access to the network. Security and QoS can be defined at this layer and propagated to the higher layers.

Figure 4-9 shows a typical campus design with the three main layers.

Figure 4-9 Hierarchical Campus Design



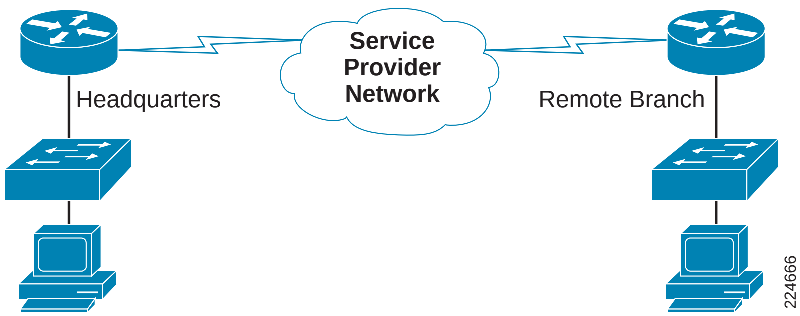
In smaller environments, it is typical to collapse the distribution and core layers into a single layer.

Wide Area Networks

A wide-area network (WAN) is used to connect different local-area networks (LANs) and typically covers a broad geographic area. WAN services are leased from service providers who provide different speeds and connectivity options.

Figure 4-10 shows how a remote branch office relies on the connectivity provided by a WAN service provider.

Figure 4-10 Service Provider Network



Deploying a video surveillance solution through a WAN environment presents challenges that are not typically seen in a LAN. In a LAN environment it is common to see 1 Gbps and 10 Gbps of bandwidth, while in a WAN environment, most connections are less than 10 Mbps; many remote connections operate on a single T1 (1.544 Mbps) or less.

These inherent bandwidth constraints require careful evaluation of the placement of cameras and Media Servers and how many viewers can be supported at remote sites simultaneously. By using child proxies, bandwidth requirements can be reduced to transport video streams across WAN connections.

The placement of recording devices also becomes important. The video may be streamed to a central site using lower frame rates or resolution, but another attractive alternative is to deploy Media Servers at the remote sites and stream the traffic using the LAN connectivity within the remote site.

Table 4-3 and Table 4-4 show typical links that are offered by service providers.

Table 4-3 Service Provider Links (1)

Digital Signal Level	Speed	"T"	Channels or DS0s
DS0	64 kbps	–	1
DS1	1.544 Mbps	T1	24
DS3	44.736 Mbps	T3	672

Table 4-4 Service Provider Links (2)

SONET Signal Level	Speed	SDH Equivalent
STS-OC-1	51.84 Mbps	STM-0
STS-OC-3	155.52 Mbps	STM-1
STS-OC-12	622.08Mbps	STM-4
STS-OC-48	2488.32 Mbps	STM-16
STS-OC-192	9.952 Gbps	

A point-to-point or leased line is a link from a primary site to a remote site using a connection through a carrier network. The link is considered private and is used exclusively by the customer. The circuit usually is priced based on the distance and bandwidth requirements of the connected sites.

Technologies such as Multilink PPP allow several links to be bundled to appear as a single link to upper routing protocols. In this configuration, several links can aggregate their bandwidth and be managed with only one network address. Because video surveillance traffic requirements tend to be larger than other IP voice and data applications, this feature is attractive for video surveillance applications.

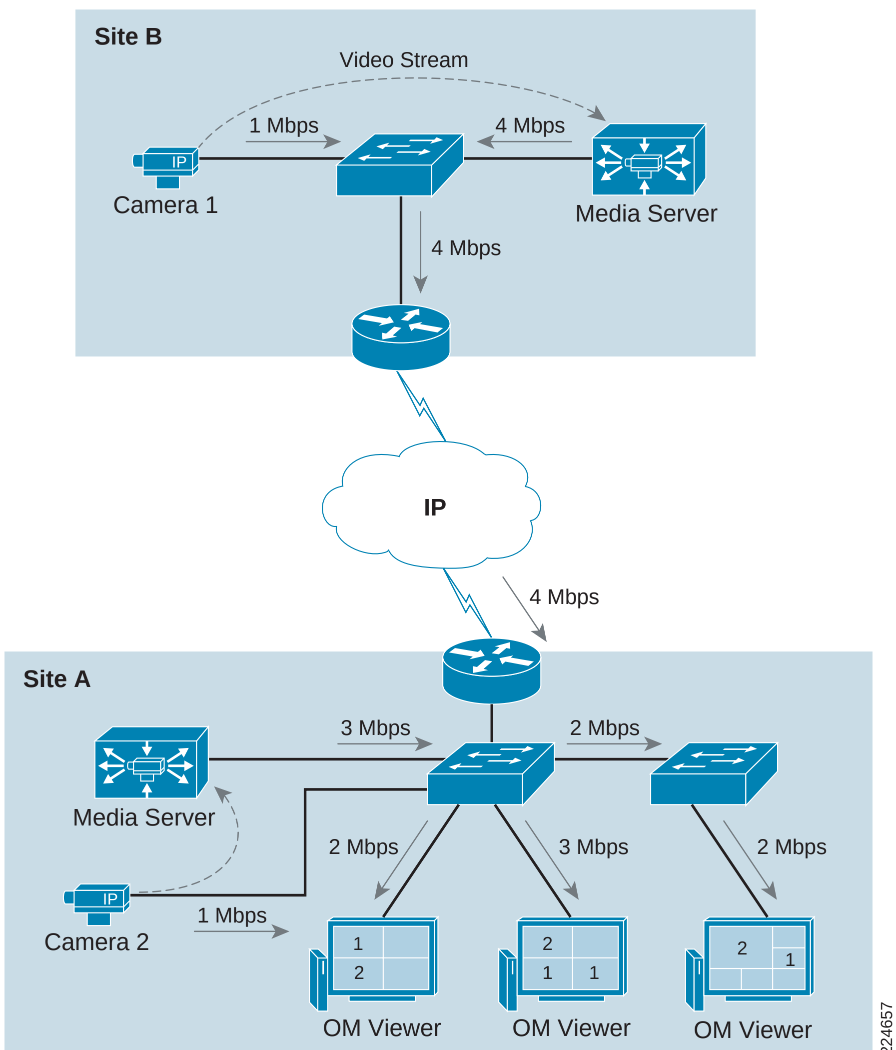
Hub-and-spoke, also known as star topology, relies on a central site router that acts as the connection for other remote sites. Frame Relay uses hub-and-spoke topology predominantly due to its cost benefits, but other technologies, such as MPLS, have mostly displaced Frame Relay.

Example 1: Network Bandwidth Usage

Figure 4-11 shows a simple scenario with two sites. Each site has a Media Server and each Media Server is the direct proxy for an IP camera. Three OM Viewers are active in Site A and each IP cameras is generating 1Mbps of network traffic. For simplicity the Operations Manager has been removed from this graphic.

Two OM Viewers are displaying video streams from Camera 1 and Camera 2 while one OM Viewer is displaying three video streams: two streams from Camera 1 and one stream from Camera 2. The network bandwidth required to display video streams for Camera 2 in Site A are relatively small for a LAN environment, but the traffic from Camera 1 can be significant for WAN environments since four different 1Mbps streams have to traverse the WAN locations.

Figure 4-11 Network Bandwidth Requirements



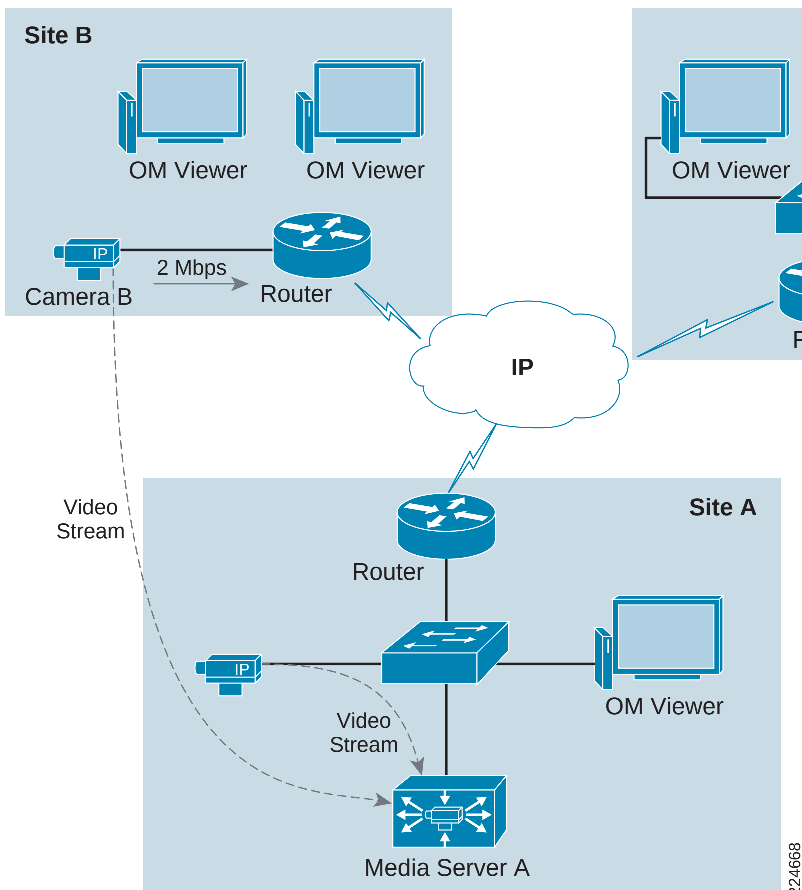
Example 2: Sites with Remote Storage

Figure 4-12 shows how Media Servers can be deployed at different WAN locations in order to minimize the bandwidth requirements. By deploying the Media Servers close to viewers and edge devices, the network traffic remains local to each site. Archiving video streams at each location is also an attractive solution to minimize the network traffic between sites.

In this example Site A and Site C have Media Servers acting as direct proxies and archives for the IP cameras. Since both sites are archiving and distributing video to the OM Viewers locally, the network traffic remains local to each site.

Site B can function without a local Media Server, but all video streams have to traverse the WAN connections. Since Media Server A is the direct proxy for Camera B, the 1Mbps stream has to reach Media Server A before reaching any OM Viewers. A total of 3Mbps would be required in order for both OM Viewers in Site B to receive video from Camera B.

Figure 4-12 Sites with Remote Storage



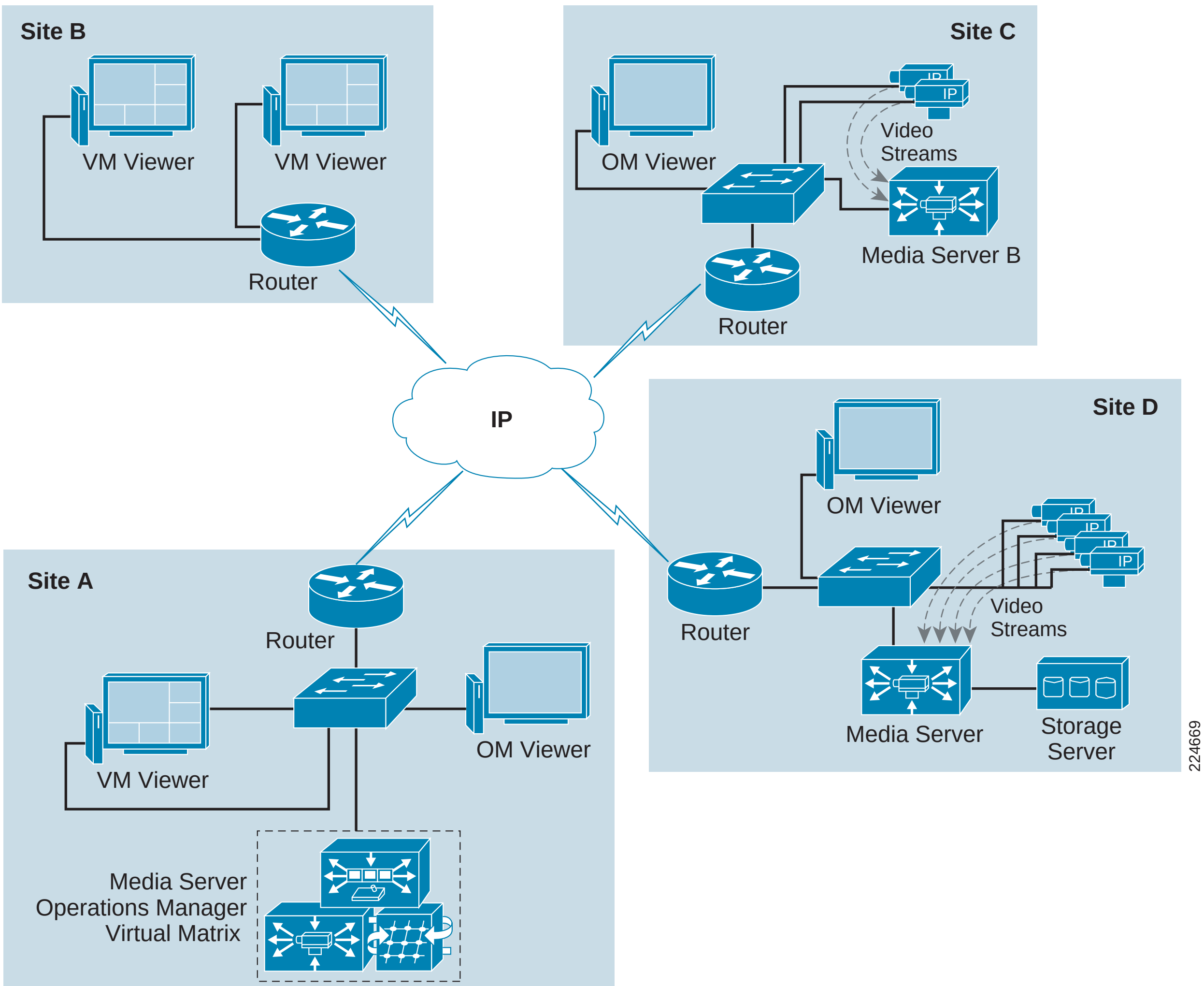
Example 3: Virtual Matrix Scenario

Figure 4-13 shows an example that includes a Virtual Matrix Server and VM monitors located at two different sites. The Server on Site A is acting as the Media Server, Operations Manager, and Virtual Matrix for the environment. In order to reduce bandwidth traffic, Media Servers are also installed on Site C and Site D.

A single Operations Manager and a single Virtual Matrix are adequate to support this scenario. Since the cameras are located on Site C and Site D, they are able to serve the local OM Viewers at those sites.

The Media Server on Site A can also be configured with child feeds that come from the remote Media Servers and provide those feeds locally to viewers and monitors on Site A.

Figure 4-13 Virtual Matrix Scenario



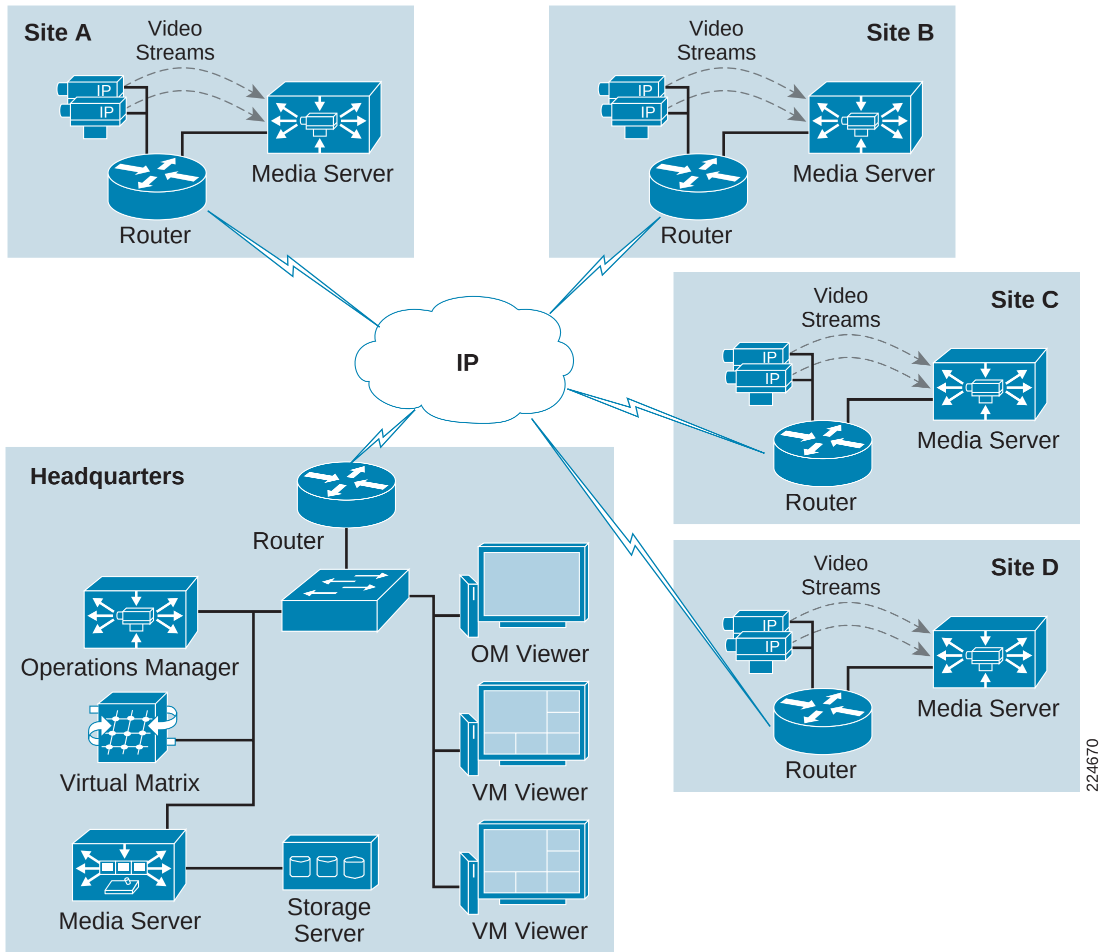
Example 4: Distributed Media Servers

Figure 4-14 shows a deployment with several remote sites, each with a local Media Server acting as the direct proxy and archive for local IP cameras.

In this scenario, all recording occurs at the remote sites and live video streams are viewed by OM Viewers and VM monitors (video walls) at the headquarters.

The Media Server at the headquarters could also have Parent-Child proxies to each remote Media Server and request the remote streams only when required at the headquarters. This would have less bandwidth impact when the same stream is requested by more than one viewer since the traffic would be contained locally in the headquarters LAN.

Figure 4-14 Distributed Media Servers



Network Requirements

This section provides an overview about the branch and campus network requirements to support IP video surveillance.

Power-over-Ethernet (PoE)

The ability to provide electrical power to an IP camera is an important aspect of IP video surveillance that is not available in analog deployments. Analog deployments require some external power supply to meet the power requirements of the cameras. IP cameras with external PTZ housings, outdoor-rated IP cameras, wireless and IP cameras that must use fibre LAN connections due to distance limitations of copper Ethernet wiring may continue to required an external power supply. However, PoE is an important cost-savings factor for IP video surveillance.

LAN Switches and Provisioning

In "Campus Implementation Case Study" section on page 4-31 and "Configuring Quality-of-Service (QoS) for IP Video Surveillance" section on page 6-21, LAN switching requirements are covered in the necessary detail for a successful deployment. There are several requirements for LAN switches, the primary being the ability to support the 802.1af PoE standard for those cameras that can make use of this feature. Also, aggregate backplane capacity as well as uplink capacity is important. At a minimum, switches should have 1Gigbps or 10Gigbps uplink and a 32Gbps effective backplane capacity. QoS support is also important, the ability to both trust the Layer-3 QoS markings (DSCP) and to set DSCP on ingress is critical. Most of commercially available switches support VLANs and trunking and these features are critical for segmenting IP video surveillance traffic into its own domain.

Support of features like port security, 802.1x port-based Network Access Control (NAC), Spanning Tree Protocol (STP) PortFast feature, and PortFast Bridge Protocol Data Unit (BPDU) guard are also useful. Because this design guide recommends marking video surveillance media streams as DSCP value CS5, switches that are configured by default for VoIP implementations are recommended as the media feeds will align with the default VoIP configurations.

Storage Requirements

In general, the recommendation is to store data as close to the source as practical. This is especially true of branch location deployments. By storing video archives locally, IP video surveillance may be deployed to locations with traditional WAN links that would otherwise not have enough bandwidth to transport the archives to a central campus/data center facility. The WAN, however, may still have sufficient bandwidth to transport or view video clips to aid in investigations or other forensic analysis. By storing locally and only transporting the small amount of video surveillance data that is needed centrally, video surveillance can be network-enabled today and tied into other BMS and analytics solutions that can benefit the business.

IP Addressing Requirements

If the network manager plans on implementing some segmentation and path isolation over the LAN/WAN by using VRF-Lite and VLANS, the IP addressing scheme may have greater flexibility than if the video surveillance networks are routed in the global routing table. However, the general recommendations for addressing IP video surveillance devices are as follows:

- Allocate an addressing scheme distinct from the end-user address space at the branch locations.
- Allocate network addressing so that IP cameras, servers, encoders, workstations, and any building management (BM) devices can be allocated from the address space at the remote locations.
- Allocate addressing to facilitate summarization of network advertisements to the core.
- Allocate addressing so that one network advertisement can encompass the entire address space for physical security (and building management) devices.
- Configure a loopback address on remote routers from the physical security address space for NTP and other management functions.

Tip Because the IP cameras are using static IP addresses, give careful attention to IP addressing deployed as reallocating IP addressing is more time consuming than when all end nodes use dynamically assigned IP addresses from a DHCP server.

Requirements for Loss, Latency and Jitter Video Flows

IP video surveillance media streams based on MPEG-4/H.264 are primarily sensitive to packet loss and latency; jitter is less of an issue. One way latency in the range of 20 to 40ms, jitter 1 to 2ms with very low or no loss will provide acceptable video quality. With Motion JPEG, which is generally transported via TCP, as latency increases, the offered frame rate will need to decrease (frames must be skipped) to account for the increase in round trip time. As a best practice, loss approaching 1 percent will introduce video quality issues in MPEG-4/H.264. The Mean Opinion Score (MOS) reported by a IP SLA UDP jitter operation can be used to provide an initial assessment of the ability of the network to provide acceptable video quality. Be cautioned, however, that the IP SLA UDP jitter operation does not take into account that video requires substantially more bandwidth than VoIP.

For sample configurations, refer to the "IP SLA Probe Sample Configurations" section on page A-1.

QoS

QoS should be implemented on both LAN and WAN and should align with the end-to-end QoS policy of the enterprise network. The "Configuring Quality-of-Service (QoS) for IP Video Surveillance" section on page 6-21 provides useful information as a baseline for enabling QoS on the network. The physical security manager and the network manger must work together to understand the bandwidth requirements of the video surveillance implementation and once sufficient LAN and WAN bandwidth is provisioned, enable QoS so both media and control plane traffic is protected during congestion.

Performance Routing

Performance Routing (PfR) is a Cisco IOS feature that extends and enhances the capabilities of traditional routing protocols to allow for rerouting around path brownouts or temporary blackouts, packet loss, or links that are least preferred due to latency. The technology uses NetFlow and IP SLA probes to determine the characteristics of equal-cost links and select the best link, or a link that meets the stated performance characteristics. PfR can also be more effective at load sharing than IP CEF, because it takes into consideration the interface utilization, which CEF does not.

The "Performance Routing (PfR) Integration" section on page 6-50 not only uses this feature to optimize video feeds, it also provides insight on how latency, jitter, and packet loss influences video quality.

Wide Area Application Services

The primary video encoding methods, Motion JPEG and MPEG4 / H.264, are compressed by the encoding function of the IP camera. Because they are already compressed, the compression functions of WAAS (LZ or DRE compression) does not provide as dramatic a compression-ratio as is seen with data packets. Because of this, implementing WAAS can be implemented to optimize data applications. It would benefit video by freeing up available bandwidth for transport of video surveillance. For more information, refer to "Wide Area Application Services (WAAS) Integration" section on page 6-61 and "Wide Area Application Services (WAAS) for iSCSI" section on page 6-74.

Redundancy

Wherever possible, the path between IP cameras and the target Media Server should include as much redundancy as practical. In the "Campus Implementation Case Study" section on page 4-31, the dual uplinks from the access switches to the distribution layer switches and between distribution and core switches have at least two paths. In the "Performance Routing (PfR) Integration" section on page 6-50 and in the "Virtualization, Isolation and Encryption of IP Video Surveillance" section on page 6-87, dual LAN/WAN links are deployed. Firewalls should be deployed in an active-standby failover configuration.

Where multiple IP cameras are covering a critical viewing area, connect cameras with the overlapping vantage points to separate access-layer switches. If the access-layer switch becomes unserviceable an alternate image from the overlapping camera may be usable.

A key element of redundancy is fault management. While having an alternate path provides availability, the network management services in the enterprise must be able to detect failures and initiate remedial action in a timely manner.

VLANs

As a best practice, where possible, segregate IP cameras, servers, and viewing stations on a VLAN separate from other devices on the network. Combined with allocating a separate IP addressing scheme for these physical security and building management endpoints, this facilitates controlling access from other users in the global routing table. Should the enterprise decide to implement end-to-end path isolation and segmentation, these VLANs can then easily be mapped to a VRF-enabled interface on the supporting router.

Segmentation, Security, Firewalls and IPSec Encryption and Firewalls

IP video surveillance, access control systems, and related building management systems are a prime candidate for being deployed on the IP network in their own domain. The applications that enable these systems have a high likelihood for interconnecting currently on in the future. Additionally, these applications have a relatively small user group with the organization; the percentage of employees in an organization relating to facilities, loss prevention, and security is typically very low. If the systems are compromised, the end result can be a very notable event that may be highly publicized. Corporations do not want their video surveillance images published on YouTube or a someone raising or lowering the building temperature in their corporate headquarters from half a world away.

Because of these reasons, isolating and protecting these resources through segmentation techniques of VLANs and VRF-Lite should be a design consideration. Additionally, encrypting and protecting access to the address space through firewalls and access control lists can be deployed with or without the control plane segmentation. The "Virtualization, Isolation and Encryption of IP Video Surveillance" section on page 6-87 demonstrates these techniques.

Video Traffic Flows

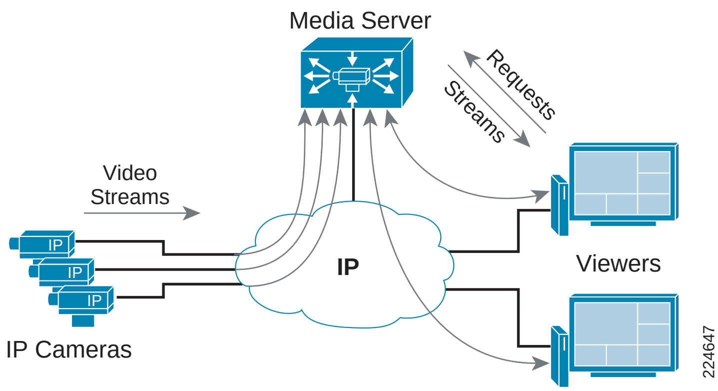
Each Video Surveillance Manager application plays a unique role in the deployment of a complete video streaming solution. When deploying and operating a Video Surveillance Manager environment, it is important to understand the video traffic flows of each application and how they interact with the system as a whole.

Video Surveillance Media Server

The Video Surveillance Media Server is the core component of the solution, providing for the collection and routing of video from IP cameras to viewers or other media servers. The system is capable of running on a single physical server or distributed across the network, scaling to handle thousands of cameras and users.

Figure 4-15 shows how IP cameras or encoders send a single video stream to the Media Server. The Media Server is responsible for distributing live and archived video streams to the viewers simultaneously over an IP network.

Figure 4-15 Media Server



For archive viewing, the Media Server receives video from the IP camera or encoder continuously (as configured per the archive settings) and only sends video streams to the viewer when requested.

In environments with remote branch locations, this becomes very efficient since traffic only needs to traverse the network when requested by remote viewers. Branch office traffic remains localized and does not have to traverse wide area connections unless is requested by users other users.

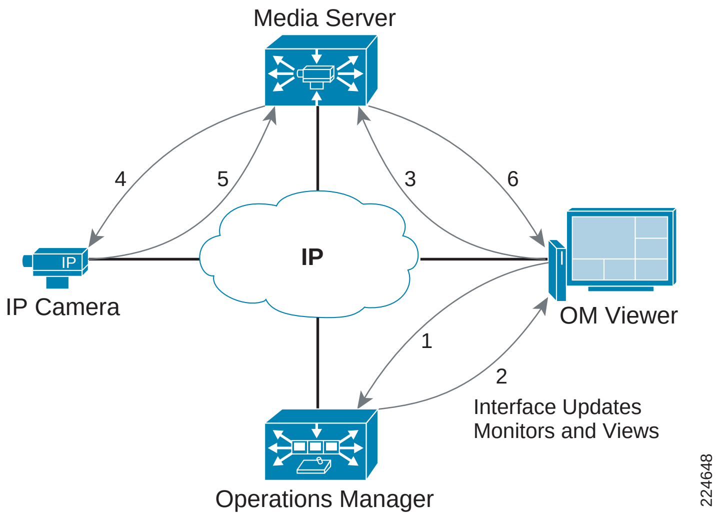
Video requests and video streams are delivered to the viewer using HTTP traffic (TCP port 80).

Video Surveillance Operations Manager

Viewers can access the Operations Manager through their web browser. The Operations Manager is responsible for delivering a list of resource definitions, such as camera feeds, video archives, and predefined views to the viewer. Once this information is provided to the viewer, the viewer communicates with the appropriate Media Server to request and receive video streams.

Figure 4-16 shows the traffic flow of video request from the viewer to the Operations Manager. The viewer is responsible for contacting the proper Media Server to receive video streams.

Figure 4-16 Operations Manager Traffic Flows



When the OM Viewer requests a video stream, the following steps occur as shown in Figure 4-16:

Step 1 The user accesses the Operations Manager screen through an ActiveX web browser. This traffic can be over TCP port 80 (HTTP) or 443 (HTTPS).

Step 2 The OM Viewer receives a complete list of resources, such as camera feeds, views, and monitors. This information is sent each time the client starts or switches to the operator view. Since the OM Viewer has a complete list of resources, the operator may choose to view live or recorded video from any camera feed or predefined views.

Step 3 The OM Viewers selects a video feed that is served by the Media Server and contacts the Media Server directly over TCP port 80.

Step 4 The Media Server is the direct proxy for the IP camera and requests the video stream from the camera. This communication can be TCP, UDP, or multicast as configured by the Operations Manager.

Step 5 The camera provides the video stream to the Media Server.

Step 6 The Media Server replicates the requested video feed to the OM Viewer using IP unicast over TCP port 80. The connection remains active until the OM Viewer selects a different video feed.

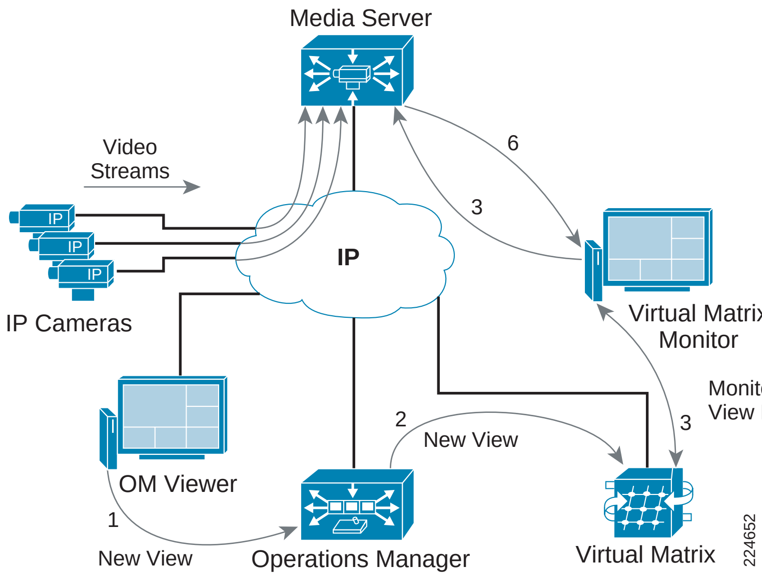
If another OM Viewer requests the video from the same IP Camera, the Media Server simply replicates the video stream as requested, and no additional requests are made to the camera.

Video Surveillance Virtual Matrix Switch

The Virtual Matrix server is responsible for providing detailed monitor layout to the Virtual Matrix monitors and the position of each camera feed on the screen. A single Virtual Matrix server can be deployed to support a large number of Virtual Matrix monitors since the communication between the monitors and the server is required only during the initialization or when a new view is pushed to the monitor.

Once the monitor layout and views are pushed to the monitors, the monitors are responsible for contacting the appropriate Media Server(s) to request video streams.

Figure 4-17 Virtual Matrix



When requesting a new view for the Virtual Matrix monitor, the following steps occur as shown in Figure 4-17.

Step 1 The OM Viewer selects a new view to be displayed by the Virtual Matrix monitor. The request is received by the Operations Manager.

Step 2 The Operations Manager sends the layout update to the Virtual Matrix server.

Step 3 The Virtual Matrix server pushes the new layout to the Virtual Matrix monitor.

Step 4 Once the Virtual Matrix monitor learns the new layout and the cameras to display, it contacts the appropriate Media Servers to request video streams.

Step 5 Video streams are sent from the Media Server directly to the Virtual Matrix monitor.

Step 6 The Virtual Matrix server sends a keepalive message to the Virtual Matrix monitor every three minutes to confirm that the display is still active.

Bandwidth Requirements

Compared to VoIP, video consumes considerably more network bandwidth. In the LAN environment, bandwidth is relatively inexpensive and in most cases, a LAN infrastructure that is supporting VoIP and data can also support IP video surveillance. In the "Video Traffic Flows" section on page 4-23, the sources and sinks of video data were examined. In this section, some bandwidth estimates are shown as well as tools to calculate bandwidth requirements. The two legs of interest are from the cameras to the Media Server and from the Media Server to the viewing station. The bandwidth from the control plane is trivial compared to the bandwidth consumed by the media streams. For capacity planning purposes the control plane traffic is of little significance; however, from a QoS perspective it is must be accurately marked and queued to prevent the drop of this traffic.

Camera Feed to Media Server

The bandwidth consumption from individual IP cameras to their Media Server is going to first be determined if the camera has an active archive or operator viewing a live feed. If a camera is not being actively viewed or an archive is not running, no video output is sent from the camera.

Tip There is one exception. If the camera has been configured by the web interface to enable IP multicast and the configuration is complete including a multicast address, the camera will stream traffic continuously to the multicast address. The router will not forward the multicast traffic past the LAN segment unless a remote node subscribes to the group (multicast) address.

The output rate from an IP camera is dependent on the configured values for the video feed, including codec (MJPEG, MPEG-4, H.264) resolution, frame rate or bit rate, and any applicable quality factors. These configuration parameters are controlled by the physical security manager and are determined by the operational objective for implementing the camera. As resolution and frame rate increase, so does the bandwidth.

For high-level planning purposes, Table 4-5 can be used for estimating network bandwidth requirements per camera.

Table 4-5 Per Camera Network Bandwidth Estimates

Camera	CODEC	Resolution	Estimated Bitrate
CIVS-IPC-2500 (Standard Definition)	MPEG-4	D1 (720x480)	1-2 Mbps
CIVS-IPC-4300 or CIVS-IPC-4500 (High Definition)	H.264	HD (1920x1080)	4-6 Mbps

Both camera series can operate at higher than the estimated bitrates shown above, however these bitrates should provide acceptable video quality. Consult the appropriate camera user's guide for the maximum bitrate and other parameters. An important part of the planning process is a pilot installation of IP cameras to gauge their suitability for the intended deployment. From this pilot, more specific data points can be determined.

One technique for determining the amount of bandwidth required for a particular model of camera is to use a laptop and connect to the API of the camera. View the video feed directly from the camera using the CODEC, resolution and frame/bit rate of interest. In Microsoft Windows, the task manager (CTL + ALT + DEL and select Task manager from the dialog box displayed) can be used to view the image in real-time. Under the Networking tab, the network utilization and link speed of the interface can be used to estimate the bandwidth requirements of the video feed.

The "Access-layer Switch Commands" section on page A-3 demonstrates how to determine the output data rate from an IP camera when connected to a switch. It is useful for both troubleshooting and for bandwidth estimates.

Media Server to Viewing Station

In order to view live or archived video feeds from a viewing station, the user first connects with the webserver of the Operations Manager (VSOM) while the camera feeds are sent from the appropriate Media Server (VSMS). To understand the data flow a sample operator screen is shown Figure 4-18.

Figure 4-18 Viewing Station—Operator Panel

The codec and bit rate/frame per second parameters are shown next to the respective video image on the operator panel in Figure 4-18. There are two cameras that have a resolution of over 1 megapixel while the remainder are standard definition cameras at D1 or 4CIF resolution.

On the operator view shown, one video image is the predominate image on the screen, covering a larger area than the seven other camera feeds. The feeds are resized on the client-viewing station, the data rate from Media Server to viewing station is not changed or adjusted by the media server based on the resolution on the screen.

Also, each video feed, regardless if the feed is Motion JPEG or MPEG-4, is transported in an individual TCP (WWW) session between viewing station and the respective Media Server. To understand the flows between the Media Server and the viewing station, a NetFlow export is captured and summarized and represented in Table 4-6.

Table 4-6 Summarized NetFlow Export of Camera Feeds

Source IP Address	Src port	Destination IP Address	dst port	Packets per Second (pps)	Average Bytes per Packet	K bits per second (kbps)
192.0.2.2	WWW	192.168.16.36	24638	97	1392	1,058
192.0.2.2	WWW	192.168.16.36	24639	97	1390	1,058
192.0.2.2	WWW	192.168.16.36	24649	364	1324	3,769
192.0.2.2	WWW	192.168.16.36	24657	53	1413	585
192.0.2.2	WWW	192.168.16.36	24661	191	1388	2,082
192.0.2.2	WWW	192.168.16.36	24665	49	1360	530
192.0.2.2	WWW	192.168.16.36	24668	55	1338	585

Source IP Address	Src port	Destination IP Address	dst port	Packets per Second (pps)	Average Bytes per Packet	K bits per second (kbps)
192.0.2.2	WWW	192.168.16.36	24671	105	1310	1,081
						10,748

The source IP address of 192.0.2.2 is the address of the Media Server. The client PC IP address is 192.168.16.36. Each line in Table 4-6 represents the flow from one of the camera feeds. The flows from VSOM to the camera is not shown.

In this example, the aggregate bit rate per second is 10,748 Kbit, or over 10 Mbps. Viewing these eight feeds over a broadband or T1/E1 WAN link would not be practical. The number of concurrent video feeds would need to be limited and a reduction in the frame rate (MJPEG) or bit rate (MPEG-4) of the individual feeds to view a panel of this complexity over the WAN.

Viewing camera feeds over the WAN is not impossible, but some consideration must be given to the aggregate data rate when viewing more than one feed or individual feeds with very high resolution and bitrate or frame rate.

Video Storage

The video surveillance storage system provides multiple options to store video and audio files. The internal storage of the Media Server may be augmented by using direct attached or SAN storage. The video surveillance storage system can store video in loops, one-time archives, or event clips triggered by alarm systems providing for redundant and remote long-term archival.

Calculating Storage Requirements

MJPEG

When using MJPEG streams, the frame size of each image plays a key role in estimating the storage and transmission requirements. Since each frame is unique and varies according to the image complexity, it is difficult to provide a guide that provides fixed frame sizes. An IP camera that provides images with low complexity will generate smaller frame sizes. Smaller frames will require less bandwidth and storage capacity.

The following formula is used to calculate the bandwidth requirements for MJPEG streams:

MJPEG storage = Average Frame size x Frame rate x duration

Example 1: For an 8-hour archive of a CIF video stream with 50 percent quality and 15 frames per second, the following is the calculation:

```
4 KB  x  15fps  x  3600s  =  216,000 KB/ hour
                          = 216MB /hour   x   8 hours
                          = 1.728 GB
```

Example 2: For a 24-hour archive of a 4CIF video stream with 100 percent quality and 5 frames per second, the following is the calculation:

```
320 KB x 5fps x 3600s  =  5,760,000 KB /hour
                       =  5,760MB /hour  =  5.76GB /hour x 24 hours
                       =  138.24 GB
```

MPEG-4/H.264

Rather than standalone images, MPEG-4 / H.264 streams take into account video frames and the size of a given video frame varies widely between I-frames and predictive frames. Typically, H.264 is more efficient than MPEG-4. MPEG-4 is generally more efficient than Motion JPEG and requires less bandwidth and storage capacity when using higher frame rates.

The following formula is used to calculate the bandwidth requirements for MPEG-4 streams:

MPEG4 storage = Bit rate (kbps) x duration

The target bit rate is configured on the camera and is already expressed in bits per second.

Example 1: For an 8-hour video stream with target bit rate of 768kbps, the following is the calculation:

```
768kbps / 8 bits/s = 96 KB /second  x  3600 s
                   = 345,600 KB/hour  /  1000
                   = 345.6 MB/hour  x  8 hours
                   = 2.764 GB
```

IP Camera Video Settings

When creating a new IP camera, several settings play a role in providing the appropriate image quality and frame rate. When using MJPEG video streams, the following image settings may be configured: *resolution*, *frame rate*, and *quality*. The frame rate setting determines the amount of video data generated at a given amount of time.

For MPEG-4 and H.264 videos streams, the *resolution, bit rate, and quality* may be configured. The bit rate setting specifies the amount of bandwidth required for the MPEG-4 / H.264 video stream. Higher values generate more video data every second, translating into smoother video and a more accurate representation of the field of view. A higher value also translates into larger archive file sizes.

Design CheckList

This design checklist in Table 4-7 facilitates pre-implementation planning and the decision process.

Table 4-7 Design Checklist

Design Checklist
Estimate the number of IP cameras required at each location.
Using a floor plan or exterior survey, determine cameras that can be powered by PoE and those requiring power supplies.
Survey existing IP or analog cameras and determine if these cameras are to be replace or migrated.
Estimate the CODEC, resolution, and frame rate or bit rate requirements for cameras at each location
Determine the retention period requirements for cameras at each location
Survey existing LAN switches for necessary features and available capacity
Based on the number of cameras per location, determine server requirements.
Using the *Campus Implementation Case Study* in the following section, determine what if any LAN infrastructure upgrades are required.
Using the estimate on the number of servers required, calculate the storage requirements for video archives based on the retention period analysis

Design Checklist
Analyze the IP addressing requirements and VLAN assignments for IP Cameras, Media Servers, routers, switches and other systems.
Determine if suitable Network Time (NTP) sources exist in the current network.
Investigate what network management servers and software are currently available for services such as Syslog and SNMP traps, TFTP/FTP for firmware download and storage.
Consider implementing network management servers for performance, fault and capacity planning such as *CiscoWorks Internetwork Performance Monitor (*end-to-end network performance) , *Cisco Secure Access Control Server for Windows (*authentication: TACACS+/RADIUS server*), CiscoWorks Device Fault Manager* (reporting of device faults) and *Cisco NetFlow Collector (*NetFlow analysis for capacity planning).
Analyze the existing QoS policies and configuration on routers and switches and incorporate the IP video surveillance requirements into the plan.
Determine requirements for external users to access video feeds. Analyze what level of encryption or access-control is required to meet the end-user requirements and to align with the corporate network security posture.
Discuss with the physical security manager and network manager the need for segmentation features such as VRF-lite, VLANS and firewalls and access-lists to limit access to end-nodes.
Determine the redundancy inherent in the existing network and develop a plan for meeting the physical security needs in the event of a line-card or access switch failure.
Consult with the physical security manager to determine what the live viewing requirements are. Determine what cameras must be viewed live and were the viewing stations are located in the network topology.
Determine skill set of existing staff and estimate training requirements for physical security installers, operators and managers in basic internetworking. Consider involving the network staff in day-to-day operations of the physical security operations staff.

Campus Implementation Case Study

This section addresses the topology considerations for deploying IP video surveillance at a campus location where a high-density of high-definition (HD) IP cameras are required. This case study is modeled after an actual customer request for design assistance in the gaming industry. Because of the high number of HD IP cameras in a dense deployment, hundreds of cameras within the maximum distance of 100 meters for Ethernet, it may be practical to implement a physically isolated LAN infrastructure for transporting, viewing, and archiving video feeds.

In other industry deployments, such as a public school system, a converged design using virtualization, path isolation, and encryption described later in this document is more applicable. In the public school system example, there may be less than 1,000 cameras deployed in 10 to 20 campus locations or 50 to 100 cameras per campus. In this case, using logical segmentation techniques, QoS on the LAN and WAN, and a converged network of voice, video, and data is the most cost-effective solution. However, the exercise of calculating the offered load from a set of cameras on a single access switch, through the distribution layer and then to the core, provides baseline information that can be leveraged elseware.

There is one key traffic engineering concept that is relevant to any IP video surveillance deployment. While there is a two-way communication between the camera and media server, the vast majority of IP traffic when using either Motion JPEG or MPEG-4/H.264 is sourced from the camera and linked to the Media Server. If large numbers of video feeds are being actively viewed, the viewing stations will likely be attached to the the interface cards in the core layer and not traversing the distribution, access, and core campus layer. Also, in many cases, the majority of video feeds are never viewed, in some cases up to 99 percent of the population of collected data.

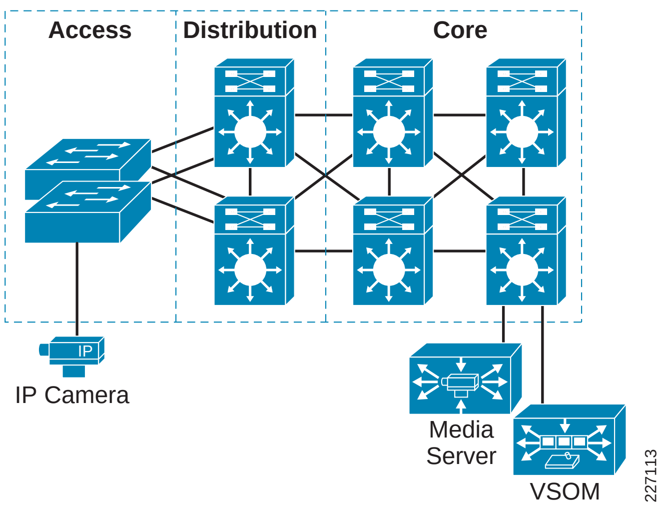
Requirements

This case study assumes the requirement is to populate every available port on the access switch with with an HD camera. If there are PC/workstation, point-of-sale terminals, printers, or IP phones, these devices are isolated on a separate access switch. The goal is to look at the worst case deployment scenario where all cameras are generating HD video 24 hours per day.

The basic assumption is that the camera is a Cisco 4000 Series with a resolution of 1080p (1920 x 1080) using the H.264 CODEC with a configured target bit-rate of 5Mbps. This model of camera can be configured for a constant bit-rate in increments of 2, 4, 6, 8, 10, 12, and 15 Mbps. In viewing live video streams, a configured rate of 4Mbps provides generally acceptable video quality. The assumption is the cameras are configured for 4Mbps. In the calculations, 5Mbps per-camera is used to accommodate any bursts by the camera, providing for a conservative estimate of bandwidth.

This campus design is a traditional three-layer design where access switches are aggregated into distribution layer switches. The distribution layer switches are connected to the core switches. The core switches provide connectivity for the media servers. The general topology is illustrated in Figure 4-19.

Figure 4-19 Traditional Three Layer Campus Design



The basic assumption is that each IP camera uses Power-over-Ethernet (PoE) and attaches to the access switch at 100Mbps. The multiservice platforms (and most server platforms) that are used for Media Servers/Video Surveillance Operations Manager (VSOM)) have two 10/100/1000M Ethernet interfaces. Assume the servers are connected at 1000Mbps (1Gbps) for receiving live video feeds.

Note VSOM runs on one or more multiservice platforms, the Media Servers run on as many instances of the multiservice platforms as required to support the number of cameras and storage requirements for video archiving.

Access Layer

One of the advantages of implementing IP video surveillance is the ability to supply electrical power to the camera using the IEEE 802.1af standard for PoE. Because of this, only PoE-capable access layer switches are considered.

Another factor is the capability of the switch to provide Layer-2 only uplinks or either Layer-2 or Layer-3 uplinks. In this design, only Layer-2/Layer-3 switches are considered because they eliminate the need to have a Layer-2 interface connecting the distribution layer switches. Additionally, a routed-access layer improves convergence times and enhances load sharing. For these and other reasons, many campus network deployments advocate using a Layer-3 connection to the access layer switch. For more information, refer to the *High Availability Campus Network Design—Routed Access Layer using EIGRP or OSPF* at the following URL: www.cisco.com/go/designzone.

For these reasons, access switches that do not support PoE and Layer-3 routing support are not considered in this campus case study.

The other produce selection considerations for access-layer switches are as follows:

- Number of ports (either 24 or 48 port models are available)
- Total switch capacity; for example, backplane capacity (32Gbps or 64 Gbps models are available)
- Uplink bandwidth available (either 1Gbps or 10Gbps is available)

Deciding which switch to deploy based on these three factors now is a matter of examining the offered load from the Cisco 4000 Series camera. The assumption is 5Mbps as a target constant bit-rate. Therefore a 24-port switch at 5Mbps per port, is 120 Mbps of offered load and a 48 port switch offers 240 Mbps. Based on this value, a switch with 48 ports, 32Gbps backplane, and 1Gbps uplinks will service these requirements. One switch that meets the requirement is the Cisco Catalyst 3560G-48PS: 48 Eth 10/100/1000 ports with PoE and 4 SFP GigE ports.

Table 4-8 represents other switches in the access switch product line. The **bolded** items meet or exceed the stated requirements.

Table 4-8 Access Switch Features

Model Catalyst	L2/L3 Multilayer Switch	Total Switching Capacity (Gbps)	Uplinks	Ports
2975GS-48PS-L	NO	32	4 SFP 1Gbps	48
3560G-24PS **3560G-48PS**	YES	32	4 SFP GigE	24 48
3750G-24PS **3750G-48PS**	YES	32	4 SFP GigE	24 48
3560E-24PD **3560E-48PD**	YES	64	2 X2 10 GigE uplinks	24 48
3750E-24PD **3750E-48PD**	YES	64	2 X2 10 GigE uplinks	24 48

Access Layer Offered Load

Given the criteria of 48 HD cameras streaming video feeds at 5mbps, the offered load from all 48 ports to the uplink ports is 48 * 5Mbps or 240 Mbps. Even if the cameras are configured at a constant bit-rate (CBF) value of 16Mbps, the total offered load to the uplink is 768 Mbps.

Tip A 48-port access layer switch fully populated with HD IP cameras uses 25% - 80% of a 1Gbps uplink.

A best practice for interface-level QoS, the priority queue should not exceed a third of the link bandwidth in a converged network of voice, video, and data. In this topology, using a target rate of 5Mbps per camera, less than a third of the available uplink bandwidth is a candidate for the priority queue. We can therefore, safely assume that replacing the cameras on the switch ports with IP phones and workstations will also not deviate from this guideline, as the VoIP traffic load is substantially less than the HD video stream.

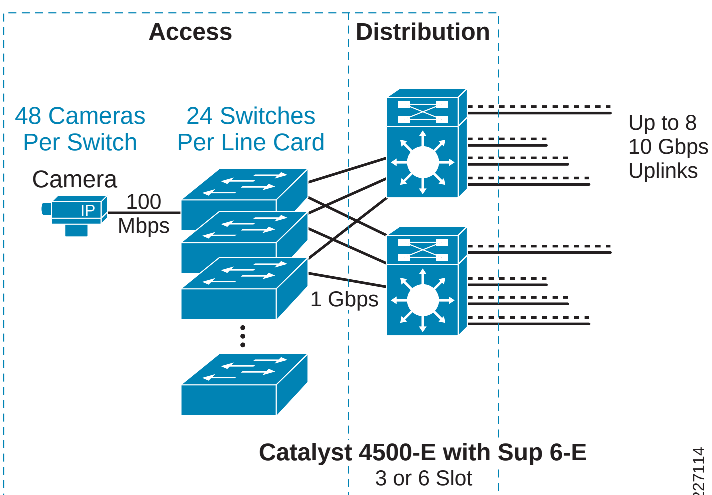
When planning for the distribution layer, assumed that each access layer switch is generating 240Mbps on one of the two uplinks, or the traffic is load sharing across the two uplinks, but does not exceed 240Mbps from a single access switch.

Distribution Layer

The distribution layer topology design incorporates deploying two or more chassis. Each chassis is outfitted with a single supervisor module and optionally dual-power supplies. Because IP routing extends to the access layer, there is no need to implement a Layer-2 link between the two distribution layer switches. The access layer switches receive routing updates from each distribution layer switches and will select an alternate path to the core if a path fails.

One recommended solution for the distribution layer switch selection is the Cisco Catalyst 4500-E in either a 3 or 6 slot chassis. With the 3 slot chassis, the Supervisor Engine 6-E and an additional uplink link card uses two slots, while the remaining contains one 24-port line card for aggregating 24 access switches. The 6 slot chassis can houses four 24-port line cards aggregating 96 access switches. By including the uplink line card, up to eight 10Gbps uplinks are available to the core layer. The access layer and distribution layer is shown in Figure 4-20.

Figure 4-20 Distribution Layer



Using a Supervisor Engine 6-E and a 3 or 6 slot chassis provides for 24Gbps of per slot aggregate bandwidth. The configuration summary is as follows:

- Catalyst 4500-E with Sup 6-E (includes 2 10 Gig Uplinks)—Either 3 or 6 slot chassis

- WS-X4606-X2-E 6-Port 10 Gigabit Ethernet (X2)—Uplinks to core switches
- WS-X4624-SFP (24 Port GigE)—Downlinks to access switches

When using the three slot chassis, 24 access switches can be aggregated for a total of 1152 cameras supported on two distribution layer switches with redundancy. When using the six slot chassis, up to 96 access switches can be attached to both chassis in a redundant configuration, supporting up to 4608 cameras.

Distribution Layer Offered Load

Assuming in a failure scenario, where one distribution switch is out of service, the offered load from the remaining switch into the core switches is in the range of either:

- 1152 cameras (5 Mbps each) approximately 6 Gbps
- 4608 cameras (5 Mbps each) approximately 24 Gbps

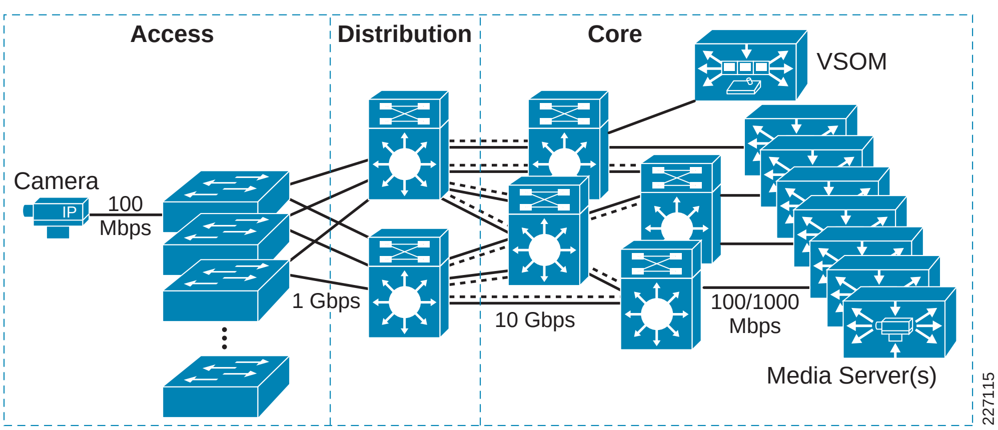
Given the above, a three slot chassis deployment would not require the installation of a WS-X4606-X2-E line card for additional uplink capacity, the two 10 Gbps uplinks on the Sup 6-E is sufficient for the offered load of 6 Gbps. The core switches, supporting the servers, are discussed next.

Core Layer

The core layer provides LAN connectivity for the Media Servers, VSOM servers, and other network management servers. The number of Media Servers required is a function of the number of cameras which each Media Server is able to support. For planning purposes, it is assumed in this case study that each server can support 16 camera feeds. Depending on the hardware of the Media Server, the number of supported cameras may be higher or lower and the network manager must adjust the number and type of core layer switches accordingly. The general guideline for the Cisco Physical Security Multi Services platforms is no more than an aggregate of 200 Mbps of I/O per chassis.

Given a projection of 16 camera per Media Server, the low end deployment using 1152 cameras requires 72 Media Servers and the upper end deployment of 4608 cameras requires 288 Media Servers. The network topology diagram is expanded to include a representation of the core layer (see Figure 4-21).

Figure 4-21 Core Layer



There are several options for core layer switches. As was deployed in the distribution layer, the Cisco Catalyst 4500-E with Sup 6-E could be used. A Cisco Catalyst 6500 Series or a Cisco Nexus 7000 Series are also options. These latter two options are ideal if the access and distribution layer deployment is going to be tied into an existing enterprise network infrastructure. In that case, it is assumed that 10Gigabit line cards and line cards to support Media Servers on 10/100/1000 RJ45 ports are available or could be added to existing chassis in the core.

For the purpose of this case study, assume dedicated Cisco Catalyst 4500-E with Sup 6-E are also used for the core layer switches. The core layer switches then include the following:

- 4500-E with Sup 6-E (includes two 10Gigabit uplinks)
- WS-X4606-X2-E—6-port 10Gigabit Ethernet (X2)
- WS-X4424-GB-RJ45—24-port 10/100/1000 Module (RJ-45)

The type of chassis can be a 6, 7, or 10 slot. Because these are core layer switches, dual-power supplies are recommended as are dual supervisors. The 7 and 10 slot chassis support dual supervisor cards.

The number of core switches required depends on how many cameras, and therefore, how many Media Servers, are implemented. It is assumed the Media Servers are are equally distributed across the available ports on the core layer switches. The access layer switches are routing peers with the core layer switches and are equal cost load sharing to the core.

