On-demand uncompressed HDTV Transmission over a GMPLS controlled Service-Aware all-optical network

R. Casellas, I. Martínez, C. Pinart, R. Muñoz, R. Martínez, F. Galán and G. Junyent

Publication:	in Proc. 33rd European Conf. on Opt. Comm. ECOC Sept, 2007
Vol.:	-
No.:	-
Date:	2007

On-demand uncompressed HDTV Transmission over a GMPLS controlled Service-Aware all-optical network

R. Casellas, I. Martínez, C. Pinart, R. Muñoz, R. Martínez, F. Galán and G. Junyent
Centre Tecnològic de Telecomunicacions de Catalunya (CTTC)
Av Canal Olímpic s/n 08860 Castelldefels (Barcelona), Spain
{rcasellas, imartinez, cpinart, rmunoz, rmartinez, fgalan, gjunyent}@cttc.es

Abstract *An intelligent optical network needs to address the heterogeneous requirements that new services like on-demand, uncompressed HDTV transmission impose, jointly considering management, control and transport planes. Such a transmission was assesed over a GMPLS network*.

Introduction

A persistent trend in network planning and design is the "service converged network", where an integrated architecture that is efficient and scalable defines the infrastructure on top of which a diversity of heterogeneous services are deployed and offered. These services are characterized by a set of mixed requirements, defined in Service Level Agreements (SLA). Current networks are in reality a series of overlay infrastructures, each supporting a service type or family. This design approach results in considerably increased costs. Alternatively, the network may be a converged infrastructure whose design is based on the performance parameter constraints of target services with rigid SLA requirements. The main advantage of this approach is that dimensioning of the converged network for these services guarantees that any service with similar or less stringent SLA can be offered, with the subsequent cost optimization both in terms of capital and operational expenses. A side drawback of this approach, which needs further study, is that the choice of too stringent service parameters may impact the use of resources, e.g. choosing a service with tight setup delay constraints as the design basis may limit the applicability of optimized but time-consuming path computation algorithms. To overcome this, selecting the subset of services for which the converged network is designed becomes a key issue.

The delivery of video services in general, and on-demand uncompressed High Definition Television (HDTV) streaming in particular, is an example of such service, imposing hard constraints in terms of SLAs. Uncompressed transmission is justified in editing and post-production scenarios, where compression and (possible) losses are undesirable, as well as in tele-medicine scenarios.

This paper briefly details the successful provisioning of an on-demand HDTV service on CTTC's experimental, GMPLS-controlled, DWDM all-optical network and the assessment of its associated SLA.

HDTV transmission service requirements

The HDTV transmission service can be characterized in terms of SLA parameters, as detailed in Table 1.

Table 1. HDTV SLA parameters

Service parameter	HDTV service
Connection setup time[1]	Seconds
Blocking probability[1] (connection setup)	< 0.1%
Latency[2] (average, maximum)	< 100 ms
Latency variation (jitter)	50 ms
Bit Error Rate	10^{-8}
Average bandwidth	1.485 Gbps
Controlling and signalling delay[1]	< 100 ms

1 Extracted from conversational/streaming parameters defined in [3].

2 Including processing time in the receiving end.

Uncompressed HDTV traffic characterization

Specifications as SMPTE 292M and SMPTE 274M [1] define the serial bit stream for the transport of HDTV signals such as 1080i/50, which generates interlaced 25 fps at 1920x1080 with 20 bits/sample, resulting in a CBR stream of 1.485 Gbps.

ADRENALINE testbed and lab trial description

ADRENALINE (All-optical Dynamic REliable Network hAndLINg IP/Ethernet Gigabit traffic with QoS) [4] is a GMPLS-based Intelligent Optical Network (ION): the all-optical transport network consist of a metropolitan DWDM bidirectional ring with 3 monitor-enabled colourless Reconfigurable - Optical Add Drop Multiplexers (R-OADMs) nodes with 8 lasers (6 of them tuneable). The GMPLS-based control network is composed of (up to) 14 Optical Connection Controller (OCC) nodes (11 of them with emulated hardware) providing both dynamic and real-time provisioning of end-to-end optical connections between client equipments. A management plane combining the standard SNMP with a service-oriented architecture based on SOAP/XML[5] is also deployed for web-based provisioning (Fig.1).

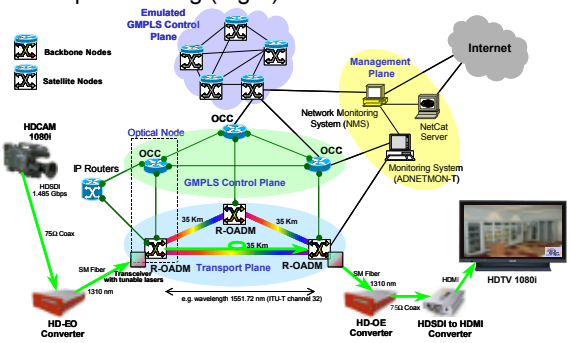

Figure 1. ADRENALINE Testbed and lab trial

End-to-End HDTV transmission is delivered by a Soft-Permanent Connection (SPC) triggered via the management plane. Upon request, the ingress node performs path computation using the OSPF-TE database and signals the establishment of the SPC using GMPLS RSVP-TE. Coexisting switched LSPs are generated with client UNI emulators.

