Optimizing the Placement of Wavelength Converters in WDM Optical Networks

Shruthi P C[1] , Indumathi T S[2]

[1] Assistant Professor, Telecommunication Department, Dr. Ambedkar Institute of Technology, Bangalore.
[2] Professor,Telecommunication Department, Dr. Ambedkar Institute of Technology, Bangalore.

Abstract- Wavelength Division Multiplexing (WDM), transmitting signals on different wavelength channels simultaneously through an optical fiber, is rapidly becoming a technology-of-choice to meet the tremendous bandwidth demand of the next generation wide-area networks. Wavelength Converters are still very expensive. Hence, it is desirable that just a limited amount of Wavelength Converters are used in the whole network. In this case, a vital question arises: how many converters are enough and where to place these converters. This motivated to do the research in the wavelength converter placement problem. Hence to define the research solution rather than applying conventional methods, intelligence based approach is taken. Fundamentally the concepts inspired by nature like Evolutionary Computation.

Index Terms- Wavelength Conversion, light-path, Optical Networks, Wavelength continuity,Wavelength-Division Multiplexing (WDM), Optimization.

I. Introduction

Optical-transmission techniques have been researched for quite some time, Optical "networking" studies have been conducted only over the past dozen years or so. The field has matured enormously over this time, a large number of start ups have been formed, and optical WDM technology is being deployed in the marketplace at a very rapid. Multiple Wavelength Division Multiplexed channels can be operated in a single fiber simultaneously, fundamental requirement in fiber-optic communication is that these channels operate at different wavelengths so as not to interfere with one another. These channels can be independently modulated to accommodate dissimilar data format, including some analog and some digital if so desired. A connection between source and destination nodes is realized by determining a path between the two nodes and allocating a free wavelength on all links of the path. Such an optical path is commonly referred to as light-path or Wavelength path. In simple WDM networks, a light-path must use the same wavelength on all links along the path. This is known as Wavelength Continuity constraint and results in high blocking probability. The restriction imposed by wavelength continuity constraint can be avoided by the use of wavelength converters. Moreover, the blocking probability does not decrease linearly with the number of converters.

Research and development on Optical WDM networks have matured considerably over the past few years, and they seem to have suddenly taken on an explosive form, as evidenced by recent publications A number of experimental prototypes have been and are currently being developed, deployed, and tested mainly by telecommunication providers including a plethora of startup companies. It is anticipated that the next generation of the Internet will employ WDM-based optical backbones. Current development activities indicate that this sort of WDM network will be deployed mainly as a backbone network for large regions, e.g., for nationwide or global coverage. WDM technology is being deployed by several telecommunication companies for point-to-point communications. This deployment is being driven by the increasing demands on communication bandwidth. When the demand exceeds the capacity in existing fibers, WDM is turning out to be a more cost-effective alternative compared to laying more fibers. A study compared the relative costs of upgrading the transmission capacity of a point-to-point transmission link.

There are many factors which affect the optimal solution to the converter placement problem. Placing a converter at a node that has a high transit traffic rate but does very little mixing (or switching) of traffic may not be desirable, as it would result in a simple swapping of the assigned wavelengths. On the other hand, if the transit traffic rate at a node is very low, then the optimal strategy may not place a converter at that node, even if it mixes a significant amount of traffic. Furthermore, the distances between converters are likely to affect the optimal placement. As the distance between converters increases, the blocking probability increases.

- Wavelengths are another kind of resource in WDM networks. The number of wavelengths available in a network is always limited due to the complexity of hardware structure.
- Quality of service, achieving load wavelength assignability, the number of wavelengths needed in a system is made minimal, the low bound of the number of wavelengths required is equal to the maximal link load.
- The Optimal Placement Converter (OPC) in multihop WDM networks has great implications to network design and applications.

II. Methodology

- Particle Swarm Optimization (PSO), a relatively recent addition to the field of natural computing.
- Evolutionary Computation techniques that may be applied in many of the same domains.

- Hybridisation is a growing area of intelligent systems research, which aims to combine the desirable properties of different approaches to mitigate their individual weaknesses.
- A range of PSO hybrids have been postulated, usually in the context of some specific application domain for which that hybrid is particularly well suited.
- Hybridisation with Evolutionary Algorithms (EAs), including Genetic Algorithms (GAs), has been a popular strategy for improving PSO performance. With both approaches being population based, such hybrids are readily formulated.

