

# Cisco Visual Quality Experience

## Product Overview

Cisco Videoscape® Distribution Suite (VDS) is an integrated system with a network-based architecture that transcends existing video solutions. It incorporates TV streaming for content delivery to digital televisions and set-top boxes (STBs), Internet streaming for content delivery to IP-connected devices, and Cisco® Visual Quality Experience (VQE) technology.

The suite of standards-based Cisco VQE applications is designed to deliver the highest video quality of experience (QoE) to consumers. The Cisco Content Delivery System (CDS) is optimized for reliable delivery of broadcast IPTV over lossy access media such as xDSL, but also is useful in optical deployments such as fiber-to-the-x (FTTx).

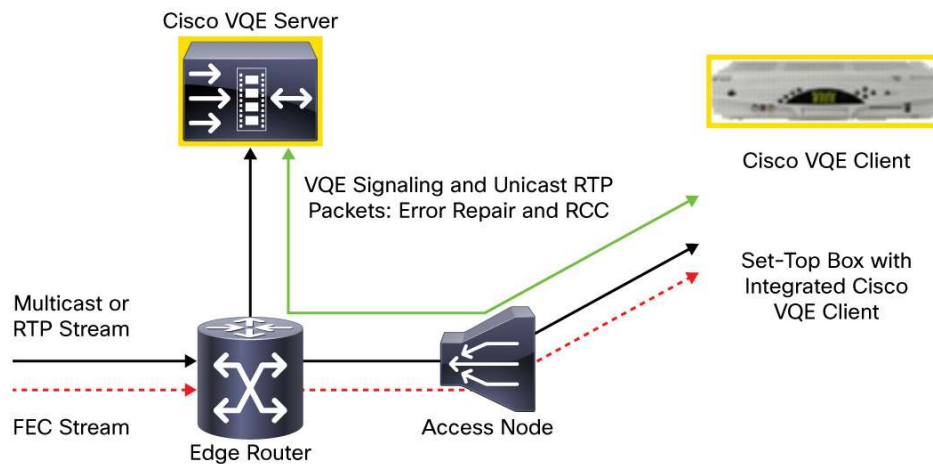
The system focuses on three applications: Error Repair(ER), Rapid Channel Change (RCC), and IPTV statistics reporting.

- Error repair effectively mitigates errors associated with IPTV packets as they traverse noisy access circuits. Cisco VQE technology also addresses losses associated with building wiring systems. It uses the Real-Time Transport Protocol (RTP) to provide selective retransmission as defined in RFC 4588, and Application Layer-Forward Error Correction (AL-FEC) as defined by the Society of Motion Picture and Television Engineers standard 2022 (SMPTE 2022) to eliminate visual or audible errors at the receiver.
- RCC mitigates several critical delay components responsible for long channel-change times, including Internet Group Management Protocol (IGMP) join latency, Intra Frames (I-Frame) or Instantaneous Decoder Refresh (IDR) acquisition time, and STB network-buffer-fill time. Cisco VQE takes advantage of the same RTP technology used for error repair to effectively reduce these and other delay components, resulting in significantly improved channel-change times.
- Cisco VQE IPTV statistics enable an innovative, transport-orientated, end-to-end analysis system that represents a major step forward in the operations of the IPTV network. RTP statistics allow service providers to perform a detailed characterization of the video service capability of the network - enabling them to quickly detect, diagnose, and correct any performance problems in the network. At the same time, these statistics support the characterization of subscriber behavior-information that the service provider can subsequently use to develop new services or deliver addressable advertising. The system offers highly granular Real-Time Control Protocol (RTCP) statistics throughout the network, from video headend devices through the network infrastructure and down to individual client STBs. RTCP XR eXtended Reports compliant with RFC 3611 are also supported, enabling capture of loss Run Length Encoding (loss RLE) from the VQE client, both pre- and post-error repair.

