Simulation of 4 x 4 Optical Packet Space Switch Array

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Abstract: Simulations of a 4 x 4 optical packet space switch array based on optically amplified suppressed interference switches (OASIS) were carried out. The OPTSim simulator was used to model the structure, to assess the behaviour and performance of this switch array. Parameters such as Q factor and bit error rate (BER) were calculated. Implications of cascadability of this switch array are investigated.

I Introduction

There is a challenge for telecommunications networks today from the traffic generated due to the popularity of IP. Packet switching is believed to be the technology trend in telecommunications [1,2].

The high demand of bandwidth for IP traffic has laid a considerable burden on traditional transmission networks. There is a call for a solution of the incremental IP traffic. Recently, the focus on packet switching has moved from the network layer down to the physical layer. The concept of traffic dynamic switching on the transmission networks has drawn the attention of increasing numbers of researchers and operators.

A high-speed optical packet routing technique using optical crossconnect space switch arrays was introduced [3]. A crossconnect based on semiconductor optical amplifier (SOA) gates has been demonstrated with good performance using the optically amplified suppressed interference switch (OASIS) technology shown in Fig 1 to achieve crossbar switching.

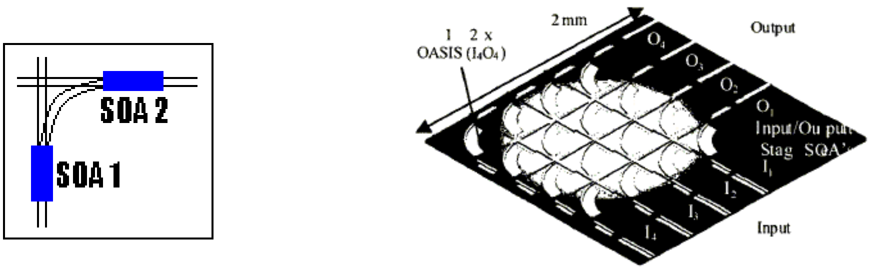

Fig 1 (a) An OASIS (Optically Amplified Suppressed Interference Switch) crossconnect [3]
(b) Plan view of 4 x 4 space switch

In this paper we describe simulations of the OASIS crossconnect using OPTSim simulator. The structure of the paper is as follows: in section II the switch array architecture and the simulation model is presented; section III addresses the simulated behaviour and performance of this switch; implications for cascadability is investigated in section IV; section V discusses some future work of this research that can be carried out from the network point of view; section VI summarizes and concludes the paper.

II 4 x 4 Optical Packet Space Switch Array

Fig 2 shows the simulation schematic of the 4 x 4 space switch. Routing is realised by applying currents to turn on the relevant gates along the route. In the absence of a current, the signal is suppressed to a very low level (about –50dB), which effectively reduces crosstalk.

In the OPTSim simulation, SOAs are used to implement the gates within the switch unit. SOA offers nanosecond switch times and produces gain changes according to the level of current applied to it. The SOA device parameters assumed are given in Table 1. 3dB loss at each splitter is added to model the real-life performance. The simulation uses Non Return to Zero (NRZ) PRBS signals at the data rate of 10Gb/s. The date stream modulates a laser with CW power of 0.1mW at a central frequency of 1550nm.

