NEC America, Inc.

NEAX 2000 IPS IP PBX, NEC BlueFire 700 Series and BlueFire IX5010 Series

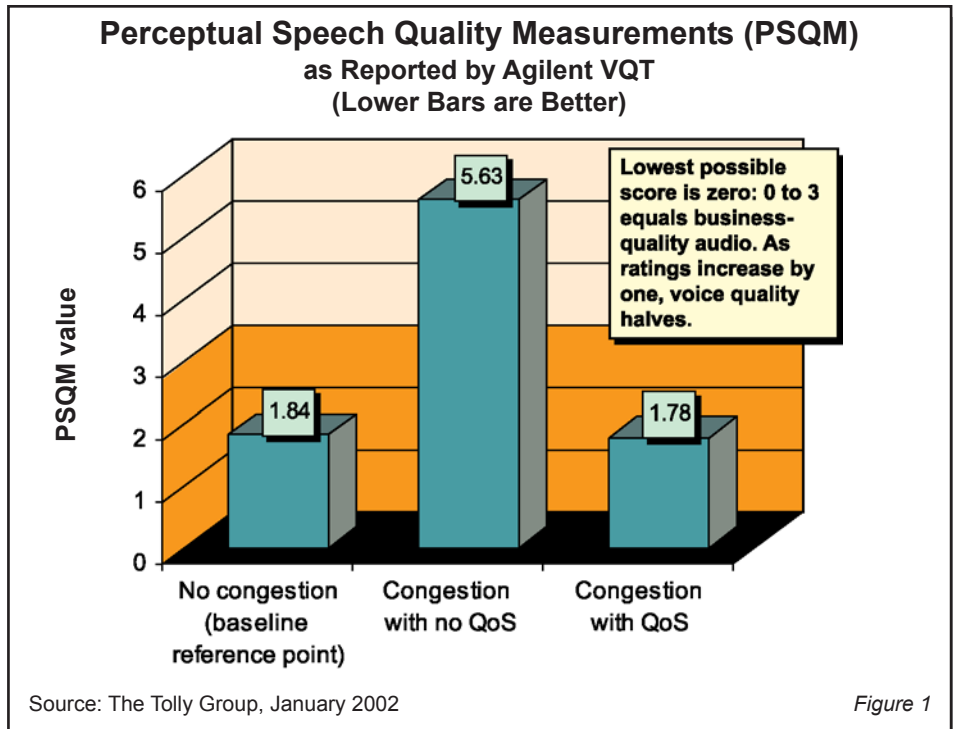### IP Telephony End-to-End Quality-of-Service Evaluation

Test Summary

Premise: With packet telephony becoming more prevalent in the networking industry today, customers are looking to migrate from legacy, circuit-based voice systems to converged voice and data IP infrastructures. The challenge presented in the converged network is maintaining acceptable voice quality traditionally offered through circuit-switched PBXs.

NEC America, Inc. commissioned The Tolly Group to evaluate the end-to-end Quality of Service and voice-quality capabilities delivered by its NEAX 2000 IPS (IP PBX), an Internet Protocol telephony server that supports peer-to-peer IP voice connectivity using the NEC Series E Dterm IP phones, together with the NEC BlueFire 720/730, a chassis-based, Layer2/Layer 3 switch, and the BlueFire IX5010, a multi-service IP switch/router. Engineers tested the QoS effectiveness of the NEC end-to-end solution to support voice over IP (VoIP) with and without "severe traffic congestion." The Tolly Group conducted testing in January 2002.

Test results show that the NEC BlueFire 720/730 switch, in conjunction with the NEC BlueFire IX5010 and the NEC IP PBX, effectively delivers QoS on an end-to-end basis, thus guaranteeing the quality of voice traffic – even during periods of heavy congestion in both the LAN and the WAN. It is critical to note that in this set of tests, engineers measured QoS effectiveness and voice call quality on an end-to-end basis – meaning from caller handset to call recipient handset with intermediary equipment factored in. This represents a broader statement of QoS effectiveness and call quality than

Test Highlights

❍ Provides digital phone packet voice across the LAN and WAN

❍ Preserves digital phone packet voice via QoS when severe LAN/WAN congestion occurs

❍ Delivers predictable voice quality whether using a peer-to-peer IP connection or traditional TDM connection

Perceptual Speech Quality Measurements (PSQM)
as Reported by Agilent VQT
(Lower Bars are Better)

Lowest possible score is zero: 0 to 3 equals business-quality audio. As ratings increase by one, voice quality halves.

