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White Papers by Polycom

Quality of Experience and Quality of Service

For IP Video Conferencing

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Introduction

H.323 video and voice applications differ from traditional data applications in that they are real-time applications, and in that they require higher bandwidth than traditional data applications. Real-time applications, especially H.323 applications, require more stringent packet handling than non-real-time (traditional IP-based) applications. This, in turn, necessitates more network management resources to assure predictable video and voice transmission. The combination of stringent packet handling and large volume network data flow are defined by *Quality of Service* (QoS).

Another term pertinent to the discussion is *Quality of Experience* (QoE). QoE is defined as the totality of Quality of Service (QoS) mechanisms, provided to ensure smooth transmission of audio and video over IP networks. These QoS mechanisms can be further distinguished as application-based QoS (AQoS) and network-based QoS (NQoS). AQoS includes those services provided by voice and video applications to enhance the desired end-to-end performance, while NQoS includes those services provided by the network and networking devices (like routers and switches) to enhance end-to-end QoS.

It is important to note that while traditional discussions of QoS discuss only the networking facilities related to QoE, not all networks are NQoS-capable or NQoS-enabled, and it often falls to the AQoS services to provide whatever QoE is available for voice/video sessions. Ensuring QoE is also difficult because there is no mandatory QoS defined within the H.323 standard specification. This results in the manufacturers of different video terminals applying different solutions for AQoS services, if they provide AQoS at all.

The quality of an end user's experience is the true litmus test of a proper video/voice deployment. Only by understanding both the application and network facilities for QoE can you absolutely ensure the highest quality user experience. The following discussion about AQoS and NQoS allows for a greater understanding of just how important the interplay of application and network QoS mechanisms are in the overall scheme of QoE.

Information Sources

This white paper has derived some of its information from existing publications, such as other white papers and RCFs. In addition, some terminology and descriptions directly pertain to a specific publication. In these cases, a number, in brackets, follows the term or description. The number identifies the specific publication that contains the information about that term or description. The publications are numbered and listed in “References” on page 12. For example, this white paper contains the term *Application-based Quality of Service [1]*. The [1] identifies the number of the publication that contains the information about Application-based Quality of Service (AQoS). In this case, the AQoS information is derived from *IP Telephony with H.323 Architectures for Unified Networks and Integrated Services*.

Application-based Quality of Service [1]

Application-based Quality of Service (AQoS) relates to the facilities embedded within an application that preserve the quality of its intended use. For H.323 video/VoIP applications, AQoS relates to two main areas:

- Call signaling
- Terminal handling of media flows, both video and audio.

The following sections review each of these areas and discuss the step-by-step process of the application flow. Application flow is the process that voice and video applications undergo during the process of media acquisition, compression, packetization, transmission decompression, and playback. Understanding the application flow process is a simple way of separating the functions of AQoS from those associated with NQoS in an overall QoE solution.

AQoS and Signaling

Signaling is the low level communication that happens between applications. Signaling utilizes industry standard protocols. The three main signaling mechanisms in H.323 are:

- **H.225-RAS** - Responsible for communication between the terminal and the gatekeeper. Additionally, terminals use H.225-RAS to obtain services from the gatekeeper.
- **H.225-Q.931** - Used between terminals for call setup and call termination.
- **H.245** - Used between terminals for the multimedia portion of call setup and negotiation.

AQoS and Media Handling

H.245 is also used to provide AQoS by measuring packet loss and then instructing the application to react. Inter-arrival packet jitter and one-way delay (latency) are also measured. In situations where no NQoS exists, H.245 is the only QoS facility reacting to packet loss, jitter, and latency. There are several techniques employed by Polycom that leverage these facilities, such as dynamic jitter buffers, Dynamic Bandwidth Allocation (DBA), and Polycom Video Error Concealment (PVEC) technology. See Table 1 on page 4 for a listing of AQoS facilities. Additional information about the specifics of Polycom AQoS can be obtained from the white paper titled *Application-based Quality of Service*, posted on http://esupport.polycom.com/whitepapers.html.

Table 1: H.323 Application Process [1] from Media Acquisition (at Sender) to Transmission Over the Network to Media Playback (at Receiver)

QoS Type	Step	Description
---	1	Input to camera and microphone (media) is digitized and buffered at sender
AQoS	2	Media is retrieved from buffer and entered into Codec
AQoS	3	Compression of media
AQoS	4	Output of compression is sent to Real-Time Transport Protocol (RTP) for packetization
AQoS	5A	RTP output is sent to User Datagram Protocol (UDP) IP layers for packetization
AQoS/ NQoS	5B	Application marks for NQoS signaling
NQoS	6	IP datagram is transmitted
NQoS	7A	Routing occurs (injection of propagation-serialization delay based on queuing)
AQoS	7B	H.245 via RTP measures loss, jitter, latency and instructs application to react
AQoS	8	Media is de-packetized at receiver's buffer
AQoS	9	Codec retrieves from buffer and adjusts delay to account for loss and jitter
---	10	Output is played

AQoS Summary

The following is a short list of the services obtained via signaling and media handling:

- Gatekeeper discovery/registration
- Endpoint registration
- Call admission
- Capabilities exchange
- Bandwidth negotiation
- AQoS relative to network loss, jitter and latency
- Call disengagement.

