BAT algorithm used for load balancing purpose in cloud computing: an overview

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Abstract: Cloud computing is modern technology that has led to significant change in different fields of life by providing different kinds of servicer like hardware and software on user demands based on pay and gain rule. Due to the rapid growth of cloud computing it faces different kinds of issues, and resource allocation is one of them. For the improvement of resource allocation system in cloud computing different kinds of technique are used, and load balancing technique is one of them. In this paper we discuss resource allocation system in virtual machines (VM) because when a user sends data in VM then a situation may occur that some VM are overloaded and some become underloaded, which may lead to failure of system or request delay. For improvement of this situation different researchers used different algorithms in load balancing technique for cloud computing. This paper only focuses on BAT algorithms which are used for load balancing technique in improved resource allocation system for VM and also defines those rules which are used for improvement in load balancing technique in cloud data centre.

Keywords: load balancing; cloud computing; classification; BAT algorithm; VM; virtualisation.

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1 Introduction

Cloud computing is contemporary equipment which is convenient on the demand network access for sharing and spooling of resources on the network like servers, storages, and different application services. Cloud computing mentions both application and hardware. The application carried as facilities on the internet and the hardware and system software in the data centres storage and other applications services (Ullah et al., 2019a). People adopt new technology in order to achieve their required goals. Cloud computing is one way to get 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 (Mandal and Sarkar, 2019). Cloud computing is foremost archetype and used for IT land purpose. VM is consider as the facilitators and processing units in cloud environment. VM provide the user demand when it access for the data and efficient utilisation of these VM can achieved through affective load balancing. Cloud computing is new technology that shared infrastructure with dynamic provision network access. VM is one of the main elements of cloud computing it needs more efficient utilisation resource and for more effective proper load balancing technique need (Gangadhar et al., 2019). Load balancing is technique used in cloud computing for management of resource on condition base that a maximum through put with slightest reaction time, also dividing traffic between server's data and different user

without any delay. Due to the rapid growth of cloud computing client demanding about better service. To dubious this problems load balancing has become the important topic and its new technique used to reduce response time in providing maximum throughput. Load balancing technique received multiple requests from users to distribute them to the different devices according to their accessibility (Ullah et al., 2019b). BAT algorithm is one of the heuristic algorithms normally used for global optimisations. BAT algorithm is nature inspired algorithm which has many applications and it is inspired from echolocation behaviour of micro BATs with pulse rate and loudness as developed by Xin-she Yang in 2010 (Chansombat et al., 2018). Normally nature inspired algorithms provide better result for solving real world problems. Due to that reason BAT algorithm is used in different optimisation problems. Load balancing is of them BAT algorithm used in optimisation purpose in cloud computing. Modified BAT algorithm for load balancing in virtual machine migration for improvement of different elements of cloud computing (Milani and Navimipour, 2016).

1.1 Main objectives of this study are

- To provide information about BAT algorithm.
- To study about load balancing technique and classification.
- To study the role of BAT algorithm in load balancing technique for resource allocation system in VM for cloud computing.

1.2 Source of information

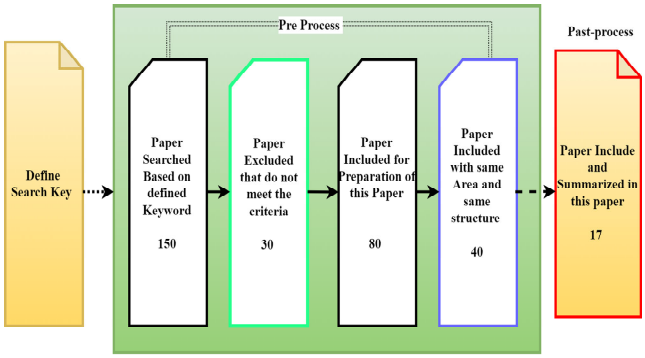
Different search engines are used for collection of papers:

- Google Scholar: https://scholar.google.com/.
- IEEE Explore: https://ieeexplore.ieee.org/Xplore/home.jsp.
- ACM Digital Library: https://dl.acm.org/.
- Science Direct: https://www.sciencedirect.com/.

1.3 Search criteria

Different terms or key words used for searching purpose like define cloud, load balancing, type of load balancing, algorithm, type of algorithm, BAT algorithm, type, modification in BAT algorithm and BAT algorithm used for load balancing purpose. This paper provides information about BAT algorithm load balancing, classification, criteria of load balancing and BAT algorithm used in cloud computing for load balancing purpose. This paper is organised as Section 1 introduction, Section 2 preliminary, Section 3 load balancing technique, Section 4 methodology, Section 5 implementation, Section 6 result and discussion and Section 7 conclusion. Figure 1 show the collection of papers in pre process and post process.

