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A Hierarchical Chemical Reaction Optimization for Varying Length Task Scheduling in Grid Computing

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ABSTRACT

A grid computing system shares the load across multiple computers to complete tasks more efficiently and quickly. Grid computing is presently a full of life analysis space. In this paper a new method is proposed for scheduling the varying length jobs in the grid environment. It presents how the jobs can be scheduled effectively by using Hierarchical scheduling. The concept of Shortest Job First algorithm is used along with Chemical Reaction Optimization algorithm in order to schedule varying length jobs efficiently. The results show that the proposed method provides better flowtime and also it performs better than the existing methods.

Keywords - **Chemical Reaction Optimization, Grid computing, scheduling algorithms, Task scheduling.**

I. INTRODUCTION

Grid computing is a computer network in which each computer's resources are shared with every other computer within the system. Processing power, memory and data storage are all community resources that the authorized users can tap into and leverage for specific tasks. A grid system may be as easy as a collection of similar computers running on the same operating system or as complex as inter-networked systems. It can be thought of as a special kind of distributed computing. In distributed computing, totally different computers within the same network share one or more additional resources. In the ideal grid computing system, each resource is shared, turning a computer network into a powerful supercomputer. With a proper user interface, accessing a grid computing system would look no different than accessing a local machine's resources. Each of the authorized computers would have access to enormous processing power and storage capacity. A grid computing system [1] shares the load across multiple computers to complete tasks more efficiently and quickly. Grid computing systems link computer resources together in a way that lets someone use one computer to access and leverage the collected power of all the computers in the system. To an individual user, it's like the user's computer has transformed into a supercomputer.

The main goal of scheduling is to achieve the highest possible system throughput and to match the applications requirements with the available computing resources. A grid usually consists of five parts: clients, the Global and Local Grid Resource Brokers (GGRB and LGRB), Grid Information Server (GIS), and resource nodes. The clients register their requests of processing their computational tasks at GGRB. Resource nodes register their donated resource at LGRB and process clients' tasks according to the instructions from LGRB. In practice, client and resource node can be the same computer. GIS collects the information regarding resources from all LGRBs, and transfers it to GGRB. This GGRB is responsible for scheduling. It possesses all necessary information about the tasks and resources and acts like a database of the grid.

Each user may differ from other users with respect to different characteristics such as types of job created, execution time and scheduling optimization strategy. Each resource may differ from other resources with respect to number of processors, cost, Speed and internal process scheduling policy. Grid computing solves high performance and high-throughput computing problems through sharing resources ranging from personal computers to supercomputers that are distributed throughout the world. A major problem to be considered is task scheduling, i.e., allocating tasks to resources. There are several algorithms for scheduling the jobs to the resources. These algorithms are not suitable for all the situations.

The Chemical Reaction Optimization is an efficient algorithm for scheduling the jobs in the grid environment. This is efficient for scheduling equal length jobs. But for varying length jobs this algorithm is not much effective. Hence a hierarchical scheduling method is proposed in this paper. This method is effective for scheduling varying length jobs.

The rest of the paper is organized as follows: related work is described in Section II. Section III describes the Chemical Reaction Optimization. In Section IV, a detailed view of Hierarchical scheduling method is given. Section V includes the result analysis. Finally, the conclusion is given in Section VI.

II. RELATED WORK

Scheduling refers to the method by which processes or tasks or jobs are given access to system resources. Scheduling can also be defined as the mapping of tasks to resources that may be distributed in various administrative domains. This is done mainly to balance a system effectively and to achieve the target. There are several algorithms such as simulated annealing, ant colony optimization, genetic algorithm, particle swarm optimization, threshold accepting and so on.

In the year 1996 Dorigo M. introduced the Ant algorithm. It is based on real ants and is derived from the social behavior of ants [2]. Ants work together to find the shortest path between their nest and food source. When an ant looks for food, it deposits some amount of chemical substance called pheromone [3] on the path. The shortest path is found using this pheromone. Here the decisions on which path to choose are made at random. It is more applicable to problems where source and destination are predefined. Simulated Annealing algorithm [4] is based on the physical process of annealing. For task scheduling in the grid environment this algorithm starts by generating an initial solution. In each iteration, it generates a new solution randomly in the neighborhood of the present solution, and it will be accepted when it is better, or accepted with a probability controlled by a temperature parameter. It is relatively simple but it may consume more time to find the good solution.

