ABSTRACT

A computer network is an interconnected group of computers with the ability to exchange data. Today, computer networks are the core of modern communication. Routing is one of the most important issues that have a significant impact on the network's performance. An ideal routing algorithm should strive to find an optimum path for packet transmission within a specified time so as to satisfy the Quality of Service (QoS) requirement. In QoS routing, routes must be determined by requirements based on the features of the data flows, such as cost, delay, bandwidth, packet loss etc. The goal of QoS routing is to find a path that satisfies the QoS requirements and to optimize the global network resource utilization.

The rapid evolution of numerous real time applications has been stimulating the demand for QoS based routing in the underlying computer communication networks. Due to the complexity and challenge of various QoS routing in real world applications, unicast and multicast routing problems have attracted significant research attention in the area of computer networks. The underlying mathematical model of the problem is a NP-complete problem. Unicast and multicast routing problems with various QoS constraints have been proven to be NP-complete optimization problems and thus attracted significant research attention for almost two decades. QoS routing is an important communication technique to support data transmission

in computer networks. Unicast routing aims at transferring information from a source to a destination and multicast routing aims at transferring information to a group of destination in a single run, while satisfying a set of QoS constraints.

This thesis is concerned with the investigation of Multi-Objective Evolutionary Algorithms (MOEAs) for QoS unicast and multicast routing problems. The routing problem is formulated as a multi-objective mathematical programming problem which attempts to minimize four QoS parameters simultaneously, while satisfying the flow conservation constraints. The four objectives considered are cost, delay, Maximum Link Utilization (MLU) and hop count.

The total cost function is the sum of cost of link along the path from the source node to the destination node. The delay function is the sum of delay of the link along a path from the source node to the destination node. The third objective is the maximum link utilization. To reduce traffic in the over utilized-links and increase the traffic in the under-utilized links, this objective is included. In order to avoid longer routes that will be obtained while optimizing the MLU, another objective function hop count is added. The objective functions are optimized subject to the flow conservation constraints. In both unicast and multicast transmission schemes, the multi-path approach to every destination node is used.

A multi-objective traffic engineering scheme using different distribution trees to multicast several flows is considered. In this thesis, Evolutionary Algorithms (EAs) are used to solve multi-objective problems that have been motivated mainly because of their population based nature that allows the generation of several solutions in a single run. To solve the multi-objective optimization problem three different MOEAs are used.

The three algorithms that are employed here are, the non-elitism based Non-dominated Sorting Genetic algorithm (NSGA), the elitism based Non-dominated Sorting Genetic Algorithm-II (NSGA-II) and Strength Pareto Evolutionary Algorithm (SPEA). In elitism, in each generation, a few good individuals in the population are directly allowed to participate in the next generation without undergoing any genetic operations. SPEA differs from the other two algorithms, by possessing internal and external population sets. This thesis extensively investigates the application and comparison of performance of MOEAs on different QoS unicast and multicast routing problems.

The performances of these MOEAs are evaluated by means of a number of experiments on benchmark instances for both unicast and multicast transmission schemes and some random networks generated. In this thesis, for unicast transmission, the simulations were done in two phases. In the first phase, experiments were done to find the best population size and combined scheme of encoding and crossover methods using a standard network. By analyzing the convergence property of all the three MOEAs, one by one, the best combination of encoding and crossover mechanism was found. In the second phase, the best population size and the best combined scheme of encoding and crossover methods were used on the randomly generated networks.

Similarly, for the multicast transmission, the experiments have been done in two phases. In the first phase of multicast transmission, experiments were done to find the best population size and the best crossover method using the standard National Science Foundation (NSF) network. Thus, using the best population size and crossover method obtained, in the second phase, they were applied on the randomly generated networks with varying topologies.

A large number of experiments have been performed to demonstrate the effectiveness and efficiency of the MOEAs undertaken in this thesis for the multi-objective unicast and multicast routing problems. The experimental results of the three MOEAs, their performance in terms of Execution Time (ET), Route Optimality (RO) and maximum number of non-dominated solutions, and the detailed analysis are presented. The results for the benchmark problems are compared with the other works reported in the literature.

From the results obtained, it is observed that, when the size of the network was small, the three algorithms, NSGA, NSGA-II and SPEA performed equally well for both unicast and multicast routing problems. For larger size networks, NSGA-II had better performance in terms of execution time and route optimality and SPEA had better performance in terms of identifying the maximum number of non-dominated solutions.