If the upper projection of 4,608 cameras are deployed, at 16 cameras per Media Server, then 288 media servers are required. Assuming four core switches, 72 servers on each, at a minimum each chassis must support 3, WS-X4424-GB-RJ45 24-port line cards. Either the 6 or 7 slot chassis meets this requirement.

If the lower projection of 1,152 cameras are deployed, then 72 total servers are required. Two core switches, with each switch supporting 36 servers, are necessary. Again, a 6 or 7 slot chassis meets this requirement.

The number of VSOM servers required for this installation depends if the implementation is headless (meaning little continuous viewing of live feeds) or if there are continuous viewing of many or all live feeds. It is recommended that a single VSOM manage any given Media Server. There is no absolute rule in the number of Media Servers per VSOM server. One guideline is to use 20 Media Servers per VSOM server. Allocating Media Servers to the respective VSOM server should follow some allocation scheme such as a geographical division. In other words, if there are three adjoining buildings with 100 cameras in each building, those cameras may be all controlled by 20 Media Servers and a single VSOM.

Core Layer Offered Load

Assuming the use of a Catalyst 4500-E with Sup 6-E, each line card slot has the capacity to support up to 24Gbps of traffic. Given the Media Servers are attached on 10/100/1000 Mbps RJ45 ports on a WS-X4424-GB-RJ45 line card, there are up to 24 Media Servers per slot. At 5 Mbps from each camera, with 16 cameras streaming video to each Media Server, that is a sustained offered rate of 80 Mbps to each Media Server. Assuming the goal is to keep the aggregate below 200 Mbps of I/O per chassis, there is available capacity for both a higher bit rate from some cameras and capacity to retrieve and view live or archived feeds stored on any one Media Server. The aggregate bandwidth per slot is approximately 2Gbps, well under the 24 Gbps rate capacity.

Tip Verify the Media Servers are successfully auto-negotiating the 1000Mbps data rate. There is an expected sustained offered rate of 80Mbps to each Media Server.

The aggregate bandwidth from distribution layer to any one of the four core switches (given 4,608 cameras) is approximately 6Gbps, or 24Gbps in aggregate from both distribution layer switches.

Summary

In this case study, we examined what characteristics an access-layer switch needed to support a deployment of high definition IP video surveillance cameras. The bandwidth requirement between the access and distribution layer was examined. Also, a distribution layer switch infrastructure was suggested which would aggregate a large number of access switches densely populated with cameras. Redundancy from the access layer, through the distribution layer to the core is enabled by choosing switches which support end-to-end Layer-3 routing. Finally, the core layer bandwidth and port requirements were examined.

CHAPTER 5

Product Selection

This chapter discusses the systems requirements and software releases evaluated.

Network Modules

The majority of testing for this guide uses these network modules running the Cisco Video Analog Gateway and the Cisco Video Surveillance Media Server and Operations Manager on the following modules:

```
EVM-IPVS-16A  16-port Analog Video Gateway
NME-VMSS-16   Cisco Video Management and Storage System NME
NME-VMSS-HP16 Cisco Video Management and Storage System HP NME 16 ports
NME-VMSS-HP32 Cisco Video Management and Storage System HP NME 32 ports
```

Network modules product life cycle is updated to meet new system requirements. Contact the appropriate support channel for information on end-of-sales (EoS) announcement and replacement part numbers. The latest modules are as follows:

```
NME-VMSS2-16   Cisco VMSS - 2GB RAM, 500GB Storage, 16 Port License
NME-VMSS2-HP32 Cisco VMSS - 2GB RAM, 500GB Storage, 32 Port License
NME-ISS        Cisco ISS  - 512 MB RAM, 500 GB Storage
```

The NME-ISS provides a supplemental 500 Gigabytes of local storage on the ISS, in addition to the storage of the NME-VMSS2 for up to 1 Terabytes of storage.

Software Releases Evaluated

Table 1 represents a list of hardware and software versions used in testing.

Table 1 Hardware and Software Components Used in Testing

Chassis	IOS Version	Module	Version
Cisco 2851	c2800nm-adventerprisek9-mz.124-15.T5	EVM-IPVS-16A	(1.1.1)
		NME-VMSS-16	Foundation version (2.0.0.14)
Cisco 3845	c3845-adventerprisek9-mz.124-15.T5	NME-VMSS-HP32	Foundation 2.0.0.14
		NME-WAE-522-K9	WAAS 4.1.1c
Cisco 3825	c3825-adventerprisek9-mz.124-15.T5	EVM-IPVS-16A	Foundation 1.0.1

Table 1 Hardware and Software Components Used in Testing (continued)

Chassis	IOS Version	Module	Version
		NME-VMSS-HP16	1.1.1
WS-C3750G-24PS	c3750-advipservicesk9-mz.122-44.SE1		
asa5510	Cisco Adaptive Security Appliance Software Version 8.0(4) Device Manager Version 6.1(5)51		asa804-k8.bin
Cisco Video Surveillance 2500 Series IP Cameras	Release 1.1 Software		CIVS-IPC-2500-1-1-1 and CIVS-IPC-2500-1.1.2W
Cisco 7206VXR (NPE400)	c7200-adventerprisek9-mz.124-15.T5		

Server System Requirements

The Cisco Physical Security Multiservices Platforms is a suite of three-server platforms. The servers have options for Fibre Channel interfaces, and can both analog and IP video directed from the network. Each platform is integrated with the Cisco Video Surveillance Manager.

- 1-rack-unit (RU) Multiservices Platform—Supports up to four 1TB SATA hard drives.
- 2RU Multiservices Platform—Supports up to twelve 1TB SATA hard drives.
- 4RU Multiservices Platform—Supports up to 24 1TB SATA hard drives.

Viewer Requirements

Many commonly used laptops do not have sufficient performance to meet the minimum system requirements for viewing video feeds from either the standard definition (SD) or high definition (HD) cameras. Refer to the appropriate Cisco Video Surveillance Manager software documentation for the release implemented to determine the minimum system requirements.

CHAPTER 6

Implementation and Configuration

This chapter provides step-by-step examples of how to configure the IP Video Surveillance environment tested by Cisco Enterprise Solutions Engineering (ESE) and contains the following main sections:

- Deploying Network Services for IP Video Surveillance, page 6-1
- Deploying a Cisco Video Surveillance IP Camera, page 6-13
- Deploying a Cisco Video Surveillance IP Camera, page 6-13
- Configuring Quality-of-Service (QoS) for IP Video Surveillance, page 6-21
- Local Storage for Video Archives Using iSCSI, page 6-41
- Performance Routing (PfR) Integration, page 6-50
- Wide Area Application Services (WAAS) Integration, page 6-61
- Wide Area Application Services (WAAS) for iSCSI, page 6-74
- Controlling Access to IP Video Surveillance, page 6-80
- Virtualization, Isolation and Encryption of IP Video Surveillance, page 6-87

Note that not every section in this chapter is necessary in all implementations. The recommendation is to read each section and then decide if the concepts in a particular section are relevant or important to the target implementation. For example, some implementations may not have the required topology to implement Performance Routing (PfR), however, this section contains a discussion and examples of how latency, jitter, and packet loss may impact the quality of video feeds on any topology. In this case, the background assumptions may be relevant general knowledge to the network manager, even if the technology approach is not implemented.

Many of the topics and concepts in this chapter are not specific to IP video surveillance deployments, while the discussion in this chapter focus on their relevance to video surveillance. Additional information is available in associated design guides or documentation at the following Cisco website http://www.cisco.com.

Deploying Network Services for IP Video Surveillance

This section discusses how various network services on the IP network can be integrated into an IP video surveillance deployment. The services include the following:

- Time Synchronization using Network Time Protocol, page 6-2
- Syslog, page 6-8
- Cisco IOS IP Service Level Agreements (SLAs), page 6-9

- Power-Over-Ethernet (PoE), page 6-11
- Cisco Discovery Protocol (CDP), page 6-12
- Simple Network Management Protocol, page 6-13

Time Synchronization using Network Time Protocol

The Network Time Protocol (NTP) is a protocol designed to synchronize the clocks of network nodes of an IP network with a reliable time source. NTP version 3 is defined in RFC-1305. The Cisco Video Surveillance Manager solution relies on NTP to synchronize the time of the servers, IP cameras and viewing stations. There are a number of third-party appliances which use GPS receivers as an accurate timing source.

The GPS receiver appliance requires line-of-sight to the sky for receiving the GPS signals. At least 4 satellites must be acquired for GPS time. To accomplish this the server is attached by a coax cable to a building exterior antenna. These servers are typically one rack unit high, have a RS-232 console port, Ethernet port and coax connection for the antenna. They are a stratum one time source and are capable of providing time synchronization accurate to within 1 to 5 milliseconds. The stratum levels refer to the distance (in number of servers) from the reference clock. Lower number is more preferred.

Also, CDMA signals, used by digital cellular telephones, can be used as a timing source. Code Division Multiple Access (CDMA)-based stations act as GPS repeaters. These signals are more readily received inside buildings. These may be an option due to the facility costs of connecting the NTP appliance to the exterior antenna.

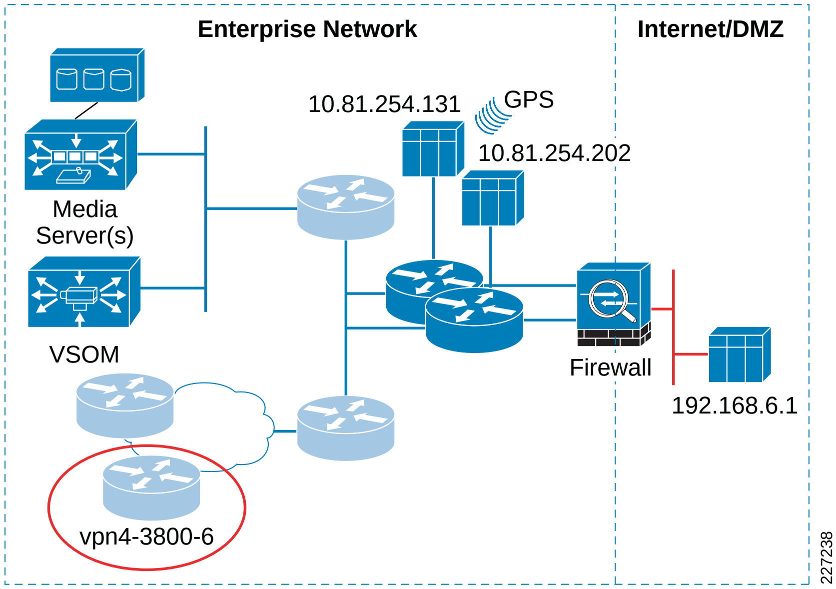
The advantage of using an enterprise owned GPS-based time server is reliability and availability. It is recommended that two of these servers be installed at diverse points in the network topology so one server remains accessible to the network in the event of a single data center disaster. Ideally, they would be located at multiple data centers or other core locations and provide the same degree of network redundancy as other network management and servers.

Topology

The topology (see Figure 1) in this chapter shows a sample configuration where the network manager has one or more time sources available in the internal network address space (10.81.254.0/24 in this example) and one or more time sources on public address space, represented by 192.168.0.0/16. The servers on the internal address space are stratum 1 sources. The server on the public address space (Internet DMZ) is a stratum 2 source referencing a clock source of the Naval Observatory (USNO) NTP servers.

The sample configuration is from a branch router configured as a stratum 12 NTP server, providing a time source to the IP cameras, Cisco Video Management and Storage System (VMSS), and the optional Analog Video Gateway Module. The branch router references lower stratum servers, the configured stratum 1 and 2 servers, and under normal operations will prefer these lower stratum source over its own internal clock.

Figure 1 Network Time Protocol Reference Topology



This design includes several advantages and best practices. By peering the routers in the network with the NTP servers rather than all devices in the network, it minimizes the polling to the servers. In a highly available network, the routers only generate a NTP poll request every 17 minutes. Because the routers have an accurate time source from the NTP servers, they are able to provide an accurate time source for hosts on their connected interfaces. This adds a level of hierarchy in the NTP deployment and can scale to very large enterprise networks.

Additionally, the design incorporates one or more internal GPS-based NTP appliances inside the enterprise firewall from the Internet. The NTP appliance (or router) located in the Internet/DMZ can be configured to peer to the internal NTP appliances (with the appropriate firewall rule allowing this inbound connection) as well as to NTP servers on the public Internet. The NTP appliance in the Internet/DMZ can also serve as a time source for remote access clients and broadband routers supporting enterprise teleworker or remote users.

By configuring the internal routers to also peer to the Internet/DMZ NTP appliance, a third-time source (although at a higher stratum) can be obtained from a publicly available server from the Naval Observatory (USNO).

Basic Router Configuration

The basic configuration of each router on the enterprise network is to specify in the configuration a **ntp master** statement with a stratum 12 value, and then reference one or more NTP appliances within the enterprise network and a router or NTP appliances on the Internet/DMZ.

```
ntp master 12
ntp server 192.168.6.1 source {source IP address}
ntp server 10.81.254.202 source {source IP address}
ntp server 10.81.254.131 source {source IP address}
```

The source IP address is optional but may be specified.

Note LAN switches in the network should also use the nearest router as their configured NTP server.

Tips and Additional Useful Information

NTP is transported by the UDP protocol and port 123. The size of the packets, including the IP header, is approximately 76 bytes. Cisco IOS sets the ToS byte in the IP header with an IP Precedence of '6' (DSCP CS6) for NTP packets.

NTP is VRF-aware and can configured to reference a VRF instance, using VRF IPVS as an example, **ntp server vrf IPVS** *{ip_address}* associates the NTP address with the appropriate VRF table.

NTP does not *converge* quickly to an alternate peer upon failure of the current master (synched) peer. This is by design and the expected behavior of NTP. It requires multiple comparisons over long periods for accurate clock synchronization.

The Cisco IOS implementation of the NTP client polls the configured servers between 64 seconds and up to 1024 seconds (over 17 minutes). When the peer is first configured, 16 polls are generated initially. After the first 64 second interval, if the poll is answered with a valid time source reply, the interval is incremented. The interval increases (or decreases) in powers of 2; for example, 64,128,256,512,1024 seconds. In a stable network, the poll interval is usually 1024 seconds.

However, not all network devices implement this backoff algorithm. For example, IP cameras may contact their configured NTP server on a polling interval based on the 64 second interval and never increase the polling interval.

Do not configure the **ntp clock-period** command when cutting and pasting from one router configuration to another. The system calculates the value on its own and includes it in the running configuration. The system may go out of synch if the user manually configures the **ntp clock-period** command. If it is manually configured, configure a **no ntp clock-period** command and reload the router so the value can be recalculated.

Output from **show ntp associations** command is shown and explained below.

```
vpn4-3800-6#show ntp associations

      address         ref clock     st  when  poll reach  delay  offset    disp
 ~127.127.7.1      127.127.7.1      11     1    64  377     0.0    0.00     0.0
+~192.168.6.1      .USNO.            2   444  1024  377     2.2   -2.83     0.9
*~10.81.254.202    .GPS.             1   350  1024  377     7.7    0.94     3.0
+~10.81.254.131    .GPS.             1   810  1024  377    18.6    6.49     2.1
 * master (synced), # master (unsynced), + selected, - candidate, ~ configured
```

- *st*—Stratum, number of levels from the time source
- *when*—Number of seconds since last ntp request was sent to this server
- *poll*—Number of seconds between ntp requests with this server
- *reach*—Bitmap represented in octal of last 8 ntp responses that were received from the NTP server for the last 8 ntp requests sent
- *delay*—Round trip delay to the reference clock in milliseconds
- *offset*—Amount to adjust our clock to correspond with the reference in milliseconds, can be negative
- *disp*—The maximum error between the local clock and the reference, in milliseconds

If the *reach* value is anything other than 377, NTP packets have been dropped by the network or server during the last 8 attempts.

NTP servers keep time in Universal Time (UTC), and each device on the network must be configured for the proper geographical time zone. The conversion to the proper local time is handled by the operating system of each device. Greenwich Mean Time (GMT), Greenwich Time and Zulu Time refer to UTC.

Sample ISR Router and VMSS Configuration

The branch router is configured to contact the internal servers, 10.81.254.202 and 10.81.254.101, sourced from the IP interface representing the inside VLAN of the branch. The external NTP server at 192.168.6.1 is sourced from the outside or WAN interface.

```
vpn4-3800-6#show run | inc ntp
ntp source Integrated-Service-Engine2/0
ntp master 12
ntp server 192.168.6.1 source GigabitEthernet0/0.150
ntp server 10.81.254.202 source Vlan1
ntp server 10.81.254.131 source Vlan1
```

The ISR router is configured as an NTP master with a stratum of 12. The NTP master stratum number identifies the relative position of this router in the NTP hierarchy. Higher numbers are less preferred sources. This router is configured to serve as a master and will provide an accurate time source to the VMSS and IP cameras and other hosts that request synchronization. Configuring the branch router as an NTP server provides a time source to the branch devices in the event WAN connectivity is disrupted and lower stratum devices are unreachable.

In this illustration, the NTP source address is Integrated-Service-Engine2/0 or IP address of 192.0.2.33, the address of the VMSS module. A loopback address of the router could also be used to source replies to client NTP packets. A loopback address would be preferred, this implementation did not provide for loopback addresses and the logical interface of the VMSS network module is used as an alternative.

Client workstations, IP cameras and other devices on the network may use any of the IP addresses associated with the router as a NTP peer IP address in their configuration, they need not only use the value specified by the **ntp source** configuration command.

The following configuration example shows the network administrator establishing a console session the VMSS network module in this ISR router, and showing that the configuration of Linux kernel on the VMSS module is using the host ISR router as a NTP peer.

```
vpn4-3800-6#sh run interface integrated-Service-Engine 2/0
Building configuration...
!
interface Integrated-Service-Engine2/0
 ip address 192.0.2.33 255.255.255.252
 ip route-cache flow
 service-module ip address 192.0.2.34 255.255.255.252
 service-module ip default-gateway 192.0.2.33
 no keepalive
end
```

The module is configured to use IP address 192.0.2.33, the IP address of the router hosting the VMSS module. These commands establish a console session to the network module operating system and displays the running configuration.

```
vpn4-3800-6#service-module integrated-Service-Engine 2/0 sess
Trying 192.0.2.33, 2130 ... Open
SITE150> en
Password:
SITE150#
SITE150# show run
Generating configuration:

clock timezone America/New_York
hostname SITE150
ip domain-name ese.cisco.com
system language preferred "en_US"
ntp server 192.0.2.33 prefer
```

Only one NTP server need be specified (192.0.2.33), because this is the IP address of the ISR router that is configured for more than one NTP server in the router configuration in addition to also being configured as an NTP master should connectivity to the lower stratum servers be lost. Note the time zone is also manually configured, as NTP exchanges time in UTC.

The NTP server associations from the VMSS network module may be displayed. The reference server (*refid*) is the time source from one of the enterprise network NTP sources, referenced in in the router configuration.

```
SITE150# show ntp servers
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
*192.0.2.33      10.81.254.202    2 u  556 1024  377    1.687   -0.445   0.008
space reject,       x falsetick,       . excess,          - outlyer
+ candidate,        # selected,        * sys.peer,        o pps.peer
```

In the event network connectivity is disrupted, making the reference source unreachable, the branch router itself would be the reference clock. The NTP source at 10.81.254.202 is the current reference because the branch router has synched to that time source, indicated by the asterick (“*”) next to the IP address.

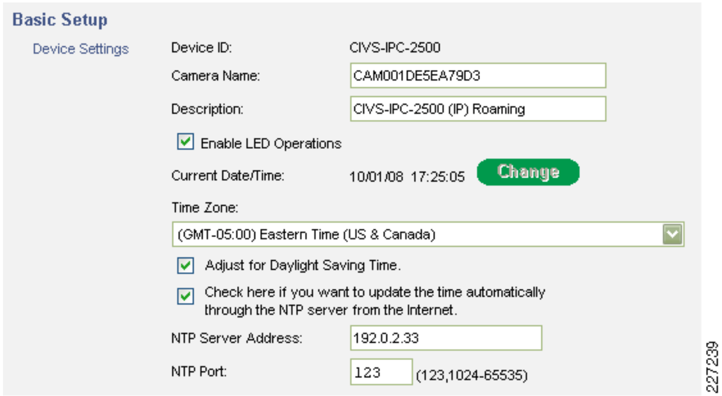
Sample IP Camera Configuration

This section illustrates the router and an IP camera configuration. The IP address of the default router in the IP configuration of the camera can also be used as the NTP server IP address if the router is configured per the recommended design. Assuming the default router is configured on the subnet of the IP camera is configured as follows:

```
router#sh run | inc ntp
ntp source Integrated-Service-Engine2/0
ntp master 12
ntp server 192.168.6.1 source GigabitEthernet0/0.150
ntp server 10.81.254.202 source Vlan1
ntp server 10.81.254.131 source Vlan1
!
interface GigabitEthernet0/1.210
 description IP Camera VLAN
 encapsulation dot1Q 210
 ip vrf forwarding IPVS
 ip address 192.0.2.97 255.255.255.224
end
```

The configuration of the IP camera can reference the NTP server as the same IP address as the default gateway for this camera, 192.0.2.97. The NTP port is not changed from the default port 123.

Figure 2 NTP Configuration for Cisco 2500 series IP Camera



The IP camera is directed to adjust the local time for Daylight Savings Time when the offset is adjusted forward or back. The appropriate time zone is selected to specify the offset from UTC/GMT and the name of the time zone. Time is based off UTC, and each device on the network must be configured to adjust the clock by the offset for their locality.

Overlaying Video Image with a Timestamp

Most IP cameras can include the current time from the internal clock of the IP camera as an overlay to the video image. Because the NTP configuration discussed in this section provides an accurate time source to the IP cameras, this video overlay can serve as a reference to the time stamps associated with the video feed by the Media Server.

Figure 3 shows an example of a video image with a timestamp overlay with the date of *30 September 2008 at 10:49*. While there is no option to include the timezone in this display, there is also the ability to include a text overlay to the video image. The timezone can be entered as alphanumeric text along with the name or other location information of the camera.

Figure 3 Timestamp Overlay

Server and Workstation Configuration

The Cisco Physical Security Multiservices platform or standalone servers running Cisco Video Surveillance Media Server (Media Servers), Video Surveillance Operations Manager (VSOM), Video Surveillance Virtual Matrix (VSVM) as well as client viewing stations, iSCSI appliances or other networked DVR servers would be similarly configured as the IP camera in this section. These devices all use the default router IP address as the NTP server IP address.

Summary

An accurate and consistent clock is important to provide for the synchronization of images archived from a variety of camera feeds. An accurate time source is vitally important for forensic uses of video surveillance data to equate a time with a point in time. By implementing NTP in an hierarchical design, accurate time service can be provided to a very large scale enterprise network and have excellent reliability and availability.

References

For additional information, refer to the *Network Time Protocol: Best Practices White Paper* at URL:

http://www.cisco.com/en/US/tech/tk869/tk769/technologies_white_paper09186a0080117070.shtml

Syslog

Syslog is a term for the standard logging facility on Unix/Linux systems. Most computer software programs and operating systems incorporate some logging file, but Syslog is a network-based protocol where the client system generates a log file entry to a syslog server. This syslog daemon (server) may run on the same host as the client, but the more useful implementation is realized by dedicating a machine on the network as a central syslog server and logging messages over the IP network from many hosts to this central repository.

Typically, these text messages are transmitted as UDP packets on port 514 in clear text. The RFC 5424 *The Syslog Protocol* provides more details.

Syslog messages are characterized by Facility and Severity. The severity is a numeric code of 0-7 which indicates the relative importance of the message. Emergency or severity 0 is more important than severity 7 for debug-level messages. Cisco routers send syslog messages to their logging server with a default facility of 'local7'. Cisco IP cameras use a facility of 'user'. Because of the differences in facility between a router and a IP camera, a syslog server which is logging Cisco router log messages must have the configuration file updated to include a directive for processing log files from cameras.

Assuming the goal is to include both router log files and IP camera log files into the same file (*/var/adm/logs/cisco.log*) on the syslog server for all logging levels (debug through emergency) the following example of a syslog configuration file is provided as an example.

```
/etc/syslog.conf
#
local7.debug                                        /var/adm/logs/cisco.log
user.debug                                          /var/adm/logs/cisco.log
```

Tip There are five tabs between the two text fields in the file. If the output file does not exist, it must be created with *touch /var/adm/logs/cisco.log* and the file permissions set with *chmod 755 /var/adm/logs/cisco.log.*

After editing the configuration file, the syslog daemon process must be reinitialized.

```
# kill -HUP `cat /etc/syslog.pid`
```

The following is a sample log message from a Cisco 2500 series IP camera.

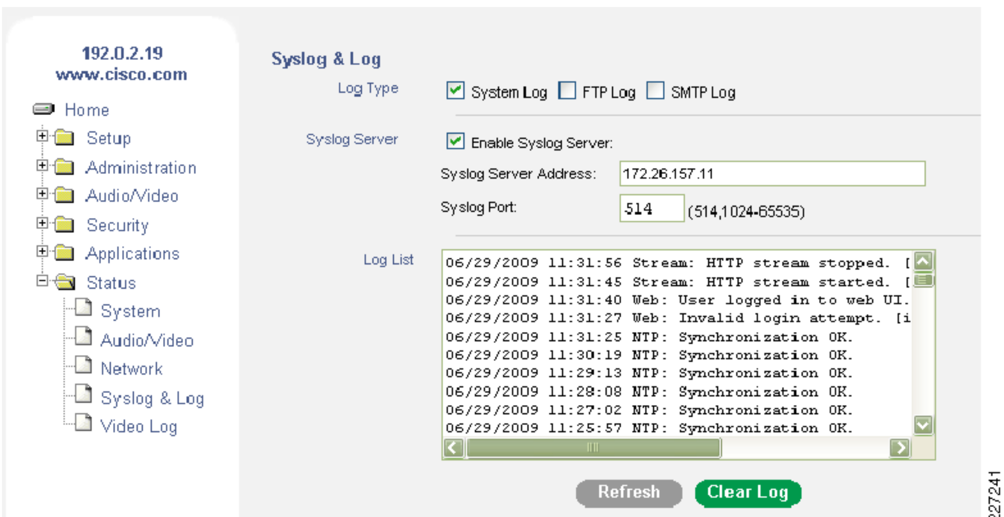
```
Sep 30 15:13:15 [192.168.16.30.4.2] 192.168.16.30 09/30/2008 15:22:42 NTP:
Synchronization OK.^M
```

```
Sep 30 15:13:48 [192.168.16.30.4.2] 192.168.16.30 09/30/2008 15:23:16 Web: User logged
in to web UI. [id: vsom, ip: 192.0.2.2]^M
Sep 30 15:13:49 [192.168.16.30.4.2] 192.168.16.30 09/30/2008 15:23:17 Web: User logged
out from web UI. [id: vsom, ip: 192.0.2.2]^M
Sep 30 15:13:50 [192.168.16.30.4.2] 192.168.16.30 09/30/2008 15:23:17 Stream: RTSP
stream started. [ip: video, UDP: 192.168.16.30:5002 -> 192.0.2.2:6500, vsom]^
M
Sep 30 15:13:56 [192.0.2.19.4.1] 192.0.2.19 09/30/2008 15:23:23 NTP: Synchronization
OK.^M
```

Note that in the log file, the time stamp inserted by the syslog daemon differs by a few minutes from the time stamp placed in the log message from the end-node, the IP camera in this example. The IP camera is indicating from the log messages that it is synchronizing successfully with the configured NTP server; therefore, it can be assumed the clock on the Syslog server is not synched. This illustrates the importance of having all devices on the network peering with a NTP server, so that the time stamps are consistent across all devices on the network.

The screen snapshot in Figure 4 from a Cisco 2500 Series IP camera shows how the Syslog file can be viewed locally from the API of the camera and where the IP address of the central Syslog server can be entered.

Figure 4 IP Camera Syslog Configuration Screen



There are a number of programs available in the public domain, either commercially or are supported by user donations, that can be implemented to monitor log messages and take some action (running a command) based on these configured alerts. The web page http://www.syslog.org/ is a clearing house for syslog implementations available to the network manager.

Cisco IOS IP Service Level Agreements (SLAs)

IP Service Level Agreements (IP SLA) is a tool for the network manager to measure and report on network performance between a Cisco router and either a remote Cisco router or other IP device. One application of this technology is to configure the router that is providing network connectivity for IP cameras to verify the availability of these IP cameras. One type of probe that can be generated by the router is ICMP echo (Ping) which will be responded to by most IP stacks, including those of IP cameras. IP SLA incorporates other probe types that require a remote Cisco router with **ip sla responder-**enabled in the configuration as the IP SLA operation requires special processing.

One application of IP SLA in a camera deployment would be to use the router to generate ICMP echo requests on a periodic basis to all the local IP camera and then to maintain a history log of any connectivity failures or responses which exceed a specified time limit.

The following sample configuration shows a router configuration that sends an ICMP echo request every 60 seconds (the default value) to the camera at IP address 192.0.2.19 with a ToS value of CS6, in VRF IPVS with a threshold of 50 milliseconds. A history file is maintained for probes that receive no response or the response is over the configured treshold. The identifier of 219 is an arbitrary numeric identifier value.

```
!
ip sla 219
 icmp-echo 192.0.2.19
 tos 192
 threshold 50
 vrf IPVS
 owner networkmgr
 tag ipvs - design guide
 frequency 60
 history lives-kept 1
 history buckets-kept 60
 history filter failures
ip sla schedule 219 life forever start-time now
```

The history output can be displayed in tabular format or 'full' or verbose format. The history file is only updated for failure events, which provides more relevancy to the log file and prevents it from wrapping as frequently as it would if all entries are logged.

```
vpn1-2851-1#show ip sla hist 219
        Point by point History
Entry    = Entry number
LifeI    = Life index
BucketI  = Bucket index
SampleI  = Sample index
SampleT  = Sample start time
CompT    = RTT (milliseconds)
Sense    = Response return code

Entry LifeI      BucketI    SampleI    SampleT    CompT      Sense      TargetAddr
219   1          1          1          708986549  128        3          192.0.2.19
219   1          2          1          709250549  88         3          192.0.2.19
219   1          3          1          709280549  0          4          192.0.2.19
219   1          4          1          709286549  0          4          192.0.2.19
```

In the verbose output of the log file, the network manager can see at what time of the day the target camera failed to respond or responded over the threshold. The last two log file entries coincide with the author removing the Ethernet cable from the rear of the IP camera. Because the camera is using PoE, the network connectivity was lost and the device also lost power. The Over threshold values may have been a result of the operating system responding slowly to the ICMP echo response (on many systems, ICMP is a background process with low priority) or due to some network congestion.

```
vpn1-2851-1#show ip sla hist 219 full
Entry number: 219
Life index: 1
Bucket index: 1
Sample time: 11:55:23.207 edt Mon Jun 29 2009
RTT (milliseconds): 128
Response return code: Over threshold

Life index: 1
```

```
Bucket index: 2
Sample time: 12:39:23.207 edt Mon Jun 29 2009
RTT (milliseconds): 88
Response return code: Over threshold

Life index: 1
Bucket index: 3
Sample time: 12:44:23.207 edt Mon Jun 29 2009
RTT (milliseconds): 0
Response return code: Timeout

Life index: 1
Bucket index: 4
Sample time: 12:45:23.207 edt Mon Jun 29 2009
RTT (milliseconds): 0
Response return code: Timeout
```

IP SLA may be implemented on production routers; however, many network managers choose to dedicate a router for the sole purpose of generating and responding to IP SLA probes. Additionally, CiscoWorks Internetwork Performance Monitor uses the IP SLA software feature embedded within the Cisco IOS and can be part of an overall network management infrastructure for managing routers, switches, servers and end-nodes such as IP cameras.

Summary

IP SLA may be used by the network manager to aid in troubleshooting connectivity failures or as a part of an overall ongoing network management strategy implemented by software packages such as CiscoWorks IPM.

Power-Over-Ethernet (PoE)

Many analog camera deployments require an external power supply to provide the typical input voltage of 12VDC/24VAC, with 24VAC at 3.5 AMP being common. Many analog deployments may implement a smart BALUN to multiplex power, RS-485 (for PTZ control) and video signal over a CAT-5 cable at an attempt to provide a similar advantage to which an IP camera with Power over Ethernet enjoys.

PoE enables power for the camera using the same cable as that used for network connection. Switches must meet the IEEE 802.3af standard to be PoE-compliant. PoE is incorporated into many access-LAN switches to support IP telephony and wireless LAN controllers also using PoE. The maximum distance is the same as the Ethernet standard, 100 meters.

Providing backup power to each analog camera may be costly and time-consuming, while providing an uninterruptible power supply (UPS) for the access switch will not only provide for backup power to an IP camera, but also other devices on the LAN switch. IP cameras have a decided advantage over analog systems because of the PoE feature. One caveat, however, is that many IP cameras that incorporate a wireless LAN connection may not support PoE to the wired-port, because the assumption is made that the reason a wireless camera was purchased was to use the wireless features.

Additionally, PoE may decrease the time required to install an IP camera due to the elimination of the need for a licensed electrician to complete the installation or may permit installation in ceilings where PoE devices are permitted but other electrical inputs are not.

Note You must use the Cisco 12V power adapter (CIVS-PWRPAC-12V) when no IEEE 802.3af standard PoE switch is available.

The Cisco 2500 Series and the 4000 Series cameras are in Device Class 3 which specifies an power consumption range of 6.49 to 12.95 Watts. The following command output is from a Cisco 3750 LAN switch with both CIVS-IPC-2500 (Standard Definition) and CIVS-IPC-4300 (High Definition) IP cameras attached to the switch. The power consumption is 9.0 watts and 13.0 watts respectively.

```
3750-access#show power inline gigabitEthernet 1/0/2
Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi1/0/2   auto   on         9.0     CIVS-IPC-2500       3     15.4

Interface  AdminPowerMax   AdminConsumption
             (Watts)           (Watts)
---------- --------------- --------------------

Gi1/0/2               15.4                 15.4
```

By omitting the interface option, all connected devices are shown as follows:

```
3750-access>show power  inline

Module   Available     Used     Remaining
          (Watts)     (Watts)    (Watts)
------   ---------   --------   ---------
1           370.0       35.0       335.0
Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi1/0/1   auto   off        0.0     n/a                 n/a   15.4
Gi1/0/2   auto   on         9.0     CIVS-IPC-2500       3     15.4
Gi1/0/3   auto   on         13.0    CIVS-IPC-4300       3     15.4
Gi1/0/4   auto   on         13.0    CIVS-IPC-4300       3     15.4
Gi1/0/5   auto   off        0.0     n/a                 n/a   15.4
```

Summary

PoE is a feature that provides a decided advantage of an IP-based video surveillance implementation over the analog counterpart. It is particularly useful in enterprise implementations that have existing IP telephony or wireless access points that also rely on PoE.

Cisco Discovery Protocol (CDP)

CDP is a Layer-2 network protocol that runs on most Cisco routers, switches and end-nodes like Cisco IP phones, access points, and also the Cisco IP surveillance cameras. CDP is primarily a troubleshooting tool, as it includes Layer-3 addressing (IP address) over a Layer-2 protocol and application information like the operating system version, capabilities, device name and type of device. It also has been enhanced to provide the value of the interface duplex setting and power requirements.

From a video surveillance perspective, it is most useful for the initial provisioning of IP cameras on the network. Cisco IP cameras have the hardware (MAC) address printed on the exterior of the IP camera. The CDP exchange also includes a reference to the MAC address through the *Device ID* field. The IP address of the camera and the firmware version are associated with the MAC address in the output of the **show cdp neighbors** command. Sample output is shown below:

```
3750-access#show cdp neighbors gigabitEthernet 1/0/2 detail
```

```
-------------------------
Device ID: 001DE5EA79D3
Entry address(es):
  IP address: 192.0.2.50
Platform: CIVS-IPC-2500,  Capabilities: Host
Interface: GigabitEthernet1/0/2,  Port ID (outgoing port): eth0
Holdtime : 153 sec

Version :
1.1.1

advertisement version: 2
Duplex: full
Power drawn: 9.000 Watts
Power request id: 57831, Power management id: 3
Power request levels are:9000 0 0 0 0
Management address(es):
  IP address: 192.0.2.50
```

If the Cisco IP camera is unable to obtain an IP address through DHCP, it will default to the address of 192.168.0.100. Either the DHCP assigned IP address or the static IP address is advertised via CDP, which provides useful information to the network manager as to the state of the camera installation.

As a best practice, IP cameras should be assigned a static IP address that is referenced in the enterprise DNS system. The initial DHCP address can be used by a remote network or physical security administrator to complete the initial configuration of the camera from the factory defaults. This includes changing the DHCP or default IP address to a static IP address registered with DNS. Once that change is made and saved, the remote administrator must reconnect to the camera and complete the initial configuration and definition within VSOM/Media Server.

Tip Some firmware versions of the Cisco IP cameras also support device discovery using the Bonjour protocol.

One additional use of CDP is device discovery. CiscoWorks Network Connectivity Monitor and other third-party software packages can autodiscover a network topology by using both CDP and SNMP access to routers and switches in the network. Because Cisco IP cameras support CDP and SNMP, these endpoints can also be discovered by these network management tools.

Simple Network Management Protocol

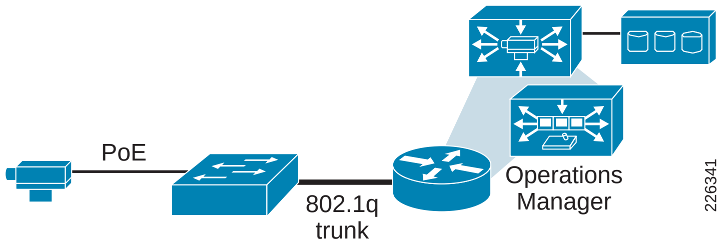
Cisco IP cameras also support the Simple Network Management Protocol (SNMP). This protocol is disabled by default, and once enabled the default read community string is *public*, which many organizations change to some site-specific value. Two SNMP trap receiver IP addresses may be entered in the dialog box on the configuration screen. There is no write SNMP option, it is a read-only implementation and must be configured from the API of the camera as there is no VSOM support for these values.

Deploying a Cisco Video Surveillance IP Camera

The Cisco Video Surveillance IP Camera User Guide provides information about installing, configuring, using, managing, and troubleshooting the Cisco Video Surveillance IP Camera model CIVS-IPC-2500. This section describes examples of one method of deploying the camera at a branch office location, facilitating and simplifying deployment.

This section assumes that the branch Cisco ISR router has an operational Cisco VMSS Network Module, a Layer-2 switch capable of providing Power-over-Ethernet (or an external power injector, or power supply is available) and a FastEthernet network connection on a VLAN dedicated to the cameras at the branch office. In this example, a Cisco 3825 ISR router and a Cisco Catalyst 3750 Series Switch is used. The router and the switch are connected by an 802.1q trunk. This toplogy is shown inFigure 5.

Figure 5 Cisco Video Surveillance IP Camera - Branch Office Deployment



Deployment Steps

Create (Verify) a DHCP Pool and Interface on the Router

This branch location is served by by less than 15 IP cameras. An IP network address with a mask of /28 (255.255.255.240) is shown in the following example. Create/verify a DHCP pool and sub-interface on the branch router.

```
!
ip dhcp pool cameras
   network 192.0.2.48 255.255.255.240
   default-router 192.0.2.49
   dns-server xx.xxx.6.247 xxx.xx.226.120
   domain-name cisco.com
!
interface GigabitEthernet0/0.208
 description inside interface for ip cameras
 encapsulation dot1Q 208
 ip address 192.0.2.49 255.255.255.240
!
end
```

The DHCP pool is used to allow the camera to initially obtain an IP address through DHCP. Once the camera has been powered and booted, the DHCP assigned IP address is made a static IP address. The VMSS network module refers to the static IP address when defining the camera.

Create a SmartPort Macro on the Switch

The Catalyst 3750 switch port for the camera can be configured using a Smartport macro. By defining the configuration commands in a macro, they can be easily applied to additional port which provide connectivity to other cameras at this location. Configure and apply the Smartports macros shown in global configuration mode.

```
macro name CIVS-IPC-2500
```

```
description Cisco Video Surveillance 2500 Series IP Camera
switchport mode access
switchport access vlan $VLAN
switchport port-security
switchport port-security mac-address sticky
switchport port-security maximum 1
switchport port-security violation shutdown
mls qos trust dscp
spanning-tree portfast
spanning-tree bpdufilter enable
load-interval 60
no shutdown
@
```

These configuration commands enable the port as a Layer-2 access port and assigns the port to a separate VLAN for IP cameras. The VLAN must match the VLAN configured on the router from the previous step. Bridge Protocol Data Unit (BPDU) filters are enabled to prevent this control traffic from being sent out the port. This command has the same effect as disabling spanning tree on the interface and can result in spanning-tree loops. However, this port is intended to be used for the IP Camera and not for connecting to another switch. The portfast feature is commonly used for end-stations and decreases the time it takes for the port to begin forwarding traffic.

Port security is defined, allowing a single MAC address, the first MAC address seen on the port is automatically entered into the configuration. If the IP Camera is unplugged from the port and another device is attached, the port security feature marks the port as error-disabled and shutsdown the port immediately. An SNMP trap is sent and a syslog message is logged. To bring the port back on-line issue a shutdown and no shutdown interface configuration commands. As a best practice, the SNMP traps and syslog messages should be monitored and alerts sent to an appropriate contact(s) within the physical security organization to alert the operators when camera are being tampered with or removed from the network.

Because the DSCP values of IP packets are set by the camera firmware, the Layer-3 QoS values are trusted by the switch. The DSCP value of CS5 (40) is manually configured for both audio and video and is shown in a later step.

Finally, the *no shutdown command* is issued on the port, which brings up the port and through the CDP exchange, will negotiate and apply power to the camera.

Power Up Camera

In this example, it is assumed the camera is attached to interface gigabitEthernet 1/0/2 and is administratively shutdown.

```
3750-access#sh run int g 1/0/2
Building configuration...

Current configuration : 48 bytes
!
interface GigabitEthernet1/0/2
 shutdown
end
```

The macro is manually applied to the interface, specifying VLAN 208 as an argument to the macro. This parameter is substituted as the macro executes. When the macro finishes executing, the link is brought up and the camera powered from the switch.

```
3750-access(config)#interface gigabitEthernet 1/0/2
3750-access(config-if)#macro apply CIVS-IPC-2500 $VLAN 208
%Warning: portfast should only be enabled on ports connected to a single
```

```
 host. Connecting hubs, concentrators, switches, bridges, etc... to this
 interface  when portfast is enabled, can cause temporary bridging loops.
 Use with CAUTION

%Portfast has been configured on GigabitEthernet1/0/2 but will only
 have effect when the interface is in a non-trunking mode.
3750-access(config-if)#
*Mar  2 17:34:29.774: %ILPOWER-7-DETECT: Interface Gi1/0/2: Power Device detecte
d: IEEE PD
*Mar  2 17:34:30.412: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed st
ate to down
*Mar  2 17:34:30.781: %ILPOWER-5-POWER_GRANTED: Interface Gi1/0/2: Power granted
*Mar  2 17:34:33.650: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed st
ate to up
*Mar  2 17:34:34.656: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEth
ernet1/0/2, changed state to up
*Mar  2 17:34:55.343: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEth
ernet1/0/2, changed state to down
*Mar  2 17:34:56.349: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed st
ate to down
*Mar  2 17:34:59.403: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed st
ate to up
*Mar  2 17:35:00.409: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEth
ernet1/0/2, changed state to up
3750-access(config-if)#
3750-access(config-if)#end
3750-access#
3750-access#
*Mar  2 17:35:19.368: %SYS-5-CONFIG_I: Configured from console by console
```

To verify the interface configuration, a *show run interface* command can be executed. The MAC address of the camera has been learned and is applied to the interface configuration.

```
3750-access#show run interface gigabitEthernet 1/0/2
Building configuration...

Current configuration : 409 bytes
!
interface GigabitEthernet1/0/2
 description Cisco Video Surveillance 2500 Series IP Camera
 switchport access vlan 208
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 001d.e5ea.79d3
 load-interval 60
 mls qos trust dscp
 macro description CIVS-IPC-2500
 spanning-tree portfast
 spanning-tree bpdufilter enable
end
```

Warning **The running configuration is not automatically saved following macro completion, enter write memory (copy running-config startup-config) to save the configuration changes.**

The following command output shows that the IP camera is a class 3 device and the switch is supplying 9 Watts to the IP Camera.

```
3750-access#show power  inline gigabitEthernet 1/0/2
Interface Admin  Oper       Power   Device              Class Max
```

```
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi1/0/2   auto   on         9.0     CIVS-IPC-2500       3     15.4

Interface  AdminPowerMax   AdminConsumption
             (Watts)           (Watts)
---------- --------------- --------------------

Gi1/0/2              15.4                 15.4
```

The IP camera, by default, will request a DHCP address. If the camera cannot obtain an IP address through DCHP within 90 seconds, it uses a default IP address of 192.168.0.100. To determine what IP address has been assigned to the IP Camera, a show *ip dhcp binding* can be issued from the branch router, and the MAC address printed on the adhesive label attached to the camera body, can be use to identify the IP address associated with the IP address of the Camera. The MAC address of the camera can also be learned from the *show mac address-table dynamic interface* command on the switch. Alternately, the IP address of the IP camera can be found from Cisco Discovery Protocol, as shown:

```
3750-access#show cdp neighbors gigabitEthernet 1/0/2 detail
-------------------------
Device ID: 001DE5EA79D3
Entry address(es):
  IP address: 192.0.2.52
Platform: CIVS-IPC-2500,  Capabilities: Host
Interface: GigabitEthernet1/0/2,  Port ID (outgoing port): eth0
Holdtime : 153 sec

Version :
1.1.1

advertisement version: 2
Duplex: full
Power drawn: 9.000 Watts
Power request id: 57831, Power management id: 3
Power request levels are:9000 0 0 0 0
Management address(es):
  IP address: 192.0.2.52

3750-access#
```

In this example, the camera has been assigned an IP address of 192.0.2.52. It can also be shown from the DHCP table of the branch router.

```
vpn4-3800-6#show ip dhcp binding
Bindings from all pools not associated with VRF:
IP address          Client-ID/              Lease expiration        Type
                    Hardware address/
                    User name

192.0.2.52          0100.1de5.ea79.d3       Feb 28 2009 02:17 PM    Automatic
```

The MAC address can be verified from the LAN switch as shown:

```
3750-access#show mac address-table interface gigabitEthernet 1/0/2
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
```

```
----    -----------      --------    -----
 208    001d.e5ea.79d3    STATIC      Gi1/0/2
Total Mac Addresses for this criterion: 1
```

In this section it has been shown that the IP address and MAC address of the IP camera can be located in several ways by issuing **show** commands on the router and switch.

Document Switch, Router and DNS

In the next step, the camera configuration is changed to use a static IP address and the hostname of the camera is configured. The following checklist is helpful for ongoing documentation.

Configure the port name on the switch (for example, *set port name or description)*

- Exclude the IP address of the camera from the DHCP pool (for example, **ip dhcp excluded-address 192.0.2.52**)
- Update DNS to reference the deployed camera
  - ipc-2500-79d3.cisco.com. IN A 192.0.2.52
  - 52.2.0.192.in-addr.arpa. IN PTR ipc-2500-79d3.cisco.com

Configure the IP Camera

It is assumed the PC is connected to a network that has connectivity to the 192.0.2.48/28 network. Because the camera has obtained an IP address, mask, default gateway and DNS servers and domain-name from the DHCP pool on the router, the PC need not be connected to the same subnet as the camera. Using the DHCP method to deploy the camera initially enables the camera to be deployed at the remote location by a technician trained in physical cable termination, while the camera, switch, router and the VMSS configuration is done by the network and physical security personal at a central location.

Use the following URL to connect to the camera at IP address 192.0.2.50:

```
https://192.0.2.52
```

Note The protocol is Hypertext Transfer Protocol over Secure Socket Layer or **HTTPS**.

After successfully connecting to the web server of the Cisco IP Camera, several configuration options should be updated before defining the camera to the VMSS module. This checklist is provided to assist in completing these tasks.

Warning **Make sure the SAVE button is selected at the bottom of the screens when changing values.**

Table 7 Camera Configuration Checklist

Camera Configuration Checklist
Factory Default Initalization Screen • **Password**—Create an appropriate password for the 'admin' username. • **HTTP**—Enable HTTP as it is required by VSOM.
Administration -> Users —Create a userid specific for VSOM to configure, start and stop camera feeds. The web interface only allows one connection per userid. In testing a userid of 'vsom' with an appropriate password with 'administrator' privilege level is used.
Setup -> Basic Setup —Configure NTP as described previously in this design guide, if the branch router is configured as a NTP server, the default gateway IP address can be entered as the IP address of the NTP server.
Setup -> Basic Setup —Change the Configuration Type to Fixed IP address from DHCP, the values populated by the DHCP server configured previously in this section, will be maintained, eliminating the need to re-enter these values.
Setup -> Basic Setup - Under Camera Name and Description, Entering the IP address, Hostname or some unique identification value in this field may be useful in ongoing operation of the network.
Setup -> Advanced Setup -> QoS —Enable QoS and set both Audio and Video to DSCP value of '40' which is CS5.
Security - > Complexity—It may be useful to only select password check option 4 - Not used , if the camera password checks conflict with corporate standards.
Audio/Video -> Video -> Options —Enable Time Stamp and Text to Display is useful in ongoing operations and management.
Status -> Syslog & Log—Enable Syslog server and enter the IP address of the server.
Setup -> IP Filter - This option is discussed in "Virtualization, Isolation and Encryption of IP Video Surveillance" section on page 6-87.

Complete Camera Installation Under VSOM

After saving changes, exit/logoff the camera web server and complete the camera configuration from the VSOM administration screens to complete the definition and configuration of the camera.

```
http://vsom-webserver
```

Then select the Admin icon to switch to Administration Mode.

In **Devices - > IP Network Cameras -> Add a New IP/Network Camera**, fill out the form to define the new network camera. Suggested values are shown below:

Camera Information

- *Camera Name: ipc-2500-79d3.cisco.com
- Description: CIVS-IPC-2500 LAB RACK
- *Camera Type: - Cisco 2500 IP Camera
- *Host IP/Name: 192.0.2.52
- *Status: Enabled

Camera Feed

- *Server: -- VSMS_Site130
- *Media Type: M PEG -4
- *Format: N TSC
- *Resolution: D1 720 x 480
- *Transport: UDP
- Multicast Address:
- *Bitrate: -- Choose One -- 5000 4000 3000 2000 1500 1024 768 640 512 511 384 256 255 128 56
- *Quality: Defaults to 50^
- Camera requires authentication
- *Username:
- *Password:
- *Confirm Password:

Note The items above in asterisks (*) are required input.

Note
- Only MPEG-4 is supported in early firmware releases, MJPEG is supported in latest code.
- The format can be NTSC or PAL, when selected, changes the options available for selection under resolution
- Check the camera requires authentication and enter the userid and password from Table 7.
- The appropriate value for Bitrate is a function of desired image quality, available storage, and bandwidth. A value of 1,024K or 2,000K is a good starting value for a standard definition camera.

Summary

By using the Smartport macro capability of the Cisco Catalyst 3750 Series Switches, the DHCP server functions of the Cisco 3825 Integrated Services Router (ISR) and the Web server configuration utility of the Cisco Video Surveillance 2500 Series IP Cameras, IP Video Surveillance cameras can be quickly defined and deployed at a branch office or campus location. While the camera installation and wiring to the LAN switch must be accomplished by a technican at the physical location of the camera, the remainder of the configuration and installation can be completed from the network operations center over the IP network.

Configuring Quality-of-Service (QoS) for IP Video Surveillance

This chapter addresses implementing quality-of-service (QoS) for IP video surveillance deployments. The primary focus of this chapter is to understand the source and sinks of video surveillance feeds so that the network manager can mark packets with the appropriate QoS values to map into the enterprise QoS model. Equally important is to understand the bandwidth requirements of video surveillance feeds and take this into consideration when implementing QoS policies on LAN and WAN interfaces.

This chapter covers the following topics:

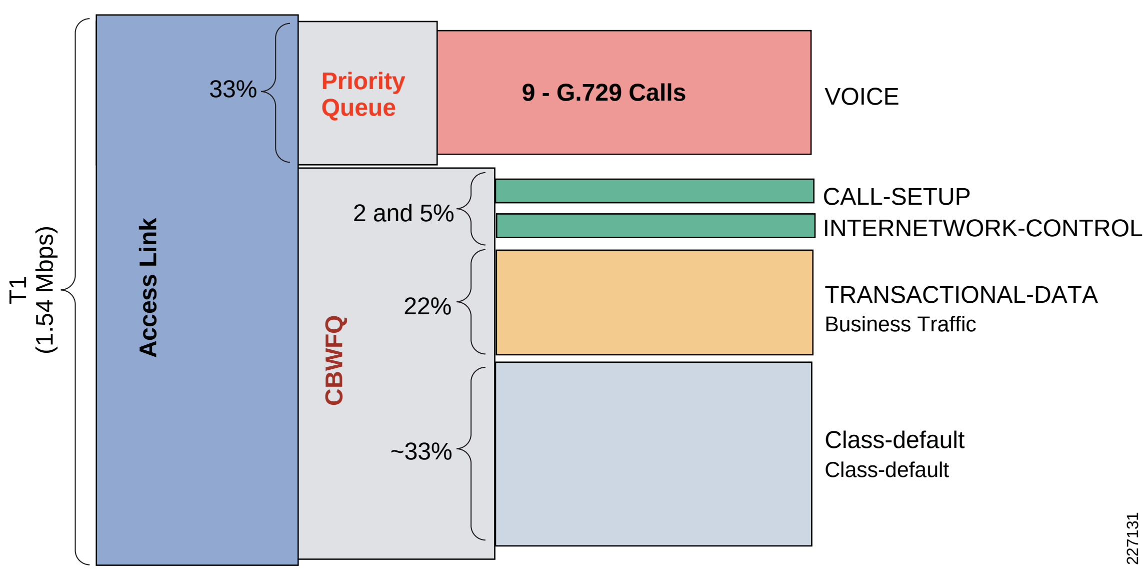
- WAN link bandwidth allocation changes for incorporating video into the network
- The QoS application classes and the DiffServ recommendations
- Examining the end-to-end traffic flows
- Ingress and end-node (IP cameras) marking of IP packets
- Examples of QoS techniques for routed MAN/WAN interfaces

WAN Link Bandwidth Allocation

The first network transition point was the introduction of VoIP to the traditional data network. In the 2004 time-frame, the Cisco Enterprise Solutions Engineering (ESE) labs extensively tested QoS-enabled encrypted VoIP and data. The traffic profile in those tests is characterized by a T1/E1 (1.5Mbps/2.0Mbps) or lower access circuit with nine G.729 VoIP calls and data traffic on the links. The data traffic is comprised of best effort traffic like file transfers and web browsing, as well as transactional data in the form of TN3270 and Telnet sessions.

The QoS service policy allocates 33 percent of the bandwidth for VoIP in a strict priority queue, 2 and 5 percent of the bandwidth for call control (CALL-SETUP) and routing protocol updates (INTERNETWORK-CONTROL). The remaining bandwidth classes were allocated for the TN3270/Telnet traffic in a TRANSACTIONAL-DATA class and the file transfers and web browsing fell to the default class (class-default). The bandwidth allocation from that testing is shown in Figure 6.

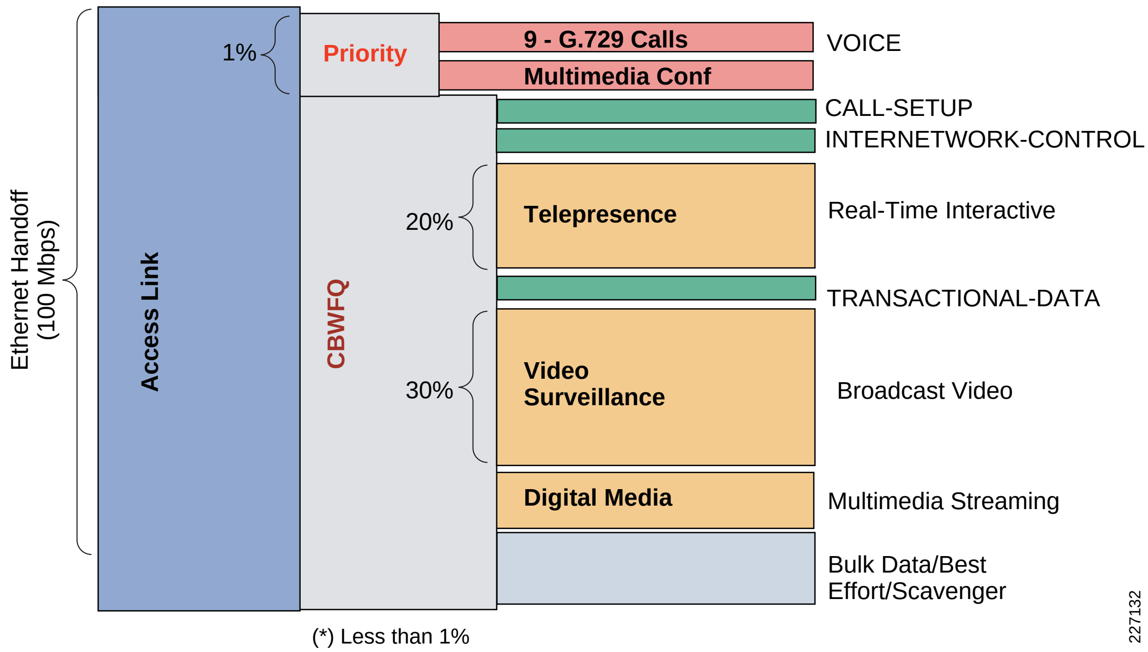
Figure 6 Bandwidth Allocation for Encrypted Voice and Data—2004



With the introduction of various video applications (Digital Media System (DMS), Telepresence, IP Video Surveillance, and Multimedia Conferencing to the VoIP and data network), the offered load to the network expands dramatically.

