International Journal of Computer Applications (0975 – 8887)
Volume 30– No.11, September 2011

Proffering a new Method for Grid Computing Resource Discovery based on Economic Criteria using Ant Colony Algorithm

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ABSTRACT
In computational grids, heterogeneous resources with different ownerships are dynamically available and distributed geographically. Resource discovery is one of the most important services of grid computing. Resource Discovery service provides mechanisms to identify the set of resources that are capable of satisfying the job requirements. It is not realistic to build the resource discovery mechanisms for such computational platform without considering economic issues. Developing computational economic-based approaches is a promising avenue for building efficient, scalable and stable resource discovery mechanisms without a centralized controller for computational grids. In this paper, a new method based on peer to peer model for the resource discovery problem with economic criteria that has essential characteristics for efficient, self-configuring and fault-tolerant resource discovery is proposed. This method employs an Ant Colony algorithm to locate the required resources. Finally proposed method with existing methods by using simulation will be compared.

Keywords
Resource discovery, ant colony, economic criteria, p2p

1. INTRODUCTION
In computational grid [2], heterogeneous resources with different ownerships are dynamically available and distributed geographically. Grid [1] and Peer-to-Peer (P2P) computing platforms enable the sharing, selection, and aggregation of geographically distributed heterogeneous resources—such as computers and data sources—for solving large-scale problems in science, engineering, and commerce. However, resource management and scheduling in these environments is a complex undertaking. The geographic distribution of resources owned by different organizations with different usage policies, cost models and varying loads and availability patterns is problematic. In computational grid the producers (resource owners) and consumers (resource users) have different goals, objectives, strategies, and requirements. Economic-based grid computing offers an incentive to resource owners for contributing and sharing resources; and motivates resource users to think about tradeoffs between the processing time (e.g., deadline) and computational cost (e.g., budget), depending on their QoS requirements. We believe that this approach is essential for promoting the Grids as a mainstream computing paradigm, which can lead to the emergence of a new service-oriented computing industry. The resource management that include discovery and selecting resource for scheduling job in Grid computing environment need to manage resources and application execution depending on resource consumers and owners requirements, and they need to continuously adapt to changes in the availability of resources. This requirement introduces a number of challenging issues that need to be addressed namely, site autonomy, heterogeneous substrate, policy extensibility, resource discovery or co-discovery, online control, resource trading, and quality of service based on economic criteria. Resource discovery service in Grid is a basic service that identifies a set of suitable resources for a given job in dynamic, distributed, and heterogeneous environments. Given a description of job requirements, the service provides information (typically address) of resources that match the job requirements. In contemporary grid systems, resources are owned by research institutes, popular universities, and large organizations. Efficient and effective resource discovery in this environment is then critical.

In this paper, a new method for resource discovery using ant colony system, based on economic criteria is proposed. In this approach resource information is distributed across the grid. An ant colony system is responsible for resource discovery within peer to peer organization of information node. This paper is organized as follows. Section 2 deals with resource discovery introduction, section 3 discusses the Economic criteria for resource discovery, in section 4 proposed peer to peer structures will be described, section 5 shows ant colony algorithm, section 6 describe request transfer strategy and section 7 shows experimental evaluation. Finally, section 8 concludes with future directions.

2. RELATED WORK
There are many projects undergoing to address the issue of service discovery in the grid. Traditionally resource discovery in grids is mainly based on centralized or hierarchical models. These models are not scalable and could be the potential bottleneck of performance and security and single point of failure.

Condor is a resource management system for compute-intensive jobs [12].Condor adopts a centralized scheduling model. Recently, several research projects have investigated techniques for P2P Grid systems which let us share resources (computers, databases, instruments, and so forth) distributed across multiple organizations. The P2P Grid is emerging as a promising platform for executing large-scale, resource intensive applications. Iamnitchi et al.

propose resource discovery approach in [8] based on an unstructured network similar to Gnutella combined with more sophisticated query forwarding strategies taken from the Freenet overlay network. Several systems exploiting DHT-based P2P approaches for resource discovery in Grids have recently been proposed [13].

Recently, some research efforts have been invested in applying Ant Colony Optimization systems to tackle the resource management and the self-organization of large-scale and distributed systems. Cao employed an ant-like self-organizing mechanism to distribute jobs evenly among available resources. A hybrid Ant Colony Optimization (ACO) algorithm is proposed and designed to select appropriate schedules in a heterogeneous computing environment [14].

