Nature Inspired Load Balancing Algorithms in a Cloud Computing Environment

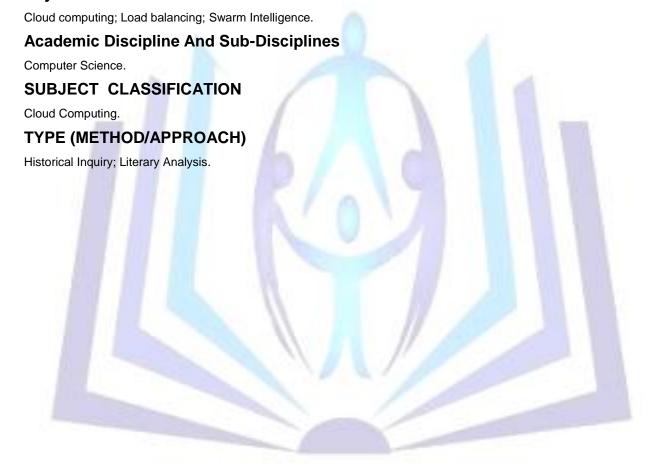Hari Prasada Raju Kunadharaju

BA Continuum India Private Limited (Bank of America Merrill Lynch), Raheja IT Park, Hyderabad

ABSTRACT

Cloud computing is a general term for anything that involves delivering hosted services over the Internet, One of the primary issues in cloud computing is implementation of a novel load balancing approach. The demanding thirst for optimal performance of the system is creating research interest in this area. Many Load Balancing algorithms that aim to enhance the overall system performance have been proposed. In this paper, we survey a special group of Load balancing algorithms that have taken inspiration from nature. We provide an overview of the current trends in the field by discussing and comparing these algorithms.

Keywords

Cloud computing; Load balancing; Swarm Intelligence.

Academic Discipline And Sub-Disciplines

Computer Science.

SUBJECT CLASSIFICATION

Cloud Computing.

TYPE (METHOD/APPROACH)

Historical Inquiry; Literary Analysis.

1. INTRODUCTION

Cloud computing is a type of computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications.The exponential growth of cloud computing in the recent years has attracted research and academia to this field. Load Balancing is a primary issue that needs to be taken care of. Several, Load Balancing algorithms have been proposed and investigated; however, there are issues yet to be addressed. Load balancing is "the process of distributing the work load among various nodes of a cloud based system to improve both resource utilization and job response time while also avoiding a situation where some of the nodes are heavily loaded while other nodes are idle or doing very little work".

Load balancing algorithms are divided as static and dynamic based upon the working environment [1], centralized and distributed based upon the control strategy [2].Static algorithms are effective in stable and homogenous environments where as Dynamic algorithms are effective in dynamic and heterogeneous environments. The centralized strategy requires an arbiter or control node to perform the load balancing act whereas in distributed strategy load balancing is performed by all the nodes of the system. Many Load Balancing algorithms have been proposed in the recent past. In this paper, we present a survey of Nature Inspired Load Balancing Algorithms that have been specifically developed for hosted environments. These algorithms use the concept of Swarm intelligence for Load Balancing [3].We consider some of the potentially viable nature inspired algorithms for load balancing in large scale cloud environments. There are two popular classes of Nature Inspired Algorithms available in the literature namely Ant Colony and Honey Bee Colony. We give an overview of these algorithms, discuss their pros and cons and analyze their properties.

The rest of this paper is organized as follows. We discuss the related work in Section II. Then, in Section III we discuss the various challenges and issues of Nature Inspired load balancing in cloud computing environment. Afterwards in Section IV, we review and compare Nature Inspired Load Balancing Algorithms that are available currently in the literature. Section V concludes the paper and highlights future enhancements that can be done in Cloud Load Balancing.

