Adv. Eng. Tec. Appl. Vol. 1 No. 1 (2012) 20-24

Advanced Engineering Technology and Application

An International Journal

Network planning framework using genetic algorithms: a review

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Received: Jul 8, 2011; Revised Oct. 4, 2011; Accepted Jan. 6, 2012
Published online: 1 May 2012

Abstract: Recent development in communication has given rise to new challenges in open Networks. Network Planning is a challenging issue when there are multiple networks in distributed environment. In this paper, we have discussed different Network Planning schemes based on Genetic Algorithms and its variations. These schemes are implemented by many researchers to make feasible selection of a network from the population of networks to improve the efficiency, cost, time delay, prediction quality, coverage and connectivity of networks.

Keywords: Genetic Algorithm; Network Topologies; Neural Networks

1 Introduction

Genetic Algorithm (GA) is introduced by John Holland in the 1992 [1]. GA is used for complex search and optimization problems which can't be done by traditional optimization techniques. In GA, population of individuals (chromosomes) is represented by solutions. The population is initialized randomly at first time. Evolve the individual fitness and rank the solutions which are fit in the population. Next generation is produced by mutation of the fittest individual in the current population. Mutation process is repeated until a required optimized solution is selected. Fig. 1 shows the general working process of a Genetic Algorithm.

To search and select an optimized and feasible network from available networks is an important research issue. One can select a version of GA [2] for getting optimized network in Networks domain.

Many researchers used the GAs for optimized network selection.

Fig. 1. shows that Genetic Algorithm uses population of solutions for process initialization, encode the population, apply mutation on the individual in the population, make the decision if most feasible solution is found, if not then use the population of offspring unless an optimized feasible solution is found.

In this paper, we have classified different Network Planning mechanisms based on different versions of GAs. We also mentioned improved factors by using

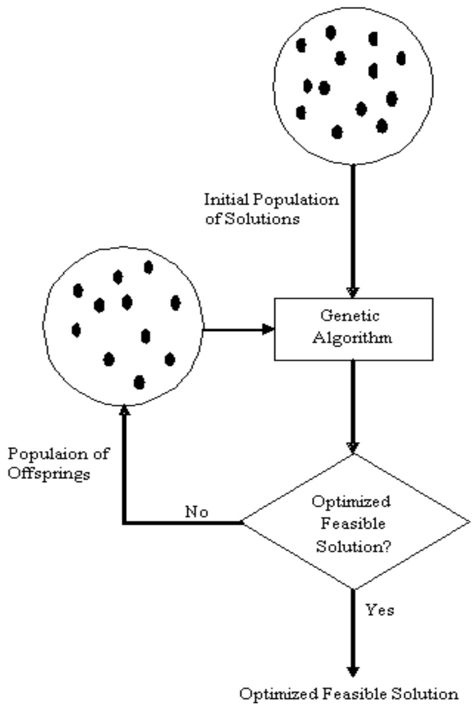

Figure 1 General Working Process of Genetic Algorithm GAs for Network Planning. These improved factors support a user for the selection of a Network with the desired parameters.

2. Related Work

In [5, 6, 7, 8, 14], Planning of Wireless Local Area Network is mentioned by using Genetic Algorithms, Neural Networks, Multi-Objective Genetic Algorithms and Analysis Hierarchy Process. In [3, 4], Planning of Local Area Network Topology is mentioned by using Pareto Converting Genetic Algorithm and Spanning Tree-based Genetic Algorithm. In [9], Planning of Optical Network is mentioned by using Genetic Algorithm. In [10], Planning of Radio Access Networks is mentioned by using Particle Swarm Optimization and Genetic Algorithm. In [11], Planning of wireless Sensor Networks is mentioned by using Genetic Algorithms. In [12], Planning of Wireless Mesh Network is mentioned by using GA. In [13, 15], Planning of Wireless Ad Hoc Networks is mentioned by using GA.

3. Network Planning by Genetic Algorithm

In this section, Genetic Algorithms and versions of GAs used by different authors for selection of different types of networks are reviewed. Networks are classified by their planning mechanism.