First, the total amount of bandwidth required for a branch location must be increased. Where VoIP and data can be transported on a T1/E1 link, 50 to 100 Mbps is required. The driver for this increase in bandwidth are the video applications provisioned on the links. Assuming similar branch requirements as is illustrated in Figure 6. Figure 7 includes additional bandwidth classes to accommodate video with an overall increase in the total amount of bandwidth.

Figure 7 Bandwidth Allocation to Provision Various Types of Video—009



While not all branches have a requirement for transporting Telepresence, Video Surveillance, or DMS over the WAN, there is a possibility that one or more of these video applications exist or will in the future and must be considered when provisioning WAN links.

Given the same number of VoIP calls, nine, from the 2004 bandwidth allocation, note that in terms of the percentage of bandwidth for the priority queue for VoIP goes from 33 percent of the total bandwidth to a fraction of a percent when the WAN link is a 100Mbps Metro Ethernet link. A single Telepresence unit can consume 15 to 20Mbps of bandwidth and live viewing of 8 to 10 IP cameras at the branch from a central command center can easily consume 10Mbps of bandwidth for a single viewing station. Digital Media and Multimedia Conferencing also may be present at the branch and also consume bandwidth.

With these requirements, the next section provides a framework to map QoS DiffServ, the Diffserv Codepoint (DSCP) values for these application classes. For those not familiar with the term DiffServ or DSCP, these terms are for a revised definition of the IP type-of-service (ToS)-byte allocation in the IP header. In the past, 3 bits of this field was used as IP precedence, providing for distinguishing traffic into eight different categories. QoS DiffServ expands this quantification to 6 bits and adds new functionality to the ToS byte. In order to use this relative priority indicator consistently from end-to-end on the network, some consistent framework must be in place so that all routers and switches on the network derive the same meaning from the marking.

Cisco Medianet Application Classes

In Figure 8, the Cisco DiffServ QoS recommendations, based on the guideline from RFC 4594, is shown.

Figure 8 ***DiffServ QoS Recommendations (RFC 4594-Based)***

Application Class	PHB	Admission Control	Queing and Dropping	Application Examples
VoIP Telephony	EF	Required	Priority Queue (PQ)	Cisco IP Phones (G.711, G.729)
Broadcast Video	CS5	Required	Optional (PQ)	Cisco IPVS/Cisco Enterprise TV
Realtime Interactive	CS4	Required	Optional (PQ)	Cisco TelePresence
Multimedia Conferencing	AF4	Required	BW Queue + DSCP WRED	Cisco Unified Personal Communicator
Multimedia Streaming	AF3	Recommended	BW Queue + DSCP WRED	Cisco Digital Media System (VoDs)
Network Control	CS6		BW Queue	EIGRP, OSPF, BGP, HSRP, IKE
Call-Signaling	CS3		BW Queue	SCCP, SIP, H.323
Ops/Admin/Mgmt (OAM)	CS2		BW Queue	SNMP, SSH, Syslog
Transactional Data	AF2		BW Queue + DSCP WRED	Cisco WebEx/MeetingPlace/ERP Apps
Bulk Data	AF1		BW Queue + DSCP WRED	Email, FTP, Backup Apps, Content Dist
Best Effort	DF		Default Queue + RED	Default Class
Scavenger	CS1		Min BW Queue (Deferential)	YouTube, iTunes, BitTorent, Xbox Live

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The applications listed under the *Application Class and Examples* column provides a description of the applications which comprise each class. For IP Video Surveillance, the media, whether it be TCP-based as is the case with Motion JPEG camera feeds, UDP/RTP-based for MPEG-4 and H.264 or TCP-based web delivery, the recommendation is to mark this traffic as DSCP decimal value **40** or **CS5**. The control plane traffic for video surveillance, such as RTSP, is recommended to be set at **CS3** or decimal value **24**. As a best practice, IP cameras are recommended to be configured for NTP, SNMP and Syslog, and these applications are suggested to be marked DSCP with decimal value **16** or **CS2**.

There is a very limited amount of network traffic in a video surveillance deployment for control plane and network management applications compared to media streams. Because of this, some network managers may find it both practical and expedient to mark media as **CS5** and all other traffic from cameras, clients and servers as either **CS3** or **CS2**. The examples shown in this section use **CS5** and **CS3** to illustrate how to identify and select traffic through access control lists and mark accordingly. The network managers can be as specific and detailed in marking as they desire.

The following configuration sample shows class-map names and the associated match statements that can be used in router and switch configurations:

```
!
class-map match-all VOICE
  match ip dscp ef
class-map match-all TELEPRESENCE
  match ip dscp cs4
class-map match-all NETWORK-CONTROL
  match ip dscp cs6
class-map match-any CALL-SIGNALING
  match ip dscp cs3
class-map match-all OAM
```

```
  match ip dscp cs2
class-map match-any MULTIMEDIA-CONFERENCING
  match ip dscp af41 af42 af43
class-map match-any MULTIMEDIA-STREAMING
  match ip dscp af31 af32 af33
class-map match-all BROADCAST-VIDEO
  match ip dscp cs5
class-map match-any LOW-LATENCY-DATA
  match ip dscp af21 af22 af23
class-map match-any HIGH-THROUGHPUT-DATA
  match ip dscp af11 af12 af13
class-map match-all SCAVENGER
  match ip dscp cs1
!
```

Tip Entering user-supplied values in upper case (for example, **SCAVENGER** versus **scavenger**) enhances readability of the configuration file.

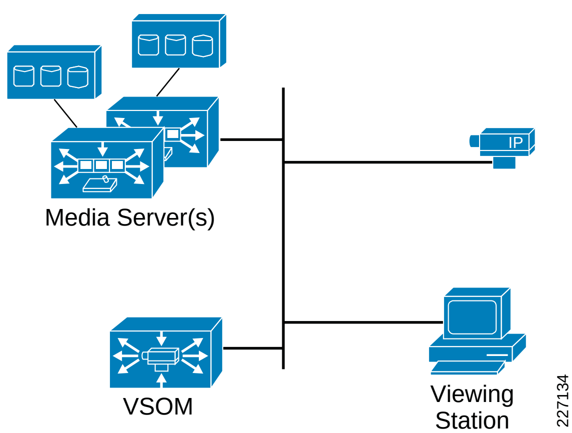
End-to-End QoS Marking

One fundamental best practice of implementing QoS on a network is to mark the ToS byte (DSCP) of the IP packets on the end nodes, or as close to the origination of the traffic as practical. In a Cisco IP Video Surveillance deployment, the primary components are as follows:

- IP Cameras—The original source of video feeds
- Viewing workstations—A destination of video feeds
- Management Software—Configure, manage, and view the video subsystem
- Storage Servers—Archives video feeds

These components are shown in Figure 9.

Figure 9 IP Video Surveillance End Nodes



In the sample deployment shown in Figure 9, there are one or more Media Servers being controlled by at least one Video Surveillance Operations Manager (VSOM) server. With a Cisco ISR router and the Video Management and Storage System (VMSS) Network Module, these two software components reside on the same logical interface. In a multiservice platform or standalone Unix implementation, they could reside on the same chassis or separate chassis. One VSOM server can control more than one Media Servers.

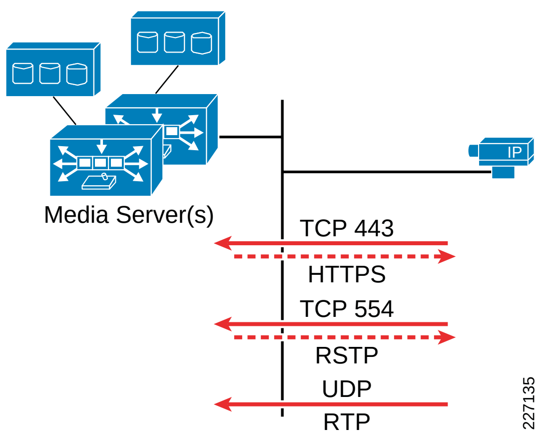
In this example, the assumption is that the IP camera is a Cisco IP camera or a camera from another vendor, which can be configured to mark the video media stream with a DSCP value. This is an example where the end-node is marking the IP packets with an appropriate DSCP value. For the viewing stations, Media Server and VSOM, it is assumed that a network device, either the first router or switch, will need to identify the traffic and mark it accordingly.

Traffic Flow Between IP Camera and Media Server

To understand how to implement QoS for IP video surveillance, we first must understand the data flows between camera, storage, and viewing station. While video from an IP camera can be viewed directly by a webserver client connecting to the camera application programming interface (API), it does not scale and introduces a security exposure and access control issues. Many IP cameras implement an access control-list feature that should be configured to deny IP access to the camera from all but authorized hosts. Typically, only the video management system servers and the address space where the configuration workstations and network management servers reside need be permitted.

Figure 10 illustrates the typical exchange between an IP camera and Media Server once the camera is installed on the network and defined through VSOM to the appropriate Media Server.

Figure 10 Traffic Flow—IP Camera and Media Server



In the implementation shown in Figure 10, the process flow is initiated by the Media Server. When a scheduled archive or live feed is needed from an IP camera, the Media Server initiates a connection to the IP camera to request the feed. Assuming the Cisco 2500 Series IP camera feed is MPEG-4, the Media Server performs the following:

- Initiates a HTTPS session with the IP camera for authentication and control plane.
- Initiates a RTSP session with the IP camera for description, initiation or termination of the media feed. Also control plane.
- The IP camera begins streaming the video feed as a UDP/RTP session on ports negotiated in the RTSP exchange. This is the media (data) plane.

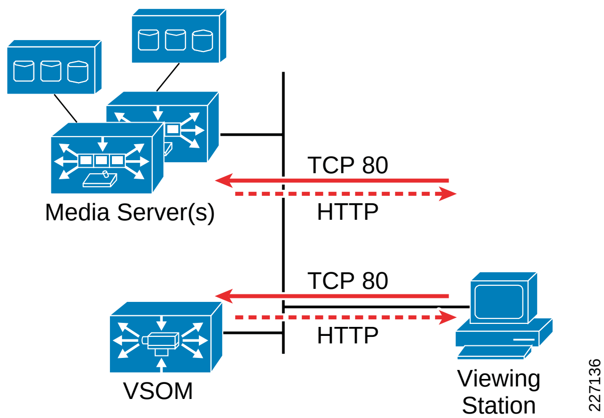
Of these exchanges, only the UDP/RTP session is marked by the Cisco 2500 Series camera with a DSCP value. The HTTPS and RTSP packets originating from the camera have a DSCP value of **0** or best effort (BE). Normally, the camera is configured for other network services such as NTP, syslog, SNMP, and this traffic is also marked BE.

However, the majority of the network traffic, certainly approaching 100 percent to and from the IP camera is the media stream. In this case, while the IP camera stack will set the DSCP value, there may still be certain types of traffic from the camera that the network manager would consider marking by the switch or router. One simple solution is to configure the switch to mark all IP packets from the camera as DSCP value **CS5**.

Traffic Flow Between Media Server and Viewing Station

The second leg of the traffic flow in the network is between the viewing station and the Media Server supporting the IP camera. Assuming that an operator has logged on the VSOM server with operator privileges, the TCP connections are initiated by the viewing station to the VSOM IP address for the control plane and the client also issues HTTP GETs to the appropriate Media Server IP address to initiate the video stream. This is shown in Figure 11.

Figure 11 Traffic Flow—Media Server and Viewing Station



Given the initial premise that the viewing station and servers are not marking IP packets with DSCP values, the later sections of this chapter will provide some examples of how an access switch can be configured to mark traffic on the port servicing these devices. In the following section, an example is provided that shows using the ISR router to mark on ingress from the logical interface when the Media Server and VSOM resides on a VMSS network module. The example shows marking flows from the Media Server (HTTP web server) port as CS5 and the remaining flows as CS3. Recall from the previous section that the Media Server originates TCP sessions for HTTPS and RTSP to an IP camera to initiate video feeds. The model assumes, therefore, that any flows that are not sources from TCP port 80 are control plane traffic to an IP camera. These flows could be specifically identified by source port if the network manager desires.

Tip If a backup Media Server is defined for a video archive, the network manager may wish to mark these flows to the IP address of the backup Media Server as AF11 for inclusion in the HIGH-THROUGHPUT-DATA class.

Enabling QoS Marking by the IP Video Surveillance Camera

The Cisco IP Video Surveillance camera firmware, and that of other manufacturers, provides a dialog within the configuration section of the camera API to set QoS parameters for traffic originating from the camera. In some implementations, it is limited to the video and audio media streams; in others, more granularity is provided to various types of traffic. In many implementations, this is in the form of a Layer-3 QoS value such as a DSCP decimal value. Figure 12 shows a screen snapshot from a Cisco 2500 Series camera where the QoS parameters are entered.

Figure 12 Advanced Setup Menu—Cisco 2500 series Video Surveillance Camera

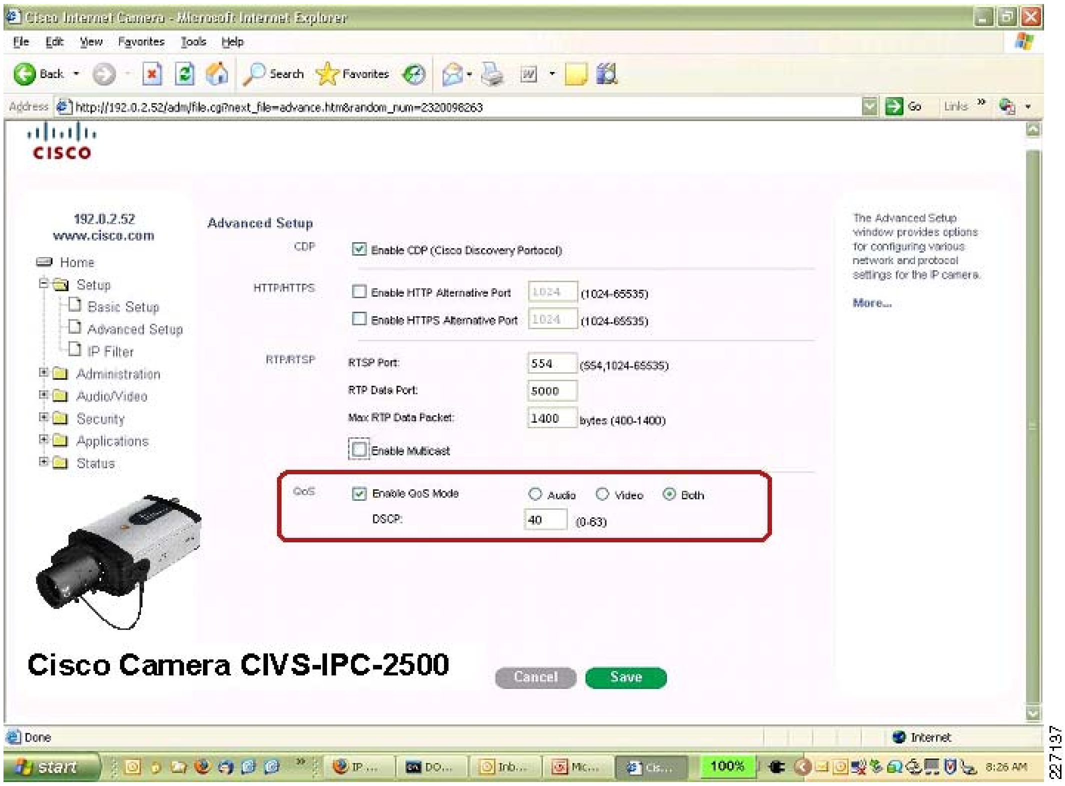


Table 8 is useful for selecting the correct decimal value to enter in the DSCP field.

Table 8 DSCP - IP Precedence - Reference Table

Code Point	IP Precedence	DSCP (binary)	DSCP (decimal)
Default	0	000000	0
CS1	1	001000	8
CS2	**2**	**010000**	**16**
CS3	**3**	**011000**	**24**
CS4	4	100000	32
CS5	**5**	**101000**	**40**
CS6	6	110000	48
CS7	7	111000	56

Note The values **CS2**, **CS3**, and **CS5** are highlighted in Table 8, because these values are recommended for network management, control and media streams from the IP cameras.

Medianet Switches

The Cisco Catalyst 2960, 2975, 3560G, 3750G, 3560-E, and 3750-E family of switches are access-layer switches that can be used for IP Video Surveillance deployments. These are considered medianet switches, meaning that they include Gigabit-Ethernet interfaces and implement in hardware a strict priority queue with at least three additional queues. The configuration examples are based on this family of switches unless otherwise noted.

Smartports Macros for IP Cameras

Smartports macros are a means of defining a collection of commands to quickly apply a common configuration for like devices. Because there may be hundreds or even thousands of IP cameras in the network, using a Smartport macro ensures that the port configuration are consistent.

The following sample Smartport macro is recommended for an IP camera. It defines the port as an access-port and the VLAN identifier is passed as a parameter to the macro. Port security may be enabled as shown, if the network manager chooses to implement this feature. Portfast is enabled to more quickly begin forwarding traffic on the port.

In this chapter the focus is on QoS, and the **mls qos trust dscp** command is included in the macro as shown:

```
macro name CIVS-IPC-2500
description Cisco Video Surveillance 2500 Series IP Camera
switchport mode access
switchport access vlan $VLAN
switchport port-security
switchport port-security mac-address sticky
switchport port-security maximum 1
switchport port-security violation shutdown
mls qos trust dscp
spanning-tree portfast
spanning-tree bpdufilter enable
load-interval 60
no shutdown
@
```

The macro is applied from interface configuration mode by specifying the name of the macro and any parameters. In this sample, the only variable substitution is the VLAN ID.

```
macro apply CIVS-IPC-2500 $VLAN 208
```

After modifying the configuration, be sure to save the running configuration using the following command:

```
write memory
```

The following output is an example of applying the macro to an interface:

```
3750-access(config)#interface gigabitEthernet 1/0/2
3750-access(config-if)#macro apply CIVS-IPC-2500 $VLAN 208
%Warning: portfast should only be enabled on ports connected to a single  host. Connecting
hubs, concentrators, switches, bridges, etc... to this  interface  when portfast is
enabled, can cause temporary bridging loops.  Use with CAUTION
%Portfast has been configured on GigabitEthernet1/0/2 but will only  have effect when the
interface is in a non-trunking mode.
3750-access(config-if)#
```

Ingress Queueing for IP Cameras

The Smartport macro previously illustrated contains the interface command **mls qos trust dscp** command, which directs the switch to honor the DSCP values set in the IP packets by the camera. IP camera is marking the media stream as DSCP value CS5. The default configuration puts CS5 traffic in the Ingress-PQ Threshold 1 (Q2T1). No additional explicit configuration commands are needed for ingress queuing.

There is no need to implement the Layer-2 CoS feature in the Cisco 4000 Series camera when the DSCP value is set by the camera and the switch trusts the DSCP value.

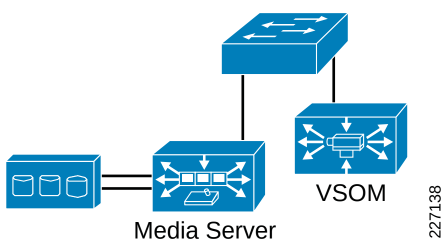
Tip CSCsz45893 Layer-2 CoS (802.1Q/p) for 4000 Series IP Camera provides additional information.

The recommendation is not to implement Layer-2 CoS for the 4000 Series IP camera.

Ingress Marking for Servers

In this section a sample access switch configuration for a port connecting to a standalone server or physical security multiservice platform is shown. The assumption is that the server is not setting the DSCP values or the values are not trusted by the network administrator.

Figure 13 Ingress Marking for Servers—Topology Diagram



The sample access switch configuration is shown below. An access-control list is configured to match on traffic originating from TCP port 80. Packets matching this access-control list are predominately live or archive video feeds from the Media Server to the client-viewing station. This is marked as DSCP value **CS5** and the remaining traffic is assumed to be primarily control plane and is marked **CS3**.

The service-policy is applied as an ingress policy.

```
hostname 3750-access
!
! System image file is "flash:c3750-advipservicesk9-mz.122-44.SE1.bin"
!
class-map match-all HTTP_acl
 match access-group name HTTP
!
policy-map VSMS
 class HTTP_acl
  set dscp cs5
 class class-default
  set dscp cs3
!
ip access-list extended HTTP
 permit tcp any eq www any
```

```
!
!
interface GigabitEthernet1/0/4
 description Physical Security Multiservices Pfm
 switchport access vlan 208
 switchport mode access
 priority-queue out
 spanning-tree portfast
 spanning-tree bpdufilter enable
 service-policy input VSMS
!
end
```

Tip The ***show policy-map interface*** command can be used to verify the service policy is matching and marking packets as intended.

The **priority-queue out** command is addressed in the "Egress Queueing for IP Cameras, Servers and Viewing Stations" section on page 6-32.

Ingress Marking for Video Management and Storage System Network Module

The Cisco Video Management and Storage System Network Module (VMSS) is a logical interface in the branch ISR router. This network module runs the Media Server and Video Surveillance Operation Manager (VSOM) software. In a deployment where this software runs on a Physical Security Multiservices Platform or stand-alone server, the QoS marking can be implemented on the LAN switch port connecting the server to the network. Because the network module implementation is a logical interface on the router, an ingress service policy is applied to the interface to mark media traffic and control plane traffic as it exists the logical interface. The relevant QoS commands are highlighted in blue in the following configuration sample.

```
!
interface Integrated-Service-Engine1/0
 ip vrf forwarding IPVS
 ip address 192.0.2.1 255.255.255.252
 ip flow ingress
 load-interval 30
 service-module external ip address 192.168.111.2 255.255.255.0
 service-module ip address 192.0.2.2 255.255.255.252
 service-module ip default-gateway 192.0.2.1
 no keepalive
 service-policy input INGRESS_VMSS
!
class-map match-any VMSS
 match access-group name HTTP
!
ip access-list extended HTTP
 permit tcp host 192.0.2.2 eq www any
!
policy-map INGRESS_VMSS
 class VMSS
  set ip dscp cs5
 class class-default
  set ip dscp cs3
!
end
```

There are two primary types of traffic leaving this logical interface and entering the IP network.

- Web traffic with a source port of 80; this is the video feeds from the Media Server to a client-viewing station.
- VSOM web traffic displaying the operator/administrator portal.

The Media Server also originates HTTP/HTTPS traffic to IP cameras for authentication and control of Motion JPEG feeds as well as RTSP command and control to IP cameras.

The basic QoS policy, therefore, is to mark TCP packets (port 80) from the logical interface with a DSCP value of **CS5** (BROADCAST-VIDEO) and mark all other traffic originated from the module **CS3** (CALL- SIGNALING).

The following **show policy-map** command was issued while a client-viewing station is watching the five video camera feeds on the ISR router.

```
vpn1-2851-1#show policy-map interface integrated-Service-Engine 1/0
 Integrated-Service-Engine1/0

  Service-policy input: INGRESS_VMSS

    Class-map: VMSS (match-any)
      760222 packets, 921342070 bytes
      30 second offered rate 7923000 bps, drop rate 0 bps
      Match: access-group name HTTP
        760222 packets, 921342070 bytes
        30 second rate 7923000 bps
      QoS Set
        dscp cs5
          Packets marked 760222

    Class-map: class-default (match-any)
      892 packets, 101243 bytes
      30 second offered rate 0 bps, drop rate 0 bps
      Match: any
      QoS Set
        dscp cs3
          Packets marked 892
vpn1-2851-1#
```

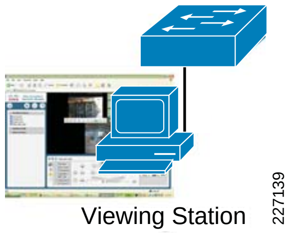
Note In this example, the video camera feed for one client-viewing station is generating approximately 8Mbps.

Ingress Marking for Viewing Stations

In the video surveillance system, there are client-viewing stations that are used to view live or archived camera feeds. The volume of packets going to the viewing station varies based on the number of cameras being displayed on the operator pane and the bit-rate and resolution of the video feeds.

The predominate type of IP packets originating from the viewing station are TCP acknowledgements, HTTP GETS and polling requests to the VSOM and Media Server web servers. This is all very low bandwidth flows from the viewing station. However, dropping of any of these packets in the network will impact the overall user experience. The viewing station is connected to an access port at the branch or campus location. See Figure 14.

Figure 14 Ingress Marking for Client Viewing Stations—Topology Diagram



This sample configuration below is very similar to that shown in "Ingress Marking for Servers" section on page 6-29. However, it specifically shows a sample of a matching on packets with a destination TCP port 80 rather than a source port 80.

```
hostname 3750-access
!
! System image file is "flash:c3750-advipservicesk9-mz.122-44.SE1.bin"
!
class-map match-all HTTP_acl_client
 match access-group name HTTP_client
!
policy-map Viewing_Station
 class HTTP_acl_client
  set dscp cs5
 class class-default
  set dscp cs3
!
ip access-list extended HTTP_client
 permit tcp any any eq www
!
!
interface GigabitEthernet1/0/5
 description Viewing Station
 switchport access vlan 208
 switchport mode access
 priority-queue out
 spanning-tree portfast
 spanning-tree bpdufilter enable
 service-policy input Viewing_Station
!
end
```

Tip The interface counters on this switch port will typically show the majority of the total bytes output to the viewing station with a relatively small number of bytes input from this viewing station. The video feeds are very unidirectional.

Egress Queueing for IP Cameras, Servers and Viewing Stations

The nature of the traffic flows between IP cameras, servers, and viewing stations are discussed in "End-to-End QoS Marking" section on page 6-24. There is minimal traffic flow from the LAN to the IP camera; as a result, there is little need to enable egress priority-queueing on a switch port connecting to a camera.

As a general best practice, it is recommended to enable egress priority-queueing on uplink ports and trunk ports between switches. The Layer-2 priority queue (1P3Q3T) is enabled with the **priority-queue out** interface command. Queue 1 is the priority queue, and it is serviced until empty before the other queues are serviced. By default, packets with a DSCP value of **CS5** (decimal **40**) are mapped to queue 1. Because the video media streams are marked DSCP **CS5**, the video traffic is serviced by the priority queue.

```
!
interface GigabitEthernet1/0/1
 description Uplink port
 switchport trunk encapsulation dot1q
 switchport mode trunk
 priority-queue out
 mls qos trust dscp
!
```

For most IPVS deployments, enabling egress priority-queueing is sufficient with all other options addressed by the default configuration values.

QoS on Routed WAN/MAN Interfaces

This section discusses QoS on MAN/WAN interfaces implementing egress shaping and queueing techniques. The branch router shown in the sample configuration has one interface configured to demonstrate Hierarchical Class-Based Weighted fair Queueing (HCBWFQ) and a second interface configuration applies a shaper for each class. These two techniques are shown because the bandwidth required to transport video from branch to campus will very likely require 50 to 100Mbps and a common deployment for these data rates is some form of Metro-Ethernet service.

The HCBWFQ configuration is characterized by shaping the Ethernet interface to an aggregate rate and then queueing the individual classes within that shaped rate. When using this shaper on the Ethernet interface, the congestion feedback mechanism is provided by the shaper function rather than the transmit (TX) ring of a serial interface. The child service policy referenced from the parent or shaper service policy could also be directly applied to a comparable speed physical interface.

The per-class shaper configuration may be used on a Metro-Ethernet service provider network where a service level agreement (SLA) is specified for each class of traffic based on some QoS marking and the data rate is capped or policed for each individual class.

Both egress QoS techniques shown optionally set the Layer-3 or Layer-2 QoS values (DSCP or CoS) accordingly.

For more detailed information on QoS for WAN/MAN handoff from a service provider, refer to the *Ethernet Access for Next Gen Metro and Wide Area Networks* at the following URL:

http:www.cisco.com/en/US/docs/solutions/Enterprise/WAN_and_MAN/Ethernet_Access_for_NG_MAN_WAN_V3.1_external.html

For additional information and detailed QoS configuration examples for the whole range of LAN switches and line cards suitable for IP Video Surveillance deployments, refer to the *Medianet Campus QoS Design 4.0* at the following URL:

http://www.cisco.com/go/designzone

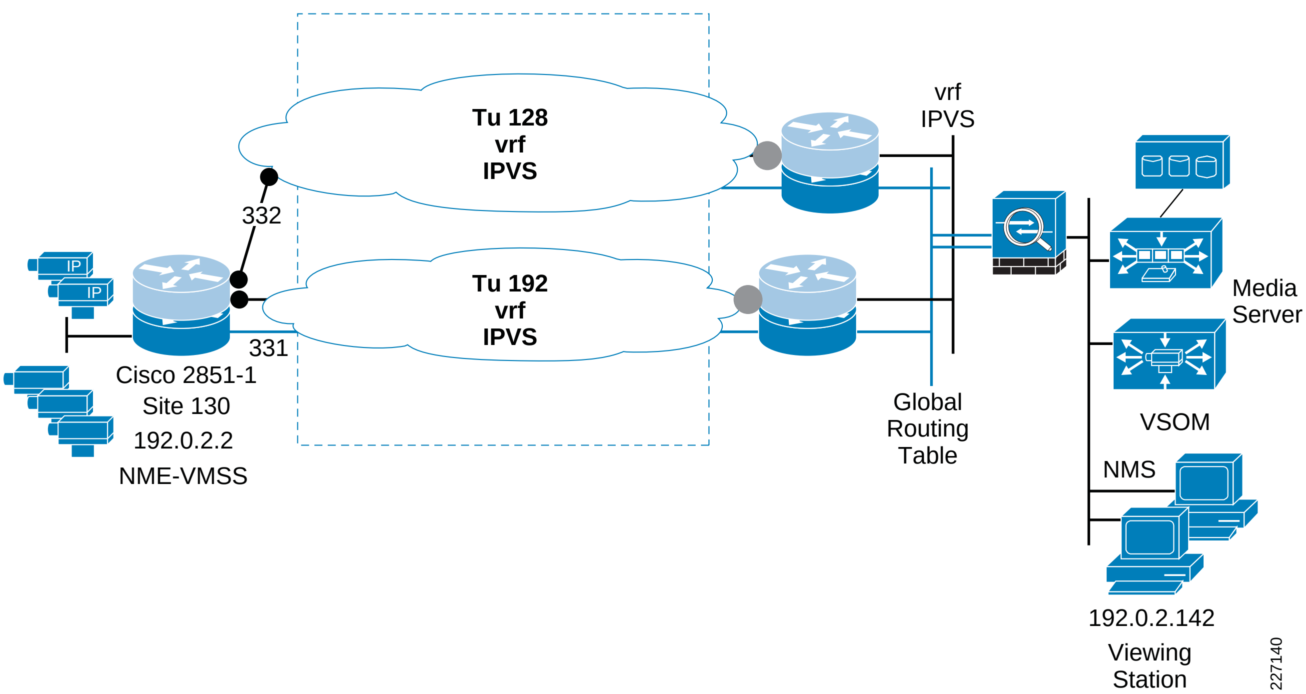
Topology

The configuration examples shown in this section are from the deployment topology from the "Virtualization, Isolation and Encryption of IP Video Surveillance" section on page 6-87. The network traffic is generated by a client-viewing station in the command center campus location. Labeled on the drawing as IP address 192.0.2.142 in Figure 15. This workstation is viewing a six-pane operator screen viewing five cameras at the branch location. Two cameras are IP cameras and three of the cameras are analog cameras attached to an Analog Video Gateway (AVG) at the branch location.

The branch router is an ISR 2851 with a NME-VMSS network module in addition to the AVG network module. The WAN interface is a Gigabit-Ethernet handoff into a service provider MAN network. There are two point-to-point virtual circuits (IEEE 802.1q) VLANs through the service provider network, one to each of the WAN aggregation routers at the central campus location.

There are two DMVPN tunnel interfaces, each sourced from one of the point-to-point links. Interface Tunnel 128 (in VRF IPVS) is transported over VLAN 332, interface tunnel 192 (in VRF IVPS) is transported over VLAN 331. The EIGRP configuration implements an *offset-list* in the EIGRP configuration. When both tunnels are up and active, the preferred path is over tunnel128. Traffic is forced over the backup path during testing by disabling ISAKMP (**no crypto isakmp enable** command) and clearing the IPSec security associations, effectively clearing and disabling the crypto tunnel from that WAN aggregation router. The topology is shown in Figure 15.

Figure 15 Topology for QoS on Routed WAN / MAN Interfaces



Ethernet Access—Per Class Shaping

Of the two WAN/MAN interfaces in this sample topology, one sub-interface is configured to transport the viewing of IP video surveillance feeds by a remote client-viewing station where the service provider offers a QoS-enabled WAN/MAN with four categories of traffic; real-time for VoIP and video, two distinct bandwidth classes and a default class. Each class is policed by the service provider to the contracted data rate within the SLA.

All classes are shaped with the exception of the real-time class. The per-class shaper for the classes GOLD, BRONZE and class-default provides a smoothing of the traffic flow into the service provider network with the goal of keeping these classes from being policed and dropped by the service provider.

The real-time class is not shaped, rather policed, but policed without a drop action. Shaping in the real-time class would introduce latency and jitter. The goal of this class is to identify if the real-time class is exceeding the configured data rate. The network manager must calculate how much bandwidth is required by the real-time class and use any techniques available to keep this class within the contracted data rate. Drops in the real-time class, either VoIP or video traffic, will degrade the quality of experience and must be avoided. In the case of VoIP, call admission control (CAC) techniques such as gatekeepers or locations in CallManager can be deployed. For the IP Video Surveillance traffic, it is more challenging as there is no global CAC technique in the application. Within VSOM, restricting what operator views are available to remote users can be used as well as defining bandwidth caps in the viewing panes. This, however, is not automatic and requires some coordination between the the network manager and the physical security manager to manage the real-time traffic in this class.

The following configuration implements per-class shaping:

```
!
interface GigabitEthernet0/1.332
 encapsulation dot1Q 332
 ip address 192.168.15.46 255.255.255.252
 service-policy output PER_CLASS_SHAPING
!
policy-map PER_CLASS_SHAPING
 class REAL_TIME
  set cos 5
    police 40000000 conform-action transmit  exceed-action transmit
 class GOLD
  shape average 2500000
  set cos 6
 class BRONZE
  shape average 2500000
  set cos 1
 class class-default
  set cos 0
  shape average 5000000
!
```

Because the DiffServ QoS recommendation is a twelve-class model and this service provider is offering four classes, the applications need be consolidated from twelve to four classes.

```
!
class-map match-any GOLD
 match ip dscp cs2  cs3  cs6  cs7
 match ip dscp af41  af42  af43
 match ip dscp af31  af32  af33
!
class-map match-any BRONZE
 match ip dscp af11  af12  af13
 match ip dscp cs1
!
class-map match-any REAL_TIME
 match ip dscp cs5
```

```
 match ip dscp cs4
 match ip dscp ef
!
end
```

The output interface (GigabitEthernet0/1.332) is in the global routing table, while the DMVPN tunnel interface sourced from the physical interface is transporting the packets.

```
vpn1-2851-1#show int tunnel 128 | include rate
  Queueing strategy: fifo
  5 minute input rate 371000 bits/sec, 679 packets/sec
  5 minute output rate 7784000 bits/sec, 815 packets/sec
```

The **show policy-map** command can be used to verify that packets are matching the appropriate class and also to report on the data rate of the applications in each class.

```
vpn1-2851-1#show policy-map interface gigabitEthernet 0/1.332
 GigabitEthernet0/1.332

  Service-policy output: PER_CLASS_SHAPING

    Class-map: REAL_TIME (match-any)
      638277 packets, 817396506 bytes
      30 second offered rate 8335000 bps, drop rate 0 bps
      Match: ip dscp cs5 (40)
        638277 packets, 817396506 bytes
        30 second rate 8335000 bps
      Match: ip dscp cs4 (32)
        0 packets, 0 bytes
        30 second rate 0 bps
      Match: ip dscp ef (46)
        0 packets, 0 bytes
        30 second rate 0 bps
      QoS Set
        cos 5
          Packets marked 638277
      police:
          cir 40000000 bps, bc 1250000 bytes
        conformed 638277 packets, 817396506 bytes; actions:
          transmit
        exceeded 0 packets, 0 bytes; actions:
          transmit
        conformed 8335000 bps, exceed 0 bps

    Class-map: GOLD (match-any)
      338 packets, 36594 bytes
      30 second offered rate 0 bps, drop rate 0 bps
      Match: ip dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
        338 packets, 36594 bytes
        30 second rate 0 bps
      Match: ip dscp af41 (34) af42 (36) af43 (38)
        0 packets, 0 bytes
        30 second rate 0 bps
      Match: ip dscp af31 (26) af32 (28) af33 (30)
        0 packets, 0 bytes
        30 second rate 0 bps
      Traffic Shaping
           Target/Average   Byte   Sustain   Excess    Interval  Increment
             Rate           Limit  bits/int  bits/int  (ms)      (bytes)
          2500000/2500000   15000  60000     60000     24        7500

        Adapt  Queue     Packets   Bytes     Packets   Bytes     Shaping
        Active Depth                         Delayed   Delayed   Active
        -      0         338       36612     0         0         no
```

```
        QoS Set
          cos 6
            Packets marked 338

      Class-map: BRONZE (match-any)
        0 packets, 0 bytes
        30 second offered rate 0 bps, drop rate 0 bps
        Match: ip dscp af11 (10) af12 (12) af13 (14)
          0 packets, 0 bytes
          30 second rate 0 bps
        Match: ip dscp cs1 (8)
          0 packets, 0 bytes
          30 second rate 0 bps
        Traffic Shaping
             Target/Average   Byte   Sustain   Excess    Interval  Increment
               Rate           Limit  bits/int  bits/int  (ms)      (bytes)
            2500000/2500000   15000  60000     60000     24        7500

          Adapt  Queue     Packets   Bytes     Packets   Bytes     Shaping
          Active Depth                         Delayed   Delayed   Active
          -      0         0         0         0         0         no
        QoS Set
          cos 1
            Packets marked 0

      Class-map: class-default (match-any)
        0 packets, 0 bytes
        30 second offered rate 0 bps, drop rate 0 bps
        Match: any
        QoS Set
          cos 0
            Packets marked 0
        Traffic Shaping
             Target/Average   Byte   Sustain   Excess    Interval  Increment
               Rate           Limit  bits/int  bits/int  (ms)      (bytes)
            5000000/5000000   31250  125000    125000    25        15625

          Adapt  Queue     Packets   Bytes     Packets   Bytes     Shaping
          Active Depth                         Delayed   Delayed   Active
          -      0         0         0         0         0         no
vpn1-2851-1#
```

Hierarchical Class-Based Weighted Fair Queueing

The second interface demonstrates applying a service policy on the Gigabit interface shaping the output traffic in aggregate to 50Mbps. Within that data rate, a child service policy (IPVS_BRANCH) is referenced to provide queueing within that shaped rate.

```
!
interface GigabitEthernet0/1.331
 encapsulation dot1Q 331
 ip address 192.168.15.22 255.255.255.252
 service-policy output UPLINK_50M
!
policy-map IPVS_BRANCH
 class BROADCAST-VIDEO
  bandwidth percent 40
 class VOICE
  priority percent 10
 class LOW-LATENCY-DATA
  bandwidth percent 4
 class HIGH-THROUGHPUT-DATA
```

```
  bandwidth percent 4
 class MULTIMEDIA-CONFERENCING
  bandwidth percent 4
 class SCAVENGER
  bandwidth percent 1
 class OAM
  bandwidth percent 1
 class NETWORK-CONTROL
  bandwidth percent 1
 class CALL-SIGNALING
  bandwidth percent 1
 class class-default
  fair-queue
policy-map UPLINK_50M
 class class-default
  shape average 50000000
  service-policy IPVS_BRANCH
```

Because the service provider is offering a SLA for the aggregate bandwidth of 50Mbps, the service policy can be more granular at the interface level than was the case in the per-class shaper example shown previously. In this example, the branch router is referencing nine of the twelve application classes in the DiffServ QoS Recommendations.

```
!
class-map match-any LOW-LATENCY-DATA
 match ip dscp af21  af22  af23
class-map match-any HIGH-THROUGHPUT-DATA
 match ip dscp af11  af12  af13
class-map match-all BROADCAST-VIDEO
 match ip dscp cs5
class-map match-all NETWORK-CONTROL
 match ip dscp cs6
class-map match-any MULTIMEDIA-CONFERENCING
 match ip dscp af41  af42  af43
class-map match-all OAM
 match ip dscp cs2
class-map match-all VOICE
 match ip dscp ef
class-map match-all SCAVENGER
 match ip dscp cs1
class-map match-any CALL-SIGNALING
 match ip dscp cs3
!
end
```

The **show policy-map** command can be used to verify packets are matching the correct class and provide insight into the data rate of application in each class.

```
vpn1-2851-1#show policy-map  interface gigabitEthernet 0/1.331
 GigabitEthernet0/1.331

  Service-policy output: UPLINK_50M

    Class-map: class-default (match-any)
      621338 packets, 792463266 bytes
      30 second offered rate 8339000 bps, drop rate 0 bps
      Match: any
      Traffic Shaping
           Target/Average   Byte   Sustain   Excess    Interval  Increment
             Rate           Limit  bits/int  bits/int  (ms)      (bytes)
         50000000/50000000  312500 1250000   1250000   25        156250
```

```
  Adapt  Queue      Packets    Bytes      Packets    Bytes      Shaping
  Active Depth                            Delayed    Delayed    Active
  -      0          621338     792463284  0          0          no

Service-policy : IPVS_BRANCH

  Class-map: BROADCAST-VIDEO (match-all)
    620942 packets, 792420308 bytes
    30 second offered rate 8339000 bps, drop rate 0 bps
    Match: ip dscp cs5 (40)
    Queueing
      Output Queue: Conversation 265
      Bandwidth 40 (%)
      Bandwidth 20000 (kbps)Max Threshold 64 (packets)
      (pkts matched/bytes matched) 0/0
  (depth/total drops/no-buffer drops) 0/0/0

  Class-map: VOICE (match-all)
    0 packets, 0 bytes
    30 second offered rate 0 bps, drop rate 0 bps
    Match: ip dscp ef (46)
    Queueing
      Strict Priority
      Output Queue: Conversation 264
      Bandwidth 10 (%)
      Bandwidth 5000 (kbps) Burst 125000 (Bytes)
      (pkts matched/bytes matched) 0/0
      (total drops/bytes drops) 0/0

  Class-map: LOW-LATENCY-DATA (match-any)
    0 packets, 0 bytes
    30 second offered rate 0 bps, drop rate 0 bps
    Match: ip dscp af21 (18) af22 (20) af23 (22)
      0 packets, 0 bytes
      30 second rate 0 bps
    Queueing
      Output Queue: Conversation 267
      Bandwidth 4 (%)
      Bandwidth 2000 (kbps)Max Threshold 64 (packets)
      (pkts matched/bytes matched) 0/0
  (depth/total drops/no-buffer drops) 0/0/0

  Class-map: HIGH-THROUGHPUT-DATA (match-any)
    0 packets, 0 bytes
    30 second offered rate 0 bps, drop rate 0 bps
    Match: ip dscp af11 (10) af12 (12) af13 (14)
      0 packets, 0 bytes
      30 second rate 0 bps
    Queueing
      Output Queue: Conversation 268
      Bandwidth 4 (%)
      Bandwidth 2000 (kbps)Max Threshold 64 (packets)
      (pkts matched/bytes matched) 0/0
  (depth/total drops/no-buffer drops) 0/0/0

  Class-map: MULTIMEDIA-CONFERENCING (match-any)
    0 packets, 0 bytes
    30 second offered rate 0 bps, drop rate 0 bps
    Match: ip dscp af41 (34) af42 (36) af43 (38)
      0 packets, 0 bytes
      30 second rate 0 bps
    Queueing
      Output Queue: Conversation 269
      Bandwidth 4 (%)
```

```
          Bandwidth 2000 (kbps)Max Threshold 64 (packets)
          (pkts matched/bytes matched) 0/0
      (depth/total drops/no-buffer drops) 0/0/0

      Class-map: SCAVENGER (match-all)
        0 packets, 0 bytes
        30 second offered rate 0 bps, drop rate 0 bps
        Match: ip dscp cs1 (8)
        Queueing
          Output Queue: Conversation 270
          Bandwidth 1 (%)
          Bandwidth 500 (kbps)Max Threshold 64 (packets)
          (pkts matched/bytes matched) 0/0
      (depth/total drops/no-buffer drops) 0/0/0

      Class-map: OAM (match-all)
        0 packets, 0 bytes
        30 second offered rate 0 bps, drop rate 0 bps
        Match: ip dscp cs2 (16)
        Queueing
          Output Queue: Conversation 266
          Bandwidth 1 (%)
          Bandwidth 500 (kbps)Max Threshold 64 (packets)
          (pkts matched/bytes matched) 0/0
      (depth/total drops/no-buffer drops) 0/0/0

      Class-map: NETWORK-CONTROL (match-all)
        396 packets, 42958 bytes
        30 second offered rate 0 bps, drop rate 0 bps
        Match: ip dscp cs6 (48)
        Queueing
          Output Queue: Conversation 271
          Bandwidth 1 (%)
          Bandwidth 500 (kbps)Max Threshold 64 (packets)
          (pkts matched/bytes matched) 0/0
      (depth/total drops/no-buffer drops) 0/0/0

      Class-map: CALL-SIGNALING (match-any)
        0 packets, 0 bytes
        30 second offered rate 0 bps, drop rate 0 bps
        Match: ip dscp cs3 (24)
          0 packets, 0 bytes
          30 second rate 0 bps
        Queueing
          Output Queue: Conversation 272
          Bandwidth 1 (%)
          Bandwidth 500 (kbps)Max Threshold 64 (packets)
          (pkts matched/bytes matched) 0/0
      (depth/total drops/no-buffer drops) 0/0/0

      Class-map: class-default (match-any)
        0 packets, 0 bytes
        30 second offered rate 0 bps, drop rate 0 bps
        Match: any
        Queueing
          Flow Based Fair Queueing
          Maximum Number of Hashed Queues 256
      (total queued/total drops/no-buffer drops) 0/0/0
vpn1-2851-1#
```

Caveats for Catalyst 4500 and 6500 Series

The Catalyst 4500 switch family only supports egress queuing models. On the classic supervisor, it can be configured as a 1P3Q1T mode, which is recommended for voice and video applications. On the supervisor 6-E it can be configured for a 1 priority queue add up to 7 bandwidth queues (1P7Q1T.)

The Catalyst 6500 Series switches support both ingress and egress queueing based on the supervisor model and policy feature card option installed. Additionally, there are line cards that support 10/100/1000 Ethernet and provide ingress queueing supporting a strict priority hardware queue with at least three additional hardware queues. For details, refer to the *Medianet Campus QoS Design 4.0* at the following URL:

http://www.cisco.com/go/designzone

Summary

All forms of video traffic on the enterprise network greatly increases the bandwidth requirements for both LAN and WAN. The existing QoS policies must include new application classes to support the various types of video traffic. For IP video surveillance, the recommended marking for the media streams is the DSCP value of **CS5**. This can be set by end nodes, such as IP cameras, or by a switch or router. While the majority of video traffic introduced by video surveillance are the media streams, the control plane and network management traffic should also be marked appropriately as well.

Local Storage for Video Archives Using iSCSI

The objections of this section is to understand the storage requirements for IP Video Surveillance at a branch location. Then, to support the iSCSI server, a branch topology is shown to provide network access to the iSCSI server for configuration and management as well as for the transport of the TCP session between the VMSS network module and the iSCSI server.

An example of how to configure the iSCSI server and format the volume for use and then select the volume for storing archives from the Video Surveillance Management Console (VMSC). There is also sample configurations and **show** commands relevant to the iSCSI file system.

Disk Space Requirements

There are many iSCSI servers in the market which provide data protection by using various RAID levels for data protection. RAID 5 is commonly used due to its low cost of redundancy. For example, a system advertised at 1 Terabyte has four individual disks, each with a raw capacity of 232 Gigabytes per disk, for a total capacity of (232 * 4) 928 Gigabytes of storage. With RAID mode 5, the usable capacity is 676 Gigabytes of usable space. With RADI mode 1 only half the total capacity is available for use. It is important to consider the usable capacity of the iSCSI server, as well as the initial cost of the chassis, the number of disk drives included in the entry level system, as well as the number of empty expansion bays available. Before selecting a system, make sure the usable capacity will meet the storage requirements of the site.

Typically the most cost effective solution on a per-Gigabyte basis is a fully populated chassis. This spreads the cost of the chassis over the maximum number of disks. On the market today, iSCSI storage can be obtained for for less than $2.00 per GB using SATA drives. Systems are available that range in scale from 2 to 96 Terabytes (TBs) of storage. Entry level systems that may support 1, 2, or 4 TB of raw storage may range in price less than $5000 USD, but for systems that support up to 96 TB of storage, the initial, minimal chassis investment may be $8,000 USD or more.

To provide some guidance on the amount of disk space required for a typical branch video surveillance deployment, Table 1 shows the amount of space required for a one-hour archive. Various media types, resolution, frame rate/target bit rates are shown for the Cisco 2500 Series IP camera as well as other cameras.

Table 1 Disk Space Required for One Hour Archive

	Media Type	Resolution	Rate (Frames or Bits Per Second	Reserved Mbytes	Actual Mbytes
Cisco CIVS-IPC-2500	MPEG-4	720 x 480 (D1)	512	241	243
Cisco CIVS-IPC-2500	MPEG-4	720 x 480 (D1)	768	347	357
Cisco CIVS-IPC-2500	MPEG-4	720 x 480 (D1)	1024	475	480
AutoDome - Analog GW	MPEG-4	704 x 480 (4CIF)	1024	477	462
Cisco CIVS-IPC-2500	MPEG-4	720 x 480 (D1)	2000	953	943
Cisco CIVS-IPC-2500	MPEG-4	720 x 480 (D1)	4000	1,860	1,800
Axis 223M	MJPEG	1600 x 1200	5	1,840	1,850
Axis 223M	MPEG-4	640 x 480 (VGA)	2000	931	68
Axis 207	MPEG-4	640 x 480 (VGA)	1024	477	405
Axis 207MW	MJPEG	1280 x 720	10	812	5,000

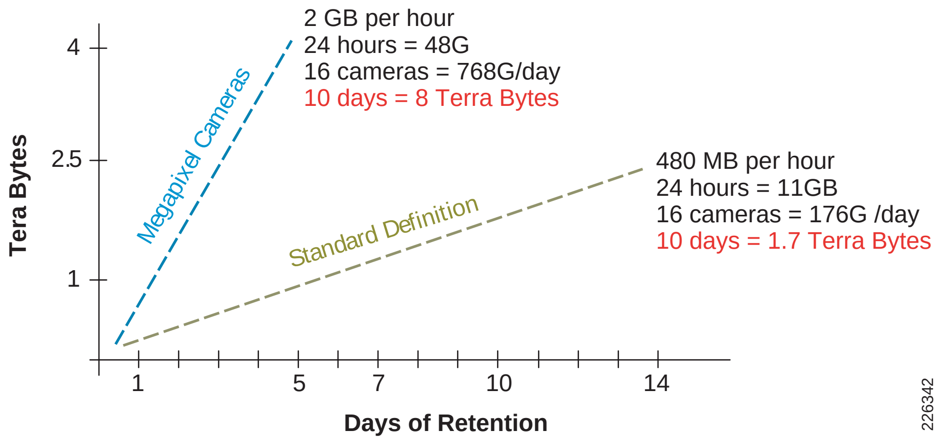
Now that a baseline is provided for an archive of one-hour duration, the next section shows an estimate of the total amount of storage required for multiple cameras based on a typical retention period.

Archive Retention and Storage Requirements

Given the enterprise may deploy standard definition cameras today and consider a megapixel (high) definition cameras in the future, or have a mixture of both, we look at both in this analysis. The Axis 223M is a megapixel camera with a resolution of 1600 x 1200 pixels. At 5 frames per-second, this camera requires almost 2GB per-hour of archived recording. The Cisco 2500 Series standard definition camera at 720x480 (D1) resolution with a target bit-rate of 1024Kbps requires 480MB of disk space per-hour of archive retained.

Assuming the enterprise has a retention period of 10 days per camera, a 16 camera deployment archiving 24 hours per day requires between 2 and 8TB of storage capacity. The megapixel camera has almost four times the storage requirements as the standard definition camera. This is illustrated in Figure 16.

Figure 16 Branch Office Video Surveillance Storage Requirements



Retention periods vary from organization to organization and some cameras may have a longer retention period than others. There may be multiple archives created from a single camera, with the longer retention period having a lower frame rate while a higher frame rate may have a retention of only a few days. Some archives are initiated only on triggered events. Additionally, the amount of storage for stored clips (local BWM/X clip repository) and backup (backup repository) must also be considered. Capacity for future camera installations as well as replacement of standard definition with high definition in the future must also be considered.

VMSS Network Module

This section provides a brief overview of the available hardware configurations of the VMSS network module. There are three models of VMSS network modules. Their characteristics are shown in Table 9.

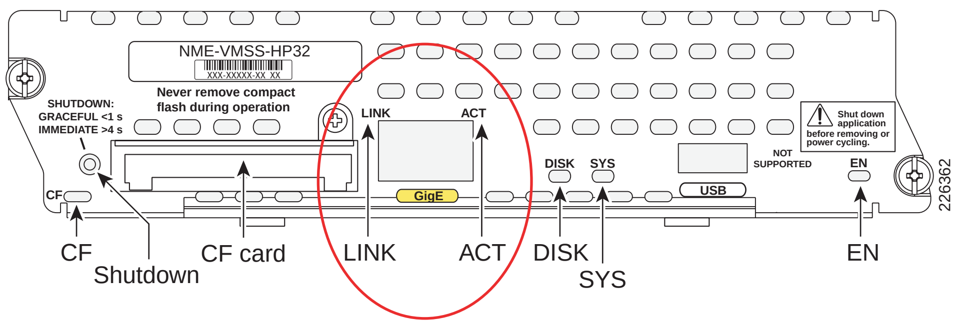
Table 9 VMSS Models

Model	Processor	Hard Disk	Memory
NME-VMSS-16	1.0 GHz	120 GB (SATA)	512 MB
NME-VMSS-HP16	1.4 GHz	160 GB (SATA)	2 GB
NME-VMSS-HP32	1.4 GHz	160 GB (SATA)	2 GB
NME-VMSS2-16	1.4 GHz	500 GB	2 GB
NME-VMSS2-HP32	1.4 GHz	500 GB	2 GB

Not all the listed hard disk space is available for archives, because the operating system files are contained on the disk as well. To meet the video archive storage requirements of the branch location that requires more storage is available on the network modules, attaching an Internet SCSI (iSCSI) appliance to the VMSS network module external interface is the preferred solution.

The VMSS faceplate has an external Gigabit Ethernet port for physically connecting to a switch to communicate with the iSCSI server. The location of the port is shown in Figure 17.

Figure 17 VMSS Faceplate Showing External GigabitEthernet

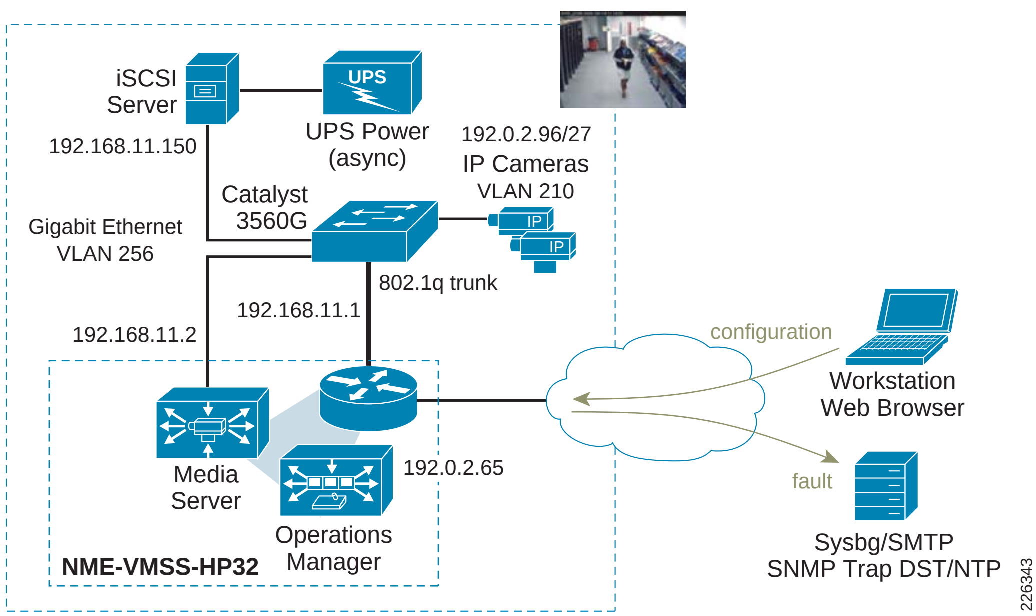


In testing three separate Buffalo TeraStation Pro II iSCSI Rackmount units are deployed on Cisco ISR 2851, 3825, and 3845 routers using the NME-VMSS-16, NME-VMSS-16HP and NME-VMSS-32 network modules. This brand of iSCSI server is used because of low initial cost, features, and availability. It is not a product recommendation. This server is available in 1,2, and 4TB configurations. In most customer deployments, servers with substantially higher storage capacity may be required.

Deployment Topology

A typical branch router deployment topology using iSCSI for local storage is shown in Figure 18.

Figure 18 Branch Router Deployment Topology using iSCSI



The LAN switch in this deployment is a Cisco Catalyst 3560G-48TS. This switch supports 48 Ethernet 10/100/1000 ports and 4 SFP-based Gigabit Ethernet ports in a 1RU form factor. The Cisco ISR router GigabitEthernet 0/1 interface is an 802.1q trunked interface. There is an isolated VLAN, 256, for the iSCSI network. The GigabitEthernet port on the face place of the VMSS network module is connected to a non-trunked switch port in VLAN 256. The Buffalo TeraStation Pro II iSCSI Rackmount TS-RI1.0TGL/R5 server is also attached to a non-trunked port on VLAN 256.

