The Need for Quality of Experience (QoE) Testing during the Deployment of Next Generation Networks – a new Paradigm

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Introduction

The race to deploy Next Generation Networks (NGN) is quickening. Twenty-four months ago, all activity was concentrated with the Network Equipment Manufacturers (NEMs), developing the components that would power these networks. 12 months ago, the number of evaluation and trials saw a marked increase. Now many players have begun to transition to the third phase of this process – deployment.

At the heart of this race to deploy NGNs is the promise of efficient and faster creation of higher revenue generating services (such as local number portability, and call forwarding and unified messaging) – providing a much-needed source of competitive differentiation for service providers. At the same time, NGNs are expected to deliver substantial savings to the service providers. UBS Warburg estimates operational savings in 10%-20% range and cost-savings versus legacy equipment in the 50%-60% range. The underlying value of these networks to the service provider is considerable.

Key facts:

- Worldwide IP telephony revenue will grow from $500 million in 1999 to $18.7 billion in 2004 (106% growth) - *IDC*
- Enhanced services revenue will increase from $270 million in 1999 to $12.6 billion in 2004 - *Ovum*
- By the year 2002, nearly 30% of international phone traffic will be carried over data lines, up from only 0.2% in 2001 - *Probe*
- Industry analysts estimate VoIP services revenue to reach $4B in 2001, growing to approximately $23B in 2004. - *Kagoor*

However, in order to capture this value, the service provider must ensure that its NGN provides at least the same Quality of Experience (QoE) that consumers have become accustomed to with the public switch network (PSTN). This is even more critical in the face of increasing competition where it is becoming easier for consumers to switch from one service provider to another.

Consequently, successful deployment of NGNs requires a new mindset in deployment testing – a paradigm that is outlined in this paper.

The Next Generation Network

The NGN is often referred to as "the Converged Network." It combines the advantages of the two global networks – the circuit-switched voice network and the packet-switched data network – to provide the flexibility of the Internet with the reliability and intelligence of the voice network. Underlying the NGN is a new architectural model that will bridge the gap between the voice and data worlds – the softswitch model. Within this model there are three major components: Media Gateways, Media Gateway Controllers (or call agents), and Feature Servers.

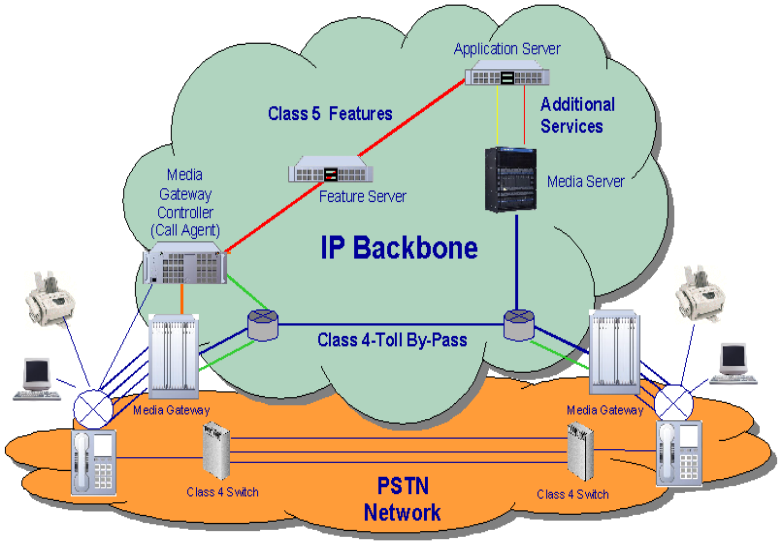

Figure 1: The Next Generation Network

These components are shown in Figure 1. Each component within the softswitch architecture provides specific functionality as outlined in Chart 1. The NGN is designed to handle voice, fax and modem traffic over an IP infrastructure.

Feature Servers	Call Waiting	Prepaid Calling Card	Messaging	Local Number Portability	Other Apps
Media Gateway Controller/ Call Agent	Call Control		SS7/C7 Signaling	Protocol Mediation	
Media Gateways	Transport & Switching				

Chart 1: The Components of the Softswitch Architecture

QoE Defined

QoE is a new term describing the emerging reality that what ultimately matters in moving to the NGN is the experience customers have with the service.