Cisco VQE technology consists of server and client components. The VQE server (VQE-S) connects to the Layer 3 multicast edge, which typically resides in the video switching office (VSO). The VQE client (VQE-C) is integrated in the consumer STB; it facilitates error-repair and RCC functions and originates transport-level statistics. The two communicate using standards-based RTCP signaling. The VQE server provides various services to downstream

VQE clients such as error repair and RCC. Figure 1 illustrates the relative positioning and communications path of the Cisco VQE client and server.

**Figure 1.** Cisco VQE Server and Client Components



## Content Delivery Applications for Visual Quality Experience

Cisco VQE, like other Cisco VDS products, is supported by the Cisco Content Delivery Engine (CDE) family. Cisco VQE is supported on the CDE 250 2V0 model. Visit the [Cisco Content Delivery Engine data sheet](#) for additional information.

Cisco Content Delivery Application (CDA) software performs ingest, storage, caching, streaming, and other real-time, scalable, and resilient capabilities. Table 1 lists the CDAs for visual quality experience.

**Table 1.** Cisco Content Delivery Applications for VQE

Content Delivery Application	Description
<b>Cisco Visual Quality Experience Server (VQE-S)</b>	<p>The Cisco VQE application, which includes the VQE server, provides error repair, RCC, and granular transport-level IPTV statistics for service providers, offering facilities-based video services over RTP. The VQE application includes an embedded management feature showing application health, status of channels, and other system parameters.</p> <p>This application is supported on the Cisco CDE 250-2V0.</p>
<b>Cisco VQE Channel Provisioning Tool (VCPT)</b>	<p>The Cisco VQE Channel Provisioning Tool offers a middleware-independent system for the configuration and provisioning of channel network information. This information is used by both the VQE server and VQE clients.</p> <p>This application is supported on the Cisco CDE 250-2V0.</p>

## Product Application

Cisco VQE is designed for service providers offering facilities-based video services over RTP.

Worldwide, service providers connect millions of subscribers to high-speed data (HSD) and voice services over xDSL broadband connections. Video services are being introduced to increase average revenue per user (ARPU) and reduce subscriber turnover. Recent improvements in video-compression algorithms have increased the percentage of broadband connections with sufficient bandwidth for video services. However, video is hypersensitive to packet loss, resulting in visible artifacts and adversely affecting the consumer experience. Although many broadband circuits provide the requisite bandwidth, most do not guarantee the low packet-loss rates required for broadcast-quality video.

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Many access lines, such as xDSL, are frequently subjected to electrical impulse noise, resulting in the random corruption of single packets or bursts of packets. Corrupted packets fail integrity checks on customer premises equipment (CPE) and are dropped at the point of entry. Packets may also be subject to the effects of impulse noise as they traverse in-house wiring systems, particularly as households add second or third television sets. Noise problems are also associated with multifamily dwelling units; many have common wiring systems that have grown organically as residents have adopted video services.

Digital Video Broadcasting (DVB), a well-respected organization in the video industry, recommends no more than one artifact per 1-hour movie. Using basic mathematics and applying the recommendation to a standard-definition MPEG-4 service, the resulting packet loss rate (PLR) must be no greater than  $7.8 \times 10^{-7}$ . Most service providers accept xDSL bit error rates (BERs) in the range of  $10^{-6}$  in order to achieve acceptable subscriber coverage. In the worst case, the resulting PLR with this level of loss would be in the range of  $1 \times 10^{-3}$ . This loss level would result in a visible artifact every minute, clearly unacceptable to the consumer.

Problems associated with impulse noise create challenges for access circuit qualification. Many service providers are now taking a conservative approach-offering video services only to subscribers connected through known good circuits. The practice often results in service fragmentation, where certain households within a given region are ineligible for video service. Service fragmentation presents challenges for marketing campaigns, especially those associated with bundled services.

The Cisco VQE products and technology mitigate the effects of impulse noise in both access circuits and in-house wiring. For example, an MPEG-4 standard-definition service with an average PLR of  $1 \times 10^{-3}$  or an artifact every minute would be transformed into a service with an average PLR of  $1 \times 10^{-6}$  or an artifact every 200 minutes. This PLR would align the service well within DVB's recommendation of one artifact per hour. The system enables video coverage to higher percentages of broadband consumers by lowering the qualification criteria. Increased customer satisfaction improves customer loyalty and elevates service provider brand value.