The Genetic Algorithm (GA) is a technique for large space search. The general procedure for GA search [5] includes Population generation, Chromosome evaluation and Crossover and mutation. Here each chromosome represents a possible solution. The search time cost is high and also the convergence time is more for this algorithm. The Particle swarm optimization (PSO) is a population-based algorithm [6] which is modeled on swarm intelligence, like bird flocking and fish schooling. It starts with a group of particles known as the swarm. A flock or swarm of particles is randomly generated initially with each particle's position representing a possible solution point in the problem space. The particles are the task to be assigned. The algorithm starts with random initialization [7] of particle's position and velocity. PSO have no overlapping and mutation calculation and hence the convergence time for PSO is less. But this method easily suffers from the partial optimism.

Threshold Accepting [8] is similar to Simulated Annealing but with a different acceptance rule. Every new solution would be accepted as long as the difference is smaller than a threshold. It begins with an initial solution and an initial threshold value. A neighborhood solution to the current solution is generated by using the perturbation scheme. The current and the candidate solution are evaluated and their objective function value is obtained. If the candidate solution is acceptable, it becomes the current solution and this completes an iteration of the procedure. It has greater convergence time even though it is simple.

III. CHEMICAL REACTION OPTIMIZATION (CRO)

Chemical Reaction Optimization is a population-based metaheuristic, and it can be used for solving many problems. CRO mimics the interactions of molecules in the chemical reactions and it searches for global optimum [9]. A chemical system undergoes a chemical reaction when it is unstable, that is when it possesses excessive energy. It manipulates itself to release the excessive energy in order to stabilize itself and this manipulation is called chemical reactions. Generally in a chemical reaction molecules interact with each other aiming to reach the minimum state of free energy. Through a sequence of intermediate reactions, the resultant molecules (i.e. the products in a chemical reaction) tend to stay at the most stable state with the lowest free energy.

When looking at the chemical substances at the microscopic level, a chemical system consists of molecules, which are the smallest particles of a compound. It retains the chemical properties of the compound. Molecules are classified into different species based on the underlying chemical properties. A chemical reaction always results in more stable products with minimum energy and it is a step-wise process of searching for the optimal point. A chemical change of a molecule is triggered by a collision. There are two types of collisions: uni-molecular and inter-molecular collisions. The former describes the situation when the molecule hits on some external substances while the latter represents the cases where the molecule collides with other molecules. The corresponding reaction change is called an elementary reaction. An ineffective elementary reaction is one which results in a subtle change of molecular structure.

There are three stages [10] in CRO: initialization stage, iteration and the final stage. The computer implements CRO by following these three stages sequentially. Each run starts with the initialization, performs a certain number of iterations, and terminates at the final stage. There are four major operations called elementary reactions in CRO: on-wall ineffective collision, synthesis, inter-molecular ineffective collision and decomposition. In CRO, the on-wall ineffective collision and inter-molecular ineffective collision correspond to local search, whereas decomposition and synthesis correspond to remote search. Through a sequence of intermediate reactions, the resultant molecules (i.e. the products in a chemical reaction) tend to stay at the most stable state with the lowest free energy. An on-wall ineffective collision occurs when a molecule hits the

wall and then bounces back. Some molecular attributes change in this collision, and thus, the molecular structure varies accordingly. An inter-molecular ineffective collision describes the situation when two molecules collide with each other and then bounce away. A decomposition means that a molecule hits the wall and then decomposes into two or more (assume two in this framework) pieces. A synthesis depicts more than one molecule which collide and combine together.

CRO includes permutation based representation, where the jobs allocated to resources is indicated using a vector. CRO is a variable population based metaheuristic [11] where the total number of solutions kept simultaneously by the algorithm may change from time to time. Decomposition and synthesis increases and decreases the number of molecules, respectively. Several CRO programs corresponding to the different modules can be implemented simultaneously. CRO is best suited to those types of problems which will benefit from parallel processing rather than sequential processing.

IV. PROPOSED SYSTEM

The existing CRO algorithm can be used for scheduling tasks of equal length. The performance of this algorithm degrades when it is used for scheduling varying length tasks. While scheduling varying length jobs the performance can be improved by using hierarchical scheduling method. This method includes two levels and the flow diagram is shown in Fig 1. The first level involves permutation based scheduling and the second level includes Shortest Job First algorithm. The permutation based scheduling is same as in CRO, which is to schedule the jobs to resources. The next step includes Shortest Job First scheduling algorithm, which selects the shortest jobs and executes them.