QoE is a concept, not a metric. It comprises all elements of a subscriber's perception of the network and performance relative to expectations. More importantly, however, QoE represents a paradigm shift – a change from the testing using an engineering perspective to testing using an end user's perspective. This implies focusing on a set of parameters that combine to determine what the end user's experience will be. The following table describes these parameters and the level of quality that customers expect.

Elements of User's Experience	Expectations for Level of Quality
Reliability	Works every time
Availability	Always available
Call Completion	Calls always completed as dialed
Connect Latency	Rings in seconds
Bearer Quality (Voice, Fax, & modem)	At least as good as the PSTN
Speech Latency	Imperceptible
Services	Always available and works as advertised
Billing	Completely accurate

Table 1: The Key Parameters of QoE

For a more detailed discussion on QoE, please review the Empirix white paper "Assuring QoE on Next Generation Networks."

Creating The NGN

The creation of the NGN can be broken into 4 phases - each with specific activities and desired outcomes. These phases are described below.

The service provider is a significant player in all but the first of these phases. Consequently it is important that the service provider not only recognizes what phase it is in (especially relative to its competition), but give sufficient thought to its approach to each phase. Not fully understanding the significance each phase will have on the delivery of its NGN could be detrimental to the service provider.

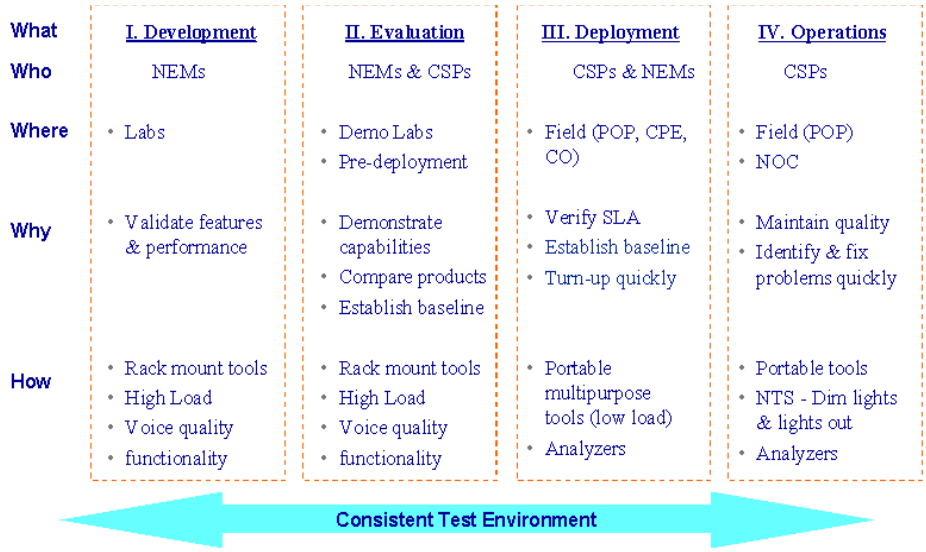

Figure 2: The Phases of Creating the NGN

Phase I: Development
In the development phase, equipment manufactures are focused on creating the network elements (media gateways, call agents, & feature servers) for the NGNs. From a testing perspective, their needs center on validating the performance and functionality of these devices in their labs.

For example, a gateway manufacturer would conduct a series of tests using load generators to determine how many simultaneous calls the gateway can support or how well do the codecs perform. Although there is still considerable activity in this Phase today, 24 months ago, the activity was almost exclusively in this area.

Phase II: Evaluation
It is during this phase that the winning service providers of the NGN world are defined.

In the evaluation phase, equipment manufacturers seek to demonstrate the capabilities of their devices to service providers while the service providers themselves wish to understand if these devices will fit their needs and perform as stated in the datasheets. With the relative newness of the NGN industry, this phase has become a critical proving ground where business is either won or lost. It is during this phase where the service provider should focus heavily on QoE in choosing between one vendor's equipment and another. To date, service providers are mainly evaluating solutions for Internet offload (or PRI offload) and tandem replacement (or toll bypass). However, as these solutions migrate towards enhanced services, the focus on QoE becomes even more important.

Because of the inherent complexity of the networks and the amount of testing required, service providers can make considerable investments in test equipment and custom scripting. This investment should be leveraged by using the results from this phase as a baseline against which to test during the next phase. Central to being able to leverage this

investment is the ability to transfer the scripts developed for tools in the lab-based trials to tools that would be used in the deployment phase.