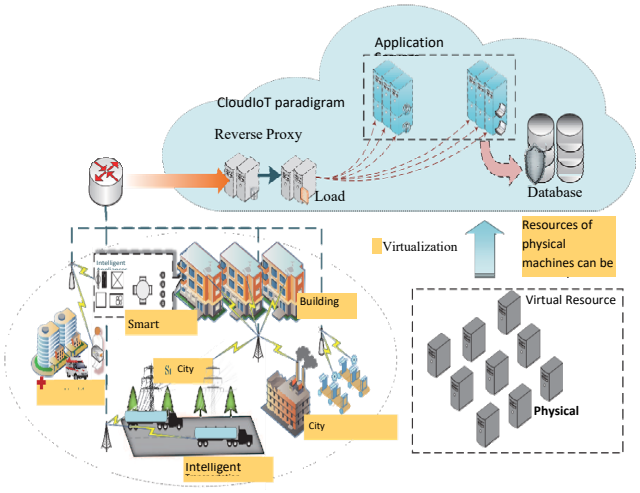
Figure 1 Paper structure (see online version for colours)



2 Preliminary

This section defines those entire elements which are related about load balancing technique in cloud computing and BAT algorithm. Cloud computing is new technology that has significantly changed over the last decade. The deliveries of virtualised IT resources over the internet are performed with the help of it. These services are delivered with the rule of pay and gain on demand with real time service (Xiao et al., 2012). Cloud resources are providing as universal tools and any user can rent and release theses service with the help of internet. It becomes 21st century technology due to combination of high bandwidth communication and low cost computing with storage. Cloud computing is type of computing technology which facilitates in sharing the resource and service over internet rather than having theses service of local servers or personal computer. The combination of service resource and application resource are known as cloud computing (Umar and Baseer, 2016). Figure 2 show the cloud computing structure and application.

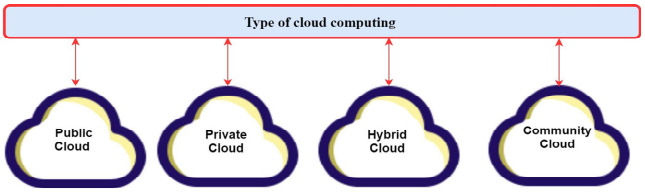
Figure 2 Cloud computing structure and working (see online version for colours)



2.1 Types of cloud computing

There are four types of cloud computing which are public, private, hybrid and community cloud. Private cloud computing used for a solitary association and it may be accomplished by the association itself or third party and it may be sited within the organisation or out of organisation. A public cloud is an infrastructure which is owned by an organisation selling cloud service for user or any public user and public cloud can be used for public business and many other activities (Premkamal et al., 2020). Hybrid cloud comprises two or more clouds that may be private or public and used for different reason and public cloud use for less sensitive data and private used for more sensitive data. Community cloud is when numerous administrations cooperatively build and segment the same infrastructure and as well as their information and values (Wu et al., 2016). Figure 3 shows the cloud types.

Figure 3 Structure of cloud computing (see online version for colours)



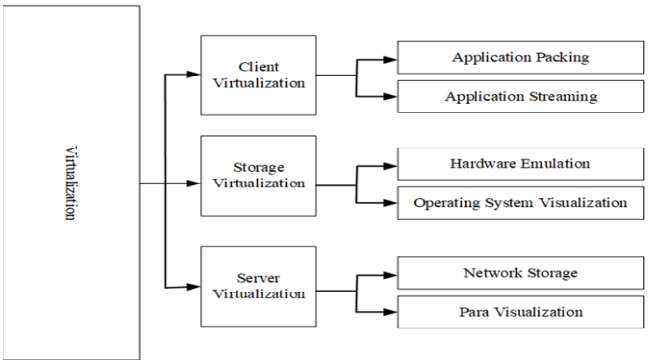
2.2 Cloud computing architecture

Normally cloud computing is divided into four layers. Application layer is the first layer of the model and it contains the actual cloud application. These are different from traditional applications. Platform layer controls the operating system and solicitation frame work the persistence of stage layer is to diminish the burden of developing an application and also provide API for storage. Infrastructure layer used for dynamic resource management system. This layer used for storage management making physical resources using as virtualisation (O'Driscoll et al., 2013). Hardware layer is where the physical resources are managed,. including switch, power system, router and cooling system. Normally the hardware layer is implemented in the data centre and contains thousands of servers and other devices are interconnected therefore the traffic management power and cooling system are also in this centre (Zhang et al., 2010).