### **Rapid Channel Change and IPTV**

IPTV possesses various network-related factors that contribute to overall channel-change time. These factors include I-Frame or IDR acquisition time, STB network-buffer-fill time, IGMP leave or join time, and MPEG table acquisition time, among others. These factors can vary significantly depending on network topology, available bandwidth, content encoding parameters, and whether or not AL-FEC is enabled. Depending on the installation, the effect on channel-change time can vary from hundreds of milliseconds to several seconds and beyond. For example, use of AL-FEC error protection with a large protection block will significantly increase the STB network-buffer-fill time and can contribute hundreds of milliseconds to the channel-change performance. Similarly, content encoding with long Group of Pictures (GOP) periods will directly increase the I-Frame or IDR delay factor and variability.

The Cisco VQE technology mitigates the effects of these channel-change factors by using capabilities of both the VQE client and VQE server. The STB channel-change request initiates control messaging between the VQE client and VQE server, resulting in a video decoder "priming" packet being sent to the VQE client to expedite the initial I-Frame and other video initialization at the decoder. This packet is immediately followed by a RTP unicast transmission of video content from the VQE server cache for the target channel. Simultaneously, the VQE client initiates an IGMP join to the target channel. The VQE solution then carefully manages a transparent handoff from the unicast to the multicast stream, completing the RCC operation while dramatically improving channel-change performance. The solution addresses both the timing and variation attributes of channel change.

## Features and Benefits

Table 2 lists Cisco VQE features and benefits.

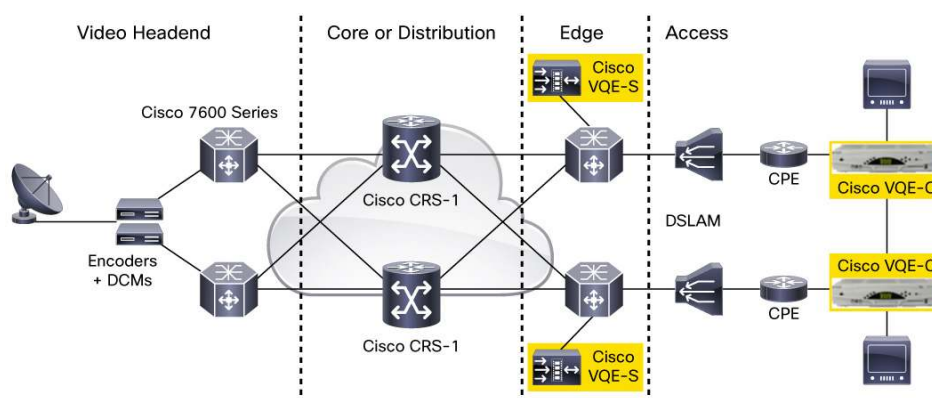
**Table 2.** Features and Benefits of Cisco VQE