During the evaluation of these NGNs, the service provider must adopt a holistic perspective and consider the range of usage scenarios or modes that their customers will interactive with their NGNs and ensure that these are tested. For example, NGNs are designed to handle voice, fax, and modem traffic.

At present, the overwhelming majority of testing for toll bypass scenarios is focused almost exclusively on voice quality with fax and modem quality being an after thought. This is a recipe for disaster – for if the other media types are tested too late in the process and the quality is found lacking, the cost to alleviate the problem may be prohibitive. Worst yet, the problems may only be found when customers attempt to place fax or modem calls over the NGNs.

Phase III: Deployment

In the Deployment Phase, service providers are "turning up" the NGN. The key to this phase is being able to bring services online quickly with a high level of service quality. Service providers that do not make the appropriate investment in time or money in the previous phase could find themselves caught with quality or performance issues after their networks have been turned up.

Testing during the turning up process is a critical step to guaranteeing service quality. If the testing is sufficiently comprehensive and early enough in the deployment process, service providers can avoid considerable costs associated with finding bugs and sources of poor service quality post deployment.

A comprehensive approach to testing during the deployment phase goes beyond the current thinking of simply using a protocol analyzer. Some forward thinking service providers have begun to see the value in using a portable version of the test tools employed in the evaluation phase to run a series of test utilizing the custom scripts created in the lab. This provides the ability to definitively say what the voice, modem & fax quality is at the point of cut over – a fundamental aspect of SLA management. The specific features and capabilities of such tools will be discussed in the next section.

The momentum is beginning to shift to this phase. The experiences that the early adopters have during this phase will set the tone for the industry and determine the eventual rate at which NGNs penetrate the mainstream.

Phase IV: Operation

Once the NGN has been successful deployed, the challenge of maintaining the NGN transfers to the operations team. It is to the advantage of the service provider to also transfer the knowledge obtained from testing in the previous phases to the operations team to aid in rapid troubleshooting and fault detection.

To facilitate a seamless transfer of knowledge across all phases of creating the NGN, it is important that the test environment be consistent. This then calls for a set of test tools that can be applied across most, if not all, of the phases.

QoE Test Tools for Deploying NGNs

At present, the de facto standard test tool used when deploying network elements is the protocol analyzer.

Protocol analyzers focus primarily on signaling and provide little insight into the quality of the bearer channel – a major component of QoE. The ideal QoE test tool should replicate the behavior of end users and provide the ability to drive real voice, fax and modem traffic through the network element being deployed. In essence, these tools should provide the ability to conduct abbreviated versions of the tests that were staged during the evaluation phase – where possible, using the same scripts.

For comprehensive QoE testing, the series of tests conducted during the turn up of new network elements should include:

- Path confirmation
- Connect latency
- Call completion rate
- Bearer channel quality (voice, fax, video & modem quality)
- Speech latency

Having all of these capabilities housed in one device is highly desirable. This would not only be more economical, but would also reduce the number of tools to be carried into the field. This tool then becomes a multi-purpose device capable of not only verifying the signaling, but also the bearer quality. Part of the reason why protocol analyzers are used in isolation to deploy network elements is that, up until now, service providers had little choice for multi-purpose QoE test tools.

Key features of this QoE test tool should include:

- Lightweight and portable.
- Integrated signaling support (ISDN, CAS & SS7)
- Simple-to-use test environment for rapid test creation, scheduling, monitoring and reporting.
- Real voice, fax, modem and data traffic generation
- Protocol analysis, quality of service measurements, and SLA verification.
- Remote control for distributed network testing, POP testing, unattended remote location testing and integration into a Network Management System.

Such as tool can also be left in the field after deployment to act as a termination point that tier 3 engineers can use to troubleshoot problems as they arise.

Bearer Channel Quality

Bearer channel quality is one of the fundamental components of QoE – one that is most often overlooked during the turn up of networking elements. As the bearer channel of NGN is designed to transport voice, fax and modem, bearer channel quality becomes a function of voice quality; fax quality, and modem quality.

Voice Quality Testing

One of the greatest customer expectations of the NGN is that it will provide voice quality comparable to the legacy network. In testing the quality of voice on the bearer channel it is recommended to use a standard-based algorithm, such as Perceptual Speech Quality Measurement (PSQM, ITU P.861) or Perceptual Evaluation of Speech Quality (PESQ, ITU P.862).

The PSQM model is optimized for the assessment of speech codecs while PESQ is designed specifically for the assessment of end-to-end voice quality.