2.3 Characteristic of cloud computing

Cloud computing has succeeded in bringing change in the different fields of life it has different models and layers which consist of different characteristics. Availability of cloud computing refers to the network performance which consists of software and hardware collectively service during executation. Previously the availability of these has been limited due to local installation of resource or due to traditional use. With the advent in cloud service resource are shift in to cloud. Due to cloud computing it provide high availability and stability for every type of user in different fields (Kaushik and Gandhi, 2020). Scalability is the attribute that presents the ability of software, network, and process of an organisation to manage the increase of user demand. Normally in cloud computing scalability means frequently speed. The ability of system or product continuous working after it context change like volume or size in order to meet the user need (Zissis and Lekkas, 2012). Cloud security consists of different policies and technology that work together to protect cloud system long with data base from unauthorised access and attracters. Cloud security is joint responsibility of cloud provider and business owner or end user. Cloud security addresses both physical and logical issue in different model and layer (Ullah and Nawi, 2020). Cloud automation is broad term which refers to the processes, tools, and resource that an organisation uses to reduce the manual efforts it associated with the managing cloud computing workloads. It can apply with different types of cloud computing. Cloud automation is fundamental building block for the cloud computing. It also can apply in software layer where complex system used to configure one and rolled out the system balances the network system. It aims to make all activities related to computing as fast and efficient and hand off as possible through the use of various systems (Buyya et al., 2009b). Virtualisation is one of the main characters of cloud computing which refers as virtual, rather than actual of something. The main role of cloud computing is to provide computing resources and with the help of the internet, it can share resources like software, hardware, and different applications. Virtualisation concept was started in 1960 and early 1970 where IBM spent consideration time to introduce more reliable and time sharing technology that is known as virtualisation (Fox et al., 2009). One of the main elements of virtualisation are virtual machines (VM), in which a single physical resource can appear as multiple resources. This process can be achieved with the help of a virtual machine. It contains matched environment for a physical computer system run an operating system and applications. Figure 4 shows the different types of virtualisation in cloud computing.

Figure 4 Types of virtualisation

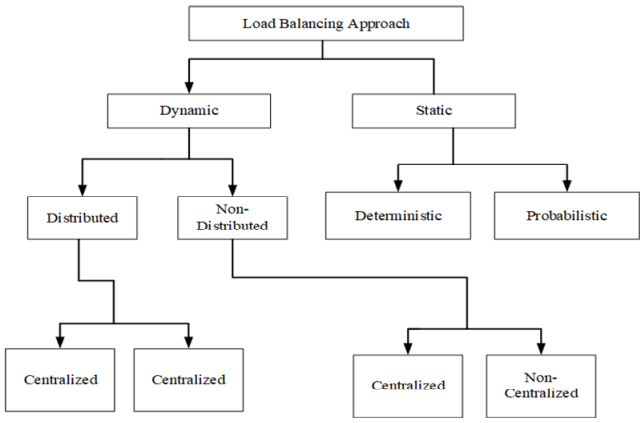


VM can be implemented with the help of software, framework, and hardware. In some environments different virtual machines are running in the different operating system; in one system they are monitored by the hypervisor (Buyya et al., 2009b). This paper covers all load balancing techniques which are used for the improvement of VM resource allocation system in cloud computing.

3 Load balancing technique

Load balancing is a technique used in cloud computing for management of resource on condition base that a maximum through put with slightest reaction time, also dividing traffic between server's data and different users without any delay. Due to the repaid growth of cloud computing client demanding about better service. To incredulous this problems load balancing has become the important topic and its new technique used to reduce response time in providing maximum throughput. Load balancing technique received multiple request from user cites distribute them to the different device according to their accessibility. If load balancing is not used in client computing then user waits for a long time when he requests for any resource (Cheng and Bounfour, 2016). Figure 5 shows the classification of load balancing.

Figure 5 Classification of load balancing



Fundamentally there are two main types of load balancing which are static load balancing and dynamic load balancing which can be divided into different sub groups. In static load balancing the enactment depends on the current state and the implementation also effect on the current state. The main theme of load balancing is to reduce the overall time consumption. It normally works homogenous and stable environment and provides good result (Cui et al., 2018). Dynamic load balancing is the process which can be changed at any stage and any location and no need previous knowledge. The main benefit of dynamic load balancing is that if any node fail it does not distress the entire system it affects only the current stage. Non-distributed load balancing the network node work discretely to realise a collective goal each node works its own. Distributed load balancing can be divided in to two types these are centralised and semi-centralised. Centralised load balancing is the type of load balancing solitary node are designs for the network and algorithms are designed for that node and are responsible for the entire system (Kaur and Luthra, 2012). In semi distributed dynamic load balancing the node is divided in to clusters and each cluster contains the load balancing out of these clusters one cluster is selected as master node and which contain all the responsibility of the entire network. Distributed dynamic load balancing algorithm works in the distributed form it executed by all nodes which are present in the system. Task of scheduling shared among all of them. Cooperative load balancing all the node work cooperative together and they have common objective for example improvement the response time and makespan (Alakeel, 2010). No cooperative load balancing in this kind of load balancing all node work independently toward their goal and they have no cooperation with each other. Deterministic load balancing is that time of load balancing in which tasks are assigned without any information of current load status. The task is assigned in the network without information in system it checks with threshold whether it needs more tasks or not (Kaur and Luthra, 2012).

