

Artificial bee colony algorithm used for load balancing in cloud computing: review

Arif Ullah¹, Nazri Mohd Nawi², Jamal Uddin³, Samad Baseer⁴, Ansam Hadi Rashed⁵

^{1,2}Faculty of Computer Science and Information Technology Universiti Tun Hussein Onn Malaysia, Malaysia

³Qurtuba University of Science and Technology, Peshawar, Khyber Pakhtunkhwa, Pakistan

¹University of Chitral–Khyber, Chitral, Khyber Pakhtunkhwa, Pakistan

^{4,5}University of Enginetnering and Technology, Lahore, Punjab, Pakistan

⁵University of Diyala, Ba'qubah, Irak

Article Info

Article history:

Received Dec 28, 2018

Revised Mar 7, 2019

Accepted May 18, 2019

Keywords:

Algorithm

Load balancing

Swarm intelligence

Virtual machine

ABSTRACT

Cloud computing is emerging technology in IT land. But it still faces challenges like load balancing. It is a technique which dynamic distributed work load among various nodes equally in a situation where some nodes are under load and some are overload. Main achievements of load balancing are resource consumption and reduce energy. Swarm intelligence provides an important role in the field of those problems which cannot easily solve and they need classical and mathematical technique. An artificial bee colony is a foraging behavior inspires algorithm it established by karaboga in 2005. It has fast convergence, strong, robustness, and high flexibility. The different researcher used ABC algorithm for improvement in load balancing. This review paper is a comprehensive study about load balancing in cloud computing using ABC algorithm. It also defines some basic concept about swarm intelligent and its property.

Copyright © 2019 Institute of Advanced Engineering and Science.
All rights reserved.

Corresponding Author:

Arif Ullah,

Faculty of Computer Science and Information Technology,

Universiti Tun Hussein Onn Malaysia,

86400 Parit Raja, Johor, Malaysia.

Email: arifullahms88@gmail.com

1. INTRODUCTION

Load balancing in cloud computing provides a well-organized result for Varity of an issue in a cloud environment. Normally there are two main type of load balancing which are task scheduling and resource scheduling in a distributed environment. One of the main elements in task scheduling is to provide user demand on time [1]. In a cloud environment virtual machine manage all the activity in the data center for load balancing activity. It contains a large amount of data and resources. Load balancing is the important concept of the batter performance within the 156nvironment [2]. With the growth of internet and cloud user demand, it needs to provide a better result for that purpose load balancing is important. For that reason, different researcher designs ABC algorithm for scheduling purpose and it improves the result in makespan and network stability. Swarm intelligence (SI) is the collective natural behavior in the form of decentralized, self-organized systems, or artificial. SI systems are typically made up of a population of simple agents interacting locally with one another and with their environment [3]. The inspiration often comes from nature, especially biological systems. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of “intelligent” global behavior, unknown to the individual agents. Natural examples of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling [4]. Research in SI started in the late 1980s. Besides the applications to conventional optimization problems, SI can be

employed in library materials acquisition, communications, medical dataset classification, dynamic control, heating system planning, moving objects tracking, and prediction. Indeed, SI can be applied to a variety of fields in fundamental research, engineering, industries, and social sciences. ABC of them and applied in cloud computing for reducing load balancing.

The main objective of this review paper are given below

- To Review previous literature about ABC algorithm.
- To Review previous literature about load balancing in cloud computing
- To identify the important of ABC algorithm in load balancing purpose

This review paper contains information about ABC algorithm, It is used for load balancing purpose. It is organized like as section 1 Introduction, Section 2 Preliminary Section 3, ABC algorithm Section 4, Implementation of ABC and Section 5 About important result.

2. PRELIMINARY

In this section, we define some basic and related terminology about ABC and load balancing in cloud computing.

2.1. Algorithm

Consists of rules which are used for solving problems in a finite number of steps. Algorithms are set of the formula used for solving problems on the basis of sequence and specific action. These kinds of programs or algorithms are frequently used in information technology [5]. A set of unambiguous instruction that is used for a given set of instruction and performed an action to achieve certain goals that have been recognizable [6]. Normally algorithms are classified in to three groups Figure 1 shows the classification of the algorithm.

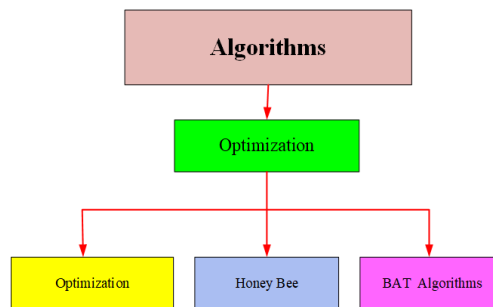


Figure 1. Classification of the algorithm

2.2. Heuristic algorithm

Used a simple approach to solve the problems by solving learning a discovering that simple method, not sure for the sufficient result. A heuristic technique used for speed up the process. We can say they are used for shut cut for time. Heuristic problems are dependent technique such as some problems are used to solve adapted using normal formula and these problems are too greedy and usually, get trapped in local optimum and fail in global optimum [7].

2.3. Met heuristics

Is problems independent technique it does not take any specificity of any problems, it can be used as a black box, they are not greedy. A met heuristic is a high-level problem independent algorithm; it delivers a set of rule for the development of optimization problems [8].