Source: The Tolly Group, January 2002   *Figure 1*

other metrics that simply measure the effectiveness of VoIP infrastructure products in the core of the network.

Tolly Group engineers employed two forms of call quality metrics – estimated Mean Opinion Scores (MOS) and

Perceptual Speech Quality Measurements (PSQM).

MOS is a subjective Mean Opinion Score of voice quality, as defined by the ITU-T P.800 specification. Scores range from 1 to 5, with 5 representing "excellent" audio

quality. A score of 4.0 or higher is considered toll quality. PSQM represents an attempt to create an automated means for objectively assessing the quality of speech flowing across a telephony network. PSQM measures the distortion of a speech signal taking into account the human perception and processing of speech. PSQM scores range between 0 and 6.5 (The best possible PSQM is 0, which means that the output or processed speech file is identical to the input or source file.)

RESULTS

END-TO-END VOICE QUALITY

In these tests, engineers transmitted actual voice traffic end-to-end from a NEC DTERM IP Telephone attached to a Fast Ethernet LAN, through a NEC BlueFire 720 LAN switch, then to an NEC BlueFire IX5010 across a simulated T-1 wide area net, and traversed a mirrored configuration on the receiving end to the called party. Tolly Group engineers recorded both PSQM and estimated MOS ratings for the end-to-end voice quality.

These end-to-end tests – from one IP phone to another – not only test the network infrastructure, but also the IP phones and associated voice coders. This represents a more comprehensive assessment of voice quality than other performance tests that just measure the quality of service of the switching infrastructure.

To establish a voice-quality baseline, engineers ran tests under optimal network conditions, with no competing network congestion present and none of the NEC BlueFire QoS features active. The test yielded a PSQM rating of 1.84 (see Figure 1). The SmartBits tester then was used to simulate typical network traffic. The SmartBits presented two 60 Mbit/s streams of data traffic to the BlueFire 720/730 along with packetized voice originating from the NEC Dterm IP phone. This combined load of 120 Mbit/s oversubscribed the BlueFire egress port by more than 20%. The
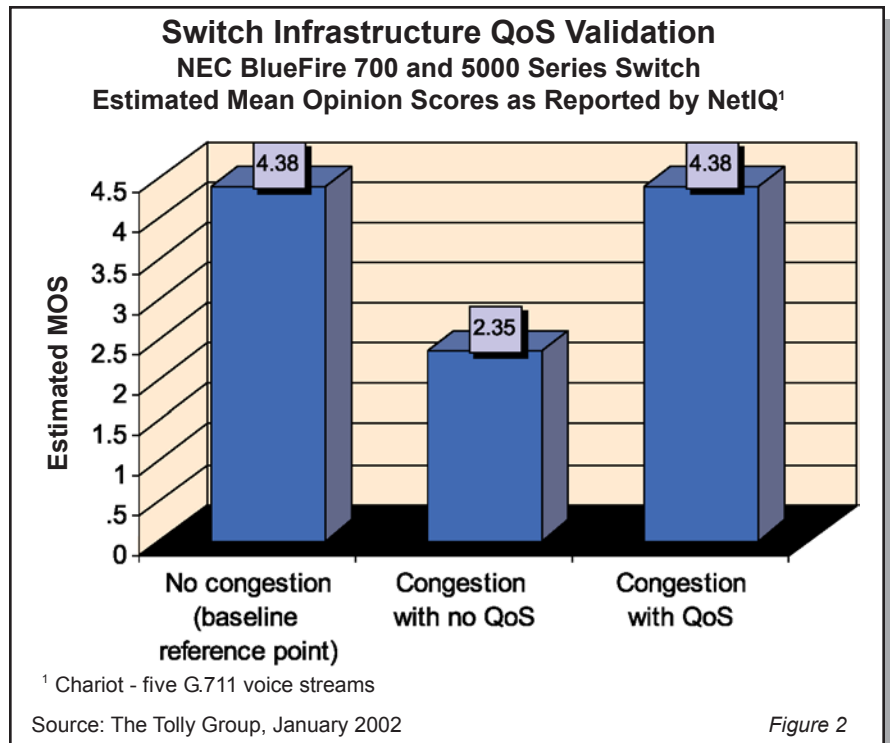