3.1 Planning of Wireless Local Area Networks

Chang et al. uses GA for better Indoor Wireless Local Area Network (WLAN) selection by calculation of the environment parameters. They measured the Received Signal Strength Index (RSSI) for quality prediction by using neural networks. Indoor environment of the building is divided into neuron networks. Prediction errors of indoor environment are corrected by this mechanism. They represented the sampling data as chromosomes. Environmental parameters are calculated by using Genetic Algorithms and then calculate the quality of these parameters by neural network calculations. They got the quality prediction by using the calibration procedure.

Chen et al. uses Genetic Algorithms and Neural Networks for prediction of WLAN in buildings. They measured and calibrated the data by RSSI with shortest prediction time. They calibrated the WLAN cards to correct the functional characteristic for that card and to minimize the RSSI loss. They divided the squared environment into sub squares and put Access Points (APs) on the sub square environments for the maximum coverage for Radio Waves in the building. They computed the RSSI of each sub squared (neuron) which is the chromosomes for GA. This technique simplifies the prediction process by determining the shortest prediction time and optimal access location.

Maksuriwong et al. uses Multi-Objective Genetic Algorithm (MOGA) for planning of APs in WLAN. They used APs as chromosomes for GA to maximize the transmission coverage. They selected the location for APs by measuring the Signal to Noise Ratio (SNR) which must be greater than 0dB. In this way, they got all APs which have SNR greater than 0dB and got the Pareto Optimal Solution by applying MOGA on all these APs. By this technique, they can find all APs which have maximum communication throughput and maximum transmission coverage.

Yeong et al. uses Neural Networks and GAs for indoor WLAN planning. They applied clustering in the neural networks. They used the neural network to get the position of APs. APs in neural network represent chromosomes. GA is used to obtain the feasible solution. After getting all APs in the same cluster, compare their RSSI and select an AP for the WLAN receiver within the same cluster which has quality RSSI. This technique effects on capacity, time optimization and cost efficiency of computational intelligence.

Chen et al. uses Analysis Hierarchy Progress (AHP) and GA for WLANs planning. For efficiency and convergence of search capabilities, they proposed the Enhanced Pareto Genetic Algorithm (E-PGA) with Tchebycheff method. They applied AHP to put the conditions on the network for better Quality of Service (QoS). They made decision matrix of decision factors on available networks. They normalized the decision matrix. They got the non-dominated solutions after elimination then they applied E-PGA to get the feasible solution. By using this technique, they can select efficient network for mobile users.

3.2 Planning of Local Area Networks

Teng et al. uses Pareto Converting Genetic Algorithm (PCGA) for Network Topology Planning problems in Local Area Networks (LANs). They used the Pareto Optimization theory and Pareto Ranking Techniques for PCGA. A LAN is analyzed for all topologies (chromosomes). Apply Pareto Ranking on the current population. Chromosomes are represented by Prüfer number because tree topology is mostly used due to its efficiency. By using this technique, they can optimize the network delay and network cost.

GEN et al. uses Spanning Tree-based Genetic Algorithms for topological planning problems of LAN. They used the Prüfer number as chromosomes (Spanning Tree) for representing the active LAN configurations. They selected the Pareto Optimization solution from the condition that if there exist a feasible solution which decrease some objective values and it will never affect other object values i.e. never increase the other objective values simultaneously. By this, they minimized the average message delay and the connection cost.

3.3 Planning of Optical Networks

Morais et al. uses Genetic Algorithms for topological planning of Optical Networks (ONs). They generated topologies randomly and by applying characteristics of telecommunication networks. They evaluated the solution by writing adjacency matrix of a network and encode that matrix to get genetic code. To find the shortest path, they applied the Dijsktra Algorithm. They got the feasible solution by applying tournaments and roulette wheel techniques. These techniques can be used for selection of better survivable network with minimum capital expenditure.

3.4 Planning of Radio Access Networks

Tudzarov et al. uses Particle Swarm Optimization (PSO) to optimize the Fuzzy Logic and GA to get optimized decision for mobile networks, Radio Access Network (RAN). They got all parameters like QoS, user requirements etc for network selection, applied decision algorithms, applied PSO to dynamically modify the Fuzzy Logic and applied GA to get optimized decision. They applied this technique for planning of network in heterogeneous environment with best results.