All of these services are areas of potential AQoS and optimization. The time for each of these services to complete as well as the accuracy and reliability of these services directly affects QoE. Imagine if the user had to continually redial a call because the call admission phase had no reliability mechanisms employed to guarantee the call. If an NQoS-enabled network has packet loss, and the application cannot compensate for the loss, the user's QoE can not be preserved. Polycom improves these scenarios by employing leading edge AQoS services to enhance the user's QoE.

Network-based Quality of Service [2]

NQoS can be provided in two different ways: hard QoS or soft QoS. Hard QoS absolutely guarantees QoS and soft QoS provides best effort QoS. Both methods provide service to marked packets over other packets.
The two fundamental purposes of NQoS as it relates to IP voice and video applications are:

- Reduce the likelihood of packet loss
- Allow IP voice and video applications to operate on the network while other applications are also using the network.

NQoS can be broken down into a four-step process as it relates to IP voice and video applications:

- Marking
- Classification
- Admission (policy)
- Scheduling (queuing).

These processes can be accomplished using one of several different, standard architectures, which are summarized below.

NQoS Architectures

Differentiated Service [3] (Diffserv)
This is considered soft QoS. Traffic flows (applications/protocols) are grouped into classes based on the level of service they require to operate most efficiently/effectively. Network devices then characterize flows and apply services according to policy and scheduling of resources for the marked class of flow.

- Allows for preferential treatment of flows without an absolute guarantee
- Works well for bandwidth-intensive data applications like video
- Marking is provided by IP precedence and Differentiated Services Code Points (DSCP).

IP Precedence
The IP precedence field in an IP packets header is used to indicate the priority with which a packet should be handled. IP precedence is made up from three bits in the IP headers Type of Service (ToS) byte.

Diffserv
Diffserv defines a field in the IP header called the Differentiated Services Code Point (DSCP). The DSCP is a six-bit field, spanning the fields formerly utilized by type-of-service and IP precedence services in the Type of Service (TOS) byte.

Diffserv is considered to be the most scalable architecture for NQoS. It can be deployed at both the edge and core of IP networks.

Integrated Services [3] (Intserv)/ RSVP
This is considered hard QoS. This service type requires a reservation of network resources in order to meet specified service classification requirements.

- Allows for preferential treatment of flows, in two ways:
  1. Without an absolute guarantee service known as *Controlled Load Service.*
  2. With a guarantee known as *Guaranteed Service.*
- Works well for bandwidth-intensive data applications like video
- Marking is accomplished via the RSVP signaling protocol, not a literal mark, actually a definition of a Path and Reservation requirements.

Intserv is considered by most to be more difficult to scale than Diffserv and not suitable for implementation in the core of IP networks. Intserv is currently being promoted as a complementary method of interoperating between RSVP at the edge and Diffserv within the core.

NQoS Process

The four steps involved in NQoS are:

1. Packet marking
2. Classification
3. Admission/policy
4. Scheduling.

These steps are all part of a continuous process that occurs over the varied data paths traversed by the application data. The data path is from the first router encountered at the very edge of a network, closest to the sender, through the core and border routers, back to the edge router closest to the receiver. It should be noted that most layer three switches provide routing facilities within the layer three switch itself. Cisco calls these Route Switch Modules (RSM).

The four steps of NQoS are summarized below.

Packet Marking

Packet marking is accomplished in two ways:

- The marking of packets is accomplished by the terminal itself
- The marking or lack of marking is written/overwritten at the nearest network node (router).

Some schools of thought believe that the further from the core the application is, mark there; the network edge (for example, the application does the marking). Other schools of thought believe that because not all applications can mark or be trusted, the policy of the network should decide and thus write/rewrite all markings at the nearest network node. Every installation is different and options for application or network node marking exist. Sometimes, a mix of both application and network marking is deployed. Polycom terminals have the ability to mark the IP precedence bit from within the application and via the Global Management System™ network management software.

Packet Classification

Packet classifiers determine the flow or Behavior Aggregate of a packet, based on its marking. Classification is the function of a network node. Classification can be done either by parsing multiple fields of the IP header (for example, source/destination address, protocol ID, source/destination port ID) or by parsing the ToS byte for class of service/precedence (for example, Diffserv code points, precedence bits).