2.1 Proposed system:

Elements inspired by the social behaviour of natural swarms, and connection with Evolutionary Computation. Particle Swarm Optimization, in its present form, has been in existence for roughly a decade. It has gathered considerable interest from the natural computing research community and has been seen to offer rapid and effective optimization of complex multidimensional search spaces, with adaptations to multiple objective and constrained optimization. A selection of these approaches is briefly surveyed here.

2.2 Evolutionary Algorithm:

A second generation multi-objective evolutionary algorithm (MOEA), successfully used to solve several engineering problems [2]. SPEA is based on three populations: the current population (PA) which is replaced by individuals from the evolutionary population (PX), and an external population (PE) that keeps the best individuals calculated during the evolutionary cycles.

In this multi-objective optimization context, the best individuals (or solutions) are known as non-dominated. Let us consider individuals x and x1. It is said that x dominates x1 (x> x1) if every objective function of x is better than or equal to the same objective function of x1, and x is strictly better than x1 in at least one objective [2].

Optimization is a process to achieve the optimal value of objective function along with satisfying the constrains if exist.

2.3 Algorithm

Each begins with a population of contending trial solutions brought to a task at hand. New solutions are created by randomly varying the existing solutions.

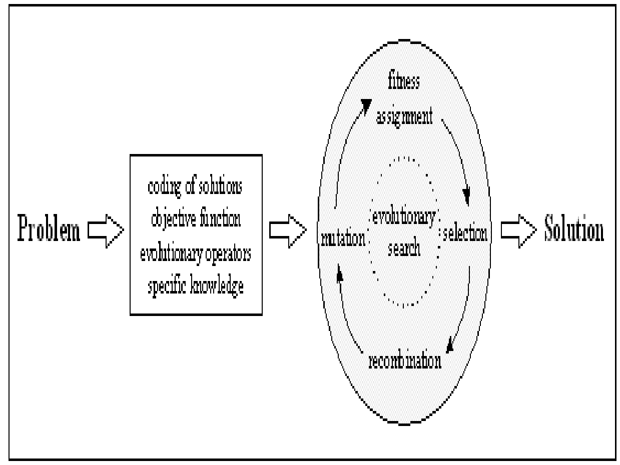


Fig. : Problem solution using evolutionary algorithms

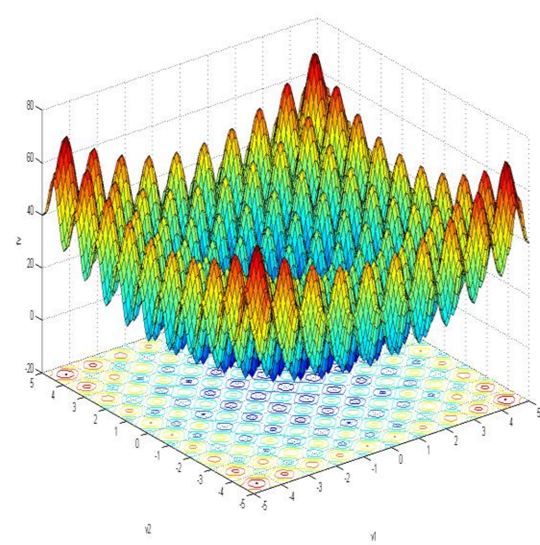
III. RESULTS

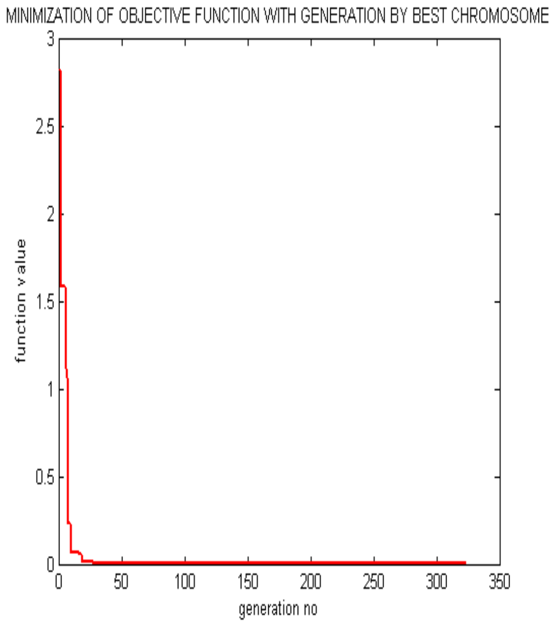
EXPERIMENTAL STUDIES: Optimization using Evolutionary programming