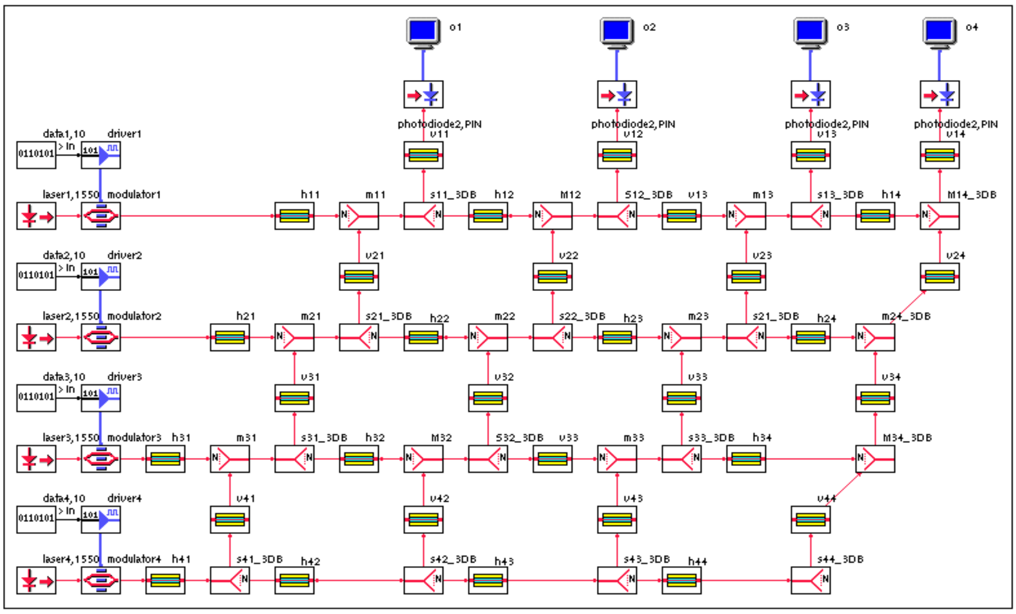

Fig 2 Simulation schematic of the 4 x 4 space switch array with inputs and outputs in OPTSim

Amplifier Length L [10^-6m]	300
Active Layer Width w [10^-6m]	1.5
Active Layer Thickness d [10^-6m]	0.15
Confinement Factor	0.35
Spontaneous carrier lifetime [ns]	0.3
Transparency carrier density N0 [cm^-3]	10^{18}
Material gain constant a [cm^2]	3×10^{-16}
Linewidth Enhancement Factor	3
Material Loss [cm^-1]	10.5
Input insertion loss [dB]	3
Output insertion loss [dB]	3
Saturation Power [mW]	9.1543

Table 1 SOA model parameters

According to the SOA characteristics examined in the simulation, an injection current amplitude of 63.4mA was chosen to turn on the gate, and keep the signal level at a linear and stable state by compensating the losses introduced by various sources along the switching route. To suppress the signal on other routes, SOAs are switched off by changing the bias current to 0.001mA.

III Simulation Results of Switch Array Performance

Q factors and BER after each SOA were calculated, from which it can be concluded that the performance of the simulated switch unit is good, though there is a slight performance decrease when the signal is routed through an increasing number of crossconnects.

The best (a) and worst (b) cases of the output signal eye diagrams after a single switch unit are shown in Fig 3. The signal degradation results from a combination of spontaneous emission noise, and signal patterning, due to the SOA nonlinearity.

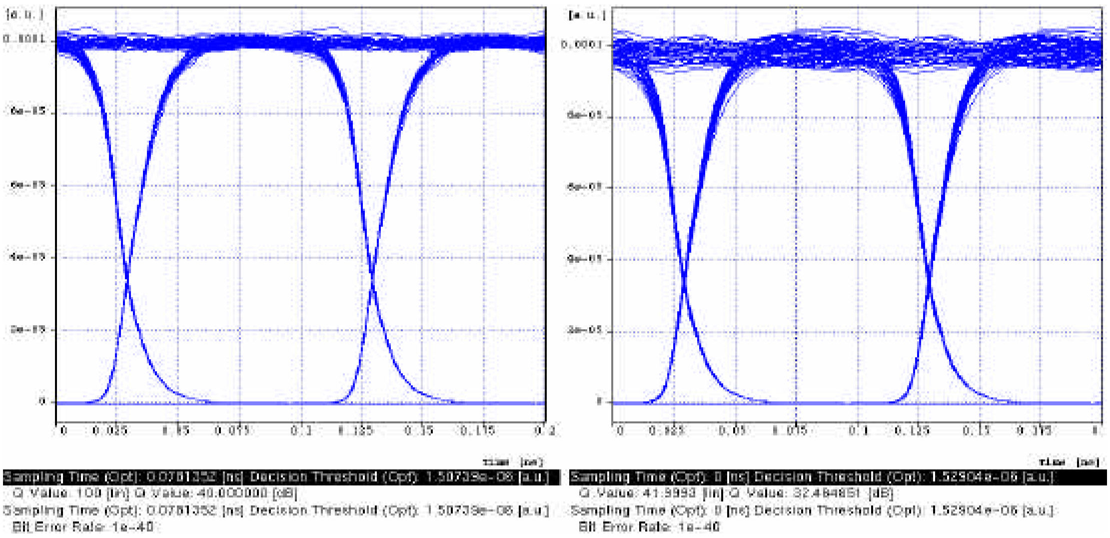

Fig 3 (a) Best case of output signal eye diagram after a single switch unit (signal passes two SOAs and one mirror)
(b) Worst case of output signal eye diagram after a single switch unit (signal passes eight SOAs and seven mirrors)