Feature	Benefits
<b>Cisco VQE Application</b>	
<b>Standards-based protocols and signaling</b>	Cisco VQE is based on RFC 3550 RTP and RFC 4588 protocols and signaling. The system is open and can interoperate with other standards-based video solutions.
<b>Nonintrusive connection for resilient video services</b>	The VQE system is not in the video path between headend and client devices. Failure or loss of VQE will not result in an interruption of the video service.
<b>Network infrastructure-aware</b>	The solution interfaces with existing quality-of-service (QoS), multicast, routing, and high-availability schemes for maximum interoperability and efficiency. Open Shortest Path First (OSPF) routing is supported, providing dynamic route configuration.
<b>Flexible deployment models</b>	The Cisco VQE application is typically deployed at the Layer 3 multicast edge, often referred to as the VSO. Centralized or distributed deployments may be supported, depending on plant error characteristics, round-trip delay, and the client scale.
<b>Flexible load balancing</b>	Multiple Cisco CDE 250 2V0 engines may be deployed to scale control-plane performance and increase data-plane performance in accordance with client scale and demands.
<b>High availability</b>	Client requests are automatically rerouted away from failed interfaces or Cisco CDE 250 2V0 units using standards-based routing protocols.
<b>Video and conditional access system-independence</b>	This transport-orientated system offers transparent support for standard- and high-definition MPEG2 (H.262) or MPEG4 (H.264/AVC) and associated conditional access systems.
<b>Integrated web server</b>	Each VQE server offers a GUI to support application health monitoring and basic per-channel statistics.
<b>RTCP statistics</b>	As RTP receivers, Cisco VQE servers originate RTCP statistics, giving network operators visibility into transport-level statistics at the network edge. Extended reports capability, including loss RLE compliant with RFC 3611, is supported.
<b>Cisco VQE Client</b>	
<b>Standards-based RTP</b>	Cisco VQE provides client support for inbound IPTV packet reordering and comprehensive dejitter functions prior to MPEG demultiplexer handoff.
<b>Standards-based packet error repair</b>	The Cisco VQE client provides lost-packet-recovery capability in concert with the associated Cisco VQE application and following the FEC repair process. The client identifies up to 17 packets for repair per error-repair request (NACK) packet issued.
<b>Standards-based Forward Error Correction (FEC)</b>	Based on RFC 2733 and SMPTE 2022 FEC standards, Cisco VQE provides lost-packet-recovery capability to incoming FEC-encoded RTP multicast streams. Recovery capability is governed by FEC block size, up to 256 packets (16L x 16D). One- and two-dimensional FEC is supported on separate IP multicast streams.
<b>Standards-based RCC</b>	Cisco VQE client provides accelerated channel-change capability in concert with the associated Cisco VQE application, offering improved performance for various delay factors, including IGMP join, I-Frame or IDR acquisition time, and STB network-buffer-fill delay.
<b>RTCP statistics</b>	As RTP receivers, Cisco VQE clients originate RTCP statistics, enabling network operator visibility into transport-level statistics on STBs, such as per-client, per-channel aggregate counters for received and dropped packets, jitter, and delay.
<b>Open-source package</b>	The Cisco VQE client package is available for implementation in third-party STBs and other consumer client devices. The package is extensible, proven, and simple to integrate, and features control-plane and data-plane separation, allowing kernel mode integration.
<b>Cisco VQE Channel Provisioning Tools (VCPT)</b>	
<b>Channel provisioning tools</b>	This middleware-independent provisioning solution gives the Cisco VQE application and clients channel network information.
<b>Flexible GUI</b>	Cisco VQE offers a highly intuitive, flexible, and scalable graphical user interface.

## Product Architecture

The Cisco VQE system is ideal for deployment at the edge of the service provider's network, but it can be deployed as a centralized system. The system consists of server- and client-side components. Typically, Cisco CDE 250 2V0 engines running the Cisco VQE application are directly connected to the multicast Layer 3 edge device, such as a Cisco 7600 Series Router. The client consists of a lightweight software component, which is integrated in a STB or potentially other suitable customer premises device such as the home access gateway (Figure 2).

**Figure 2.** High-Level Network Diagram



## Primary Functions of the Cisco VQE Application

### Join and Cache Video Content

Service providers use multicast groups to transport linear TV channels across the network infrastructure from video headend to provider edge. Cisco VQE joins multicast groups using the industry-standard IGMP. The Cisco VQE application caches up to several seconds of content for each channel in high-speed DRAM. Content continuously ages out and is refreshed. Cached content provides VQE services such as error repair and RCC to downstream VQE clients.

### NAT Support

The Cisco VQE application supports an embedded serial tunnel (STUN) server to facilitate all Cisco VQE client Network Address Translation (NAT) mapping types, including symmetric NAT per RFC 4787. VQE clients exchange messaging with the VQE application STUN server to resolve NAT mapping parameters. Universal Plug and Play (UPnP) NAT transversal support has been added.