This iSCSI server has a facility for SMTP email alerts, NTP, syslog, and has an imbedded web server for configuration and management. To use these management functions and to access the server from the central campus location, the default gateway of the server is configured with the IP address of the branch router Gigabit Ethernet interface, 192.168.11.1. This network is advertised by the dynamic routing protocol (EIGRP) configured on the branch router.

The IP addressing of the router, external interface of the VMSS module and the iSCSI server are shown in Table 10.

Table 10 Devices and their IP Addresses

Device	IP Address
Branch router GigE VLAN 256	192.168.11.1
VMSS External Interface	192.168.11.2
iSCSI Server	192.168.11.150
VMSS-HP32 (VSOM/Media Server)	192.0.2.65

There are two interfaces connected to subnet 192.168.11.0/25 from the branch router; one through the GigabitEthernet interface on the ISR router chassis, the second through the external interface of the VMSS network module.

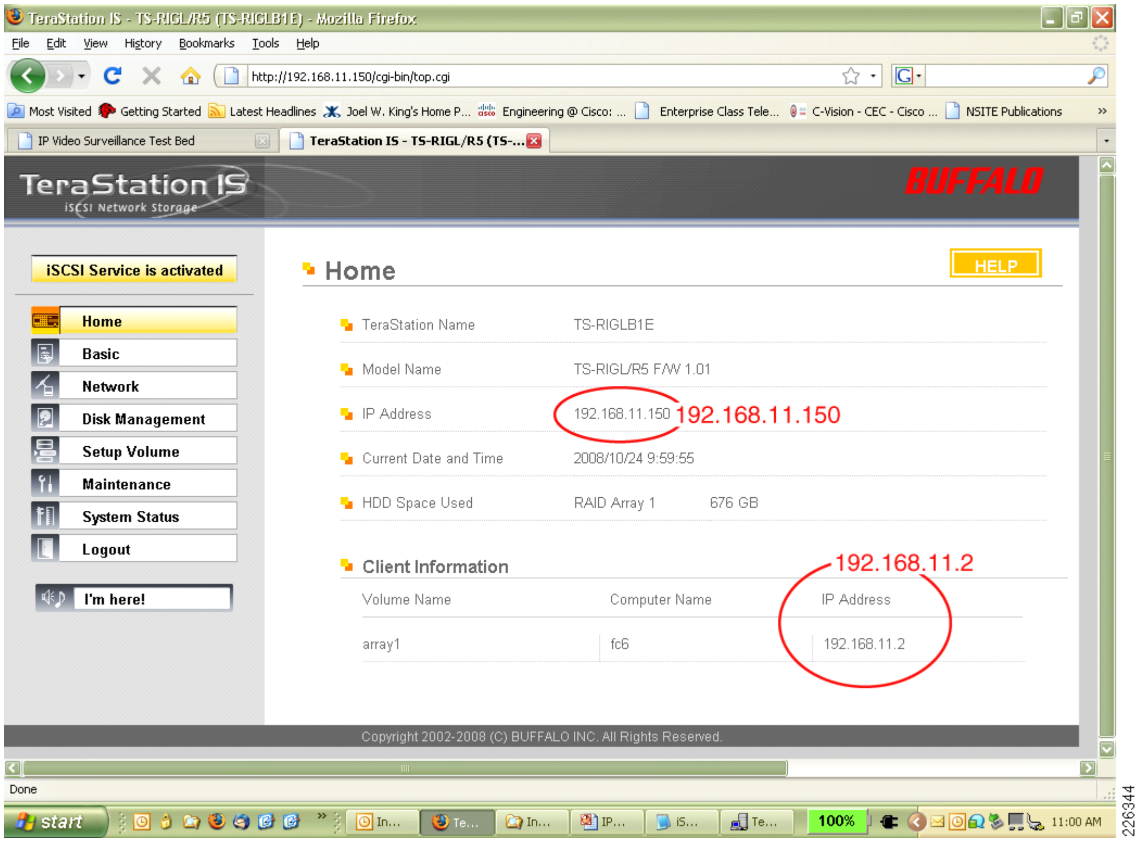
Installation and Configuration of iSCSI Server

This iSCSI server implementation uses DCHP to obtain an initial IP address, or if no DHCP server is accessible on the network, defaults to a documented static IP address. The recommended implementation approach is to configure a DHCP pool on the branch router, connect the iSCSI server to the network and and power up. After waiting a few minutes for the server to boot and obtain an IP address from this pool, use the **show ip dhcp binding** command to determine the IP address allocated to the server. Use a workstation and web browser to connect to the IP address of the server. The server used in testing also displays the IP address on the LCD status panel on the front of the unit.

From the web browser, change the default password, configure the NTP parameters, SNMP server, syslog server address, and any other parameters that may be relevant. Finally, change the IP address of the server to a static IP address and update this information in the corporate DNS services. Because the VMSS network module must be configured with a target IP address or hostname in the configuration, a static IP address is needed.

The following sample iSCSI configuration screen is shown in Figure 19.

Figure 19 Sample iSCSI configuration screen



The screen shot in Figure 19 shows the VMSS network module's external address listed as a client connection at IP address 192.168.11.2. The IP address of the server is 192.168.11.150. The default gateway is the ISR router at address 192.168.11.1. Default network access through the router allows the iSCSI server to communicate with the corporate network devices through the ISR router while maintaining a direct, LAN-based connection to the iSCSI client, the VMSS network module.

Sample Branch Router iSCSI Configuration

The following configuration is the relevant portion of the branch router interfaces related to the iSCSI server deployment.

```
!
hostname vpn1-3845-1
!
interface GigabitEthernet0/1
 description Trunk
 no ip address
 duplex auto
 speed auto
 media-type rj45
!
interface GigabitEthernet0/1.150
 description Outside (WAN) Interface
 encapsulation dot1Q 150
 ip address dhcp
!
```

```
interface GigabitEthernet0/1.250
 description INSIDE VLAN
 encapsulation dot1Q 250
 ip address 10.81.7.1 255.255.255.248
!
interface GigabitEthernet0/1.256
 description iSCSI VLAN
 encapsulation dot1Q 256
```

This is the default gateway IP address for the iSCSI server.

```
 ip address 192.168.11.1 255.255.255.0

!
interface Integrated-Service-Engine3/0
 description NME-VMSS-HP32
 ip address 192.0.2.64 255.255.255.254
 ip flow ingress
```

The VMSS operating system learns the external IP address from this configuration statement

```
 service-module external ip address 192.168.11.2 255.255.255.0
 service-module ip address 192.0.2.65 255.255.255.254
 service-module ip default-gateway 192.0.2.64
 no keepalive
!
router eigrp 64
 network 10.0.0.0
 network 192.0.2.64 0.0.0.63
```

A network statement for the iSCSI subnet is included to advertise this network to the intranet.

```
 network 192.168.11.0
 no auto-summary
 eigrp stub connected
!
end
```

Tip Following the configuration of the external IP address, the network module must be reloaded for the VMSS operating system to learn the configured address; for example, **service-module in2/0 reload**.

Verify IP Addressing on the VMSS Network Module

After completing the configuration of the external IP address and the module reload, use the **service-module** <*interface*> **session** command to access the console of the network module and verify the IP addresses are configured. Issue the **show interfaces** command as shown below.

```
VMSS-SITE140# show interfaces
GigabitEthernet 0 is up, line protocol is up
  Internet address is 192.0.2.65 mask 255.255.255.254 (configured on router)
     9101 packets input, 961197 bytes
     0 input errors, 0 dropped, 0 overrun, 0 frame errors
     9560 packets output, 2449037 bytes
     0 output errors, 0 dropped, 0 overrun, 0 collision errors
     0 output carrier detect errors

GigabitEthernet 1 is up, line protocol is up
  Internet address is 192.168.11.2 mask 255.255.255.0 (configured on router)
     382068 packets input, 31118652 bytes
     0 input errors, 0 dropped, 0 overrun, 0 frame errors
     8074102 packets output, 3415145010 bytes
     0 output errors, 0 dropped, 0 overrun, 0 collision errors
```

```
     0 output carrier detect errors

IDE hd0 is up, line protocol is up
     18699 reads, 2678064128 bytes
     0 read errors
     115791 write, 817836032 bytes
     0 write errors
```

If the GigabitEthernet 0 and 1 interfaces are not configured with an IP address from the router, verify the ISR router interface configuration and reload.

Formatting iSCSI Storage

The iSCSI storage must be formatted by the VMSS network module prior to use. While remaining on the console of the network module, enter configuration mode (**configure terminal**) and define the iSCSI tag (media 1 to 9) and target IP address of the iSCSI appliance. The IP address must be a static IP address defined in the corporate DNS, not the DHCP supplied IP address used in the initial configuration. The iSCSI server used in testing had an option to disable and enable the iSCSI service. Verify that the service is enabled, otherwise these steps will fail. The following examples assume the iSCSI tag is **media1**.

Configure the target IP address of ISCSI server as follows:

```
VMSS-SITE140(config)# storages iscsi media1
VMSS-SITE140(config-iscsi)# target-ip 192.168.11.150
VMSS-SITE140(config-iscsi)#exit
```

Verify/attach External Gig E port of the network module to the LAN switch as follows:

```
VMSS-SITE140(config)# storages iscsi media1
Modifying existing iscsi
VMSS-SITE140(config-iscsi)# state enable
iSCSI volume not formatted or unsupported file system:
VMSS-SITE140(config-iscsi)#exit
```

Format the storage as follows:

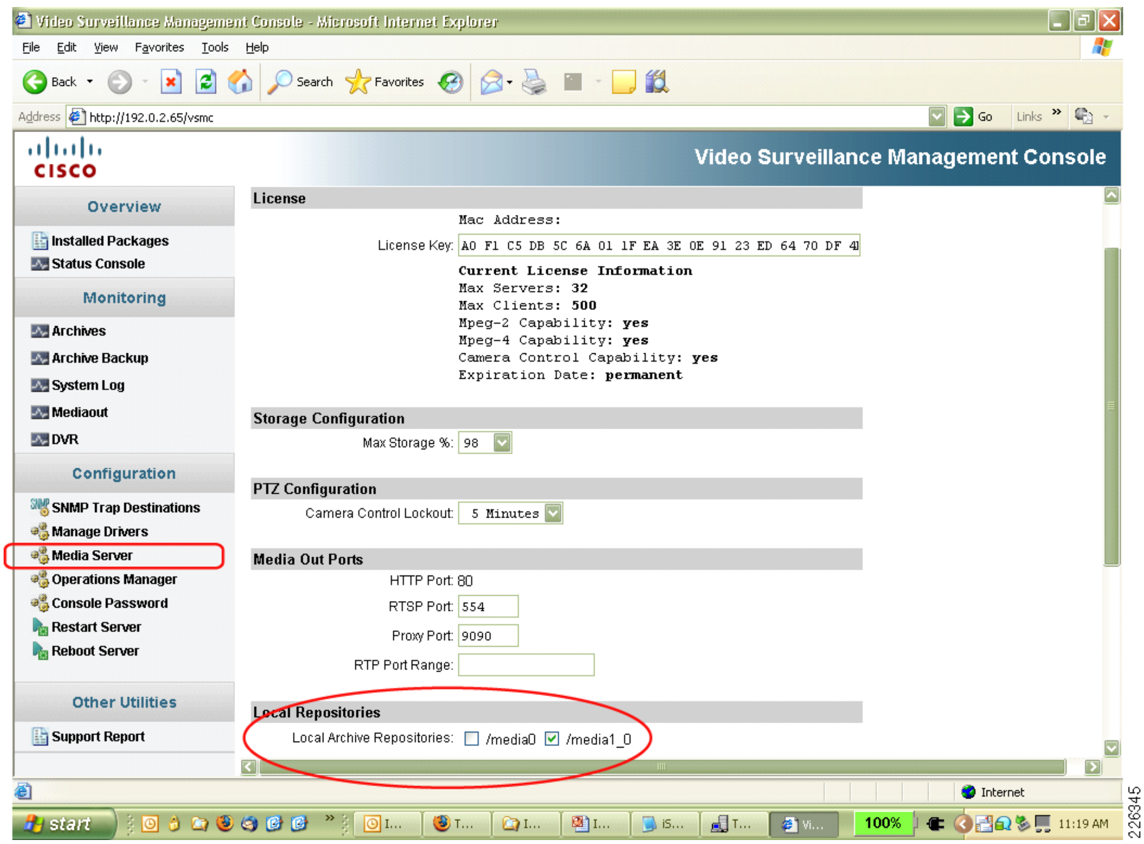
```
VMSS-SITE140# format storages iscsi media1
The storage device you are about to format has the following parameters:

Target name: iqn.2004-08.jp.buffalo:TS-RIGLB1E-001D73262B1E:array1 LUN: 0

[output deleted for brevity]

Writing inode tables: done
Creating journal (8192 blocks): done
Writing superblocks and filesystem accounting information: done

This filesystem will be automatically checked every 21 mounts or
180 days, whichever comes first.  Use tune2fs -c or -i to override.
    Done.
To use the storage, please issue "state disable" then "state enable"
 on media1

VMSS-SITE140(config)# storages iscsi media1
Modifying existing iscsi
VMSS-SITE140(config-iscsi)# state disable
VMSS-SITE140(config-iscsi)# state enable
Media successfully enabled!
```

At this point the volume is formatted and available for use.

Select iSCSI Volume for Use

Now that the volume is mounted and ready, connect to the Video Surveillance Management Console (http://192.0.2.65/vsmc) and select Media Server and at Local Repositories, deselect the on-board disk at **/media0** and select iSCSI disk **/media1_0** as shown in Figure 20.

Figure 20 Video Surveillance Management Console



Clipping and backup can also be directed to the iSCSI device.

VMSS Network Module Configuration

After formatting is complete, the configuration of the VMSS network module appears as follows.

The **target-ip** line with the volume name and the iSCSI Qualified Name (IQN) is entered automatically, only the **target-ip** address need be manually configured.

```
storages iSCSI media1
 target-ip 192.168.11.150
  target-ip 192.168.11.150 volumeName iqn.2004-08.jp.buffalo:TS-RIGLB1E-001D7326
2B1E:array1 LUN 0
```

```
 end storages-iscsi
end
```

To verify the detailed status of the volume, the **show storages iscsi** command can be entered.

```
VMSS-SITE140# show storages iscsi status  detail
       Fou Log                                                          Portal
  Tag  nd  in   Device    Mounts    LUN  FS Types      iSCSI Portal      Reachab
le IO Target Name
====== === === ======== =========== ===  ======== ===================== =======
== == ==============
media1 yes yes /dev/sdb /media1_0     0   ext3      192.168.11.150:3260,1    Yes
   rw iqn.2004-08.jp.buffalo:TS-RIGLB1E-001D73262B1E:array1
```

Tip The status of 'rw'read-write should be verified. If the status is 'ro', read-only, the volume cannot be written to and archives will fail.

Summary

In practically all branch office video surveillance deployments, an external iSCSI device is needed to provide sufficient disk space for storage of local video archives. The branch topology must be configured to provide network connectivity for fault and configuration management of the iSCSI server. The enterprise network management system must monitor the iSCSI server, router and VMSS network modules to insure the operational health of the surveillance system at the branch location.

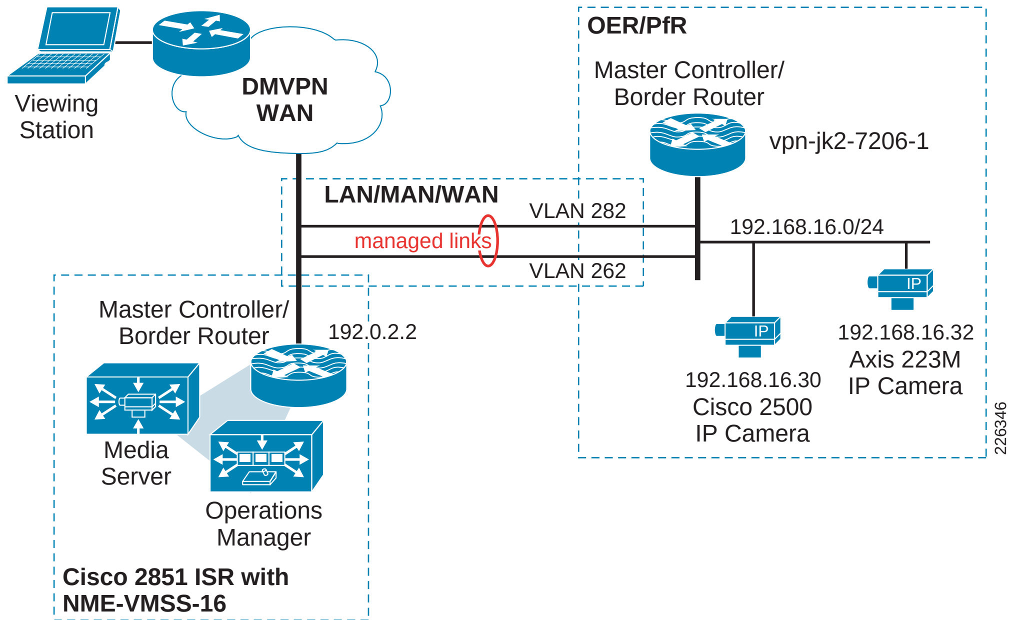
Performance Routing (PfR) Integration

This section shows that the video traffic flows from a video surveillance camera to the Media Server and then live or archived feed can be viewed through the Video Surveillance Operations Manager (VSOM) using a client viewing station. Viewing stations are workstations running Microsoft Internet Explorer (IE). Examples showing the impact of loss, latency, and jitter on the video feed are presented. Given an understanding of the requirements of the video surveillance traffic, a demonstration of how Performance Routing (PfR) is implemented on multiple WAN links to enhance the video quality. PfR intelligently selects the best WAN link, or a link that meets the configured criteria, from the available paths. Because video surveillance images often have a forensic use for identifying or criminally prosecuting subjects, optimal video quality is imperative for IP Video Surveillance deployments.

Topology

To illustrate how latency, loss, and jitter effect video feeds, we have set up a topology where the originating video feeds are not directly attached to the LAN of the Media Server recording the video. This allows test tools to introduce impairments in the network. The IP cameras are attached to a VLAN on a separate router from the branch location where the Video Management and Storage System (VMSS) network module resides. A WAN is simulated by injecting latency, loss, and jitter by a test appliance connected to two VLANs separating these locations. The branch router is a Cisco 2851 ISR with a NME-VMSS-16 network module. This topology is shown in Figure 21.

Figure 21 Performance Routing Test Topology



The PfR Master Controller and Border Router function are configured on the Cisco 2851 (IOS Release 12.4(15)T5) as well as the Cisco 7200 Series router at the campus location. The Cisco IP camera is Firmware Version is 1.1.1.

Video (MPEG-4) Characteristics

Before configuring PfR to select the best link, or a link that meets the minimum service level, we must first examine how the video in this example is encoded and transported between the camera and the Media Server. Most IP Video Surveillance cameras support Motion JPEG and MPEG-4. MPEG-4 usually refers to MPEG-4 part 2 encoding. Some cameras also support H.264, which is the nomenclature for MPEG-4 Part 10 or the Advanced Video Coding (AVC). The biggest difference between MPEG-4 part 2 and MPEG-4 Part 10 is the efficiency of the video compression.

MPEG-4 encoding is object-oriented compression, meaning it detects "objects" in the frame and sends out information when there is a change. A complete frame is sent to resynchronize periodically. This is called a key frame (slice) referred to as an I-frame. Predicted frames (P or B) build upon a reference slice. Usually, the key frame requires more than one IP packet for transport. In testing up to 30 IP packets have been observed to transport a single I-frame. Predicted frames may fit in a single IP packet but usually require more than one. MPEG-4 is typically encapsulated in UDP/RTP and is connectionless. The RTP header includes a packet sequence number so that the receiver can identify if packets are lost, but due to the connectionless nature of UDP, there is no retransmission of lost packets. When viewing the video feed with 1 percent or more loss, most people find the image noticeably degraded for standard definition images.

The Cisco 2500 Series IP camera uses UDP/RTP transport for video feeds to the Media Server. For IP cameras which MJPEG is supported, as is the case with the Axis 223M, the video feed between camera and Media Server is TCP-based. When viewing a live or archived video feed from a viewing station logged on VSOM, both MPEG-4 and MJPEG images are encapsulated in TCP/HTTP.

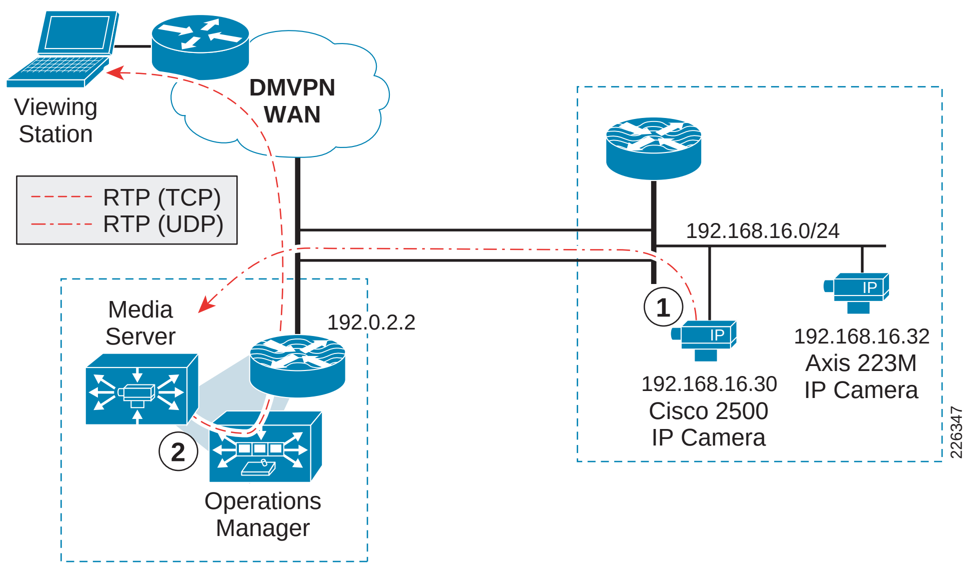
In this section PfR is used to optimize the UDP/RTP packets between camera and media server. In a later section, Wide Area Application Services (WAAS) is incorporated into the topology and both PfR and WAAS is used to optimize video feeds transported in TCP.

Media Server as a De-Jitter Buffer

In a Video Surveillance Manager (VSM) implementation, video from a surveillance camera is not viewed directly by a viewing station off the IP camera. Rather, the viewing station, a PC, connects to the web server of the Video Surveillance Operations Manager (VSOM). VSOM communicates with the Media Server and displays a video feed from the selected camera. If there is no active feed from the camera, the Media Server contacts the camera and initiates a live feed. The viewing station can display both live and archived feeds from one or more cameras defined to the Media Server.

Because camera feeds are not viewed directly from the camera, the Media Server acts as a de-jitter buffer for MPEG4-based video. This process is shown in Figure 22.

Figure 22 Video Path from Camera to Viewing Station



In general, packet loss presents more of an impairment to video quality than latency and jitter in this RTP/UDP deployment topology.

In VoIP deployments, latency impacts usability. As latency increases, the likelihood that two people would talk at the same time increases. This is referred to as the Walkie-talkie effect. Latency does not impact audio fidelity, it impacts usability. In VoIP, excessive jitter may be addressed by the de-jitter buffer in the IP telephone, but in some instances packets with excessive jitter are dropped if they arrive too late and must be dropped. Single packet loss for VoIP may not be noticed by the listener if packet loss concealment is implemented.

Video requirements differ from VoIP deployments in that surveillance applications have no two-way, real-time exchange of data. If the surveillance camera is a fixed camera, no Pan-Tilt-Zoom functions, the only two-way communication is the authentication step and RTSP step to initiate a camera feed. While latency in the network will slow down these packet flows, once the camera is initiating the RTP stream, no two-way communication is necessary. This packet flow between Media Server and IP Camera is described in more detail in the next section.

Loss for MPEG-4, however, cannot be recovered. There is no retransmission of lost packets. If the packet loss occurs in a 'key slice', and this slice required 30 IP packets for transmission, this single packet loss causes the 'key slice' to be incomplete. Packet loss degrades the MPEG-4 video quality.

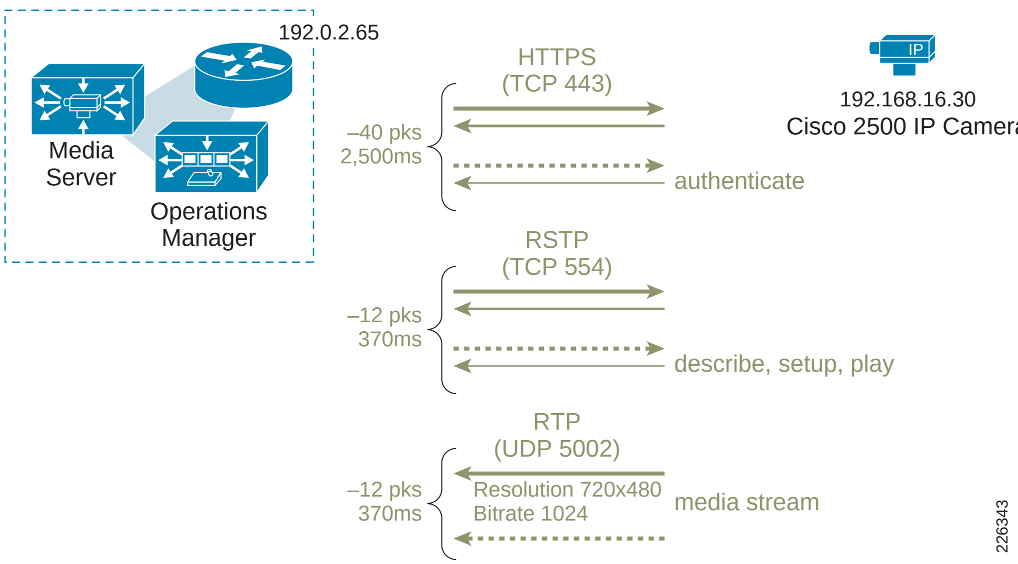
The network characteristics to provide good video quality is different and, in some cases, more stringent than for VoIP. In general, VoIP is more tolerant to packet loss than video, while video is more forgiving to latency and jitter than VoIP.

Packet Flow Between Camera and Media Server

To better the network requirements for IP Video Surveillance, it is helpful to understand the process flow between a Cisco 2500 Series IP camera configured for MPEG-4 and the Media Server. In the authentication phase, the Media Server contacts the Cisco IP Camera with Hypertext Transfer Protocol over Secure Socket Layer (HTTPS - TCP port 443). This process takes approximately 2.5 seconds with 40 IP packets between the camera and Media Server. Next, the Media Server contacts the camera over the Real Time Streaming Protocol (RTSP - TCP port 554) to issue instructions to describe, setup, and play the video media stream. This requires approximately 12 packets over the period of 370ms. The IP camera then, begins to unicast the media stream (video feed) as Real-Time Transport Protocol (RTP - UDP port varies) packets. The RTP data is to be carried on an even UDP port number and the corresponding Real-time Transport Control Protocol (RTCP) packets are to be carried on the next higher (odd) port number. RTCP is not implemented on the Cisco IP Camera at this time.

The video feed continues until the Media Server instructs the camera to stop the media stream again through RTSP commands. This exchange is shown in Figure 23.

Figure 23 Packet Flow Between Camera and Media Server



In this test, the camera has a resolution of 720x480 (D1) with a target bit-rate of 1024Kbps. The resulting RTP stream is observed at approximately 115 packets per second with an average of 1,054 bytes per packet.

Warning **The Cisco IP camera can be configured to set the DSCP value of the RTP stream. However, the HTTPS or RTSP stream is not configurable and, unless set by a router or switch, is DSCP best effort.**

Reference Tests—Illustrate Loss versus Latency

Before configuring PfR to demonstrate how this feature can select and use one WAN link over another, we must first understand what impairment has the biggest impact on video quality. Once the application requirements are understood, PfR can be configured to manage the WAN links to optimize the application performance.

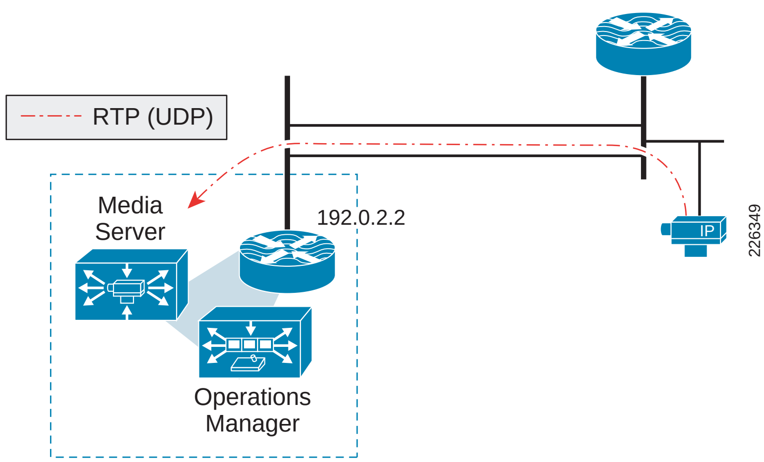
In the previous section, it was asserted that the quality of the video feed is degraded by packet loss more than latency. To illustrate this point, three tests were run and the video images are subjectively analyzed.

The Cisco IP Video Surveillance camera used in testing was configured with the following parameters:

```
Camera Name: CIVS-IPC-2500 ESELAB
Description: 001DE5EA7999
Camera Type: Cisco 2500 IP Camera
Server: VSMS_Site130
Host IP/Name: 192.168.16.30
Resolution: 720 x 480
Format: NTSC
Media Type: MPEG-4
UDP: On (UDP)
Bitrate: 1024
Quality: 50
```

Between the camera and Media Server there are two WAN links. Before PfR is enabled on the routers, the link that is used by the camera feed is subject to latency (jitter is influenced by the randomness of latency applied) and loss. The topology of the test is shown in Figure 24.

Figure 24 Reference Tests - Loss versus Latency



For each test, an archive is scheduled and retained for later viewing, with the WAN network simulator configured for the following criteria.

Typical Latency—Low Loss

- Drop on-in 1,000 (1/10th 1%)
- Delay 30 to 40ms

High Latency—No Loss

- Drop off (no configured packet loss)
- Delay 120 to 150ms

LAN Latency—High Loss

- Delay off (typical minimal LAN switching delay)
- Drop one-in 100 (1%)

The results of the three tests are described in the following sections.

Typical Latency—Low Loss

In this first test, latency was measured by an IP SLA probe traversing the same WAN link as the camera feed. The probe reported an average latency of approximately 35 milliseconds with jitter at 3ms. The MOS score is 4.06. Latency was applied in both directions, with a result of a round trip time (RTT) of approximately 71ms on average. Latency values in this range are not uncommon, for example, between two locations in North America serviced by Internet T1 links.

A snapshot from the video archive is shown in Figure 25.

Figure 25 Snapshot of Typical Latency—Low Loss Archive

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The motion in the view of the camera is generally smooth. The subject is dropping packing peanuts in a lab environment with racks of network equipment, allowing the fan exhaust to blow the peanuts across the floor. Several peanuts are on the floor and to the left of the right knee of the subject, you can see several peanuts falling.

There are some artifacts with quick motion, but they are not excessive. This is used as a baseline to determine the difference in quality for the remaining tests.

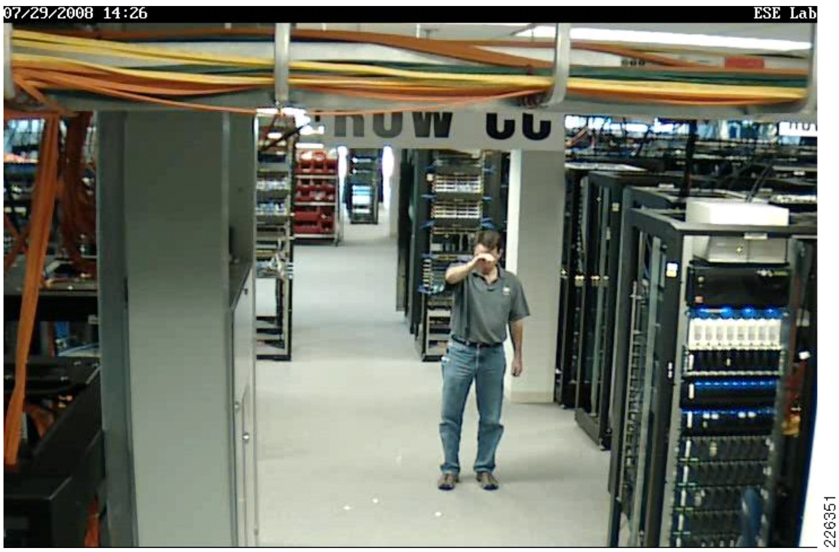
A copy of this archive can be viewed at http://tools.cisco.com/cmn/jsp/index.jsp?id=84464

High Latency—No Loss

In this test, latency and jitter were increased. The IP SLA measured latency averaged 274ms RTT with one-way latency in the 135ms to 139ms range. Jitter averaged between 9 to 10ms with a maximum value of 25ms. The MOS score reported as 3.88. This latency is typical of links with high serialization delay such as dialup Internet connections, or with high propagation delay such as intercontinental Frame-Relay communications.

A snapshot from the archive is shown in Figure 26.

Figure 26 Snapshot of High Latency - No Loss Archive



The image quality is very similar to the baseline test. Motion is smooth. There is the same degree of video artifacts as the baseline test; artifacts are apparent when quick motion changes a large number of pixels. However, latency in the 150ms range (one-way) does not produce substantially different video quality than the baseline test.

A copy of this archive can be viewed at http://tools.cisco.com/cmn/jsp/index.jsp?id=84463

LAN Latency—High Loss

In this test, the artificially introduced delay was eliminated, but packet loss is 1 dropped packet in 100 packets, or 1 percent. The average RTT is only 2ms, or LAN like latency performance, but because of the packet loss, the IP SLA MOS score is 3.76. The network characteristics are the opposite of the previous test, but the packet loss introduced its own set of challenges for video. A snapshot from the archive is shown in Figure 27 with a white circle indicating the area of particular interest.

Figure 27 Snapshot of LAN Latency - High Loss Archive

MPEG-4 has a high inter-frame dependency and artifacts become pronounced around 1 percent packet loss. In this archive, the artifacts are more pronounced than both the baseline and the previous test. They linger substantially longer. In many cases, the disruption of video quality is to such a degree that the subject is not identifiable.

The white circle overlay on the snapshot calls out an area of the image from which the subject has recently moved. His movement is from the right to left in the frame. What occurred in the video image is commonly called microblocking, tiling , mosaicking, or pixelating. These are terms used to describe a condition when the contents of a macroblock is missing or in error. Macroblocks are noticeable in an image as square-areas in the picture do not have complete information. The macroblock could be seen as a single color or a low-resolution block with noticeable edges.

Tip A macroblock represents a block of 16 by 16 pixels. The contents of the macroblock contains both luminance (brightness) and chroma (color) definitions.

From this example, it is apparent that packet loss greatly impacts the video quality of this surveillance image. To address this, PfR is configured to select the path with packet loss as the primary differentiator between multiple links.

A copy of this video archive can be viewed at http://tools.cisco.com/cmn/jsp/index.jsp?id=84462

Implement Performance Routing to Address Packet Loss

There are two existing design guides that provide information on implementing performance routing in an enterprise network. These documents are available at the following URLs:

- *Transport Diversity: Performance Routing (PfR) Design Guide*

  http://www.cisco.com/en/US/docs/solutions/Enterprise/WAN_and_MAN/Transport_diversity/Transport_Diversity_PfR.html

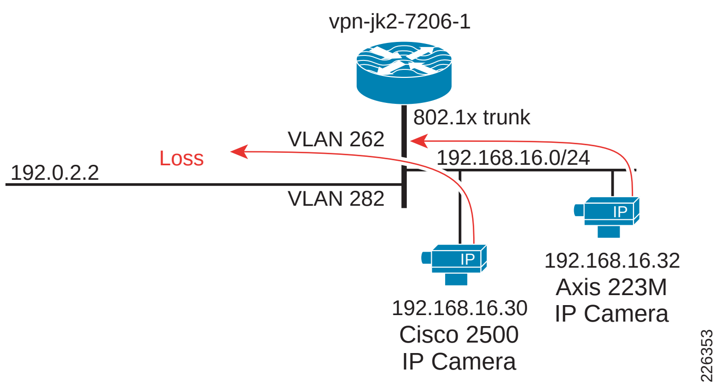
- *Performance Routing (PfR) Master Controller Redundancy Configuration*

  http://www.cisco.com/en/US/docs/solutions/Enterprise/WAN_and_MAN/Transport_diversity/PfR_Master_Controller_Redundancy.html

Topology

In the test topology, two links exist between the cameras and Media Server. These are FastEthernet links with a delay and loss generation tool configured to introduce 5 percent packet loss on the VLAN 262 (upper) link with a RTT of approximately 71ms. The second link, the lower link shown, has no loss but has the same 71ms round-trip delay. The MOS score of the link with the packet loss was 2.95 while the other link was 4.06. The topology is shown in Figure 28.

Figure 28 PfR Test Topology



Without PfR enabled, both links are in the IP routing table and Cisco Express Forwarding (CEF) load shares over the two links, based on source and destination IP address. In this example, both IP cameras are routed over the link with loss. This can be seen with the **show ip cef exact-route** command.

```
vpn-jk2-7206-1#show ip cef exact-route 192.168.16.30 192.0.2.2
192.168.16.30   -> 192.0.2.2       : FastEthernet0/1.262 (next hop 192.168.12.2)
vpn-jk2-7206-1#show ip cef exact-route 192.168.16.32 192.0.2.2
192.168.16.32   -> 192.0.2.2       : FastEthernet0/1.262 (next hop 192.168.12.2)
```

CEF does not take into consideration link characteristics. It uses a hash to determine which link is used for any one source and destination IP address pair. Based on the IP address of the source addresses, both cameras happen to use the same link. CEF can provide a degree of load sharing as the number of source/destination pairs increase, because statistically traffic will routed across both links. CEF can provide a degree of load sharing, but not load balancing. It has no mechanism to select an alternate path if the WAN performance is degraded due to latency or packet loss. At this point in the test, the OER master controller was administratively shutdown.

PfR Configuration

In this configuration, both master controller and the border router exist on the same router: the Cisco 7200 Series at the campus location. A similar configuration is implemented on the branch router. PfR has a requirement for at leas two external links (exit points) and one internal interface. These are shown configured under the border router section of the configuration.

Also a requirement of PfR, two equal cost routes, or parent routes, are included in the routing table. They are in the routing table from the two static routes defined in the configuration. In this example, they are default routes (0.0.0.0 / 0.0.0.0), but any equal cost route to the destination subnet is sufficient.

The destination network is explicitly identified by a prefix-list definition, as referenced in the oer-map named **LOSS**, which is invoked by the **policy-rules** command under the master controller definition. Learn mode is configured, but these statements apply to traffic observed in the NetFlow cache, traffic that is also on the network but not explicitly identified by the **oer-map** command.

The relevant configuration on the Cisco 7200 series router for PfR is shown below:

```
!
hostname vpn-jk2-7206-1
!
key chain PURPLE
 key 10
   key-string 7 xxxxxx
!
oer master
 policy-rules LOSS
 logging
 !
 border 192.168.16.1 key-chain PURPLE
  interface FastEthernet0/1.282 external
  interface FastEthernet0/1.262 external
  interface FastEthernet0/1.216 internal
 !
 learn
  throughput
  delay
  periodic-interval 0
  monitor-period 1
  expire after time 30
  aggregation-type prefix-length 27
 no max range receive
 mode route control
 mode select-exit best
!
!
oer border
 local FastEthernet0/1.216
 master 192.168.16.1 key-chain PURPLE
!
!
ip route 0.0.0.0 0.0.0.0 192.168.13.2 name OER_Parent
ip route 0.0.0.0 0.0.0.0 192.168.12.2 name OER_Parent
!
ip prefix-list SITE_130 seq 5 permit 192.0.2.0/27
!
oer-map LOSS 10
 match traffic-class prefix-list SITE_130
 set mode select-exit best
 set mode route control
 set mode monitor fast
 set resolve loss priority 1 variance 10
 set loss relative 100
 set active-probe jitter 192.0.2.1 target-port 32000 codec g729a
 set probe frequency 10
!
end
```

The **oer-map** command specifies that the 'best' exit is used, and the **monitor mode fast** command is configured to provide for continuous probing of all exits at 10 seconds frequency. An explicitly configured active jitter probe is enabled using the G729a codec. The IP address target of the probe is the branch router VMSS network module logical interface IP address. On the branch router, the **ip sla responder** command must be configured so that the probes are replied to by the branch router.

Enabling PfR

In this test, the video feeds are active and being archived. PfR is enabled by entering configuration mode on the Cisco 7206 router at the campus location and initiating operation by issuing the **no shutdown** command to the master controller. This function is shown as follows:

```
vpn-jk2-7206-1(config-oer-mc)#no shut
vpn-jk2-7206-1(config-oer-mc)#
Aug 12 11:04:48.110 edt: %OER_MC-5-NOTICE: System enabled
Aug 12 11:04:51.870 edt: %OER_MC-5-NOTICE: BR 192.168.16.1 UP
...
Aug 12 11:04:52.062 edt: %OER_MC-5-NOTICE: Uncontrol Prefix 192.0.2.0/27, Traffi
c Class in Fast Mode
Aug 12 11:05:18.306 edt: %OER_MC-5-NOTICE: Route changed Prefix 192.0.2.0/27, BR
 192.168.16.1, i/f Fa0/1.282, Reason None, OOP Reason Timer Expired
```

From the timestamps in the syslog messages, the elapsed time from the startup of operations to a point where PfR is managing the explicitly configured prefix is approximately 30 seconds. The exit chosen is the path with the least amount of packet loss. To view the current state of the network prefix, issue the **show oer master prefix** command. Sample output is shown below:

```
vpn-jk2-7206-1#show oer master prefix
OER Prefix Statistics:
 Pas - Passive, Act - Active, S - Short term, L - Long term, Dly - Delay (ms),
 P - Percentage below threshold, Jit - Jitter (ms),
 MOS - Mean Opinion Score
 Los - Packet Loss (packets-per-million), Un - Unreachable (flows-per-million),
 E - Egress, I - Ingress, Bw - Bandwidth (kbps), N - Not applicable
 U - unknown, * - uncontrolled, + - control more specific, @ - active probe all
 # - Prefix monitor mode is Special, & - Blackholed Prefix
 % - Force Next-Hop, ^ - Prefix is denied

Prefix                  State     Time Curr BR         CurrI/F         Protocol
                      PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos
                      ActSDly  ActLDly   ActSUn   ActLUn      EBw      IBw
                      ActSJit  ActPMOS  ActSLos  ActLLos
--------------------------------------------------------------------------------
192.0.2.0/27            HOLDDOWN     @106 192.168.16.1    Fa0/1.282       STATIC

                             U        U        0        0        0        0
                            72       72        0        0      723        1
                             3        0        0        0
```

In the output above, there are several items of interest. First, the prefix is in HOLDDOWN state. This is because the route for the prefix has recently changed. A prefix is placed in HOLDDOWN state to avoid link flapping and resulting destabilization of the network-wide routing tables. The exit bandwidth (EBw) and the input bandwidth (IBw) are shown. There is a great disparity between the two, although not unexpected. The traffic flow is from cameras to Media Server and very little traffic is destined for these cameras in this topology. Only control plane traffic would be sent to the cameras. The current exit interface (Fa0/1.282) is shown and this can also be verified by viewing the routing table. The short-term active delay and jitter is 72ms and 3ms, respectively.

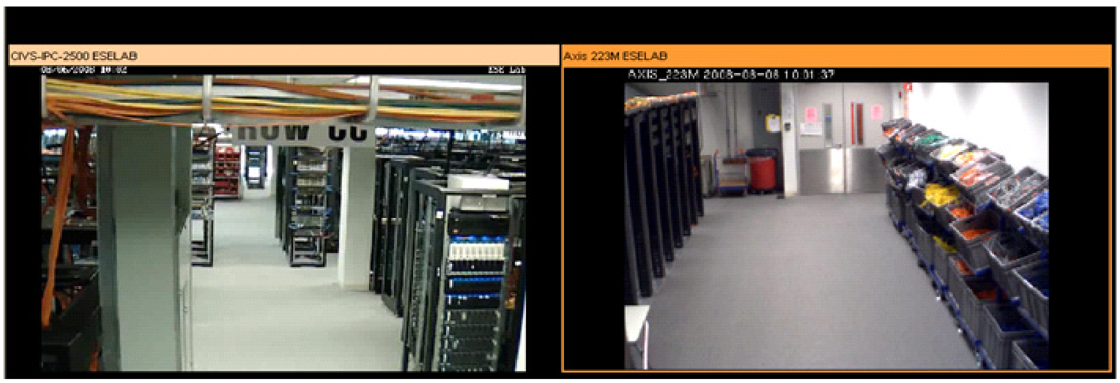
Tip The **show oer master prefix 192.0.2.0/27 detail** command can be used to provide more verbose information on this prefix.

Effect on Video Quality

Previously, it was discussed how 1-percent packet loss can lead to noticeable degradation of the video image. In the test topology, the link that is the path of the video feeds when CEF is loadsharing over the two WAN link, has 5 percent loss. In the video archive, with this amount of loss, the faces of the people in the image are not recognizable, motion is very choppy, and artifacts clutter the video image and linger for long periods of time. The video does not clear up until a clean key slice is received to refresh the image. This amount of packet loss dramatically degrades the video quality.

When PfR is enabled and begins sending the video traffic over the link with no loss, immediately the video quality improves to what is normal for the camera. The snapshot in Figure 29 is the video images from both cameras after PfR has routed the traffic over the best link.

Figure 29 Video Images with Performance Routing Active



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In a production network with two links between camera and Media Server, 5 percent packet loss is obviously an excessive amount of loss that should be identified by the enterprise network management system (NMS) function. The link with this excessive amount of loss must be taken out-of-service and corrected before being brought back online; however, PfR can circumvent the problem and take almost immediate action to preserve the quality of the video. PfR therefore is an important tool to address problems that may be a temporary disruption or need a short-term solution until a log-term fix can be implemented.

Summary

Packet loss dramatically degrades video quality. Constant or sustained packet loss at levels of 1 percent or more will decrease the usefulness of video images. Because of the forensic nature of IPVS, minimizing packet loss is critical to this video application. Loss can be attributed to hardware or soft failures that may not be identified by Layer-2 keepalives, static routes, or a Layer-3 Routing Protocol. When multiple links exist between the source of the video image and the storage system, PfR is an effective tool to select the best among several links between the video endpoints.

Wide Area Application Services (WAAS) Integration

Because of the benefits customers have realized by implementing the Cisco Wide Area Application Services (WAAS) between branch offices and central locations, the question of how WAAS might also provide bandwidth savings and TCP optimization for IP Video Surveillance traffic is frequently asked. The objective of this section is to understand the impact of WAAS on IP Video Surveillance traffic. Two types of video transport are discussed in this section:

- Camera Feeds to Media Server (TCP transport of Motion JPG)
- Video Surveillance Operations Manager (VSOM) to client viewing station (HTTP)

In the "Wide Area Application Services (WAAS) for iSCSI" section on page 6-74, a discussion on WAN transport of iSCSI video archives is also addressed.

The topology for these scenarios is a branch router, a Cisco ISR 3845, with a VMSS network module (NME-VMSS-HP-32), and a WAAS network module (NME-WAE-522-K9). The campus location hosts a core Cisco Wide Area Application Engines (WAEs) and WAAS Central Manager. This topology builds upon the PfR integration topology where multiple WAN links exist between branch and campus location. The WAAS optimization of IPVS traffic across multiple WAN links managed by PfR was verified in this test phase. Included in this section are various Cisco IOS show commands and reports and exported data from the WAAS Central Manager, as well as verification from NetFlow exports from the routers in the tested topology.

Feature Overview

WAAS implements both data compression and optimization of the TCP session across the WAN between the branch (or edge) WAE and the core WAE. Two compression techniques are implemented: Persistent Lempel-Ziv (LZ) compression and Data Redundancy Elimination (DRE). LZ compression can achieve compression ratios in the order of 2:1, 5:1 or 100:1 if the data contains common strings or phrases. This form of compression is helpful for data that has not been previously seen or suppressed by DRE. DRE operates by maintaining a database of data that has been seen previously traversing the network. One advantage of DRE is that it is application-independent, meaning the redundant data may be part of a HTTP session or iSCSI archive and if commonalities exist, DRE can eliminate the redundant traffic. DRE can eliminate up to 99 percent of redundant network traffic and provide up to 100:1 compression.

However, both Motion JPEG and MPEG4 / H.264 camera feeds are compressed by the encoding function of the IP camera. Given this fact, the prospects of dramatic compression ratios by either LZ or DRE compression is unlikely. The data in this section supports that assumption.

WAAS uses the transport flow optimization (TFO) features to optimize TCP traffic. The specific techniques are as follows:

- Windows scaling (RFC 1323)
- TCP Initial Window Size Maximization RFC 3390
- Increased Buffering
- Selective Acknowledgement (SACK) (RFC 2018)

Note that a WAN transport with sufficient bandwidth to transport the video surveillance feeds are likely based on some form of Metro Ethernet service or DS3. DS3 bandwidth is capable of speeds up to 45 Mbps and Metro Ethernet may range in one to 10Mbps increments, using a 10/100/1000 Mbps interface handoff. Metro Ethernet services are usually policed by class or in aggregate by the service provider according to the contracted service. In the lab testing environment, between 10 to 20Mbps of WAN bandwidth was needed to transport the camera feeds for 1 to 4 cameras in the deployment. Given a viewing station observing 4 feeds simultaneously, with each feed at a target bit rate of 1Mbps, would therefore require approximately 4Mbps per viewing station. With these data rates as an example, it is obvious that viewing or archiving the video surveillance data across the WAN requires more bandwidth than a single T1 to the branch location.

Windows scaling and the enhanced buffering algorithm increase link utilization and take advantage of the available bandwidth. While these techniques may be optimal in a T1 WAN environment, the sheer amount of WAN bandwidth required for this deployment may render the advantages of these techniques less effective. Selective Acknowledgement provides efficient packet loss recovery and retransmission. If the WAN also transports UDP/RTP-based video, such as is the case with Telepresence and H.264/MPEG-4-based IP Video Surveillance, the loss needs to be closely monitored and addressed to preserve the video quality of these connectionless video feeds. Ideally, the WAN will exhibit very low loss and minimalize the need for selective acknowledgement.

Key Concepts

Some basic concepts must be understood to better understand the nature of the traffic and applications tested in this section. WAAS does not optimize traffic that is non-TCP (i.e., UDP or ICMP) traffic. Because H.264/MPEG-4 is typically RTP/UDP encapsulated, there is no optimization if this traffic is traversing the WAAS optimized WAN. Currently, all traffic between client viewing station and Media Server is TCP-based. Both MPEG-4 and Motion JPEG camera feeds, live, or archived are encapsulated in TCP. Motion JPEG camera feeds are typically TCP encapsulated. The Video Surveillance Media Server (VSMS) version tested is 6.0.0 and the Video Surveillance Operations Manager (VSOM) is 4.0.0. This version supports a Motion JPEG feed from the Axis 223M camera, TCP-based, and this camera was installed in the campus location to provide a TCP-based feed across the WAN. Currently, the Cisco Video Surveillance IP Camera (CIVS-IPC-2500) is not supported for MJPEG from VSMS 4.0.

Warning **Future releases of the client viewing station code are slated to incorporate RTSP support that may implement MPEG-4 streams between the media server and viewing station to UDP.**

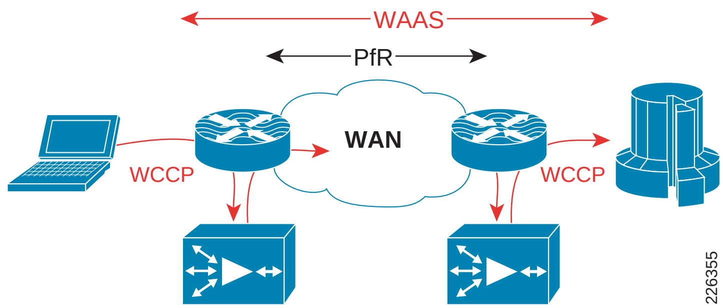
The WAAS tested version is 4.1.1c for the branch WAE, core WAE, and WAAS Central Manager. The video component in this version relates to Windows Media live video broadcasts that use RTSP over TCP. The video accelerator implemented by this feature eliminates duplicate video streams on the WAN and creates multiple streams to serve multiple clients on the LAN. This video acceleration is not applicable to IP Video Surveillance.

Traffic Optimization Overview

In the test topology, WAAS is added to the existing topology which is also performance Routing (PfR)-enabled. This overview and illustration is helpful to better understand how WAAS and PfR co-exist over the WAN. PfR manages two or more WAN links between the branch and campus router. PfR selects a path which meets the criteria, or the best path of so configured. In this video surveillance testing, sample configurations are shown which select the best path based on loss, or a combination of loss and delay. PfR is highly configurable and very granular; down to specific applications, if desired.

AS shown in Figure 30, PfR manages the WAN links between two routers, while WAAS intercepts traffic on the LAN interface of each router, routing the optimized traffic across the WAN interface in the IP routing table. PfR injects routes into the IP routing table or by policy-based routing (PBR).

Figure 30 *Traffic Optimization Overview*

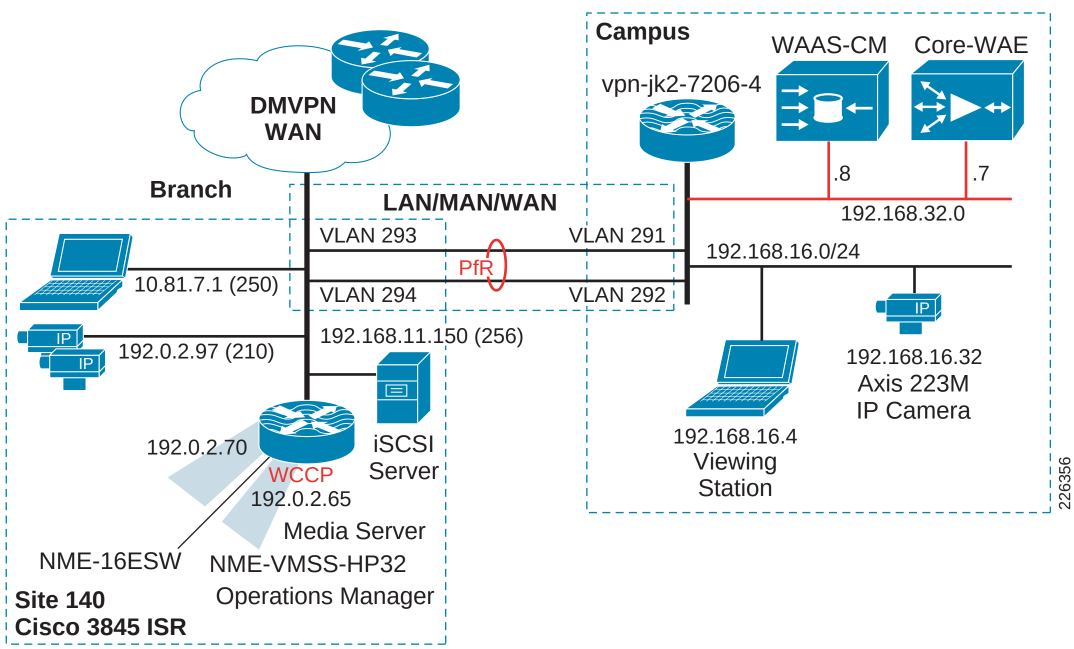


In these tests, traffic is intercepted with Web Cache Communication Protocol version 2 (WCCP v2) and redirected to the WAE. WCCP v2 supports any IP protocol (including any TCP or UDP). Intercepted TCP traffic is optionally a candidate for optimization. The WAE adds information to the TCP header to flag the next WAE that this traffic is being optimized. In the test lab, NetFlow is used to analyze the extent of WAN bandwidth savings. From the analysis of that data, it is noted that the WAAS sets the Explicit Congestion Notification (ECN) flag in the ToS byte. Because NetFlow v5 reports flows based on source/destination IP address, port, protocol, and ToS byte, a flow with the ECN bits set and one without is reported, even though they are actually part of the same flow if the ECN bits are ignored.

Topology

The tested topology is shown in Figure 31 discussed below.

Figure 31 *WAAS Integration Topology*



Some highlights of the topology are as follows:

- The branch Cisco ISR 3845 houses both NME-WAE-522 and NME-VMSS-HP32
- A branch VLAN for MPEG-4 and Motion JPEG cameras

- The campus 7200 Series router has a VLANs for WAAS-CM and core WAE appliance
- A campus VLAN for viewing station and a Motion JPEG (Axis 223M) camera.
- The WAN is dual FastEthernet links with two delay generation devices to introduce loss, latency, and jitter

PfR is implemented similarly on both the campus and branch router. WCCP is configured on the logical interface of the NME-VMSS-HP32 and on the VLAN of the viewing station/IP camera at the campus. Note that there is a Motion JPEG (Axis 223M) configured camera at the campus and transporting the video to the branch. Typically, a video surveillance deployment would not transport a video feed from the campus to a branch location for management and storage. It is not a recommended configuration, but it was inserted into the topology to demonstrate that WAAS could intercept TCP-based camera feeds across a WAN environment. Several customer deployments have been planned that require a single remote IP camera at an isolated location with the Media Server role at a larger branch deployment or campus location. This camera is included in the topology as a demonstration of that topology.