3.1 Why load balancing technique in cloud computing

Even though a lot of resource data is distributed such that it is possible for a large number of user request to small number of resource. Then remain large number of resource not being used. Thus large pool or resources are affected. By load balancing technique used to distributed load among many resource as even they possible. This is called an efficient load balancing therefore in cloud computing load balancing technique need and update at each moment and period of time (Xiong et al., 2017).

3.2 Load balancing challenges

Cloud computing is becoming more attractive in advanced research field. Some of the main issues in load balancing challenges are geographical distribution resource in general data centre of cloud computing are geographically distributed for computing purpose. These resources and nodes are treated as single location system for efficient executation of user request. When some loads balancing are design for small purpose they affect like network delay, communication delay, distance. Thus designing load balancing algorithm is needed to overcome this issue (Beloglazov et al., 2011). Single points of failure in this case various algorithms are designed where some technique is non-distributed and the control made my centre node. In the centre node fails then the entire system crash the system. Therefore no need to develop such condition algorithm (Ullah et al., 2018). Virtual machine migration process allows creating several VMs from physical machine. These VMs are independent have different configuration. If physical machine gets overloaded then it shifts to VMs. Where it check which VM are under loaded and which one is overloaded with VM migration load balancing approach

(Wood et al., 2007). Storage management cloud computing solve the old tradition data storage problems that need personal management system with high cost along with hardware. Nowadays cloud allowed the user to store data and access that data with any problems. But due to the rapid growth of user increase day by day it causes replication and inconsistency of data. Due to the replication of data it makes complexity for load balancing technique. Therefore need to developed more accurate and efficient load balancing technique (Rimal et al., 2009). Load balancer stability on user demand viability and scalability of cloud service need quickly due to good load balancer it can be achieved. For good load balancer it needs proper load balancing in cloud computing that provide good viability in service (Ullah et al., 2017). Algorithm complexity in cloud computing needs simple and easy to implement a complex algorithm will reduce the performance and efficiency of cloud system (Calheiros et al., 2011). Heterogeneous node during early research in cloud load balancing, researchers theorised about homogeneous nodes. In cloud computing, user requirements change in early day cloud computing consist of homogenous node. But the user demand and change in to heterogeneous environment therefore now it need more accurate algorithm to minimise the response time and requirement (Knepper, 2017).

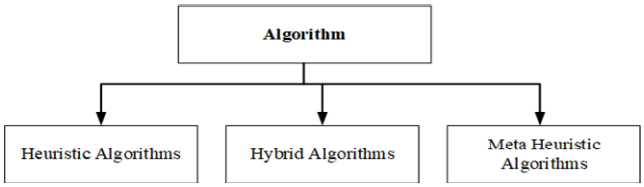
3.3 Load balancing performance metrics

Cloud load balancing techniques, unlike their traditional on-premise counterparts, are less expensive and simple to implement. Enterprises can make their client applications work faster and deliver better performances, that too at potentially lower costs. To check the load balancing accuracy and performance these metrics are used. Throughput used for the calculation of the entire task those have been finished and the recital of several coordination is enhanced if the throughput is high. Fault tolerance means the system regaining from failure. Load balancing is a good method to shelter from fault tolerant (Wang et al., 2019). Migration time means the time in which one job or possessions migrate from one node to other nodes. If we minimise migration time then the enactment of the system will increase. Response time it is processed in which an algorithm takes time to complete a particular assignment in the system. This factor should need for decreased for enhanced concert of the system. Scalability it is the capacity of an algorithm to execute load balancing for any determinate digit of nodes of system (Kapgate, 2014). Network stability is the capacity of a network to execute it work load properly to the destination. The performance of the network which measure the number of job complete with. This paper focus on the improvement of load balancing technique in cloud computing for resource allocation system in VM (Tang and Chanson, 2000). For the improvement of VM resource allocation system different algorithm used by different researcher.

3.4 Algorithm

Algorithms are set of the formula used for solving problems on the basis of sequence and specific action. A set of unambiguous instructions that are used for a given set of instruction and performed an action to achieve certain goals that have been recognisable (Coello et al., 2007). Normally algorithms are classified in to three types: Figure 6 shows the classification of the algorithms.