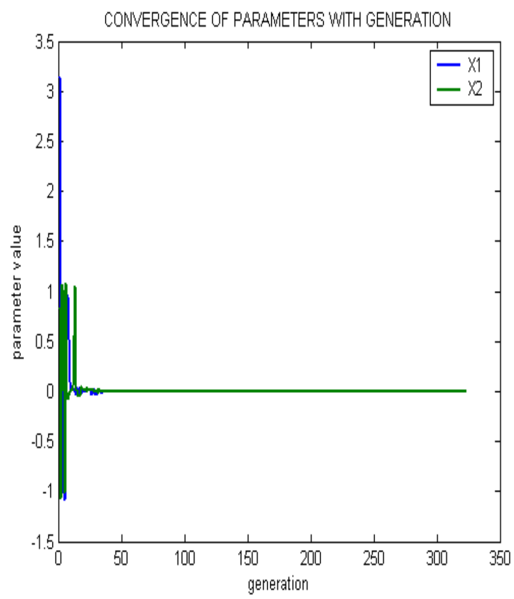
Population size taken for all cases equal to 100;

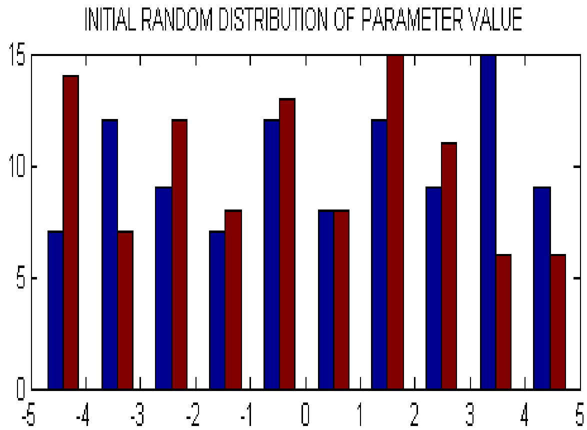
Case1:

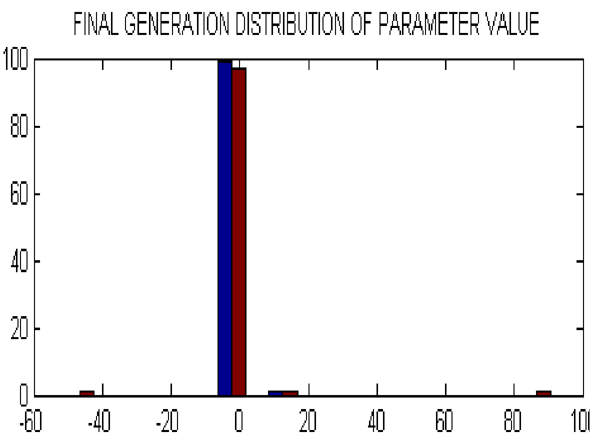
Function Name: Generalized Rastringin's Function
Nature of problem: Multimodel characteristics
fun=20+x1.^2+x2.^2-10*(cos(2*pi*x1)+cos(2*pi*x2));