Switch Infrastructure QoS Validation
NEC BlueFire 700 and 5000 Series Switch
Estimated Mean Opinion Scores as Reported by NetIQ[1]

[1] Chariot - five G.711 voice streams

Source: The Tolly Group, January 2002   *Figure 2*

100 Mbit/s output of the BlueFire 720/730 was presented to the IX5010, which routed the stream over the much slower T-1 connection.

This test configuration oversubscribed both the BlueFire 720/730 and IX5010. Without a mechanism for prioritizing the voice over the data, engineers expected to see a severe degradation in voice quality. When congestion was introduced to the scenario, the PSQM rating jumped to 5.63 — well out of toll-quality range. Engineers then activated NEC's QoS features and the PSQM rating fell back to 1.78 (lower numbers are better with PSQM) – slightly better than the baseline under optimal conditions (see Figure 1).

Even when engineers used the MOS metric, the NEC systems under test achieved results consistent with the PSQM findings. Without the benefit of NEC's QoS features enabled, the MOS rating was 1.26 – well under the 2.0 mark considered poor voice quality. Yet when engineers enabled QoS on the NEC gear, the MOS rating climbed to 3.98 – at a level often identified with toll-quality voice.

VOICE-QUALITY BASELINE

Prior to determining the end-to-end voice-quality rating, engineers first established a baseline estimated MOS for the core of the VoIP network. This scenario helps users understand how the switching infrastructure can handle VoIP calls while independently testing the capability of the BlueFire 700 Layer 2/Layer 3 switches and the IX5010 IP Router to support multiple VoIP streams when presented with competing network congestion.

The test network included NEC BlueFire 720 and BlueFire IX5010 systems, which were fed simulated VoIP traffic streams by a NetIQ Chariot on a simulated Fast Ethernet LAN and T-1 WAN with no other traffic and no QoS. Under optimal network conditions, the NEC solution achieved a MOS of 4.38 out of a possible 5 – with a score of 4.0 being considered toll quality (see Figure 2). When congestion was introduced to the network, the MOS rating slipped to 2.35 with all NEC QoS features turned off. When engineers enabled QoS on both NEC devices, the MOS bounced back to 4.38 even while operating under severe congestion conditions.

Analysis

Consistently delivering toll-quality voice in a converged network poses a significant challenge to network designers. This is particularly challenging during periods of severe network congestion and port over-subscription.

The NEC BlueFire 700 series, in conjunction with the BlueFire IX5010, successfully demonstrated the capability to implement QoS effectively in both the LAN and the WAN. Unlike other test scenarios that measure only the voice call quality of the network infrastructure – meaning the internal switches and gateways – the NEC America tests demonstrated true end-to-end voice call quality, from IP handset to IP handset. This provides users with a truer measurement of voice call quality from a solutions standpoint. This ensures that the most important metric of the user experience — call quality — does not change because the core network infrastructure, the PBX and the VoIP endpoints all work together to deliver superior voice quality to end users. This homogenous approach to call quality provides network planners with the security that call quality, and the necessary QoS support that ensures it, will remain predictable.

Test Configuration and Methodology

The Tolly Group tested an NEC America BlueFire 720/730, V2.3(ed20), an NEC BlueFire IX5010, v6.1.18, and an NEC IP PBX, version MP:D2 0.30 (300 Series) IP PAD A1 025.