Control and Transport Plane issues

Several issues were addressed in order to fulfil the requirements of the SLA, as detailed:

- Minimization of routing overhead and convergence times by disabling proprietary OSPF-TE extensions. No per-wavelength state information dissemination.
- Reduction of setup delay by means of simple C-SPF based path computation. Priorization of shorter paths to reduce latency and physical impairments due to transparency, guaranteeing OSNR levels.
- Transponders that convert the optical signal from 1310 nm to the selected DWDM wavelength using tuneable lasers and vice versa, were configured in bypass mode (2R and not 3R), since commercial, off-the-shelf transponders can just perform clock recovery at SONET/SDH bitrates. Clock recovery at High Definition Serial Digital Interfaces (HDSDI at 1.485 Gbps) is performed externally at the HD converter.

Experimental Validation and Results

The setup delay, considered both from the control plane (CP) and from the management plane (MP). The CP setup delay corresponds to the GMPLS Path-Resv end-to-end signalling. MP includes the processing by the SNMP agents and the upcalls to the network management system. Measured values are below the SLA.

Blocking Probability (BP). To assess the SLA, we evaluate the maximum traffic that the network can accept keeping the BP below the required threshold. Dynamic requests for lightpaths are generated using GMPLS-UNI client. The request arrival process is Poisson with a negative exponential holding time of average 240s (corresponding to a 4min video streaming) and varying mean interarrival depending on offered traffic. With 10^4 requests, no unidirectional connection was blocked below 24 Erlangs.

Latency, considering the transmission from the transceivers attached to a source client port to the corresponding destination port.

Bandwidth: a whole wavelength up to 2.5 Gbps was allocated to the transmission.

*Bit Error Rate (*BER) is estimated from OSNR using the well-known expression in [2], where the optical bandwidth of the spectral monitor is the same as the one of the photodetector. Measured OSNR values, around 30 dB, result in an error-free transmission (BER << 10^{-15}) (Fig.2).

Table 2 Measured values for SLA parameters

SLA		1-Hop path	2-Hop path
Connection Setup Time[1]	RSVP-TE signalling	~ 200 ms	~ 250 ms
	NMS request	~ 400 ms	~ 500 ms
	Laser (Link up)	~ 1500 ms	~ 1500 ms
	User perception (e2e)	~ 5-6 s	~ 5-6 s
Blocking Probability		<0.1% Offered Traffic <24Erlangs	
Network Latency	Theory[2]	35 Km ~ 175 µs	70 Km ~ 350 µs
	Minimum	178.76 µs	354.76 µs
	Average	180.58 µs	355.54 µs
	Maximum	180.82 µs	356.68 µs
Jitter		< 5 µs	< 10 µs
OSNR	Signal level	~ -0.1 dBm	~ -9.8 dBm
	Noise level	~ -30 dBm	~ -40 dBm
BER[3]		error-free	error-free
BW guaranteed		1.485 Gbps	1.485 Gbps
Signalling Delay (RSVP-TE)	o.w. delay forward	< 80 ms	< 120 ms
	o.w. delay backward	< 120 ms	< 150 ms

(1) Including OXC hardware cross-connect. (2) Transmission delay of 5µs / Km. (3) BER estimation from OSNR according to [2].

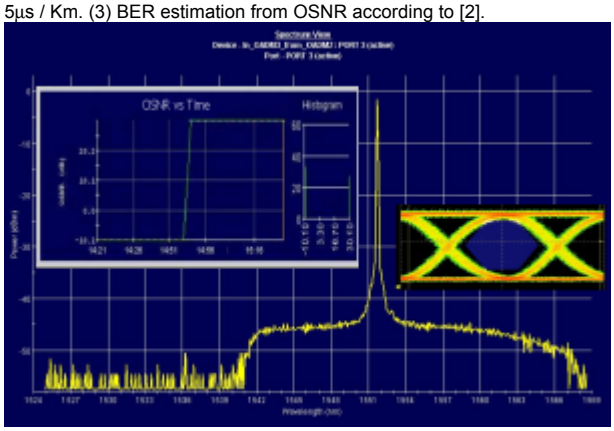

Figure 2. OSNR level and eye-diagram for 1-hop path

Conclusions and further work

We selected the on-demand uncompressed HDTV transmission service to dimension the optical network, covering a wide range of data services with less stringent SLA requirements. We assessed the performance of the network, verifying the HDTV SLA parameters. ADRENALINE is currently being extended to unify Ethernet and Lambda switching capabilities, so packetized, multicast/broadcast HDTV and conferencing solutions can also be evaluated.

Acknowledgements

This work has been partially funded by Spanish Ministry of Education and Science (MEC), via RESPLANDOR project grant TEC2006-12910/TCM.

References

1 ANSI/SMPTE 292M, Tv.
2 P. A. Humblet et al, “On the bit error rate of lightwave systems with optical amplifiers”, JLT. Nov 1991.
3 IST NOBEL Proj. (FP6-506760) D17, Feb 2005.
4 R. Muñoz et al. IEEE ComMag V. 43(n18) s40-s48.
5 C. Pinart et al. IEEE JSTQE, V. 12. (n4) 635-644.