2.4. Hybrid algorithm

Is the mixture of two or more than of algorithm, they solved the same problems. It does not rise to simple coalescing numerous algorithms to decipher a different problem and may algorithm used for solving the same problems but hybrid used to solve those problems in a better way. Normally animals are living in group form as compare individuals because if they are in the group from then can solve their problems as comparing individuals and they protected them self easily and better [9]. Recently the theory of self-organization in animal behavior and the study of collective behavior has promoted solving different

problems. On that basis, a different algorithm is designed and used in different fields. Swarm intelligence (SI) one of the main disciplines of artificial intelligence (AI), based on multi-agent system inspired by the behavior of social insects such as ants, bee, wasps and as well as animals like flocks, fish [10]. With the help of collective behavior and decentralized and self-organized system are known as swarm intelligence. SI-based on characteristically prepared of inhabitants of simple agents who are intermingling with each other in the atmosphere they inspired from nature especially biological systems. ABC algorithm is an example of SI which inspires from bee behavior [11].

2.5. Swarm intelligent

Becomes very popular in the research field and may researcher used for their requirement. A different attempt is made to design an algorithm or distributed problems for solving device by stimulated by the cooperative behavior of social behavior like colonies and other animal's behavior. The tenure swarm is used for any unemotional assortment of intermingling agent or beings; one of the main examples is bee [12]. Swarm intelligent is a novel field which statements the study of the cooperative behavior of a system that coordinate with each other by using central control system and self-association Large part of research in SI concern with antithesis engineering and adaptation of combined behavior of nature system. Swarm intelligent (SI) is a discipline of artificial intelligent (AI) which apprehensive with the intention of the multi-agent system by tasking creativeness of collective behavior of social insects such as a bee, wasps, ants and other animals like birds, fishes [13]. Normally in swarm intelligent different number of homogeneous and simple number of agent interacting them self and their surroundings with no central control with global interesting behavior with each other and there are different models of swarm intelligent which referred as computational models some of the modes are ant colony optimization, particle swarm optimization, artificial bee colony, bacterial foraging, cat optimization, and glowworm swarm intelligent [14]. Figure 2 shows the nature based algorithm.

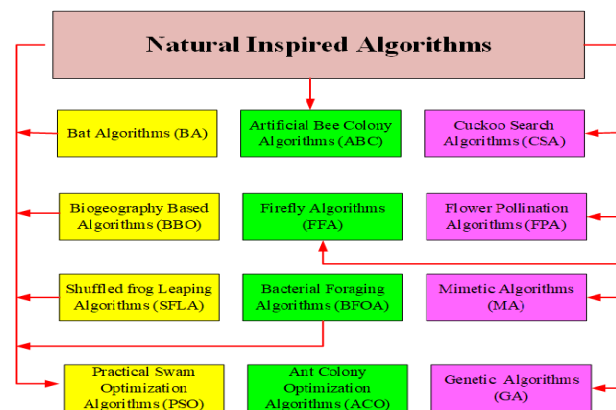


Figure 2. Nature based algorithm

2.6. Different stage of honey bee Foraging behavior

The most important character of honey bee is the foraging behavior. In this process bee left the hive and start searching for food source where she find the food source she extract the nectar from it and then store in to her stomach. After extract the amount from the nectar till 30 to 120 mints according to the condition she star making bee when it reached in to hive the amount of bee ready it put it in to hive. Then it shares the information to other bee in dance form [15].

2.7. Dance

The steps of dance are performed tell to other bee about the food source, direction, amount of nectar and quality and different type of dance performed in the hive area. When she dancing other bee touches him with antenna in order to taste the nectar of food source. Different types of dance are.

2.8. Round dance

This kind of dance does not inform about the distance but this kind of dance are used when the hive is near or when they reached to the food hive.

2.9. Waggle dance

This dance is used to inform another bee about food source and direction of food source if the food source is far away the employed bee used this dance for the direction [16].

2.10. Tremble dance

If the bee takes longer time in the food source then she starts this kind of dance to know about the current position of the bee because they take load time before informing other.

2.11. Nest site selection

The process of nest selection consists of some important issue like the size of crack to hold combs and stiffness of the opening weather and manufacture time, the main point is that given incorporated resolution given to all swarm without conflicts. For the achievement of this mission many scout bee working in parallel for exploring the potential nest site and split in rank about an explored site with other dancing scout bee.

2.12. Navigation

Forger bee used special kind of map similar to the association of spatial memory for a homing food source and search flight. This consist of two computation component knows as vector and viewpoint landmark. And the navigation consists of two main elements these are stimuli of bee and the second one is encoded spatial information dance [17].

2.13. Task selection

Normally the different tasks are distributed into a different bee and these tasks are dynamically distributed in the environment and change to the given environment. Some tasks are special for a special group or individual bee [18].

2.14. Cloud computing

People adopting new technology in order to achieve their required goals. Cloud computing is one of them people getting a huge amount of data in high speed and large memory storage. The exciting field of cloud computing change in to new it land with large advancement in business and operation [19]. The increase of energy and envirment both are concern with cloud computing. Therefore more and more attraction are need to change cloud computing in to green computing [20]. Figure 3 shows cloud computing.