Figure 6 Classification of algorithms



These three main types of algorithm are inspired for different thing but this study we focus on nature inspired algorithms which are mention in Figure 7.

Figure 7 Shows the types of BAT algorithm

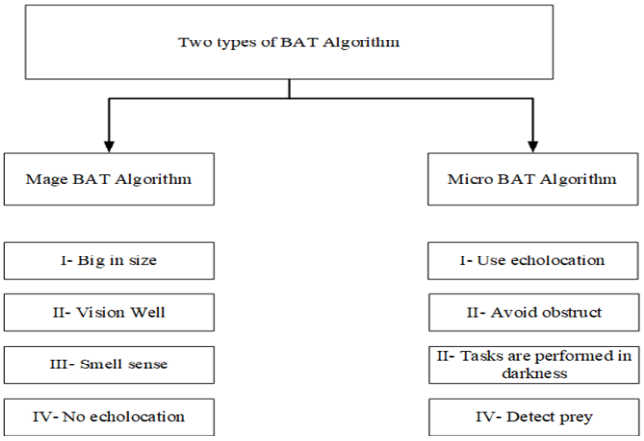


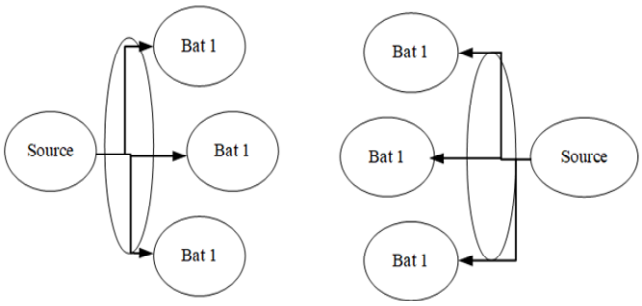
Figure 7 show the nature inspired algorithms, which are a set of rules used to solve novel problems they inspire from nature. Some of nature-inspired algorithm are artificial neural networks (ANN), fuzzy systems (FS), evolutionary computing (EC), and swarm intelligent (SI). In this study, the algorithm belongs to SI group. This paper BAT algorithm selected and we check at which section of load balancing purpose for improvement of resource allocation system BAT algorithm used. Next section consists of BAT algorithm definition.

3.5 BAT algorithm

BAT is one of the metaheuristic nature-inspired algorithms normally used for global optimisations. They which have many applications and it inspired from echolocation behaviour of micro BATs with pulse rate and loudness and it developed by Xin-she Yang in 2010. Figure 8 shows the two main types of BAT algorithm along with their type.

Echolocation almost 1,000 species of BAT and their size start from 1.5 gram to 1 kg. Normally echolocation used by micro BAT. Micro BAT have poor eyesight and good hearing it make them to know about insert flying. Micro BAT hunt in dark using technique called echolocation to find insects. Till 1950 few people know about how BAT found their ground way in darkness until Donald Griffin discovered echolocation. BAT can see but some can see better and few species are flying in darkness (Wang and Anderson, 2019). There are two main types of echolocation which are low duty cycle echolocation and high duty cycle echolocation. Low duty cycle echolocations estimate the distance from an object based on time and sound when the echo returns the call of BAT. Echolocation among the loudest airborne sound from the echolocation among the animals. High duty cycle echolocation gives BATs information about the motion and the three dimensional location of prey (Wheeler et al., 2016). This type of echolocation a BAT emits continues call while listening to the change in the frequency of then return echo. Most BAT type used sonar known as echolocation which is used for communication and recognise different type of insects sense to their prey and movie without hitting any obstacle even in darkness. BAT algorithm used frequency tuning technique for increase the diversity of the solutions in the population it used zooming system to balancing system for exploration and explications during the search process with the help of pulse emission rate and loudness of BAT (Wertheim et al., 2014). Normally BAT sent signal with the help of loudness of frequency from 20 kHz to 200 kHz when the signal deflect back when they strike with the object, then echo signal create and back to BAT. For calculated the distance it measured the distance from the BAT to the object or destination of the object. BATs try to get the minimum object. They reduce their pulse rate when reached near to the object. BATs try to reach near to the distance and when the distance becomes zero (Wang et al., 2017). BAT is relatively new meta-heuristic optimisation algorithm it inspires by echolocation behaviour of BAT. It used for solving optimisation problems in continuous and discrete space now days it successfully applies in different field of life. Normally two main elements which affected the search of BAT algorithm which are expiations and exploration. Exploration is the process of an algorithm that used for promising the solution of various unknown region while the exploitation improved after they region are found. BATs adjust their position and frequencies according to the movement of prey (Fister et al., 2013). They adjust from different phase like search phase to approach phase and tracking phase to terminal phase. From phase to phase they arrange them self-according to the prey, normally BAT used two type of signal, narrowband and broadband these signal are future categorised into two types like modulated (FM) and signal and constant frequency (CF) signal for different purpose BAT used this signal like FM signal for target the distance. CS is used for detections from target motion to overcome from pulse echo overlap of BAT shorten duration of FM signal produced in the presence of pulse emission by one BATs to avoid this interface BAT cease vocalisation of sound waves and echo to avoid this senior BAT used vocalisation and enter silent mode. BAT avoid overlapping due to echo received during approach of target from terminal phase for prey capturing they come from angle in mouth side, if large angle then it increase the exploration they are able for target different prey with the help of echolocation (James, 1985). Figure 8 shows the sound calculation of BAT echo system.