2.RELATED WORK

Klaithem Al Nuaimi, Nader Mohamed, Mariam Al Nuaimi and Jameela Al-jaroodi have presented a survey of Load Balancing in Cloud Computing. The paper gives an overview of Load Balancing Algorithms like INS, ESWLC, CLBDM, Ants Colony, Mapreduce, VM Mapping and DDFTP. It compares the algorithms based upon on certain parameters[1]. Martin Randles, David Lamb,A. and Taleb-Bendiab have presented a comparative study of three distributed load balancing algorithms namely Honeybee based load balancing, Biased Random Sampling and Active Clustering. The paper describes and compares the algorithms by performing experiments using simulations set up in Repast.NET[4].Rich Lee and Bingchiang Jeng in their work made a comparitative analysis of Round-Robin, Weighted Round-Robin,Least Connection, Shortest Expected Delay, Resource Best and Resource Fit algorithms using a simulation program based on GNU R[5]. V. Sesum-Cavic and E. Kuhn have presented the advantages of using swarm intelligence in load balancing in their works [6].

3.ANALYSIS OF ISSUES RELATED TO NATURE INSPIRED CLOUD LOAD BALANCING ALGORITHMS

In this section we give an introduction to the major challenges a Nature Inspired Cloud Load Balancing Algorithm must address before it is implemented in the system. These challenges if not addressed properly may affect the performance of the algorithm. These challenges are summarized as follows.

3.1. Nature of the Cloud

Static Nature Inspired Cloud Load Balancing Algorithms are designed to work with static clouds. The performance of these algorithms is satisfactory in stable cloud environments. However, it is a challenge to design a dynamic Nature Inspired Cloud Load Balancing Algorithm that is flexible and adapts to the dynamic changes in the attributes of the system.

3.2. Control Mode

Nature Inspired Cloud Load Balancing Algorithms are mostly centralized. Having a single point of control in large scale cloud computing environments makes load balancing a daunting task. Moreover, if the arbiter goes down it brings the whole system to a halt which is not desirable. Hence, distributed or even hybrid algorithms are required. Designing a distributed Nature Inspired Cloud Load Balancing Algorithm that gives optimal performance is a challenge.

3.3. Resource Awareness

 Nature Inspired Cloud Load Balancing Algorithms are designed to work with homogenous resources. But in most cases, a cloud computing environment is a collection of heterogeneous resources. If the algorithm being implemented is not resource aware then its performance will be adversely affected. Hence, developing a Resource aware Nature Inspired Cloud Load Balancing Algorithm is a challenge.

3.4. Geographical separation of the cloud nodes

Algorithms that perform well with cloud nodes distributed over geography are yet to be devised. There are some additional parameters that must be considered by the algorithm during balancing. The parameters include network speed, distance between processing node and clients, distance between nodes. Hence algorithms that work well with geographically separated cloud nodes are required [7].

3.5. Replication Model

In order to guarantee the SLA's Nature Inspired Cloud Load Balancing Algorithms must support data replication. This can be either complete or partial replication. A fully replicated algorithm comes with additional costs as data on replication nodes must be maintained. It doesn't use the available storage efficiently. On the other hand even though partial replication algorithms utilize the storage resources efficiently, they are very complex to design [8].

3.6. Ease of implementation

It is desirable that Nature Inspired Cloud Load Balancing Algorithms are easily implemented and operated. Complexity in algorithm's implementation will raise performance issues. Therefore, Simple algorithms are required [9].

3.7. Network Overhead

Nature Inspired Cloud Load Balancing Algorithms have to deal with overhead of the network as the so called software ants honey bees continuously traverse through the network to gather information of the cloud nodes. The presence of large number of ants or bees may sometimes degrade the system performance [10].

3.8. Scalability

The scale of a cloud computing platform can be very large. Nature Inspired Cloud Load Balancing Algorithms must be devised to take in to consideration the scalability factor. They must be flexible enough to work in a situation where a resource can be randomly added. The algorithm must quickly take into consideration the newly added resource and perform load balancing with little effect on system performance.