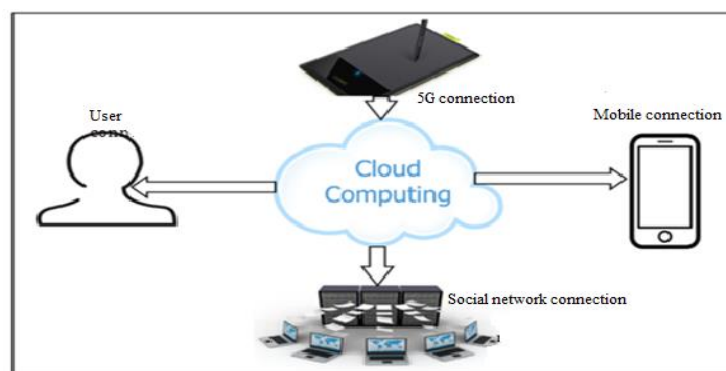


Figure 3. Shows cloud computing

Due to the growth of cloud computing the user demand for more batter result and better service due to this demand load balancing become more important and interesting concept. Load balancing disseminated the load among different in cloud computing in situations where some node are heavily loaded and some are under load this senior make issue in cloud computing to solve this situation load balancing used. Load balancing is the process of managing the total load in to individual node for the collective system and improvement of resource utilizations [21]. Figure 4 shows the load balancing approach. Figure 4 shows the type of load balancing normally there are two main type of load balancing which are dynamic and static and they are further divided in to a different group. Table 1 show the matric of load balancing along with their expiations. In research field a researcher take one or two parameter and them try to improve the load balancing.

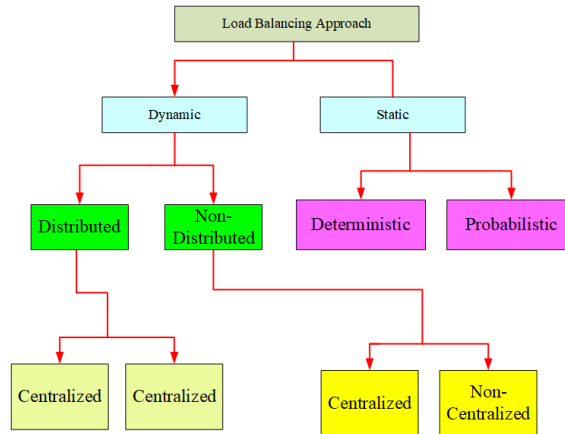


Figure 4. Load balancing approach

Table 1. Show the metric of load balancing

Metric	Expiations
Throughput	The number of tasks those execution has been completed is calculated that process is known as throughput. If it is higher than improve the performance.
Fault Tolerance	When job or resources are a movie from the node to another node in this process time taken that is known as fault tolerance. It needs to minimize in order to reduce the performance.
Response time	The amount number of time taken by a particular load balancing algorithm in a distributed system. This action must be minimized.
Scalability	It is the ability of an algorithm to perform load balancing for a system with any finite number of nodes. This metric should be improved.
Performance	It checks all the parameter like a reasonable cost reduces task response time and needs an acceptable delay.
Overhead	When implementing a load balancing algorithm it determines the amount of overhead. It occurs interposes communication. It must be minimized for load balancing technique.
Resource utilizations	It checks the resource which is used and optimization technique used for fewer resource utilizations.

Figure 5 shows the basic load balancing policies which are classified in to four groups they are information strategy, triggering strategy; transfer strategy and location strategy and these are future divided in to groups. But ABC algorithm applied in transfer strategy and all the paper which are used ABC algorithm for transfer strategy are mention along with other parameter are mention in Table 2.

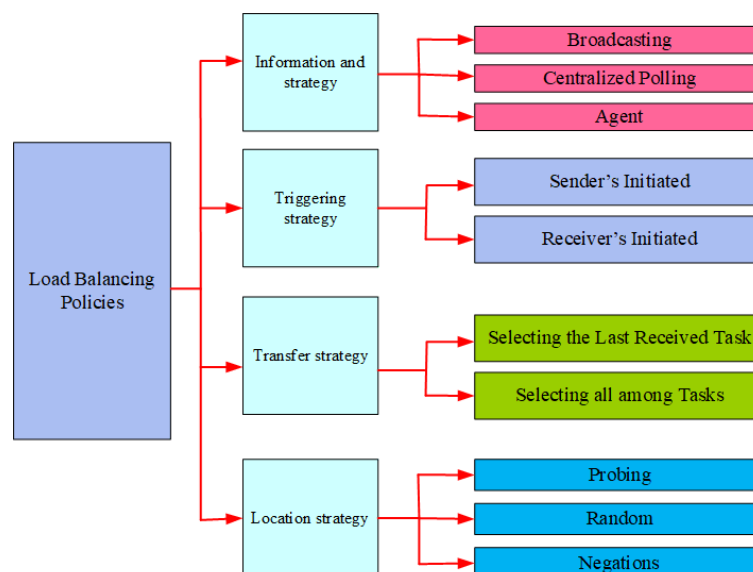


Figure 5. Shows load balancing polices

3. ABC ALGORITHMS

Karaboga has designed an artificial bee colony (ABC) algorithm to mimic the foraging behavior of honey bee swarm intelligence. Meta-Heuristic is Greek words and it consists Meta which means high-level and heuristics means to find or to know. Meta-heuristic is set of the intelligent step which enhances the efficiency of heuristic procedure [22]. An artificial bee colony is nature enthused algorithm which is based on the foraging behavior of bee. Artificial bee colony (ABC) algorithm new optimization method which is good at consideration but poor at manipulation. The artificial algorithm is proposed for optimization technique and they used intelligent foraging behavior of honey bees. The collection honey bee is called swarm which can productively complete task concluded collective cooperation; normally there are two fundamental processes which derive for the ABC population which are global optimum and local optimum [23]. An optimization technique is an important role in a different field from the previous last two decades several swam intelligent algorithm are used, ABC is one of them. ABC is one the most recent swam base algorithm it competitive to solve optimization purpose; however there is still some working remaining to improve in exploitation but it good in exploration ABC is one of the wide search algorithm and research are inspiring from it and used for real world problems there are three group of bees which are explained below [24].

