Multi-Objective Optimization To Find The Shortest Paths Tree Problem

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Abstract :- The Shortest paths tree problem when considering cost and bandwidth constraints is addressed in this paper as multi-objective shortest paths tree problems. A multi-objective genetic algorithm is acceptable to solve the problem. The objective of the proposed algorithm is to search the optimal set of edges connecting all nodes such that the sum of costs is minimized and the value bandwidth is maximized.

Keywords :- Genetic Algorithm, Multi-objective shortest paths. Computer network.

1. INTRODUCTION :-

Genetic Algorithms are adaptive methods which may be used to solve search and optimization problems. They are based on the genetic processes of biological organisms. The Shortest paths tree rooted at vertex s is a spanning tree T of G, such that the path distance from v to u in G. When considering multicast tree, presented an algorithm to find the shortest Best Path Tree (SBPT) based on labeling techniques. Younes proposed a genetic algorithm to determine the k shortest paths with bandwidth constraints from a single source node to multiple destinations nodes. Liu et. al. presented an oriented spanning tree based genetic algorithm for solving both the multi-criteria shortest path problem and the multi-criteria constrained shortest path problems. Younes presented the genetic algorithm to find the low-cost multicasting tree with bandwidth and delay constraints. Gen and Lin used a multi-objective hybrid genetic algorithm to improve solutions of the bicriteria network design problem. Mooney and Winstanley state that Martins' labeling algorithm works well in theory but is prohibitive in practice in terms of its implementation due to memory cost. This paper presents a multi-objective genetic algorithm based on Random Weighted genetic. Algorithm (RWGA) to solve the shortest paths tree problem subject to cost and bandwidth constraints. The objective of the proposed algorithm is to search the optimal set of edges connecting all nodes such that the sum of costs is minimized and the bandwidth value is maximized. A genetic algorithm is presented to solve the paths tree problem under cost constraint.

2. NOTATIONS

G	A network graph
N	The number of nodes in G
E	The number of edges in G
e_{ij}	An edges between node i and node j in G
c_e	An cost of edge e
M	The connection matrix of the given network
CM	The cost matrix of the given network
NP	The number of paths from node s to t
T_s	The shortest path rooted at node s
P_{size}	The population size
P_c	The crossover rate
P_m	The mutation rate
ng	The number of generations
RWGA	Random Weighted Genetics Algorithm
MSPP	The multi-criteria shortest path problem

3. THE PROBLEM FORMULATION AND DESCRIPTION

The optimal shortest paths tree rooted at vertex s is the collection of optimal paths from the source (root) node s to the destination node di. The path $P_{(sd)}$ is optimal if it has minimum cost and maximum bandwidth. Let $C(P_{(sd)})$ and B $(P_{(s,d)})$ be he cost and the bandwidth of the path $(P_{(s,d)})$ respectively. The multi-objective paths tree problem is formulated as follows.

$$Minimize\ C(P_{(s,di)})$$
$$Miximize\ B(P_{(s,di)})$$

where

$$C(P_{(s,di)}) = \sum_{e \in P_{(s,di))}} C_e$$
$$B(P_{(s,di)}) = min_{b_e \in P_{(s,di))}} (b_e)$$

The multi-objective problem in the case of a maximal and minimal objective is transformed into either a multi-objective is transformed into either a multi-objective minimization problem or a multi-objective maximization problem. Therefore, the original problem formulation is modified to be of the minimal type :

$$Minimize\ ob_1 = C(P_{(s,di)})$$
$$Minimize\ ob_2 = \hat{B}(P_{(s,di)})$$

Where $\hat{B}(P_{(s,di)}) = 1/B(P_{(s,di)})$

Therefore, the minimum-cost paths tree T_s is the collection of minimum cost path from the source (root) node s to the destination d_i :

$$C(T_{s)} = \sum_k C^k(P_{(s,di)})$$

The bandwidth of the tree T is defined as the minimum available residual bandwidth at any link along the tree :

$$B(T_{s)} = min(B(e), e \in T_s)$$

The present method depends on reading both the connection, cost and bandwidth matrices of a given network, and then finds the shortest paths tree rooted at the sources node.

4. THE PROPOSED ALGORITHM BASED ON RWGA

In the proposed GA, each candidate path is represented by a binary string with length N that can be used as a chromosome. Each element of the chromosome represents a node in the network topology. So, for a network of N nodes, there are N string components in each candidate solution x. Each chromosome must contain at least two none zero elements.

4.1 INITIAL POPULATION

The following steps show how to generate P_{size} chromosomes of the initial population:

1. Randomly generate a chromosome x.
2. Check if x represents a real candidate path, i.e. contains at least two non-zero elements.
3. Repeat step 1 and step 2 to generate P_{size} chromosome.

4.2 THE FITNESS FUNCTION

Step 1: Find the normalized value of ob_1 and ob_2.

Step 2: Calculate the Fitness value for each solution.

Step 3 : Calculate the selection probability of each solution.

4.3 GENETIC CROSSOVER OPERATION

In the proposed GA, we use the single cut point crossover to breed a new offspring from two parents. The crossover operation will be performed if the crossover ration (Pc=0.90) is verified. The cut point is randomly selected.

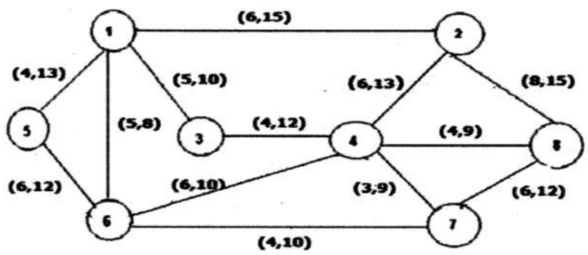


Fig. 1: The cost and bandwidth of the links (cost, bandwidth) for eight nodes network

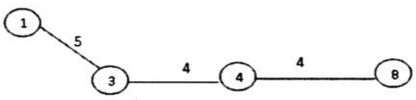
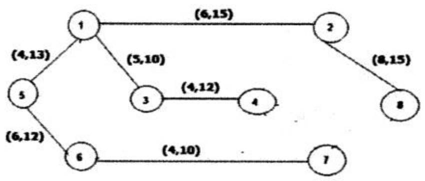


Fig. 2: A candidate Path

1	2	3	4	5	6	7	8
1	0	1	1	0	0	0	1

Fig. 3: The chromosome corresponding to the path given in Figure 2



4.4 GENETIC MUTATION OPERATION

In the proposed approach, the mutation operation will be performed if the mutation ration (P_m) is verified. The P_m in this approach is chosen experimentally to be 0.02. The point to be mutated is selected randomly.

5. CONCLUSION

The paper presented a multi-objective genetic algorithm based on Random Weighted Genetic Algorithm (RWGA) to solve the shortest paths tree problem subject to cost and bandwidth constraints. The objective of the proposed algorithm is to search the optimal set of edges connecting all nodes such that the sum of costs is minimized and the value bandwidth is maximized.

6. REFERENCE

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