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# Comparative Study of Ant Colony Optimization and Particle Swarm Optimization for Grid Scheduling

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## Abstract
This paper represents the comparative study of Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) for Grid scheduling. The objective of ACO and PSO is to dynamically generate an optimal schedule so as to complete the tasks in minimum period of time as well as utilizing the resources in an efficient way. Makespan is the performance measure used for the comparison of the scheduling techniques. This paper compares both the above said optimization techniques and it is concluded that particle swarm optimization has better performance compared to ant colony optimization for grid scheduling.

**Keywords**: Grid Computing, Grid Scheduling, ACO, PSO, Optimal Schedule.

## 1. Introduction
A grid is a collection of computing resources that perform tasks. In its simplest form, a grid appears to users as a large system that provides a single point of access to powerful distributed resources. Grid computing is applying the resources of many computers in a network to a single problem at the same time - usually to a scientific or technical problem that requires a great

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number of computer processing cycles or access to large amounts of data. The sharing of computational jobs is a major application of grids. Grid resource management provides functionality for discovery and publishing of resources as well as scheduling, submission and monitoring of jobs [1].

One of the major challenges for the grid computing researchers is to find out the efficient allocation of resources to the tasks submitted by users [2]. Scheduling and efficient and adaptive resource management is major technical challenges in grid computing. The scheduling of a workflow focuses on mapping and managing the execution of tasks on grid shared resources that are not directly under the control of these workflow systems. Thus, choosing the best strategy for workflow execution in a grid is a challenging research area.

Grid scheduling requires a series of challenging tasks. It include, searching for resources in the collection of geographically distributed heterogeneous computing systems and making scheduling decisions, taking into consideration quality of service. A grid scheduler differs from a scheduler for conventional computing systems in several respects. One of the primary differences is that the grid scheduler does not have full control over the grid. More specifically, the local resources are in general not controlled by the grid scheduler, but by the local scheduler. The scheduling problem is a NP-hard problem and it is not trivial. Grid scheduling, similar to resource discovery and monitoring, is inherently more complex in Grid environments. Numerous research efforts have been made in Grid scheduling mechanisms [3].

The term quality of service (QoS) refers to resource reservation control mechanisms rather than the achieved service quality. Quality of service is the ability to provide different priority to different applications, users, or data flows or to guarantee a certain level of performance to a data flow. In current Grid task scheduling, tasks with different levels of QOS requests compete for resources. The remaining section of this paper is organized as follows. Section 2 explains the related work. Section 3 describes the Grid Scheduling, ACO for grid scheduling is detailed in Section 4, PSO for grid scheduling is explained in section 5, Section 6 explained comparative study of ACO and PSO and in section 7 detailed the conclusion.

## 2. Related Work

Job scheduling problem is NP-complete [4]. Meta-heuristic methods have been used to solve well known NP-complete problems. Yarkhanan and Dongarra used simulated annealing for grid job scheduling. The Simulated Annealing scheduler is compared to a Ad-Hoc Greedy scheduler used in earlier experiments. The Simulated Annealing scheduler exposes some assumptions built into the Ad-Hoc scheduler and some problems with the Performance Model being used [5]. Genetic Algorithm for grid job scheduling is addressed in several works [6, 7].

The benefits of the usage of the Genetic Algorithms to improve the quality of the scheduling are discussed. The result of this paper suggests the usage of local search strategy to improve the convergence when the number of jobs to be considered is big as in real world operation [6]. In this paper, we have proposed an evolutionary approach to solve Grid job scheduling problem with time uncertainties. The aim of the optimization problem was to find the best CF value at fastest convergent speed without losing stability [7].Similarly Ricardo Poli, James Kennedy, Tim Blackwell used Particle swarm optimization for grid job scheduling [8].

In [10], author present a particle swarm optimization (PSO) based scheduling heuristic for data intensive applications that takes into account both computation cost and data transmission cost. It experiment with a workflow application by varying its computation and communication costs. It analyzes the cost savings when using PSO as compared to using existing ‘Best Resource Selection’ (BRS) algorithm. It results show that it can achieve as much as 3 times cost savings as compared to BRS and good distribution of workload onto resources, when using PSO based scheduling heuristic.

In [11], scheduling the jobs using ACO method in computational grid system is dealt. It provides a real distributed real time system with no global control for schedulers. This method will sense the current environment and aware the contexts to decide what do to next. The resource allocation decision is not directly made by the grid system. The algorithm can adopt the system environment freely at runtime. It uses the previous information and allocates the resource optimally and adaptively in the scalable, dynamic and distribute controlled environment.