Role of WAAS Central Manager

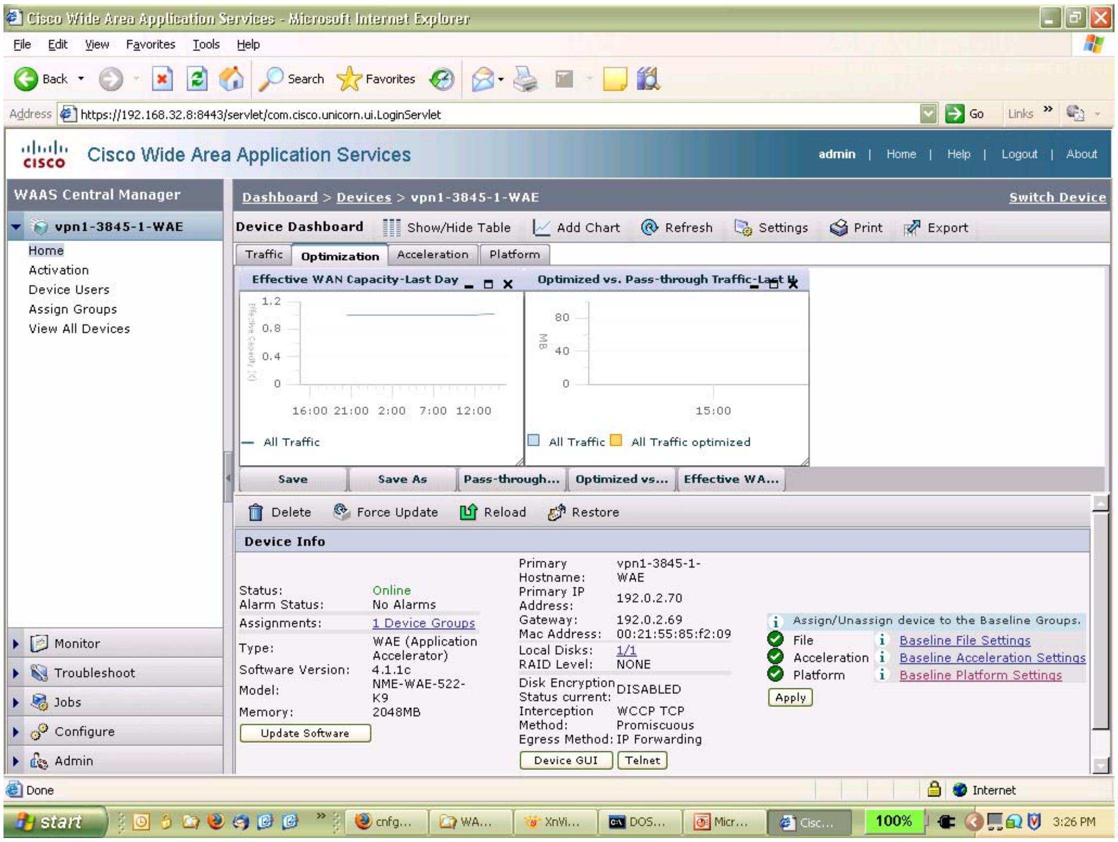
The role of the WAAS Central Manager (CM) is to provide the network administrator with a graphical user interface for fault, configuration, performance of WAE(s). For detailed information on the WAAS CM , refer to the appropriate *Cisco Wide Area Application Services Configuration Guide* on www.cisco.com.

To illustrate the role of the WAAS CM, a screen snapshot is included showing the view of a remote WAE. To connect to the WAAS CM, the testbed campus PC accesses the WAAS CM by connecting to the IP address of the CM at port 8443 using the HTTP/SSL. For example:

```
https://192.168.32.8:8443/
```

Once validated, the branch WAE device can be selected. The screen snapshot in Figure 32 provides an idea of the GUI interface available to the network manager.

Figure 32 WAAS Central Manager Device Dashboard



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From the device dashboard screen shown above, the reports for the WAE can be viewed, the device can be managed by Telnet or a WEB browser, and other pertinent information like software version, alarms, IP address, and the MAC address can be displayed.

For the branch and core WAE to identify themselves to the CM, the configuration on the WAE must include the address of the CM; in the following example, 192.168.32.8.

```
vpn1-3845-1-WAE#sh run
! WAAS version 4.1.1c
! (build b16 Nov  5 2008)
!
device mode application-accelerator
!
hostname vpn1-3845-1-WAE
!
… [lines removed]
!
central-manager address 192.168.32.8
cms enable
!
! End of WAAS configuration
```

Once that is configured and the WAE contacts the CM, the remote WAE devices can be managed from the CM GUI interface.

Test Goals

The goal of this testing was to demonstrate PfR routing traffic over the WAN link that exhibits the best path between branch and campus. Once PfR is operational in the WAN, WAAS is implemented to optimize the TCP/HTTP traffic to and from the Video Management and Storage System (VMSS) logical interface in the branch Cisco 3845 ISR.

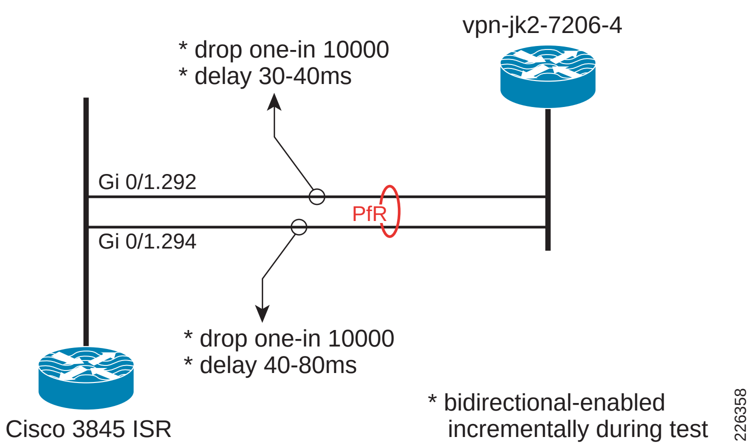
The Cisco IOS Release tested at the branch is **c3845-adventerprisek9-mz.124-15.T5** using the NME-VMSS-HP-32 (version 4.0/6.0) network module and the NME-WAE-522-K9 network module using WAAS version 4.1.1.c. To verify the bandwidth savings, both NetFlow and the WAAS CM Report Effective WAN Capacity (bandwidth savings) data are used.

The approach is therefore to first describe the WAN characteristics, examine the PfR configuration, and then enable WAAS on the topology. The PfR configuration in this section builds upon the configuration in the previous section. In this testing, PfR is now managing both on packet loss and delay. Loss is the first priority and delay is the second priority. In testing, path changes are triggered by both loss and delay.

WAN Characteristics

On the two WAN links, a latency and packet loss tool is used to introduce loss, latency, and jitter. The values shown are applied in each direction. Both links have packet loss of one packet in every 10,000 packets, or 1/100th of 1 percent loss. Delay is in the range of 30 to 40 milliseconds on one link and 40 to 80 milliseconds on the other link. The variation in delay introduces jitter into the traffic. These values are shown in Figure 33.

Figure 33 WAN Characteristics - Latency, Jitter and Loss



At the beginning of the test, neither WAN link had any appreciable loss or delay, the tool is enabled during the test to simulate WAN links that are changing characteristics over a period of time.

PfR Configuration

The PfR configuration deployed in this testing uses the Fast Reroute feature. The Fast Reroute feature probes all exits continuously. This allows PfR to have the current state of all managed links reflected in its database. An explicitly configured active jitter probe (UDP jitter) is configured to characterize the delay, loss, and jitter of all exits. This probe also provides voice statistics such as Mean Opinion Score

(MOS) although MOS is not, in this testing, used to make path selection determinations. PfR is selecting the best path, rather than a path that simply meets the criteria. Loss is the first priority, then delay as the second priority. The probe frequency is every 10 seconds.

The **oer-map** command that implements this configuration is shown as follows:

```
oer-map LOSS 10
  sequence no. 8444249301975040, …
  match ip prefix-lists: CAMPUS
  backoff 300 3000 300
  delay threshold 80
  holddown 300
  periodic 0
 *probe frequency 10
 *mode route control
 *mode monitor fast
 *mode select-exit best
 *loss relative 100
  jitter threshold 20
  mos threshold 3.60 percent 30
  unreachable relative 50
  next-hop not set
  forwarding interface not set
 *resolve loss priority 1 variance 10
 *resolve delay priority 2 variance 10
 *resolve utilization priority 12 variance 20

  Forced Assigned Target List:
   active-probe jitter 192.168.16.1 target-port 32014 codec g729a

* Overrides Default Policy Setting
```

This **oer-map** command is referenced in the configuration sample by the policy-rules statement shown later in this document.

Path Selection Based on Loss and Delay

PfR can select the best exit based on the loss and delay criteria. When PfR selects a new route, the change can be seen in the logging buffer of the master controller. During testing, this output was captured and is included here for review. Note that the route is changed for reason of delay in the first instance and for reason of packet loss in the second instance.

```
Dec 19 10:14:19.855 est: %OER_MC-5-NOTICE: Route changed Prefix 192.168.16.0/20,
 BR 192.168.0.1, i/f Gi0/1.294, Reason Delay, OOP Reason None

Dec 19 10:19:56.862 est: %OER_MC-5-NOTICE: Route changed Prefix 192.168.16.0/20,
 BR 192.168.0.1, i/f Gi0/1.293, Reason Loss, OOP Reason Loss
```

Given the low amount of loss in the test environment (1/100th of 1 percent) and that delay is incurred for all traffic, it is not unexpected to occasionally observe route changes alternate between loss and delay. In the Performance Routing (PfR) Integration chapter it was shown that PfR can manage links based on loss, and there was a high amount of loss on one link verses the other. In this test, loss is very minimal and the same on both links during the test, while the links have different delay characteristics.

Branch Router Configuration Details

Relevant portions of the branch router configuration is shown below with imbedded annotations:

```
hostname vpn1-3845-1
!
```

WCCP Version 2 is enabled by default and WCCP services 61 and 62 (TCP promiscuous mode)

```
ip wccp 61
ip wccp 62
```

Cisco Express Forwarding (CEF) is required for PfR to function.

```
ip cef
!
oer master
 policy-rules LOSS
 logging
 !
```

At least one internal interface and two or more external interfaces are required. The In3/0 interface is the NME-VMSS-HP32 logical interface.

```
 border 192.168.0.1 key-chain PURPLE
  interface Integrated-Service-Engine3/0 internal
  interface GigabitEthernet0/1.293 external
  interface GigabitEthernet0/1.294 external
  interface GigabitEthernet0/1.210 internal
  interface GigabitEthernet0/1.250 internal
 !
```

For traffic not selected by the oer-map, learn mode is enabled to allow PfR to control routes for traffic exiting from VLANS 210 and 250 identified as internal interfaces above.

```
 learn
  throughput
  delay
  periodic-interval 0
  monitor-period 1
  expire after time 30
  aggregation-type prefix-length 29
 no max range receive
 delay threshold 80
 mode route control
 mode select-exit best
!
```

The border router and master controller are both configured on this branch router, the key-chain of PURPLE is not shown, but is a requirement of PfR.

```
oer border
 local Loopback0
 master 192.168.0.1 key-chain PURPLE
!
```

The WAN interfaces are VLAN 293 and 294, these VLANs attach to the delay and loss appliance.

```
interface GigabitEthernet0/1.293
 description To vpn-jk2-7206-1 for PfR
 encapsulation dot1Q 293
 ip address 192.168.15.6 255.255.255.252
!
interface GigabitEthernet0/1.294
 description To vpn-jk2-7206-1 for PfR
 encapsulation dot1Q 294
 ip address 192.168.15.2 255.255.255.252
!
```

```
!
interface Integrated-Service-Engine2/0
 description NME-WAE-522-K9
 ...
  ip wccp redirect exclude in
!
```

This interface is an internal interface for PfR and is configured for WCCP redirection; therefore, traffic entering and leaving this interface are candidates for WAAS optimization.

```
interface Integrated-Service-Engine3/0
 description NME-VMSS-HP32
 ip address 192.0.2.64 255.255.255.254
 ip wccp 61 redirect in
 ip wccp 62 redirect out
 ...
```

PfR requires parent routes in the routing table. These routes identify the campus subnet of the viewing station and IP camera. The corresponding prefix-list selects traffic for the oer-map.

```
!
ip route 192.168.16.0 255.255.240.0 192.168.15.1 name OER_Parent
ip route 192.168.16.0 255.255.240.0 192.168.15.5 name OER_Parent

ip prefix-list CAMPUS seq 5 permit 192.168.16.0/20
!
```

The oer-map shown was also shown previously in this section.

```
oer-map LOSS 10
 match traffic-class prefix-list CAMPUS
 set mode select-exit best
 set mode route control
 set mode monitor fast
 set resolve loss priority 1 variance 10
 set resolve delay priority 2 variance 10
 set loss relative 100
 set active-probe jitter 192.168.16.1 target-port 32014 codec g729a
 set probe frequency 10
!
end
```

Note The target of the active-probe defined above is the campus router with an IP address of 192.168.16.1. This router is also contains a similar PfR configuration. The UDP jitter probe requires the **ip sla responder** command in the configuration.

PfR Verification

To verify PfR is managing the path to the campus network prefix where the viewing station and IP camera resides, the output of the **show oer master prefix detail** command is shown.

```
vpn1-3845-1#show oer masert prefix detail
Prefix: 192.168.16.0/20
   State: INPOLICY    Time Remaining: @0
   Policy: 10

   Most recent data per exit
   Border          Interface         PasSDly  PasLDly  ActSDly  ActLDly
  *192.168.0.1     Gi0/1.294               0        0       75       75
   192.168.0.1     Gi0/1.293               0        0      128      128
```

```
 Most recent voice data per exit
 Border          Interface          ActSJit  ActPMOS  ActSLos  ActLLos
*192.168.0.1     Gi0/1.294                4        0        0        0
 192.168.0.1     Gi0/1.293               11        0        0        0

 Latest Active Stats on Current Exit:
 Type      Target          TPort Attem Comps     DSum      Min      Max      Dly
 jitter    192.168.16.1    32014     1   100     7510        1      106       75
 jitter    192.168.16.1    32014     1   100     7490        1      106       74
 jitter    192.168.16.1    32014     1   100     7458        1      106       74
 jitter    192.168.16.1    32014     1   100     7564        1      106       75
 jitter    192.168.16.1    32014     1   100     7527        1      106       75


 Latest Active Voice Stats on Current Exit:
 Type      Target          TPort      Codec Attem Comps  JitSum       MOS
 jitter    192.168.16.1    32014      g729a     1   100     413      4.06
 jitter    192.168.16.1    32014      g729a     1   100     443      4.06
 jitter    192.168.16.1    32014      g729a     1   100     451      4.06
 jitter    192.168.16.1    32014      g729a     1   100     425      4.06
 jitter    192.168.16.1    32014      g729a     1   100     392      4.06
```

…

In the above output, under *Most recent data per exit*, the active short and long-term delay values are 75 and 128 milliseconds. This is consistent with the WAN characteristics described previously. Also, the active short-term jitter is 4 and 11 milliseconds, which is a result of the range of latency values introduced by the test tool on each link.

WAAS Implementation

WAAS is also tested and documented in the V3PN large scale IPSec aggregation testbed and included in the following document:

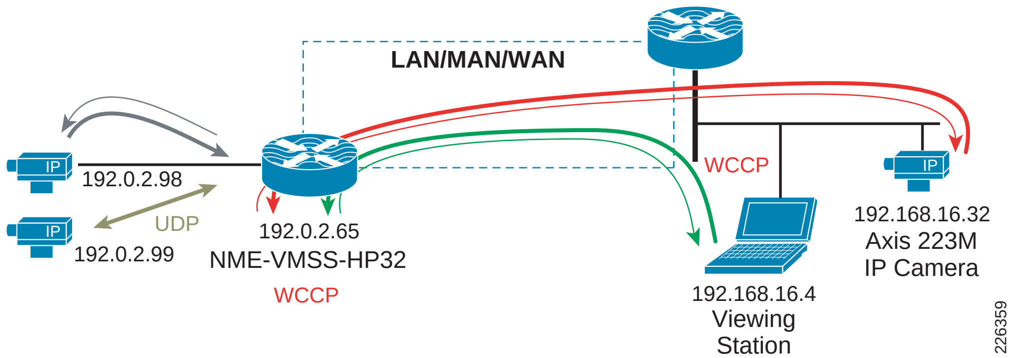
- *Transport Diversity: Performance Routing (PfR) Design Guide*

  http://www.cisco.com/en/US/docs/solutions/Enterprise/WAN_and_MAN/Transport_diversity/Transport_Diversity_PfR.html.html

The traffic profile used in the PfR and WAAS testing consisted of VoIP and data. The testing referenced here, WCCP enabled on the VMSS logical interface and therefore the target traffic for optimization is the HTTP requests the Client Viewing Station (Internet Explorer) makes to the VSOM web server. The nature of this traffic is video feeds displayed on the PC as well as the underlying web interface. Because in this phase of testing the Axis 223M camera is also located on the campus subnet, the TCP session for the Motion JPEG is also traversing the WAN to the Media Server IP address under the VMSS logical interface. This traffic is therefore also a candidate for optimization.

Figure 34 illustrates these flows to and from the VMSS logical interface.

Figure 34 Traffic Flows Optimized by WAAS



The flow from the IP camera to the Media Server is Motion JPEG (MJPEG) is at 5 video frames per second. The flows between VSOM and the Viewing Station are MJPEG/MPEG-4 (three cameras) along with the the HTTP control traffic. To verify these flows are candidates for optimization, the accelerated flows can be displayed on the branch WAE network module as shown in the following example:

```
vpn1-3845-1-WAE#show statistics connection  all

D:DRE,L:LZ,T:TCP Optimization,
C:CIFS,E:EPM,G:GENERIC,H:HTTP,M:MAPI,N:NFS,V:VIDEO

ConnID  Source IP:Port        Dest IP:Port          PeerID             Accel
20334   192.0.2.65:36908      192.168.16.32:80      0:14:5e:85:54:7b   THDL
20467   192.168.16.4:65488    192.0.2.65:80         0:14:5e:85:54:7b   THDL
20468   192.168.16.4:65485    192.0.2.65:80         0:14:5e:85:54:7b   THDL
20469   192.168.16.4:65482    192.0.2.65:80         0:14:5e:85:54:7b   THDL
20489   192.168.16.4:65508    192.0.2.65:80         0:14:5e:85:54:7b   THDL

Local IP:Port       Remote IP:Port      Peer ID             ConnType
192.0.2.98:80       192.0.2.65:41233    N/A                 PT No Peer
192.0.2.65:41233    192.0.2.98:80       N/A                 PT No Peer
```

There are a total of five TCP/HTTP flows being optimized by TFO and targeted for DRE and LZ compression. This is signified by the THDL designation at the right of each connection detail line. The two flows that are listed as ‘No Peer’ are the camera feeds on the branch LAN to the Media Server. These are not optimized because there is no WAN transport of these feeds, the camera feeds are local to the router.

Table of Effective Capacity

In the test results reported here, data is collected for over a hour and the results from the WAAS CM are shown Table 2. These results are summarized from an export of the device dashboard to a CSV file and analyzed. The following table represents the Effective WAN Capacity report for the remote (vpn1-3845-1-WAE) WAE.

Table 2 Effective WAN Capacity

	Bandwidth Savings Bytes	Reduction % (include pass-through)	Reduction % (Exclude Pass-through)	Pass-through Traffic (Bytes)	Application Traffic (Bytes)
	769,179,772	6	10	5,128,480,196	12,473,380,864

The WAN bandwidth savings is shown at less than 10 percent. As a point of reference, the test results in the *Transport Diversity: Performance Routing (PfR) Design Guide* demonstrated compression ratios in the range of 3:1 to over 40:1 for Web and File Transfer sessions generated by Chariot/IXIA. From this, it can be concluded that data traffic is more compressible than the video traffic used in this test.

WCCP Configuration

This section includes the WCCP configurations on the campus and branch router.

Campus Router

The relevant WCCP configuration for the campus router is as follows:

```
hostname vpn-jk2-7206-1
!
ip wccp 61
ip wccp 62
ip cef
!
interface FastEthernet0/1.216
 description CAMPUS with IP Cameras and PC
 encapsulation dot1Q 216
 ip address 192.168.16.1 255.255.240.0
 ip wccp 61 redirect in
 ip wccp 62 redirect out
!
interface FastEthernet0/1.232
 description CAMPUS with WAAS CM and Core WAE
 encapsulation dot1Q 232
 ip address 192.168.32.1 255.255.240.0
 ip wccp redirect exclude in
!
end
```

Branch Router

The relevant WCCP configuration for the branch routers is as follows:

```
hostname vpn1-3845-1
!
ip wccp 61
ip wccp 62
ip cef
!
interface Integrated-Service-Engine2/0
 description NME-WAE-522-K9
 ip address 192.0.2.69 255.255.255.252
 ip wccp redirect exclude in
```

```
 service-module ip address 192.0.2.70 255.255.255.252
 service-module ip default-gateway 192.0.2.69
 no keepalive

interface Integrated-Service-Engine3/0
 description NME-VMSS-HP32
 ip address 192.0.2.64 255.255.255.254
 ip wccp 61 redirect in
 ip wccp 62 redirect out
 ip flow ingress
 ip route-cache flow
 service-module external ip address 192.168.11.2 255.255.255.0
 service-module ip address 192.0.2.65 255.255.255.254
 service-module ip default-gateway 192.0.2.64
 no keepalive
!
```

Summary

Video feeds from IP Video Surveillance cameras to the Media Server are TCP-based when the camera is configured for Motion JPEG. Additionally, viewing live or archived feeds through VSOM by a client viewing stations is also TCP/HTTP based for feeds which are either MJPEG or MPEG-4. While TCP-based traffic can be optimized and compressed by WAAS, for this video traffic the compression is on the order of less than 10 percent. Video feeds are compressed by the encoder of the IP camera before being transported over the IP network. Additional compression by WAAS does not provide as dramatic savings as is the case with typical user data traffic.

However, both WAAS and PfR can be implemented effectively together and PfR is shown to manage multiple WAN links and select the path with the least loss and lowest delay.

Wide Area Application Services (WAAS) for iSCSI

The Cisco ISR router Video Management and Storage System (VMSS) network module houses an external Gigabit Ethernet interface on the module faceplate to provide connectivity to a locally attached Internet Small Computer System Interface (iSCSI) storage server. This iSCSI filesystem supplements the on-board disk drive for storing video archives. Cisco Video Management And Storage System (NME-VMSS-HP16/32 NME-VMSS-16) include GigE port for local iSCSI attachment. This is the preferred method and is described in "Local Storage for Video Archives Using iSCSI" section on page 6-41.

While the recommended design is to archive locally, it is possible to route the iSCSI traffic through the ISR router backplane and the WAN interface(s) to reach a target IP address in the enterprise campus. Locating an iSCSI server in the campus and transporting archives across the WAN is of interest to customers for management and support efficiencies. Many customers, knowing the amount of bandwidth required to transport video feeds from surveillance cameras, have requested design guidance on what, if any, benefit implementing WAAS has on iSCSI transport of video archives over a WAN.

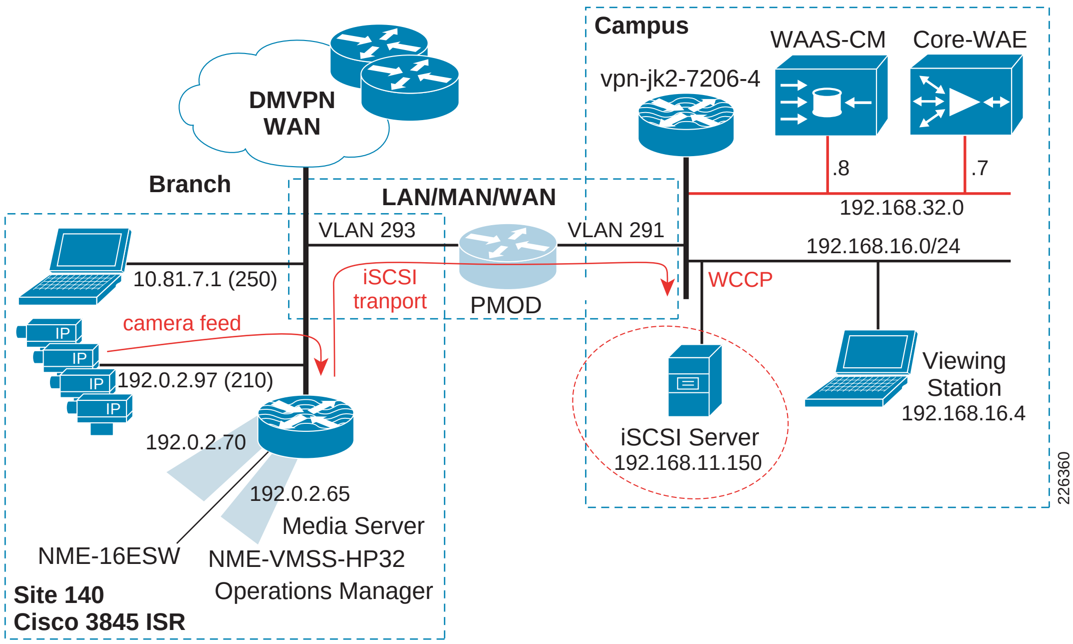
iSCSI Overview

The iSCSI operates over TCP port 3260 in this implementation. It does not require any dedicated cabling, it uses existing LAN switches and the IP network. iSCSI operates as a clear text protocol, there is no encryption inherent in the protcol. If it is transported over a public WAN or the nature of the video feeds require the need for data privacy, IPSec encryption must be deployed to meet that requirement. The TCP session between the NME-VMSS and iSCSI appliance is persistent, or long-lived. It is only terminated or initiated to recover from a timeout or manual shutdown.

Topology

The test topology is very similar to the topology used to test WAAS and PfR between branch and campus. The notable difference is the placement of the iSCSI appliance. Previously, it was attached to a LAN Gigabit Ethernet switch in the branch location. Now, it is connected to the LAN switch in the campus location. The IP address of the server has changed accordingly. There are four IP Video Surveillance cameras in the topology; an Axis 223M (MJPEG), Axis 207 (MPEG-4), Axis 207MW (MJPEG), and a Cisco 2500 series (MPEG4). Results are consistent across all cameras. The iSCSI server is a Buffalo (www.buffalotech.com) TeraStation Pro™ II iSCSI Rackmount Storage System. Figure 35 illustrates the topology.

Figure 35 WAAS and iSCSI Deployment Topology



The path of the camera video feeds, iSCSI transport and location of the iSCSI server in the topology are shown for reference.

Configuration

The relevant portion of the branch router configuration is shown in this section. The WCCP configuration on the router is not changed from what was documented in the previous chapter. Because the iSCSI TCP session originates from the NME-VMSS-HP32 logical interface (Integrated-Service_Engine 3/0) the iSCSI TCP session is intercepted by WCCP configured on that interface.

```
!
hostname vpn1-3845-1
```

```
!
boot-start-marker
boot system flash
   flash:c3845-adventerprisek9-mz.124-15.T5
!
!
interface GigabitEthernet0/1.210
 description IP Camera VLAN
 encapsulation dot1Q 210
 ip address 192.0.2.97 255.255.255.224
!
!
interface Integrated-Service-Engine2/0
 description NME-WAE-522-K9
 ip address 192.0.2.69 255.255.255.252
 ip wccp redirect exclude in
 service-module ip address 192.0.2.70 255.255.255.252
 service-module ip default-gateway 192.0.2.69
 no keepalive

interface Integrated-Service-Engine3/0
 description NME-VMSS-HP32
 ip address 192.0.2.64 255.255.255.254
 ip wccp 61 redirect in
 ip wccp 62 redirect out
 ip flow ingress
 ip route-cache flow
 ! service-module external ip address 192.168.11.2 255.255.255.0
 service-module ip address 192.0.2.65 255.255.255.254
 service-module ip default-gateway 192.0.2.64
 no keepalive
!
```

The external IP address which was in use as the iSCSI local subnet, 192.168.11.0/24, is commented out of the configuration.

The steps to move the iSCSI server from the branch to the campus is to:

Step 1 Deselect Media1_0 as disk from the Media Server.

Step 2 Enter configuration mode of the VMSS network module and issue a ‘state disable’ for Media1 to gracefully shutdown the service.

Step 3 Shutdown the iSCSI service on the iSCSI server, change the IP address and physically move the connection to the correct VLAN at the campus and again enable the iSCSI service.

Step 4 Change the target IP address on the VMSS network module. Because the volume is already formatted, it will become available for use.

Step 5 Select Media1_0 as a disk to be used by the Media Server.

Following the above changes, the relevant portion of the VMSS network module configuration is shown as follows:

```
hostname VMSS-SITE140
storages iSCSI media1

 target-ip 192.168.16.150
  target-ip 192.168.16.150 volumeName iqn.2004-08.jp.buffalo:TS-RIGLB1E-001D7326
2B1E:array1 LUN 0
```

```
 end storages-iscsi

end
```

Verification

To verify WAAS has selected the iSCSI TCP session for optimization, connection statistics for the remote WAE can be displayed with the **show statistics connection** command. Detailed output from the connection specific to the iSCSI TCP session is shown below:

```
vpn1-3845-1-WAE#show statistics connection conn-id 29275


Connection Id:            29275
    Peer Id:                  00:14:5e:85:54:7b
    Connection Type:          EXTERNAL CLIENT
    Start Time:               Fri Jan  9 10:23:56 2009
    Source IP Address:        192.0.2.65
    Source Port Number:       57326
    Destination IP Address:   192.168.16.150
    Destination Port Number:  3260
    Application Name:         Storage
    Classifier Name:          iSCSI
    Map Name:                 basic
    Directed Mode:            FALSE
    Configured Policy:        TCP_OPTIMIZE + DRE + LZ
    Derived Policy:           TCP_OPTIMIZE + DRE + LZ
    Peer Policy:              TCP_OPTIMIZE + DRE + LZ
    Negotiated Policy:        TCP_OPTIMIZE + DRE + LZ
    Accelerators:             None
```

Note The above command was issued on Wed Jan 14 14:06:04 edt 2009 and the start time of the WAAS optimization is 9 January, demonstrating the persistence of the iSCSI TCP session.

WAN Characteristics

In this test, the WAN link in use has a random delay averaging 60 milliseconds in each direction with packet loss of 1 packet per 10,000 packets.

Optimization Validation

In the previous section, the WAAS Effective WAN capacity report is used to demonstrate the bandwidth savings. In this section, NetFlow is used as a demonstration of another method of validating the WAN bandwidth savings. Understanding how NetFlow reports the flows prior to de-compression by the WAE as well as from WAE to the application server also provides a means of understanding how WAAS interception functions. In this test, a NetFlow export is configured on the campus router to a unix server. These Version 5 flows are captured and summarized.

The complete record layout for NetFlow Version 5 Flow Record Format is available on www.cisco.com. The SNMP index of the input and output interface is part of the flow record. In order to associate these Ifindex values with the interface name, the **show snmp mib ifmib ifindex** command is issued on the campus router and portions of the output are as follows:

```
vpn-jk2-7206-1# show snmp mib ifmib ifindex
FastEthernet0/0: Ifindex = 1
Null0: Ifindex = 6
…
FastEthernet0/1.232: Ifindex = 26
…
FastEthernet0/1.216: Ifindex = 25

FastEthernet0/1.291: Ifindex = 31
```

Both the WAAS compressed and optimized and the original flows are reported by NetFlow in the exported records. Because the source and destination IP address and port numbers are unchanged by WAAS, the Ifindex values are needed to identify the flows seen input from the WAN interface, and then the flow as it is observed following WCCP redirection.

NetFlow summarizes and reports the flow based on the source and destination IP address, port number, protocol, and ToS byte. The ECN bits are part of the ToS byte. The ECN field is bits 6 and 7 in the IPv4 ToS octet.

The layout of the ToS byte from RFC 3168 is as follows:

```
0     1     2     3     4     5     6     7
+-----+-----+-----+-----+-----+-----+-----+-----+
|          DS FIELD, DSCP           | ECN FIELD |
+-----+-----+-----+-----+-----+-----+-----+-----+
     DSCP: differentiated services codepoint
      ECN: Explicit Congestion Notification
```

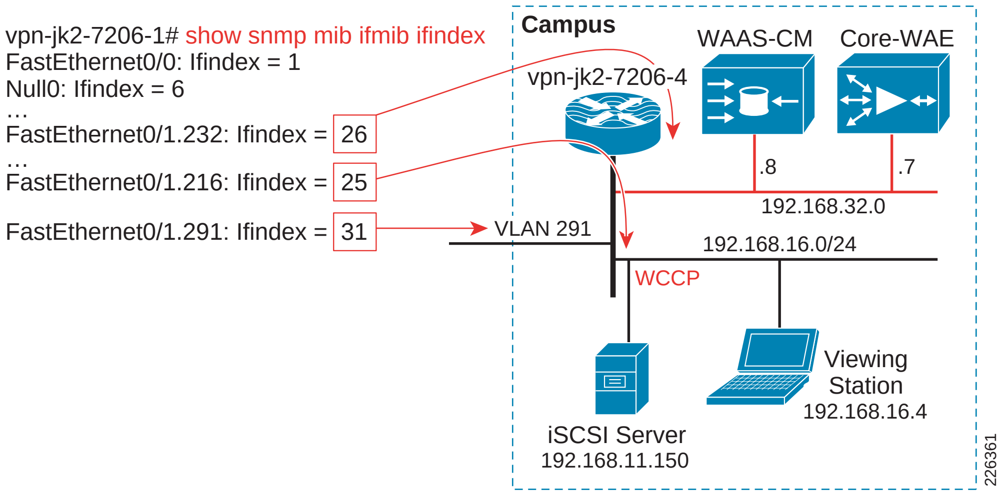
WAAS sets the ECN bits and because NetFlow v5 reports all eight bites of the ToS byte, the flow observed from the WAN interface is reported as two flows; with and without the ECN bits set.

The Ifindex numbers displayed by the **show snmp mib ifmib ifindex** command are referenced on the topology as follows:

- Ifindex 26 is VLAN 232—Core-WAE
- Ifindex 25 is VLAN 216—iSCSI Server
- Ifindex 31 is VLAN 291—WAN
- Ifindex 0 is the router chassis itself

These are shown in Figure 36.

Figure 36 Ifindex to Interface Mapping



In testing, NetFlow v5 export is configured on the campus 7206 and summarized. The iSCSI traffic flows are extracted from the summarized data and presented in Table 11. A single archive of one camera, an Axis 207MW, is active during the data capture.

Table 11 NetFlow Export Summarized Data for Axis 207MW

Src IP / port	SrcIfIndex	Dst IP/ port	DstIfindex	PPS	Bytes per Packet	Protocol/ToS Byte	Total Bytes
Core WAE	to	iSCSI	Server				
192.0.2.65 57326	26	192.168.16.150 3260 [iSCSI]	25	363	1430	TCP / 0	245,092,552
WAN	to	Core WAE					
192.0.2.65 57326	31	192.168.16.150 3260 [iSCSI]	0	8	250	TCP / 0	839,682
192.0.2.65 57326	31	192.168.16.150 3260 [iSCSI]	0	352	1451	TCP / 2	240,762,778

There is a single flow reported from the core WAE to the iSCSI server. This is the flow post WAE processing. From the WAN to the core WAE, there are two flows reported: one flow with a ToS byte of 0 another with a ToS byte value of 2. The ToS byte value of 2 flow are packets in the WAN traffic with the ECN field populated.

To compare the flows from the WAN to the core WAE and from the core WAE to the iSCSI server, we must add the total bytes from WAN to core WAE (839,682 + 240762778) for a combined value of 242,602,460 bytes. The number of bytes for the core WAE to the iSCSI server is 245,092,552. By comparing these two sets of values, the optimized verses the unoptimized traffic, the impact of WAAS compression on the flows is less than two percent.

As a point of comparison and verification, the Media Server provides the details of that same data when stored as an archive on the iSCSI disk. This output is shown as follows:

```
Archive History Details: 5MIN_207MW_only

Archive Name   : a_p_Axis_207MW__192_0_2_98_-_a_5MIN_207MW_only
Storage Path   : /media1_0/1000
Archive Type   : regular
Video Width    : 1280
Video Height   : 720
Archive Status  : SHELVED
Archive Media  : jpeg
Recording Rate  : 10.581754 Mbps
Video Quality  : 50
Video Framerate : 30.000000 fps
Video Bitrate  : 640
Archive Expiry  : 5 days
Archive Size   : 224512 Kbytes
Archive Start Time: Fri Jan  9 16:00:02 2009
Archive End Time  : Fri Jan  9 16:04:46 2009
Max Fps  : 13.482701
Max Frame Size  : 103171 bytes
Archive Duration : 300 seconds
Current Duration : 284 seconds
Current Retention: 94.67%
```

This is a five-minute archive of a 1280 x 720 resolution Motion JPEG that on disk is 224,512 Kbytes. The NetFlow export includes IP Layer-3 overhead which accounts for the higher number of bytes reported by NetFlow.

Summary

Both Motion JPEG and MPEG4 or H.264 camera feeds are compressed by the encoding function of the IP Camera. Persistent Lempel-Ziv (LZ) compression can achieve compression ratios in the order of 2:1, 5:1 or even up to 100:1 if the data contains common strings of characters. LZ compression can be beneficial for data which has not been previously traversed the network and categorized by Data Redundancy Elimination (DRE). DRE maintains a database of data that has been observed on the network. DRE is application independent. DRE can eliminate up to 99 percent of redundant network traffic and provide up to 100:1 compression.

Because the files being transported and archived to the iSCSI server are solely video feeds, and this data has been compressed by the encoding function of the IP cameras, the iSCSI transport shows little bandwidth savings. However, WAAS can be very instrumental in compressing application data to free bandwidth for other uses, including network video traffic.

Controlling Access to IP Video Surveillance

This section provides a high-level overview of how to control access using policy-based access-control lists on Cisco IOS routers to limit access to IP video surveillance resources. Included is an example on how to block traffic to video surveillance resources when these services exist in the enterprise global routing table along with other end-user devices. There are two subsections:

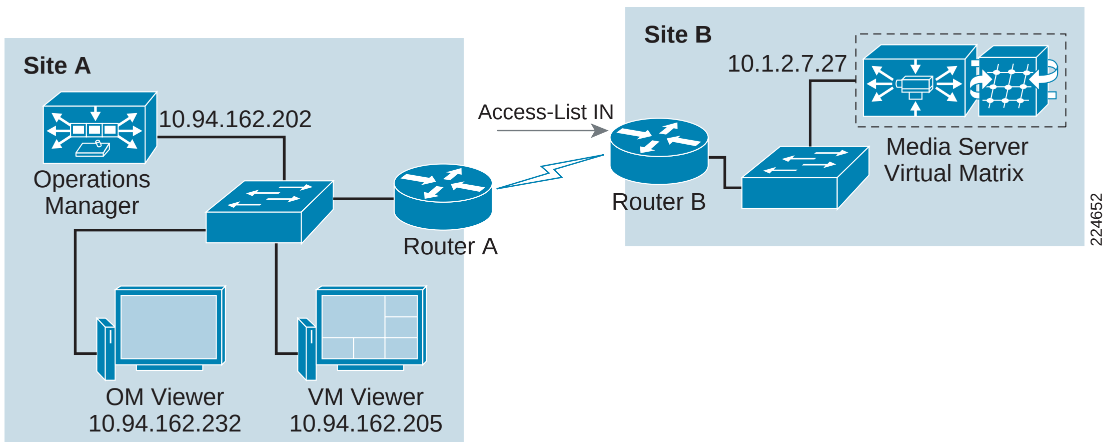
- Securing IP Video Surveillance Traffic, page 6-81
- Securing Access to ISR VMSS Network Modules, page 6-83

In the Virtualization, Isolation and Encryption of IP Video Surveillance chapter, a more detailed discussion on implementing both policy-based and control plane access control is provided. Each enterprise deployment must balance the need for access control to resources against the cost and complexity. The next two chapters provide the network manager with a review of the techniques to deploy very basic or very advanced access control techniques.

Securing IP Video Surveillance Traffic

Figure 37 shows an example where the viewers and the Operations Manager are separated from the Media Server and Virtual Matrix through Cisco IOS routers. The Media Server and Virtual Matrix applications are installed on the same server. In this example IOS access lists are used but other security devices, such as the Cisco ASA 5500 Adaptive Security Appliance may be used.

Figure 37 Traffic Filtering



The following access lists shows simple ways to block traffic to these resources and control what devices can receive video streams. The same examples can be used if a firewall is in place to protect video streams.

The syntax may vary when using different IOS or firewall devices.

The following access list may be applied to Router B to allow traffic destined for the servers on Site B.

```
interface Multilink1
 ip address 10.1.20.2 255.255.255.252
 ip access-group ALLOW_VMS in
 ppp multilink
 ppp multilink group 1
!
!
ip access-list extended ALLOW_VSM_TRAFFIC
 permit tcp any host 10.1.27.27 eq www
 permit tcp any host 10.1.27.27 eq 1066
 permit tcp any host 10.1.27.27 eq 8086
 deny   ip any any
```

The access-list is applied to the Multilink1 interface on the incoming direction and specifies what traffic can reach the server Site B. This access list allows any hosts to reach the 10.1.27.27 server and blocks all other types of traffic. Access lists have an implicit deny statement at the end of the list in order to block traffic types that were not explicitly permitted with the access list.

The access-list only allows the following traffic types to reach the server with IP address 10.1.27.27:

- HTTP traffic. This traffic is required for all viewers to reach the Media Server and receive video streams
- TCP port 1066, required by the VM monitor client to reach the Virtual Matrix server
- TCP port 8086, required by the Operations Manager to reach the Virtual Matrix server

The following example shows an access-list with more granular statements to allow traffic only from specific hosts and block any other hosts from access video streams.

```
interface Multilink1
 ip address 10.1.20.2 255.255.255.252
 ip access-group ALLOW_VSM_HOSTS in
 ppp multilink
 ppp multilink group 1
!
!
ip access-list extended ALLOW_VSM_HOSTS
 permit tcp host 10.94.162.202 host 10.1.27.27 eq 8086
 permit tcp host 10.94.162.205 host 10.1.27.27 eq 1066
 permit tcp host 10.94.162.232 host 10.1.27.27 eq www
 permit tcp host 10.94.162.205 host 10.1.27.27 eq www
 deny   ip any any
```

This access list is also applied to the incoming traffic of Router B and only allows traffic from the hosts on Site A to reach the server resources at 10.1.27.27. This example allows the network administrator to ensure that video streams reach only the intended recipients.

The diagram in Figure 37 does not show IP Cameras or encoders but the traffic from those devices can also be blocked or configured to reach only the intended Media Server acting as the direct proxy.

For MJPEG transmission, Media Servers communicate with edge devices using TCP port 80 (HTTP) but in some cases a different transmission and protocol may be selected.

When using MPEG-4 video transmission, the Media Server communicates with cameras using unique UDP port numbers. The ports listed in Table 12 show the UDP ports used by different manufacturers.

Table 12 UDP Ports Used for MPEG-4

Edge Device Model	UDP Ports
Axis	16400
Bosch	6001–60001
Cisco	65000
Cornet	16400
Mango	2000
Panasonic	1024
Smartsigth	19000
Sony	1024
Teleste	
MPEG2	16400
MPEG4	16100–65534
Vbrick	18000

The network path must allow for the appropriate TCP and UDP ports to travel freely between edge devices, application servers, and viewing stations. If access control lists (ACL) or firewalls are deployed between the devices, they should be configuration to allow traffic between all video surveillance devices.

Securing Access to ISR VMSS Network Modules

The Video Management and Storage Software implementation on the ISR network modules must establish a connection, usually through the web server of the IP cameras, to direct the camera to initiate video feeds to the media server for live viewing and archiving, If the IP camera requires authentication, as does the Cisco IP Cameras, a username and password is entered on the ‘Add a new IP/Network Camera’ and the ‘Camera requires authentication’ dialog box is selected on the form.

Passwords in a Cisco IOS router can be entered in the configuration as clear text (type 0), a type 7 encryption (hashing) or type 5, which uses the MD5 algorithm. Type 5 passwords are the most secure of the three. There is currently no known method for decrypting a type 5 password, but can compromised by a initiating a brute-force or dictionary attack. The password strings in the IOS configuration file can be viewed if someone has physical access to the router, can log into the router either through the console or over the network (Telnet, SSH, HTTP, etc.) and can access the router in enable mode (privilege level 15) which allows the configuration file to be viewed. Additionally, router configuration files are often stored on a TFTP or FTP server for backup and recovery purposes. Access to these files must also be safeguarded to prevent unauthorized access.

Type 0 Passwords

In Cisco IOS, type 0, or clear text passwords are stored without the benefit of any hash or encryption algorithm. Here is an example of the configuration file with a clear text password.

```
no service password-encryption
username test password 0 w3nd0v3r
```

Passwords for the IP cameras defined to the VMSS network module are stored as **.xml** files with the password, username, camera IP address, and other configuration information in clear text.

Type 7 Passwords

Type 7 passwords are obfuscated, not encrypted. These passwords can be displayed in clear text by several publicly available scripts, as does the Cisco IOS show command 'show key chain'. An example username with the type 7 password is entered and then displayed.

```
service password-encryption
username test password 7 044C58080B715A1D1B
!
key chain decrypt
 key 1
   key-string 7 044C58080B715A1D1B
!

vpn4-3800-6#show key chain decrypt
Key-chain decrypt:
    key 1 -- text "w3nd0v3r"
        accept lifetime (always valid) - (always valid) [valid now]
        send lifetime (always valid) - (always valid) [valid now]
```

The Type 7 passwords are used for PAP configurations, as with PAP, passwords are sent over the circuit "in the clear". Cisco IOS must have some means of recovering the original clear text from hashed value of the type 7 password for PAP and other protocols.

Type 5 Passwords

Type 5 passwords are the most secure of the three. There is currently no known method for decrypting a type 5 password, but can compromised by a initiating a brute-force or dictionary attack. An example of a type 5 password from a Cisco IOS configuration file is as follows:

```
username wendover privilege 15 secret 5 $1$02OG$.fgh.mKdXD8hiVOUi6kb6/
```

IP Camera Passwords

These usernames and passwords are stored in the individual camera configuration files clear text and by default, require no user authentication on the VMSS network module to view the files. This has been identified by defect

```
CSCsu36435 ISR VMSS IP Camera passwords displayed in clear text without authenticat
```

While type 7 passwords obfuscation could be used for the camera username and password, which would provide some degree of protection, the more pressing issue with the CSCsu36453 defect is the fact that no authentication is required to see the .XML configuration files by default. The next section describes one method of addressing this issue.

Control Access to the VMSS Network Module

To limit exposure of this vulnerability, several configuration options must be implemented on the ISR router to require authorization and a secure network channel between network devices and the VMSS network module. Access to the VMSS network module is through telnet to a port on the host router which corresponds to the console of the Integrated Service Engine (VMSS) network module. The 'service-module' command in Cisco IOS is essentially a reverse-telnet command to the appropriate port number assigned to the network module. To determine which port is used for the module, issue the *service-module* command. The port number assigned is the TTY line plus 2000. In this example, the port number for interface In2/0 is 2130.

```
vpn4-3800-6#service-module integrated-Service-Engine 2/0 status
Service Module is Cisco Integrated-Service-Engine2/0
Service Module supports session via TTY line 130
Service Module is in Steady state
Getting status from the Service Module, please wait..
Cisco Foundation 1.1.1
FNDN Running on NME
```

To prevent unauthorized remote access to the network module, and to the camera configuration files, several Cisco IOS hardening concepts should be implemented to limit exposure.

- **Enable SSH on the Router**—Enabling SSH first requires generating an RSA key for the router.

```
vpn-jk3-2651xm-1(config)#cry key generate rsa
The name for the keys will be: vpn-jk3-2651xm-1.ese.cisco.com
Choose the size of the key modulus in the range of 360 to 2048 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]: 1024
% Generating 1024 bit RSA keys, keys will be non-exportable...[OK]

vpn-jk3-2651xm-1(config)#
Sep 12 15:15:57.562 edt: %SSH-5-ENABLED: SSH 1.99 has been enabled
```

- **Disable Telnet access, enable SSH access** —The router and VMSS network module should not be network accessible through an insecure channel. Only allow SSH connections to the VTY ports of the router.

```
line vty 0 4

 transport input ssh
```

- **Permit access to the VMSS module from the host router**— deny all other access. The forces the use of SSH over the WAN. This example assumes the interface addressing as shown, with a TTY line of 130 (TCP port 2130). The log option on the deny statement is optional, however is useful for troubleshooting.

```
!
interface Integrated-Service-Engine2/0
 ip address 192.0.2.33 255.255.255.252
 service-module ip address 192.0.2.34 255.255.255.252
 service-module ip default-gateway 192.0.2.33
!
!
ip access-list extended LOCAL_LOGIN
 permit tcp host 192.0.2.33 any eq 2130
 deny   ip any any log
!
```

The access-list is applied to the TTY line in the following example.

- **Require authentication for reverse Telnet to the network module**—A local username with a type 5 password can be configured on the host router, or radius can be used for authentication.

```
username wendover privilege 15 secret 5 $1$02OG$.fgh.mKdXD8hiVOUi6kb6/


line 130
 access-class LOCAL_LOGIN in vrf-also
 login local
 no activation-character
 no exec
 transport preferred none
 transport input telnet
 transport output none
!
!
line vty 0 4
 transport input ssh
 login local
!
```

In the above configuration example, remote access is SSH only, Telnet has been disabled, and the login is locally authenticated. Access to the network module is only permitted from the IP address of the logical interface and is also re-authenticated.

Test the Configuration

To test this configuration, attempt a session to the service module after successfully logging into the host router. The output is shown below:

```
vpn4-3800-6#service-module in2/0 session
Trying 192.0.2.33, 2130 ... Open

   C i s c o S y s t e m s
     ||               ||
     ||               ||       Cisco Systems, Inc.
    ||||             ||||      IT-Transport
 .:|||||||:.......:|||||||:..
  US, Asia & Americas support:    + 1 408 526 8888
 EMEA support:                   + 31 020 342 3888
  UNAUTHORIZED ACCESS TO THIS NETWORK DEVICE IS PROHIBITED.
 You must have explicit permission to access or configure this
 device. All activities performed on this device are logged and
 violations of this policy may result in disciplinary action.


User Access Verification

Username: wendover
Password:
Password OK
SITE150>
SITE150>


SITE150> show video-surveillance configs
...
```

To verify that access to the VMSS network module is blocked without first logging on the host router, initiate a telnet to port 2130 of the host router. The connection must fail and the logging option on the access-list has identified the source IP address of the PC nictitating the Telnet session.

```
C:>telnet 192.0.2.33 2130
Connecting To 192.0.2.33...Could not open connection to the host, on port 2130:
Connect failed
```

```
vpn4-3800-6#
Sep 12 15:12:44.150 edt: %SEC-6-IPACCESSLOGP: list LOCAL_LOGIN denied tcp
10.81.7.78(4223) -> 0.0.0.0(2130), 1 packet
```

This demonstrates that access to the configuration files of the VMSS network module can be secured over the WAN by requiring SSH to access the host router, and to require multiple userid and password checks before an administrator can access the network module.

References

Additional tools and techniques to protect and secure Cisco routers can be found in the *Cisco Guide to Harden Cisco IOS Devices* - Document ID: 13608 at the following URL:

http://www.cisco.com/en/US/tech/tk648/tk361/technologies_tech_note09186a0080120f48.shtml

Additional security related documentation is available at www.cisco.com.

Virtualization, Isolation and Encryption of IP Video Surveillance

This section demonstrates how to secure and logically separate an enterprise network to support IP Video Surveillance. The design described in this section implements the concepts of virtualization, path isolation, and encryption at both branch and campus LAN/WAN. If remote users have a business requirement to view live and archived video feeds, an option to provide an authenticated and secure VPN connection is also shown.

Definitions and Goals

The term *network virtualization* is the creation of logical isolated network partitions over a common network infrastructure. The concept of virtualization of computing resources is not new, IBM released the operating system Virtual Machine Facility/370 in 1972. This software implemented a virtual hardware architecture on IBM 370 hardware. The primary advantage of virtualization for network or computing resources is to share a common hardware within the bounds of isolating the address space of one user from another.

In networking terms, *path isolation* is an important component of virtualization and it describes the creation of independent logical traffic paths over a shared physical network infrastructure. Path isolation is implemented in LAN switches by means of virtual LANs (VLANs). In WAN environments, path isolation is typically implemented through the use of virtual circuits. Both Frame-Relay and ATM include the concept of virtual circuits. Physically separate circuits can be associated with a Virtual Routing and Forwarding Lite (VRF-Lite) instance, a virtual router, and isolated from other VRF instances or the global routing table. Generic Routing Encapsulation (GRE) or IPSec encrypted tunnels can also be configured to provide path isolation. Examples of this are shown in "Configuring DMVPN Tunnel Interface" section on page 6-97, a Cisco IPsec/GRE solution.

By implementing VLANs, VRF-Lite and optionally IPSec/GRE, the network manager can provide access to a common network infrastructure while maintaining a separate address space, broadcast domain, and separation of one user group from another. *Segmentation* is the term often used to describe this technique and is synonymous with the term *isolation*. In layman's terms, network virtualization is a general concept, while path isolation is specific to maintaining a separation of the isolated network partitions between two points in the topology.

Historically, the physical security manager and the network manager had little interaction between their respective responsibilities. The physical security manager relied on a network infrastructure of coaxial cable (COAX) between camera, matrix switch, CCTV monitor, and networked digital video recorder (NDVR). Twisted pair (RS-485) is deployed for Pan Tilt Zoom control of analog cameras. The key requirement of any video surveillance implementation is the three Rs: *resolution, retention, and reliability.* Resolution in analog deployments is typically '4CIF/30', meaning 704x576 pixels at 30 frames per second. Retention is based on the number of days and is either regulated by a government agency, such as the State of Nevada Gaming Control board, a corporate policy, or the necessities of costs and the available disk space. Reliability is accomplished through a combination of the separate physical cable plant and human controls verifying the usefulness of the video images.

In many cases the physical security manager is going to be more confident in his ability to address the surveillance needs of the enterprise with a reliable, physically separate, cable plant for which he has total control.

Historically neither the physical security manager of value added resellers (VARs) are experts in IP networking. Therefore, the idea of transporting video over the enterprise IP network, with cameras sharing the same network with end-user workstations, servers, voice over IP (VoIP), and Internet traffic is an unknown, a cause for concern for the physical security manager. The physical security manager now must rely on the network manager for some degree of success and this is a barrier to acceptance.

Techniques to Achieve Virtualization

There are two primary techniques used to achieve network virtualization: policy-based and control plane-based. In this section, both techniques are implemented in a synergistic fashion to logically separate the video surveillance traffic from the other network traffic.

Policy-Based

Policy-based network virtualization restricts the forwarding of traffic to a specific destination based on some rule or administrative policy. These policies are independent of the control plane, meaning the destination is reachable and it may be listed in the routing table, but it is administratively prohibited. The most common implementation example is an access control list (ACL) on a router or firewall.

To implement policy-based controls, the router or firewall examines IP packets entering an interface and either forwards or drops packets based on matching fields in the IP header, transport header, or in more advanced implementations, some character string or fields in the payload of the packet. Firewalls also implement general policy-based matches on the security level of the source and destination interface of the packets. By default, firewalls permit packets to flow from a higher (more trusted) interface to a lower (less trusted) interface and the return path of that session is dynamically permitted. Packets that must be permitted from the less to more trusted interface must be explicitly defined and permitted.

Control Plane-Based

Control plane-based network virtualization is implemented by restricting the propagation of routing information. In other words, the routing tables are virtualized. The IP networks are segregated by their respective virtual routing table, or VPN routing and forwarding (VRF) table. VRF-Lite is one method of segmenting the routing tables, by creating virtual routing domains. These domains may reuse the same IP network addresses, they need not be globally unique. The can use separate address spaces from the remainder of the enterprise network or private address spaces based on RFC 1918 addressing. However, to aid in troubleshooting, it may be easier for the enterprise network manager to allocate unique IP addressing to each VRF domain. Allocating address space that facilitates summarization is as applicable to a VRF as is the case with routes in the global routing table.

Both policy-based and control plane-based techniques can be implemented in a synergistic approach to segment the network. The topology implemented in this sample deployment demonstrates both techniques. A firewall is implemented to connect the global routing table and the IP video surveillance domain (IPVS VRF) to allow a controlled and restricted access between the two domains.

IPSec Encryption

IPSec encryption provides privacy of the data, voice, and video on an IP network. Digital signatures is an important component of any IPSec implementation, providing authenticity (verifying the identity of the peer) and hashing techniques provide integrity (verifying packets have not been manipulated in transit).

In many encryption implementations, a logical tunnel interface joins two or more crypto peers, which in itself facilitates path isolation. Dynamic Multipoint VPN (DMVPN), generic routing encapsulation (GRE) over IP Security (IPSec) , IPSec/GRE, and Static Virtual Tunnel Interfaces (SVTI) are all examples of logical tunnel implementations. Group Encrypted Transport VPN (GET VPN) and Secure Sockets Layer virtual private network (SSL/VPN) are examples of payload encryption that have no logical tunnel interface. An IPSec implementation based on logical tunnels is more applicable to path isolation than payload encryption, because the logical tunnel endpoints can be in the global routing table with the tunnel itself residing in a VRF.

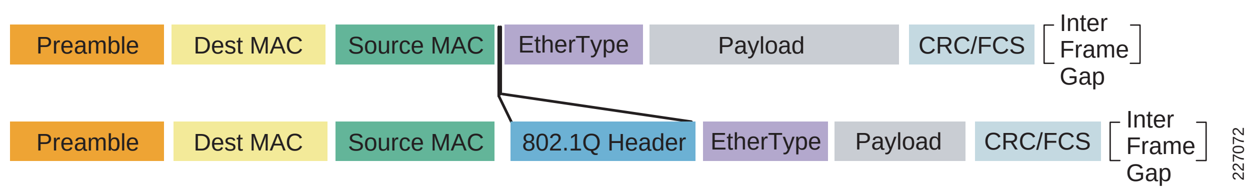
Multiple logical tunnels may be transported over a single physical path, providing an effective means of path isolation without the additional costs of a separate physical circuit. Alternately Layer-2 virtual circuit such as is implemented by ATM, 802.1Q trunking or Frame Relay could also be used, but there is no inherent privacy, authentication, or integrity component as with IPSec.