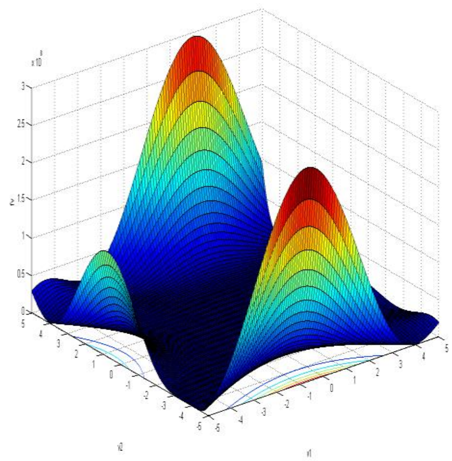


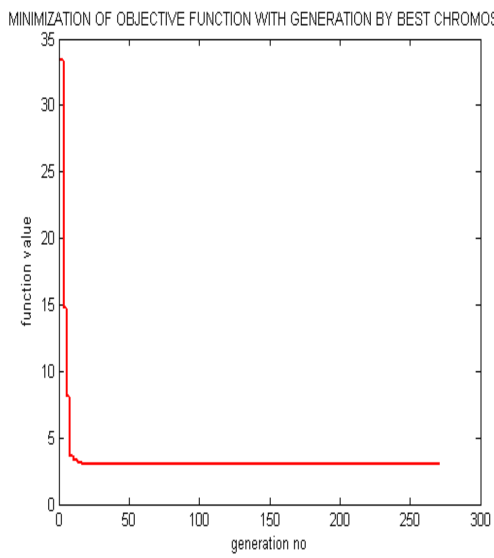
Parameter	Evolved obtained value	Optimal value
X1	0.4778e-6	0
X2	-0.0139e-6	0
Obj.function	2.2524e-12	0

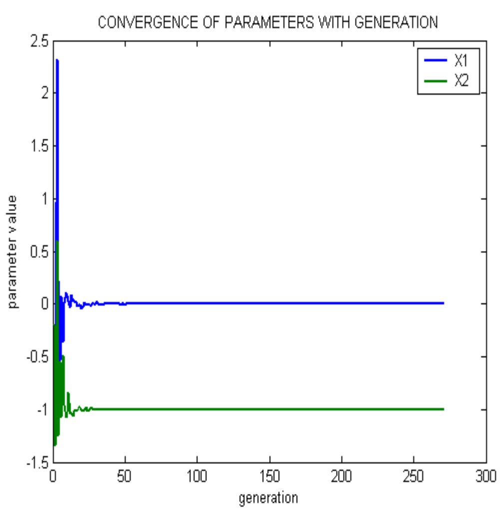
Case2

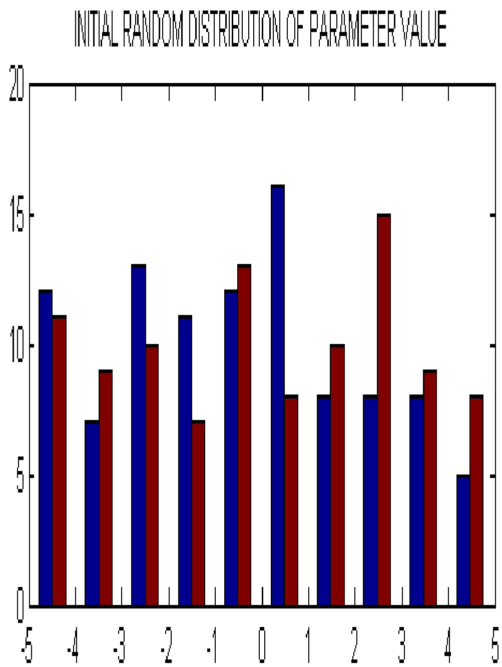
Nature of problem: Multimodal characteristics

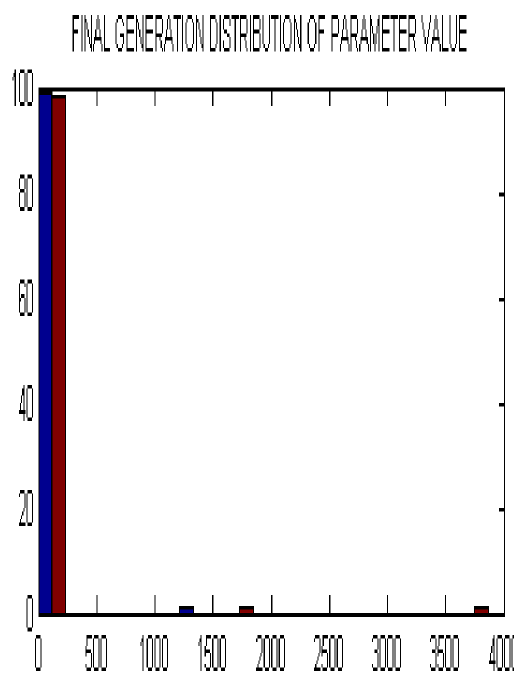
fun=(1+(x1+x2+1).^2.*(19-14*x1+3*x1.^2-14*x2+6*x1.*x2+3*x2.^2)) .*(30+((2*x1-3*x2).^2).*(18-32*x1+12*x1.^2+48*x2-36*x1.*x2+27*x2.^2));