3. RESOURCE DISCOVERY

The grid resource discovery problem [8] can be defined as the problem of matching a query for resources, described in terms of required characteristics, to a set of resources that meet the expressed requirements. The problem is complicated by the fact that some resource information (e.g., CPU load or available storage) changes dynamically. Resource discovery techniques maintain the resource attribute and status information in a distributed database and differ in the way they update, organize, or maintain the distributed database.

The challenge is to devise highly distributed discovery techniques that are fault tolerant and highly scalable.

Matching the needs of an application with available resources is one of the basic and key aspects of a Grid system. Resource Discovery is systematic process of determining which grid resource is the best candidate to complete a job with following trade-offs.

- In shortest amount of time.
- With most efficient use of resources.
- At minimum cost

In this paper a new method for resource discovery mechanism based on ant colony algorithm with the aims of cost optimization is proposed. Proposed model organized resource as a p2p model.

Peer-to-peer systems have several desirable properties, including high scalability and reliability and the capability of self-healing the P2P overlay when nodes fail or join the network. Several researchers have observed that P2P and Grid paradigms have several goals in common, and some P2P Grid services have been developed [10]. In this paper, challenges and advantages of applying p2p techniques to Grid resource discovery services is described. Proposed method employs an Ant Colony System (ACS) [5] algorithm in peer to peer environment to locate the required resources for incoming job. At the next section characteristics of p2p environment will be describe.

4. ECONOMIC CRITERIA FOR RESOURCE SELECTION

In economic computational grid [3-4], resources have prices and the users must pay for executing their applications. The user determines his deadline and budget and then requests cost or time optimization. A grid resource discovery mechanism that adopts cost optimization strategy should discover heterogeneous grid resources for heterogeneous user jobs so that their execution finishes in the specified deadline with minimum cost. In this paper, a new mechanism for cost optimization based on ant colony method for grid resource discovery is proposed.

5. PROPOSED PEER TO PEER STRUCTURE

In this paper a flat structure for organization of information nodes is proposed. All grid resource information is registered in information nodes. The Proposed structure is an efficient and extendable environment. It does create a dynamic network of directories. Resource search in this structure uses peer to peer method. Directory is an aim of information node or peer in peer to peer search method. Peer to peer resource search method is fully distributed. In this way information's nodes that participate in resource search are equally in terms of importance. That means each information node can be process every query search and perform the search. This structure is illustrated in fig 1.

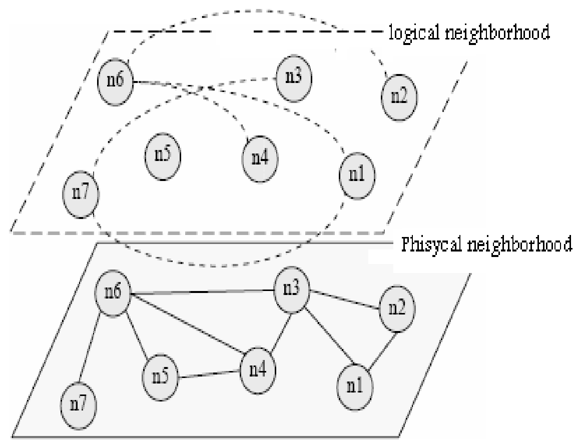

Fig 1: proposed P2P structure for information node organization.

Grid from resource searching perspective is a set of information nodes that are geography distributed. Each information node can be attached to other information nodes through contacting with them. In peer to peer search method each information node knows limited set of information nodes that associated with them. These set known as neighborhood of this node. These neighborhoods are logical neighbors' not physical ones. Note to fig 1.

Users send their request to known nodes. If any information about the location of required resource in user request exists in local node, this nodes return information to user, otherwise request sends to one of the neighbors. This operation repeated until appropriate resource was found or TTL is valid. A Time-to-Live (TTL) value is used to manage the number-of-hop permitted in any query search. For transfer of request from a node to another node ant colony method is used.

6. ANT COLONY ALGORITHM

Ant colony optimization (ACO) is a Meta heuristic alternative for solving the complicated optimization problems [13]. The base of this algorithm is based on the mass movement of ants in the nature. To attain to the food,

initially, an ant begins randomly moving and along its route, it will leave a material called pheromone [14]. Passing the time, it will increase its content to such extent that resulted in using the same route by other ants to attain their goal.
ACO was expressed for the first time in a PhD thesis for solving the problem of hawker seller [15]. In this problem we are going to find the shortest route in the weighted graph such that all nodes can be met only once. In this problem, ants will be put on different nodes of graph. Any ant may choose its next node randomly and by calculating the special probability function according to equation (1). In any repeat in the problem, such choices will be continued to such extent that all nodes could be surveyed.

