CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusions

The combined effect of crosstalk and noise due to various components in a WDM network can lead to an increasing BER and higher power-penalty. In this research work, analysis is carried out for a multi-hop WDM point-to-point communication link considering the effect of ASE noise and crosstalk in L-WIXCs when EDFA optical amplifier with direct detection receiver is used. The performance degradation resulted in a multi-hop WDM network due to space switches, mux/demux, optical filters and optical amplifiers is identified and analytical expressions for the Signal to Crosstalk plus Noise ratio is developed. Subsequently, BER performance of a WDM network considering various architectures of L-WIXCs is evaluated depending on various received power. The variation of BER with received power with a given hop distance of 80 Km and different number of hops is shown in Fig.4.1 (a)-(l) for 32 input fibers and 16 wavelength channels. It is noticed that degradation of BER occurs at higher received power and is significantly affected by induced crosstalk and ASE noise power while travelling multiple hops. For example, for Share-per-Node architecture incoherent case shown in Fig 4.1 (b), received power is to be -27.5 dBm, -26.37 dBm and -25.3 dBm to maintain BER of 10^{-4}, 10^{-6} and 10^{-9} respectively for a single hop. For multiple hops in the same architecture, values of received power is found to be -19.95 dBm, -18.2 dBm and -17.2dBm for 10, 20 and 30 hops respectively.

It is found that the combined effect of ASE noise and crosstalk accumulated through hops deteriorates the BER performance which has to be compensated by higher received power increasing the power penalty. Therefore, the BER curves obtained for various number of input fibers and wavelengths per fiber are investigated for variation of received power and presented in Table I to VI for subsequent analysis of system power penalty performance that occurs for maintaining specific BER at 10^{-9} for all the architectures. For example, for MWSF-based architecture coherent case as shown in Table VI, it is found that received powers are -24.71 dBm, -23.03 dBm and -21.96 dBm for 4, 16 and 32 input fibers with 4 wavelengths per fiber and 10 hops.

An increased power penalty is observed due to accumulated noise and crosstalk with increased number of hops and with the increase of any of the parameters such as number of wavelengths or number of input fibers. For example, in Share-per-Link incoherent case using 4 input fibers, power penalty is 9.5 dB, 12.12 dB and 14.12 dB for 4, 10 and 16 wavelength channels respectively as shown in Fig 4.3 (b). For the same architecture in same configuration, it is observed that 4, 12 and 18 hops can be travelled using 4, 10 and 16 wavelengths respectively maintaining 12 dB power penalty.

These power penalty trends for all the architectures found in the analyses are then utilized to calculate maximum achievable hop length for different number of wavelengths per fiber and different number of input fiber in the network at sustainable power penalty level of 12 dB as shown in Fig 4.8 to Fig 4.13. It is found that the increase in number of wavelengths and input fibers in the network design affects maximum number of hops that can be travelled by a signal. For example, as shown in Fig 4.12(a), in a WSXC architecture coherent case with 4 input fibers in the network, signal can travel maximum about 18, 14 and 8 hops for 4, 6 and 10 wavelengths respectively while maintaining 12 dB power penalty. The same are 14, 12 and 7 hops for if the network is designed with 16 input fibers.

Thereafter, a comparative study of system performance for different architectures of limited wavelength interchanging cross-connect is depicted in Fig 4.14. This comparison will be immensely beneficiary for the system designer to choose the desirable and effective combination while designing an all-optical WDM network. Share per link Incoherent Case and DCS-2 Incoherent case shows the best performance in respect of travelling further hops compared to all the cases while using same number of wavelengths per fiber. For the said analysis we considered that the signals traverse multiple hops, the converted signal is free from FWM and the crosstalk due to wavelength conversion.

The performance analysis for different network topologies such as ring network or star network are not considered in this thesis. It is observed that the accumulated effect of crosstalk and noise in a multi-hop environment limits the maximum achievable number of hops at a given BER. Therefore, it is preferable to design the network with lesser number of wavelengths per channel or lesser number of input channels when the network is needed to reach further hops.

These observations on the combined effect of crosstalk and noise power supports the consideration of suitable design parameters like number of input wavelengths (M) and number of input channels (N) for the design of a WDM network with different L-WIXC architecture having sustainable BER and minimum power-penalty.

5.2 Future Scope of the Work

This thesis deals with the performance parameters when the signals traverse multiple hops in a point-to-point WDM network. Further research work can be carried out to study the performance parameters when the signal traverse multiple hop in different types of WDM networks such as ring network or star network. In this thesis work signal extinction ratio is considered to be infinite. But signal extinction ratio plays a significant role on the system performance. Therefore the role of system crosstalk on its performance can be studied by transmitting signals having finite extinction ratio. In this research work it is assumed that the converted signal is free from the crosstalk carried with it before wavelength conversion and the input-output characteristic is also assumed unity except propagation delay and phase change. So this research work can be extended to include the input-output characteristic of wavelength converter at all input power. Further research can be carried out to include the effect of FWM induced crosstalk as well as cross-phase modulation (XPM) in a multi-wavelength optical transport network (MWTN) with wavelength converters.

LIST OF PUBLICTIONS

Journal Paper

Munira Haque and S. P. Majumder, “Performance Evaluation of a Multi-hop WDM Network with Share per Node L-WIXC Architecture” Ahead of Print in Journal of Optical Communication.

Conference Paper

M. Haque and S. P. Majumder, "Analysis of Crosstalk and Noise Limitation in a WDM Network with MWSF Based Limited Wavelength Interchange Optical Cross Connect," *2020 IEEE 3rd International Conference on Information Communication and Signal Processing (ICICSP)*, Shanghai, China, 2020, pp. 15-19, doi: 10.1109/ICICSP50920.2020.9232060.

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