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PERFORMANCE IMPROVEMENT OF OPTICAL NETWORK USING DYNAMIC BANDWIDTH ALLOCATION

M.Prabazhini
PG Scholar
K.Ramakrishnan College of Engineering,
Trichy, Tamilnadu, India

Abstract— ***Optical transport is evolving from traditional opaque networks that use all-electronic switching techniques toward all-optical transparent net-works. But there is a maximum transparent reach limit for signals in all-optical transparent networks that initiates the need for signal regeneration. An optical translucent network is a cost-effective, power-efficient solution, which 2R and/or 3R regenerators that bridge the gap between the opaque and transparent network architectures. Here contention resolution is achieved through the wavelength converter (WC). WCs is an expensive and power-consuming device that has to be shared in a network. WC sharing requires complex switching fabrics. In this project, we perform parameter analysis of different translucent networks based on asynchronous WC-sharing packet switches. To further improve the performance dynamic bandwidth allocation scheme is used.After modelling a set of translucent WC-sharing architectures their performance parameters are compared.***

Keywords—Regenerator, Translucent network, Wavelength converter.

I. INTRODUCTION

Optical transport networks (OTNs) have been undergoing an architectural evolution from traditional opaque toward transparent architectures. To provide the required quality of transmission (QoT), current opaque architectures need on electrical 3R (re- timing, re-shaping and re-amplification) regeneration at every node. Regeneration strongly depends on several data transmission parameters such as the line rate and the modulation format, it is clear that the opaque concept poses serious scalability problems regarding, among other things, heat dissipation, power consumption, physical space, and costs.

These issues triggered the evolution toward transparent networks. However, transparency is not yet achievable, as the immaturity of all-optical 3R regeneration leaves no means to properly mitigate the strong signal degradation induced by physical layer impairments (PLIs). Indeed, despite the fact that all-optical 3R regeneration has been and is the focus of intensive research.

The translucent network allows 3R regeneration, not all nodes are regenerator locations but only a subset of them, thereby leading to a cost-effective, power-efficient network model, which is very attractive to network operators. With the help of these translucent networks some of the architectures are designed and their performances are compared to improve the quality of transmission.

Different architectures are as follows,

- Dedicated wavelength converter architecture (DWC)
- Shared per node architecture (SPN)
- Shared per input wavelength architecture (SPIW)
- Shared per output wavelength architecture (SPOW)
- In these different architectures different type of wavelength converters are used, those are as follows,
- Fixed-Input/Fixed-Output Wavelength Converters (FFWCs)
- Tunable-Input/Tunable-Output Wave-Length Conver ters (TTWCs).
- Fixed-Input/Tunable-Output Wavelength Converters (FTWCs).
- Tunable-Input/Fixed-Output Wavelength Converters (TFWCs).

II. SHARED WAVELENGTH CONVERTERS

Wavelength converters are classified based on the range of wavelengths that they are handled at their input and output. wavelength converters are classified as follows,

2.1 Fixed-Input/Fixed-Output Wavelength Converters (FFWCs)

A fixed-input, fixed-output device always takes in a fixed-input wavelength and converts it to a fixed-output wavelength.

2.2 Tunable-Input/Tunable-Output Wavelength Converters (TTWCs)

A tunable-input, tunable-output device can convert any input wavelength to any output wavelength.

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2.3 Fixed-Input/Tunable-Output Wavelength Converters (FTWCs)

A fixed-input, tunable-output device takes in a fixed-input wavelength and converts it to a variety of wavelengths.

2.4 Tunable-Input/Fixed-Output Wavelength Converters (TFWCs)

A tunable-input, fixed-output device takes in a variety of wavelengths but always converts the input signal to a fixed-output wavelength.

III. TRANSLUCENT WC-SHARING ARCHITECTURES

The main components considered in these architectures are,

- Optical gates,
- 3R regenerators,
- Wavelength converters.

3.1 Dedicated Wavelength Converter Architecture (DWC)

In this dedicated wavelength converter architecture a dedicated full-range fixed-input, tunable-output wavelength converter (FITO-WC) is available for each wavelength and input port. Contention resolution is achieved through all-optical wavelength converters (WCs) PLIs in the network are mitigated by equipping, some of the nodes with a limited size pool of regenerators.

This pool consists of a set of R fixed receivers, an electrical buffering stage and a set of R lasers emitting at pre-defined wavelengths (i.e., ¸1, . . . ,¸R).
Since the output signal of a FITO-WC is handled by the SWS node controller, fairness in the access to the regenerator pool can be achieved.

