QOS EXPERIMENTS ON A GMPLS BASED DYNAMIC OPTICAL NETWORK PART I: THE OBJECTIVE TESTS

(ESPERIMENTI DI QUALITÀ DEL SERVIZIO SU UNA RETE OTTICA DINAMICA CON GMPLS – PARTE I I TEST OGGETTIVI)

Abstract: the introduction of intelligence for management and control of optical networks with GMPLS architecture and the Quality of Service (QoS) are key issues for the evolution of the next generation transparent optical network. In this paper the authors report experimental results, in agreement with DiffServ architecture, related to different traffic flows of a real optical network obtained by means of an installed cable between Rome and Pomezia.

1. Introduction

The telecom networks are evolving towards a integration between IP and optical technology. The TLC carriers, interested to expand their wider-area infrastructure, look into the facilities provided by the Ethernet Technology in terms of flexibility, simplicity and lower cost than traditional wide-area interfaces. The reason of this evolution is due to the growth of bandwidth request induced by the introduction of new advanced services based, and to the increasing customer demand for high quality voice, data and video services, the so called triple play!

In this scenario the key aspect to be investigated is the capability of integrated networks to manage the quality of service.

It can be possible to manage the quality of service over a network with DiffServ technique and MPLS/GMPLS[1-2].

MPLS (and GMPLS) is a scheme for set up different paths through the network with different QoS parameters and traffic engineering, adding labels to packet and switching them on a core network, it is independent of Layer-2 and Layer-3 protocols.

The DiffServ works at the class level that is an aggregation of many flows. In a DiffServ network all the packets in each traffic flow are marked with a DiffServ code point (DSCP). Packets containing the same code point receive identical forwarding treatment by routers and switches placed along the path. In the DiffServ architecture there are three different class of service: Best Effort, Expedited Forwarding, Assured Forwarding. The Expedited Forwarding Per Hop Behavior (PHB) 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".

Assured Forwarding PHB is suggested for applications that require a better reliability than the Best-Effort service. In the Assured Forwarding class there are four subclasses of service, and within each subclass there are three different drop precedences.

In this scenario, the authors report investigations related to the behavior of a GMPLS based dynamic optical network, in presence of a multiplicity of services whose priority is managed through the DiffServ architecture [3-5].

In the second part we will show the subjective tests made by the help of a certain number of observes on a suitable video streaming, transmitted with various QoS classes. This video stream will be realized with usual multimedia codecs used in broadband networks.
At a later date we will expand the capability of our dynamic network by the adoption of a wavelength converter, based on a semiconductor optical amplifier (SOA), in order to simulate a GMPLS situation.

2. Test bed structure and equipment

The experimental optical network, as reported in Fig. 1, is based on the adoption of two core routers with GMPLS protocol capabilities, one Ethernet traffic generator-analyzer, one simulated source of different kind of traffic (A) and one multimedia server (B) [6]. Both the routers are connected to an optical ring-like structure, based on the fibres contained inside a deployed cable between Rome and Pomezia, for an overall length of 50 Km. In particular, the cable contains different kind of fibres such as NZD (G.655), DS (G.653) and SF (G.652) fibres.

The traffic generator-analyzer, with two GigaEthernet optical interfaces and eight FastEthernet interfaces, has been connected to the optical ring as reported in Fig.1. It has been used for overloading the optical link under test. The overloading traffic, labeled in various way and in agreement with the DiffServ architecture, is generated by two GigabitEthernet optical interfaces and four FastEthernet interfaces, and it is addressed for saturating the link under test. In this test bed there is one data server (A) and one multimedia server (B). The first one has been realized through a software, that is able to simulates data exchange between the PCs (Client 1 and Client 2) connected to the two routers.

A client version of this software is installed on these PCs. The type of exchanged data that can be setted are: video conference realized by means of Netmeeting session, data downloads or VoIP sessions. Moreover, it is possible to send the traffic at the rate set by the operator and it is possible to label it in accord with the DiffServ architecture for the management of the QoS. The Multimedia Server, reported in Fig. 1, has been realized through a RealProducer software that provides an encoding able to convert a variety of media data into RealAudio and RealVideo formats.