## 3. Grid Scheduling

The Scheduling is a key concept in computer multitasking, multiprocessing operating system and real-time operating system designs. Scheduling refers to the way processes are assigned to run on the available CPUs, since there are typically many more processes running than there are available CPUs. This assignment is carried out by software known as a scheduler or dispatcher.

A Scheduling algorithm is the method by which threads, processes or data flows are given access to system resources. This is usually done to load balance a system effectively or achieve a target quality of service. The need for a scheduling algorithm arises from the requirement for most modern systems to perform multitasking and multiplexing. Scheduling refer to the way process are assigned to run on the available CPU. Job scheduling is a fundamental issue in achieving high performance in grid computing systems. However, it is a big challenge for efficient scheduling algorithm design and implementation. Unlike scheduling problems in conventional distributed systems, this problem is much more complex as new features of Grid systems such as its dynamic nature. And the high degree of heterogeneity of jobs and resources must be tackled. Job scheduling in computational grids is a multi-objective optimization problem.

***Scheduling Algorithm:*** The following are some of the scheduling algorithm to solve the scheduling problems in grid environment.

***Genetic algorithms (GA):*** maintain a pool of solutions rather than just one. The process of finding superior solutions mimics that of evolution, with solutions being combined or mutated to alter the pool of solutions, with solutions of inferior quality being discarded.

***Simulated annealing (SA):*** is a related global optimization technique which traverses the search space by generating neighboring solutions of the current solution. A superior neighbor is always accepted. An inferior neighbor is accepted probabilistically based on the difference in quality and a temperature parameter. The temperature parameter is modified as the algorithm progresses to alter the nature of the search.

***Tabu search (TS):*** is similar to simulated annealing in that both traverse the solution space by testing mutations of an individual solution. While simulated annealing generates only one mutated solution, tabu search generates many mutated solutions and moves to the solution with the lowest fitness of those generated. To prevent cycling and encourage greater movement through the solution space, a tabu list is maintained of partial or complete solutions. It is forbidden to move to a solution that contains elements of the tabu list, which is updated as the solution traverses the solution space.

***Artificial immune system (AIS):*** algorithms are modeled on vertebrate immune systems. It is a source of constant inspiration to various computing systems. It is concerned with abstracting the structure and function of the immune system to computational systems, and investigating the application of these systems towards solving computational problems from mathematics, engineering, and information technology

***Particle Swarm Optimization (PSO):*** a Swarm intelligence method. Particle Swarm Optimization in its basic form is best suited for continuous a variable, that is the objective function can be evaluated for even the tiniest increment. The method has been adapted as a binary PSO to also optimize binary variables which take only one of two values.

***Ant Colony Optimization (ACO):*** a Swarm intelligence method. Ant colony optimization algorithms have been applied to many combinatorial optimization problems, ranging from quadratic assignment to fold protein or routing vehicles and a lot of derived methods have been adapted to dynamic problems in real variables, stochastic problems, multi-targets and parallel implementations. It has also been used to produce near-optimal solutions to the traveling salesman problem.

## 4. ACO for Grid Scheduling

Ant colony optimization algorithms have been used to produce near-optimal solutions to the traveling salesman problem. The first ACO algorithm was called the Ant system and it was aimed to solve the traveling salesman problem, in which the goal is to find the shortest round-trip to link a series of cities. The general algorithm is relatively simple and based on a set of ants, each making one of the possible round-trips along the cities. At each stage, the ant chooses to move from one city to another according to some rules:

- It must visit each city exactly once;
- A distant city has less chance of being chosen (the visibility);
- The more intense the pheromone trail laid out on an edge between two cities, the greater the probability that that edge will be chosen;
- Having completed its journey, the ant deposits more pheromones on all edges it traversed, if the journey is short;
- After each iteration, trails of pheromones evaporate.

Real ants foraging for food lay down quantities of pheromone (chemical cues) marking the path that they follow. An isolated ant moves essentially at random but an ant encountering a previously laid pheromone will detect it and decide to Ant Algorithm for Grid Scheduling Problem 407 follow it with high probability and thereby reinforce it with a further quantity of pheromone. The repetition of the above mechanism represents the auto catalytic behavior of real ant colony where the more the ants follow a trail, the more attractive that trail becomes [13]. It introduces a tasks scheduling algorithm for grid computing. It searches for the best tasks scheduling for grid computing. In [11], scheduling the jobs using ACO method in computational grid system is dealt. It provides a real distributed real time system with no global control for schedulers. The resource allocation decision is not directly made by the grid system. The algorithm can adopt the system environment freely at runtime. It uses the previous information and allocates the resource optimally and adaptively in the scalable, dynamic and distribute controlled environment.