$$P_k(i,j) = \frac{[\tau(i,j)]^{\alpha}.[\eta(i,j)]^{\beta}}{\sum_{l \in N_i^K} [\tau(i,l)]^{\alpha}.[\eta(i,l)]^{\beta}} \quad (1)$$

Where artificial ant K in node i will choose node j, with probable value $P_k(i,j)$. In addition, $\eta(i,j) = \frac{1}{d(i,j)}$ is a heuristic function where $d(i,j)$ is he distance between two towns i and j. N_i^k indicates the neighborhoods of node i where ant K has not yet met it. $\tau(i,j)$ is also indicating the rate of pheromone existing in the route. Meanwhile, the rate of pheromone present in a route may not be remained in the same size and may be changed according to equation (1) .

$$\tau(i,j) = \rho.\tau(i,j) + \sum_{k=1}^{m} \Delta\tau_k(i,j) \quad (2)$$

Where ρ is the evaporation rate of pheromone and m is the number of ants. The $\Delta\tau_k(i,j)$ which is equal with the size of ants remained, will be calculated according to equation (2).

$$\Delta\tau_k(i,j) = \begin{cases} L_k & \text{If arc (i,j) is used by ant k} \\ 0 & \text{Otherwise} \end{cases}$$

According to Elitist algorithm, at the end of choosing whole nodes by any ant, the ant that could find the best rout allowed to be updated [5]. It must be noted that in all problems that are being solved by any way using ant colony optimization, choosing the parameters is very important.

6.1 Advantage of Ant Colony Algorithms

Ant Colony Algorithm based systems are very flexible and robust with respect to environmental constraints and disturbances which makes them very attractive for technical realizations [4]. Moreover, Ant Colony Algorithms inherits some important advantages such as:
Scalability: The number of individuals can be adapted to the network size.

Fault tolerance*:* Since the behavior of an ant is not controlled by a centralized entity, the loss of a few individuals does not cause catastrophic failure.

Adaptation*:* The ant can react to environmental changes due to the fact that each individual has the ability to adapt. This leads to a high value of flexibility.

Speed*:* Changes in the network can be spread very quickly among network users.

Modularity*:* Individuals act independently of other network layers.

Autonomy*:* Little or no human control is required.

Parallelism*:* Operations of individuals are executed in a parallel manner.

7. REQUEST TRANSFER STRATEGY

When request R_j receive to information node n_i and the correct answer does not exist in this node, then contact with neighbors of this node that since does not participate in process searching and corresponding score with it's R_j request type that is registered in it's pheromone table is requested. Corresponding score with request type R_j in neighbors of that node is shown with SC_{kj}. n_k is neighbor of that node. Then the value of SC_{kj} is compared with each other. The request sent to neighbor that has a most SC_{kj}. If the value of all neighbors is the same, then the next neighbor's should be chosen according to different way.

8. UPDATING PHEROMON TABLE

Here how to updating pheromone table is explained. The node that is nearer to resource from a node that is farther to it is more suitable node. When searching process is reached to ending node, in case of being a successful searching process, answers are produced and sent to initial and middle nodes. These answers are as follow:

$$U_{ij} = \frac{1}{d_i^{rel}} \quad \forall i \in \{1,2,...,e-1\} \quad (3)$$

That d_i^{rel} is relative distance expressed in 3 relations. Then the values of SC_{ij} (SC_{ij} is associated score with R_j type in n_i node) will be updated. As explained above, one of the main criteria in this paper is choosing resource that in comparing with other resource has lowest cost for user. So economic parameter should be involved in the pheromone table updating. As told in previous section cost of implementation a millisecond of each resource is shown with C parameter. Therefore the reverse relation of it should be entered in updating pheromone table, so that it causes the updating pheromone table in accordance with economic criteria. Therefore pheromone tables in each n_i node is updated according to the following relation:

$$SC_{ij}(t) = SC_{ij}(t-\alpha) * f(\alpha) + U_{ij} + g(C) \quad \forall i \in \{1,2,...,e-1\} \quad (4)$$

$$0 <= f(t) <= 1, \qquad f(t) = \frac{1}{t}, \qquad g(c) = \frac{1}{c}$$

α is time distance to the last time of updating score value. f(t) is evaporation coefficient of pheromone and is related to environment dynamics. g(C) is economic function for updating pheromone table.

9. REVIEW OF PREVIOUS WORK

New approach that is known with ANT_CO_ALG with proposed mechanism by author in [7] as LA_NEU_ALG and proposed approach by buyya in [11] as BCO algorithm in terms of Error rate, Resource Selection Time, Consuls per request and average cost for purchase is compared.

