Abstract

Distributed Heterogeneous Computing System (DHCS) is emerging as a viable alternative to parallel computing system for executing computationally intensive applications. It has the potential to provide low cost and high performance computing environment when the complex application is broken into tasks that can be distributed to various processors for parallel execution. In DHCS, an application is partitioned into tasks by task partitioning algorithm and is presented in the form of Directed Acyclic Graph (DAG). However, the potential of DHCS can be realized with an efficient task scheduling algorithm, which minimizes the overall makespan or completion time of the application by proper scheduling of tasks onto the suitable processors.

Task scheduling algorithms are broadly classified into two categories namely, static and dynamic task scheduling algorithms. In these algorithms, the characteristics of tasks are execution time, the size of data communicated among the tasks and the task dependencies. In static task scheduling algorithm, these characteristics are known a priori whereas, in dynamic scheduling they are known at run-time. The static task scheduling algorithms generate better schedules with lesser scheduling overhead than the dynamic scheduling algorithms. This research work mainly focuses on development of static task scheduling algorithms.

In general, the static task scheduling problem is proved to be NP-complete. Consequently, several heuristic-based algorithms have been presented in the literature. These task scheduling algorithms are categorized as List-scheduling, Clustering, and Task Duplication-based algorithms. In addition, Genetic algorithms have also been investigated in the literature to provide better task scheduling. The existing algorithms mainly focus on the scheduling of tasks in homogeneous processors. However, scheduling algorithms have not been fully explored for the heterogeneous processors. Therefore, in this research work task scheduling algorithms for DHCS consisting of bounded number of completely connected processors are explored. This has led to the development of task scheduling
algorithms in each of the following categories namely, list-scheduling, task duplication-based scheduling and genetic based scheduling approaches.

List-scheduling algorithm provides sub-optimal schedule with minimum scheduling overhead. The list-scheduling algorithms such as the Heterogeneous Earliest Finish Time (HEFT), Critical Path On a Processor (CPOP), Dynamic Level Scheduling (DLS) and Heterogeneous Critical Parent Trees (HCPT) are well known and widely referred algorithms. In this research work, two list-scheduling algorithms namely, High Performance task Scheduling (HPS) algorithm and Performance Effective Task Scheduling (PETS) algorithm have been developed to provide improved performance compared to the existing algorithms.

The task duplication-based algorithm duplicates the tasks onto one or more processors thereby reducing the communication cost, network overhead and potentially reducing the start times of waiting tasks. The widely referred algorithms in this category include, Levelized Duplication-Based Scheduling (LDBS), Heterogeneous Critical Node First (HCNF), Task duplication-based scheduling Algorithm for Network of Heterogeneous systems (TANH), Heterogeneous Critical Parents with Fast Duplicator (HCPFD) and the Dynamic Critical Path Duplication (DCPD). In this research work, two task duplication-based scheduling algorithms namely, High Performance Duplication-based Compile-time task Scheduling (HPDCS) with completely connected processors and Highly Communicating and Dependent Based Task Scheduling (HCDBTS) with arbitrarily connected processors for DHCS have been developed to generate better schedules than the existing algorithms.

Further, the task scheduling problem using the genetic approach is also investigated in the literature to find the optimal schedule. In contrast to list-scheduling and task duplication-based scheduling algorithms, genetic algorithms provide better schedules at the cost of increase in time complexity. Some well known genetic algorithms presented in the literature include Problem Space Genetic Algorithm (PSGA) and Genetic Simulated Annealing (GSA). In this research work, two genetic algorithms namely, Genetic Algorithms for Task Scheduling (GATS) and
Duplication-based Genetic Algorithms for Task Scheduling (DGATS) have been developed.

Currently, Mobile Computing System (MCS) is extensively used in many areas. The advancements in the computing and communication technology excel the mobile computing devices with the potential to execute a larger application. However, the functioning of the mobile devices is constrained by battery power/energy. Though there exist few scheduling algorithms addressing the power/energy efficiency, significant research has not been carried out to execute larger application represented by DAG in MCS. In this research, scheduling of DAG onto the MCS has been explored and a scheduling algorithm namely, High Performance task Scheduling for Mobile computing system (HPSM) has been developed. The HPSM algorithm provides better results in terms of minimization of the schedule length or energy/power consumption or both.

The performance of the various algorithms developed in this research has been compared with the well known and widely referred existing algorithms. Simulation experiments have been conducted using a large set of randomly generated task graphs and the graphs of some real world applications such as Gaussian Elimination algorithms, Fast Fourier Transformations, Molecular Dynamics code, Cholesky factorization and Diamond graphs. The experimental results show that the developed algorithms outperform the existing ones in terms of various evaluation parameters such as schedule length, efficiency, speedup, etc..

The limitations of the task scheduling algorithms developed in this research have also been identified and presented for further exploration.