- Food source: The bee collected food from a particular flower that is known as a food source. Form this food source the bee knows about the amount of food, distance and how easily the food gets to form the nectar. Bee stores this information for the sake of convincing and simplicity to share with upcoming of bee group [25].
- Employed bee: These are the group of the bee which contains all the information like richness, distance, and direction from the hive all bout food sources are known as employed bee [26].
- Unemployed bee: share the information with another group that is known as an employed bee. Unemployed bees are responsible to summarize that information which they get from employed bee for food source purpose. Unemployed bees are future divided in to two types which are onlooker bee and scout bee [27].
- Onlooker bee: Are those which collected information from employed bee which is present in the hive after the analysis.
- Scout bee: Are responsible for searching new food source around in hive. When they find some existing food source they start searching new one in the given environment normally honey bee swarm average 50% are employed bee. 50% are an unemployed bee, and 5% to 10% are scout bee [28]. Figure 6 shows the working of the different bee.

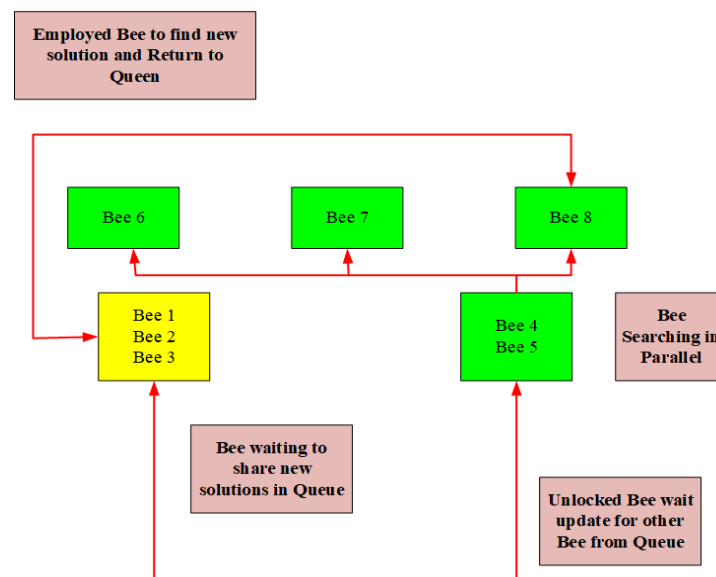


Figure 6. Working of bee

Figure 6 shows the information about bee and their selection method of next food source along with communication technique Table 2 conations basic information about ABC, along with their explanations.

$$P_i = \frac{\text{fit}}{\sum_{i=1}^n \text{fit}} \quad (1)$$

Where n present the number of food source.
fit is the fitness value of food source.
Pi is the probability of the solution.

Table 2. Shows the basic information about ABC.

Author	Year	Narrative
Karaboga	2005	The originator of ABC algorithm on the source of a honey bee swarm
Basturk and karaboga	2006	First conference paper published about ABC algorithms
Karaboga and Basturk	2007	The first journal paper and also compared the performance with another algorithm
Karaboga and Akay	2009	Start optimization in a different field of research and these used optimizations for the numerical test function.

Figure 7 shows the flow chat of ABC in the first section tell about size, priority, and requirement. Then after selection policy used when it meets the criteria then it stops working. In selection criteria conations different step which are mention below.

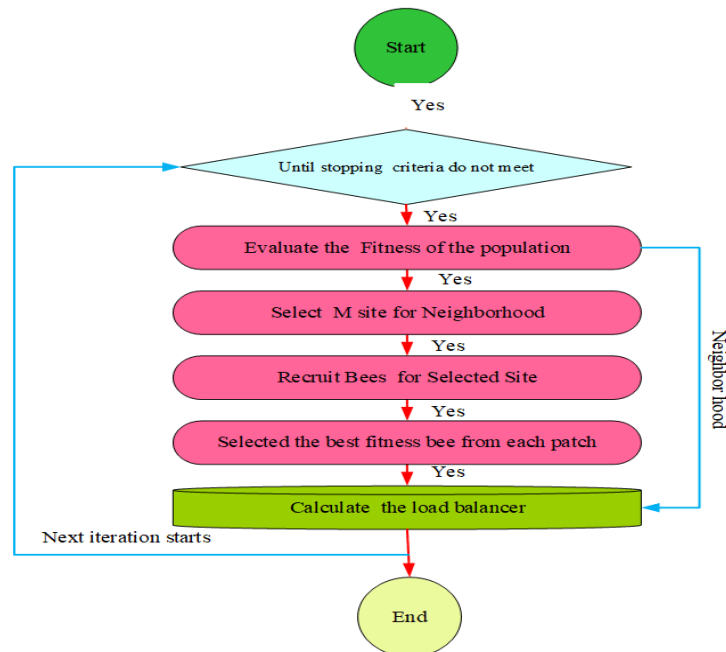


Figure 7. Shows the flow chat of ABC

3.1. Initialization population of ABC algorithm

Initially uniform distributed population generate by the ABC algorithm in SN where each resolution of $X_i (i = 123 \dots SN)$ in S -dimensional of a vector. And where D is the number of a variable optimization of $\{123 \dots SN\}$ problems and X_i signifying the food resource in the given population [29].