3.9. Synchronization

Nature Inspired Cloud Load Balancing Algorithms perform the operation of load balancing with the help of agents like artificial ants or honey bees. The algorithm generates a large number of agents. These agents continuously traverse through the cloud and monitor it. Achieving synchronization among the agents is a challenging task for the algorithms.

4. REVIEW OF NATURE INSPIRED CLOUD LOAD BALANCING ALGORITHMS

In this section we give a review of Nature inspired cloud load balancing algorithms that are currently available in the literature. Nature inspired cloud load balancing algorithms can be categorized in to two classes namely, Ant Colony Inspired Algorithms and Honey Bee Inspired Algorithms. We first discuss the Ant colony Inspired Algorithms that have been developed for cloud load balancing. Then later discuss the Honey Bee Inspired cloud load balancing algorithms. TABLE I shows a comparison of Nature Inspired Load Balancing Algorithms that are reviewed in this paper.

4.1. Ant Colony Inspired Load Balancing Algorithms

All Ant Colony Inspired Load Balancing Algorithms are based on ACO algorithm [11, 12]. Individual ants are quite simple insects but colony of ants collectively perform a variety of tasks such as building anthills, foraging for food with great reliability and consistency[13,14].This social behavior of ants has inspired researchers to solve many computational problems that includes even the problem of Load Balancing a Cloud. We discuss three popular ant colony inspired load balancing algorithms.

Zehua Zhang and Xuejie Zhang have proposed a Load Balancing Mechanism based on Ant Colony and Complex Network Theory (LBMACCN) in open cloud computing federation (OCCF)[15]. The mechanism aims to solve the issue of complex and dynamic load balancing in OCCF. Underload load balancing, Overload balancing, Pheromone updating, and Network Evolution are the major modules of LBMACCN. The operation of the algorithm suits for heterogenic cloud environments. The algorithm is designed to work with distributed clouds. The fault tolerance and the scalability factor of the mechanism are excellent. The algorithm requires a full replication model. It has to deal with network overhead problem because ants keep on traversing across the network which sometimes may lead to delays. Synchronization of the ants and Static nature of the algorithm are issues to be considered.

Kumar Nishant et al. - have proposed an algorithm that performs the task of load balancing of nodes in cloud using the Ant colony optimization [10]. The algorithm is an improved version of algorithm presented in [15]. It aims at efficient load distribution among the cloud nodes such that the ants never come across a dead end during network traversal for building an optimum solution set. The algorithm suits for heterogenic and distributed clouds. The fault tolerance and the scalability factor are excellent. The issue of synchronization between ants is solved. The algorithm requires a full replication model and has to deal with network overhead problem. It is a Static Load Balancing Algorithm.

Both the above mentioned algorithms work in the following manner, ants and pheromones are generated from a head node once a request is generated .In order to gather node information for task scheduling ant behavior is used. The ants start their forward route from the 'head'. A forward movement means that the ant is searching for overloaded nodes whereas reverse movement indicates it is searching for an underloaded node. The authors of [10] have introduced a new feature termed 'suicide' to the ants. Once the target node is found the ant will be terminated preventing unnecessary backward movement.

Kun Li et al. - have proposed LBACO (Load Balancing Ant Colony Optimization) algorithm for load balancing in cloud based systems [16]. The algorithm is simulated using CloudSim version 2.1 toolkit package. The algorithm is based on ACO algorithm [11, 12]. The algorithm considers the past task scheduling time to carry out new scheduling strategy. It reserves the current optimal solution and uses it to make a decision in future Load balancing scenarios.

The experiment discussed in [16] proves that LBACO is more effective when compared with ACO algorithm. The algorithm suits for dynamic, distributed and heterogeneous clouds. The algorithm assumes that the tasks are mutually independent, preemptive and computationally intensive.