Admission/Policy

Admission control consists of bandwidth control and policy control. Applications like Polycom video communications terminals can request a particular QoS for their traffic. The devices in the network through which this traffic passes can either grant or deny the request depending on various factors, such as capacity, load, policies, etc. If the request is granted, the application has a contract for that service,

which will be honored in the absence of disruptive events, such as network outages.

Scheduling/Queuing

Traffic flows/classes can be assigned to different queues based on their classification. The placement or switching of packets into different queues provides for the diverse service needs of marked packets. Special requirements, such as low delay can be provided to packets by servicing their queue more frequently. The selection of queue is based on a packets marked classification. The QoS queuing discipline that is implemented determines and/or schedules which queued packets enter or exit the queues.

NQoS Summary

NQoS can potentially increase the QoE for the user of IP voice and video applications. Polycom terminals can mark the IP precedence bit for NQoS. The default setting is five with a range from zero to seven; with zero indicating no priority and seven indicating the highest priority. iPower™ sets independent precedence bits for audio and video.

For a more detailed discussion about NQoS, see the white paper *Network-based Quality of Service*, posted on http://esupport.polycom.com/whitepapers.html.

Quality of Experience and Polycom's IPriority Facilities

Polycom's IPriority™ (see Table 2 on page 9) initiative is a portfolio of all facilities relating to QoE. Within the IPriority portfolio are facilities that are supported between terminals within network infrastructure, Multipoint Control Units (MCUs), Gateways (GW), and signaling capabilities for standards-based network QoS mechanisms. These facilities work with, and in some instances, improve upon standards-based implementations in an effort to provide the highest quality user experience. Polycom is committed to continually provide leadership in the areas of improved quality and usability of their market-leading video and voice technologies.

Table 2: Polycom IPriority Facilities

IPriority Facility	Network Traffic	Network Mgmt	Terminal Support	Video Infra-structure Support
IP precedence (ToS) / DSCP (CoS)	X		X	N[1]
Dynamic bandwidth allocation	X		X[2]	N[1]
Polycom video error concealment	X		X[3]	N[1]
Proactive network monitoring	X	X	X	X
Packet and jitter control	X		X	X
NAT support	X		X[4]	X
Asymmetric speed control	X		X	N[1]
Fixed port firewall supported	X		X	
H.323/H.320 interop testing	X		X	X
Remote diagnostics		X	X	X
On-screen diagnostics		X	X	X
Transcoding: Frame rate, audio protocols, video format, video protocols	X			X
Lip synchronization	X		X	X
Echo cancellation			X	X
Echo suppression			X	X

1. Scheduled development for 2002.
2. ViewStation SP ver 6.0, ViewStation FX ver 2.0, and ViaVideo ver 1.0.
3. ViewStation FX ver 4.0. Scheduled development for ViaVideo and iPower in 2002.
4. iPower does not support.

IPriority Summary

The quality a user experiences using voice or video application is based on more than just one method of QoE. NQoS and AQoS are required to ensure the highest level of user satisfaction. Polycom is committed to working with their networking partners to maintain interoperability in the areas of NQoS. (See www.polycom.com/custPartners/partners/partners_family.html) for a list of Polycom's networking partners.) Polycom is also committed to continuous innovation and implementation of AQoS mechanisms within their market-leading terminal and infrastructure technologies.

Terminology

Table 3 explains the various terms used in this white paper.

Table 3: Terminology

Term	Definition
Application Quality of Service (AQoS)	The facilities provided within an application to provide Quality of Experience to users. Implemented to provide a quality user experience.
Behavior aggregate (BA)	A collection of packets with the same DS codepoint crossing a link in a particular direction.
Classifier	An entity that selects packets based on the content of packet headers according to defined rules.
Differentiated Services Code Point (DSCP)	A specific value of the DSCP portion of the DS field, used to select a PHB.

Table 3: Terminology

Term	Definition
DS field	The IPv4 header ToS octet or the IPv6 Traffic Class octet when interpreted in conformance with the definition given in [DSFIELD]. The bits of the DSCP field encode the DS codepoint, while the remaining bits are currently unused.
Marker	A device that performs marking.
Marking	The process of setting the DS codepoint in a packet based on defined rules; pre-marking, re-marking.
Network Quality of Service (NQoS)	Typically referred to as IP QoS. Derived from Integrated services (IETF Intserv working group) and/or Differentiated Services (RFC 2475).
Per-Hop-Behavior (PHB)	The externally observable forwarding behavior applied at a DS-compliant node to a DS behavior aggregate.
Policy	A set of administrative rules used to classify the response afforded a marked packet, Behavior Aggregate, PHB group.
Quality of Experience (QoE)	The measure of the facilities of Quality of Service applied to a voice/video communication session. Application QoS or network alone or a combination of the two.

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