Class-of-service (CoS) can be configured to provide multiple classes of service for different applications. In fact, the capability of the Routers to configure multiple forwarding classes for packets transmitting gives the possibility to define which packets are placed into a choosen output queue, to schedule the transmission service level for each queue and to manage congestion using a Random Early Detection (RED) algorithm. Two parameters can be configured to control the congestion at the output stage. The first parameter defines the delay-buffer bandwidth, which provides packet buffer space to absorb burst traffic up to the specified duration of delay. Once the specified delay buffer becomes full, packet with 100 percent drop probability are dropped from the head of the buffer.

The second parameter define the drop probabilities across the range of delay-buffer occupancy, supporting RED process. Depending on the drop probabilities, RED might drop packets aggressively long before the buffer loading, or it might drop only few packets even if the buffer is almost full. So, for these reasons, we test different profiles in order to reach acceptable QoS requirements.

The CoS applications of Router, used in this test bed, are Differentiated Services and MPLS EXP. The first application supports DiffServ as well as six-bit IP header ToS (Type of Service) byte settings. The configuration uses DiffServ code point (DSCPs) in the IP ToS field to determine the forwarding class associated with each packet. The MPLS EXP application support configuration of mapping of MPLS experimental (EXP) bit settings to router forwarding classes and vice versa. The Router CoS features used during the experimental measurements are: 1) classifiers, 2) forwarding classes, 3) loss priorities, 4) transmission scheduling and 5) rate control. The classifier allows associating incoming packets with a forwarding classes.
and loss priority, and assigning the packets to the output queues. The forwarding classes affect the forwarding scheduling and marking policies applied to packets as they transit inside a router. Four forwarding classes are supported: best effort, assured forwarding, expedited forwarding and network control. The forwarding class plus the loss priority define the per-hop behavior. The loss priorities allow setting a packet dropping priority. Transmission scheduling and rate control allow defining the priority, bandwidth, delay buffer size, rate control status and RED drop profile to be applied to a particular forwarding class for packet transmission.

3. Description of the tests

A data flow, labeled with DiffServ characteristic, between the two PC clients is simulated by means of the Data Server (A). When the various flows reach the router it examines the DSCP field and manages every flow in accord with such information. Then it sends the data on its GigaEthernet exit interface toward the GigaEthernet input interface of the other router. Then the router examines the DSCP field and in relationship to such value it applies the opportune politics of QoS. Then it routes the flow toward its FastEthernet exit interface, to arrive to the PC client.

In table 1 we report the minimum requirements, in terms of QoS, that we adopted as references for our experimental tests.

<table>
<thead>
<tr>
<th>TRAFFIC</th>
<th>DSCP</th>
<th>PACKET LOSS MAX</th>
<th>JITTER MAX</th>
<th>ONE WAY DELAY MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>VoIP</td>
<td>EF</td>
<td>1 percent</td>
<td>30 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Videoconferencing</td>
<td>EF</td>
<td>1 percent</td>
<td>30 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Streaming Video</td>
<td>AF</td>
<td>2 percent</td>
<td>5 s</td>
<td>-</td>
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<tr>
<td>Data</td>
<td>BE</td>
<td>variable</td>
<td>variable</td>
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</table>

Table 1. Minimum Multimedia QoS Requirements

In the test bed we have implemented different services and every service has been assigned at the same time to all the forwarding classes. We have carried out a series of measurements to show like the network treats every service according to its label. By means of the traffic generator-analyzer we have realized the tests in condition of network overload.

3.1 Tests about video conference - Netmeeting

The video conference service requires very low values of jitter, one-way delay and packets loss... These kind of service requirements must be maintained also in case of overload network.