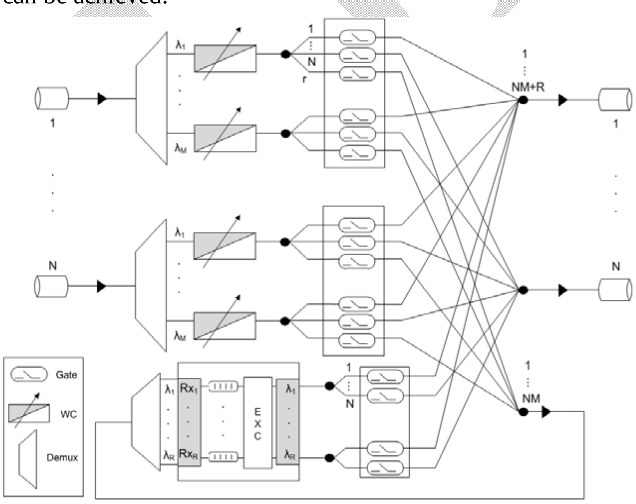

Fig. 1 : Dedicated Wavelength Converter Architecture

Here, fairness means that any packet entering the regenerator pool may access any regenerator, and thus there exists a fair competition for the use of regenerators.

3.2 Shared Per Node Architecture (SPN)

The most well-known instance is the shared-per-node (SPN) configuration, which represents the perfect sharing scheme, as a pool of WCs is fairly shared among all wavelengths from all input ports. In SPN, WCs are required to be tunable-input, tunable-output WCs (TITO-WCs).

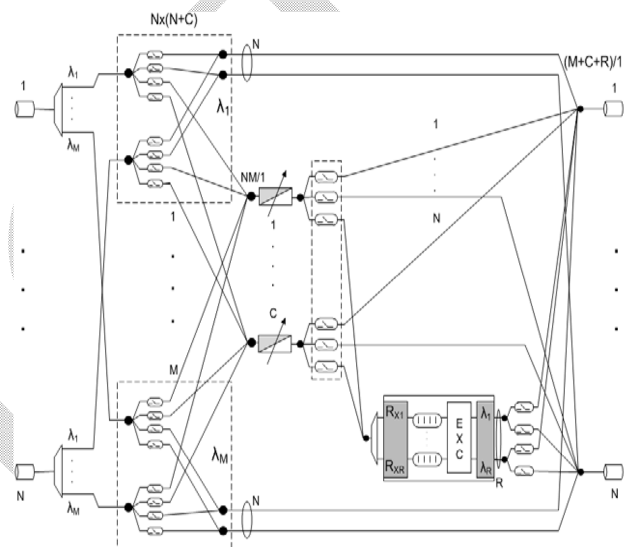

Fig. 2 : Shared Per Node Architecture

SPN switching fabric including a pool of R regenerators that is used to mitigate the impact of PLIs. Since in these schemes WCs are a scarce resource, an initial splitting stage, which consists of a bank of high-speed switching SOA gates, can transfer the signal either directly to the selected output fiber (if no wavelength conversion is needed) or to a bank of C TITO-WCs, which is perfectly shared among all wavelengths from all input ports.

It is worth noticing that, thanks to the tunability of the output wavelength at WCs, fair access to the regenerator pool is also provided with this architecture.

3.3 Shared Per Input Wavelength Architecture (SPIW)

In this case, WCs are arranged in small banks of size r w and dedicated to each input wavelength.

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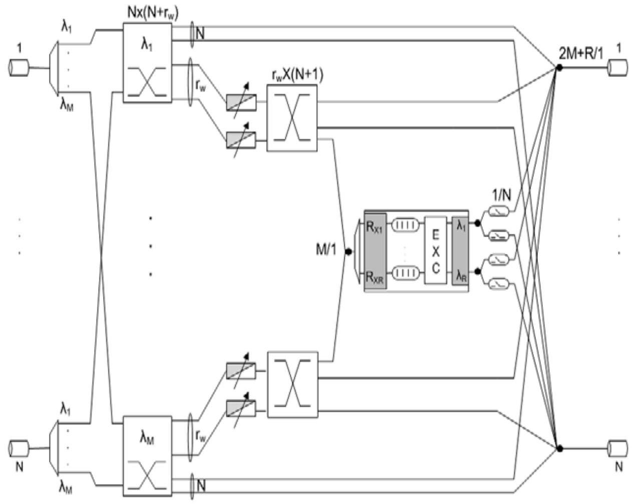

Fig. 3: Shared Per Input Wavelength Architecture

Hence, if there is a packet arriving at λ1 requiring wavelength conversion, whatever the input port is, it will only have access to the bank of WCs dedicated to λ1. A common pool of regenerators can be fairly shared.

