CHAPTER 7

This chapter presents the conclusion of the work on addressing scheduling problems using meta-heuristic algorithms on grid computing environments. It also briefly details the main lines of future work for improving the current results.

7. CONCLUSION AND FUTURE WORK

This work presented the application of sequential meta-heuristic algorithms for solving the scheduling problem in heterogeneous computing and grid environments. For the past two decades, the growth of distributed computing environment for solving the complex problem has been at a fast pace. Hence the scheduling problem became the important issue while executing tasks in heterogeneous computing and grid environments. The static version of the problem was considered since it adequately models the planning in distributed clusters and HC multiprocessors, while it also provides a first step for solving more complex scheduling problems arising in distributed and dynamic environments. The grid task scheduling problem was categorized in the scheduling theory using the notation by Graham et al. (1979), and two different computing models such as independent and dependent task models in the related literature were detailed. The proposed meta-heuristics was designed to find good HCSP solutions in an efficient way using a bounded time stopping. The grid job scheduling algorithms were developed using MATLAB R2010a and run on an Intel(R) Core(TM) i5 2.67GHz CPU with 4GB RAM for solving a large set of scheduling problem instances.

At first, the performance of meta-heuristics to solve a small-sized standard test suite of instances was studied. In the second stage, a set of large-sized HCSP instances, which model the realistic distributed HC and grid scenarios, was used to study the value of the proposed meta-heuristic-based grid job scheduling algorithms.
The test suite comprises several problem instances, ranging from 3×13 to 4096×128, that were designed following a methodology based on the well-known ETC model for execution time estimation by Ali et al.

The first experimental analysis allowed drawing some conclusions about the applicability of meta-heuristics to solve the HCSP based on independent task model to minimize the makespan of the grids. The experiments were conducted to analyze the efficiency of the existing meta-heuristics, namely Biogeography-Based Optimization algorithm, Differential Evolution algorithm, RASA algorithm and Variable Neighborhood Search algorithm to solve a de facto standard set of small-sized HCSP instances. Based on the concepts gained through the previous study, two novel algorithms, namely DE/RASA algorithm and TPVNS algorithm were proposed. Extensive experiments were conducted to determine the parameters of various meta-heuristic algorithms. The performance of meta-heuristic algorithms was studied by applying the various benchmark heterogeneous computing test instances. The value of the proposed algorithms was evaluated by comparing the obtained results with the best results published in the literature and with the lower bound values. TPVNS improves the makespan of 105 test instances out of 124 test instances considered for the experimentation. In order to have a fair comparison with the previously published algorithms, a clear comparison concerns not only the best solution value achieved by the TPVNS but also the average one. It is found that TPVNS algorithm achieves a better average makespan value than the best value of the reported algorithms of this study for 70% of test instances considered for the experimentation. The average gap value of the TPVNS algorithm with the lower bound value is about nearly 1% and 5% for the benchmark problems proposed by Braun et al. and Nesmachnow et al. respectively.
The second part of the experimentation covered the study of application of the meta-heuristic algorithms for the grid task scheduling algorithms to minimize both makespan and flowtime. The combination of the variant of PALS algorithm with the meta-heuristic algorithms, namely BBO, DE, RASA, DE/RASA, GA, ACO, PSO and VNS algorithm caused the emergence of novel hybrid algorithms. The hybrid algorithms were applied for the multi-objective version of the grid task scheduling problem, and their performances were analyzed by considering the metrics, namely solution quality, speed of convergence and the percentage of resource utilization. The percentage of improvement of multi-objective VNS algorithm was found to be better when compared with the other considered algorithms. The BBO and DE/RASA algorithms were found to produce good results than GA, ACO and PSO algorithms. VNS approach produces good quality schedule for 34 test cases out of 36 medium size test instances.

The results of MVNS algorithm for 72 large-scale test instances were compared with the deterministic heuristic Min-Min algorithm, Simulated Annealing algorithm and GRASP algorithm. It was observed that MVNS produces a good quality schedule for all the test instances.

The third part of the experimentation dealt with the DAG task scheduling problem in order to reduce the makespan. Efficient numerical results were reported in the experimental analysis performed on a large set of randomly generated graphs, and also the graphs abstracted from three well-known real applications: Gaussian elimination, Fast Fourier Transform (FFT) and molecular dynamics application. The comparative study shows that the proposed VNS algorithm is able to achieve better performance than the leading heuristic scheduling algorithm, HEFT algorithm and to
find better solutions faster than Genetic algorithm. The average percentage of improvement of VNS is found to be 5.51 over GA and 9.87 over HEFT algorithm.

The fourth part of the experimentation was carried with the applications discussed in the third part of the experimentation. The combination of HEFT with VNS algorithm is considered to be HTPHVNS algorithm. By extracting the features of HEFT algorithm, HTPHVNS algorithm is able to meet the requirements of scheduler with both strict execution time requirements and loose execution time requirements. Compared with VNS, HTPHVNS algorithm achieves the makespan reduction of 4.07% on average.

In future, VNS algorithm for multi-objective complex scheduling problems and workflow model of grid scheduling problems may be developed. Also, energy-aware scheduling algorithms may be concentrated by considering the power and energy consumption in modern-day and future computing and communication systems.