Starting at the core, two NEC BlueFire IX5010s connected via a T-1 link (see Figure 3). Each BlueFire IX5010 connected via Fast Ethernet to a NEC BlueFire 720/730, each of which in turn connected to an NEC Series E Dterm IP phone. The NEC IP PBX also connected to the BlueFire 720/730 and provided voice call and feature control. An Acterna Domino Internetwork Analyzer sat in line between the NEC BlueFire IX5010 and the NEC BlueFire 730 on one side of the simulated WAN; an identical

Domino Internetwork Analyzer sat in line between the NEC BlueFire 720 and an NEC IP PBX on the other side of the simulated WAN. An Agilent Telegra VQT 4.0 with an IP phone handset adapter tapped into each IP phone to measure voice quality directly from the IP phone's handset interface.

Engineers configured SmartBits to continuously generate a single unidirectional 512-byte data stream at 100% of the Fast Ethernet link to the BlueFire 720/730 LAN switches for tests with no QoS enabled. Two unidirectional data streams were used for tests with QoS enabled. Engineers configured each of the two streams to use 512-byte packets on Fast Ethernet interfaces configured for 60% utilization, thus oversubscribing the single egress port of the BlueFire 700 series by 20%. Engineers also configured Agilent VQT to generate voice traffic simultaneously. For classification of traffic, engineers implemented a strict queuing algorithm that assigned Type of Service (TOS) bits 5 and 6 to the highest priority queue; they also employed a Priority Queuing (PQ) prioritization algorithm on all traffic streams. Engineers also configured all ports on the system under test for 100 Mbit/s full-duplex transmission.

The BlueFire 720/730 presented a combined 100 Mbit/s voice and data stream to the BlueFire IX5010 router, which was configured to prioritize voice in preference over data. The offered 100 Mbit/s traffic load was forwarded to the T-1 link. This required the IX5010 to police and prioritize 100 Mbit/s of ingress traffic for transport over a much slower WAN link.

Engineers disabled Spanning Tree, flow control and all other ancillary functions.

Engineers recorded PSQM scores for a single VoIP call as reported by the Agilent VQT. The Agilent VQT voice sample played five times for a total test duration of approximately 60 seconds. Engineers executed each test three times and averaged the results.

NEC America, Inc.

NEC NEAX 2000 IPS IP PBX, NEC BlueFire 700 Series and BlueFire IX5010

**IP Telephony End-to-End Quality-of-Service Evaluation**

NEC America, Inc.
NEC NEAX 2000 IPS IP PBX, NEC BlueFire 700 Series and BlueFire IX5010 Product Specifications*

❍ No compromise IP telephony with over 500 PBX features

❍ Peer-to-peer and end-to-end with the capability to handle the most stringent requirements

❍ Delivers the same features, functions, and quality as a traditional PBX with all the advantages of converged IP telephony

❍ High-quality digital IP phone with full PBX features and functions

❍ A sensible migration path to IP telephony without compromising the user experience

❍ NEC's Enterprise Open Network (NEON) assures "open" support to work with the customer's network

❍ An all NEC solution "end-to-end" delivering value

❍ BlueFire 700 Layer 2/Layer 3 switches provide wire-speed performance in a family of scalable products

❍ BlueFire IX5010 full-feature multi-service WAN router with advanced QoS features

❍ Provides Quality of Service (QoS) across the LAN and WAN with high availability and reliability

❍ Imposes minimal delay and assures excellent voice transmission quality

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Vendor-supplied information not verified by The Tolly Group

