QOS MONITORING SYSTEM

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With the explosive growth of the Internet, Quality of Service (QoS) over the networks has become important. In order to evaluate the networks, we have developed a QoS Monitoring System with a QoS Probe and QoS Manager Software. The IQ1000 QoS Probe captures and measures the users' actual packets with passive measurements, and then transmits the measured data to the QoS Manager Software. The QoS Manager Software collects the measured data and calculates packet delay (latency), latency variation (jitter), packet loss and bandwidth (throughput) of each one-way end-to-end communication network. The IQ1000 has dedicated hardware, which assures less packet-capturing loss. With the Simple Network Management Protocol Management Information Base (SNMP MIB) function, the QoS Monitoring System can be incorporated into general network management software.

INTRODUCTION

The Internet has been evolving based on a best-effort architecture that aims at benefiting the whole network but does not guarantee service quality. However, as use of the Internet is becoming explosively widespread, users have been progressively changing their attitudes, demanding QoS (Quality of Service) instead of the conventional best-effort services from telecommunication carriers and ISPs (Internet Service Providers). In particular, advances in communications and image compression technologies have made real-time applications possible, such as VoIP (Voice over Internet Protocol), image transfer, music distribution, Internet videoconference, and multi-player games, which challenge the infrastructure's communications quality. For example, with Internet telephones using the VoIP, packet delay (latency) and latency variation (jitter) generated over the network greatly affect voice quality and can interrupt telephone calls.

Implementing a high-quality communications service requires the measurement of network characteristics used in the development of network equipment, and in deployment, testing, and operation of the network. Various QoS control technologies including MPLS (MultiProtocol Label Switching) and Diffserv (Differentiates Services) are being developed. QoS measurement is essential for development of network equipment that implements these technologies, and especially when operating networks where communications quality has to be regularly monitored as failure occurrence and causes have to be detected and corrected as soon as possible. Telecommunication carriers and ISPs are currently working on clarifying service quality levels and evaluating them objectively. Some ISPs have already started offering an SLA (Service Level Agreement) which guarantees network availability, failure notification time, average round-trip time for a given month, average packet loss for a given month, and other items. It can be safely said that more detailed quality measurement will be in high demand for providing

Figure 1 IQ1000 QoS Probe

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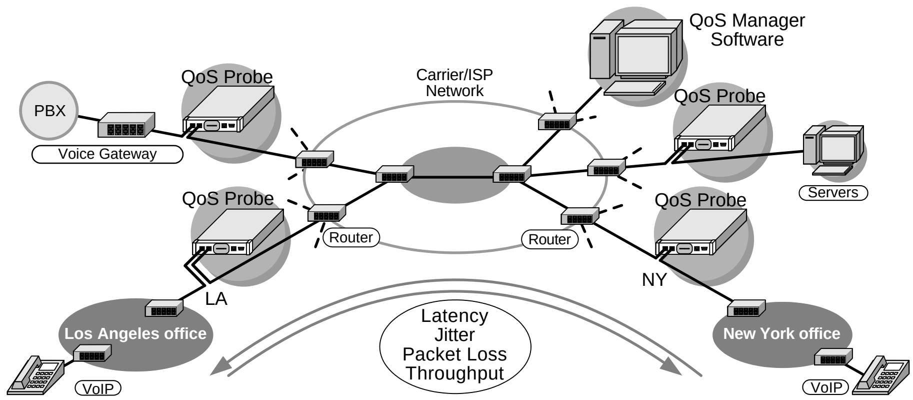

Figure 2 Example of System Configuration

premium SLAs.

We have developed a QoS monitoring system consisting of QoS Probes and QoS Manager Software. Figure 1 shows an external view of the IQ1000 QoS Probe.

TECHNOLOGY FOR NETWORK QUALITY MEASUREMENT

Network quality has the following four major parameters. To measure theses QoS parameters, there are two methods; active measurement and passive measurement.

- Latency
- Jitter
- Packet loss
- Throughput

With active measurement, the QoS parameters are measured by transmitting and receiving test packets, which emulate user packets. Active measurement can be categorized into two types: one requires only the standard IP functions (ping, etc.), and the other requires agent software or other tools need to be installed. For instance, RTT (Round Trip Time) and packet loss can be measured with the standard ping. The drawbacks to active measurement are that generally the emulation results by test packets does not accord with those of the actual user packets, or measurement itself cannot be implemented. This becomes a serious problem when test packets and user packets go through different processes, resulting from priority control or filtering as part of QoS control. Other drawback is test packets in themselves can be a load to the target network. In addition, the target software installed in a user server or client machine measure the performance including some application performances, so that only the network performance cannot be single out as the measured item.