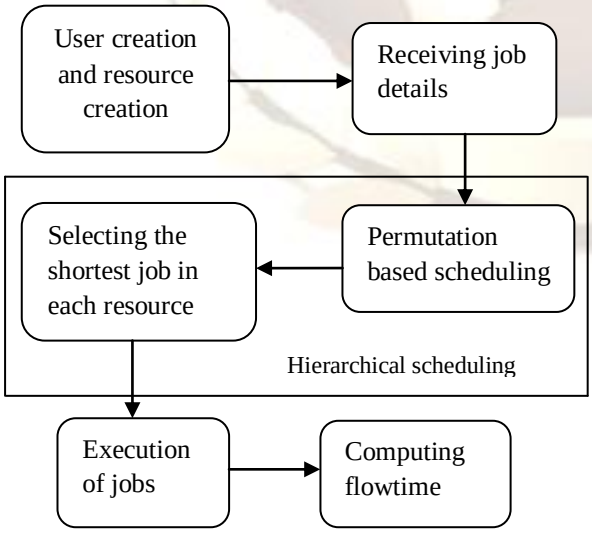

Fig. 1: Flow diagram for proposed system

The first level i.e., Permutation based method includes scheduling of jobs to the resources. This is done by means of several operators such as Insertion operator, Position-based operator and Two-exchange operator. The details regarding these operators are described in the previous section. Once the jobs are scheduled to the resources using permutation based method, each resource will have jobs of different lengths. If these jobs are executed in the same order in which they are allocated to each resource, there is a possibility for the smaller jobs to wait for the larger jobs to complete. To avoid this, the next level must be included.

The second level of hierarchical scheduling involves selection of shortest job and executing them prior to the larger jobs. The concept of Shortest Job First algorithm is utilized here for identifying the smaller jobs. Jobs of different lengths will be allocated to each of the resources. In each resource the shortest job will be selected and executed first. The next step is to execute the jobs and to compute the flowtime. The flowtime is defined as the time consumed by all the tasks to complete its execution.

This Hierarchical scheduling process eliminates the need for smaller jobs to wait for the larger jobs to complete. This Hierarchical scheduling method improves the flowtime and it also provides better performance.

V. RESULT ANALYSIS

The results show that the proposed Hierarchical scheduling method is better than the existing techniques. The graph shown in Fig 2 provides a better understanding about the variations in flowtime while scheduling the jobs using the existing and proposed algorithms.

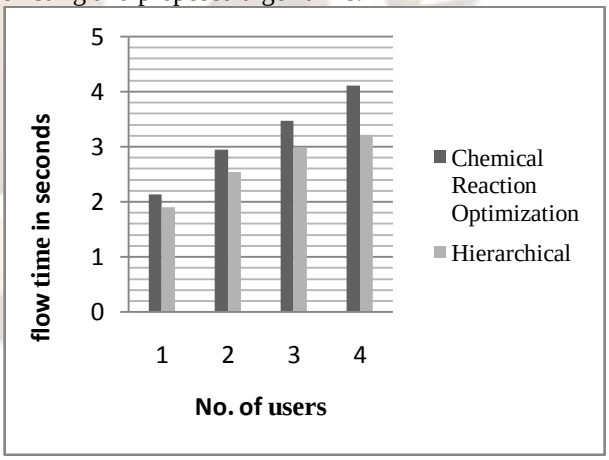

Fig. 2: Variations in flowtime

From this graph it is clear that the flowtime for Hierarchical scheduling method is lesser than the Chemical Reaction Optimization technique. Also there is no need for the smaller jobs to wait for the larger jobs to complete, thus the waiting time for the smaller jobs is minimized. Thus the Hierarchical

scheduling method provides better performance than the existing methods.

VI. CONCLUSION

One of the important research area in the field of computer networking is grid computing. The most important issue to be considered in the field of grid computing is efficient scheduling of jobs. The Chemical Reaction Optimization algorithm is suitable for scheduling equal length jobs. But when used for scheduling varying length jobs it results in increased flowtime. The hierarchical scheduling method is suitable for scheduling varying length jobs. The results show that the flowtime in Hierarchical scheduling method is minimized than the existing method. This Hierarchical scheduling method is a good solution for task scheduling and it makes the process of scheduling varying length jobs easier.

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