- The position of employed bee: In employed stage, the bee modifies them self by showing their contemporary resolution based on given information of individual experience and the fitness value or (nectar amount). If the fitness value is higher than the old one then the bee update their location with the new one and cut the old one. The update location is given below

$$V_{ij} = X_{ij} + J_{ij}(X_{ij} - X_k) \quad (2)$$

Where K denotes $\{123 \dots D\}$ and j belong to $\{123 \dots D\}$ are randomly choice indicates. K Is dissimilar from i J_{ij} is an arbitrary number between $[-1,1]$ [30].

- Onlooker bee role: After the process of employed bee phase then onlooker phase start, in onlooker stage, all the employed bee shared their information about new fitness in turn (nectar) of the food source. And tell about their position and information with the onlooker bee in their hive. Onlooker bee analysis the in order and selected the solution of prospect P_i associated with the fitness. It can be calculated by using the expression.

$$P_i = \frac{fit_i}{SN} \frac{1}{\sum_{l=1}^{SN} fit_l} \quad (3)$$

Where fit is the fitness assessment of the solution in I is in the employed bee in the case of employed bee make amendment in the location and the given reminiscence and check the fitness of the runner cause. If the fitness value is elevated than the bee memory is a new situation and the forget the mature one [31].

- Scout bee phase: The location of the food cradle is not to update to a prearranged quantity of cycle. Then the food source is implicit to be neglected and then scout phase start. In this phase, the bee-related with the reckless food source become scout bee and then interchanged by randomly chosen food source. And the scout bee replaces the food source randomly with generated as follows

$$X_{ij} = X_{minj} + rand[0,1](X_{maxj} - X_{minj}) \text{ for } j \in [1, 2, 3 \dots D] \quad (4).$$

Normally in the ABC algorithm for the food source position show the optimization predicament. The nectar shows the amount of food spring corresponds to the excellence (fitness) of a source. The number of onlooker bee and employed bee are equal to the solution of the population [32]. Meta heuristic algorithms are lofty stage heuristic algorithms, meta revenue privileged level or beyond. Or meta heuristic means literally find out the solution using high-level technique through a certain process. Meta heuristics consider as high level technique and they combine it to low-level technique and used for tactics for Exploration and exploitation for huge space parameter search. Normally there are two important components used in meta heuristics these are spiraling and diversification [33].

4. IMPLEMENTATION OF ABC ALGORITHM FOR LOAD BALANCING PURPOSE

Cloud computing contains a large number of resources like a data center virtual machine and other software resources. In load balancing purpose VM play important role because different researcher implementing to reduce load balancing with the help of a different algorithm. But in this review paper, we focus on the ABC algorithm that used to reduce load balancing. Figure 8 shows the different policy where different researcher modifying and implementing a technique to reduce load balancing. The above Figure 9 shows the implementation of the ABC algorithm according to diagram different data are assign to the data center after that allocation of virtual machine take place. In this section different researcher designing different technique to solve load balancing problems. Table 3 show all the technique, paper name and author which try ABC algorithm implement load balancing in cloud computing.

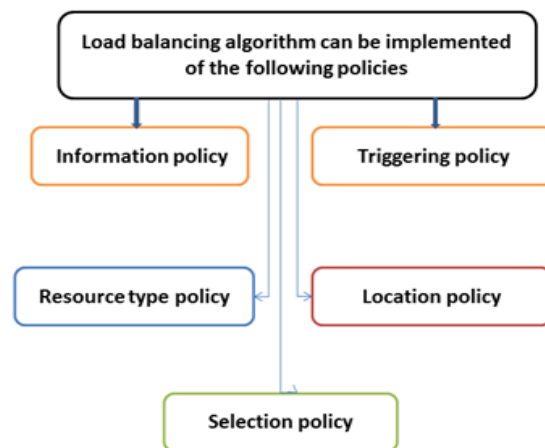


Figure 8. Load balancing policy

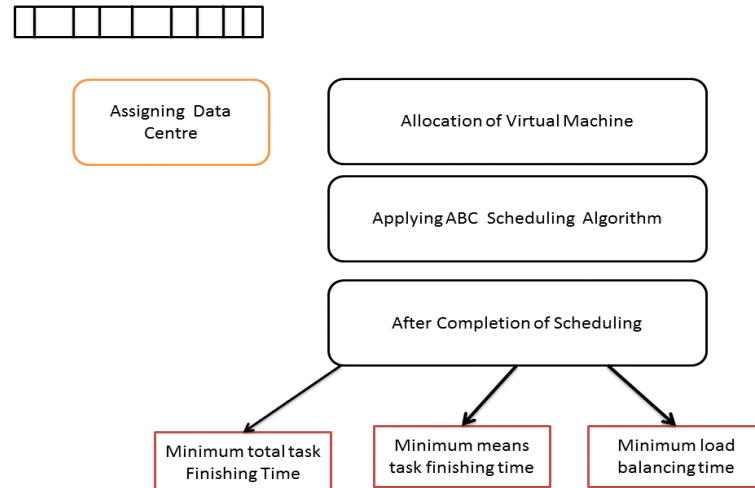


Figure 9. Implementation of ABC

5. IMPORTANT RESULTS

In this section, we mention all those result and figure which are found in this review paper. Table 3 mention all those paper about ABC algorithm which are modified for load balancing purpose and used. It conations information about algorithm name year, author, technique, and reference of paper also. It also mentions the total number of paper and which parts of virtual machine are used for improving load balancing method.