### RTP and RTCP

The Cisco VQE application listens for inbound RTCP messages from downstream VQE clients. Messages request specific VQE services such as error repair or RCC, or they present RTP receiver statistics. To service client requests, the Cisco VQE application responds to the originating client with appropriate action. It responds to NACKs with missing video packets. RCC requests results in an acknowledgement packet, followed by video priming data and unicast RCC transmission bursts on the selected channel. Inbound RTP receiver statistics are periodically exported, using TCP, to an appropriate database and video quality analysis application.

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## Primary Functions of the Cisco VQE Client

### Packet Reordering and Jitter Elimination

The Cisco VQE client, integrated with a STB, monitors RTP sequence numbers of inbound IPTV packets in its network buffer. As a fully compliant RFC 3550 RTP receiver, the client resequences out-of-order packets and mitigates the effects of network-induced jitter before forwarding packets to the STB MPEG demultiplexer stage.

### Forward Error Correction

The Cisco VQE client receives standards-based FEC repair packets and searches for missing RTP sequence numbers encountered across a FEC-protected block period of N packets. FEC protection periods are determined at the headend by definition of the FEC block size in terms of L columns by D rows of packets. The VQE client automatically corrects missing RTP packets within the FEC block coverage by using received FEC protection packets. Any missing RTP packets beyond FEC coverage are forwarded to the selective retransmission function.

### Error Repair: Selective Retransmission

The Cisco VQE client waits for missing RTP sequence numbers. If packets have been dropped and remain uncorrected following FEC repair, the client requests retransmission of the packets from its designated VQE server. Retransmitted packets are resequenced and dejittered in the client network buffer prior to MPEG demultiplexer handoff. A single RCTP message may request retransmission of multiple contiguous or noncontiguous packets.

### Rapid Channel Change

The Cisco VQE client notifies the designated VQE server of a channel-change request from the viewer. The VQE server responds with a positive or negative acknowledgement. If negative, the VQE client conducts a standard channel-change procedure and does not employ acceleration techniques. If positive, the VQE client engages with the VQE server to conduct a RCC procedure. Video decoder priming information is delivered next, followed by RTP unicast transmission for the target channel. The STB decoder begins video playout soon after initial video packets arrive, resulting in greatly improved channel-change time. Simultaneously, the VQE client performs IGMP leave or join and STB network-buffer-fill operations, concluding the RCC procedure with a transfer to the target channel multicast RTP stream.

### RTP Receiver Reports

Clients transmit RTCP receiver reports to their designated VQE server. Reports provide cumulative counts of lost and received packets as well as packet latency and jitter; per-channel statistics are provided. Network operators may set the frequency of periodic reports using the Cisco VQE Channel Provisioning Tool.