In LA_NEW_ALG, tow phase for resource scheduling designed: 1) Resource discovery 2) Resource selection. In resource discovery phase a neural network based system for discovery of resources that have minimum requirement for incoming job is designed. In the second phase the best resource form this set based on economic criteria by using of learning automata is selected, selected resource at the end of this phase has a lowest cost. More details are presented in [7].

The second mechanism that will be compared with proposed mechanism in this paper is BCO. In this algorithm a designation queue is allocated to each resource. The customers request are set in the designation queue in an ascending order of time that require to resource. The purchasers are registered in the resource based upon the in an ascending order from the cheapest one and the number of customers that each resource can fulfill. These customers are deleted from the designation queue and the resources are apportioned to them in turns. This trend keeps on until the next round of bidding. More details are described in [11].

10. SIMLUALATION ASSUMPTION

1- Experiments are performed in environment with 1000 to 5000 information node.
2- There is 10000 different type of resource in grid environment.
3- It is assumed that the multiplicity of resource is same and there is 100 sample of each resource in grid environment.
4- The bandwidth of all links can be considered constant.
5- TTL is equal to 100.
6- In each experiments 10 information nodes randomly selected and to each of them independently set of 200 requests are sent.
7- Implementation cost of each resource for users is between 0.0001 to 10 cents for one millisecond.

11. PERFORMANCE EVALUATION

The goal of these experiments is to compare the performance of the proposed mechanism with existing ones. We simulate grid environment to evaluate experimentally based on above assumption by means of gridsim [9].Reported results, is for average 20 times of simulation. Grid resources are high heterogeneous. Error rate parameter is regard to each selection for instance in failure cases of discovery, or in cases demanding re-discovery of resource. As the fig 2 shows this parameter is less than from LA_NEU_ALG and is more than from BCO algorithm. In proposed mechanism in this paper resource selection time as fig 3 shows is less than from LA_NEU_ALG and is more than from BCO algorithm. As fig 4 shows in comparison between the numbers of consultations on each request, performance of proposed method is between LA_NEU_ALG and BCO. And finally based on fig 5 average cost for purchase of selected resource in proposed method is less than from LA_NEU_ALG and BCO algorithm. According to our aims in this paper that is selecting resource based on economic criteria, as fig 5 shows proposed method in this parameter has a significant improvement over previous approaches. However, it seems that other parameters can be improved by combining this method to other techniques.

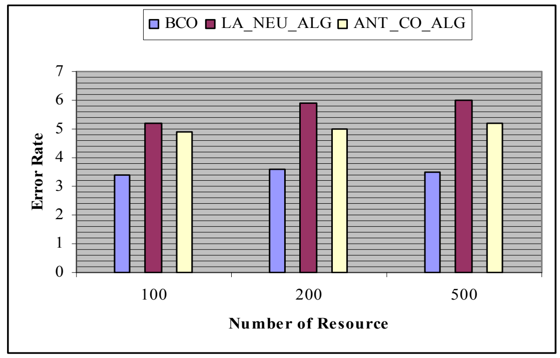

Fig 2: Error rate comparison.

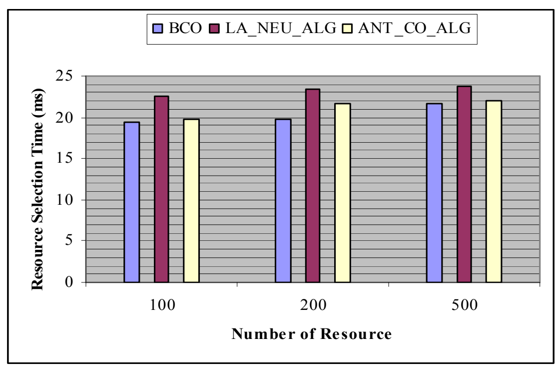

Fig 3: Resource selection time comparison.

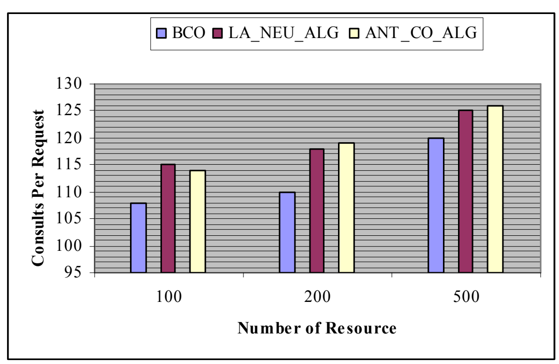

Fig 4: Consults per request comparison.