Table 3. Shows the result of ABC algorithm

No	Author	Year	Old /New Name Of ABC	Technique	Load balancing area
1	B. Kruekaew and W. Kimpan [34].	2011	ABC	Mange overload /under load task	Virtual Machine Scheduling Management
2	Hu, & Fu [35].	2013	PS-ABC	Bayes Theorem	Live Virtual Machine Migration Policy
3	Rana & Kar [36]	2014	ABC	Mange overload /under load node	System performance
4	Hesabian & Javadi [37]	2015	HBB-LB.	Task scheduling	Resources scheduling
5	Rathore & Saluja [38]	2015	HBBLB	load scheduling	Virtual Machine
6	Rastkhadiv & Zamanifar [39]	2016	ABC	load scheduling	Virtual machines
7	Awasthi & Bansal [40].	2016	ABC	Task scheduling	Virtual machines
8	M. A., & Elhady	2016	ABC	Task Scheduling	Virtual machines
9	Gamal, & Elhady, [41].	2017	H_BAC	Makespan	Virtual machine (VM)
10	Walaa <i>et all</i> [42].	2017	ABC/LBA_HB	Mange overload /under load task	Virtual machine (VM) task allocating
12	Sharma & Arora [43]	2017	ABC	VM Placement Algorithm	VM Placement Algorithm
13	Kaur & Khullar [44].	2017	ABC	Quality of Service	Virtual Machine
14	Sultanpure & Reddy [45].	2017	ABC	Server	Job scheduling
15	Ehsanimoghadam & Effatparvar [46].	2018	HBB-LB	Waiting times of tasks in the queue.	Virtual machine (VM)
16	Gamal& Elnaghi [47].	2019	OH_BAC	VM Policy	Energy consumption
17	Shameer & Subhajini [48].	2019	OABC	VM Policy	Energu And QOS
18	Madni <i>et all</i> [48].	2019	(HGDCS)	VM Policy	Resource scheduling
19	Thanka <i>et all</i> [50].	2019	ABPS	Load Balancing	Degree of imbalance outperform
20	Adhikari <i>et all</i> [51].	2019	LB-RC	Load Balancing	Resource scheduling

Figure 10 shows about the paper collection. According to the figure most of the paper are collected from the year 2017 and 2019. All the papers are about the modification of the ABC algorithm which are used to improve in load balancing technique in cloud computing.

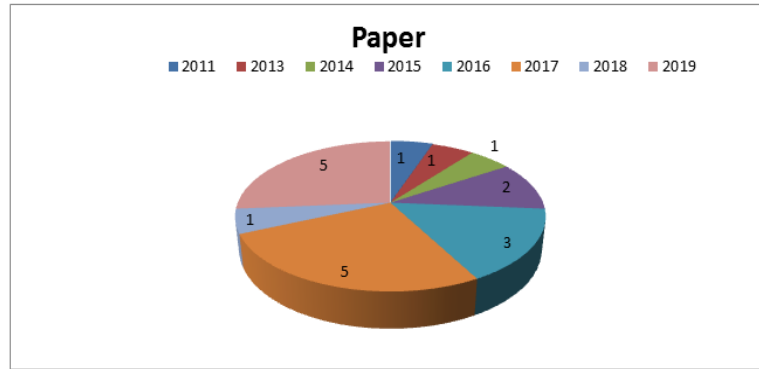


Figure 10. Shows the total number of paper

Figure 11 shows the techniques which are used by different researcher in different paper. According to the collection of paper more number of researcher focus on task scheduling and some of the researcher focus on resource scheduling. These are the two main area where researcher focusing and implementing ABC algorithm.

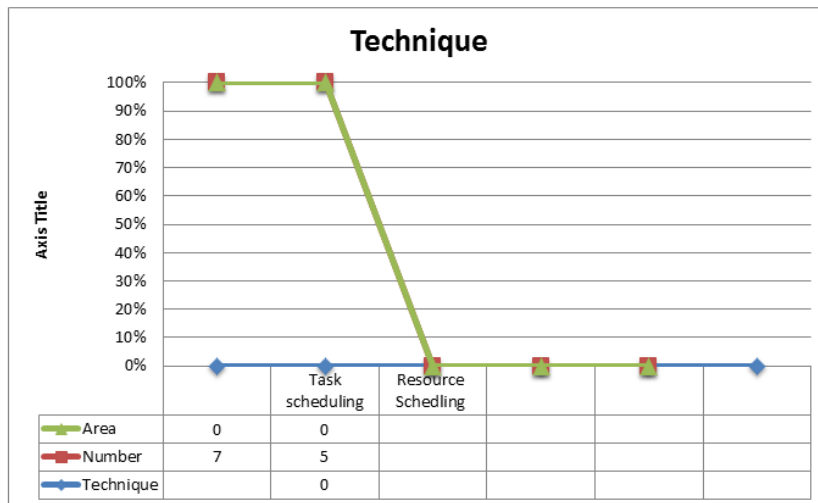


Figure 11. Show the technique used for load balancing

CONCLUSION

In this review paper different paper are collected about ABC algorithms which are used for load balancing purpose. Due to the depth review of those paper shows that large numbers of researchers were concentrated about load balancing in cloud computing using virtual machine policy. Also mention basic concept about load balancing, type, artificial bee colony algorithm and it application. Most of the researcher using ABC algorithm in virtual machine by selection different policy, it almost improves the performance of load balancing. If future study we focus VM replacement study.

