HYBRID ANT COLONY SYSTEM ALGORITHM FOR STATIC AND DYNAMIC JOB SCHEDULING IN GRID COMPUTING

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Abstrak

Pengkomputeran grid adalah sistem teragih dengan infrastruktur heterogen. Sistem pengurusan sumber (RMS) adalah salah satu komponen terpenting yang mempunyai pengaruh besar ke atas prestasi pengkomputeran grid. Bahagian utama RMS adalah algoritma penjadual yang bertanggungjawab untuk memeta tugas kepada sumber sedia ada. Kerumitan masalah penjadualan dianggap sebagai satu masalah lengkap polinomial tidak berketentuan (NP-lengkap) dan oleh itu, satu algoritma pintar diperlukan untuk mencapai penyelesaian penjadualan yang lebih baik. Salah satu algoritma pintar yang menonjol adalah ant colony system (ACS) yang digunakan secara meluas untuk menyelesaikan pelbagai jenis masalah penjadualan. Walau bagaimanapun, ACS mengalami masalah genangan dalam pengkomputeran grid bersaiz sederhana dan besar. ACS berasaskan mekanisma eksploitasi dan penerokaan di mana eksploitasi adalah mencukupi tetapi berkurangan pada penerokaan. Penerokaan dalam ACS adalah berasaskan kepada pendekatan rawak tanpa sebarang strategi. Kajian ini mencadangkan empat algoritma hibrid di antara ACS, Genetic Algorithm (GA), dan Tabu Search (TS) untuk meningkatkan prestasi ACS. Algoritma tersebut adalah ACS(GA), ACS+GA, ACS(TS), dan ACS+TS. Algoritma hibrid yang dicadangkan ini akan meningkatkan ACS dari segi mekanisma penerokaan dan penghalusan penyelesaian dengan melaksanakan penghibridan tahap rendah dan tinggi algoritma ACS, GA, dan TS. Semua algoritma yang dicadangkan telah dinilai dan dibandingkan dengan dua belas metaheuristic algoritma dalam persekitaran pengkomputeran grid statik (masa jangkaan kepada model pengiraan) dan dinamik (corak taburan). Satu simulator yang dinamakan ExSim telah dibangunkan untuk meniru sifat statik dan dinamik pengkomputeran grid. Keputusan eksperimen menunjukkan algoritma yang dicadangkan mengatasi ACS dari segi nilai makespan terbaik. Prestasi ACS(GA), ACS+GA, ACS(TS) dan ACS+TS adalah lebih baik daripada ACS dengan masing-masing meningkat sebanyak 0.35%, 2.03%, 4.65% dan 6.99% untuk persekitaran statik. Untuk persekitaran dinamik, prestasi ACS(GA), ACS+GA, ACS+TS dan ACS(TS) adalah lebih baik daripada ACS iaitu masing-masing meningkat sebanyak 0.01%, 0.56%, 1.16%, dan 1.26%. Algoritma yang dicadangkan boleh digunakan untuk penjadualan tugas dalam pengkomputeran grid dengan prestasi yang lebih baik dari segi makespan.

Kata Kunci: Algoritma metaheuristik, Ant colony system, Genetic algorithm, Tabu search, Penjadualan kerja dalam pengkomputeran grid.

Abstract

Grid computing is a distributed system with heterogeneous infrastructures. Resource management system (RMS) is one of the most important components which has great influence on the grid computing performance. The main part of RMS is the scheduler algorithm which has the responsibility to map submitted tasks to available resources. The complexity of scheduling problem is considered as a nondeterministic polynomial complete (NP-complete) problem and therefore, an intelligent algorithm is required to achieve better scheduling solution. One of the prominent intelligent algorithms is ant colony system (ACS) which is implemented widely to solve various types of scheduling problems. However, ACS suffers from stagnation problem in medium and large size grid computing system. ACS is based on exploitation and exploration mechanisms where the exploitation is sufficient but the exploration has a deficiency. The exploration in ACS is based on a random approach without any strategy. This study proposed four hybrid algorithms between ACS, Genetic Algorithm (GA), and Tabu Search (TS) algorithms to enhance the ACS performance. The algorithms are ACS(GA), ACS+GA, ACS(TS), and ACS+TS. These proposed hybrid algorithms will enhance ACS in terms of exploration mechanism and solution refinement by implementing low and high levels hybridization of ACS, GA, and TS algorithms. The proposed algorithms were evaluated against twelve metaheuristic algorithms in static (expected time to compute model) and dynamic (distribution pattern) grid computing environments. A simulator called ExSim was developed to mimic the static and dynamic nature of the grid computing. Experimental results show that the proposed algorithms outperform ACS in terms of best makespan values. Performance of ACS(GA), ACS+GA, ACS(TS), and ACS+TS are better than ACS by 0.35%, 2.03%, 4.65% and 6.99% respectively for static environment. For dynamic environment, performance of ACS(GA), ACS+GA, ACS+TS, and ACS(TS) are better than ACS by 0.01%, 0.56%, 1.16%, and 1.26% respectively. The proposed algorithms can be used to schedule tasks in grid computing with better performance in terms of makespan.