Parameter	Evolved obtained value	Optimal value
X1	0	0
X2	-1	-1
Obj.function	3.0	3

3.1 Objective function f(x):

When there is any problem the purpose associated, practically that purpose transform as a mathematical equation and is objective function.

The 2 possibilities existing with the objective function interms of minimization or maximization.

To make the solution computationally efficient many times maximization of objective is transformed as minimization.

3.2 Analysis:

1. Learning is different from optimization, especially in evolutionary computation.

2. Population contains more information than any single individual. Exploiting useful population information can be achieved for different kinds of population-based learning, either evolutionary or non-evolutionary.

IV. Future Enhancement

One possible future research avenue is to carry out more extensive studies on the design of a single generic wavelength converter placement algorithm that can achieve good performance under different RWA algorithms.

The reality could be that some iterative approaches be taken in order to achieve better overall blocking performance. This is currently under investigation.

V. Conclusion

Particle Swarm Optimization is used to find out how to achieve near-ideal performance of the network using minimum number of wavelength converters.

The number of available converters is limited, a judicious placement of converters is necessary to balance these tradeoffs.

References

[1] Sheng Chen, Tee Hiang Cheng, “Placement of wavelength converters and light splitters in a WDM network using the generic graph model,” Journal Computer Communications, Volume 33 Issue 7, May, 2010 , Elsevier Science Publishers B. V. Amsterdam, The Netherlands,

[2] Rodrigo Maciel, Marco Sobrino, “Optimal wavelength converter allocation: a new approach based MOEA;LANC'09” Proceedings of the 5th International Latin American Networking Conference ACM,NewYork,USA,2009.

[3] Alec Banks, Jonathan Vicent, Chukwudi Anyakoha “A review of Particle swarm optimization PartII: Hybridization, combinatorial, multicriteria and constrained optimization and inductive applications” Springer science + Businessmedia Nat Comput (2008) pg no 109-124 Issue no. DOI 10.1007/s 11047-007-9050-Z.

[4] Phuong Nga Tran, Ulrich Killat, “An Exact ILP Formulation for Optimal Wavelength Converter Usage and Placement in WDM Networks,” IEEE "GLOBECOM" 2008

[5] Chunsheng Xin, “Dynamic Traffic grooming in optical networks with wavelength conversion”, IEEE Trans. On Selected Area in Communications, Supplement on Optical Communication and Networking, December 2007.

[6] Kejie Lu,Gaoxi Xiao, Imrich Chlamtac “Analysis of Blocking probability for Distributed light path establishment in WDM Optical Network” IEEE/ACM Transactions on networking Vol. 13 no.1 Feb 2005 1063-6692/2005.

[7] H.Y. Jeong, S.W. Seo, “A binary linear program formulation for the placement of limited-range wavelength converters in wavelength-routed WDM networks”, IEEE/OSA Journal of Lightwave Technology, vol. 23, No. 10, October 2005.

[8] Choon Fang Teo, Yun Cie Foo, “Wavelength Converters Placement in All Optical Networks Using Particle Swarm Optimization” Springer, Photonic Network Communications ,Volume 10, Number 1, 23-37, 2005.

[9] X-H .Jia, D-Z Du, X-D Hu, H.J. Huang D-Y.Li, “Placement of Wavelength Converters for minimal wavelength usage inWDM Networks” City University of Hong Kong No.70007 78.0-7803-7476-2/02 IEEE 2002.

Authors

First Author – Shruthi P C, Assistant Professor, Telecommunication Department, Dr. Ambedkar Institute of Technology,Bangalore., pcshruti@gmail.com
Second Author – Indumathi T S, Professor,Telecommunication Department, Dr. Ambedkar Institute of Technology,Bangalore. indumathi_ts@yahoo.co.in