ABSTRACT

Heterogeneous distributed systems are widely deployed for executing computationally intensive parallel applications with diverse computing needs. The efficient execution of applications in such environments requires effective scheduling strategies that take into account both algorithmic and architectural characteristics to achieve a good mapping of tasks to processors, i.e., to minimize the schedule length (Makespan). In addition, failures of resources (processor/link) in such systems may occur and can have an adverse effect on applications. Consequently, there is an increasing need for developing techniques to achieve maximum reliability of a system, i.e., to minimize the failure probability of a system during execution of an application and minimizing the schedule length. These two requirements are conflicting and it is not possible to minimize both at the same time.

An application can be modeled as a Directed Acyclic Graph (DAG). A heterogeneous distributed computing system can be modeled as a resource graph. The problem of executing an application on heterogeneous distributed computing systems is NP-hard. Thus, various heuristic and metaheuristics approaches have been developed in the literature to solve the problem. The most studied heuristic methods are so called list scheduling algorithms. They were primarily developed for generating schedules of good quality considering the single objective of minimal schedule length. The traditional list scheduling heuristics are good in generating schedules due to
their greedy nature. This was the motivation factor for this research to use them for handling the two objectives of makespan and reliability.

Genetic Algorithm is one of the widely used metaheuristics for solving the task scheduling problem. The efficiency of using GA for solving the task scheduling problem has been proved in various studies. Hence, the multiobjective genetic algorithms are used in this research to solve the problem under study. The capability of generating a set of non-dominated points by genetic algorithm on one hand and evolutionary programming on the other hand is compared. Various performance metrics are available in the literature to measure the convergence and diversity of the obtained non-dominated solutions of the multiobjective evolutionary algorithms. The spacing and spread metric are used for measuring the performance in this research. The performance has been compared for random and real application task graphs.

Though GA based methods outperform the heuristic based methods in schedule quality, it is still prone to premature convergence traps due to limited exploration ability. Thus, it is better to consider the hybridization of metaheuristics, also called as memetic algorithms. The two Pareto based multiobjective genetic algorithms: NSGA-II and SPEA2 are implemented in the pure and hybrid version and compared. The convergence and diversity of the obtained non-dominated solutions are evaluated. The performance is evaluated for the random and real application task graphs. The suitability of using hybrid NSGA-II for solving the task scheduling problem is confirmed by the simulations.
The contribution of this research work includes the development of a tool for generating random and real application task/resource graphs of any size. The task graph generated with this tool was used as input for comparing the performance of the proposed heuristic and metaheuristics in this research.

In summary, this research work reports a novel list scheduling algorithm, named IRHEFT (Improved Reliable HEFT) for solving the bi-objective task scheduling problem. A comparison of the metaheuristics and their hybrid version is also reported for random and real application task graphs on heterogeneous distributed systems.