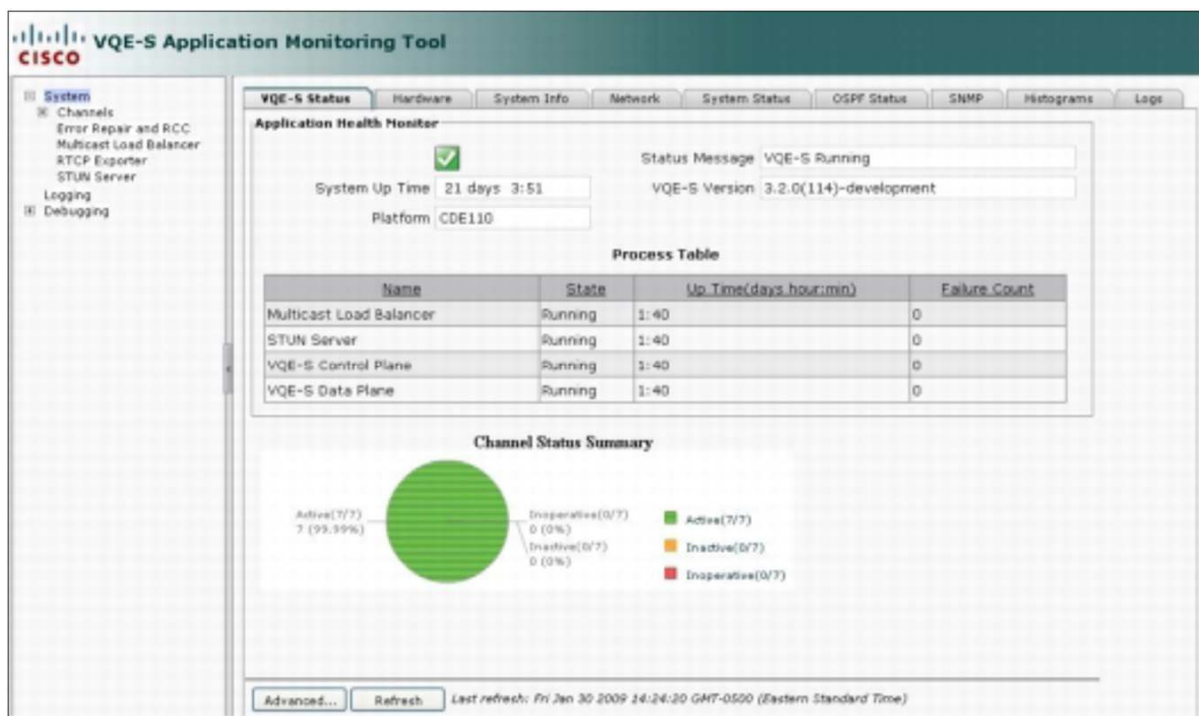
## Monitoring and Channel Provisioning

### Monitoring

The Cisco VQE application incorporates an integrated web server, allowing network operators to access application health and per-channel summary statistics. They can use any standard web browser that supports HTTPS to access this information. Figure 3 displays a view of the Cisco VQE application health monitoring interface.



**Figure 3.** Cisco VQE Application Health Monitoring



The Cisco VQE monitoring interface may be used to provide basic channel lineup information. Specifically, it provides network-level information: ingest health and a snapshot of active VQE clients associated with each channel. Figure 4 shows an example of this view.

**Figure 4.** Cisco VQE Application Channel Lineup Information

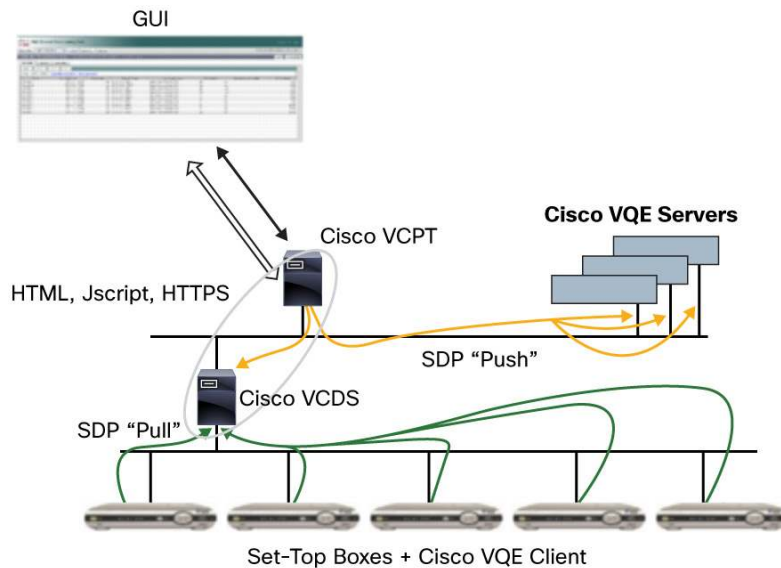


## Channel Provisioning

The Cisco VQE Channel Provisioning Tool (VCPT) provides a middleware-independent application to define and associate channel network information with VQE servers and clients. The highly intuitive graphical interface uses a template-based approach to simplify channel and server configuration. The application offers a powerful clone facility to help expedite channel definitions.