3.4 Shared Per Output Wavelength Architecture (SPOW)

In the SPOW switching fabric, where WCs are arranged in small banks of size r w, one per output wavelength. In this case, however, since the less expensive TIFO-WCs are used, the WC output is fixed to a different wavelength in each bank. In SPOW, an arriving packet at λ1 has more chances to find a free WC than in the SPIW configuration, as it can try any bank of WCs except for the one where the output wavelength is set to λ1.

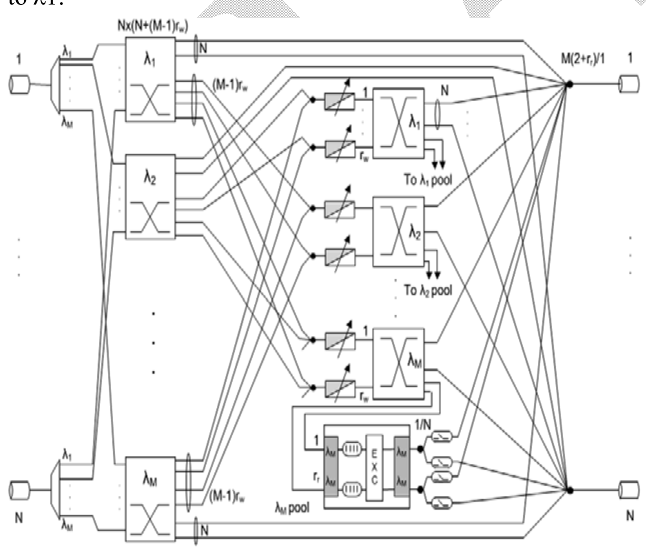

Fig. 4: Shared per output wavelength architecture

As to the regenerator pool configuration, and in order to maximize the sharing of regenerators, it has to be arranged in small banks, each consisting of a set of regenerators for the same wavelength (fixed by the output of each FITO-WC).

IV. DYNAMIC BANWIDTH ALLOCATION

Dynamic bandwidth allocation is a technique by which traffic bandwidth in a shared telecommunications medium can be allocated on demand and fairly between different users of that bandwidth. This is a form of bandwidth management. Dynamic bandwidth allocation takes advantage of several attributes of shared networks.

- All users are typically not connected to the network at one time
- Even when connected, users are not transmitting data at all times
- Most traffic occurs in bursts -there are gaps between packets of information that can be filled with other user traffic.

Dynamic bandwidth allocation improves the efficiency of the optical network. Fuzzy based Dynamic Bandwidth Allocation scheme is used. Fuzzy logic uses linguistic variables, seven membership functions and forty nine fuzzy rules. Based on the input using fuzzy rules bandwidth was dynamically allocated.

Fuzzy logic dynamically tracks the bandwidth requirements ensuring network efficiency and also avoiding traffic congestion and wastage of bandwidth. Since the FL does not depend on the specific traffic parameters robustness is also achieved. Fuzzy logic implementation is preferred because of the guaranteed robustness in the network and also it is fast and accurate.

V. PARAMETER ANALYSIS

After designing the architectures following parameters are analysed.

- Packet loss
- Power
- Noise

5.1 Packet loss

Packet loss can be caused by a number of factors including signal degradation over the network medium. Packet loss occurs when one or more packets of data travelling across a network fail to reach their destination. We analyze the packet loss probability (PLP) as a function of the wavelength conversion ratio (ψ).

$$Plp(k)= \log (l(k)/\alpha(k)) \qquad (1)$$

Corresponding Author: Ms. M.Prabazhini, K.Ramakrishnan College of Engineering, Trichy, Tamilnadu , India

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Where l(k) is the number of lost packets during the transmission and α(k) is the number of packets that arrive during the transmission.

Packet loss probability (PLP) for four different type of architectures are calculated interms of wavelength conversion ratio and their output graphs are shown below.

To calculate the packet loss probability three different loads are applied for each architectures after that the packet loss probabilities are calculated and graph was plotted.