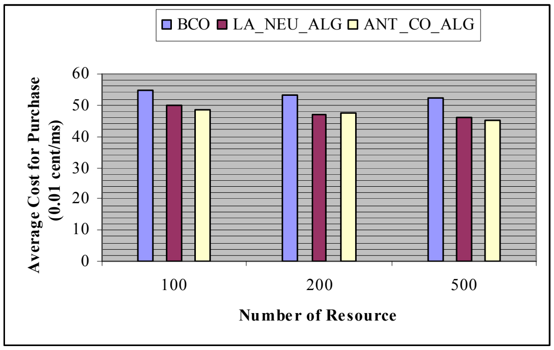

Fig 5: Average cost for purchase comparison.

12. CONCLUSION

Resource discovery is one of the phases for Job scheduling in the computational grids. A new approach for resource discovery in this paper is presented which is based on ant colony system that use of economic criteria. Proposed method uses a peer to peer structure for organization of information node. All grid resource information is registered in information nodes. User requests are sent to information node. Request transfer from a peer or node to another node uses ant colony algorithm. One of the most important factors for request transfer is economic criteria. Economic parameter has a prominent role in updating of pheromone table of each node. Finally performance of proposed approach with existing methods is compared by means of gridsim simulation software.

13. ACKNOWLEDGMENTS

This paper is resulted of research project supported by Toyserkan Branch, Islamic Azad University Toyserkan Iran have been titled "Proffering a brand new methodology for resource discovery in computational grid based on economic criteria using ant colony". I am very grateful from Dr jamebozorgi and Dr Hokmabadi for their assistance during research.

14. REFERENCES

[1] I. Foster, C. Kesselman and S. Tuecke, "The anatomy of the Grid: Enabling scalable virtual organizations", International Journal of Supercomputer Applications, 2008.

[2] Viktors Berstis, "Fundamentals of Grid Computing", IBM Redbook series, November 2009, http://ibm.com/redbooks.

[3] R. Buyya, D. Abramson, and J. Giddy, "A Case for Economy Grid Architecture for Service-Oriented Grid Computing", Proceedings of the 10th IEEE International Heterogeneous Computing Workshop, April 2010.

[4] R. Buyya, D. Abramson, and J. Giddy, Economy Driven Resource Management Architecture for Global Computational Power Grids", Proceedings of the 2000 International Conference on Parallel and Distributed Processing Techniques and Applications, June 2008.

[5] M. Dorigo, V. Maniezzo and A. Colorni, "The Ant System: Optimization by a colony of cooperating agents", In IEEE Transactions on Systems, Man, and Cybernetics Part B: ybernetics, 26(1):29--41, 2005.

[6] M. Dorigo and L. M. Gambardella, "Ant Colony System: A cooperative Learning Approach to the Traveling Salesman Problem", In IEEE Transactions on Evolutionary Computation, Vol.1, No.1, 2006.

[7] A. Sarhadi, M. meybodi, A.Yousefi, "proffering a brand new methodology to resource discovery in grid based on economic criteria using learning automata" waset conference vol 38 2009.

[8] Iamnitchi and I. Foster, "On Fully Decentralized Resource Discovery in Grid Environments," IEEE International Workshop on Grid Computing,Denver, CO, 2008.

[9] R. Buyya and M. Murshed, GridSim: A Toolkit for the Modeling and Simulation of Distributed Resource Management and Scheduling for Grid Computing, Technical Report, Monash University, Nov. 2001. To appear in the Journal of Concurrency and Computation: Practice and Experience (CCPE), 1-32pp, Wiley Press, May 2007.

[10] M. Ripeanu, "Peer-to-Peer Architecture Case Study: Gnutella Network,". proc. 1st IEEE Int. Conf. on Peer-to-Peer Computing (P2P2001), Linkoping Sweden, August 2007.

[11] Rajkumar Buyya, *Economic-based Distributed Resource Management and Scheduling for Grid Computing*, Ph.D. Thesis, School of Computer Science and Software Engineering, Monash University, Melbourne, Australia, April 2008.

[12] M. Litzkow and M. Livny, Experience with the Condor Distributed Batch System, Proc. IEEE Workshop on Experimental Distributed Systems, 2004.

[13] Andrzejak, A., Xu, Z., Scalable, Efficient Range Queries for Grid Information Services, Proc. of 2nd IEEE Int. Conf. on Peer-to-peer Computing (P2P'02), Link¨oping, Sweden, 2006.

[14] Ritchie G and Levine J, A hybrid ant algorithm for scheduling independent jobs in heterogeneous computing environments, Proc of the 23rd workshop of the UK planning and scheduling special interest group, 2009.