Test Bed

Source: The Tolly Group, January 2002   *Figure 3*
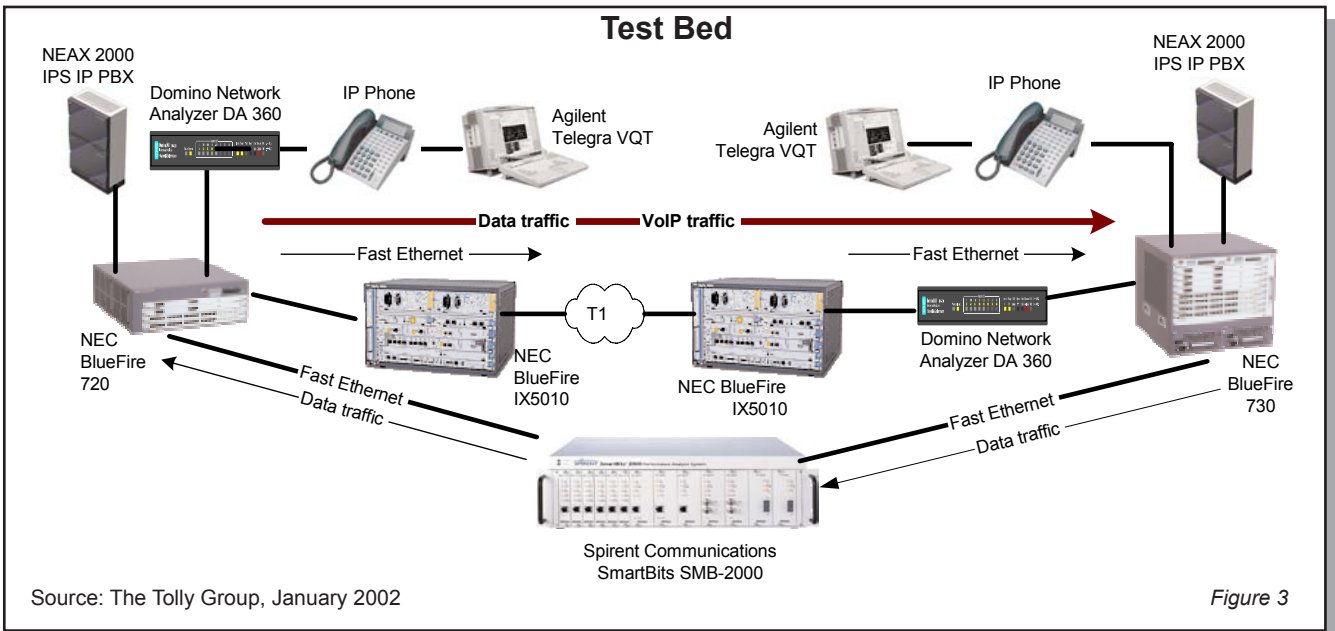
The Tolly Group gratefully acknowledges the providers of test equipment used in this project.

Vendor	Product	Web address
Acterna Corp.	Domino FastEthernet Internetwork Analyzer	http://www.acterna.com
Agilent Technologies	Voice Quality Tester (VQT) 4.0	http://www.agilent.com
NetIQ	NetIQ Chariot 4.1	http://www.netiq.com
Raritan Computer, Inc.	Master Console	http://www.raritan.com
Spirent Communications	SMB-2000/6000	http://www.spirentcom.com

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Tolly Group Services

With more than a decade of testing experience of leading-edge network technologies, The Tolly Group employs time-proven test methodologies and fair testing principles to benchmark products and services with the highest degree of accuracy. Plus, unlike narrowly focused testing shops, The Tolly Group combines its vast technology knowledge with focused marketing services to help clients better position product benchmarks for maximum exposure. The company offers an unparalleled array of reports and services including: Test Summaries, Tolly Verifieds, performance certification programs, educational Webcasts, white paper production, proof-of-concept testing, network planning, industry studies, end-user services, strategic consulting and integrated marketing services. Learn more about The Tolly Group services by calling (732) 528-3300, or send E-mail to info@tolly.com.

For info on the Fair Testing Charter, visit: www.tolly.com/About/ftc.asp

Project Profile

Sponsor: NEC America, Inc.
Document number: 202110
Product class: End-to-end VoIP solution
Products under test:
- NEC BlueFire IX5010, v.6.1.18
- NEC BlueFire 720/730, v.2.3(ed20)
- NEAX 2000 IPS IP PBX MP: D2 0.30 (300 series) IP PAD A1 0.25
- NEC IP phone, Series E Dterm

Testing window: January 2002
Software status: Generally available
Additional information available:
- Configuration files
- Data files

For more information on this document, visit our Web site at http://www.tolly.com, send E-mail to info@tolly.com, or call (732) 528-3300.

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