We realized the following configuration of traffic: the data server simulates a data-exchange between the PC clients made of: 1 flow at 10 Mbps Best Effort labeled, 1 flow at 10 Mbps Expedited Forwarding labeled, 3 flows altogether at 26 Mbps of Assured Forwarding traffic labeled. To simulate a condition of network overload, the traffic generator-analyzer transmits 800 Mbps of Best Effort traffic, 80 Mbps of Assured Forwarding traffic, 32 Mbps of Expedited Forwarding traffic.

The Fig. 2 shows the throughput of the various flows which have the same nominal bit rate but different performances in agreement to the relative class of service. The Expedited Forwarding flow has a low variation of the throughput, close to the nominal.

The Assured Forwarding traffic has a lower throughput than the Expedited Forwarding flow and a greater variability but it remains always in the limits of QoS requirements. The Best Effort flow is the worst and highly varying in terms of throughput.

The Fig. 3 shows the data lost. The Expedited Forwarding traffic has very low losses, the Best Effort flow has unacceptable losses for this kind of service, while for the Assured Forwarding flow the losses are about 1.4-1.5%, respecting the QoS requirements of Assured Forwarding traffic.
The Fig. 4 shows the one way delay of the different flows. In particular, the Expedited Forwarding traffic has a negligible delay while the Best Effort traffic has the most greater delay due to a greater buffering.

3.2 Test about services of data transfer

In this series of measurements we have simulated a file sending as reported in Fig. 5. The source transmits one Expedited Forwarding flow, one Assured Forwarding flow and one Best Effort flow. To simulate a condition of network overload the traffic generator-analyzer transmits 800 Mbps of Best Effort traffic, 80 Mbps of Assured Forwarding traffic, 32 Mbps of Expedited Forwarding traffic. In this case we have an evident difference of performances. The Expedited Forwarding traffic has the greater bit rate, with average value of around 26 Mbps, the Assured Forwarding traffic has an average throughput of around 14 Mbps and the Best Effort traffic has the lowest throughput equal to 0.037 Mbps.

3.3 Tests about services audio-video not real time

This series of measurements simulates services of not real-time streaming audio-video. In particular, the simulated service is the streaming video and the simulated application is Real-Player. The data server simulates the following configuration of traffic: one Expedited Forwarding flow of 20 Mbps, one Best Effort flow of 20 Mbps and one Assured Forwarding flow of 20 Mbps. In order to simulate a condition of network overload the traffic generator-analyzer transmits 800 Mbps of Best Effort traffic, 80 Mbps of Assured Forwarding traffic, 32 Mbps of Expedited Forwarding traffic.

As shown in Fig. 6, the Best Effort traffic has the lowest throughput.

3.4 Transmission of a real time streaming video

In this test we use a multimedia server as a source. The signal is produced through acquisition of video flow coming from a satellite transmissions and by means of multimedia server it is transmitted on the network. Subsequently, we can see the video streaming on the PC client. To simulate a condition of network overload the traffic generator-analyzer transmits 800 Mbps of Best Effort
traffic, 80 Mbps of Assured Forwarding traffic, 32 Mbps of Expedited Forwarding traffic. In case of network overload, if the video streaming is Best Effort labeled, the quality of the image is really poor. If the video streaming is Expedited Forwarding labeled there is not difference between the case of overload network and unloaded network.

4 Conclusions

All the measurements confirm the DiffServ approach, therefore the network that was realized is able to manage, in a differentiated way, all the traffic flows. Infact, the results showed that the DiffServ architecture is able to manage, in different kind of traffic network conditions, different types of data flows with acceptable QoS. The differentiation of the services has been implemented with success in the core routers. They have shown an optimal behaviour in the management of the classes of service. In all the measurements, it is evident that the Expedited Forwarding class and Assured Forwarding class are also protected under conditions of network overload and are well appropriate for the real-time services; the Best Effort class has very low performances in any type of services.

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6 References


[6] At all, "MPLS boost Ethernet capability" Fiber System Europe magazine, September 2004
NOTE

Test Plan utilizzato nella sperimentazione