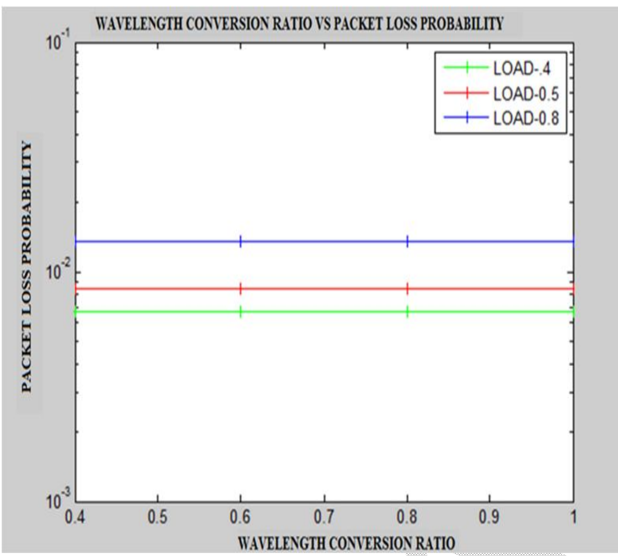

Fig. 5(a) : PLP of DWC Architecture

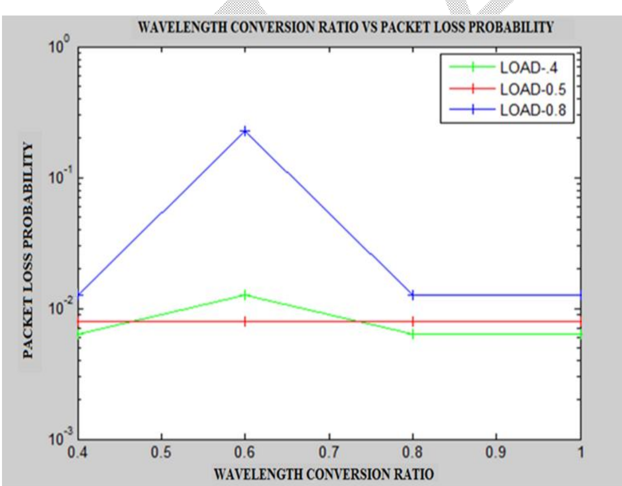

Fig. 5(b) : PLP of SPN architecture

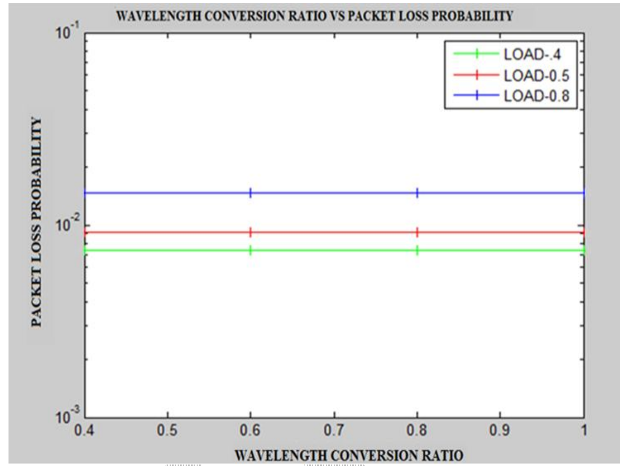

Fig. 5(c) : PLP of SPOW Architecture

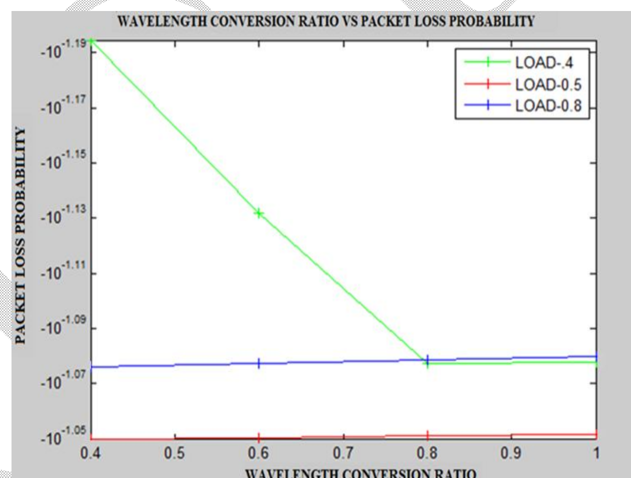

Fig. 5(d) : PLP of SPIW Architecture

Figs 5(a), 5(b), 5(c) and 5(d) provide the packet loss probability for different architectures. We consider three different load (ρ) values (i.e., 0.4, 0.5 and 0.8) for the nodes.DWC has the PLP of 10-2.0dB,SPN has the PLP of 10-1.56 dB, SPOW has the PLP of 10-1.98 dB and SPIW has the PLP of -101.08dB. Therefore Of these four architectures SPIW is found to be best with probability of packet loss at the range of-101.08dB.

5.2 Power

Power constraints of each component are calculated for the different type of architectures. The optical power budget is the amount of light required to transmit signals successfully over distance through a fiber-optic connection. The amount of light energy available within the setup will dictate how long

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organizations can extend fiber-optic cable links between media converters within the network.

