A Framework and Toolkit for the Collection and Analysis of QoS Statistics for Voice Traffic in Next Generation Networks

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Abstract

The multi-service, multi-architecture nature of NGNs is so complex that the management of services, in addition to networks, emerges as a research challenge. Despite QoS limitations, VoIP (as opposed to VoATM), dominates the Internet and enterprise markets, and is evolving to handle the carrier space. This paper presents a strategy that abstracts QoS away from both VoATM and VoIP in order to manage voice QoS in an NGN environment.

1. Introduction

To eventually handle carrier-grade voice services in Next Generation Networks (NGN), Voice over Internet Protocol (VoIP) networks must meet strict Quality of Service (QoS) performance criteria such as the minimization of call refusals, network latency, packet loss, and disconnects. The voice service management process should be transparent so that a manager and his/her tools do not need to know the details of underlying infrastructures. Management issues such as security, addressing, accounting, and QoS should be transparently managed to effectively handle next generation voice delivery systems [5].

2. Quality of Service

Whereas IP was not designed to provide built in QoS, Asynchronous Transfer Mode (ATM), was. The ATM Forum defined five service categories in order to provide varying levels of QoS:

- Constant Bit Rate (CBR)
- Real-time Variable Bit Rate (rt-VBR)
- Non-Real-Time Variable Bit Rate (nrt-VBR)
- Available Bit Rate (ABR)
- Unspecified Bit Rate (UBR) [2, 4].

Armed with these service categories and the AToM Management Information Base (MIB) for the Simple Network Management Protocol (SNMP) [3, 14, 15], the process of collection of QoS statistics for Voice over ATM (VoATM) is rather simple [13]. The collection of QoS statistics for VoIP, on the other hand, is more complicated.

3. NGN Management Complexity

Figure 1 attempts to convey the complexities of a possible NGN, with particular emphasis on VoIP and interoperability with contemporary voice services.

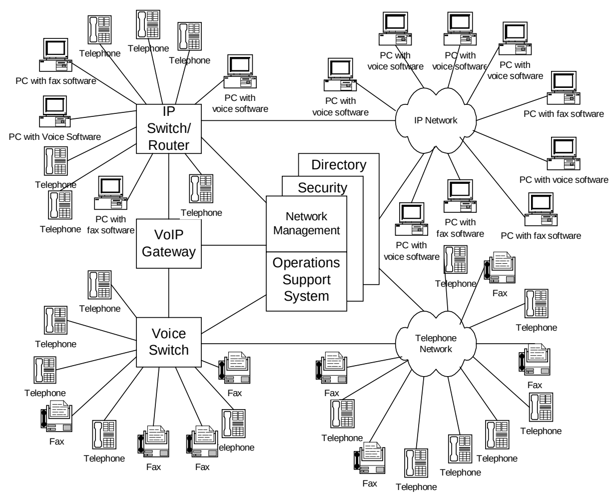

Figure 1 VoIP and NGN Complexities

A management system of such an NGN requires an architecture that is capable of coping with the complexity and size of these networks, in addition to the ever-increasing amount of traffic they are expected to handle. With a vast variety of protocols, vendors and legacy equipment in the market, performance degradation and resource constraints are serious issues. The components of a management system must be able to monitor and gather data from the network with limited information loss and without placing too much strain on the network infrastructure and its elements.

ATM QoS is a given. Sending real-time voice and video over an IP network is only economically feasible if high QoS levels can be maintained (see Figure 1). Carriers and telcos have no intention of providing voice services over IP networks that are of poor quality. A fundamental requirement of VoIP, then, is that VoIP must provide “Toll Quality” services, meaning that the QoS-dependent services over data networks must at least match the quality of voice services over the Public Switched Telephone Network (PSTN) [11].

In general, three factors impact QoS for voice traffic.

- Delay [8, 10].
- Jitter [10].
- Packet Loss [10].

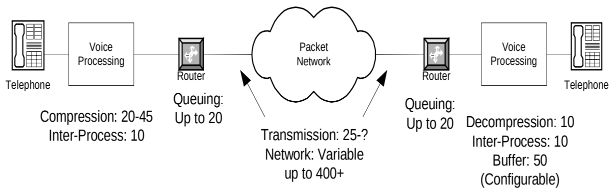

Figure 2 Packet-based Delay and Jitter

As we move toward the NGN, the problem is not to manage VoIP, and VoATM separately, but to collect QoS statistics on voice services independently of the network platforms over which voice is being run.

4. Dedicated VoIP Networks

There have traditionally been two distinct communications networks, the data (digital) network and the telecommunications (analog and digital) network. Now, these two worlds are being integrated into broadband multi-service networks.