REFERENCE

[1] Rana, M., Bilgaiyan, S., & Kar, U. (2014, July). *A study on load balancing in a cloud computing environment using evolutionary and swarm based algorithms*. In Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 International Conference on (pp. 245-250). IEEE.

[2] Antonopoulos, N., & Gillam, L. (2010). *Cloud computing*. London: Springer.

[3] Boussaïd, I., Lepagnot, J., & Siarry, P. (2013). A survey on optimization metaheuristics. *Information Sciences*, 237, 82-117.

- [4] Das, S., Abraham, A., & Konar, A. (2008). Swarm intelligence algorithms in bioinformatics. In *Computational Intelligence in Bioinformatics* (pp. 113-147). Springer, Berlin, Heidelberg.
- [5] Bersohn, M., & Esack, A. (1976). Computers and organic synthesis. *Chemical Reviews*, 76(2), 269-282.
- [6] Leinhardt, G., & Greeno, J. G. (1986). The cognitive skill of teaching. *Journal of educational psychology*, 78(2), 75.
- [7] Coello, C. A. C. (2002). Theoretical and numerical constraint-handling techniques used with evolutionary algorithms: a survey of the state of the art. *Computer methods in applied mechanics and engineering*, 191(11-12), 1245-1287.
- [8] Lourenço, H. R., Martin, O. C., & Stützle, T. (2003). Iterated local search. In *Handbook of metaheuristics* (pp. 320-353). Springer, Boston, MA.
- [9] Bion, W. R. (2003). Experiences in groups: And other papers. Routledge.
- [10] Krause, J., Ruxton, G. D., & Krause, S. (2010). Swarm intelligence in animals and humans. *Trends in ecology & evolution*, 25(1), 28-34.
- [11] Hassanalian, M., & Abdelkefi, A. (2017). Classifications, applications, and design challenges of drones: A review. *Progress in Aerospace Sciences*, 91, 99-131.
- [12] Bonabeau, E., Marco, D. D. R. D. F., Dorigo, M., Théraulaz, G., & Theraulaz, G. (1999). Swarm intelligence: from natural to artificial systems (No. 1). Oxford university press.
- [13] Zhang, Y., Agarwal, P., Bhatnagar, V., Balochian, S., & Yan, J. (2013). Swarm intelligence and its applications. *The Scientific World Journal*, 2013.
- [14] Bonabeau, E., Marco, D. D. R. D. F., Dorigo, M., Théraulaz, G., & Theraulaz, G. (1999). Swarm intelligence: from natural to artificial systems (No. 1). Oxford university press.
- [15] Karaboga, D., & Basturk, B. (2008). On the performance of artificial bee colony (ABC) algorithm. *Applied soft computing*, 8(1), 687-697.
- [16] Karaboga, D. (2005). An idea based on honey bee swarm for numerical optimization (Vol. 200). Technical report-tr06, Erciyes University, engineering faculty, computer engineering department.
- [17] Thom, C. (2003). The tremble dance of honey bees can be caused by hive-external foraging experience. *Journal of Experimental Biology*, 206(13), 2111-2116.
- [18] Robinson, G. E. (1992). Regulation of division of labor in insect societies. *Annual review of entomology*, 37(1), 637-665.
- [19] Umar, S., & Baseer, S. (2016, August). *Perception of cloud computing in universities of Peshawar, Pakistan*. In Innovative Computing Technology (INTECH), 2016 Sixth International Conference on (pp. 87-91). IEEE.
- [20] Ullah, A., Nawi, N. M., Shahzad, A., Khan, S. N., & Aamir, M. (2017). An E-learning System in Malaysia based on Green Computing and Energy Level. *JOIV: International Journal on Informatics Visualization*, 1(4-2), 184-187.
- [21] Cook, D. J., & Das, S. K. (2012). Pervasive computing at scale: Transforming the state of the art. *Pervasive and Mobile Computing*, 8(1), 22-35.
- [22] Du, K. L., & Swamy, M. N. S. (2016). Search and optimization by metaheuristics. Birkhäuser) July.
- [23] Mosa, M. A., Anwar, A. S., & Hamouda, A. (2018). A survey of multiple types of text summarization based on swarm intelligence optimization techniques.
- [24] Bäck, T., & Schwefel, H. P. (1993). An overview of evolutionary algorithms for parameter optimization. *Evolutionary computation*, 1(1), 1-23.
- [25] Seeley, T. D. (2009). The wisdom of the hive: the social physiology of honey bee colonies. Harvard University Press.
- [26] Seeley, T. D. (2010). Honeybee democracy. Princeton University Press.
- [27] Yao, J., & He, J. H. (2012, April). *Load balancing strategy of cloud computing based on artificial bee algorithm*. In Computing Technology and Information Management (ICCM), 2012 8th International Conference on (Vol. 1, pp. 185-189). IEEE.
- [28] Boussaïd, I., Lepagnot, J., & Siarry, P. (2013). A survey on optimization metaheuristics. *Information Sciences*, 237, 82-117.
- [29] Tuba, M., & Bacanin, N. (2014). Artificial bee colony algorithm hybridized with firefly algorithm for cardinality constrained mean-variance portfolio selection problem. *Applied Mathematics & Information Sciences*, 8(6), 2831.
- [30] Madureira, A., Pereira, I., Pereira, P., & Abraham, A. (2014). Negotiation mechanism for self-organized scheduling system with collective intelligence. *Neurocomputing*, 132, 97-110.
- [31] Xu, C., Duan, H., & Liu, F. (2010). Chaotic artificial bee colony approach to Uninhabited Combat Air Vehicle (UCAV) path planning. *Aerospace Science and Technology*, 14(8), 535-541.
- [32] Fei, Z., Li, B., Yang, S., Xing, C., Chen, H., & Hanzo, L. (2017). A survey of multi-objective optimization in wireless sensor networks: Metrics, algorithms, and open problems. *IEEE Communications Surveys & Tutorials*, 19(1), 550-586.
- [33] Ternyik, S. I. Monetary Science/collected papers.
- [34] Kruekaew, B., & Kimpan, W. (2014, March). *Virtual machine scheduling management on cloud computing using artificial bee colony*. In Proceedings of the International MultiConference of engineers and computer scientists (Vol. 1, pp. 12-14).
- [35] Xu, G., Ding, Y., Zhao, J., Hu, L., & Fu, X. (2013). A novel artificial bee colony approach of live virtual machine migration policy using Bayes theorem. *The Scientific World Journal*, 2013.