Passive measurement can perform precise evaluation because the actual user packets themselves are measured and the elimination of test packets enables measurements without applying extra load on the target network. However, fast processing is necessary to measuring all the actual user packets securely. The QoS Monitoring System performs passive measurement utilizing special hardware.

SYSTEM CONFIGURATION AND FEATURES

The QoS Monitoring System measures packets flowing over the network by means of QoS Probes installed at the desired measurement points. The measurement data from each QoS Probe are transferred to and collected on a personal computer in which QoS Manager Software is installed, and the QoS parameters are calculated.

Figure 2 shows a configuration example of the QoS Monitoring System used for evaluation of an inter-company VoIP telephone system utilizing IP-VPN (IP Virtual Private Network) services. In this example, a VoIP telephone line connecting a Los Angeles office and a New York office is shown, with a QoS Probe installed at each end point of the telecommunication carrier network in both LA and NY.

The QoS Probe at the LA point searches packets passing through it and saves to internal memory only the specified parts of specific packets along with the time stamps of passing time. Another QoS Probe at the NY point saves data in the same way. The measurement data in memory are collected using the QoS Manager Software and the same packets are identified. The QoS Manager Software then computes the latency time from the differences between the time stamps, and the QoS parameters as well. All the data are saved in files.

Since the QoS Manager Software is equipped with an SNMP (Simple Network Management Protocol) MIB (Management Information Base), the QoS Monitoring System can be incorporated into general network management software. The QoS Monitoring System has the following advantages:

- Measures one-way latency (with 50-µs resolution), jitter, packet loss, and throughput in both directions
- Passive measurement with the actual user packets
- Continuous measurement in real time
- Secure measurement using special hardware

One-way QoS parameters between two end points can be

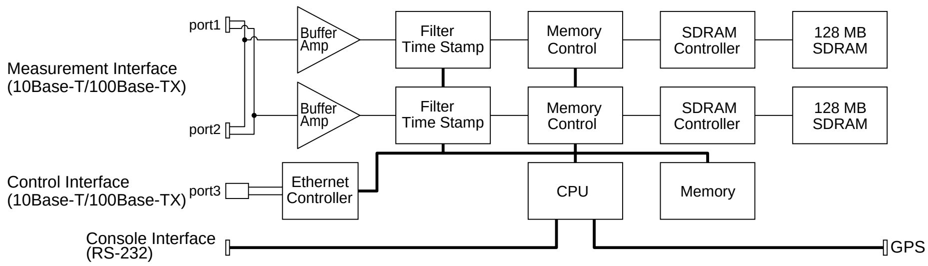

Figure 3 Block Diagram of IQ1000 QoS Probe

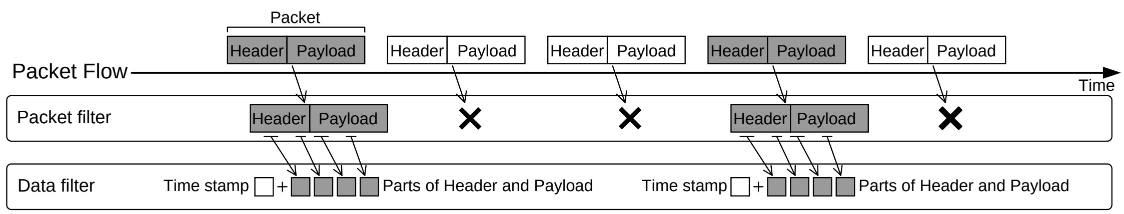

Figure 4 Filter

measured by installing a QoS Probe at each measurement point. Transfer routes, traffic, and QoS control techniques can be different between both directions on a network. Conventional measurements including ping, which measure data at one end point, however, can measure only the round-trip latency and thus cannot be used for accurate measurement of network quality.

A series of routines, from capturing packets passively to adding time stamps to them, are performed by the QoS Probe's special hardware, which does not miss catching the specific passing packets and can achieve reliable measurements. All data are measured in real time and can be measured continuously.

QOS PROBE STRUCTURE AND FEATURES

Figure 3 shows a block diagram of the QoS Probe. The QoS Probe measures packets passing between ports 1 and 2, filters the packets to extract the specified parts of specific packets, and saves them into memory (two 128-MB SDRAMs) along with time stamps (with 50-µs resolution). Then the QoS Probe sends out the measurement data in the memory to the QoS Manager Software through port 3. It is also possible to connect port 1 or 2 to a switch or other devices configured with a mirror port, and measure the packets from the mirror port. Both ports 1 and 2 support 10 Base-T/100 Base-TX.

The filter function can roughly be divided into packet filtering and data filtering. Figure 4 shows the concept of the filter function. The packet filter picks out only the specified packets from all data flowing on the network. A filter condition can be set in one-bit increments for any packet header or payload. And the data filter picks up only the specified data from the packets filter output. The QoS Manager Software uses the picked parts by the data filter as matching patterns to compare and identify packets. A matching pattern is usually specified so as to uniquely identify the measured packets. These two filters contribute to minimizing communications traffic between the QoS Manager Software and probes.

