

Quality of Service perceptiveness versus network performance in a wide Area optical MPLS test bed

F. Matera, F. Matteotti, P. Pasquali, L. Rea, A. Tarantino, V. Baroncini, G. Del Prete, G. Gaudino

Abstract- We experimentally investigate about the Quality of Service perceived by the users, in a wide area IP network based on Fiber to the Building architecture, as a function of the network performance (throughput, packet jitter,...). The network consists of a real optical network based on core routers with optical Gigabit Ethernet interfaces connected by means of long single mode fibers (about 50 km).

Introduction. Management and control of the Quality of Service (QoS) are key issues for the evolution of the next generation IP network [1]. In the past QoS measurements mainly regarded the television environment and most of the methods were defined in the ITU-R organism [2]. But due to impressive presence of triple play services over IP new normative has been introduced to define the QoS in an IP environment [3]. However, at our knowledge, a deep investigation about the correlation among typical measurements on the network performance as throughput, packet loss, packet jitter and delay (objective or network measurements) and the quality of service perceptiveness shown by the users (subjective or perceptive measurements) is still absent.

In order to have a representative ensemble of comparison between objective and subjective measurements an IP network test bed, representing a wide regional network environment, including both an access and core part, was implemented and QoS investigations were performed by testing some multimedia services.

Test bed structure and equipments

The network test bed, as reported in Fig. 1, is based on 3 core routers with Multi Protocol Label Switching (MPLS) capabilities [4], one Ethernet traffic generator-analyzer and one MULTIMEDIA SERVER. The Multimedia Server, that was realized through a Real Producer software, provided an encoding able to convert a variety of media data into Real Audio and Real Video formats.

The routers are connected to an optical ring-like structure, based on the fibres contained inside a deployed cable between Rome and Pomezia (25 Km, 50 km with loop in Pomezia) containing NZD (G.655), DS (G.653) and SF (G.652) fibres. The PCs were connected to the Routers by means of UTP copper cables; this configuration represents an example of access based on the Fiber To The Building (FTTB) architecture. This way we want to underline the QoS behavior at router level, neglecting further degradations that could be added by the access devices.

The traffic generator-analyzer, with two GbE optical interfaces and eight FastEthernet interfaces, has been used to overload the optical links under test.

In order to properly manage the QoS we used the Differentiated Service (DiffServ) over MPLS [4] that is a well known method to distinguish several Class of Services (CoS). MPLS is a scheme for set up different paths through the network with different QoS parameters and traffic engineering, adding labels to packets to improve switching processes in the network.

In a DiffServ network all the packets in each traffic flow are marked with a Diffserv Code Point (DSCP) consisting of six bits that allows us to distinguish 64 CoS's according to the RFC2474 and RFC2475 standards. For our purposes, we considered only three CoS's since we believe them as sufficient to represent the main service behaviours in a network. Our three CoS's correspond to the Expedited Forwarding (EF), to the Assured Forwarding (AF) and to the Best Effort (BE). We remember that the EF is suggested for applications that require a hard guarantee on the delay and jitter, in particular in a service with attributes similar to a "leased line". AF is suggested for applications that require a better reliability than the Best-Effort.

Evaluation of the perceived quality

To obtain a correlation between the perceived quality (from the Human point of view) and the

measurement of the network performance, it is necessary to carry out a particular subjective assessment test, that in our case was implemented according to the ITU-R recommendation BT 500-11, and in particular using the SSCQE (Single Stimulus Continuous Quality Evaluation) test method. This method allows to track in a continuous way the level of quality perception provided by a selected panel of viewers.

The test method protocol envisages the use of sliders to perform the quality assessment. The result of a SSCQE test session is a graph in which a line detaches from the top of the scale for all the time impairments have been detected. It shows a real time score (QoS perceptive value) versus time between 0 (bad imagine) and 100 (excellent imagine). In our case 16 viewers, located in a silent room, participated to the experiment and they were screened for visual acuity (Snellen chart) and color blindness (Yshihara tables).

QoS measurements. Images submitted under evaluation were produced through acquisition of video flow coming from a DVD Video and by means of the multimedia server they were transmitted in the network to reach the PC clients. To simulate a condition of network overload the traffic generator-analyzer transmits a traffic load up to 912 (800 Mbps BE , 80 Mbps AF and 32 Mbps EF). The movie test sequences were shown to the viewers, by using the three different DiffServ labeling, i.e.: EF, AF and BE

In fig. 2 we report the QoS perceptiveness values, n , for a video test (tennis match 30 second long), after an averaged made over the 16 viewers, versus the corresponding network performance in terms of throughput.

As shown by the figure, in the EF case we always measured very good network performance (throughput close to the nominal one, i.e. between 8 and 10 Mbps) and the corresponding n was close to 100.

Conversely in the case of AF the network performance was worse, with a reduction of the throughput (and a small increase of the jitter not reported in the figure) and a consequent QoS degradation.

Looking at fig. 2 we understand that perceptive measurements, for each test session, can be

characterized by two parameters: $\langle n \rangle - \sigma$ and $\langle n \rangle + \sigma$ ($\langle n \rangle$ is the time average of n and σ is the standard deviation). These parameters are reported in fig. 3 for the same video streaming for different total traffic load conditions of the network. 912 Mbps correspond to the traffic of fig. 2. It is relevant that BE has a strong QoS degradation when the traffic load is higher than 400 Mbps. QoS in EF case is practically independent on the traffic load, while AF maintains an excellent QoS up to a traffic threshold of 700 Mb/s.

Conclusions. The QoS measurements made on this test bed show the importance of methods to distinguish the packet forwarding in IP networks according to the service requirements, especially in the presence of a future high traffic growth. We underline the necessity of adopting methods to measure the user perceptiveness versus network performance.

ACKNOWLEDGEMENTS

This work has been carried out in the framework of the QoS-IP projects (supported by Italian Communication Ministry) and of IST E-PHOTON/ONE+ (VD-C) european project.

REFERENCES

- [1] Eurescom Project P918-GI Deliverable 4 “An integration of IP over optical networks: Networking and Management” <http://www.eurescom.de/~pub-deliverables/p900-series/p918/d4/p918d4.pdf> September 2000.
- [2] ITU-R BT 500-10 “Methodology for the subjective assessment of the quality of television pictures”
- [3] ITU-T Recommendation Y.1540 (2002), ITU-T Recommendation Y.1541 (2002)
- [4] F. Le Faucheur, F., L. Wu, L., Davie, B., Davari, S., Vaananen, P., Krishnan, R., P. Cheval, P., Heinanen, J. “Multi-Protocol Label Switching (MPLS) support of Differentiated Services” RFC 3270, May 2002, <http://www.ietf.org/rfc/rfc3270.txt>

Authors' affiliations:

F. Matera, F. Matteotti, P. Pasquali, L. Rea, A. Tarantino, V. Baroncini are in Fondazione Ugo Bordoni, via B. Castiglione 59, 00142 Rome, Italy, G. Del Prete and G. Gaudino are in Istituto Superiore delle Comunicazioni e delle Tecnologie delle Informazione (ISCOM), viale America 2001, 00144 Rome Italy.

Corresponding e-mail: mat@fub.it

Figure captions

Fig.1. Network experimental set-up

Fig. 2: QoS perceptiveness values vs throughput for EF and AF CoS's, in case of a traffic load equal to 912 Mbps in case of a tennis match video 30 second long.

Fig. 3: Worse ($\langle n \rangle - \sigma$) and better ($\langle n \rangle + \sigma$) QoS perceptiveness vs traffic load for EF, AF and BE.