Other factors that affect voice quality are echo and Voice Activity Detection (VAD).

Echo can occur either when a percentage of the transmitted voice signal is reflected back to the speaker or when the network impairs the voice signal that is heard by the listener. Devices known as echo cancellers are often used in NGN to remove echo. However, the effectiveness of echo cancellers hinges on how well they are "tuned" – the iterative process of testing for echo and adjusting the parameters on the cancellers accordingly. As a result, testing for echo during the deployment of new network elements is critical.

Voice Activity Detection (VAD) is essentially a voice gate. When the caller is talking, the gate is open and voice packets are allowed to flow. When the caller is silent, the gate is closed and no packets flow. Since normally only one person talks at a time, a VAD can realize a bandwidth reduction of 40-50% over an aggregation of channels. By virtue of this gating function, there is the potential for a portion of the speaker's first words to be cut off – a phenomenon known as Front End Clipping (FEC).

During deployment, it is therefore also important to test that the VAD is working correctly and how much FEC is taking place.

Fax Quality Testing

The legacy fax protocols (ITU-T T.30, T.4, and T.6) were never optimized for transport over a packet network. Fax is digital in nature, but is converted to analog for transport over the legacy network at 64 kbps. Thus when a legacy fax call is being transported over a packet network, special handling features are necessary. Gateway devices must first identify that this is a fax call and then invoke special handling features to ensure that fax is transmitted successfully. Consequently, two new standards have been developed to facilitate the transfer of analog fax over digital-packetized networks.

ITU-T T.37 Store and Forward Fax Transmission

When utilizing this methodology, fax messages are not delivered in real time. An incoming analog fax is stored in the transmitting gateway. Since we are not dealing in real-time delivery, the transmitting gateway may deliver the fax when it is convenient. This helps mitigate timing problems that may be introduced by a congested network.

T.38 Real-Time Fax Delivery

T.38 Real-time fax protocol is designed to emulate the handshaking of the T.30 protocol across the IP network. An incoming fax call is demodulated in the transmitting gateway and changed into the IP Fax Protocol for delivery across the network. At the receiving gateway it is remodulated and changed back into the T.30 protocol for delivery to the receiving fax machine. Real-time fax delivery is subjected to all the network problems that affect voice quality of service. Inherent delay (latency) may cause timing problems while trying to maintain end-to-end T.30 timing compliance. To mitigate this, the gateways must implement "spoofing techniques" to fool the fax machines and prevent timeouts.

Consequently, when a new gateway is being deployed, its ability to correctly handle fax traffic should quickly be tested. Simple analysis includes the ability to determine if the gateway recognizes the difference between a voice call and a fax call. The test set should also analyze the gateway's ability to provide protocol conversion, implement spoofing techniques, and provide metrics regarding the fax delivery. Complex testing may require complete protocol analysis of the fax transmission.

Network Modem Testing

Modem traffic has been optimized for transport over packet networks and is less challenging than integrating VoIP or Fax traffic. When users are having trouble with modem connections, they inherently blame it on the network.

Testing modem performance in the network is something that many providers ask for, but it is only available on selected multi-function voice quality test sets.

Some of the important factors that determine modem quality include:

- Connection time; how long does it take the modem to set-up and negotiate a connection

- Connection rate; at what rate was the initial modem connection made?
- Throughput; establishing a large number of connections and measuring the effective throughput over each connection.
- Long-term bit and block error estimation; establishing a large number of connections and estimating the bit and block error performance.

Final Analysis

The vast potential the Next Generation Network holds is unquestionable. What is in question, however, is the ability of the service provider to fully capture this value.

The NGN is being created in distinct phases. Each service provider must realize what phase it is in, what phase its competitors are in, and have a plan for navigating the remaining phases – especially deployment.

Many service providers understand the need for extensive QoE testing during the evaluation phase. However, QoE testing during the deployment of NGN elements is equally fundamental to the service provider being able to guarantee the level of service that customers are expecting. Failure to deliver this level of quality would result in high customer churn and lost revenue.

It is therefore imperative that service providers employ test tools that would allow them to easily replicate the behavior of their customers during the deployment of new network elements. Through the use of these tools, service providers can test the quality of both the bearer and signaling channels. Short of using these tools, the service provider would not be able to anticipate what their customer's experience is going to be.

Those that awaken to this new paradigm will be ahead of the pack.