3.5 Planning of Wireless Sensor Networks

Leal et al. uses GA for planning of routes in Wireless Sensor Networks (WSNs). They used the Linguistic variables (Energy, Fuzzy Logic and number of hopes) and determined the numbers of primary terms of these variables by GA. Primary terms are evaluated by Fizzy procedure and got the fizzy output by defizzification. In this way, they selected a most feasible route in Wireless Sensor Networks.

3.6 Planning of Wireless Mesh Networks

Barolli et al. uses GA for selection of Wireless Mesh Network (WMN). They represented the individuals in matrix form. They evaluated the matrix to get the feasible solution by GA. They maximized the network convergence and connectivity.

3.7 Planning of Wireless Ad Hoc Networks

Hoffmann et al. uses Genetic Algorithm for planning of Wireless Ad Hoc Networks (WAHN). They used the Graph Theory to represent the networks. They used the ranking and tournament methods to select the individuals from the population. They applied the GA to get feasible solution. By using this technique, they can minimize the average packet delay.

Gundry et al. uses GAs for Planning of configurations and selection of optimized configuration in WAHN. For this, they distributed the nodes uniformly. They introduced Force-based Genetic Algorithm (FGA) for convergence in a small communication area. By this technique, they can select an efficient network by small movement in small communication region.

4. Categories the Improved Factors for the Planning of Networks by Genetic Algorithms

In this section, we have summarized the Network Planning Mechanisms with Improved Factors by Genetic Algorithms. Table 1 shows network applications for various versions of Genetic Algorithms and their improved factors in those Networks.

5. Conclusion and Future Work

From the above discussion, it is clear that Genetic Algorithm behaves like a backbone for searching an optimized solution for Network Planning from available solutions in a complex environment. Genetic Algorithm is efficient because it not only gives the optimized solution in Network Planning but also give feasible solution in different network domains. Genetic Algorithms are flexible because many authors enhanced the Genetic Algorithms to fulfill their requirements. Pareto Genetic Algorithm, Enhanced Pareto Genetic Algorithm, Pareto Converting Genetic Algorithm and Forced Genetic Algorithm are examples of Genetic Algorithms which are enhanced by many researchers to get optimal solution for their problems domain. In future, we intend to analyze Performance of Genetic Algorithms in various Network domains.

Table 1 Genetic Algorithms Applications in Networks with Improved Factors.

Applications in Network	Version of Genetic Algorithm applied	Improved Factors in Particular Network Problem
Topological Planning [4]	Pareto Converting Genetic Algorithm (PCGA)	Optimized the Network Delay and Network Cost
Topological Planning [3]	Spanning Tree-based Genetic Algorithm	Minimize the Average Message Delay and the Connection Cost
Indoor WLAN Planning [6]	Genetic Algorithm for Calculation of the Environmental Parameters	Maximize the Quality Prediction
Indoor WLAN Planning [7]	Genetic Algorithm and Neural Network	Shortest Prediction Time and Optimal Access Location
Access Points Planning in WLAN [8]	Multi-Objective Genetic Algorithm	Maximum Communication Throughput and Maximum Transmission Coverage
Indoor WLAN Planning [5]	Neural Network and Genetic Algorithm	Effect on Capacity, Time Optimization and Cost Efficiency of Computational Intelligence
WLAN Planning [14]	Analysis Hierarchy Progress and Genetic Algorithm	Select Efficient Network for Mobile Users
Optical Network Topological Planning [9]	Genetic Algorithm	Selection of Better Survivable Network with Minimum Capital Expenditure
Radio Access Network Planning [10]	Particle Swarm Optimization and Genetic Algorithm	Heterogeneous Environment Parameters with Best Results
Wireless Sensor Networks Planning [11]	Genetic Algorithm	Feasible Route in Wireless Sensor Network.
Wireless Mesh Network Planning [12]	Genetic Algorithm	Maximize the Network Convergence and Connectivity
Wireless Ad Hoc Network Planning [13]	Genetic Algorithm	Minimize the Average Packet Delay
Wireless Ad Hoc Network Planning [15]	Genetic Algorithm	Efficient Network Selection by Small Movement in Small Communication Region

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