Cisco VCPT is designed to run on a dedicated Cisco CDE 250 2V0. It uses industry-standard signaling and protocols to communicate with associated VQE servers and clients. The system transmits channel network information to servers using the industry-standard Session Description Protocol (SDP). Figure 5 shows the relationship between Cisco VCPT and other VQE network components.

**Figure 5.** Cisco VQE Channel Lineup Information



Cisco VCPT provides four primary functions:

- Definition and configuration of channel lineups, specifically network-related information
- Definition and identification of VQE servers, specifically network addresses
- Association of channel lineups with groups of servers
- Option to save configuration files and push configuration files to appropriate VQE servers

Figure 6 displays a channel lineup summary from the Cisco VCPT application.

**Figure 6.** Cisco VCPT Channel Summary Information

The screenshot shows the Cisco VQE Channel Provisioning Tool interface. The main table displays the following data:

Channel	Channel Name	Channel ID	Channel Type	Channel Description	Channel Status	Channel Category	Channel Subcategory	Channel Subcategory	Channel Subcategory
Channel 1	229.1.1.1	81070	yes	12.228.2.2	81071	SDPFC Referral	yes	yes	4300
Channel 10	229.1.1.10	81076	yes	12.228.2.2	81077	Unicast Referral	yes	no	4300
Channel 2	229.1.1.2	81074	yes	12.228.2.2	81075	Unicast Referral	yes	yes	4300
Channel 3	229.1.1.3	81075	yes	12.228.2.2	81076	Unicast Referral	yes	yes	4300
Channel 4	229.1.1.4	81072	yes	12.228.2.4	81073	Unicast Referral	no	no	4300
Channel 5	229.1.1.5	81073	yes	12.228.2.4	81074	Unicast Referral	no	no	2300
Channel 6	229.1.1.6	81074	yes	12.228.2.4	81075	Unicast Referral	no	no	2300
Channel 7	229.1.1.7	81075	yes	12.228.2.7	81076	Unicast Referral	no	no	15000
Channel 8	229.1.1.8	81076	yes	12.228.2.8	81077	Unicast Referral	no	no	15000
Channel 9	229.1.1.9	81077	yes	12.228.2.8	81078	Unicast Referral	yes	no	23000



## Product Specifications

Table 3 lists the specifications for the Cisco VQE application.

**Table 3.** Specifications for Cisco VQE Application

<b>Protocols</b>	Network protocols: <ul style="list-style-type: none"><li>• IPv4</li><li>• Simple Traversal of User Datagram Protocol (UDP) through NATs (STUN)</li><li>• All NAT mapping types, including Symmetric NAT</li><li>• Address Resolution Protocol (ARP)</li><li>• Dynamic Host Configuration Protocol (DHCP)</li><li>• Domain Name System (DNS)</li><li>• Ping and traceroute</li><li>• IGMPv2 and IGMPv3</li><li>• RTP, RTCP, and RTCP-eXtended Reports (RFCs 3550, 4588, and 3611, respectively)</li><li>• Pro MPEG code of practice 3 (CoP3) and SMPTE 2022 FEC encoding</li><li>• RTP FEC payload format (RFC 2733)</li><li>• Real Time Streaming Protocol (RTSP)</li><li>• Equal Cost Multipath Routing (ECMP)</li><li>• Simple Network Management Protocol Version 2 (SNMPv2)</li><li>• Telnet (disabled by default)</li><li>• Secure Shell (SSH) Protocol</li><li>• SDP</li><li>• Syslog</li><li>• FTP and secure FTP</li><li>• XML</li><li>• HTTPS</li><li>• OSPF</li></ul>
<b>MIBS</b>	<ul style="list-style-type: none"><li>• SNMPv2 and SNMP (SNMP protocol-related counters, including cold and warm start and authentication failure traps)</li><li>• IFMIB (interface status and statistics)</li><li>• HOST-RESOURCE-MIB (except Hrprinter table) System, memory, storage, device, processor, network, disc, partition, FS, software version information about Linux host</li></ul>

## System Requirements

The Cisco VQE application and Cisco VQE Channel Provision Tool are designed to run on separate dedicated Cisco CDE 250 2V0 servers. Please refer to the Cisco Content Delivery Engine data sheet for technical details of these appliances.

