First demonstration of an asynchronous optical packet switching matrix prototype for MultiTerabit-class routers/switches

(1) D. Chiaroni, P. Bonno, O. Rofidal, J.C. Jacquinot, P. Poignant, C. Coeurjoly, F. Fernandez, E. Mestre, J.L. Moncelet, A. Noury, A. Jourdan, T. Zami, A. Dupas

(2) M. Renaud, N. Sahri, D. Keller, S. Silvestre

(3) G. Eilenberger, S. Bunse, W. Lautenschlaeger

(4) F. Masetti

Alcatel Research & Innovation

(1) Route de Nozay, F-91460 Marcoussis, France; (2) OPTO+ Route de Nozay, F-91460 Marcoussis, France; (3) Holderaeckerstr.35, D-70499, Stuttgart, Germany; (4) 1201 E. Campbell Road, Richardson, Texas, 75081-1936, USA;

(Dominique.Chiaroni@alcatel .fr)

Abstract: An optical packet switching matrix for MultiTerabit-class routers/switches has been prototyped. It is based on novel integrated optical gate arrays and asynchronous packet-mode receivers. Full asynchronous operation with 10G RZ oprical packets is demonstrated for the first time.

Introduction

With the massive introduction of Internet applications in the network, there will be a need for a new generation of multi-Terabit routers in a next future. A large router can be built from sub-Terabit switches arranged in a clos network as represented on the left side of the figure 1 or from one unique plane capable to handle large capacities. Optics could be used efficiently to implement such switching planes in the core of a router through the exploitation of space and wavelength switching [1]. The contention resolution could be achieved then in electrical buffers at the periphery of the optical matrix. In addition, the foot print can be reduced because of the natural high throughput per rack provided by optical technologies.

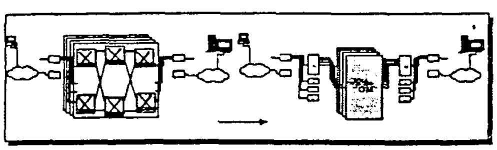

Figure 1 : Multi-Terabit router based on electrical matrices in a clos arragement (left side) or adopting high throughput optical packet switching matrices (rigth side)

To evaluate the potential of optics, an optical matrix prototype adapted to a MultiTerabit-class router with optimised foot print has been realised and tested in our labs. A fully asynchronous operation is demonstrated, a point very often overlooked in previous works, althrough essential to such systems.

Broadcast-and-Select optical matrix and technology

The matrix adopted is a broadcast-and-select optical architecture as illustrated in figure 2 and [2]. It is basically composed of :

- one WDM space switch for the selection of the input port
- wavelength selection stages to select the correct wavelength in the selected input port.

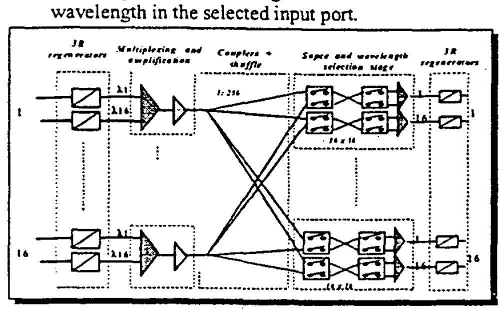

Figure 2 : Schematic of the Broadcast-and-Select optical matrix

Based on an integrated Semiconductor Optical Amplifiers (SOA) technology, this matrix can have the wished performance and the required compacity to envisage large throughputs with small foot print. Thus, a 32 SOA module integrating HF drivers has been realised and successfully tested. More details are given in [3].

To make the building of the optical matrix cheap (no complex power control and no drastic path equalisation), we assumed that the matrix could operate in an asynchronous mode. Therefore, a second important element was the asynchronous packet mode receiver. Such a receiver has been designed and realised. It is capable to handle 10 dB of power variations between two consecutive packets and is fully transparent to the packet payload bit phase [4].

Optical matrix prototype

Based on the technology previously described, a sub-equipped prototype has been built. It can offer a throughput of 640 Gbit/s (8 ports, each port having 8 wavelengths at 10 Gbit/s, RZ), all the boards being integrated in one rack. Realised boards consist in : input boards including amplification for broadcast loss compensation, output selection boards (integrating the two switching stages and handling each a potential capacity of 2.56 Tbit/s x 40 Gbit/s), 10 Gbit/s transceiver boards, a passive shuffle and control boards (monitoring and clock distributions). Thes boards are mounted in subracks incorporating a backpannel with software, high speed electronics, and optical connection interfaces. An embedded computer has been integrated in the rack to control all the system An agent software has been developped for demonstration purposes, and for dialogue with a future management plane.