Power Budget = Actual Transmitter Power - Actual Receiver Sensitivity.

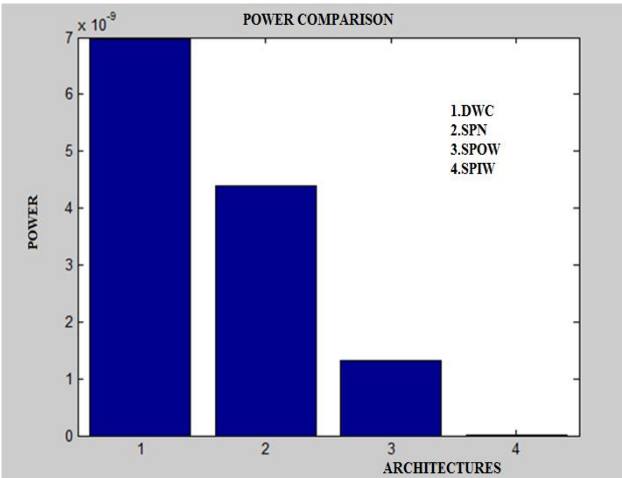

Fig. 6 : power comparison with DWC, SPN, SPIW, SPOW

Fig 6 provide the power comparison with DWC,SPN,SPIW and SPOW architectures. The power consumptions are 6.9724e-09dBm, 4.4400e-09dBm, 1.3180e-09dBm, 2.3496e-12dBm to the corresponding architectures DWC, SPN, SPOW and SPIW.As shown above SPIW consumes less power than the other three architectures.

5.3 Noise

Noise is unwanted electrical or electromagnetic energy that degrades the quality of signals and data. Noise occurs in digital and analog systems, and can affect communications. In general, noise originating from outside the system is inversely proportional to the frequency, and directly proportional to the wavelength. The traditional method has been to minimize the signal bandwidth to the greatest possible extent. The less spectrum space a signal occupies, the less noise is passed through the receiving circuitry. However, reducing the bandwidth limits the maximum speed of the data that can be delivered.

Fig. 7 provides the noise comparison between the different architectures. Noise levels are0.0168dB, 0.0158dB, 0.0085dB and 0.0057dB to the corresponding architectures DWC, SPN, SPOW and SPIW. The Shared Per Input Wavelength architecture provides less noise than other three methods.

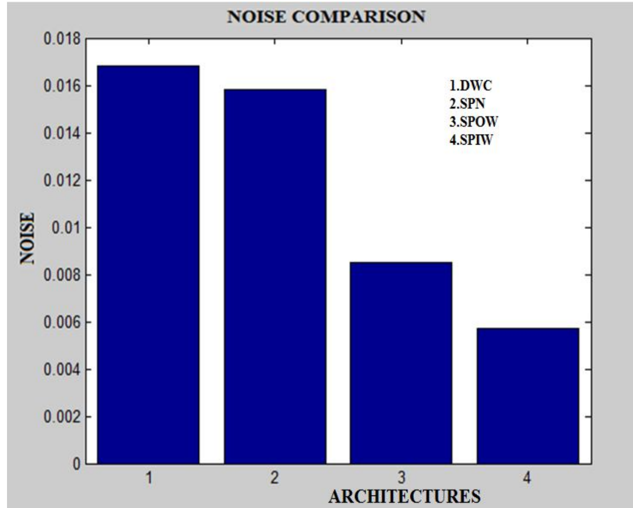

Fig. 7 : Noise Comparison With DWC,SPN,SPOW,SPIW

Table 1: Comparison

Architectures	Packet Loss Probability (dB)	Power (dBm)	Noise (dB)
Dedicated Wavelength Converter (DWC)	10-2.0	6.9724e-09	0.0168
Shared Per Node (SPN)	10-1.56	4.4400e-09	0.0158
Shared Per Output Wavelength (SPOW)	10-1.98	1.3180e-09	0.0087
Shared Per Input Wavelength (SPIW)	-101.08	2.3496e-12	0.0057

The above table compares the different parameters for four architectures. Of these four Architectures the Shared per Input wavelength architecture is proved to best with low packet loss probability, power and noise.

V. CONCLUSION

This paper addressed the feasibility of deploying future translucent SWS OTNs based on WC-sharing photonic switches. To this end, we have first modeled a set of translucent WC-sharing node architectures by equipping nodes with limited size pools of electrical 3R regenerators. These architectures are compared to found which produce the better quality of transmission. Of these four architectures Shared Per Input Wavelength (SPIW) is found to be best with probability of packet loss at the range of -101.08 dB, consumes the least power in the order of 2.3496e-12dBm and with the least noise 0.0057dB.

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