Table 4 summarizes performance information of the Cisco CDE 250 2V0 with the Cisco VQE Server application.

**Table 4.** Scale and Performance Summary: Cisco CDE 250 2V0 with Cisco VQE Server Application

Parameter	Performance
<b>Maximum number of ingest channels</b>	<ul style="list-style-type: none"><li>• Up to 3 Gbps of IP multicast ingest capacity; 1000 channels maximum</li><li>• For Example:<ul style="list-style-type: none"><li>◦ 350 MPEG4 high-definition (8.5Mbps) channels or</li><li>◦ 1000 MPEG2 standard-definition (3 Mbps) channels</li></ul></li></ul>
<b>Maximum number of simultaneous Cisco VQE clients</b>	<ul style="list-style-type: none"><li>• 128,000 simultaneous Cisco VQE clients</li><li>• Control plane policing: Support for up to 30,000 repair requests per second</li><li>• Support for up to 150,000 repair packet transmissions per second</li><li>• Per-client rate policer: 5 percent stream rate default</li></ul>
<b>Maximum number of channels in Cisco VCPT database</b>	<ul style="list-style-type: none"><li>• Mapping of 1000 channels across multiple Cisco VQE servers</li></ul>

Parameter	Performance
<b>Cisco CDE 250-2V0 bandwidth scaling</b>	<ul style="list-style-type: none"> <li>• 9.0 Gbps aggregate output bandwidth: ER + RCC</li> <li>• 1.8 Gbps ER output bandwidth maximum</li> <li>• 7.2 Gbps RCC output bandwidth maximum</li> </ul>
<b>Recommended client round-trip delay to Cisco VQE server</b>	<ul style="list-style-type: none"> <li>• Client round-trip delay <math>\leq 100</math> ms</li> </ul>

## Ordering Information

To place an order, visit the [Cisco Ordering Home Page](#) and refer to Table 5. To download software, visit the [Cisco Software Center](#).

**Table 5.** Ordering Information

Product Name	Part Number
<b>CDE 250-2V0 Engine for VQE</b> 4x 10GbE Interface with SFP+, 4x 1GbE Interface, AC, or DC option (3-tier PID bundle required)	CDE250-K9 + CB-48-XVR-2WPL + SB-1F200
<b>VQE Server Software Application (VQES) Version 3.6</b>	CDAVQES-3.6-K9
<b>Base VQE Error Repair License, 2000 clients</b>	CDAVQES-ER-02000
<b>Additional Error Repair License, 1000 clients</b>	CDAVQES-ER-UP1000
<b>Base VQE Rapid Channel Change License, 2000 clients</b>	CDAVQES-CC-02000
<b>Additional Rapid Channel Change License, 1000 clients</b>	CDAVQES-CC-UP1000
<b>VQE Channel Provisioning Tools (VCPT) Version 3.6</b>	CDAVCPT-3.6-K9

Please contact Cisco for technical details, location, and availability of Cisco VQE open-source client software.

## Service and Support

Using the Cisco Lifecycle Services approach, Cisco and our partners provide a broad portfolio of end-to-end services and support that can help increase the business value of your network and your return on investment. This approach defines the minimum set of activities needed, by technology and by network complexity, to help you successfully deploy and operate Cisco technologies and optimize their performance throughout the lifecycle of your network.

## For More Information

For more information about the Cisco Content Delivery System or Cisco Content Delivery Engines, contact your local Cisco account representative or visit <http://www.cisco.com/en/US/products/ps7127/index.html>.

The Cisco Content Delivery Engine data sheet is available at <http://www.cisco.com/en/US/products/ps7126/index.html>.

The Delivering Video Quality in Your IPTV Deployment white paper is available at [http://www.cisco.com/en/US/netsol/ns610/networking\\_solutions\\_white\\_paper0900aecd8057f290.shtml](http://www.cisco.com/en/US/netsol/ns610/networking_solutions_white_paper0900aecd8057f290.shtml).




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