Figure 4 shows one 2.56Tbit/s x 40 Gbit/s SOA board mounted, and one asynchronous packet mode receiver.

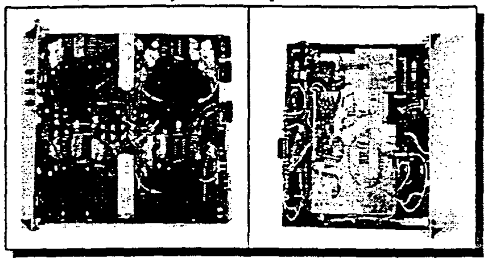

Figure 4 : SOA-based switching board (left side) and asynchronous packet mode reciever (rigth side)

Performance of the optical matrix

The optical signal to noise ratio at the output of the switch is still higher than 24 dB and the available output power between −14 and −10 dBm. Figure 5 shows the OSNR measurements at the output of the SOA board #3.

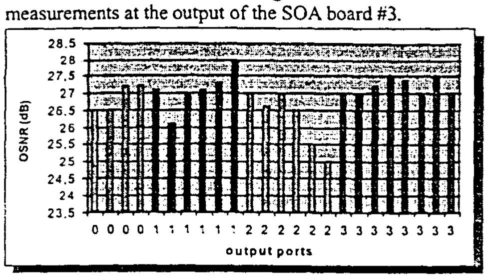

Figure 5 : As an example, distribution of the OSNR at the output of the SOA board #3

After static characterisations, the optical matrix has been tested in transmission and switching regime and its operation is validated through BER measurements at 10Gbit/s in RZ format.

Figure 6 shows the packet stream and more particularly the the eye diagrams obtained. In switching regime, a power unbalancement can be observed (figure 6).

Figure 7 shows typical BER characteristics of the optical matrix. Among the numerous measurements done we have plotted the most representatives : some BER curves shown in figure 7a are for the two wavelengths at the boundary of the comb (1547,72 nm, 1558,98 nm) and for some are for wavelength surrounded by two wavelengths. It can be noticed that no BER floor has been recorded indicating that no critical crosstalk (in band or out-of-band) or four wave mixing affects the quality of the signal. In a second step we have tested the optical matrix in switching regime. The same sensitivity penalty has been recorded indicating that the switching regime doesnot affect the operation of the optical gates whatever the scenario is (several test scenario have been tested). Once again, figure 7b exhibits only representative curves (switching between two consecutive wavelengths or extrem wavelengths (1558,98 nm and 1547,72 nm). In both cases the BER curves are similar : no BER floor and dispersion of the sensitivity not exceeding 2 dB.

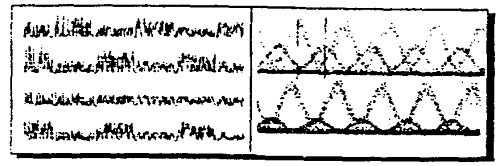

Figure 6 : Packet stream recorded at the output of the optical matrix and eye diagrams in switching regime

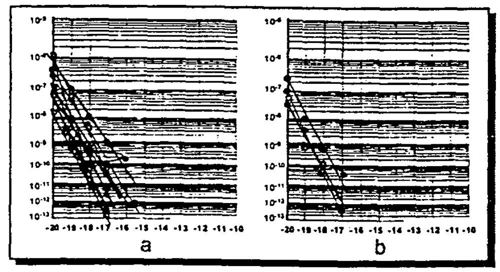

Figure 7 : BER curves recorded at the output of the optical matrix , a : in transmission regime, b : in switching regime

Conclusions

In this paper we have realised and tested the prototype of a MultiTerabit-class optical switching matrix. Based on a new integrated SOA technology and on a new asynchronous packet mode receiver, we have demonstrated for the first time to our knowledge a successful operation of an asynchronous switching regime with 10Gbit/s RZ packets in several configurations. In addition, we noticed a stable operation fully transparent to the traffic pattern.

This Broadcast-and-select switching matrix by providing simplicity (only one plane to switch large capacities relaxing the contention resolution), robustness (SOA in gain switching), stability (no tuneable device) can bring a concrete solution to build future MultiTerabit-class routers.

References

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