The Internet Protocol pushes packets with "best effort" regardless of content or priority. As a result, the Internet is unpredictable and QoS cannot be guaranteed [9]. However, because the Internet paradigm and its technologies have become ubiquitous, *dedicated* IP networks (see Figure 3) are presently being deployed in the enterprise. These dedicated IP networks provide end-to-end control over the network, providing reasonable levels of QoS with mechanisms such as RSVP [18], DiffServ [1], and MPLS [16] and links to the PSTN.

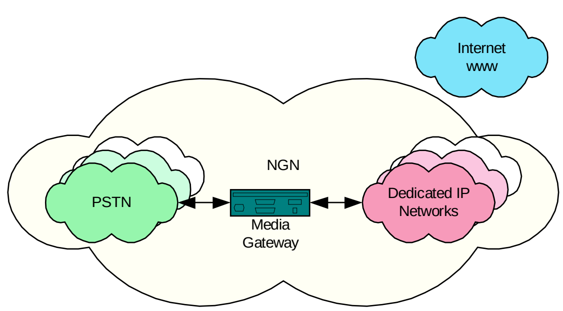

Figure 3 Dedicated IP Networks

As opposed to the proprietary nature of the PSTN, the Internet paradigm makes it easier to develop and deliver services for customers. Figure 4 depicts a future where market forces cause the PSTN to fall away completely.

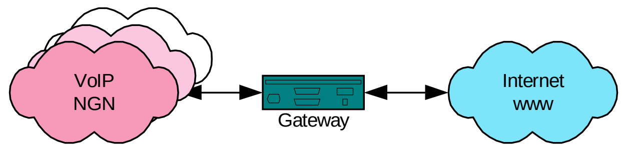

Figure 4 The Future of Networking

The need thus arises for a network management system that is capable of managing multi-vendor, multi-protocol and distributed networks with hardware and software that require a variety of management protocols. A number of generic solutions exist, such as Openview, CiscoWorks, and Tivoli [6] with support for various vendors' VoIP products. However, this research is directed at a generic framework and toolkit for collecting voice-related QoS statistics for an NGN, where VoIP, VoATM, and even VoIP over ATM co-exist [9, 19].

5. A Solution Framework

The International Organization for Standards (ISO) has defined network management in terms of the following strategic issues: fault, configuration, security, performance and accounting management [7, 17]. Figure 5 depicts the relationships between all of these issues and QoS.

To achieve voice QoS management in an NGN, we must map the ISO issues to QoS in both VoIP and VoATM domains. The foundation of QoS management is to collect statistics in order to analyze and enforce policies to minimize delay, jitter and packet loss ratios. Ultimately, this approach will enable us to provide QoS on NGNs. ATM may provide the initial definition of QoS, but we shall use the IP paradigm to lead us to a unified solution framework.

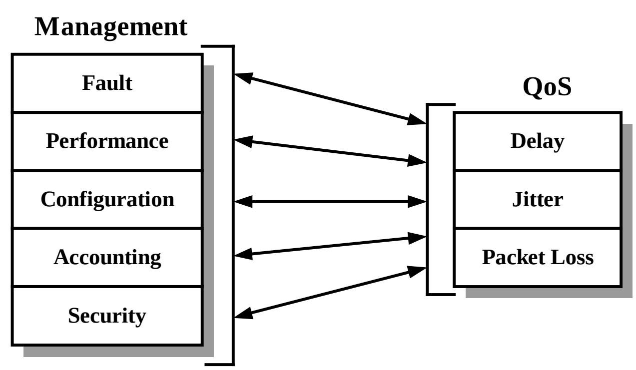

Figure 5 Network Management and QoS

Of the three primary VoIP QoS mechanisms, RSVP is a "here and now" technology, with wide industry implementation and support. [5, 18] RSVP is a network-control protocol that enables IP applications to reserve bandwidth to guarantee various qualities of service. RSVP defines three types of traffic, namely: best-effort, rate-sensitive, and delay-sensitive traffic. Best-effort traffic is traditional IP traffic. Rate-sensitive traffic is willing to give up timeliness for guaranteed rate. Delay-sensitive traffic is traffic that requires timeliness of delivery and varies its rate accordingly [18]. These types of traffic map roughly to ATM-defined QoS types.

The Common Object Request Broker Architecture (CORBA) [21] allows the use of object-oriented technology to provide seamless interoperability in a complex distributed environment. A distributed CORBA approach also has the advantage to reduce and balance the load on an inter-network by deploying multiple Object Request Brokers (ORB) to farm out the work. Perhaps the aspect of CORBA that we wish most to exploit is to abstract the QoS statistics collection away from VoIP and VoATM platform dependencies.

Other advantages include the ability to code each component of the system in a different programming language, as CORBA is language independent. With the rapid growth of web-based applications, it is important that any management system be able to run within an environment on a browser as it provides portability, and accessibility. Most CORBA ORBs have the Internet Inter-Orb Protocol (IIOP) built-in. This, in addition to the implementation of the user interface in Java, supports interoperable web-based management [7, 21].