Path Isolation for LANs

In a campus LAN environment, IEEE 802.1Q (also known as VLAN tagging) is a means of associating a VLAN identifier with a Ethernet frame. This facility allows multiplexing several VLANs over the same physical switch and links between other switches, routers, and hosts. This allows for path isolation in a Layer-2 LAN in a campus or Metro-Ethernet service provider.

The Ethernet frame is not encapsulated, as is the case with IPSec or GRE tunnels; rather, a header is inserted between the source MAC address and the EtherType field in the frame. This concept is shown in Figure 38.

Figure 38 Ethernet Frame with VLAN Tagging



The 802.1Q header contains two fields of interest to the network manager: the VLAN identifier and the priority code point, or IEEE 802.1p class-of-service (CoS). The CoS field may be used to mark packets for the purpose of Layer-2 prioritization. The Cisco 4000 Series IP cameras can mark both CoS (Layer-2

QoS) and DSCP (Layer-3 QoS). Many LAN switches can prioritize frames based on the Layer-3 DSCP value so the use of Layer-2 QoS marking may be of less importance than the VLAN identifier associated with a tagged frame.

Note *CSCsz45893 Layer-2 CoS (802.1Q/p) for 4000 Series IP Camera* provides more information on the switch port configuration to support this feature.

In the topology demonstrated in this section, IP cameras are attached to switch ports that are configured as access ports associated with the appropriate VLAN, and the branch ISR routers are connected to the switch over an IEEE 802.1Q trunk link. This configuration allows both corporate end-users to share the same switch chassis as the IP video surveillance cameras, while maintaining isolation through unique VLANS and IP addressing.

Path Isolation for WANs

The ability to provide access from a central command center to video surveillance systems located at remote or branch offices is a key business driver for deploying IP-based systems. Many retail organizations currently create a physical CD-ROM / DVD of video feeds needed by the command center and use an overnight courier service to transport the media. Alternately, the investigation team may travel to the store location and view the video archive in-person at the store. Both of these methods of exchanging the video archive are costly and introduce delay of one or more days. Given the business requirement to demonstrate segmentation for IP video surveillance and the need to view video from a branch by the central command center, the WAN must therefore extend the segmentation between VLANs at the branch and command center.

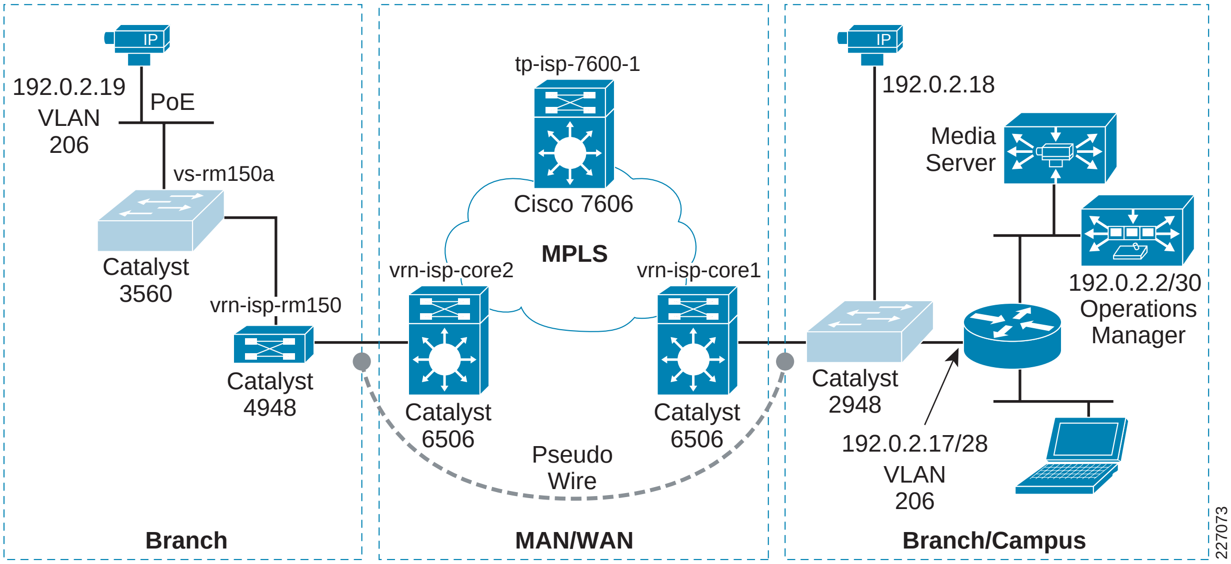
While segmentation with VLANs on a single switch incurs no costs, provisioning physically separate WAN circuits to connect these VLANs may be cost prohibitive. While Layer-2 virtual circuits based on Frame Relay and/or Frame Relay/ATM service interworking could be used to extend these LANs and provide path isolation, the exiting branch access circuit will likely have insufficient bandwidth. Many legacy branch access circuit data rates are typically at T1/E1 (1.5/2.0 Mbps) or less. As a rule of thumb, a standard definition IP camera requires approximately 1 Mbps and a high definition IP camera requires 3 to 4Mbps per feed.

Branches with access-circuits of dedicated leased lines (T1/E1 or DS3) that have no concept of a virtual circuit at the data link layer can be logically segmented by the use of multiple IPSec or GRE tunnels traversing the physical circuit. The test topology in this section demonstrates how to implement path isolation with IPSec tunnels (specifically DMVPN) as well as with Layer-2 path isolation using VLANs simulating a Metro-Ethernet type deployment.

As a best practice, video feeds from the cameras are stored to the local disk subsystem of the Media Server. The WAN connectivity between branch and campus location is segmented by VRF-Lite. Video is stored locally and only transported over the WAN occasionally for investigative purposes. As a point of reference, it is possible to implement a MPLS pseudowire deployment such that a camera at a remote location appears to be attached to the same LAN segment local to the Media Server and Operations Manager, and viewing stations.

This topology is illustrated in Figure 39.

Figure 39 MPLS Pseudowire Deployment



One practical application of this topology is a deployment where no corporate user-access is required and a single camera is sufficient for the business needs at the remote location. However, because the video feed is transmitted across the MPLS pseudowire WAN before being archived on the Media Server, packet loss must be managed by the service provider SLA and QoS marking, shaping, and queueing by both the enterprise and service provider. Costs in this deployment must also be considered, because the access circuit will likely be a dedicated T1/E1 that could be cost prohibitive. Single camera deployments may be better served by a teleworker class router, such as a Cisco 880 Series and a business class broadband access circuit.

While this topology may be implemented, the recommended solution is to store video locally, as close to the camera generating the feed as practical, and only transport across the WAN for occasional viewing or off-hours backup.

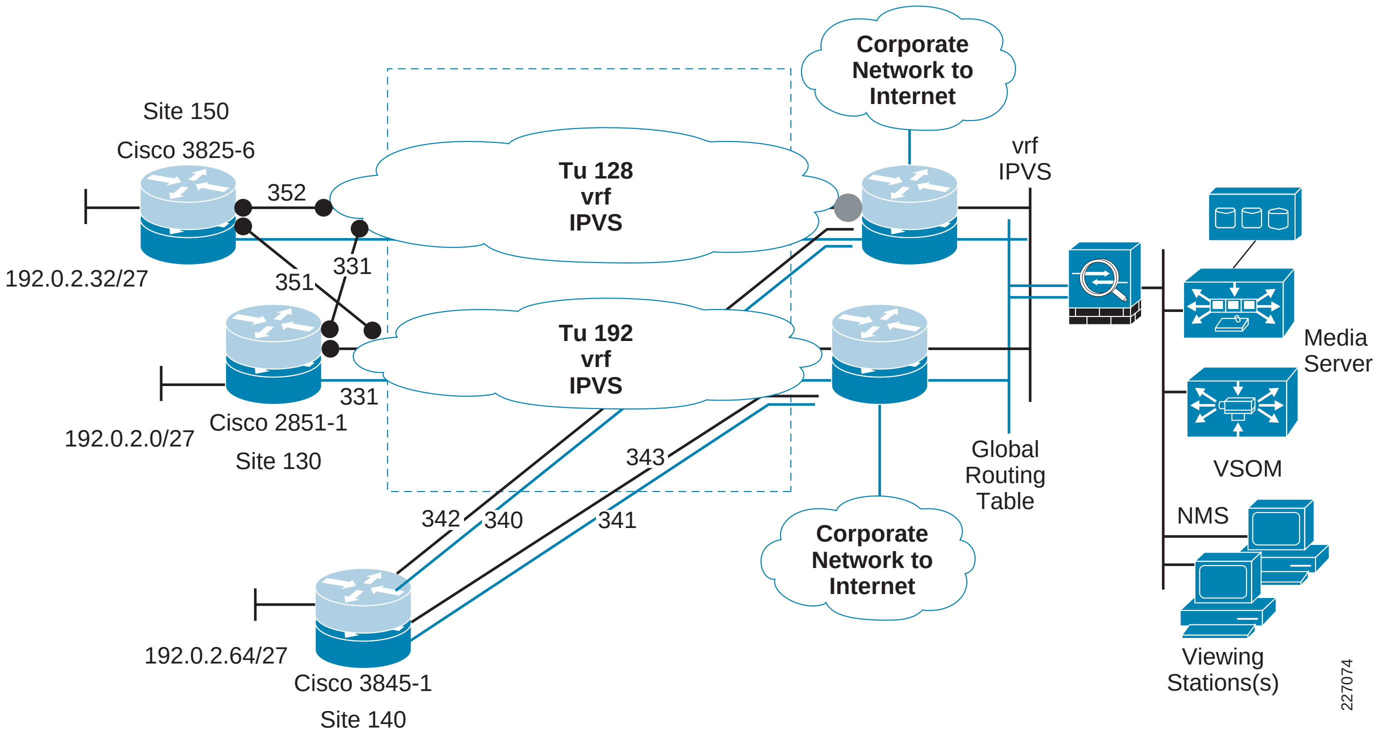
Implementing Virtualization

In this section the configuration of the switches, routers, and firewalls are discussed and the relevant configuration commands are shown to implement network virtualization and path isolation to segment the IP video surveillance devices and end-points from the global routing table. This segmentation of the network is accomplished by isolation of the control plane and network address space at the branch locations and campus command center by the use of VRF-Lite to create virtual routing tables. IP networks are comprised of both Layer-3 (routed) and Layer-2 (switched) domains. VRF-lite (VRFs without MPLS) is used in this enterprise network example to implement a virtual routing protocol instance. To provide end-to-end segmentation, both Layer-2 and Layer-3 are virtualized and mapped to each other accordingly.

Topology Diagram

The testing topology used is shown in Figure 40.

Figure 40 Virtualization Topology



In Figure 40, there are three branch locations each with a single Cisco ISR router. Both blue and grey router icons are shown to represent virtualization of the routing table. The blue icons represent the global routing table and the grey router icons represent the IPVS virtual routing table. The WAN aggregation routers shown in the center of the diagram terminate the branch locations and connect to the corporate network and Internet through separate DMVPN tunnels. These aggregation routers therefore are tunnel aggregation routers for the branches in the topology, and are spoke routers for connectivity to the corporate network. The aggregation routers are configured with HSRP on both the global routing table interface to the firewall as well as the IPVS interface.

Topology Description

In Figure 40, the Video Management and Storage System (VMSS) and Analog Video Gateway (AVG) network modules are logical interfaces. They, along with the DMVPN tunnel interfaces, are mapped to a Layer-3 domain: the VRF. The tunnel source and destination IP address are in the global routing table while the logical tunnel interface itself is in the video surveillance VRF. This separate VRF is named IPVS (for IP Video Surveillance). The iSCSI appliances, IP cameras, and viewing stations reside on a VLAN separate from the underlying corporate IP network and is in the IPVS VRF.

There are three branches shown in this topology example. Two branches demonstrate the deployment of DMVPN and one branch uses multiple virtual circuits (simulating MetroE MAN/WAN) for path isolation. At the branch locations, the iSCSI servers and IP cameras are in their own unique VLANs, which are dedicated to their respective function. Separate VLANS exist for the normal end-user traffic at the branch location and access to these devices are accomplished through the existing global routing table.

To demonstrate policy-based access control, a Cisco ASA5510 firewall is deployed at the command center location. This firewall includes two external interfaces, one in the global routing table and a second in the IPVS VRF. The inside, or most secure interface, is connected to a LAN switch and a VLAN to support the command center Media Server, VSOM, cameras, storage servers and viewing stations are deployed. This inside interface uses a subnet of the IP network address space allocated to the IPVS VRF. Access to the command center VLAN is controlled by firewall policy and static IP routes on the core routers and firewall. The NAT/pNAT configuration on firewall as well as the security levels and access-list permits communication from the IPVS VRF to the global routing table, provided that the session is initiated from the command center VLAN. There is no inbound global routing table access permitted to the IPVS VRF; only the return path to established sessions are permitted. Next, controlled inbound access is implemented by deploying a VPN concentrator.

The VPN concentrator (Cisco VPN 3000 Series) is added to the topology to allow access for selected users in the global routing table to the command center VLAN. The Cisco VPN client on the workstations connects to the VPN concentrator to authenticate the end-user and create a private and secured access to view live or archived video feeds. Adding the concentrator demonstrates a technique by which an external agency, such as a law enforcement department, can be provided with secured and authenticated access over the Internet/extranet.

Because the VPN concentrator allocates an IP address from the IPVS VRF address space, no NAT/pNAT exists inside the crypto tunnel. There are issues with access to a VSOM/Media Server web addresses and ports when these devices are behind a NAT/pNAT device. This is discussed in a separate section.

Address Table

Details of the IP addressing scheme in use for the following topology examples is shown in Table 3.

Table 3 Virtualization IP Addressing Scheme

Routing Table/VLAN	IP Address	Comments
WAN/MAN Global	192.168.15.0/26	MAN/WAN Interfaces (w/ crypto)
vpn4-3800-6 351	192.168.15.28/30	GigabitEthernet0/0.351
vpn4-3800-6 351	192.168.15.28/30	GigabitEthernet0/0.351
vpn4-3800-6 352	192.168.15.48/30	GigabitEthernet0/0.352
Global	10.81.7.0/24	Enterprise end-user
vpn4-3800-6 203	10.81.7.88/29	GigabitEthernet0/0.203
WAN IPVS vrf	192.168.15.64 /26	MAN/WAN Interfaces (w/o crypto)
DMVPN Tu128 IPVS vrf	192.168.15.128/26	vpn-jk2-7206-1 Headend
DMVPN TU192 IPVS vrf	192.168.15.192/26	vpn-jk2-7206-2 Headend
IP VS Net IPVS vrf	192.0.2.0/24	Branch / Command Center Cameras, VSOM, AVG, Media Svr
vpn4-3800-6 IPVS vrf	192.0.2.32/27	Null0 - summary
vpn4-3800-6 IPVS vrf	192.0.2.32/30	Integrated-Service-Engine2/0 (VMSS)
vpn4-3800-6 IPVS vrf	192.0.2.36/30	Video-Service-Engine1/0 (AVG)
vpn4-3800-6 208	192.0.2.48/28	GigabitEthernet0/0.208 (Cameras)
iSCSI IPVS vrf	192.168.nnn.0/24	iSCSI Mgmt networks
vpn1-3845-1 256	192.168.11.0/24	
vpn1-2851-1 254	192.168.111.0/24	
vpn4-3800-6 258	192.168.211.0/24	

Implementation Overview

In the following sections, sample configuration files are shown to demonstrate the techniques used in creating a virtualized network for IP Video Surveillance. These steps include:

- Defining the VRF and Mapping Logical Interfaces
- Mapping Layer-2 (VLAN) to Layer-3 (VRF)
- Configuring VRF-Aware Routing Protocol
- Configuring DMVPN Tunnel Interface
- Configuring WAN Aggregation Router
- Configuring Firewall Interface
- Configuring Firewall Management Interface and Software Version
- Configuring Firewall Routes, Access-lists and NAT/pNAT
- Configuring Policy-based Features of Cisco IP Surveillance Cameras

Defining the VRF and Mapping Logical Interfaces

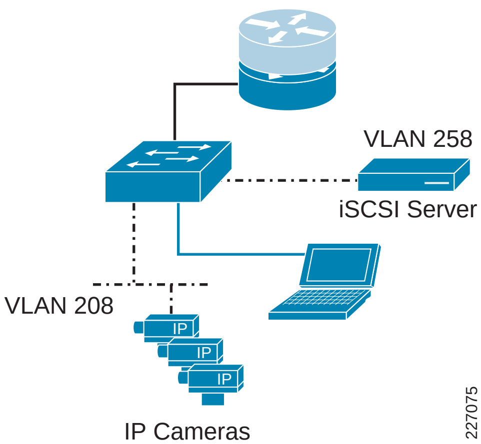
On the branch router, the VRF is defined and the logical interfaces of the AVG and the VMSS network module are associated with the VRF by the **ip vrf forwarding** interface command. The following is an example from one branch router, vpn4-3800-6:

```
hostname vpn4-3800-6
!
ip vrf IPVS
 rd 100:10
 route-target export 100:10
 route-target import 100:10
!
!
interface Video-Service-Engine1/0
 description EVM-IPVS-16A
 ip vrf forwarding IPVS
 ip address 192.0.2.37 255.255.255.252
 ip route-cache flow
 service-module ip address 192.0.2.38 255.255.255.252
 service-module ip default-gateway 192.0.2.37
 no keepalive
!
interface Integrated-Service-Engine2/0
 description NME-VMSS-HP16
 ip vrf forwarding IPVS
 ip address 192.0.2.33 255.255.255.252
 ip route-cache flow
 service-module external ip address 192.168.211.2 255.255.255.0
 service-module ip address 192.0.2.34 255.255.255.252
 service-module ip default-gateway 192.0.2.33
 no keepalive
!
```

Mapping Layer-2 (VLAN) to Layer-3 (VRF)

IP networks are comprised of both Layer-2 (switches) and Layer-3 (routers) devices. To provide for end-to-end segmentation, the VLANs and the VRF must be mapped together. An association between Layer-2 and Layer-3 must be established. Using the branch topology as an example, the IP cameras are attached to access ports in VLAN 208 with an IEEE 802.1Q trunk port connecting the switch and the ISR router. The IPVS iSCSI server is on VLAN 258. The end-user workstations are in the global routing table. The topology is shown in Figure 41.

Figure 41 Mapping VLAN to VRF



The following sample configuration shows the router sub-interface for VLAN 208 and 258. They are associated with the IPVS VRF.

```
vpn4-3800-6#
!
interface GigabitEthernet0/0.208
 description inside interface for ip cameras
 encapsulation dot1Q 208
 ip vrf forwarding IPVS
 ip address 192.0.2.49 255.255.255.240
!
interface GigabitEthernet0/0.258
 description iSCSI Management Subnet
 encapsulation dot1Q 258
 ip vrf forwarding IPVS
 ip address 192.168.211.1 255.255.255.0
!
```

From the switch configuration, the uplink port to the ISR router and the access port for the IP camera is shown. The port for the iSCSI server would be similarly configured as the camera, but in VLAN 258. The following is a sample configuration:

```
!
interface GigabitEthernet1/0/1
 description trunk to vpn4-3800-6
 switchport trunk encapsulation dot1q
 switchport mode trunk
 load-interval 60
 priority-queue out
 mls qos trust dscp
!
interface GigabitEthernet1/0/2
 description CIVS-IPC-2500
 switchport access vlan 208
 switchport mode access
end
```

The mapping of the VLAN to VRF is the responsibility of the supporting router, as the VLAN ID and the VRF name are associated with each other, because both references share the router sub-interface configuration.

Configuring VRF-Aware Routing Protocol

The branch router has interfaces in both the global routing table as well as the IPVS VRF and both network address spaces must be defined to the routing protocol. In the following example, EIGRP is the routing protocol used to illustrate the configuration.

```
!
router eigrp 65
 network 10.81.7.88 0.0.0.7
 network 192.168.15.0 0.0.0.63
 no auto-summary
 !
 address-family ipv4 vrf IPVS
  network 192.0.2.32 0.0.0.31
  network 192.168.15.128 0.0.0.127
  network 192.168.211.0
  no auto-summary
  autonomous-system 65
 exit-address-family
!
```

In the above sample configuration:

- Subnet 192.0.2.32/27 is for the AVG and VMSS network modules and IP cameras.
- Network 192.168.15.128/25 is for the DMVPN tunnels.
- Network 192.168.211.0/24 is for the iSCSI server at this branch.
- In the global routing table, 10.81.7.88/29 is for the end-user workstations and network 192.168.15.0/26 is for the WAN interfaces connecting this branch to the hub routers.

To display an instance of the virtual routing table associated with IPVS, the target VRF must be specified as shown in the following example:

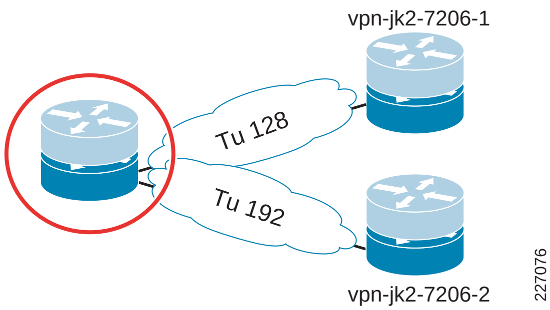
```
vpn4-3800-6#show ip eigrp vrf IPVS neighbors
IP-EIGRP neighbors for process 65
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
1   192.168.15.129          Tu128             14 01:17:47  134   5000  0  182
0   192.168.15.193          Tu192             10 01:17:47  132   5000  0  167
```

In the following section, the DMVPN tunnel interface configuration is shown for Tunnel 128. Tunnel 192 is configured similarly but not shown.

Configuring DMVPN Tunnel Interface

In this section, the configuration from one of the two tunnels of the branch router is shown (see Figure 42). The crypto topology deployed is a DMVPN dual-hub, dual-cloud implementation.

Figure 42 DMVPN Tunnel Interface Configuration



This branch router has a point-to-point Metro-Ethernet MAN link to the primary headend router, vpn-jk2-7206-1. This interface is in the global routing table and is VLAN 332 through the service provider network.

```
!
interface GigabitEthernet0/1.332
 encapsulation dot1Q 332
 ip address 192.168.15.46 255.255.255.252
!
```

The logical tunnel interface is in the IPVS VRF, the tunnel source is the above interface in the global routing table and the destination is Loopback 0 interface on vpn-jk2-7206-1, which is also in the global routing table.

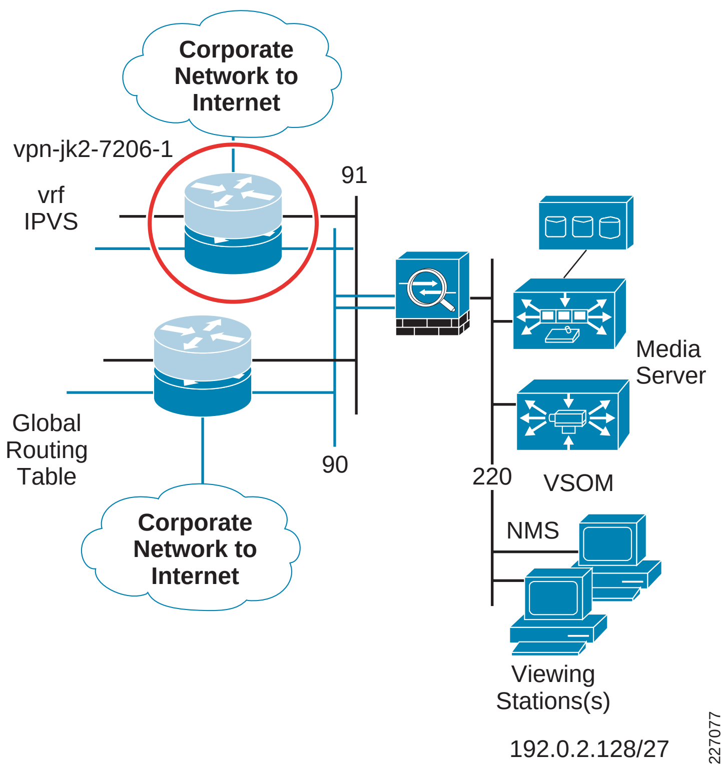
```
!
interface Tunnel128
 ip vrf forwarding IPVS
 ip address 192.168.15.130 255.255.255.192
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map 192.168.15.129 192.168.15.40
 ip nhrp map multicast 192.168.15.40
 ip nhrp network-id 128
 ip nhrp nhs 192.168.15.129
 ip summary-address eigrp 65 192.0.2.0 255.255.255.224 5
 tunnel source GigabitEthernet0/1.332
 tunnel destination 192.168.15.40
 tunnel key 128
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile
!
ip route 192.168.15.40 255.255.255.255 192.168.15.45 name vpn-jk2-7206-1_Loopback_0
!
end
```

A static route to the tunnel destination is included so that this tunnel interface has an affinity to the physical interface; Tunnel 128 traffic is always transported over VLAN 332.

Configuring WAN Aggregation Router

This section examines the interfaces and topology of the WAN aggregation routers (see Figure 43). There are two WAN aggregation routers for high availability to the branch locations. Only one of these two similarly configured WAN aggregation router configuration is shown for the sake of brevity.

Figure 43 WAN Aggregation Router Configuration



The WAN aggregation router vpn-jk2-7206-1 has interfaces in both the global routing table and in the IPVS VRF. For clarity, the interfaces in the global routing table are shown in blue in the following sample configuration. The IPVS interfaces are shown in black text. The tunnel's logical interface is in the IPVS VRF while the tunnel source/destination IP addresses are in the global routing table.

```
vpn-jk2-7206-1#sh run b | beg interface Loopback0
interface Loopback0
 description Loopback for Global RT
 ip address 192.168.15.40 255.255.255.255
!
interface Tunnel128
 description DMVPN tunnel/cloud to Branches
 ip vrf forwarding IPVS
 ip address 192.168.15.129 255.255.255.192
 no ip redirects
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map multicast dynamic
 ip nhrp map multicast 192.168.15.40
 ip nhrp network-id 128
 ip nhrp nhs 192.168.15.129
 ip nhrp server-only
 ip route-cache flow
 no ip split-horizon eigrp 65
 ip summary-address eigrp 65 192.0.2.0 255.255.255.0 5
 tunnel source Loopback0
 tunnel mode gre multipoint
 tunnel key 128
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile
!
interface Tunnel300
 description DMVPN Tunnel to Enterprise/Internet
```

```
 ip address 10.81.7.254 255.255.255.240
 ip mtu 1400
 ip pim sparse-mode
 ip nhrp authentication BAR
 ip nhrp map multicast dynamic
 ip nhrp map 10.81.7.241 64.102.223.24
 ip nhrp map multicast 64.102.223.24
 ip nhrp network-id 22341
 ip nhrp nhs 10.81.7.241
 ip route-cache flow
 load-interval 30
 tunnel source FastEthernet0/0
 tunnel destination 64.102.223.24
 tunnel key 300
 tunnel protection ipsec profile DMVPN_IPSEC_PROFILE
!
interface FastEthernet0/1.90
 description ASA DMZ Global
 encapsulation dot1Q 90
 ip address 10.81.7.161 255.255.255.248
 ip flow ingress
 standby 0 ip 10.81.7.166
 standby 0 preempt delay minimum 60
!
interface FastEthernet0/1.91
 description ASA DMZ vrf IPVS
 encapsulation dot1Q 91
 ip vrf forwarding IPVS
 ip address 192.168.15.97 255.255.255.248
 ip flow ingress
 standby 0 ip 192.168.15.102
 standby 0 preempt delay minimum 60
!
!
interface FastEthernet0/1.332
 description MAN/WAN to Site 130 (vpn1-2851-1)
 encapsulation dot1Q 332
 ip address 192.168.15.45 255.255.255.252
 ip flow ingress
!
interface FastEthernet0/1.340
 description MAN/WAN to Site 140 (vpn1-3845-1)
 encapsulation dot1Q 340
 ip address 192.168.15.13 255.255.255.252
 ip flow ingress
!
interface FastEthernet0/1.342
 description MAN/WAN to Site 140 (vpn1-3845-1)
 encapsulation dot1Q 342
 ip vrf forwarding IPVS
 ip address 192.168.15.77 255.255.255.252
 ip flow ingress
 ip summary-address eigrp 65 192.0.2.0 255.255.255.0 5
!
interface FastEthernet0/1.352
 description MAN/WAN to Site 150 (vpn4-3800-6)
 encapsulation dot1Q 352
 ip address 192.168.15.49 255.255.255.252
 ip flow ingress
!
end
```

The Cisco ASA 5510 firewall is connected to the two WAN aggregation routers and there are FastEthernet interfaces in both the global and IPVS VRF to the firewall. Two of the three branch routers in this topology are cryptography-enabled and have a single MAN link between the branch and each aggregation router. One branch, vpn1-3845-1 (Site 140), router demonstrates a branch without crypto on the MAN, and to implement path isolation, there are two physical links, one in the global routing table and one in the IPVS VRF.

Connectivity from this central command center location to the remainder of the corporate network and to the Internet is provided by way of Tunnel300 in the global routing table.

Configuring Firewall Interface

Referring to the topology in Figure 43 on page 6-98, the firewall interface configuration is shown below. The blue text highlights the interface description in the global routing table while the interfaces in black text are associated with the VRF IPVS.

```
!
interface Ethernet0/0
 description Campus_IPVS VLAN 220
 nameif Campus_IPVS
 security-level 70
 ip address 192.0.2.129 255.255.255.224
!
interface Ethernet0/1
 description DMZ_IPVS VLAN 91
 nameif DMZ_IPVS
 security-level 50
 ip address 192.168.15.99 255.255.255.248
!
interface Ethernet0/2
 description DMZ_Global VLAN 90
 nameif DMZ_Global
 security-level 10
 ip address 10.81.7.163 255.255.255.248
!
```

In this topology, the firewall is functioning as a policy-based network virtual device and there are no interface configuration commands that make the ASA 5510 VRF-aware. The interface named *Campus_IPVS* is attached to VLAN 220 on the campus switch. Access to this address space from the global routing table and branch locations in the IPVS VRF is policy-based. The firewall configuration controls the access between the three interfaces.

Configuring Firewall Management Interface and Software Version

A management interface is connected to the lab FlashNet network to facilitate software upgrades and out-of-band (OOB) management of the firewall. The management interface-related commands are shown below and will not be referenced in any subsequent sections of this chapter.

```
!
interface Management0/0
 description FlashNET
 speed 100
 duplex full
 nameif FlashNET
 security-level 0
 ip address 172.26.156.3 255.255.254.0
!
route FlashNET 172.26.0.0 255.255.254.0 172.26.156.1 1
!
```

```
access-group MANAGEMENT in interface FlashNET control-plane
access-list MANAGEMENT extended permit tcp 172.26.0.0 255.255.254.0 interface FlashNET

http server enable
http 172.26.156.0 255.255.254.0 FlashNET
snmp-server location ESE Lab
snmp-server contact foo.bar@cisco.com
snmp-server enable traps snmp authentication linkup linkdown coldstart
!
telnet 172.26.156.0 255.255.254.0 FlashNET
telnet timeout 60
!
ssh 172.26.156.0 255.255.254.0 FlashNET
ssh timeout 60
console timeout 0
```

The software version used in testing is: as follows

```
vpn-jk2-asa5510-1# sh ver

Cisco Adaptive Security Appliance Software Version 8.0(4)
Device Manager Version 6.1(5)51

Compiled on Thu 07-Aug-08 20:53 by builders
System image file is "disk0:/asa804-k8.bin"
```

Configuring Firewall Routes, Access-lists and NAT/pNAT

The global routing table has the lowest security-level (ignoring the security-level 0 management interface, FlashNet) and this configuration is intended to deny access to the IPVS VRF from the outside. No access-lists are configured to permit inbound access. The branch locations are in the IPVS VRF which is at security-level of 50, lower than the security level of the command center at 70. For initiating access from a lower value security level to a higher value requires the definition of access-list.

The access-lists are configured on the firewall to permit the branch routers, switches, cameras and the iSCSI servers to send traffic to the network management server(s) located in the command center.

The following sample configuration assumes that syslog, snmptraps, NetFlow export (UDP port 7777) and any viewing stations at the branch (TCP to port 80 or WWWW) are permitted from the branch IPVS VRF to the command center.

```
!
access-list IPVS-CC extended permit udp any 192.0.2.128 255.255.255.224 eq syslog
access-list IPVS-CC extended permit udp any host 192.0.2.139 eq snmptrap
access-list IPVS-CC extended permit udp any host 192.0.2.139 eq 7777
access-list IPVS-CC extended permit tcp 192.0.2.0 255.255.255.0 any eq www
access-group IPVS-CC in interface DMZ_IPVS
!
```

For troubleshooting purposes, ICMP is also permitted. This can be disabled if specified by the security policy of the enterprise network.

```
icmp unreachable rate-limit 1 burst-size 1
icmp permit any Campus_IPVS
icmp permit any DMZ_IPVS
icmp permit any DMZ_Global
!
```

The two next-hop IP addresses in the following route statements are HSRP addresses configured on the WAN aggregation routers: 10.81.7.166 and 192.168.15.102. A default route is configured for the global routing table and routes to the IP addresses present in the IPVS VRF are shown.

```
route DMZ_Global 0.0.0.0 0.0.0.0 10.81.7.166 1
route DMZ_IPVS 192.0.2.0 255.255.255.0 192.168.15.102 1
route DMZ_IPVS 192.168.11.0 255.255.255.0 192.168.15.102 1
route DMZ_IPVS 192.168.111.0 255.255.255.0 192.168.15.102 1
route DMZ_IPVS 192.168.211.0 255.255.255.0 192.168.15.102 1
!
```

Tip In this example, the IP subnets for the iSCSI management networks are not allocated from contiguous address space. Had that been done, these three routes could have been consolidated into a single route, as is the case with the 192.0.2.0 network. Address allocation that allows summarization is an aid to reducing the size and complexity of configurations.

Lastly, the NAT/pNAT configuration implements the policy that the command center address space is port address translated (PAT) to the global interface IP address. No address or port translation takes place between the IPVS VRF address space at the branch locations and the command center.

```
global (DMZ_Global) 1 interface
nat (Campus_IPVS) 1 192.0.2.128 255.255.255.224
static (Campus_IPVS,DMZ_IPVS) 192.0.2.128 192.0.2.128 netmask 255.255.255.224
```

Configuring Policy-based Features of Cisco IP Surveillance Cameras

The Cisco 2500 Series IP cameras have several policy-based features that protect the camera resource from unauthorized access. There are three steps in initiating a video feed between the camera and the media server.

1. First, the authentication step, is initiated via HTTPS and as such the payload of this session is encrypted. The control plane negotiation, RTSP, and the video feed, RTP, are not secured by any payload encryption. The topology described in this section demonstrates how IPSec encryption can be implemented on the WAN to provide encryption and the resulting privacy of video feeds that leave the campus for live or archive viewing, or for archive backup.
2. The camera software includes access control, through userid and password, which is configured on both the camera configuration and the corresponding VSOM definition of the camera. Because the Cisco camera software allows only a single concurrent login, a unique account (userid) for the media server, when the camera is defined through VSOM, is recommended. This allows an administrator to be logged on the camera while the media server is starting or stopping video feeds. This aids in troubleshooting. The log files can be viewed in real-time without disrupting the command and control function of the media server.
3. The Cisco 2500 Series IP camera software, as many other vendor camera software does, provides an access control-list to permit or deny what IP addresses are authorized to attempt to access the camera. While implementations differ, one advantage of the Cisco implementation is the ability to define a range of IP address and either permit or deny access from that range. The addressing scheme deployed in this test topology uses 192.0.2.0/24 for branch and command center IPVS VRFs. The WAN interfaces and the iSCSI network address is in the 192.168.0.0/16 address space. Given this addressing scheme, a workstation in the command center in the 192.0.2.128/27 address space or the branch VMSS network modules at 192.0.2.2/32, 192.0.2.34/32 and 192.0.2.65/32, can access their respective cameras when all cameras are configured to:

   permit ip 192.0.2.0 255.255.255.0

   deny ip any

The advantage of selecting an address scheme that can be consolidated in this manner provides a simple configuration on all IP cameras in the network, yet provides a reasonable level of access control that does not require frequent updates.

Tip Both 192.0.2.0/24 and 192.168.0.0/16 are RFC3330 special use IPv4 addresses. 192.0.2.0/24 is assigned as *TEST-NET* and used in documentation and example code. 192.168.0.0/16 is used in private networks and is documented in RFC1918. Neither address block should appear, or be routed, on the public Internet.

Summary

This section addressed the need for implementing a logically separate IP network infrastructure to support an IP based video surveillance deployment in an existing enterprise network. Both control plane virtualization as well as policy-based techniques are deployed. IPSec encryption is also implemented to leverage the inherent path isolation of a logical tunnel as well as to make private the video feeds as they traverse the MAN/WAN. Access to resources outside the IPVS VRF must be initiated from hosts on the command center in order for the firewall to permit inbound packets. Because the IP addressing in use is based on addresses that are not routed on the public Internet, the firewall implements NAT/pNAT of these sessions from the IPVS VRF to the Internet or other enterprise address space.

In this next section, the configuration is enhanced to permit workstations external to the IPVS address space to view video feeds.

External Access to IPVS VRF

The goal of this section is to demonstrate a method of providing access to video feeds for viewing stations (PCs) that are in the global routing table, extranet, or even the Internet.

Topology Description

To accomplish this, a VPN concentrator, a Cisco VPN 3080, is deployed on the remaining unused interface on the Cisco ASA 5510 firewall. Client PCs connect to the VPN concentrator by installing the VPN 3000 client software from *www.cisco.com*. Access to the VPN concentrator is authenticated on a group name and key, as well as a userid and password. In these examples, the group/key and userid/password are stored locally on the VPN concentrator and can be administered by the command center security operations manager, or based on enterprise security policies, can be in an external database. The external authentication server database option improves scalability and manageability.

Because the VPN concentrator uses IPSec encryption, the video feeds that are leaving IPVS VRF through the command center VLAN are encrypted and hashed. In testing 3DES/HMAC-MD5 is used. To limit outside access to the VPN concentrator, the firewall is configured to permit inbound access to the outside interface of the VPN concentrator to only.

- UPD 500 (IKE)
- UDP 4500 (IKE/IPSEC with NAT-T)
- Protocol ESP (Protocol ‘50’)
- ICMP (for troubleshooting and verification of connectivity)

This firewall configuration, therefore, rejects all other packets that are not required for transporting the IKE/IPSec tunnels and ICMP (ping). This, in addition to deploying a group/key and userid/password to authenticate the end-users, is a commonly deployed best practice.

Alternatives to the VPN Concentrator

Cisco announced the end-of-sale and end-of-life dates for the Cisco® VPN 3000 Series Concentrators. The product becomes obsolete August 4, 2012. See the *EOL/EOS for the VPN 3000 Series Concentrators* document on www.cisco.com.

An alternative to the VPN concentrator is a remote access solution based on Secure Sockets Layer Virtual Private Network (SSL VPN). SSL VPN clients can be terminated on a Cisco ASA 5500 Series device or on a Cisco modular ISR routers (1800, 2800, 3800) with the appropriate SSL VPN hardware acceleration.

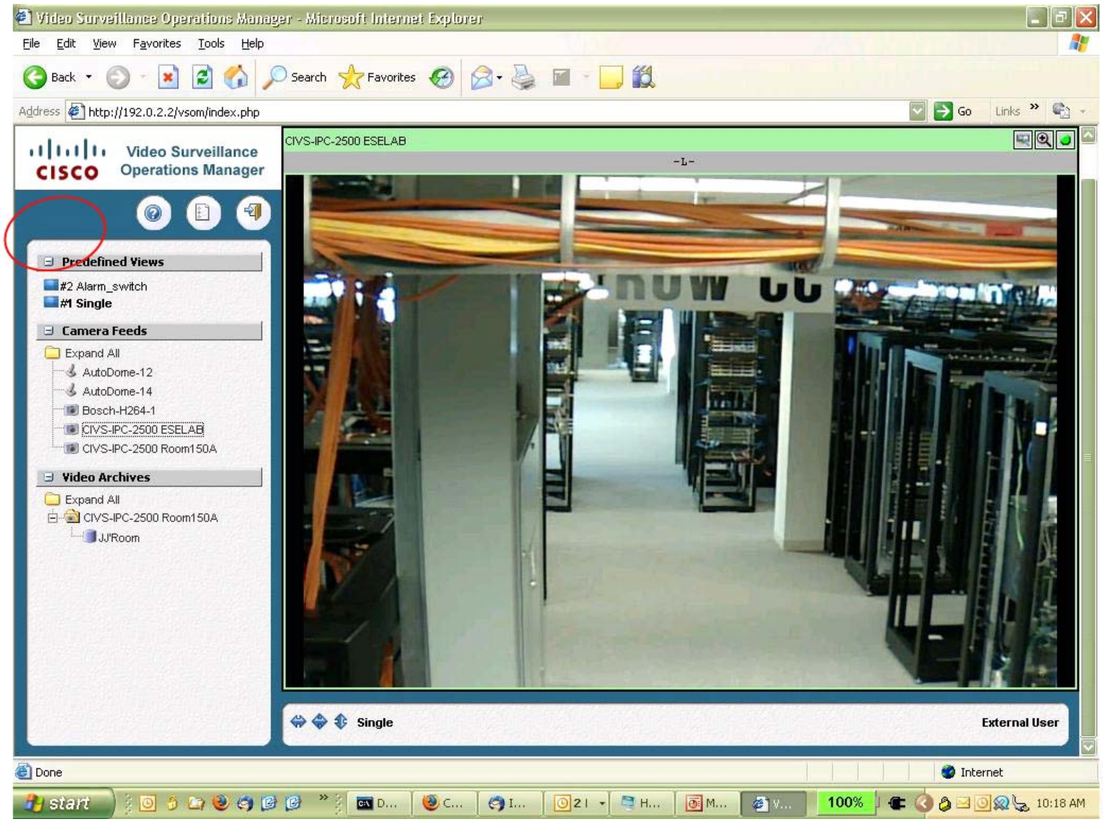
As a best practice, terminate the VPN concentration function on a device separate from the firewall. In other words, an ISR router or ASA device could be substituted for the VPN 3000 Series concentrator shown.

Limiting Authority in VSOM

Once the remote PC has connected and authenticated to the VPN Concentrator, the user has access to devices in the IPVS VRF. In the previous section, the policy-based features of the IP surveillance cameras are implemented to limit access to a configured address space within the IPVS VRF. The VPN concentrator is configured with an address pool that is not included in the IP camera access-list, which means users connecting through the VPN concentrator are not permitted direct access to the web server on the camera.

For remote users to view the live or archive video feeds, they must connect to the appropriate Video Surveillance Operations Manager (VSOM)/Media Server Web Server using a supported browser. To gain access to the video feeds, a userid and password must be entered. It is recommended that users are provided only the privileges necessary for their job function. In this case, the remote user only requires operator privileges, and as such a user account is configured accordingly. When a user with only operator privileges is logged on VSOM, no admin icon exists on the screen; the user may view live or archived video, but no configuration changes are permitted. A sample operator screen is shown in Figure 44.

Figure 44 Sample VSOM Operator Screen



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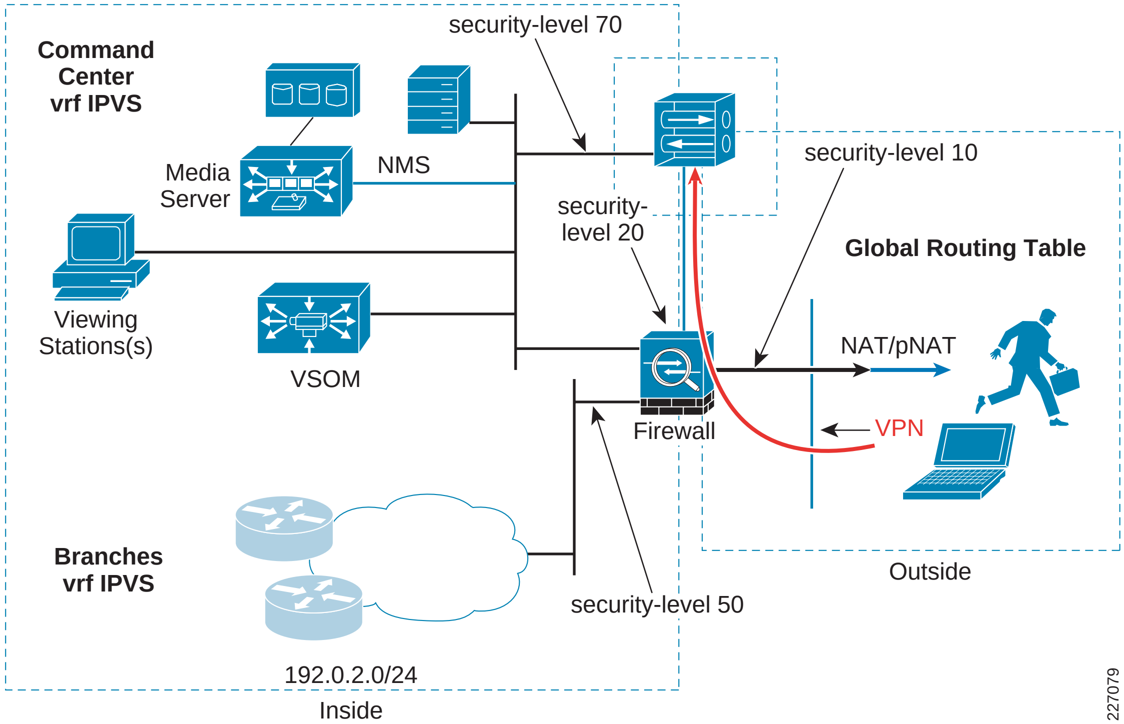
Other than the obvious differences associated with available bandwidth to the remote user, there is no difference in the presentation of the video feed for a remote user connected through the VPN concentrator versus a PC attached to the LAN in the command center.

Topology Diagram

The VPN concentrator consists of a public and private interface configuration. The public, or outside, interface is attached to the remaining unused interface on the ASA5510. The private (or inside) interface is attached to the LAN switch on VLAN 220, the command center VLAN. The security level of the ASA interface connecting to the VPN concentrator is 20. Because this value is numerically higher than the firewall outside interface with security-level 10, access-control lists are created on the firewall to allow the port numbers and protocols permitted to reach the VPN concentrator.

Figure 45 illustrates where in the topology the VPN concentrator is located.

Figure 45 Virtualization Topology with VPN Concentrator



The revised interface configuration of the ASA 5510 and the IP addressing for the VPN concentrator is shown in the following subsections.

Implementation Overview

To show how the VPN concentrator is deployed in the topology, the following configuration steps are implemented or updated from the previous sections.

- Configuring VPN Concentrator Interface and Address
- Configuring Firewall Interface
- Configuring WAN Aggregation Routing
- Configuring Firewall NAT/pNAT and Routing
- Configuring Firewall Access-lists
- Configuring VPN Concentrator User/Group/Proposals

Configuring VPN Concentrator Interface and Address

The public VPN concentrator interface is on a point-to-point network to the firewall. The VPN concentrator is at 10.81.7.57 and the firewall is at 10.81.7.58. The public interface in the global routing table is highlighted in blue. The management interface on FlashNET is shown, but is optional.

```
vpn2-3080-1: Config -> 1

This table shows current IP addresses.

  Intf          Status       IP Address/Subnet Mask          MAC Address
-------------------------------------------------------------------------------
```

```
Ether1-Pri|      UP       |    192.0.2.136/255.255.255.224| 00.03.A0.88.3F.58
Ether2-Pub|      UP       |     10.81.7.57/255.255.255.252| 00.03.A0.88.3F.59
Ether3-Ext|      UP       |  172.26.157.15/255.255.254.0  | 00.03.A0.88.3F.5A
```

The remote clients are allocated an IP address from the configured pool. This assigned address is used to identify the remote PC inside the IPSec tunnel interface. The address pool list used in this configuration is five IP addresses from the 192.168.15.64/29 subnet. If more concurrent remote sessions are required, a larger IP address pool must be allocated. Allocate as a large a pool as required, but not more than necessary.

```
vpn2-3080-1: Address -> 2

  This is the Address Pool List

   Start Addr          End Addr          Subnet Mask
------------------------------------------------------
 192.168. 15. 65 | 192.168. 15. 70 | 255.255.255.248 |
------------------------------------------------------
```

The IP routing configuration on the VPN concentrator is straight forward. A default route is configured to the firewall IP address and a network route is configured to 192.0.2.0/24. As discussed in the previous sections, note the iSCSI devices and the WAN interfaces in the IPVS VRF are allocated from the 192.168.0.0/16 address space; therefore, with this configuration, the remote users can only reach IP hosts on the 192.0.2.0/24 subnet: the VSOM and Media Servers. The IP cameras are on the 192.0.2.0/24 subnet, but access-control lists prevent any connectivity from source IP address in the address pool 192.168.15.64/29.

```
vpn2-3080-1: Routing -> 1

Static Routes
-------------
Destination     Mask            Metric Destination
------------------------------------------------------------
0.0.0.0         0.0.0.0              8 10.81.7.58
172.26.0.0      255.255.0.0          1 172.26.156.1
192.0.2.0       255.255.255.0        8 192.0.2.129
```

Note The 172.26.0.0 network is lab FlashNet for management of the device.

Configuring Firewall Interface

The previously unused interface Ethernet 0/3 is now deployed as the point-to-point interface to the VPN concentrator. All other interfaces are the same as discussed in the previous sections. The interfaces in the global routing table are highlighted in blue.

```
vpn-jk2-asa5510-1# show run
: Saved
:
ASA Version 8.0(4)
!
hostname vpn-jk2-asa5510-1
domain-name ese.cisco.com
enable password [removed] encrypted
passwd [removed] encrypted
names
dns-guard
!
interface Ethernet0/0
 description Campus_IPVS VLAN 220
```

```
 nameif Campus_IPVS
 security-level 70
 ip address 192.0.2.129 255.255.255.224
!
interface Ethernet0/1
 description DMZ_IPVS VLAN 91
 nameif DMZ_IPVS
 security-level 50
 ip address 192.168.15.99 255.255.255.248
!
interface Ethernet0/2
 description DMZ_Global VLAN 90
 nameif DMZ_Global
 security-level 10
 ip address 10.81.7.163 255.255.255.248
!
interface Ethernet0/3
 description DMZ for VPN3080
 nameif DMZ_VPN3080
 security-level 20
 ip address 10.81.7.58 255.255.255.252
!
```

There is no NAT/pNAT address translation between Ethernet 0/2 and Ethernet 0/3. The WAN aggregation routers must have a route to the VPN concentrator IP address, 10.81.7.57.

Configuring WAN Aggregation Routing

The WAN aggregation routers needs to be configured to include the two additional IP networks which are required to support the VPN concentrator. These networks are the public interface and the IP address pool for the remote client workstations. In this sample topology, these networks are

- 10.81.7.56/30 —Public subnet
- 192.168.15.64/29—IP address pool

Because the WAN routers are not exchanging routing updates from the firewall and VPN concentrator, a static route for the public subnet must be added to the global routing table and redistributed to the dynamic routing protocol to update the global routing tables.

```
ip route 10.81.7.56 255.255.255.252 10.81.7.163 name ASA5510
```

The second route is included in the IPVS VRF, and is also redistributed to the dynamic routing protocol to inform the branch routers of this route.

```
ip route vrf IPVS 192.168.15.64 255.255.255.248 192.168.15.99 name VPN3080_pool
!
```

The remainder of the WAN aggregation routers configuration addresses defining these two networks in the appropriate prefix-list and route-map and then redistributing these networks under the appropriate autonomous system (AS) number and VRF.

```
ip prefix-list ASA5510_VPN3080 seq 5 permit 10.81.7.56/30
!
route-map ASA5510_VPN3080 permit 10
 match ip address prefix-list ASA5510_VPN3080
!
ip prefix-list COMMAND_CENTER seq 100 permit 192.0.2.128/25
ip prefix-list COMMAND_CENTER seq 101 permit 10.81.7.0/24
ip prefix-list COMMAND_CENTER seq 102 permit 192.168.15.64/29
!
route-map COMMAND_CENTER permit 10
 match ip address prefix-list COMMAND_CENTER
```

```
 set tag 2128
!
router eigrp 64
 redistribute static metric 1000 100 255 1 1500 route-map ASA5510_VPN3080
 redistribute eigrp 65 metric 1000 100 255 1 1500 route-map Branch_Networks
 passive-interface FastEthernet0/1.90
 network 10.0.0.0
 no auto-summary
 eigrp stub connected redistributed
!
router eigrp 65
 redistribute eigrp 64 metric 1000 100 255 1 1500 route-map DEFAULT
 network 192.168.15.0 0.0.0.63
 no auto-summary
 !
 address-family ipv4 vrf IPVS
  redistribute static metric 1000 10 255 1 1500 route-map COMMAND_CENTER
  network 192.168.15.64 0.0.0.63
  network 192.168.15.128 0.0.0.63
  distribute-list route-map Branch_Net_vrf_IPVS_RT in
  no auto-summary
  autonomous-system 65
 exit-address-family
!
```

Note EIGRP AS 64 is used to connect to the enterprise address space. EIGRP AS 65 is used to connect to the branch networks for both the global routing table and the IPVS VRF.

Configuring Firewall NAT/pNAT and Routing

The NAT/pNAT configuration on the firewall is changed by adding two static entries to the configuration deployed in the previous section. The first static entry for 192.168.15.56/30 defines that no address translation occurs between the outside global routing table and the point-to-point network address between the firewall and the concentrator.

The second static entry, for 192.168.15.64, defines that no address translation occurs for the IP address pool defined in the VPN concentrator for remote users and the IPVS VRF.

```
global (DMZ_Global) 1 interface
nat (Campus_IPVS) 1 192.0.2.128 255.255.255.224
!
static (DMZ_VPN3080,DMZ_Global) 192.168.15.56 192.168.15.56 netmask 255.255.255.252
static (Campus_IPVS,DMZ_IPVS) 192.0.2.128 192.0.2.128 netmask 255.255.255.224
static (Campus_IPVS,DMZ_IPVS) 192.168.15.64 192.168.15.64 netmask 255.255.255.248
!
```

A route in the firewall for the concentrator address pools is required. All other routes are the same as from the previous section.

```
route Campus_IPVS 192.168.15.64 255.255.255.248 192.0.2.136 1
!
```

Configuring Firewall Access-lists

In addition to the access-list and group IPVS-CC, documented in the previous section, with the addition of the VPN concentrator, access-lists permitting the protocols and ports needed for the encryption protocols are added to the firewall configuration. Protocol ESP, UDP 500 and 4500, and ICMP are permitted. This allows the remote VPN client to contact the concentrator.

```
access-group INBOUND in interface DMZ_Global
access-list INBOUND extended permit esp any host 10.81.7.57
access-list INBOUND extended permit udp any host 10.81.7.57 eq isakmp
access-list INBOUND extended permit udp any host 10.81.7.57 eq 4500
access-list INBOUND extended permit icmp any host 10.81.7.57

icmp permit any DMZ_VPN3080
!
```

The VPN concentrator is at IP address 10.81.7.57.

Configuring VPN Concentrator User/Group/Proposals

It is recommended to use an external database server for authentication in large deployments. A complete VPN concentrator configuration is outside the scope of this document, however, configuration notes for the miscellaneous configuration for the user, group, and IKE proposals are shown below.

```
vpn2-3080-1: User Management -> 2

                              Current User Groups
-------------------------------------------------------------------------------
| 1. foo (Internal)                   |                                       |
-------------------------------------------------------------------------------

vpn2-3080-1: User Management -> 3

Internal groups are configured on the VPN 3000 Concentrator's Internal Database.
ESP-3DES-MD5 with IKE Keepalive - Tunnel Type is Remote Access - Authentication Internal
IPSec UDP (allow NAT-T)

                                   Current Users
-------------------------------------------------------------------------------
| 1. aprilmay                         |                                       |
-------------------------------------------------------------------------------

User(s) arein group 'foo', IPSEC and WebVPN are selected as the tunneling protocol with a
30 minute idle timeout, Simultaneous Logins (5000)  ESP-3DES-MD5 and store password
on client is permitted (when using the software client, authenticating user is prompted by
the VPN software client on the PC)

vpn2-3080-1: IKE Proposals -> 1

                           The Active IKE Proposals
-------------------------------------------------------------------------------
| 1. IKE-3DES-MD5                     | 2. IKE-3DES-SHA                       |
-------------------------------------------------------------------------------
```

In testing the userid of **aprilmay**, the configured password is entered when prompted for this information by the Cisco VPN client. The group name **foo** and group key are configured in the client software along with the destination IP address of the concentrator, 10.81.7.57 and IPSec/UDP is defined as the transport.

Summary

This section addresses the need to provide secure, authenticated, network access from the enterprise network and the public Internet to the video surveillance VRF for real-time viewing of surveillance feeds. One method of accomplishing this is through the use of a VPN concentrator that can be accessed by appropriately configured workstations. This technique extends access to the segemented and logically isolated video surveillance deployment from any location with sufficient bandwidth to view the video feed.