4.2. Honey Bee Inspired Load Balancing Algorithms

Honey Bee inspired technique is used as a search technique in many computing applications where the system is highly scalable and dynamic [17]. A bee hive works as follows. There are two roles a bee can play namely forager bee and follower bee. Forager bees search for a suitable source of food, when found, they return back to the colony and advertise the same using a "waggle dance". The quality, distance and quantity of the food are judged based upon the intensity of the dance. Follower bees are sent out to harvest the discovered food. The waggle dance is used to determine whether more bees are required to harvest or the exploited source to be abandoned. The same phenomenon is being applied in load balancing of nodes in cloud computing environment. We discuss 2 popular bee inspired Load Balancing Algorithms that are available in the literature.

Martin Randles, David Lamb and A. Taleb-Bendiab have proposed a Honey bee inspired Load Balancing algorithm [4].The working of the algorithm can be explained as follows. The servers in the cloud take the role of either foragers or harvesters' .An advert board that mimics the waggle dance of the bees is maintained. A server successfully executing a request will post on the board. A server that reads the board follows the chosen advert, and then serves the request; thus mimicking the harvest bee. The server not reading the advert board serves a random virtual server's queue request; thus mimicking the forager bee. The total colony profit is calculated based upon just-serviced virtual server profit. If the just serviced virtual server's profit is high then the forager server will keep on posting an advert for it until the calculated profit becomes low. The algorithm is suitable for large scale, dynamic and heterogeneous cloud environments. The algorithm suffers with Network Overhead and replication issues. Given an optimum profit calculation method, this algorithm provides a good distributed solution to the problem of Load balancing in cloud computing environment.

Jing Yao and Ju-hou He, have presented a Load Balancing Strategy for cloud computing based on Artificial Bee algorithm [18]. The algorithm is an improved version of the algorithm proposed in [4]. The previous mechanisms were considering only lightly loaded nodes for balancing where the technique in [18] considers all resources in the cloud iteratively. The algorithm includes some extra operations that improve the quality of service. Experimental results show that in a system with a fixed number of systems and increasing number of requests the algorithm generates an improved throughput whereas a change in number of servers and fixed number of requests the original ABC algorithm performs well. The algorithm is dynamic, distributed and suitable for heterogeneous cloud systems; whereas, it suffers in a highly scalable system. Network Overhead and replication model should also be considered before implementing this algorithm in a cloud based system.

5. CONCLUSIONS AND FUTURE WORK

We present a survey of Nature Inspired Load Balancing Algorithms that are available in the literature. We have discussed the challenges that these algorithms must address. The pros and cons of the algorithms have also been depicted. We have drawn out comparisons between the algorithms by taking into account the necessary parameters. All the algorithms discussed in the paper suffer with one or the other issue. Hence there is scope for improvement in the algorithms. Therefore, as part of future work we plan to propose our own Nature Inspired Load Balancing Algorithm for cloud computing that addresses the issues discussed earlier.

	LBMACCN	LBMACCN in [17]	LBACO	ABC in [20]	ABC in [21]
Dynamic	NO	NO	YES	YES	YES
Distributed	YES	YES	YES	YES	YES
Heterogeneous	YES	YES	YES	YES	NO
Geographical Separation of nodes	NO	NO	NO	NO	NO
Complexity	EASY	EASY	MEDIUM	EASY	MEDIUM
Network overhead	YES	LESS	YES	YES	YES
Scalability	NO	NO	YES	NO	NO
Synchronization	NO	YES	YES	NO	YES

TABLE 1: Comparison of Nature Inspired Load Balancing Algorithms

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Author' Biography with Photo

Mr. Hari kunadharaju is a diligent IT professional with a proven track record of successful delivery in the areas of Application Development and Service Delivery. He is currently working as Senior Manager @ Bank of America Merrill Lynch. He has a Master's degree in Telecommunications Engineering from Monash University, Australia. His research interests include Data Mining, Data Warehousing, Cloud Computing and Software Engineering. He is always focused on achieving the end result with a quiet determination, overcoming any obstacles and exceeds all expectations. He has a strong support experience in the areas of Fixed Income Securities and Reconciliation systems pertaining to Global Markets. He is a Microsoft SQL Server, Oracle PL/SQL and ITIL (*Information Technology Infrastructure Library)* Certified Professional.