IV Implications for Cascadability

To investigate the implications for cascadability, the 4 x 4 switch array unit was put into a user-defined component in OPTSim to hide the inner structure. The longest route in the switch array – from the 4^{th} input to the 4^{th} output, was taken to examine the worst-case performance. Results of Q factor and BER after each switch unit show that, with ideal links between the switch units, the number of switches that can be cascaded is approximately 10 before a BER of 10^{-9} is reached. The Q factor decreased from 32.5dB at the output of the first switch unit, to about 12.6dB after the twentieth; and BER increased from 10^{-40} to 1.4×10^{-5} at the same measurement points of each switch. The overall trend of the Q factor and BER versus the number of switch units is shown in Fig 4.

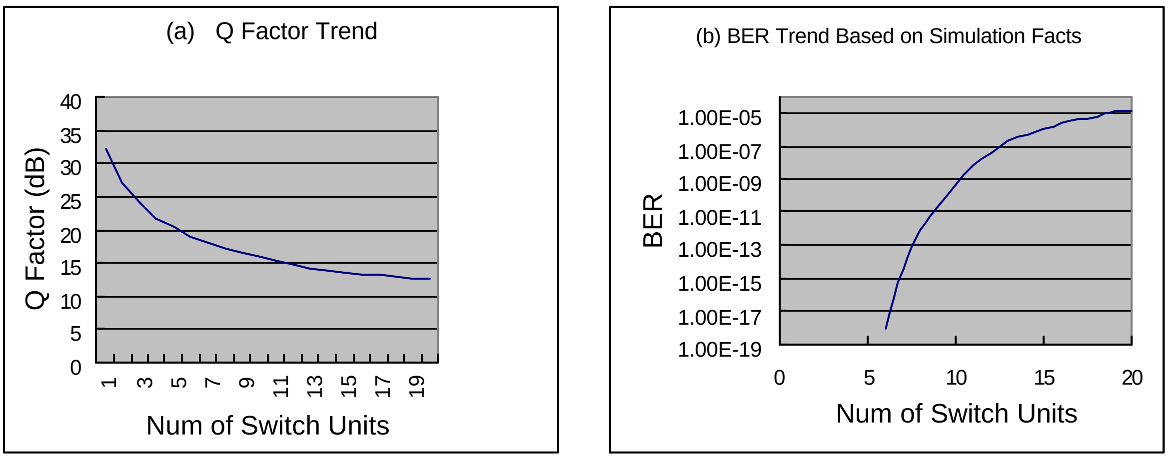

Fig 4 (a) Q factor trend as number of cascaded switch units increases
(b) BER trend as number of cascaded switch units increases

V Future Research Orientation

The research study addressed in this paper is mainly within the OSI physical layer. It is planned to place this switch unit into a network to look at the implementation side, and issues about network planning using this particular 4 x 4 switch. Some work has been carried out to produce detailed layouts of components and wavelength usage of different network scenarios with five switching nodes – mesh, ring and star network topologies.

VI Conclusions

In this paper, simulations using OPTSim investigating the behaviour and performance of 4 x 4 optical packet switch were described. The results of the study on a single switch unit as well as a cascaded switch network were then discussed.

Routing of 10Gb/s optical data packets has been analyzed using the simulation model. The results show that the switch has a good performance, allowing cascading of up to 10 nodes before a BER > 10^{-9} is reached, and has great potential to be applied to route optical packet streams with high data rate for future optical packet switched networks.

Acknowledgments

The author would like to thank her project supervisors, Dr. Robert Killey and Prof. Andy Valdar. Special thanks are given to Dr. Izzat Darwazeh for his thoughtful comments and insightful instructions, and Frederic Lucarz for his encouragement in preparing and submitting this paper.

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