Ant colony optimization algorithms have been applied to many combinatorial optimization problems, ranging from quadratic assignment to fold protein or routing vehicles and a lot of derived methods have been adapted to dynamic problems in real variables, stochastic problems, multi-targets and parallel implementations. It has also been used to produce near-optimal solutions to the traveling salesman problem.

They have an advantage over simulated annealing and genetic algorithm approaches of similar problems when the graph may change dynamically; the ant colony algorithm can be run continuously and adapt to changes in real time. This is of interest in network routing and urban transportation systems.

## 5. Particle Swarm Optimization

Particle swarm optimization (PSO) is a global optimization algorithm for dealing with problems in which a best solution can be represented as a point or surface in an n-dimensional space. Hypotheses are plotted in this space and seeded with an initial velocity, as well as a communication channel between the particles. Particles then move through the solution space, and are evaluated according to some fitness criterion after each timestamp. Over time, particles are accelerated towards those particles within their communication grouping which have better fitness values. The main advantage of such an approach over other global minimization strategies such as simulated annealing is that the large numbers of members that make up the particle swarm make the technique impressively resilient to the problem of local minima.

Particle swarm optimization is inspired by this kind of social optimization. A problem is given, and some way to evaluate a proposed solution to it exists in the form of a fitness function. A communication structure or social network is also defined, assigning neighbors for each individual to interact with. Then a population of individuals defined as random guesses at the problem solutions is initialized. These individuals are candidate solutions. They are also known as the particles, hence the name particle swarm. An iterative process to improve these candidate solutions is set in motion. The particles iteratively evaluate the fitness of the candidate solutions and remember the location where they had their best success. The individual's best solution is called the particle best or the local best. Each particle makes this information available to their neighbors. They are also able to see where their neighbors have had success. Movements through the search space are guided by these successes, with the population usually converging, by the end of a trial, on a problem solution better than that of non-swarm approach using the same methods.

So a particle has the following information to make a suitable change in its position and velocity:

- A global best that is known to all and immediately updated when a new best position is found by any particle in the swarm.
- Neighborhood best that the particle obtains by communicating with a subset of the swarm.
- The local best, which is the best solution that the particle has seen.

The particle swarm optimization in its basic form is best suited for continuous variables that are the objective function can be evaluated for even the tiniest increment. The method has been adapted as a binary PSO to also optimize binary variables which take only one of two values.

Several methods exist to handle discrete variables which may be in one of multiple states, the simplest being rounding an internal continuous representation of the solution to the closest coordinates at which the objective function can be evaluated. Methods also exist to extend the particle swarm to search combinatorial variables where moving from state to state does not have the same meaning as moving in a coordinate space. Particle Swarm Optimization (PSO) based scheduling heuristic for data intensive applications that take into account both computation cost and data transmission cost.

We experiment with a workflow application by varying its computation and communication costs [10]. PSO has become popular due to its simplicity and its effectiveness in wide range of application with low computational cost.

Particle Swarm Optimization (PSO) is another evolutionary optimization technique. It simulates the process of a swarm of insects preying and works well in many global optimal problems [14,15].

Although a relatively new paradigm, PSO has been applied to a variety of tasks, such as the training of artificial neural networks and for finite element updating. Very recently, PSO has been applied in combination with grammatical evolution to create a hybrid optimization paradigm called "grammatical swarms".

## 6. Comparison of ACO and PSO

In this paper compare both the optimization on the basis of makes pan. Makespan is used to measure the throughput of the grid system. Reduction of makespan is the prime aim of grid scheduling. ACO provides a real distributed real time system with no global control for schedulers. The resource allocation decision is not directly made by the grid system. Ant Colony Optimization algorithms succeeded in the above problems in the distributed scheduling of workflows, but could not complete more workflows within the deadline [3]. PSO achieve the high through put in run time. PSO has become popular due to its simplicity and its effectiveness in wide range of application with low computational cost [10]. In the Grid environment the proposed particle swarm optimization will achieve high throughput as compared with previous ant system.

## 7. Conclusion

Selecting the appropriate resources for the specific task is the one of the challenging work in computational grid. Here, ACO and PSO are to dynamically generate an optimal schedule so as to complete the tasks in minimum period of time as well as utilizing the resources in an efficient way. When comparing both the techniques with the makespan it is concluded that particle swarm optimization has better performance than ant colony optimization for grid scheduling

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