- [36] Rana, M., Bilgaiyan, S., & Kar, U. (2014, July). *A study on load balancing in cloud computing environment using evolutionary and swarm based algorithms*. In Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 International Conference on (pp. 245-250). IEEE
- [37] Hesabian, N., Haj, H., & Javadi, S. (2015). Optimal scheduling in cloud computing environment using the bee algorithm. *Int J Comput Netw Commun Secur*, 3, 253-258.
- [38] Rathore, M., Rai, S., & Saluja, N. (2015). Load balancing of virtual machine using honey bee galvanizing algorithm in cloud. *IJCSIT*.
- [39] Rastkhadiv, F., & Zamanifar, K. (2016). Task scheduling based on load balancing using artificial bee colony in cloud computing environment. *International Journal of Advanced Biotechnology and Research (IJBR)*, 7(5).
- [40] Bansal, N., Awasthi, A., & Bansal, S. (2016). Task scheduling algorithms with multiple factor in cloud computing environment. In *Information Systems Design and Intelligent Applications* (pp. 619-627). Springer, New Delhi.
- [41] Tawfeek, M. A., & Elhady, G. F. (2016). Hybrid Algorithm Based on Swarm Intelligence Techniques for Dynamic Tasks Scheduling in Cloud Computing. *International Journal of Intelligent Systems and Applications*, 8(11), 61.
- [42] Gamal, M., Rizk, R., Mahdi, H., & Elhady, B. (2017, September). *Bio-inspired load balancing algorithm in cloud computing*. In International Conference on Advanced Intelligent Systems and Informatics (pp. 579-589). Springer, Cham
- [43] Hashem, W., Nashaat, H., & Rizk, R. (2017). Honey Bee Based Load Balancing in Cloud Computing. *KSII Transactions on Internet and Information Systems (TIIS)*, 11(12), 5694-5711
- [44] Gamal, M., Rizk, R., Mahdi, H., & Elnaghi, B. E. (2019). Osmotic Bio-Inspired Load Balancing Algorithm in Cloud Computing. *IEEE Access*, 7, 42735-42744.
- [45] Shameer, A. P., & Subhajini, A. C. (2019). Quality of Service Aware Resource Allocation Using Hybrid Opposition-Based Learning-Artificial Bee Colony Algorithm. *Journal of Computational and Theoretical Nanoscience*, 16(2), 588-594.
- [46] Madni, S. H. H., Latiff, M. S. A., & Ali, J. (2019). Hybrid gradient descent cuckoo search (HGDCS) algorithm for resource scheduling in IaaS cloud computing environment. *Cluster Computing*, 22(1), 301-334.
- [47] Thanka, M. R., Maheswari, P. U., & Edwin, E. B. (2019). A hybrid algorithm for efficient task scheduling in cloud computing environment. *International Journal of Reasoning-based Intelligent Systems*, 11(2), 134-140.
- [48] Adhikari, M., Nandy, S., & Amgoth, T. (2019). Meta heuristic-based task deployment mechanism for load balancing in IaaS cloud. *Journal of Network and Computer Applications*, 128, 64-77.
- [49] Ehsanimoghadam, P., & Effatparvar, M. (2018). Load Balancing based on Bee Colony Algorithm with Partitioning of Public Clouds. *International Journal of Advanced Computer Science and Applications*, 9(4), 450-455.
- [50] Kaur, R., & Khullar, V. ABC Optimized Weighted Task Load Balancing Algorithm in Cloud Computing
- [51] Sharma, E. A., & Arora, E. N. (2017). Load Balancing in Cloud Computing Through Virtual Machine Placement. *Resource*, 1, 2.