Figure 8 Calculation of distance



In Figure 8 it shows that when BAT make sound it spared to different prey in frequency form after that when it time to count the distance it collected all the signal then the distance. Natures inspired are the most powerful algorithms and design for optimisation purpose BAT is one of them. It can used for nonlinear with single and multi-object function. It run independently and targets the node in order to make localised coordination (McClelland et al., 2016). Equation (1) the movement of BAT for food source.

$$f = \left(\frac{c}{c + vs}\right) fo \tag{1}$$

$$f = \left(\frac{c + vr}{c}\right) fo \tag{2}$$

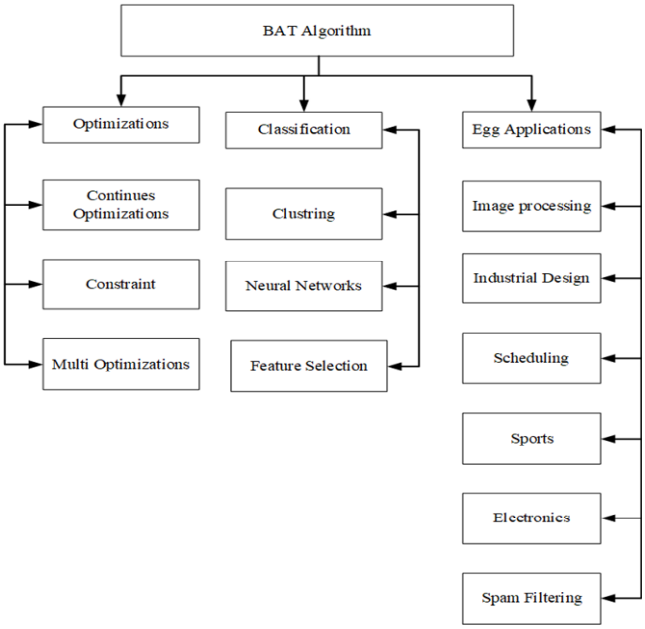
$$f = \left(\frac{c + vr}{c + vr}\right) fo \tag{3}$$

where

- c is the velocity of the waves in the medium.
- vr is the velocity of the source if it moves to source then it called positive signal.
- vs is the velocity of source if it moves away from the source then it called positive signal.

Figure 9 shows the main application of BAT algorithm which are used in different files.

Figure 9 BAT algorithm application



4 Methodology

Cloud computing consists of three main layer which are software layer, platform layer and infrastructure layer.

Figure 10 Different layer of cloud computing (see online version for colours)

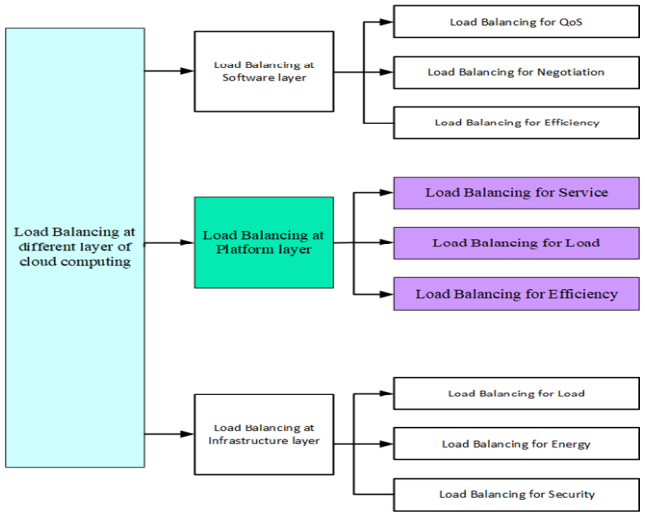


Figure 10 shows the three main layers of cloud computing and load balancing technique are performance at each layer during the load balancing process these layers are divided in to sub groups which are mention in the figure and these sub groups are used for improvement load balancing technique for different section.