Keywords: Metaheuristic algorithms, Ant colony system, Genetic algorithm, Tabu search, Job scheduling in grid computing.

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List of Abbreviations

ABC	Artificial Bee Colony
ACO	Ant Colony Optimization
ACS	Ant Colony System
ACS(GA)	Low level hybridization between ACS and GA algorithms
ACS(TS)	Low level hybridization between ACS and TS algorithms
ACS+GA	High level hybridization between ACS and GA algorithms
ACS+TS	High level hybridization between ACS and TS algorithms
AS	Ant System
AS(GA)	Low level hybridization between AS and GA algorithms
AS(TS)	Low level hybridization between AS and TS algorithms
AS+GA	High level hybridization between AS and GA algorithms
AS+TS	High level hybridization between AS and TS algorithms
AS_{rank}	Rank-Based Ant System
BABC	Binary Artificial Bee Colony
BACO	Balanced Ant Colony Optimization
BFO	Bacterial Foraging Optimization
BWAS	Best-Worst Ant System
cMA	Cellular Memetic Algorithm
CV	Coefficient of Variation
DE	Differential Evolution
DETC	Dynamic Expected Time to Compute
EA	Evolutionary Algorithms

EAS	Elitist strategy for Ant System
EBABC1	Efficient Binary Artificial Bee Colony
EBABC2	Efficient Binary Artificial Bee Colony with flexible ranking
ET	Execution Time
ETC	Expected Time to Compute
FANT	Fast Ant System
FCFS	First Come First Served
FPLTF	Fastest Processor to Largest Task First
GA	Genetic Algorithm
GA(TS)	Low level hybridization between GA and TS algorithms
GA+TS	High level hybridization between GA and TS algorithms
GBF	Genetic Bacterial Foraging
GSA	Genetic and Simulated Annealing
GTSP	Generalized Traveling Salesman Problem
HACO	Hybrid Ant Colony Optimization
HC	Hill Climbing
HCACO	Hybrid Converse Ant Colony Optimization
HGS	Hierarchic Genetic Strategy
HPDSs	High Performance Distributed Systems
IACO	Improved Ant Algorithm
JSP	Job Scheduling Problem
KPB	K-Parents Best
LJFR-SJFR	Longest Job to Fastest Resource-Shortest Job to Fastest Resource
LM	Local Move
LMCTS	Local Minimum Completion Time Swap

MA	Memetic Algorithms
MA+TS	High level hybridization between Memetic and Tabu Search
MACO	Multiple Ant Colonies Optimization
MCT	Minimum Completion Time
MDS	Metacomputing Directory Service
MET	Minimum Execution Time
MI	Million Instructions
MIPS	Million Instructions Per Second
MMAS	Max-Min Ant System
MTEDD	Minimum Time Earliest Due Date
MTERD	Minimum Time Earliest Release Date
OLB	Optimization Load Balancing
PGA1	Player's Genetic Algorithm
PGA2	Parallel Genetic Algorithm
PMCT	Player's Minimum Completion Time
PSO	Particle Swarm Optimization
PSO-GELS	Particle Swarm Optimization and Gravitational Emulation Local Search
QoS	Quality of Service
RGA	Risky Genetic Algorithm
SA	Simulated Annealing
SGA	Struggle Genetic Algorithm
SLM	Steepest Local Move
SS	Scatter Search
SSGA	Steady-State Genetic Algorithm

SwA	Switching Algorithm
TS	Tabu Search
TSP	Traveling Salesman Problem

CHAPTER ONE

INTRODUCTION

The concept of grid systems goes back to 1969 when Leonard Kleinrock wrote, “We will probably see the spread of computer utilities, which, like present electric and telephone utilities, will service individual homes and offices across the country” (Wankar, 2008). From that time, many researchers presented various works and contributed in grid systems fields. The popularity of grid systems started by the late 1990s when Foster developed a grid system called Globus Toolkit (Foster & Kesselman, 1997; 2004).

Grid systems evolves from existing technology such as distributed computing, web service, and Internet (Magoules, Pan, Tan, & Kumar, 2009). According to Xhafa and Abraham (2010), grid computing is defined as “Geographically distributed computers, linked through the internet in a Grid-like manner, which are used to create virtual supercomputers of vast amount of computing capacity able to solve complex problem from e-Science in less time than known before”.

Magoules, Nguyen, and Yu (2009) presented an extensive definition for grid systems as “A hardware and software infrastructure that provides transparent, dependable, pervasive and consistent access to large-scale distributed resources owned and shared by multiple administrative organizations in order to deliver support for a wide range of applications with the desired qualities of service. These applications can perform either: high throughput computing, on-demand computing, data intensive computing, or collaborative computing”.

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