References

The concepts in this chapter are intended to be focused on a targeted deployment for implementing IP video surveillance at the branch and central command center campus with controlled access from the enterprise network. For additional deployment information and a more thorough discussion of these concepts, refer to the following documents:

- *Network Virtualization—Path Isolation Design Guide Network Virtualization 3.0 - CVD*

  http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/PathIsol.html
- *Ethernet Access for Next Gen Metro and Wide Area Networks*

  http://www.cisco.com/en/US/docs/solutions/Enterprise/WAN_and_MAN/Ethernet_Access_for_NG_MAN_WAN_V3.1_external.html
- Other relevant Cisco Validated Design (CVD) design guides, refer to the following URL:

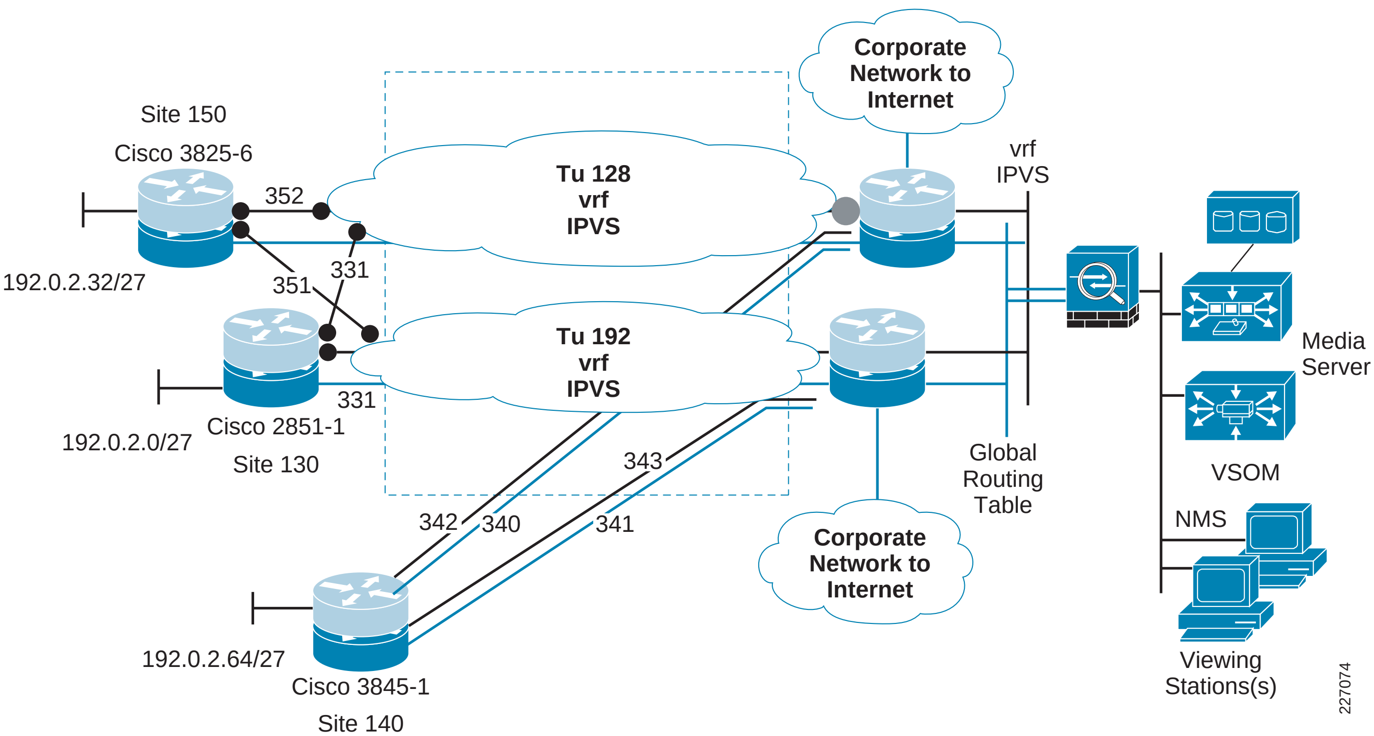
  www.cisco.com/go/designzone

CHAPTER 7

Network Diagram and Configuration Files

This chapter contains a topology diagram and the associated router, firewall, and switch configuration files for the devices in this sample implementation. See Figure 1.

Figure 1 Network Diagram



Router and Firewall Configurations

In this section the running configuration files from the routers shown in the previous topology diagram are included as reference.

vpn-jk2-7206-1

This configuration is for the upper WAN aggregation router shown in the topology diagram.

```
!
! Last configuration change at 13:06:43 edt Tue Aug 4 2009
! NVRAM config last updated at 13:07:50 edt Tue Aug 4 2009
!
upgrade fpd auto
version 12.4
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service password-encryption
!
hostname vpn-jk2-7206-1
!
boot-start-marker
boot system flash disk0:c7200-adventerprisek9-mz.124-15.T5
boot-end-marker
!
logging buffered 2000000
enable secret 5 [removed]
!
no aaa new-model
clock timezone est -5
clock summer-time edt recurring
ip wccp 61
ip wccp 62
ip cef
!
!
no ip dhcp use vrf connected
!
!
!
ip vrf IPVS
 rd 100:10
 route-target export 100:10
 route-target import 100:10
!
no ip domain lookup
ip domain name cisco.com
ip host rtp5-esevpn-ios-ca 10.81.0.27
ip multicast-routing
ip auth-proxy max-nodata-conns 3
ip admission max-nodata-conns 3
!
multilink bundle-name authenticated
!
!
!
crypto pki trustpoint rtp5-esevpn-ios-ca
 enrollment url http://rtp5-esevpn-ios-ca:80
 revocation-check none
!
!
crypto pki certificate chain rtp5-esevpn-ios-ca
 certificate 0D
  3082023A 308201A3 A0030201 0202010D 300D0609 2A864886 F70D0101 04050030
  6B310C30 0A060355 04081303 204E4331 11300F06 03550407 13082052 616C6569
  419A9E33 E84ABC15 FCCFB1CC EBC1AE94 F07752CC 22A803C7 99AE4097 BA2D
    quit
```

```
 certificate ca 01
  308202AF 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 04050030
  47DC2CE3 BC3F5F40 32409535 C9E0E6C0 F29D4E
    quit
archive
 log config
  hidekeys
!
!
crypto isakmp policy 100
 encr 3des
 group 2
crypto isakmp keepalive 10
crypto isakmp nat keepalive 10
crypto isakmp profile IPVS_Branches_isakmp_profile
   description IPVS_Branches_isakmp_profile
   self-identity address
   ca trust-point rtp5-esevpn-ios-ca
   match identity host domain ese.cisco.com
crypto isakmp profile DMVPN_IKE_PROFILE
   description DMVPN Profile
   self-identity fqdn
   ca trust-point rtp5-esevpn-ios-ca
   match identity address 64.102.223.24 255.255.255.255
   keepalive 10 retry 2
!
!
crypto ipsec transform-set 3DES_SHA_TUNNEL esp-3des esp-sha-hmac
crypto ipsec transform-set 3DES_SHA_TRANSPORT esp-3des esp-sha-hmac
 mode transport
!
crypto ipsec profile DMVPN_IPSEC_PROFILE
 set transform-set 3DES_SHA_TRANSPORT
 set isakmp-profile DMVPN_IKE_PROFILE
!
crypto ipsec profile IPVS_Branches_ipsec_profile
 description IPVS_Branches_ipsec_profile
 set transform-set 3DES_SHA_TRANSPORT 3DES_SHA_TUNNEL
 set isakmp-profile IPVS_Branches_isakmp_profile
!
!
controller ISA 5/1
!
!
class-map match-any LOW-LATENCY-DATA
 match ip dscp af21  af22  af23
class-map match-any HIGH-THROUGHPUT-DATA
 match ip dscp af11  af12  af13
class-map match-all BROADCAST-VIDEO
 match ip dscp cs5
class-map match-all NETWORK-CONTROL
 match ip dscp cs6
class-map match-any MULTIMEDIA-CONFERENCING
 match ip dscp af41  af42  af43
class-map match-all OAM
 match ip dscp cs2
class-map match-all VOICE
 match ip dscp ef
class-map match-all SCAVENGER
 match ip dscp cs1
class-map match-any CALL-SIGNALING
 match ip dscp cs3
!
!
```

```
policy-map IPVS_BRANCH
 class BROADCAST-VIDEO
  bandwidth percent 40
 class VOICE
  priority percent 10
 class LOW-LATENCY-DATA
  bandwidth percent 4
 class HIGH-THROUGHPUT-DATA
  bandwidth percent 4
 class MULTIMEDIA-CONFERENCING
  bandwidth percent 4
 class SCAVENGER
  bandwidth percent 1
 class OAM
  bandwidth percent 1
 class NETWORK-CONTROL
  bandwidth percent 1
 class CALL-SIGNALING
  bandwidth percent 1
 class class-default
  fair-queue
policy-map 30M
 class class-default
  shape average 30000000
  service-policy IPVS_BRANCH
!
!
!
!
!
interface Loopback0
 description Loopback for Global RT
 ip address 192.168.15.40 255.255.255.255
!
interface Tunnel128
 description DMVPN tunnel/cloud to Branches
 ip vrf forwarding IPVS
 ip address 192.168.15.129 255.255.255.192
 no ip redirects
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map multicast dynamic
 ip nhrp map multicast 192.168.15.40
 ip nhrp network-id 128
 ip nhrp nhs 192.168.15.129
 ip nhrp server-only
 ip route-cache flow
 no ip split-horizon eigrp 65
 ip summary-address eigrp 65 192.0.2.0 255.255.255.0 5
 tunnel source Loopback0
 tunnel mode gre multipoint
 tunnel key 128
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile
!
interface Tunnel300
 description DMVPN Tunnel to Enterprise/Internet
 ip address 10.81.7.254 255.255.255.240
 ip mtu 1400
 ip pim sparse-mode
 ip nhrp authentication BAR
 ip nhrp map multicast dynamic
 ip nhrp map 10.81.7.241 64.102.223.24
 ip nhrp map multicast 64.102.223.24
 ip nhrp network-id 22341
```

```
 ip nhrp nhs 10.81.7.241
 ip route-cache flow
 load-interval 30
 tunnel source FastEthernet0/0
 tunnel destination 64.102.223.24
 tunnel key 300
 tunnel protection ipsec profile DMVPN_IPSEC_PROFILE
!
interface FastEthernet0/0
 description FLASH156
 ip address 172.26.157.3 255.255.254.0
 no ip proxy-arp
 load-interval 30
 duplex full
 speed 100
!
interface FastEthernet0/1
 no ip address
 ip flow ingress
 duplex auto
 speed auto
!
interface FastEthernet0/1.90
 description ASA DMZ Global
 encapsulation dot1Q 90
 ip address 10.81.7.161 255.255.255.248
 ip flow ingress
 standby 0 ip 10.81.7.166
 standby 0 preempt delay minimum 60
!
interface FastEthernet0/1.91
 description ASA DMZ vrf IPVS
 encapsulation dot1Q 91
 ip vrf forwarding IPVS
 ip address 192.168.15.97 255.255.255.248
 ip flow ingress
 standby 0 ip 192.168.15.102
 standby 0 preempt delay
!
interface FastEthernet0/1.332
 description MAN/WAN to Site 130 (vpn1-2851-1)
 encapsulation dot1Q 332
 ip address 192.168.15.45 255.255.255.252
 ip flow ingress
 service-policy output 30M
!
interface FastEthernet0/1.340
 description MAN/WAN to Site 140 (vpn1-3845-1)
 encapsulation dot1Q 340
 ip address 192.168.15.13 255.255.255.252
 ip flow ingress
 service-policy output 30M
!
interface FastEthernet0/1.342
 description MAN/WAN to Site 140 (vpn1-3845-1)
 encapsulation dot1Q 342
 ip vrf forwarding IPVS
 ip address 192.168.15.77 255.255.255.252
 ip flow ingress
 ip summary-address eigrp 65 192.0.2.0 255.255.255.0 5
 service-policy output 30M
!
interface FastEthernet0/1.352
 description MAN/WAN to Site 150 (vpn4-3800-6)
```

```
 encapsulation dot1Q 352
 ip address 192.168.15.49 255.255.255.252
 ip flow ingress
!
router eigrp 64
 redistribute static metric 1000 100 255 1 1500 route-map ASA5510_VPN3080
 redistribute eigrp 65 metric 1000 100 255 1 1500 route-map Branch_Networks
 passive-interface FastEthernet0/1.90
 network 10.0.0.0
 no auto-summary
 eigrp stub connected redistributed
!
router eigrp 65
 redistribute eigrp 64 metric 1000 100 255 1 1500 route-map DEFAULT
 network 192.168.15.0 0.0.0.63
 no auto-summary
 !
 address-family ipv4 vrf IPVS
  redistribute static metric 1000 10 255 1 1500 route-map COMMAND_CENTER
  network 192.168.15.64 0.0.0.63
  network 192.168.15.128 0.0.0.63
  distribute-list route-map Branch_Net_vrf_IPVS_RT in
  no auto-summary
  autonomous-system 65
 exit-address-family
!
ip forward-protocol nd
ip route 10.81.0.27 255.255.255.255 172.26.156.1 name rtp5-esevpn-ios-ca
ip route 10.81.7.56 255.255.255.252 10.81.7.163 name ASA5510
ip route 10.81.254.0 255.255.255.0 172.26.156.1 name NTP_Servers
ip route 64.102.223.16 255.255.255.240 172.26.156.1 name cryptHE
ip route 172.26.0.0 255.255.0.0 172.26.156.1
ip route vrf IPVS 10.81.7.0 255.255.255.0 192.168.15.99 name ASA5510_PAT
ip route vrf IPVS 192.0.2.128 255.255.255.224 192.168.15.99 name ASA5510
ip route vrf IPVS 192.168.15.64 255.255.255.248 192.168.15.99 name VPN3080_pool
no ip http server
no ip http secure-server
!
ip flow-cache timeout inactive 30
ip flow-cache timeout active 1
ip flow-export version 5
!
!
ip access-list standard Branch_Net_vrf_IPVS_RT
 permit 192.0.2.0 0.0.0.255
ip access-list standard DEFAULT
 permit 0.0.0.0
!
ip prefix-list ALL_VMSS seq 5 permit 192.0.2.0/24
!
ip prefix-list ASA5510_VPN3080 seq 5 permit 10.81.7.56/30
!
ip prefix-list Branch_Net_vrf_IPVS_RT seq 132 permit 192.168.111.0/24
ip prefix-list Branch_Net_vrf_IPVS_RT seq 142 permit 192.168.11.0/24
ip prefix-list Branch_Net_vrf_IPVS_RT seq 152 permit 192.168.211.0/24
!
ip prefix-list Branch_Networks seq 130 permit 10.81.7.152/29
ip prefix-list Branch_Networks seq 131 permit 192.0.2.0/27
ip prefix-list Branch_Networks seq 132 permit 192.168.111.0/24
ip prefix-list Branch_Networks seq 140 permit 10.81.7.0/29
ip prefix-list Branch_Networks seq 141 permit 192.0.2.64/26
ip prefix-list Branch_Networks seq 142 permit 192.168.11.0/24
ip prefix-list Branch_Networks seq 150 permit 10.81.7.88/29
ip prefix-list Branch_Networks seq 151 permit 192.0.2.32/27
```

```
ip prefix-list Branch_Networks seq 152 permit 192.168.211.0/24
!
ip prefix-list COMMAND_CENTER seq 100 permit 192.0.2.128/25
ip prefix-list COMMAND_CENTER seq 101 permit 10.81.7.0/24
ip prefix-list COMMAND_CENTER seq 102 permit 192.168.15.64/29
!
ip prefix-list SITE_130 seq 5 permit 192.0.2.0/27
!
ip prefix-list SITE_140 seq 5 permit 192.0.2.64/26
ip sla responder
logging alarm informational
snmp-server enable traps tty
!
!
!
route-map Branch_Net_vrf_IPVS_RT permit 10
 match ip address prefix-list Branch_Net_vrf_IPVS_RT
 set tag 5011
!
route-map Branch_Net_vrf_IPVS_RT permit 20
 match ip address Branch_Net_vrf_IPVS_RT
 set tag 5011
!
route-map COMMAND_CENTER permit 10
 match ip address prefix-list COMMAND_CENTER
 set tag 2128
!
route-map Branch_Networks permit 10
 match ip address prefix-list Branch_Networks
 set tag 5010
!
route-map DEFAULT permit 10
 match ip address DEFAULT
!
route-map ASA5510_VPN3080 permit 10
 match ip address prefix-list ASA5510_VPN3080
!
!
!
!
control-plane
!
!
!
gatekeeper
 shutdown
!
banner exec
=
==
===
==== This is the WAN/MAN router for IPVS branches
===
==
=

!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
```

```
 password 7 [removed]
 login
!
ntp master 12
ntp update-calendar
ntp server 10.81.254.202
ntp server 10.81.254.131
!
end
```

vpn-jk2-7206-2

This configuration is for the bottomWAN aggregation router shown in the topology diagram.

```
!
! Last configuration change at 13:10:14 edt Tue Aug 4 2009
! NVRAM config last updated at 13:11:17 edt Tue Aug 4 2009
!
upgrade fpd auto
version 12.4
no service pad
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service password-encryption
!
hostname vpn-jk2-7206-2
!
boot-start-marker
boot system disk0:c7200-adventerprisek9-mz.124-15.T5
boot-end-marker
!
enable secret 5 [removed]
!
no aaa new-model
clock timezone est -5
clock summer-time edt recurring
ip cef
!
!
!
!
ip vrf IPVS
 rd 100:10
 route-target export 100:10
 route-target import 100:10
!
no ip domain lookup
ip domain name cisco.com
ip host rtp5-esevpn-ios-ca 10.81.0.27
ip multicast-routing
ip auth-proxy max-nodata-conns 3
ip admission max-nodata-conns 3
!
multilink bundle-name authenticated
!
!
crypto pki trustpoint rtp5-esevpn-ios-ca
 enrollment url http://rtp5-esevpn-ios-ca:80
 revocation-check none
!
```

```
!
crypto pki certificate chain rtp5-esevpn-ios-ca
 certificate 12
  3082023A 308201A3 A0030201 02020112 300D0609 2A864886 F70D0101 04050030
  D2993DBF 32824A8C 420DC983 C5BF7E17 28D1406E 0D937B7D 152C6FB3 D581
    quit
 certificate ca 01
  308202AF 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 04050030
  47DC2CE3 BC3F5F40 32409535 C9E0E6C0 F29D4E
    quit
archive
 log config
  hidekeys
!
!
crypto isakmp policy 100
 encr 3des
 group 2
crypto isakmp keepalive 10
crypto isakmp nat keepalive 10
crypto isakmp profile IPVS_Branches_isakmp_profile
   description IPVS_Branches_isakmp_profile
   self-identity address
   ca trust-point rtp5-esevpn-ios-ca
   match identity host domain ese.cisco.com
!
!
crypto ipsec transform-set 3DES_SHA_TUNNEL esp-3des esp-sha-hmac
crypto ipsec transform-set 3DES_SHA_TRANSPORT esp-3des esp-sha-hmac
 mode transport
crypto ipsec transform-set AES_SHA_TUNNEL esp-aes esp-sha-hmac
crypto ipsec transform-set AES_SHA_TRANSPORT esp-aes esp-sha-hmac
 mode transport
!
crypto ipsec profile IPVS_Branches_ipsec_profile
 description IPVS_Branches_ipsec_profile
 set transform-set 3DES_SHA_TRANSPORT 3DES_SHA_TUNNEL
 set isakmp-profile IPVS_Branches_isakmp_profile
!
!
controller ISA 5/1
!
!
class-map match-any LOW-LATENCY-DATA
 match ip dscp af21  af22  af23
class-map match-any HIGH-THROUGHPUT-DATA
 match ip dscp af11  af12  af13
class-map match-all BROADCAST-VIDEO
 match ip dscp cs5
class-map match-all NETWORK-CONTROL
 match ip dscp cs6
class-map match-any MULTIMEDIA-CONFERENCING
 match ip dscp af41  af42  af43
class-map match-all OAM
 match ip dscp cs2
class-map match-all VOICE
 match ip dscp ef
class-map match-all SCAVENGER
 match ip dscp cs1
class-map match-any CALL-SIGNALING
 match ip dscp cs3
!
!
policy-map IPVS_BRANCH
```

```
 class BROADCAST-VIDEO
  bandwidth percent 40
 class VOICE
  priority percent 10
 class LOW-LATENCY-DATA
  bandwidth percent 4
 class HIGH-THROUGHPUT-DATA
  bandwidth percent 4
 class MULTIMEDIA-CONFERENCING
  bandwidth percent 4
 class SCAVENGER
  bandwidth percent 1
 class OAM
  bandwidth percent 1
 class NETWORK-CONTROL
  bandwidth percent 1
 class CALL-SIGNALING
  bandwidth percent 1
 class class-default
  fair-queue
policy-map 30M
 class class-default
  shape average 30000000
  service-policy IPVS_BRANCH
!
!
interface Loopback0
 description Loopback for Global RT
 ip address 192.168.15.41 255.255.255.255
!
interface Tunnel192
 ip vrf forwarding IPVS
 ip address 192.168.15.193 255.255.255.192
 no ip redirects
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map multicast dynamic
 ip nhrp map multicast 192.168.15.41
 ip nhrp network-id 192
 ip nhrp nhs 192.168.15.193
 ip nhrp server-only
 ip route-cache flow
 no ip split-horizon eigrp 65
 ip summary-address eigrp 65 192.0.2.0 255.255.255.0 5
 tunnel source Loopback0
 tunnel mode gre multipoint
 tunnel key 192
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile
!
interface FastEthernet0/0
 ip address 172.26.157.4 255.255.254.0
 no ip proxy-arp
 ip route-cache flow
 duplex full
 speed 100
!
interface FastEthernet0/1
 description MAN/WAN to Branches
 no ip address
 ip route-cache flow
 duplex full
 speed 100
!
interface FastEthernet0/1.90
```

```
 description ASA DMZ Global
 encapsulation dot1Q 90
 ip address 10.81.7.162 255.255.255.248
 ip flow ingress
 standby 0 ip 10.81.7.166
 standby 0 priority 90
 standby 0 preempt delay minimum 60
!
interface FastEthernet0/1.91
 description ASA DMZ vrf IPVS
 encapsulation dot1Q 91
 ip vrf forwarding IPVS
 ip address 192.168.15.98 255.255.255.248
 ip flow ingress
 standby 0 ip 192.168.15.102
 standby 0 priority 90
 standby 0 preempt delay minimum 60
!
!
interface FastEthernet0/1.331
 encapsulation dot1Q 331
 ip address 192.168.15.21 255.255.255.252
 service-policy output 30M
!
interface FastEthernet0/1.341
 encapsulation dot1Q 341
 ip address 192.168.15.25 255.255.255.252
 service-policy output 30M
!
interface FastEthernet0/1.343
 encapsulation dot1Q 343
 ip vrf forwarding IPVS
 ip address 192.168.15.89 255.255.255.252
 ip summary-address eigrp 65 192.0.2.0 255.255.255.0 5
 service-policy output 30M
!
interface FastEthernet0/1.351
 encapsulation dot1Q 351
 ip address 192.168.15.29 255.255.255.252
!
router eigrp 64
 redistribute eigrp 65 metric 1000 100 255 1 1500 route-map Branch_Networks
 passive-interface FastEthernet0/1.90
 network 10.0.0.0
 no auto-summary
 eigrp stub connected redistributed
!
router eigrp 65
 redistribute eigrp 64 metric 1000 100 255 1 1500 route-map DEFAULT
 network 192.168.15.0 0.0.0.63
 no auto-summary
 !
 address-family ipv4 vrf IPVS
  redistribute static metric 1000 10 255 1 1500 route-map COMMAND_CENTER
  offset-list 0 out 1000
  network 192.168.15.64 0.0.0.63
  network 192.168.15.192 0.0.0.63
  distribute-list route-map Branch_Net_vrf_IPVS_RT in
  no auto-summary
  autonomous-system 65
 exit-address-family
!
ip forward-protocol nd
ip route 10.81.0.27 255.255.255.255 172.26.156.1 name rtp5-esevpn-ios-ca
```

```
ip route 10.81.7.56 255.255.255.252 10.81.7.163 name ASA5510
ip route 10.81.254.0 255.255.255.0 172.26.156.1 name NTP_Servers
ip route 64.102.223.16 255.255.255.240 172.26.156.1 name cryptHE
ip route vrf IPVS 10.81.7.0 255.255.255.0 192.168.15.99 name ASA5510_PAT
ip route vrf IPVS 192.0.2.128 255.255.255.224 192.168.15.99 name ASA5510
ip route vrf IPVS 192.168.15.64 255.255.255.248 192.168.15.99 name VPN3080_pool
no ip http server
no ip http secure-server
!
!
!
ip access-list standard Branch_Net_vrf_IPVS_RT
 permit 192.0.2.0 0.0.0.255
ip access-list standard DEFAULT
 permit 0.0.0.0
!
!
!
ip prefix-list Branch_Net_vrf_IPVS_RT seq 132 permit 192.168.111.0/24
ip prefix-list Branch_Net_vrf_IPVS_RT seq 142 permit 192.168.11.0/24
ip prefix-list Branch_Net_vrf_IPVS_RT seq 152 permit 192.168.211.0/24
!
ip prefix-list Branch_Networks seq 130 permit 10.81.7.152/29
ip prefix-list Branch_Networks seq 131 permit 192.0.2.0/27
ip prefix-list Branch_Networks seq 132 permit 192.168.111.0/24
ip prefix-list Branch_Networks seq 140 permit 10.81.7.0/29
ip prefix-list Branch_Networks seq 141 permit 192.0.2.64/26
ip prefix-list Branch_Networks seq 142 permit 192.168.11.0/24
ip prefix-list Branch_Networks seq 150 permit 10.81.7.88/29
ip prefix-list Branch_Networks seq 151 permit 192.0.2.32/27
ip prefix-list Branch_Networks seq 152 permit 192.168.211.0/24
!
ip prefix-list COMMAND_CENTER seq 100 permit 192.0.2.128/25
ip prefix-list COMMAND_CENTER seq 101 permit 10.81.7.0/24
ip prefix-list COMMAND_CENTER seq 102 permit 192.168.15.64/29
logging alarm informational
!
!
!
route-map Branch_Net_vrf_IPVS_RT permit 10
 match ip address prefix-list Branch_Net_vrf_IPVS_RT
 set tag 5011
!
route-map Branch_Net_vrf_IPVS_RT permit 20
 match ip address Branch_Net_vrf_IPVS_RT
 set tag 5011
!
route-map COMMAND_CENTER permit 10
 match ip address prefix-list COMMAND_CENTER
 set tag 2128
!
route-map Branch_Networks permit 10
 match ip address prefix-list Branch_Networks
 set tag 5010
!
route-map DEFAULT permit 10
 match ip address DEFAULT
!
control-plane
!
!
!
gatekeeper
 shutdown
```

```
!
!
line con 0
 transport output all
 stopbits 1
line aux 0
 transport output all
 stopbits 1
line vty 0 4
 password 7 [removed]
 login
 transport input all
 transport output all
!
ntp clock-period 17179966
ntp master 12
ntp update-calendar
ntp server 10.81.254.202
ntp server 10.81.254.131
!
end
```

vpn-jk2-asa5510-1

This configuration is for the firewall shown in the topology diagram

```
: Saved
: Written by enable_15 at 13:55:41.021 edt Tue Aug 4 2009
!
ASA Version 8.0(4)
!
hostname vpn-jk2-asa5510-1
domain-name ese.cisco.com
enable password 2KFQnbNIdI.2KYOU encrypted
passwd [removed] encrypted
names
dns-guard
!
interface Ethernet0/0
 description Campus_IPVS VLAN 220
 speed 100
 duplex full
 nameif Campus_IPVS
 security-level 70
 ip address 192.0.2.129 255.255.255.224
!
interface Ethernet0/1
 description DMZ_IPVS VLAN 91
 speed 100
 duplex full
 nameif DMZ_IPVS
 security-level 50
 ip address 192.168.15.99 255.255.255.248
!
interface Ethernet0/2
 description DMZ_Global VLAN 90
 speed 100
 duplex full
 nameif DMZ_Global
 security-level 10
 ip address 10.81.7.163 255.255.255.248
```

```
!
interface Ethernet0/3
 description DMZ for VPN3080
 speed 100
 duplex full
 nameif DMZ_VPN3080
 security-level 20
 ip address 10.81.7.58 255.255.255.252
!
interface Management0/0
 description FlashNET
 speed 100
 duplex full
 nameif FlashNET
 security-level 0
 ip address 172.26.156.3 255.255.254.0
!
boot system disk0:/asa804-k8.bin
ftp mode passive
clock timezone est -5
clock summer-time edt recurring
dns server-group DefaultDNS
 domain-name ese.cisco.com
access-list MANAGEMENT extended permit tcp 10.81.7.0 255.255.255.0 interface FlashNET
access-list IPVS-CC extended permit udp any 192.0.2.128 255.255.255.224 eq syslog
access-list IPVS-CC extended permit udp any host 192.0.2.139 eq snmptrap
access-list IPVS-CC extended permit udp any host 192.0.2.139 eq 7777
access-list IPVS-CC extended permit tcp 192.0.2.0 255.255.255.0 any eq www
access-list INBOUND extended permit esp any host 10.81.7.57
access-list INBOUND extended permit udp any host 10.81.7.57 eq isakmp
access-list INBOUND extended permit udp any host 10.81.7.57 eq 4500
access-list INBOUND extended permit icmp any host 10.81.7.57
pager lines 24
logging enable
logging buffered debugging
logging asdm debugging
mtu Campus_IPVS 1500
mtu DMZ_IPVS 1500
mtu DMZ_Global 1500
mtu DMZ_VPN3080 1500
mtu FlashNET 1500
no failover
icmp unreachable rate-limit 1 burst-size 1
icmp permit any Campus_IPVS
icmp permit any DMZ_IPVS
icmp permit any DMZ_Global
icmp permit any DMZ_VPN3080
asdm image disk0:/asdm-61551.bin
no asdm history enable
arp timeout 14400
global (DMZ_Global) 1 interface
nat (Campus_IPVS) 1 192.0.2.128 255.255.255.224
static (DMZ_VPN3080,DMZ_Global) 192.168.15.56 192.168.15.56 netmask 255.255.255.252
static (Campus_IPVS,DMZ_IPVS) 192.0.2.128 192.0.2.128 netmask 255.255.255.224
static (Campus_IPVS,DMZ_IPVS) 192.168.15.64 192.168.15.64 netmask 255.255.255.248
access-group IPVS-CC in interface DMZ_IPVS
access-group INBOUND in interface DMZ_Global
access-group MANAGEMENT in interface FlashNET control-plane
route DMZ_Global 0.0.0.0 0.0.0.0 10.81.7.166 1
route FlashNET 172.16.0.0 255.240.0.0 172.26.156.1 1
route DMZ_IPVS 192.0.2.0 255.255.255.0 192.168.15.102 1
route DMZ_IPVS 192.168.11.0 255.255.255.0 192.168.15.102 1
route Campus_IPVS 192.168.15.64 255.255.255.248 192.0.2.136 1
route DMZ_IPVS 192.168.111.0 255.255.255.0 192.168.15.102 1
```

```
route DMZ_IPVS 192.168.211.0 255.255.255.0 192.168.15.102 1
timeout xlate 3:00:00
timeout conn 1:00:00 half-closed 0:10:00 udp 0:02:00 icmp 0:00:02
timeout sunrpc 0:10:00 h323 0:05:00 h225 1:00:00 mgcp 0:05:00 mgcp-pat 0:05:00
timeout sip 0:30:00 sip_media 0:02:00 sip-invite 0:03:00 sip-disconnect 0:02:00
timeout sip-provisional-media 0:02:00 uauth 0:05:00 absolute
dynamic-access-policy-record DfltAccessPolicy
http server enable
http 172.26.156.0 255.255.254.0 FlashNET
http 10.81.7.0 255.255.255.0 FlashNET
snmp-server location ESE Lab
snmp-server contact joel.king@cisco.com
snmp-server enable traps snmp authentication linkup linkdown coldstart
crypto ipsec security-association lifetime seconds 28800
crypto ipsec security-association lifetime kilobytes 4608000
telnet 10.81.7.176 255.255.255.248 FlashNET
telnet 172.26.156.0 255.255.254.0 FlashNET
telnet timeout 60
ssh 10.81.7.0 255.255.255.0 FlashNET
ssh 172.26.156.0 255.255.254.0 FlashNET
ssh timeout 60
console timeout 0
dhcpd dns 64.102.6.247
dhcpd wins 64.102.6.247
dhcpd lease 28880
dhcpd domain ese.cisco.com
dhcpd option 3 ip 192.0.2.129
!
dhcpd address 192.0.2.140-192.0.2.150 Campus_IPVS
dhcpd enable Campus_IPVS
!
threat-detection basic-threat
threat-detection statistics access-list
no threat-detection statistics tcp-intercept
ntp server 10.81.7.162
ntp server 10.81.7.161
ssl encryption rc4-sha1
!
class-map inspection_default
 match default-inspection-traffic
!
!
policy-map type inspect dns migrated_dns_map_1
 parameters
  message-length maximum 512
policy-map global_policy
 class inspection_default
  inspect dns migrated_dns_map_1
  inspect ftp
  inspect h323 h225
  inspect h323 ras
  inspect netbios
  inspect rsh
  inspect rtsp
  inspect skinny
  inspect esmtp
  inspect sqlnet
  inspect sunrpc
  inspect tftp
  inspect sip
  inspect xdmcp
!
service-policy global_policy global
prompt hostname context
```

```
Cryptochecksum:3d4d4e2f06d5a11ff2dd5d5643e862f5
: end
```

vpn1-2851-1

This configuration is for the branch 2851 model router shown in the topology diagram

```
!
! Last configuration change at 13:26:29 edt Tue Aug 4 2009
! NVRAM config last updated at 13:27:56 edt Tue Aug 4 2009
!
version 12.4
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service password-encryption
service udp-small-servers
service tcp-small-servers
!
hostname vpn1-2851-1
!
boot-start-marker
boot-end-marker
!
logging buffered 8192
enable secret 5 [removed]
!
no aaa new-model
clock timezone est -5
clock summer-time edt recurring
!
crypto pki trustpoint rtp5-esevpn-ios-ca
 enrollment url http://rtp5-esevpn-ios-ca:80
 revocation-check none
 source interface Vlan1
!
!
crypto pki certificate chain rtp5-esevpn-ios-ca
 certificate 0F
  3082023B 308201A4 A0030201 0202010F 300D0609 2A864886 F70D0101 04050030
  32C8325C 8DF24E4B D16823BA AF45A2F8 A6AA3C9C 8E33E400 CBAE2184 09F267
    quit
 certificate ca 01
  308202AF 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 04050030
  47DC2CE3 BC3F5F40 32409535 C9E0E6C0 F29D4E
    quit
dot11 syslog
!
!
ip cef
ip dhcp use vrf connected
ip dhcp excluded-address 192.168.111.1 192.168.111.149
ip dhcp excluded-address 192.0.2.17 192.0.2.19
!
ip dhcp pool CAMERAS
   vrf IPVS
   network 192.0.2.16 255.255.255.240
   default-router 192.0.2.17
   dns-server 64.102.6.247 171.68.226.120
   domain-name cisco.com
!
ip dhcp pool iSCSI-temp
```

```
   network 192.168.111.0 255.255.255.0
   default-router 192.168.111.1
   domain-name cisco.com
!
!
ip vrf IPVS
 rd 100:10
 route-target export 100:10
 route-target import 100:10
!
no ip domain lookup
ip host harry 172.26.129.252
ip host rtp5-esevpn-ios-ca 10.81.0.27
ip multicast-routing
ip auth-proxy max-nodata-conns 3
ip admission max-nodata-conns 3
!
multilink bundle-name authenticated
!
!
voice-card 0
 no dspfarm
!
!
username joeking privilege 15 secret 5 [removed]
!
!
crypto isakmp policy 120
 encr 3des
 group 2
crypto isakmp keepalive 10
crypto isakmp nat keepalive 10
crypto isakmp profile IPVS_Branches_isakmp_profile
   self-identity fqdn
   ca trust-point rtp5-esevpn-ios-ca
   match identity address 192.168.15.40 255.255.255.255
   keepalive 10 retry 2
crypto isakmp profile IPVS_Branches_isakmp_profile_2
   self-identity fqdn
   ca trust-point rtp5-esevpn-ios-ca
   match identity address 192.168.15.41 255.255.255.255
   keepalive 10 retry 2
!
!
crypto ipsec transform-set AES_SHA_TUNNEL esp-aes esp-sha-hmac
crypto ipsec transform-set 3DES_SHA_TUNNEL esp-3des esp-sha-hmac
crypto ipsec transform-set 3DES_SHA_TRANSPORT esp-3des esp-sha-hmac
 mode transport
crypto ipsec transform-set AES_SHA_TRANSPORT esp-aes esp-sha-hmac
 mode transport
!
crypto ipsec profile IPVS_Branches_ipsec_profile
 description IPVS_Branches_ipsec_profile
 set transform-set 3DES_SHA_TRANSPORT 3DES_SHA_TUNNEL
 set isakmp-profile IPVS_Branches_isakmp_profile
!
crypto ipsec profile IPVS_Branches_ipsec_profile_2
 set transform-set 3DES_SHA_TRANSPORT 3DES_SHA_TUNNEL
 set isakmp-profile IPVS_Branches_isakmp_profile_2
!
!
archive
 log config
  hidekeys
```

```
!
!
ip finger
!
class-map match-any GOLD
 match ip dscp cs2  cs3  cs6  cs7
 match ip dscp af41  af42  af43
 match ip dscp af31  af32  af33
class-map match-all TELEPRESENCE
 match ip dscp cs4
class-map match-any LOW-LATENCY-DATA
 match ip dscp af21  af22  af23
class-map match-any BRONZE
 match ip dscp af11  af12  af13
 match ip dscp cs1
class-map match-any HIGH-THROUGHPUT-DATA
 match ip dscp af11  af12  af13
class-map match-any VMSS
 match access-group name HTTP
class-map match-all BROADCAST-VIDEO
 match ip dscp cs5
class-map match-all NETWORK-CONTROL
 match ip dscp cs6
class-map match-any MULTIMEDIA-CONFERENCING
 match ip dscp af41  af42  af43
class-map match-all OAM
 match ip dscp cs2
class-map match-all FOO
class-map match-any REAL_TIME
 match ip dscp cs5
 match ip dscp cs4
 match ip dscp ef
class-map match-all VOICE
 match ip dscp ef
class-map match-all SCAVENGER
 match ip dscp cs1
class-map match-any CALL-SIGNALING
 match ip dscp cs3
class-map match-any MULTIMEDIA-STREAMING
 match ip dscp af31  af32  af33
!
!
policy-map IPVS_BRANCH
 class BROADCAST-VIDEO
  bandwidth percent 40
 class VOICE
  priority percent 10
 class LOW-LATENCY-DATA
  bandwidth percent 4
 class HIGH-THROUGHPUT-DATA
  bandwidth percent 4
 class MULTIMEDIA-CONFERENCING
  bandwidth percent 4
 class SCAVENGER
  bandwidth percent 1
 class OAM
  bandwidth percent 1
 class NETWORK-CONTROL
  bandwidth percent 1
 class CALL-SIGNALING
  bandwidth percent 1
 class class-default
  fair-queue
policy-map UPLINK_50M
```

```
 class class-default
  shape average 50000000
  service-policy IPVS_BRANCH
policy-map INGRESS_VMSS
 class VMSS
  set ip dscp cs5
 class class-default
  set ip dscp cs3
policy-map PER_CLASS_SHAPING
 class REAL_TIME
  set cos 5
    police 40000000 conform-action transmit  exceed-action transmit
 class GOLD
  shape average 2500000
  set cos 6
 class BRONZE
  shape average 2500000
  set cos 1
 class class-default
  set cos 0
  shape average 5000000
policy-map 30M
 class class-default
  shape average 30000000
  service-policy IPVS_BRANCH
!
!
interface Tunnel128
 ip vrf forwarding IPVS
 ip address 192.168.15.130 255.255.255.192
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map 192.168.15.129 192.168.15.40
 ip nhrp map multicast 192.168.15.40
 ip nhrp network-id 128
 ip nhrp nhs 192.168.15.129
 ip summary-address eigrp 65 192.0.2.0 255.255.255.224 5
 tunnel source GigabitEthernet0/1.332
 tunnel destination 192.168.15.40
 tunnel key 128
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile
!
interface Tunnel192
 ip vrf forwarding IPVS
 ip address 192.168.15.194 255.255.255.192
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map multicast 192.168.15.41
 ip nhrp map 192.168.15.193 192.168.15.41
 ip nhrp network-id 192
 ip nhrp nhs 192.168.15.193
 ip summary-address eigrp 65 192.0.2.0 255.255.255.224 5
 tunnel source GigabitEthernet0/1.331
 tunnel destination 192.168.15.41
 tunnel key 192
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile_2
!
interface GigabitEthernet0/0
 description Inside
 no ip address
 ip flow ingress
 load-interval 30
 duplex auto
 speed auto
```

```
!
interface GigabitEthernet0/0.204
 description Inside
 encapsulation dot1Q 204
 ip address 10.81.7.153 255.255.255.248
 ip flow ingress
!
interface GigabitEthernet0/0.206
 description VLAN 206 for IP Cameras
 encapsulation dot1Q 206
 ip vrf forwarding IPVS
 ip address 192.0.2.17 255.255.255.240
 ip flow ingress
!
interface GigabitEthernet0/1
 description Outside
 no ip address
 load-interval 30
 duplex auto
 speed auto
!
interface GigabitEthernet0/1.130
 description To vpn-jk3-2651xm-4 Primary WAN
 bandwidth 30000
 encapsulation dot1Q 130
 ip address dhcp
!
interface GigabitEthernet0/1.254
 description iSCSI Management Subnet
 encapsulation dot1Q 254
 ip vrf forwarding IPVS
 ip address 192.168.111.1 255.255.255.0
!
interface GigabitEthernet0/1.331
 encapsulation dot1Q 331
 ip address 192.168.15.22 255.255.255.252
 service-policy output 30M
!
interface GigabitEthernet0/1.332
 encapsulation dot1Q 332
 ip address 192.168.15.46 255.255.255.252
 service-policy output PER_CLASS_SHAPING
!
interface FastEthernet0/3/0
 duplex full
 speed 100
!
interface FastEthernet0/3/1
!
interface FastEthernet0/3/2
!
interface FastEthernet0/3/3
!
interface Integrated-Service-Engine1/0
 ip vrf forwarding IPVS
 ip address 192.0.2.1 255.255.255.252
 ip flow ingress
 load-interval 30
 service-module external ip address 192.168.111.2 255.255.255.0
 service-module ip address 192.0.2.2 255.255.255.252
 service-module ip default-gateway 192.0.2.1
 no keepalive
 service-policy input INGRESS_VMSS
!
```

```
interface Video-Service-Engine2/0
 ip vrf forwarding IPVS
 ip address 192.0.2.5 255.255.255.252
 ip flow ingress
 service-module ip address 192.0.2.6 255.255.255.252
 service-module ip default-gateway 192.0.2.5
 no keepalive
!
interface Vlan1
 description Flashnet
 ip address 172.26.156.51 255.255.254.0
 no ip proxy-arp
!
router eigrp 65
 network 10.81.7.152 0.0.0.7
 network 192.168.15.0 0.0.0.63
 no auto-summary
 !
 address-family ipv4 vrf IPVS
  network 192.0.2.0 0.0.0.31
  network 192.168.15.128 0.0.0.63
  network 192.168.15.192 0.0.0.63
  network 192.168.111.0
  no auto-summary
  autonomous-system 65
 exit-address-family
!
ip forward-protocol nd
ip route 10.81.0.27 255.255.255.255 172.26.156.1 name rtp5-esevpn-ios-ca
ip route 172.26.0.0 255.255.0.0 172.26.156.1 name Miles
ip route 192.168.15.40 255.255.255.255 192.168.15.45 name vpn-jk2-7206-1_Loopback_0
ip route 192.168.15.41 255.255.255.255 192.168.15.21 name vpn-jk2-7206-2_Loopback_0
ip route 64.102.223.16 255.255.255.240 dhcp
ip route 192.5.41.40 255.255.255.254 dhcp
!
ip flow-cache timeout active 1
ip flow-export version 5
ip flow-export destination 172.26.157.11 7777
!
ip http server
ip http secure-server
no ip pim dm-fallback
ip pim autorp listener
!
ip access-list extended HTTP
 permit tcp host 192.0.2.2 eq www any
ip access-list extended VSOM
 permit tcp host 192.0.2.2 eq www 192.168.16.0 0.0.15.255
 permit tcp host 192.0.2.2 eq 443 192.168.16.0 0.0.15.255
!
!
ip prefix-list CAMPUS seq 5 permit 192.168.16.0/20
ip sla responder
ip sla 219
 icmp-echo 192.0.2.19
 tos 192
 threshold 50
 vrf IPVS
 owner networkmgr
 tag ipvs - design guide
 frequency 64
 history lives-kept 1
 history buckets-kept 60
 history filter failures
```

```
ip sla schedule 219 life forever start-time now
logging 172.26.157.11
snmp-server enable traps tty
!
!
control-plane
!
!
banner exec

  C i s c o S y s t e m s
      ||               ||
      ||               ||       Cisco Systems, Inc.
     ||||             ||||      IT-Transport
 .:|||||||:.......:|||||||:..
  US, Asia & Americas support:    + 1 408 526 8888
 EMEA support:                   + 31 020 342 3888
  UNAUTHORIZED ACCESS TO THIS NETWORK DEVICE IS PROHIBITED.
 You must have explicit permission to access or configure this
 device. All activities performed on this device are logged and
 violations of this policy may result in disciplinary action.
Questions regarding this device should be directed to
xxxxxxx

banner motd
=
==
=== Site 130   === vpn1-2851-1
==
=

alias exec analog service-module Video-Service-Engine2/0 session
!
line con 0
 exec-timeout 0 0
line aux 0
line 66
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh
line 130
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh
line vty 0 4
 exec-timeout 0 0
 password 7 [removed]
 login local
!
scheduler allocate 20000 1000
ntp clock-period 17180366
ntp source GigabitEthernet0/0.206
ntp master 12
ntp server 192.168.4.1 source GigabitEthernet0/1.130
ntp server 10.81.254.202 source GigabitEthernet0/0.204
ntp server 10.81.254.131 source GigabitEthernet0/0.204
!
end
```

vpn1-3845-1

This configuration is for the branch 3845 model router shown in the topology diagram

```
!
! Last configuration change at 13:21:52 edt Tue Aug 4 2009
! NVRAM config last updated at 13:23:50 edt Tue Aug 4 2009
!
version 12.4
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
no service password-encryption
service udp-small-servers
service tcp-small-servers
!
hostname vpn1-3845-1
!
boot-start-marker
boot system flash flash:c3845-adventerprisek9-mz.124-15.T5
boot system flash flash:c3845-adventerprisek9-mz.124-22.T
boot-end-marker
!
logging buffered 2000000
enable secret 5 [removed]
!
no aaa new-model
clock timezone est -5
clock summer-time edt recurring
dot11 syslog
ip wccp 61
ip wccp 62
ip cef
!
!
ip dhcp use vrf connected
ip dhcp excluded-address 192.0.2.97 192.0.2.102
!
ip dhcp pool ENTERPRISE
   network 10.81.7.0 255.255.255.248
   default-router 10.81.7.1
   dns-server 64.102.6.247 171.68.226.120
   domain-name ese.cisco.com
   netbios-name-server 171.68.235.228 171.68.235.229
!
ip dhcp pool CAMERAS
   vrf IPVS
   network 192.0.2.96 255.255.255.224
   default-router 192.0.2.97
   dns-server 64.102.6.247 171.68.226.120
   domain-name ese.cisco.com
!
!
ip vrf IPVS
 rd 100:10
 route-target export 100:10
 route-target import 100:10
!
no ip domain lookup
ip domain name ese.cisco.com
ip host rtp5-esevpn-ios-ca 10.81.0.27
ip auth-proxy max-nodata-conns 3
```

```
ip admission max-nodata-conns 3
ip dhcp-client default-router distance 239
!
multilink bundle-name authenticated
!
voice-card 0
 no dspfarm
!
!
!
key chain PURPLE
 key 10
   key-string 7 00[removed]00
!
!
!
oer master
 policy-rules LOSS
 shutdown
 logging
 !
 border 192.168.0.1 key-chain PURPLE
  interface GigabitEthernet0/1.250 internal
  interface GigabitEthernet0/1.210 internal
  interface GigabitEthernet0/1.294 external
  interface GigabitEthernet0/1.293 external
  interface Integrated-Service-Engine3/0 internal
 !
 learn
  throughput
  delay
  periodic-interval 0
  monitor-period 1
  expire after time 30
  aggregation-type prefix-length 29
 no max range receive
 delay threshold 80
 mode route control
 mode select-exit best
!
oer border
 local Loopback0
 master 192.168.0.1 key-chain PURPLE
!
crypto pki trustpoint rtp5-esevpn-ios-ca
 enrollment url http://rtp5-esevpn-ios-ca:80
 revocation-check none
 source interface Vlan1
!
!
crypto pki certificate chain rtp5-esevpn-ios-ca
 certificate 0E
  3082023B 308201A4 A0030201 0202010E 300D0609 2A864886 F70D0101 04050030
  DE5E201F F1A6CB47 D57C7260 70BE64AD 78656E15 A2EB7E43 9D969FB5 C4233B
    quit
 certificate ca 01
  308202AF 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 04050030
  47DC2CE3 BC3F5F40 32409535 C9E0E6C0 F29D4E
    quit
!
!
username joeking privilege 15 secret 5 [removed]
archive
 log config
```

```
  hidekeys
!
!
crypto isakmp policy 100
 encr 3des
 group 2
crypto isakmp keepalive 10
crypto isakmp nat keepalive 10
crypto isakmp profile DMVPN_IKE_PROFILE
   description DMVPN Profile
   self-identity fqdn
   ca trust-point rtp5-esevpn-ios-ca
   match identity address 64.102.223.24 255.255.255.255
   keepalive 10 retry 2
crypto isakmp profile DMVPN_IKE_PROFILE_2
   description DMVPN Profile
   self-identity fqdn
   ca trust-point rtp5-esevpn-ios-ca
   match identity address 64.102.223.25 255.255.255.255
   keepalive 10 retry 2
!
!
crypto ipsec transform-set 3DES_SHA_TUNNEL esp-3des esp-sha-hmac
crypto ipsec transform-set 3DES_SHA_TRANSPORT esp-3des esp-sha-hmac
 mode transport
!
crypto ipsec profile DMVPN_IPSEC_PROFILE
 set transform-set 3DES_SHA_TRANSPORT
 set isakmp-profile DMVPN_IKE_PROFILE
!
crypto ipsec profile DMVPN_IPSEC_PROFILE_2
 set transform-set 3DES_SHA_TRANSPORT
 set isakmp-profile DMVPN_IKE_PROFILE_2
!
ip finger
!
class-map match-any LOW-LATENCY-DATA
 match ip dscp af21  af22  af23
class-map match-any HIGH-THROUGHPUT-DATA
 match ip dscp af11  af12  af13
class-map match-all BROADCAST-VIDEO
 match ip dscp cs5
class-map match-all NETWORK-CONTROL
 match ip dscp cs6
class-map match-any MULTIMEDIA-CONFERENCING
 match ip dscp af41  af42  af43
class-map match-all OAM
 match ip dscp cs2
class-map match-all VOICE
 match ip dscp ef
class-map match-all SCAVENGER
 match ip dscp cs1
class-map match-any CALL-SIGNALING
 match ip dscp cs3
!
!
policy-map DATA
 class class-default
  fair-queue
  random-detect
policy-map IPVS_BRANCH
 class BROADCAST-VIDEO
  bandwidth percent 40
 class VOICE
```

```
  priority percent 10
 class LOW-LATENCY-DATA
  bandwidth percent 4
 class HIGH-THROUGHPUT-DATA
  bandwidth percent 4
 class MULTIMEDIA-CONFERENCING
  bandwidth percent 4
 class SCAVENGER
  bandwidth percent 1
 class OAM
  bandwidth percent 1
 class NETWORK-CONTROL
  bandwidth percent 1
 class CALL-SIGNALING
  bandwidth percent 1
 class class-default
  fair-queue
policy-map 30M
 class class-default
  shape average 30000000
  service-policy IPVS_BRANCH
!
policy-map 2M
 class class-default
  shape average 2000000
  service-policy DATA
!
!
interface Loopback0
 description for OER peering
 ip address 192.168.0.1 255.255.255.255
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex full
 speed 100
 media-type rj45
!
interface GigabitEthernet0/1
 description Trunk
 no ip address
 ip route-cache flow
 load-interval 30
 duplex auto
 speed auto
 media-type rj45
!
interface GigabitEthernet0/1.140
 description WAN
 encapsulation dot1Q 140
 ip address dhcp
!
interface GigabitEthernet0/1.210
 description IP Camera VLAN
 encapsulation dot1Q 210
 ip vrf forwarding IPVS
 ip address 192.0.2.97 255.255.255.224
!
interface GigabitEthernet0/1.250
 description INSIDE VLAN
 encapsulation dot1Q 250
 ip address 10.81.7.1 255.255.255.248
!
```

```
interface GigabitEthernet0/1.256
 description management interface for iSCSI
 encapsulation dot1Q 256
 ip vrf forwarding IPVS
 ip address 192.168.11.1 255.255.255.0
!
interface GigabitEthernet0/1.293
 description To vpn-jk2-7206-1 for PfR
 encapsulation dot1Q 293
 ip address 192.168.15.6 255.255.255.252
 shutdown
!
interface GigabitEthernet0/1.294
 description To vpn-jk2-7206-1 for PfR
 encapsulation dot1Q 294
 ip address 192.168.15.2 255.255.255.252
 shutdown
!
interface GigabitEthernet0/1.340
 encapsulation dot1Q 340
 ip address 192.168.15.14 255.255.255.252
 service-policy output 2M
!
interface GigabitEthernet0/1.341
 encapsulation dot1Q 341
 ip address 192.168.15.26 255.255.255.252
 service-policy output 2M
!
interface GigabitEthernet0/1.342
 encapsulation dot1Q 342
 ip vrf forwarding IPVS
 ip address 192.168.15.78 255.255.255.252
 ip summary-address eigrp 65 192.0.2.64 255.255.255.192 5
 service-policy output 30M
!
interface GigabitEthernet0/1.343
 encapsulation dot1Q 343
 ip vrf forwarding IPVS
 ip address 192.168.15.90 255.255.255.252
 ip summary-address eigrp 65 192.0.2.64 255.255.255.192 5
 service-policy output 30M
!
interface FastEthernet1/0
 description connection to Flashnet
 duplex full
 speed 100
!
interface FastEthernet1/1
!
interface FastEthernet1/2
!
interface FastEthernet1/3
!
interface FastEthernet1/4
!
interface FastEthernet1/5
!
interface FastEthernet1/6
!
interface FastEthernet1/7
!
interface FastEthernet1/8
!
interface FastEthernet1/9
```

```
!
interface FastEthernet1/10
!
interface FastEthernet1/11
!
interface FastEthernet1/12
!
interface FastEthernet1/13
!
interface FastEthernet1/14
!
interface FastEthernet1/15
!
interface GigabitEthernet1/0
 shutdown
!
interface Integrated-Service-Engine2/0
 description NME-WAE-522-K9
 ip address 192.0.2.69 255.255.255.252
 ip wccp redirect exclude in
 service-module ip address 192.0.2.70 255.255.255.252
 service-module ip default-gateway 192.0.2.69
 no keepalive
!
interface Integrated-Service-Engine3/0
 description NME-VMSS-HP32 ip wccp 61 red in 62 red out
 ip vrf forwarding IPVS
 ip address 192.0.2.64 255.255.255.254
 ip nbar protocol-discovery
 ip flow ingress
 ip route-cache flow
 load-interval 30
 service-module external ip address 192.168.11.2 255.255.255.0
 service-module ip address 192.0.2.65 255.255.255.254
 service-module ip default-gateway 192.0.2.64
 no keepalive
!
interface Vlan1
 ip address 172.26.156.53 255.255.254.0
 no ip proxy-arp
!
router eigrp 65
 network 10.81.7.0 0.0.0.7
 network 192.168.15.0 0.0.0.63
 no auto-summary
 !
 address-family ipv4 vrf IPVS
  network 192.0.2.64 0.0.0.63
  network 192.168.11.0
  network 192.168.15.64 0.0.0.63
  no auto-summary
  autonomous-system 65
 exit-address-family
!
ip forward-protocol nd
ip route 192.168.16.0 255.255.240.0 192.168.15.1 230 name OER_Parent
ip route 192.168.16.0 255.255.240.0 192.168.15.5 230 name OER_Parent
ip route 192.168.32.0 255.255.224.0 192.168.15.1 230 name OER_Parent
ip route 192.168.32.0 255.255.224.0 192.168.15.5 230 name OER_Parent
ip route 64.102.223.16 255.255.255.240 dhcp
!
ip flow-cache timeout active 1
ip flow-export source Integrated-Service-Engine3/0
ip flow-export version 5
```

```
ip flow-export destination 172.26.157.11 7777
!
no ip http server
no ip http secure-server
!
!
ip prefix-list CAMPUS seq 5 permit 192.168.16.0/20
ip sla responder
ip sla 293
 udp-jitter 192.168.15.5 14216 source-ip 192.168.15.6 codec g729a codec-numpackets 50
 tos 184
 timeout 500
 owner joeking
 tag VERIFICATION for Vlan 293
ip sla schedule 293 life forever start-time now
ip sla 294
 udp-jitter 192.168.15.1 14214 source-ip 192.168.15.2 codec g729a codec-numpackets 50
 tos 184
 timeout 500
 owner joeking
 tag VERIFICATION for Vlan 294
ip sla schedule 294 life forever start-time now
snmp-server enable traps tty
!
!
!
oer-map LOSS 10
 match traffic-class prefix-list CAMPUS
 set mode select-exit best
 set mode route control
 set mode monitor fast
 set resolve loss priority 1 variance 10
 set resolve delay priority 2 variance 10
 set loss relative 100
 set active-probe jitter 192.168.16.1 target-port 32014 codec g729a
 set probe frequency 10
!
control-plane
!
!
!
line con 0
 exec-timeout 120 0
line aux 0
line 130
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh
line 194
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh
line vty 0 4
 login local
!
scheduler allocate 20000 1000
ntp clock-period 17180273
ntp source Integrated-Service-Engine3/0
ntp master 12
ntp server 10.81.254.202 source Vlan1
```

```
ntp server 10.81.254.131 source Vlan1
!
end
```