Figure 11 VM development process

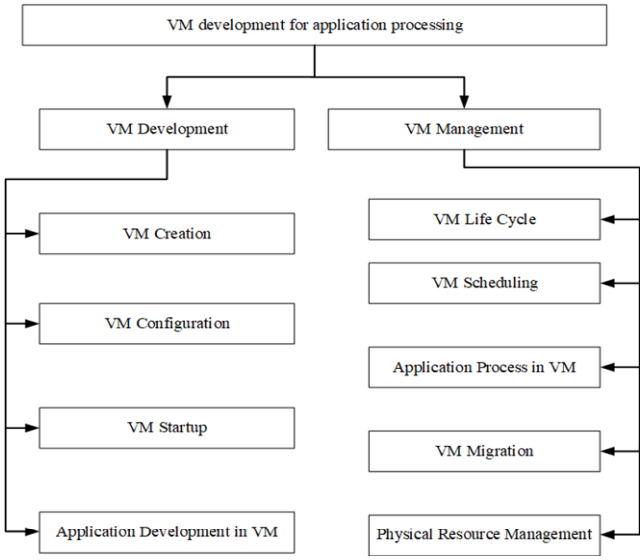
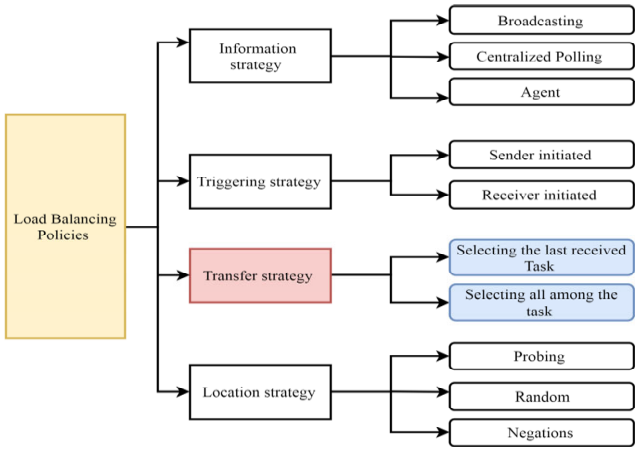


Figure 11 shows the internal structure of VM it consists of two main parts which are VM development phase and VM management system. First phase consist of VM creation, VM configuration, VM start-up and application development. In development phase these element are developed during data centre development or network establishment phase. In second phase VM management which consists of VM life cycle, VM scheduling, Application process in VM, VM migration and physical management. Second phase can be change during the request demand or according the requirement. Different algorithms are implementing in this layer. Figure 12 shows load balancing policies which are used for implementing these algorithms.

Figure 12 Load balancing policies in VM (see online version for colours)

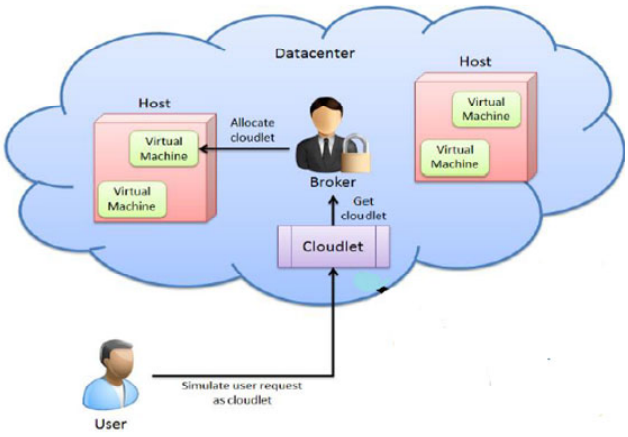


Normally four main strategies are used in load balancing technique for cloud computing which are information strategy, triggering strategy, transfer strategy and location strategy. They can be divided in to different sub types and different researchers use algorithms by using these policies. Data centre consists of N hosts and each host consists of different number of VM.

4.1 Cloud data centre

Cloud data centre consist of physical and virtual infrastructure resources that consist of server and network system and different resources. Different user demands can access with the help of these data centre in accurate and fast time. It contains large amount of data and information which work certain rule and regulation (Buyya et al., 2009b). Figure 13 shows the data centre of cloud computing.

