Thesis

TRANSMISSION NETWORK PLANNING USING GENETIC ALGORITHMS

By

M.T.A.P. Wickramarathna

THIS THESIS WAS SUBMITTED TO THE DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING OF THE UNIVERSITY OF MORATUWA IN PARTIAL FULFILLMENT OF THE REQUIERMENT FOR THE DEGREE OF MASTER OF SCIENCE.

COMPUTER SCIENCE AND ENGINEERING
UNIVERSITY OF MORATUWA
SRI LANKA
APRIL 2003

Declaration

The work submitted in this thesis is the result of my own investigations, except where otherwise stated.

It has not already been accepted in substance for any degree, and also is not being concurrently submitted for any other degrees.

Signed

MTAP Wickramarathna.
(Candidate)

Signed ***UOM Verified Signature***

Dr N Wickramarachchi.
(Supervisor)

Abstract

This project presents an application of Genetic Algorithm (GA) to solve Transmission Network Panning (TNP). The non-convexity that has been observed in the Transmission Network Planning cannot be solved effectively by conventional mathematical methods. GA has the ability to find the global optimal point in such a non-convex function.

It is recognized that the allocation of transmission costs in a competitive environment requires careful evaluation of alternative transmission network plans. As a result, the need for methods that are able to synthesize optimal transmission network plans has become more important than ever. Unfortunately, practice has shown that conventional optimization procedures are unable to produce optimal solutions for networks. The reason is that the transmission network planning problem is hard, large-scale combinatorial problem. The number of options to be analyzed increases exponentially with the size of the network.

The objective of TNP is to determine the installation plans of new facilities (lines & other network equipment) so that the resulting bulk power system may be able to meet the forecasted demand at the lowest cost, while satisfying prescribed technical, financial and reliability criteria. Although the conventional methods are somewhat successful in transmission network planning, some problems still exist:

1) Non-convexity (as described above): Therefore, the optimization process sometimes stops at non-optimal solutions.

2) Non-linearity: increases the iterations of the optimization algorithm and sometimes causes divergence.

As there are no fractional transmission lines, transmission network planning becomes a very complex mixed integer non-linear programming problem. GA can be used to select the optimal new transmission lines network with the least investment cost, while meeting the total load demands without any load curtailment.

The project done under the "Transmission Network Planning using Genetic Algorithm" has been successfully completed giving good results for the particular transmission network.

Acknowledgement

The research for the Degree of Master of Science was carried out at the Department of Computer Science & Engineering, University of Moratuwa, Sri Lanka.

I would like to acknowledge the support received under the Science & Technology Personnel Development Project SRI (SF) 1535 by the Asian Development Bank for the work described in this thesis.

I would express firstly great thanks to the Department of Computer Science & Engineering, and the members of the Post Graduate committee specially, Prof. Mrs. N Ratnayake, for having accepted me to commence the research for 15 months time.

I must express my profound gratitude and sincere thanks to my supervisor Dr. N Wickramarachchi who guidance, encouragements and motivation in all the time of the research. He also provided constructive comments during my thesis time as well as the preliminary version of this thesis. I was great pleasure to conduct the work under his supervision.

I am deeply indebted to my former supervisor Dr. J Peris. He supervised my research work and encouraged me to go ahead with my works during the first 4 months of the research period.

I must specially mentioned Prof. Priyantha Wijeyatunga and Dr. G Dias, my project review committee members. They provided me an invaluable support without any hesitation to continue my research. Therefore I would like to express my grateful thanks for giving their hands to success my research.

The research has been supported by the officers, in Ceylon Electricity Board for collection of transmission line data. So I am grateful to the staff members in CEB.

I would like to thank all my friends at the Research Laboratory for providing encouragement and a very exciting work environment, especially to Kamala, Rohana and Nilani. I am very thankful to all my good friend that supported me throughout this work, especially Dilan.

TABLE OF CONTENTS

CHAPTER ONE 8
1.1 Introduction

CHAPTER TWO
2.1 Introduction to GAs 11
2.1.1 Biological Background 11
2.1.2 How are Genetic Algorithms different from traditional methods 12
2.2 A Simple Genetic Algorithm 13
2.3 Representation 14
2.4 Types of GAs 17
2.4.1 Generational GAs 17
2.4.2 Steady State GAs 17
2.5 Fitness Function 18
2.6 GAs Operators 19
2.6.1 Selection 19
2.6.1.1 Types of Selection methods 19
2.6.1.1.1 Roulette Wheel Selection 20
2.6.1.1.3 Ranking Selection 20
2.6.2 Crossover (Recombination.) 21
2.6.2.1 Types of Crossover methods. 21
2.6.2.2 Single-Point Crossover 21
2.6.2.3 Multi-Point Crossover 22
2.6.2.4 Uniform Crossover 22
2.6.2.5 Bit Simulated Crossover 23
2.6.2.6 Problem-Centred Crossover 23
2.6.2.7 Specialized Crossover 24
2.6.3 Mutation 24
2.6.3.1 Role of Mutation 25
2.6.4 Crossover and Mutation Probability 26
2.6.4.1 Crossover probabiility 26
2.6.4.2 Mutation probability 26
2.7 Search Space 26
2.8 Optimization Continuous and Discrete Problems 27
2.9 Applications of Genetic Algorithms 30

CHAPTER THREE
3.1 Modeling of GAs 31
3.1.1 Schemata and Other Terminology 31
3.1.2 Sets and Subsets 32
3.1.3 Processing 32
3.1.4 The Dynamics of a Schema 33
3.1.5 Compensating for Destructive Effects 34
3.1.6 Mathematical Models 35

CHAPTER FOUR 46
4.1 Introduction to Transmission Network Planning 46
4.1.1 Main Objectives of Transmission Network Planning 48
4.2 Load Flows 49

4.2.1 Bus Classification 50
4.2.2 Development of Load Flow Equations

CHAPTER FIVE
5.1 Implementation 61
5.2 Flow Chart 63
5.3 Initialize the Population 63
5.3.1 Representation 63
5.3.2 Population Size 63
5.4 Load Flow Calculation 63
5.4.1 Fitness Evaluation 64
5.4.2 Minimize the cost 64
5.4.3 Reduce the number of over loaded lines 65
5.4.4 Increase the performance of the network 65
5.4.5 Line Fitness 65
5.4.6 Total Fitness of population 65
5.5 Selection 66
5.6 Crossover 67
5.7 Mutation 67

CHAPTER SIX
6.1 Results 69
6.2 Conclusion 94

APPENDIX A 95
APPENDIX B 110

LIST OF ILLUSTRATION

Figure 2.1 16

Figure 2.3 18

Figure 2.4 20

Figure 3.1 31

Figure 4.1 50

Figure 5.1 62

Figure 3.2 43

LIST OF TABLES

Table 3.1 40

Table 3.2 40

Table 3.3 41

Table 3.4 42

Table 3.5 43

Table 3.6 44

Table 3.7 44

Table 4.1 50