vpn4-3800-6

This configuration is for the branch 3825 model router shown in the topology diagram

```
! ================= vpn4-3800-6  ==================================
!
! Last configuration change at 13:33:32 edt Tue Aug 4 2009
! NVRAM config last updated at 13:35:16 edt Tue Aug 4 2009
!
version 12.4
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service password-encryption
service udp-small-servers
service tcp-small-servers
!
hostname vpn4-3800-6
!
boot-start-marker
boot-end-marker
!
enable secret 5 [removed]
!
no aaa new-model
clock timezone est -5
clock summer-time edt recurring
dot11 syslog
ip cef
!
!
ip dhcp use vrf connected
ip dhcp excluded-address 192.168.211.1 192.168.211.149
ip dhcp excluded-address 192.0.2.52
!
ip dhcp pool cameras
   vrf IPVS
   network 192.0.2.48 255.255.255.240
   default-router 192.0.2.49
   domain-name ese.cisco.com
   dns-server 64.102.6.247 171.68.226.120
!
ip dhcp pool iSCSI-temp
   network 192.168.211.0 255.255.255.0
   default-router 192.168.211.1
   domain-name cisco.com
!
!
ip vrf IPVS
 rd 100:10
 route-target export 100:10
 route-target import 100:10
!
ip host rtp5-esevpn-ios-ca 10.81.0.27
ip host harry 172.26.129.252
ip multicast-routing
ip auth-proxy max-nodata-conns 3
ip admission max-nodata-conns 3
!
```

```
multilink bundle-name authenticated
!
voice-card 0
 no dspfarm
!
!
!
crypto pki trustpoint rtp5-esevpn-ios-ca
 enrollment url http://rtp5-esevpn-ios-ca:80
 revocation-check none
!
!
crypto pki certificate chain rtp5-esevpn-ios-ca
 certificate 13
  3082023B 308201A4 A0030201 02020113 300D0609 2A864886 F70D0101 04050030
  6C240A83 ADF2674E D83B7BEF 59A04BC8 A0474C0C 492CAD79 2713CCFA 1783F4
    quit
 certificate ca 01
  308202AF 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 04050030
  A9C7FB7B F68000AE 7C8FABF5 24279B82 8A394A91 4DF83555 D2C9D52E 84779C37
  47DC2CE3 BC3F5F40 32409535 C9E0E6C0 F29D4E
    quit
!
!
username joeking privilege 15 secret 5 vpn4-3800-6
username test password 7 vpn4-3800-6
archive
 log config
  hidekeys
!
!
crypto isakmp policy 100
 encr 3des
 group 2
crypto isakmp keepalive 10
crypto isakmp nat keepalive 10
crypto isakmp profile IPVS_Branches_isakmp_profile
   self-identity fqdn
   ca trust-point rtp5-esevpn-ios-ca
   match identity address 192.168.15.40 255.255.255.255
   keepalive 10 retry 2
crypto isakmp profile IPVS_Branches_isakmp_profile_2
   self-identity fqdn
   ca trust-point rtp5-esevpn-ios-ca
   match identity address 192.168.15.41 255.255.255.255
   keepalive 10 retry 2
!
!
crypto ipsec transform-set 3DES_SHA_TUNNEL esp-3des esp-sha-hmac
crypto ipsec transform-set 3DES_SHA_TRANSPORT esp-3des esp-sha-hmac
 mode transport
crypto ipsec transform-set AES_SHA_TUNNEL esp-aes esp-sha-hmac
crypto ipsec transform-set AES_SHA_TRANSPORT esp-aes esp-sha-hmac
 mode transport
!
crypto ipsec profile IPVS_Branches_ipsec_profile
 description IPVS_Branches_ipsec_profile
 set transform-set 3DES_SHA_TRANSPORT 3DES_SHA_TUNNEL
 set isakmp-profile IPVS_Branches_isakmp_profile
!
crypto ipsec profile IPVS_Branches_ipsec_profile_2
 set transform-set 3DES_SHA_TRANSPORT 3DES_SHA_TUNNEL
 set isakmp-profile IPVS_Branches_isakmp_profile_2
!
```

```
!
!
!
ip finger
!
class-map match-any LOW-LATENCY-DATA
 match ip dscp af21  af22  af23
class-map match-any HIGH-THROUGHPUT-DATA
 match ip dscp af11  af12  af13
class-map match-all BROADCAST-VIDEO
 match ip dscp cs5
class-map match-all NETWORK-CONTROL
 match ip dscp cs6
class-map match-any MULTIMEDIA-CONFERENCING
 match ip dscp af41  af42  af43
class-map match-all OAM
 match ip dscp cs2
class-map match-all VOICE
 match ip dscp ef
class-map match-all SCAVENGER
 match ip dscp cs1
class-map match-any CALL-SIGNALING
 match ip dscp cs3
!
!
policy-map IPVS_BRANCH
 class BROADCAST-VIDEO
  bandwidth percent 40
 class VOICE
  priority percent 10
 class LOW-LATENCY-DATA
  bandwidth percent 4
 class HIGH-THROUGHPUT-DATA
  bandwidth percent 4
 class MULTIMEDIA-CONFERENCING
  bandwidth percent 4
 class SCAVENGER
  bandwidth percent 1
 class OAM
  bandwidth percent 1
 class NETWORK-CONTROL
  bandwidth percent 1
 class CALL-SIGNALING
  bandwidth percent 1
 class class-default
  fair-queue
policy-map 30M
 class class-default
  shape average 30000000
  service-policy IPVS_BRANCH
!
!
interface Tunnel128
 ip vrf forwarding IPVS
 ip address 192.168.15.131 255.255.255.192
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map 192.168.15.129 192.168.15.40
 ip nhrp map multicast 192.168.15.40
 ip nhrp network-id 128
 ip nhrp nhs 192.168.15.129
 ip summary-address eigrp 65 192.0.2.32 255.255.255.224 5
 tunnel source GigabitEthernet0/0.352
 tunnel destination 192.168.15.40
```

```
 tunnel key 128
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile
!
interface Tunnel192
 ip vrf forwarding IPVS
 ip address 192.168.15.195 255.255.255.192
 ip mtu 1400
 ip nhrp authentication FOO
 ip nhrp map 192.168.15.193 192.168.15.41
 ip nhrp map multicast 192.168.15.41
 ip nhrp network-id 192
 ip nhrp nhs 192.168.15.193
 ip summary-address eigrp 65 192.0.2.32 255.255.255.224 5
 tunnel source GigabitEthernet0/0.351
 tunnel destination 192.168.15.41
 tunnel key 192
 tunnel protection ipsec profile IPVS_Branches_ipsec_profile_2
!
interface GigabitEthernet0/0
 description TRUNK
 no ip address
 ip route-cache flow
 load-interval 30
 duplex full
 speed 100
 media-type rj45
!
interface GigabitEthernet0/0.150
 description Outside WAN
 encapsulation dot1Q 150
 ip address dhcp
!
interface GigabitEthernet0/0.203
 description Inside global routing for corporate end-users
 encapsulation dot1Q 203
 ip address 10.81.7.89 255.255.255.248
!
interface GigabitEthernet0/0.208
 description Inside interface for IP Cameras
 encapsulation dot1Q 208
 ip vrf forwarding IPVS
 ip address 192.0.2.49 255.255.255.240
 ip pim sparse-mode
!
interface GigabitEthernet0/0.258
 description iSCSI Management Subnet
 encapsulation dot1Q 258
 ip vrf forwarding IPVS
 ip address 192.168.211.1 255.255.255.0
!
interface GigabitEthernet0/0.351
 description vpn-jk2-7206-2 [Second Head-end]
 encapsulation dot1Q 351
 ip address 192.168.15.30 255.255.255.252
 service-policy output 30M
!
interface GigabitEthernet0/0.352
 description vpn-jk2-7206-1 [Primary Head-end]
 encapsulation dot1Q 352
 ip address 192.168.15.50 255.255.255.252
 service-policy output 30M
!
interface GigabitEthernet0/1
 no ip address
```

```
 duplex auto
 speed auto
 media-type rj45
!
interface FastEthernet0/2/0
 description Flashnet
 duplex full
 speed 100
!
interface FastEthernet0/2/1
!
interface FastEthernet0/2/2
!
interface FastEthernet0/2/3
!
interface Video-Service-Engine1/0
 ip vrf forwarding IPVS
 ip address 192.0.2.37 255.255.255.252
 ip route-cache flow
 service-module ip address 192.0.2.38 255.255.255.252
 service-module ip default-gateway 192.0.2.37
 no keepalive
!
interface Integrated-Service-Engine2/0
 ip vrf forwarding IPVS
 ip address 192.0.2.33 255.255.255.252
 ip route-cache flow
 service-module external ip address 192.168.211.2 255.255.255.0
 service-module ip address 192.0.2.34 255.255.255.252
 service-module ip default-gateway 192.0.2.33
 no keepalive
!
interface Vlan1
 description FlashNet
 ip address 172.26.156.105 255.255.254.0
 no ip proxy-arp
!
router eigrp 65
 network 10.81.7.88 0.0.0.7
 network 192.168.15.0 0.0.0.63
 no auto-summary
 !
 address-family ipv4 vrf IPVS
  network 192.0.2.32 0.0.0.31
  network 192.168.15.128 0.0.0.127
  network 192.168.211.0
  no auto-summary
  autonomous-system 65
 exit-address-family
!
ip forward-protocol nd
ip route 10.81.0.27 255.255.255.255 172.26.156.1 name IOS-CA
ip route 192.168.15.40 255.255.255.255 192.168.15.49 name vpn-jk2-7206-1_Loopback_0
ip route 192.168.15.41 255.255.255.255 192.168.15.29 name vpn-jk2-7206-2_Loopback_0
ip route 64.102.223.16 255.255.255.240 dhcp
ip route 192.5.41.40 255.255.255.254 dhcp
!
ip flow-cache timeout active 1
ip flow-export version 5
ip flow-export destination 172.26.157.11 7777
!
ip http server
no ip http secure-server
!
```

```
ip access-list extended LOCAL_LOGIN
 permit tcp host 192.0.2.33 any eq 2130
 deny   ip any any log
!
snmp-server enable traps tty
!
!
control-plane
!
!
banner exec
3825
192.0.2.32 /30  ISR NM NME-VMSS-HP16
192.0.2.36 /30  EVM-IPVS-16A
192.0.2.40      reserved .40 to .47
192.0.2.48 /28  Reserved for IP Cameras (0.0.0.15)

banner motd
   C i s c o S y s t e m s
     ||              ||
     ||              ||       Cisco Systems, Inc.
    ||||            ||||      IT-Transport
 .:|||||||:.......:|||||||:..
  US, Asia & Americas support:    + 1 408 526 8888
 EMEA support:                   + 31 020 342 3888
  UNAUTHORIZED ACCESS TO THIS NETWORK DEVICE IS PROHIBITED.
 You must have explicit permission to access or configure this
 device. All activities performed on this device are logged and
 violations of this policy may result in disciplinary action.

!
line con 0
 exec-timeout 0 0
line aux 0
line 66
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh
line 130
 access-class LOCAL_LOGIN in vrf-also
 login local
 no activation-character
 no exec
 transport preferred none
 transport input telnet
 transport output none
line vty 0 4
 exec-timeout 0 0
 login local
!
scheduler allocate 20000 1000
ntp clock-period 17178750
ntp source Integrated-Service-Engine2/0
ntp master 12
ntp server 192.168.6.1 source GigabitEthernet0/0.150
ntp server 10.81.254.202 source Vlan1
ntp server 10.81.254.131 source Vlan1
!
end
```

3750-access

This configuration is for an access-layer switch not explicitly shown in the topology diagram. It is a cisco WS-C3750G-24PS model.

```
! System image file is "flash:c3750-advipservicesk9-mz.122-44.SE1.bin"
!
3750-access#sh run b
Building configuration...

Current configuration : 6533 bytes
!
version 12.2
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname 3750-access
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
switch 1 provision ws-c3750g-24ps
system mtu routing 1500
vtp mode transparent
ip subnet-zero
no ip domain-lookup
!
ip multicast-routing distributed
!
mls qos
!
crypto pki trustpoint TP-self-signed-798490880
 enrollment selfsigned
 subject-name cn=IOS-Self-Signed-Certificate-798490880
 revocation-check none
 rsakeypair TP-self-signed-798490880
!
!
crypto pki certificate chain TP-self-signed-798490880
 certificate self-signed 01
!
!
!
!
macro name cisco-camera-2500
#Assign Port Description

description Connected to IPVS Camera

#Assign Cisco IPVS Camera in unique Layer 2 VLAN
switchport access vlan $VLAN

#Statically configure Cisco Camera port in access-mode
switchport mode access

#Enable Layer 2 Port-Security
switchport port-security
```

```
#Dynamically register secured IPVS MAC address.
switchport port-security mac-address sticky

#Set maximum allowed secured MAC entry to 1. Default value, but with macro it wi
ll override manual setting.
switchport port-security maximum 1

#Set port security violation action to shutdown physical port. Default setting,
but will macro it will override manual setting.
switchport port-security violation shutdown

#Enable QoS on Cisco Camera port and trust incoming DSCP value.

mls qos trust dscp

#Expedite port bring up process by enabling portfast configuration.
spanning-tree portfast

#Disable transmitting and receiving STP BPDU frame on Cisco Camera port
spanning-tree bpdufilter enable
@
macro name CIVS-IPC-2500
description Cisco Video Surveillance 2500 Series IP Camera
switchport mode access
switchport access vlan $VLAN
switchport port-security
switchport port-security mac-address sticky
switchport port-security maximum 1
switchport port-security violation shutdown
mls qos trust dscp
spanning-tree portfast
spanning-tree bpdufilter enable
load-interval 60
no shutdown
@
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
vlan 10,208,220-221
!
!
class-map match-all HTTP
 match protocol http
class-map match-all HTTP_acl
 match access-group name HTTP
class-map match-all HTTP_acl_client
 match access-group name HTTP_client
!
!
policy-map VSMS
 class HTTP_acl
  set dscp cs5
 class class-default
  set dscp cs3
policy-map Viewing_Station
 class HTTP_acl_client
  set dscp cs5
 class class-default
  set dscp cs3
!
!
```

```
!
!
interface GigabitEthernet1/0/1
 description trunk to vpn1-2851-1 [vpn-jk2-2948-1]
 switchport trunk encapsulation dot1q
 switchport mode trunk
 load-interval 60
 priority-queue out
 mls qos trust dscp
!
interface GigabitEthernet1/0/2
 description Cisco Video Surveillance 2500 Series IP Camera
 switchport access vlan 208
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 001d.e5ea.79d3
 load-interval 60
 mls qos trust dscp
 macro description CIVS-IPC-2500
 spanning-tree portfast
 spanning-tree bpdufilter enable
!
interface GigabitEthernet1/0/3
 description 4300 IP camera 0021.1bfd.df85
 switchport access vlan 220
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 0021.1bfd.df85
 load-interval 60
 mls qos trust dscp
 spanning-tree portfast
 spanning-tree bpdufilter enable
!
interface GigabitEthernet1/0/4
 description 4300 IP camera 0021.1bfd.df62
 switchport access vlan 220
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 0021.1bfd.df62
 load-interval 60
 mls qos trust dscp
 spanning-tree portfast
 spanning-tree bpdufilter enable
!
interface GigabitEthernet1/0/5
 description Viewing Station
 switchport access vlan 208
 switchport mode access
 priority-queue out
 spanning-tree portfast
 spanning-tree bpdufilter enable
 service-policy input Viewing_Station
!
interface GigabitEthernet1/0/6
!
interface GigabitEthernet1/0/7
!
interface GigabitEthernet1/0/8
!
interface GigabitEthernet1/0/9
!
```

```
interface GigabitEthernet1/0/10
!
interface GigabitEthernet1/0/11
 description CIVS-IPC-4500-1
 switchport access vlan 220
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 001e.bdfc.19d6
 load-interval 60
 mls qos trust dscp
 spanning-tree portfast
 spanning-tree bpdufilter enable
!
interface GigabitEthernet1/0/12
 description CIVS-IPC-4500-2
 switchport access vlan 220
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 0021.1bfd.dfc1
 load-interval 60
 mls qos trust dscp
 spanning-tree portfast
 spanning-tree bpdufilter enable
!
interface GigabitEthernet1/0/13
 description CIVS-IPC-4500-3
 switchport access vlan 220
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 001b.53ff.6cb9
 load-interval 60
 mls qos trust dscp
 spanning-tree portfast
 spanning-tree bpdufilter enable
!
interface GigabitEthernet1/0/14
 description CIVS-IPC-4500-4
 switchport access vlan 220
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 001e.bdfc.19c9
 load-interval 60
 mls qos trust dscp
 spanning-tree portfast
 spanning-tree bpdufilter enable
!
interface GigabitEthernet1/0/15
!
interface GigabitEthernet1/0/16
!
interface GigabitEthernet1/0/17
!
interface GigabitEthernet1/0/18
!
interface GigabitEthernet1/0/19
!
interface GigabitEthernet1/0/20
!
interface GigabitEthernet1/0/21
!
```

```
interface GigabitEthernet1/0/22
!
interface GigabitEthernet1/0/23
!
interface GigabitEthernet1/0/24
!
interface GigabitEthernet1/0/25
!
interface GigabitEthernet1/0/26
!
interface GigabitEthernet1/0/27
!
interface GigabitEthernet1/0/28
!
interface Vlan1
 no ip address
 shutdown
!
ip classless
ip http server
ip http secure-server
!
!
ip access-list extended HTTP
 permit tcp any eq www any
ip access-list extended HTTP_client
 permit tcp any any eq www
!
!
control-plane
!
!
line con 0
 exec-timeout 0 0
line vty 0 4
 login
line vty 5 15
 login
!
!
end
```

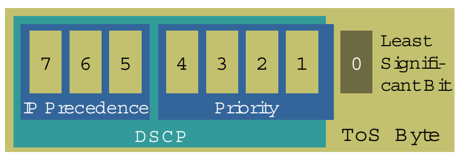
APPENDIX A

Appendix

IP Video Surveillance QoS Reference Chart

The reference chart in Figure A-1 is useful when implementing IP video surveillance on routers and switches. The formula for converting a ToS byte value to DSCP using decimal values is to divide the ToS byte number by 4. Example ToS decimal value of 160 / 4 = 40. The DSCP value of ‘40’ is CS5.

Figure A-1 IP Video Surveillance QoS Reference Chart



ToS Hex	ToS Decimal	IP Precedence	Class-map Name	DSCP	Binary
E0	224	7 Network Control		56 CS7	11100000
C0	192	6 Internetwork Control	NETWORK-CONTROL	48 CS6	11000000
B8	184		VOICE	46 EF	10111000
A0	160	5 Critical	BROADCAST-VIDEO	40 CS5	10100000
88	136			34 AF41	10001000
80	128	4 Flash Override		32 CS4	10000000
68	104			26 AF31	01101000
60	96	3 Flash	CALL-SIGNALING	24 CS3	01100000
48	72			18 AF21	0101000
40	64	2 Immediate	OAM	16 CS2	01000000
20	32	1 Priority		8 CS1	00100000
00	0	0 Routine		0 Dflt	00000000

IP SLA Probe Sample Configurations

These are sample IP SLA UDP Jitter operation probes which can be used as a baseline for determining a range of network performance suitable for transporting video surveillance media feeds. It is assume that sufficient bandwidth exists between source and sink nodes. These probes are reporting on a range of network latency, jitter and loss which should provide acceptable video quality.

Tip Reported MOS score values of 4 or above should be expected to provide a baseline for serviceable video quality.

WAN Latency Probe

This probe provides a baseline for a WAN connection suitable for transporting H.264 based video.

```
no ip sla 1090
ip sla 1090
 udp-jitter 10.81.0.26 16090 source-ip 10.81.7.25 codec g729a codec-numpackets 50
 tos 160
 threshold 100
 timeout 500
 owner VideoSurveillance
 tag IPVS_test_probe
ip sla schedule 1090 start-time now life 7200
```

The round trip time (RTT) is approximately 30ms with jitter of approximately 2ms. No loss was detected, however, this probe only generates 50 sample packets.

```
zhallxxx-vpn-881#show ip sla stat 1090
IPSLAs Latest Operation Statistics

IPSLA operation id: 1090
        Latest RTT: 30 milliseconds
Latest operation start time: 17:34:05.074 edt Mon Jul 13 2009
Latest operation return code: OK
RTT Values:
        Number Of RTT: 50               RTT Min/Avg/Max: 28/30/42 milliseconds
Latency one-way time:
        Number of Latency one-way Samples: 50
        Source to Destination Latency one way Min/Avg/Max: 12/13/22 milliseconds
        Destination to Source Latency one way Min/Avg/Max: 15/17/29 milliseconds
Jitter Time:
        Number of SD Jitter Samples: 49
        Number of DS Jitter Samples: 49
        Source to Destination Jitter Min/Avg/Max: 0/2/9 milliseconds
        Destination to Source Jitter Min/Avg/Max: 0/2/9 milliseconds
Packet Loss Values:
        Loss Source to Destination: 0           Loss Destination to Source: 0
        Out Of Sequence: 0      Tail Drop: 0
        Packet Late Arrival: 0  Packet Skipped: 0
Voice Score Values:
        Calculated Planning Impairment Factor (ICPIF): 11
MOS score: 4.06
Number of successes: 1
Number of failures: 0
Operation time to live: 7187 sec
```

LAN Latency Probe

This probe is from the test lab environment and has expected LAN latency. In LAN environments, RTT is expected to be less than 4ms, jitter should be reported as zero (0), and loss should approach zero.

```
no ip sla 22
ip sla 22
 udp-jitter 192.0.2.1 16000 codec g729a codec-numpackets 50
 tos 160
 timeout 500
 threshold 100
 owner VideoSurveillance
 tag IPVS_test_probe
```

```
 vrf IPVS
ip sla schedule  22 start now life 7200



vpn-jk2-7206-1#show ip sla stat 22

Round Trip Time (RTT) for       Index 22
        Latest RTT: 1 milliseconds
Latest operation start time: 09:56:54.073 edt Tue Jul 14 2009
Latest operation return code: OK
RTT Values:
        Number Of RTT: 50               RTT Min/Avg/Max: 1/1/2 milliseconds
Latency one-way time:
        Number of Latency one-way Samples: 0
        Source to Destination Latency one way Min/Avg/Max: 0/0/0 milliseconds
        Destination to Source Latency one way Min/Avg/Max: 0/0/0 milliseconds
Jitter Time:
        Number of SD Jitter Samples: 49
        Number of DS Jitter Samples: 49
        Source to Destination Jitter Min/Avg/Max: 0/0/0 milliseconds
        Destination to Source Jitter Min/Avg/Max: 0/1/1 milliseconds
Packet Loss Values:
        Loss Source to Destination: 0           Loss Destination to Source: 0
        Out Of Sequence: 0      Tail Drop: 0
        Packet Late Arrival: 0  Packet Skipped: 0
Voice Score Values:
        Calculated Planning Impairment Factor (ICPIF): 11
MOS score: 4.06
Number of successes: 2
Number of failures: 0
Operation time to live: 7130 sec
```

Tip Historically, the minimum interval between clock interrupts in Cisco IOS has been 4ms. Reporting values between 0 and 4ms may not be precise.

Access-layer Switch Commands

The following **show** commands are from the Cisco Catalyst 3750 Series switch. These commands illustrate how to determine what interface a particular Cisco IP camera is attached and what data rate the camera is streaming to the Media Server.

Determine Interface

Determine which interface a particular camera is attached by specifying the last four digits of the MAC address of the camera as a filter to the **show cdp neighbors** command. The MAC address is printed on the exterior label of the camera. In this example, the last four digits are '79D3'. The entire MAC address can be specified, but usually the last four digits are unique in the small population of cameras attached to an individual switch.

```
3750-access#show cdp neighbors detail | begin 79D3
Device ID: 001DE5EA79D3
Entry address(es):
  IP address: 192.0.2.52
Platform: CIVS-IPC-2500,  Capabilities: Host
```

```
Interface: GigabitEthernet1/0/2,  Port ID (outgoing port): eth0
[output truncated]
```

Determine Data Rate

From the output above, the camera in question is at IP address 192.0.2.52 on interface GigabitEthernet1/0/2. To view the interface statistics, the ***show interfaces*** command can be issued for the target interface.

```
3750-access#show interfaces gigabitEthernet 1/0/2
GigabitEthernet1/0/2 is up, line protocol is up (connected)
  Hardware is Gigabit Ethernet, address is 0019.2f98.0102 (bia 0019.2f98.0102)
  Description: Cisco Video Surveillance 2500 Series IP Camera
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 2/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s, media type is 10/100/1000BaseTX
  input flow-control is off, output flow-control is unsupported
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:49, output 00:00:01, output hang never
  Last clearing of "show interface" counters 00:08:50
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  1 minute input rate 1082000 bits/sec, 107 packets/sec
  1 minute output rate 0 bits/sec, 0 packets/sec
[output truncated]
```

From the output above, the video feed of the camera is transmitting approximately 1Mbps at 107 packets per second over the time period of the last minute. The **load-interval interface** command has overridden the default value of 5 minutes to 1 minute in this example.

The **show interfaces** command can also be issued with the **summary** keyword and this method provides useful information on transmitted and received data rates as well as queue drops.

```
3750-access#show interfaces g1/0/2 summary

 *: interface is up
 IHQ: pkts in input hold queue     IQD: pkts dropped from input queue
 OHQ: pkts in output hold queue    OQD: pkts dropped from output queue
 RXBS: rx rate (bits/sec)          RXPS: rx rate (pkts/sec)
 TXBS: tx rate (bits/sec)          TXPS: tx rate (pkts/sec)
 TRTL: throttle count

  Interface               IHQ   IQD  OHQ   OQD  RXBS RXPS  TXBS TXPS TRTL
-------------------------------------------------------------------------
* GigabitEthernet1/0/2     0     0    0     0 1097000  108     0    0    0
```

Tip The asymmetrical bandwidth consumption of IP video surveillance is evident in the above display. The sample camera is configured with a resolution of D1 at a constant bit rate (CBR) of 1Mbps using MPEG-4 as the codec. The switch is receiving approximately 1Mbps from the camera, but transmitting zero (0) Mbps to the camera.

Interface Configuration

The interface configuration for the sample camera is shown below.

```
3750-access#show run int g 1/0/2
Building configuration...

Current configuration : 409 bytes
!
interface GigabitEthernet1/0/2
 description Cisco Video Surveillance 2500 Series IP Camera
 switchport access vlan 208
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 001d.e5ea.79d3
 load-interval 60
 mls qos trust dscp
 macro description CIVS-IPC-2500
 spanning-tree portfast
 spanning-tree bpdufilter enable
end
```

Service-module session command

The **service-module session** command is used to Telnet into the NME-VMSS Cisco Video Management and Storage System NME and the EVM-IPVS-16A 16-port Analog Video Gateway for management. When these logical interfaces are configured in a VRF (*ip vrf forwarding IPVS*, for example) the **service-module session** command will fail because the interface IP address in the the VRF and the session is initiated from the global routing table.

A circumvention is to initiate the **service-module session** command, identify the IP address and port number (see *Trying 192.0.2.1, 2066* ... below), allow the session command to timeout or reset (CTL+ SHIFT6+x), and then issue a Telnet command sourcing from the VRF. Examples are shown below for both types of modules.

```
vpn1-2851-1#service-module integrated-Service-Engine 1/0 session
Trying 192.0.2.1, 2066 ...
% Connection reset by user

vpn1-2851-1#telnet 192.0.2.5 2066 /vrf IPVS
Trying 192.0.2.1, 2066 ... Open

=
==
=== Site 130   === vpn1-2851-1
==
=
SITE130-VSM>



vpn1-2851-1#service-module video-Service-Engine 2/0 session
Trying 192.0.2.5, 2130 ...
% Connection reset by user

vpn1-2851-1#telnet 192.0.2.5 2130 /vrf IPVS
Trying 192.0.2.5, 2130 ... Open
```

```
=
==
=== Site 130   === vpn1-2851-1
==
=
SITE130-Analog-Gateway>
```

IP Multicast

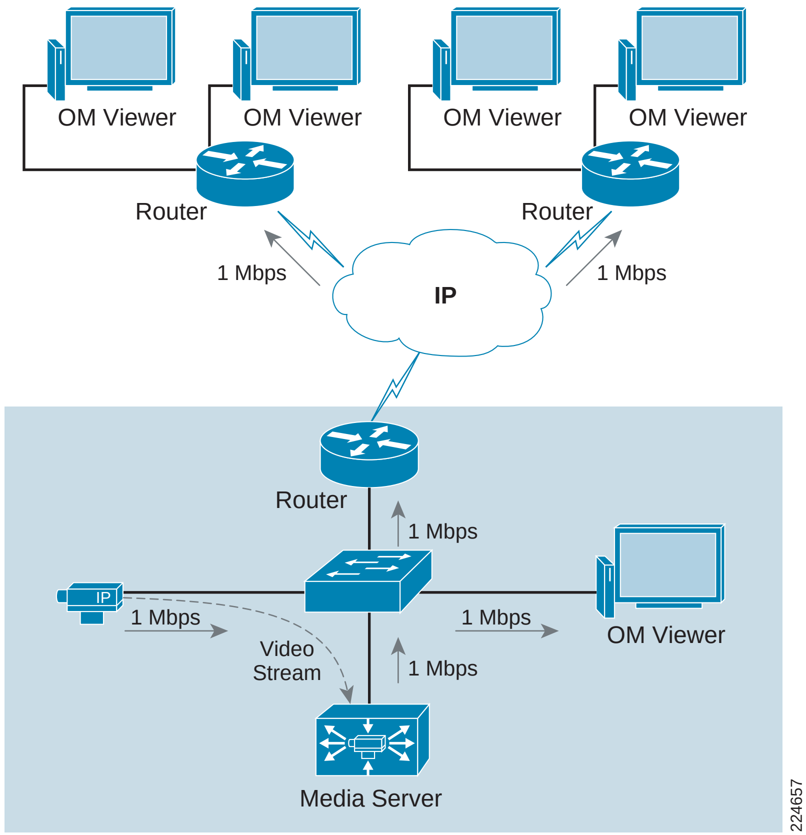
In IP multicast transmissions, a host sends one copy of each packet to a special address that can be used by several hosts interested in receiving the packets. Those hosts are members of a designated multicast group and can be located anywhere on the network. Using IP multicast to transmit video traffic reduces the overall network load and minimizes the impact on the source of the video from unnecessary replication of a common data stream.

By using multicast protocols, the hosts that want to receive traffic from a multicast group can join and leave the group dynamically. Hosts can be members of more than one group and must explicitly join a group before receiving content. Since IP multicast traffic relies on UDP, which, unlike TCP, has no built-in reliability mechanism such as flow control or error recovery mechanisms, tools such as QoS can improve the reliability of a multicast transmission.

Some edge devices may communicate with the Media Server using unicast or multicast communications. The use of IP Multicast offers some benefits when a video stream is to be archived by several Media Servers, since only a single stream is required from the IP camera or encoder.

Figure A-2 shows an example where a single multicast stream is generated by an IP camera and archived by two Media Servers. The Media Servers propagate the video streams to the viewers using IP Unicast transmission. Using multicast protocols, Cisco routers and switches replicate the video stream to only the segments and hosts that require it, using approximately 8 Mbps of bandwidth throughout the network.

Figure A-2 IP Multicast



Note The Media Server only supports IP unicast between the Media Server and the viewers, but it can communicate through IP multicast with edge devices that support IP multicast.

Multicast Addressing

IP multicast uses the class D range of IP addresses, from 224.0.0.0 through 239.255.255.255. Within this range, several addresses are reserved by the Internet Assigned Numbers Authority (IANA):

- **224.0.0.0 through 224.0.0.255**—Link-Local addresses that are used by network protocols only in a local segment.
- **224.0.1.0 through 238.255.255.255**—Globally scoped addresses that can be routed across the Internet or any organization. They are unique and globally significant.
- **239.0.0.0 through 239.255.255.255**—Used in private domains and not routed between domains. Similar to the IP address range from RFC1918.

Forwarding Multicast Traffic

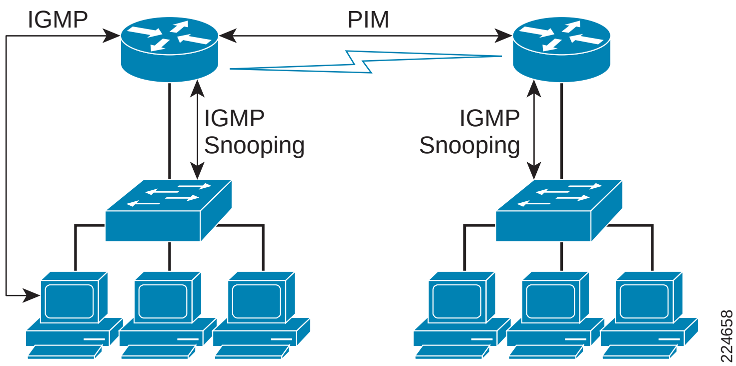
Forwarding multicast packets through a network is different than unicast routing. With unicast traffic, routers consider the destination address and how to find the single destination host. In multicast traffic, the source sends traffic to a multicast group address, which in turn can be reached by multiple hosts or receivers.

Routers rely on distribution trees to reach all multicast receivers. The two types of multicast trees are as follows:

- **Source trees**—The root is located at the multicast source and a tree to all receivers is formed via the shortest path tree (SPT).
- **Shared trees**—The root is not necessarily the multicast source. The tree is shared by all sources relying on a defined common root. This shared root is the Rendezvous Point (RP).

Similar to IP unicast, IP multicast traffic uses its own Layer 2, management, and routing protocols. Figure A-3 shows the interaction between these different protocols.

Figure A-3 Interaction Between IGMP and PIM



- PIM is the multicast routing protocol that is responsible for building multicast delivery trees and for enabling multicast packet forwarding.
- IGMP is used by hosts to dynamically register to multicast groups. The communication occurs between the router and the host.
- IGMP snooping is used to prevent multicast flows from flooding all ports on a VLAN by monitoring the Layer 3 IGMP packets.

Proxy Processes

Proxy processes allow for the replication of individual video feeds at different frame rates for multiple users or system processes. When a video feed is first registered with the Media Server, the server creates a proxy or process to manage connections and video streams from video sources into the Media Server.

The Media Server can support a large number of proxy processes on a single server or an architecture with distributed proxy processes on multiple Media Servers.

There are two types of proxy processes:

- Direct Proxy
- Parent-Child Proxies

Direct Proxy

A direct proxy is the process created on the Media Server to maintain connectivity with the edge device (IP camera or encoder). The proxy is capable of requesting video from the edge device with different video configurations such as frame rate and video resolution. One direct proxy exists for a given video stream.

In the example in Figure A-4, the Media Server maintains connectivity and receives video from four different IP cameras. The Media server is responsible for replicating the video feeds to four different viewers.

Figure A-4 Direct Proxy

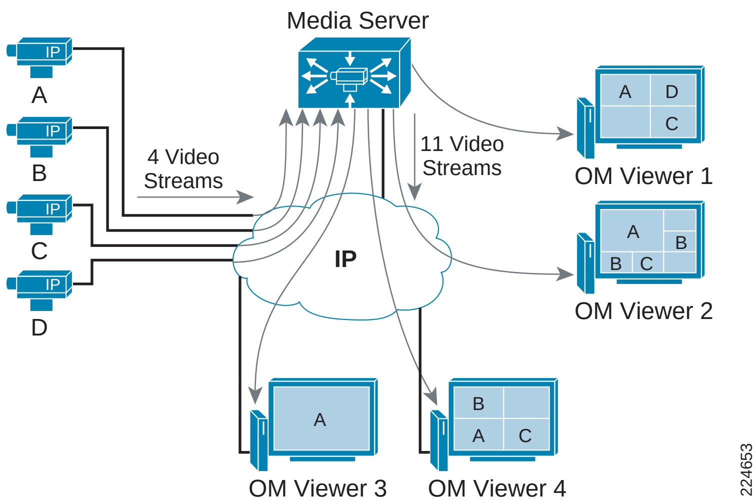


Table A-1 shows the active processes from Figure A-4. The four OM viewers are viewing live video from different cameras; each of the viewers is receiving the video feeds directly from the Media Server. The Media Server is receiving four unique video streams, replicating them a total of 11 times.

Table A-1 Active Processes

Video Source	**Active Viewers**	**Number of Active Streams from the Media Server to Clients**
Camera A	Viewer 1, Viewer 2, Viewer 3, Viewer 4	4
Camera B	Viewer 2, Viewer 2, Viewer 4	3 (two streams to Viewer 2)
Camera C	Viewer 1, Viewer 2, Viewer 4	3
Camera D	Viewer 1	1
Total Streams		11

Parent-Child Proxies

Video feeds can originate from the direct proxy or from a different Media Server. A proxy video feed can be the parent to another video feed served by a different Media Server. Parent proxies may be from remote or local hosts and may be nested in a hierarchy with inheritance rights.

A direct proxy becomes a parent when a child proxy is created. A child proxy receives its video directly from a parent proxy. A child proxy has the same resolution, quality, and media type of its parent, but in the case of MJPEG video streams, a lower frame rate may be configured for the child feed.

Parent-child proxies allow for more efficient network utilization by distributing video feeds closer to the viewers. This is very important in environments with remote branch offices or with limited bandwidth available for video delivery. By replicating a single video feed to a location with several viewers, the bandwidth requirements throughout the network are reduced.

In order to conserve bandwidth, the child process connects to the parent source only when video streaming is requested by a viewer.

In Figure A-5, Media Server MS1 is acting as the parent for two feeds that are served by Media Server MS2. Video feeds from cameras A and B are replicated to Media Server MS2, which in turn can be served to a large number of users or other child feeds.

The environment in Figure A-5 has generated a total of six proxy processes:

- Media Server MS1 is the direct proxy to four edge devices but also replicates eleven different video streams to other viewers or child feeds.
- Media Server MS2 has created two child proxy feeds, Child A and Child B. These feeds can be propagated to any viewers locally on Site B, reducing the bandwidth requirements across the wide area connections.

Figure A-5 Parent-Child Proxy

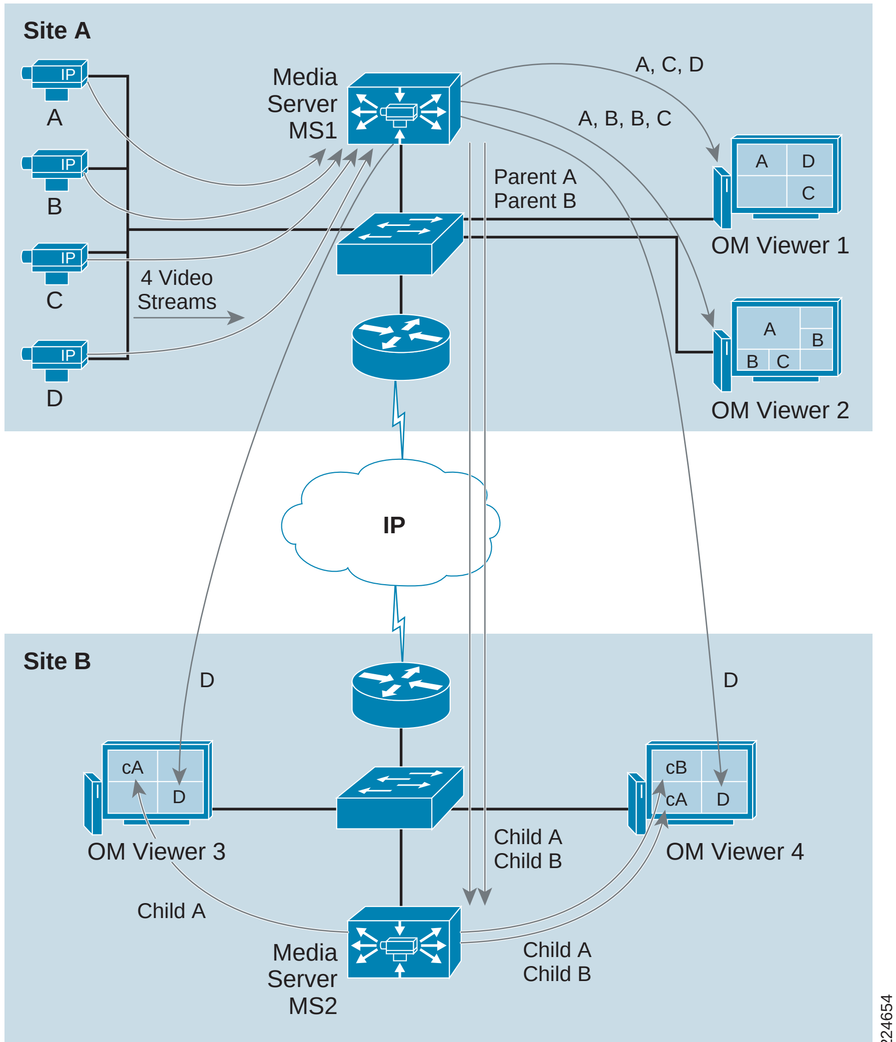


Table A-2 shows the different streams required to distribute the video feeds from Figure A-5.

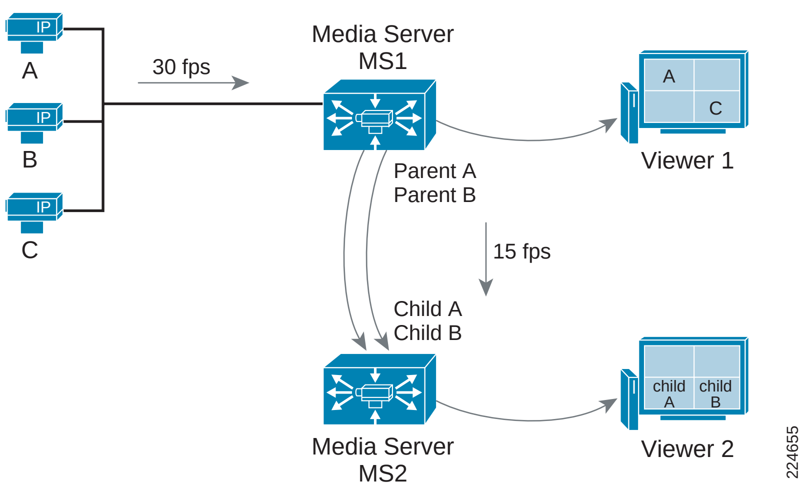
Table A-2 Parent-Child Proxies

Video Source	Active Viewers	Number of Active Streams from the Media Server to Clients
Camera A	Viewer1, Viewer 2, MS2	3
Camera B	Viewer 2, Viewer 2, MS2	3 (two streams to OM Viewer 2)
Camera C	Viewer 1, Viewer 2	2
Camera D	Viewer 1, Viewer 3, Viewer 4	3
Parent A	MS2	1
Parent B	MS2	1
Child A	Viewer 3, Viewer 4	2
Child B	Viewer 4	1
Site B: Local Streams		3
Site B: Remote Streams		4

Since Media Servers do not provide transcoding features, the video quality and resolution remain the same for all child feeds. When using MJPEG streams, the frame rate can be lowered to reduce the bandwidth utilization by child feeds. Figure A-6 shows an example of how frame rates can be lowered between parent and child feeds. The original video feed for all cameras is 30 fps, but is reduced to 15 fps by child feeds A and B in order to conserve bandwidth.

The example in Figure A-6 also shows how video feeds can be replicated indefinitely between Media Servers. In this example, Media Server MS1 is the direct proxy to three IP camera feeds. In turn, two of the feeds are parents for feeds going into Media Server MS2.

Figure A-6 MJPEG Frame Rate Reduction for Child Feeds



Note The frame rate of a MJPEG child feed can only be equal to or lower than the parent feed.

Glossary

A	
Alarm	The action or event that triggers an alarm for which an event profile is logged. Events can be caused by an encoder with serial contact closures, a motion detected above defined thresholds, or another application using the soft-trigger command API.
Alarm Trigger	The action or event that triggers an alarm for which an event profile is logged. Events can be caused by an encoder with serial contact closures, a motion detected above defined thresholds, another application using the soft-trigger command API, or a window or door opening/closing.
Alert	The action or event that triggers an alarm for which an event profile is logged. Events can be caused by an encoder with serial contact closures, a motion detected above defined thresholds, or another application using the soft-trigger command API.
API	Application Programming Interface
Archive	A place in which records or historical documents are stored and/or preserved. An archive is a collection of video data from any given proxy source. This enables a feed from a camera-encoder to be stored in multiple locations and formats to be viewed at a later time. There are three types of archives: Regular, where the archive recording terminates after a pre-set time duration lapses and is stored for the duration of its Days-to-Live. Loop, where the archive continuously records until the archive is stopped. Loop archives reuse the space (first-in-first-out) allocated after every completion of the specified loop time. Clip, the source of the archive is extracted from one of the previous two types and is stored for the duration of its Days-to-Live.
Archive Clip	The source of the archive that is extracted from one of the other two types and stored for the duration of its Days-to-Live.
Archive Server	Programs which receive incoming video streams or loops, interprets them, and takes the applicable action.
Archiver	An application that manages off-line storage of video/audio onto back-up tapes, floppy disks, optical disks, etc.
C	
Camera Controls	Permits users to change the camera lens direction and field view depth. Panning a camera moves its field of view back and forth along a horizontal axis. Tilting commands move it up and down the vertical axis. Zooming a camera moves objects closer to or further from the field of view. Many of these cameras also include focus and iris control. A camera may have a subset of these features such as zoom, pan, or tilt only.
Camera Drivers	Responsible for converting standardized URL commands supported by the module into binary control protocols read by a specific camera model.

Child Proxy	An agent, process, or function that acts as a substitute or stand-in for another. A proxy is a process that is started on a host acting as a source for a camera and encoder. This enables a single camera-encoder source to be viewed and recorded by hundreds of clients. There are three types of proxies: A “direct” proxy is the initial or direct connection between the edge camera-encoder source. By definition at least one direct proxy exists for a given video source. A “parent” proxy is the source of a nested or child proxy. Parent proxies may be from remote or local hosts. Proxies are nested in a hierarchy with inheritance rights. A “child” proxy is the result of a nested or parent proxy. Child proxies run on the local host. Proxies are nested in a hierarchy with inheritance rights. A child proxy has the same resolution, quality, and media type of its parent, but can have a lower framerate for motion JPEG.
Clip	A place in which records or historical documents are stored and/or preserved. An archive is a collection of video data from any given proxy source. This enables a feed from a camera-encoder to be stored in multiple locations and formats to be viewed at a later time. There are three types of archives: Regular: where the archive recording terminates after a pre-set time duration lapses and is stored for the duration of its Days-to-Live. Loop: where the archive continuously records until the archive is stopped. Loop archives reuse the space (first-in-first-out) allocated after every completion of the specified loop time. Clip: the source of the archive is extracted from one of the previous two types and is stored for the duration of its Days-to-Live.
D	
Direct Proxy	An agent, process, or function that acts as a substitute or stand-in for another. A proxy is a process that is started on a host acting as a source for a camera and encoder. This enables a single camera-encoder source to be viewed and recorded by hundreds of clients. There are three types of proxies: A “direct” proxy is the initial or direct connection between the edge camera-encoder source. By definition at least one direct proxy exists for a given video source. A “parent” proxy is the source of a nested or child proxy. Parent proxies may be from remote or local hosts. Proxies are nested in a hierarchy with inheritance rights. A “child” proxy is the result of a nested or parent proxy. Child proxies run on the local host. Proxies are nested in a hierarchy with inheritance rights. A child proxy has the same resolution, quality, and media type of its parent, but can have a lower frame rate for motion JPEG.
DVR	Digital Video Recorder/Recording: broadcasts on a hard disk drive which can then be played back at a later time
E	
Encoder Driver	Sends the output of a camera driver to the encoder to which the camera is attached (via the network protocol supported by a particular type of encoder).
ES	Cisco Video Surveillance Encoding Server
Event	When an incident or event occurs, it is captured by a device or application and is tagged. An event is a collection of information about an incident, including name, associated video sources, and a timestamp. If the event setup includes triggered clips, an event will have trigger tracking or video data associated directly with it. Users will need to use the event log to refer to times within a referenced archive, typically a master loop. By using the API to seek to a specific UTC timestamp, events can be used to look up occurrences in an archive that were not necessarily associated with the original event.

Event Setup	A collection of processes and configurations designed to track and notify when alarms or alerts are triggered. Types of event profiles includes event trigger tracking only, event triggers with archive clips, and motion detection. When an event profile includes a trigger from an encoder, part of the profile includes scripts copied to the encoder which release an event notification. When an event profile includes event triggered clips, a pre-post buffer archive is started from the proxies associated with the event profile. Once a trigger occurs, a clip is extracted from the pre-post buffer.
F	
Feed	The transmission of a video signal from point to point.
FPS	Frames Per Second
Frame Rate	The rate at which the source is being recorded. For motion JPEG sources, the play rate is the number of frames-per-second or fps. For MPEG sources, the play rate is the number of megabits-per-second or Mbps and kilobits per second or Kbps.
H	
HTTP	Hypertext Transfer Protocol
J	
J2EE	Java 2 Enterprise Edition
JPEG	JPEG (pronounced “jay-peg”) stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard. JPEG is designed for compressing full color or gray-scale images of natural, real-world scenes. JPEG is “lossy,” meaning that the decompressed image is not exactly the same as the original. A useful property of JPEG is that the degree of lossiness can be varied by adjusting compression parameters. This means that the image maker can trade off file size against output image quality. The play rate is the number of frames-per-second or fps.
K	
Kbps	The rate at which the source is being recorded. For motion JPEG sources, the play rate is the number of frames-per-second or fps. For MPEG sources, the play rate is the number of megabits-per-second or Mbps and kilobits per second or Kbps.
L	
Layout	The geometric description of one or more video panes.
LDAP	Lightweight Directory Access Protocol
Loop	A loop is a hardware or software device which feeds the incoming signal or data back to the sender. It is used to aid in debugging physical connection problems.
M	
Mbps	The rate at which the source is being recorded. For motion JPEG sources, the play rate is the number of frames-per-second or fps. For MPEG sources, the play rate is the number of megabits-per-second or Mbps and kilobits per second or Kbps.
Media Server	A device that processes multimedia applications.
MPEG	MPEG (pronounced “em-peg”) stands for Moving Picture Experts Group and is the name of family of standards used for the compression of digital video and audio sequences. MPEG files are smaller for and use very sophisticated compression techniques. The play rate is the number of megabits-per-second or Mbps and kilobits per second or Kbps.
N	
NTSC	National Television System Committee
P	

Pan-Tilt-Zoom Controls	Permits users to change the camera lens direction and field view depth. Panning a camera moves its field of view back and forth along a horizontal axis. Tilting commands move it up and down the vertical axis. Zooming a camera moves objects closer to or further from the field of view. Many of these cameras also include focus and iris control. A camera may have a subset of these features such as zoom, pan, or tilt only.
Parent proxy	An agent, process, or function that acts as a substitute or stand-in for another. A proxy is a process that is started on a host acting as a source for a camera and encoder. This enables a single camera-encoder source to be viewed and recorded by hundreds of clients. There are three types of proxies: A “direct” proxy is the initial or direct connection between the edge camera-encoder source. By definition at least one direct proxy exists for a given video source. A “parent” proxy is the source of a nested or child proxy. Parent proxies may be from remote or local hosts. Proxies are nested in a hierarchy with inheritance rights. A “child” proxy is the result of a nested or parent proxy. Child proxies run on the local host. Proxies are nested in a hierarchy with inheritance rights. A child proxy has the same resolution, quality, and media type of its parent, but can have a lower frame rate for motion JPEG.
Proxy	An agent, process, or function that acts as a substitute or stand-in for another. A proxy is a process that is started on a host acting as a source for a camera and encoder. This enables a single camera-encoder source to be viewed and recorded by hundreds of clients. There are three types of proxies: A “direct” proxy is the initial or direct connection between the edge camera-encoder source. By definition at least one direct proxy exists for a given video source. A “parent” proxy is the source of a nested or child proxy. Parent proxies may be from remote or local hosts. Proxies are nested in a hierarchy with inheritance rights. A “child” proxy is the result of a nested or parent proxy. Child proxies run on the local host. Proxies are nested in a hierarchy with inheritance rights. A child proxy has the same resolution, quality, and media type of its parent, but can have a lower frame rate for motion JPEG.
Proxy Command	A URL-based API that is neither application-platform nor programming language specific. Commands are sent to dynamically loaded modules (e.g. info.bwt, command.bwt, event.bwt, &c.) using arguments in the form of name-value pairs.
Proxy Server	An agent, process, or function that acts as a substitute or stand-in for another. A proxy is a process that is started on a host acting as a source for a camera and encoder. This enables a single camera-encoder source to be viewed and recorded by hundreds of clients. There are three types of proxies: A “direct” proxy is the initial or direct connection between the edge camera-encoder source. By definition at least one direct proxy exists for a given video source. A “parent” proxy is the source of a nested or child proxy. Parent proxies may be from remote or local hosts. Proxies are nested in a hierarchy with inheritance rights. A “child” proxy is the result of a nested or parent proxy. Child proxies run on the local host. Proxies are nested in a hierarchy with inheritance rights. A child proxy has the same resolution, quality, and media type of its parent, but can have a lower frame rate for motion JPEG.
Proxy Source	An agent, process, or function that acts as a substitute or stand-in for another. A proxy is a process that is started on a host acting as a source for a camera and encoder. This enables a single camera-encoder source to be viewed and recorded by hundreds of clients. There are three types of proxies: A “direct” proxy is the initial or direct connection between the edge camera-encoder source. By definition at least one direct proxy exists for a given video source. A “parent” proxy is the source of a nested or child proxy. Parent proxies may be from remote or local hosts. Proxies are nested in a hierarchy with inheritance rights. A “child” proxy is the result of a nested or parent proxy. Child proxies run on the local host. Proxies are nested in a hierarchy with inheritance rights. A child proxy has the same resolution, quality, and media type of its parent, but can have a lower frame rate for motion JPEG.

PTZ: Pan Tilt Zoom	Permits users to change the camera lens direction and field view depth. Panning a camera moves its field of view back and forth along a horizontal axis. Tilting commands move it up and down the vertical axis. Zooming a camera moves objects closer to or further from the field of view. Many of these cameras also include focus and iris control. A camera may have a subset of these features such as zoom, pan, or tilt only.
R	
Rate	The rate at which the source is being recorded. For motion JPEG sources, the play rate is the number of frames-per-second or fps. For MPEG sources, the play rate is the number of megabits-per-second or Mbps and kilobits per second or Kbps.
Record Rate	The rate at which the source is being recorded. For motion JPEG sources, the play rate is the number of frames-per-second or fps. For MPEG sources, the play rate is the number of megabits-per-second or Mbps and kilobits per second or Kbps.
Recording	A place in which records or historical documents are stored and/or preserved. An archive is a collection of video data from any given proxy source. This enables a feed from a camera-encoder to be stored in multiple locations and formats to be viewed at a later time. There are three types of archives: Regular, where the archive recording terminates after a pre-set time duration lapses and is stored for the duration of its Days-to-Live. Loop, where the archive continuously records until the archive is stopped. Loop archives reuse the space (first-in-first-out) allocated after every completion of the specified loop time. Clip, the source of the archive is extracted from one of the previous two types and is stored for the duration of its Days-to-Live.
Recording Archive	An archive whose state is running/recording. A running regular archive gathers additional data and increases in size. A running loop archive gathers more data and reuses its allocated space. Regular archives that have not reached their duration and loops that are still recording are running. Running archives have a Days-to-Live value of v”-1” which does not update until they have stopped.
Repository	A central place where data is stored and maintained. A repository can be a place where multiple databases or files are located for distribution over a network, or a repository can be a location that is directly accessible to the user without having to travel across a network.
S	
Stopped Archive	An archive whose state is stopped. A shelved archive does not gather additional data or increase in size. Regular archives, clips, recordings, and loops that have reached their duration are considered shelved. Shelved archives are stored for the duration of their Days-to-Live.
Stored Archive	An archive whose state is stopped. A shelved archive does not gather additional data or increase in size. Regular archives, clips, recordings, and loops that have reached their duration are considered shelved. Shelved archives are stored for the duration of their Days-to-Live.
Stream	Any data transmission that occurs in a continuous flow.
T	
Tagged Event	When an incident or event occurs, it is captured by a device or application and is tagged. An event is a collection of information about an incident, including name, associated video sources, and a timestamp. If the event setup includes triggered clips, an event will have trigger tracking or video data associated directly with it. Users will need to use the event log to refer to times within a referenced archive, typically a master loop. By using the API to seek to a specific timestamp, events can be used to look up occurrences in an archive that were not necessarily associated with the original event.
Time stamp	An international and universal time system. Representation of time used by computers and many programming languages are most often accurate down to the millisecond. UTC values are used to track archive date/time values and records when events are triggered.

Trap	Used to report alerts or other asynchronous event s pertaining to a managed subsystem.
Trigger	The action or event that triggers an alarm for which an event profile is logged. Events can be caused by an encoder with serial contact closures, a motion detected above defined thresholds, or another application using the soft-trigger command API.
U	
UI	User Interface
Update Proxy	Changes the registered information for a proxy source so that the proxy process will serve multiple videos as required. Once a proxy has been updated, all requests for that proxy will be served via the new feed. All clients requesting the feeds will be switched. Proxies are not trans-coded meaning some attributes may not be changed once registered.
V	
Video Feed	The transmission of a video signal from point to point. View: A layout, dwell time, and media sources. VM: Cisco Video Surveillance Virtual Matrix Client VMR: Video Mixing Renderer
W	
Window	All or a portion of the camera view. The display can contain multiple windows either by stacking (only the top one is entirely visible) or tiling (all are visible) or a combination of both.
WMV	Windows Media Video

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- *Secure Delivery of IP Video Surveillance - whitepaper*
- *Network Management in IP Video Surveillance networks whitepaper*