In the example of evaluation of the VoIP telephone system, the IP/UDP (User Datagram Protocol) protocol and telephone IP addresses can be used as conditions for the packet filter, with the data filter using packet identifiers as conditions.

The QoS Monitoring System offers two measurement modes, continuous and window, depending on the application as shown in Figure 5. In the continuous mode, the QoS Probe continuously measures packets going through it. This mode which all the

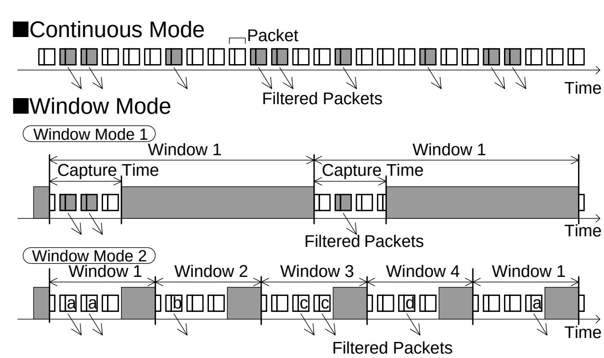

Figure 5 Measurement Modes

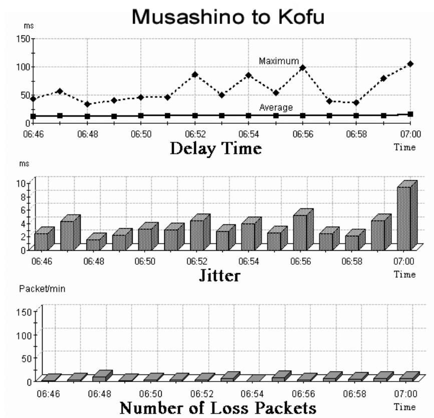

Figure 6 Measurement Results (Musashino-Kofu)

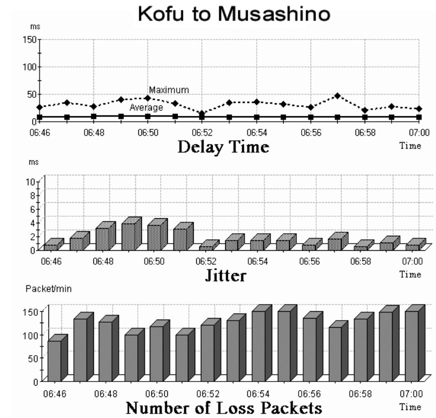

Figure 7 Measurement Results (Kofu-Musashino)

packets are subject to filtering makes solving problems that have occurred on the network much easier.

In the window mode, the QoS Monitoring System measures passing packets at regular intervals (windows) that pass during a given period of time (capture time). This lightens the data processing load on the QoS Manager Software, and this mode can be used in measurements where many QoS Probes are connected or the network traffic is much increased. By using the window mode, SLAs that require regular monitoring can be easily implemented. In addition, filtering conditions can be separately set for each of up to 32 windows, and various types of packets can be measured. In the example shown in Figure 5, window mode 2 uses four windows, and two filtering conditions can be set for each of the windows, i.e., a total of up to eight filtering conditions can be set.

Measurement of absolute latency requires time synchronization among the QoS Probes. This can be selectively achieved by synchronizing the QoS Probes with an NTP server (Network Time Protocol) or by applying a GPS (Global Positioning System). Time synchronization through input/output of an external 1-pps clock is also available.

EXAMPLE OF MEASUREMENT RESULTS

Figures 6 and 7 show examples of measurement results for a VoIP telephone system that connects Tokyo's suburb city of Musashino and Kofu in Yamanashi, based on IP-VPN services for a WAN (report tool: SLM/SLA software from InfoVista Corporation, U.S.A.). These figures chart the average/maximum latency, jitter, and packet loss at one-minute intervals. This example indicates that the latency is longer for the Musahino-to-Kofu line while the packet loss is larger in the opposite direction.

As is clearly seen in this example, it is possible to determine network quality fully and properly by measuring one-way QoS parameters in real time, as well as to easily monitor network data and solve problems.

CONCLUSION

This paper outlined the configuration and features of the QoS Monitoring System, which can greatly help evaluate network equipment during installation and monitor networks already in operation, including evaluation of network quality and creating reports required by SLAs, in order to provide high-quality communications services as a whole. We expect the QoS Monitoring System to contribute actively to network management segments at telecommunication carriers, ISPs, ASPs (Application Service Provider), manufacturers, schools, and public agencies, as well as for network systems and equipment designers and developers. ◆

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