The task, then, is to feed such web-based management systems with the QoS statistics that they need in order to manage voice services. Most, if not all, Network Element (NE) hardware has support for some version of the SNMP.

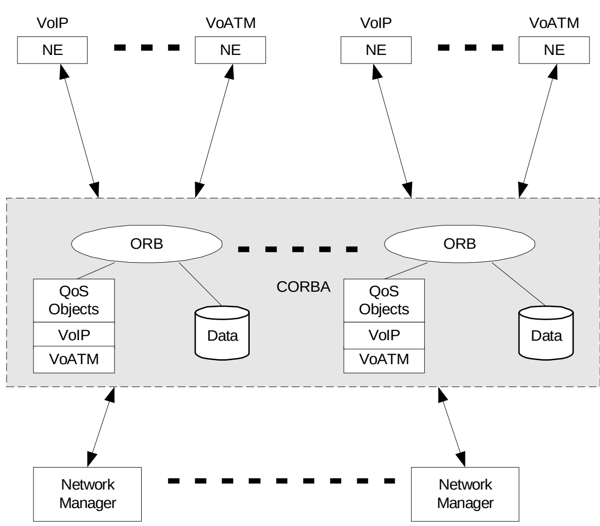

Figure 6 Sketch of CORBA-based Solution

SNMP uses a server/agent approach that a CORBA-based approach can readily utilize. We shall register VoIP and VoATM service objects inside a distributed collection of ORBs. These objects talk platform-dependent SNMP to the NEs where the QoS statistics are collected, primarily using IP (or IP over ATM where necessary). The network management software collects QoS statistics (not VoIP or VoATM) from the ORBs. The ORBs store statistics in local databases. Figure 6 provides an overview of the solution framework.

To prove the feasibility of this framework, we intend to produce a toolkit implementation that any SNMP-based network management tool can take advantage of. This entails defining (or refining) a QoS MIB by borrowing MIB components from both ATM and IP MIBs currently in use. This MIB will be defined by the mapping between VoIP and VoATM QoS. We hope that an SNMP and CORBA-based solution will be scalable, and designed in such a way that CMIP [17], RMON [20], or any other protocols and hardware can be added with ease at a later stage.

6. Test Scenario

In order to test the feasibility and capabilities of the system, we will build networks of voice-enabled equipment from different platforms and vendors inside the UWC Computer Science Department's NetLab (http://www.whipper.uwc.ac.za/cscoe/NetLab/). These networks will consist of a pure IP, a pure ATM and an IP over ATM network. The NetCom Systems' SmartBits 200 [12], armed with Ethernet and ATM blades, can generate the traffic (both voice and data) across all networks, as depicted in Figure 7.

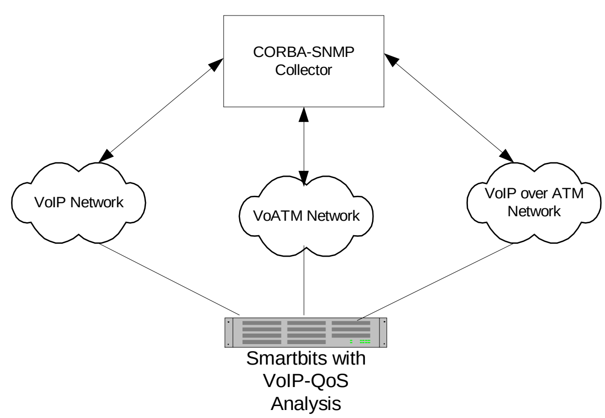

Figure 7 Test Scenario

We intend to devise traffic profiles for testcases to evaluate QoS parameters across all target platforms. Testcases will be defined for pure voice traffic, as well as combinations of multi-service traffic. The goal will be to determine how QoS for voice can be measured in both Internet and NGN domains, as the methods for statistics collection are fundamentally identical.

7. The Bigger Picture: South Africa

A third world country can have its drawbacks - one of the most important is the lack of educational facilities. The mission of the Centre of Excellence in ATM & Broadband Networks and their Applications at UWC is to provide world-class, bandwidth-hungry, distance education systems to people, anywhere, anytime, especially in South Africa. In an NGN where services provided by the PSTN, wireless, and data networks are seamlessly integrated, the infrastructure for delivery of such systems is made plausible. Yet, delivery cannot be accomplished without powerful management suites. We feel that our SNMP-CORBA approach to QoS statistics collection may serve as a model for collecting statistics for *any* service one will find on an NGN. We feel that a service-based approach to network management, borrowing heavily from the Internet paradigm, will provide the foundation for the management of tomorrow's networks, today.

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