Figure 13 Structure of data centre (see online version for colours)



Data centre normally used to control the various activities such as VM creation and destruction, routing of user request, network management, resource management and load balancing. Data centre broker is responsible for assigning or mapping the cloudlets to the VMs. Service broker is the main responsibility of these components is to handle the traffic routing between user base and data centres. There are different policies and the service broker can user one of them. Host is the physical model of services in a cloud-based data centre (Xue et al., 2017). It consist of memory and storage list of processing element (PE) in a multi core of machine in all allocation policy of sharing and the processing power among the virtual machine, memory and bandwidth. Host classes associated with the data centre and used for hosting VM. It takes action when it related about scheduling of VM according to the VM allocation policy. VM load balancer: VM load balancer is main technique which is used to determine which cloudlets for processing are assigned to VM (Buyya et al., 2009a). VM provisioner is the abstract class which represents the provisioning policy that a VM monitor the VM allocating host. Main role of VM provisioner is it selected the viable host data in data centre which control meet memory storage and viability and requirement for VM development. Cloudlets are the grouping the user requests, the numbers of request are bundled in to single and configurable form. It carries the information such as request of execution of command and size and input and output files. It is responsible for the creation of cloudlets or task along with the characteristic of those cloudlets and it public class it show the ID of the VM to which it mapped. VM allocation policy it is abstract class which is used to implements the host provisioning policy (Mushtaq et al., 2017). It is responsible for the allocation and deal location of VM with the hosts. Allocation policy is the class which is responsible for assigning the caller for specified allocation scheme and finding the idea host for the VM. Cloud information service (CIS) the architecture of data centre consists of CIS is the repository which contains all the information about all available resource in cloud environment and it registry of data centre. When we developed data centre then it register to the CIS and different hosts are present in data centre. Each host has different PEs with RAM and bandwidth characteristics. Virtual machine also contains the above element. Different capacity of VM used according to their demand and network requirement (Mishra et al., 2017).

5 Implementation

BAT algorithm implement in VM to check the load balancing technique in cloud computing. It used to search optimal VM among all the available VM for exestuation of incoming job. When any task arrives in load balancer BAT assign the best VM. When they become under loaded and overloaded BAT algorithm manager them. Let VM = [VM1, VM2, VM3, …, VMn] where N is virtual machine and task = [k1, k2, k3, …, k] k is number of task. In BAT algorithm every number of initial populations is uniformly distributed randomly between 0 and n – 1.The position of BAT are $X_{ij} \in [0, n]$ velocity is V_{ij} where I present the population and j present j^{th} task thus the initialisation formula is

$$X_{ij} = X_{min} + (X_{max} - X_{min}) \times \partial \tag{4}$$

where

$$X_{max} = n \text{ and } X_{min} = 0 \tag{5}$$

δε [0, 1] is random number of distance for search next step

$$f_i = f_{min} + (f_{max} - f_{min}) \times B \tag{6}$$

$$V_{IJ}^{t+1} = V_{ij}^{t} + \left(X_{ij}^{t} - gbest_j\right) Xf_i \tag{7}$$

$$X_{ij}^{t+i} = X_{ij}^{t} + V_{ij}^{t+1} \tag{8}$$

$B \in [0, 1]$ is the random number put for uniform distribution. gbest is the best number of task put in VM f_i is the frequency of BAT (i). (t) is the current number of iteration. Local search uniformly distributed random number.

$$X_{ij}^{t+1} = X_{Ij}^{t+1} + \text{rand}(-1, 1) \times A^t \tag{9}$$

where R and (–1, 1) is uniform distribution A^t is the average loudness of the t^{th} is iterations

For update loudness and pulse emission and frequency make the following update.

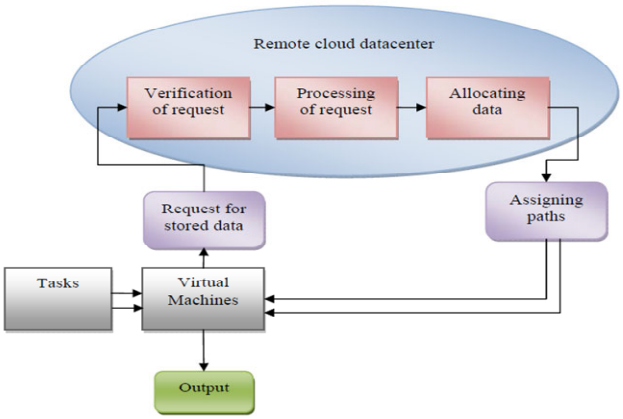
$$f_i = f_{new} \tag{10}$$

$$Ai_i^{t+1} = \alpha A_i^t \tag{11}$$

$$\delta_i^{t+1} = \delta_i^t \left(1 - e^{-rt}\right) \tag{12}$$

The above equations show the BAT algorithm different steps which are used during implementation process of the algorithm (Willebeek-LeMair and Reeves, 1993). Figure 14 show the working of VM.

Figure 14 VM working steps (see online version for colours)



6 Result and discussion

In this section discuss about all those paper which are selected for post process after that only 17 papers are selected because in these papers BAT algorithm is used for load balancing purpose for improvement of resource allocation system in VM as we know that there are different methods and technique used for improvement of load balancing technique in cloud computing.

Figure 15 Search engine result (see online version for colours)

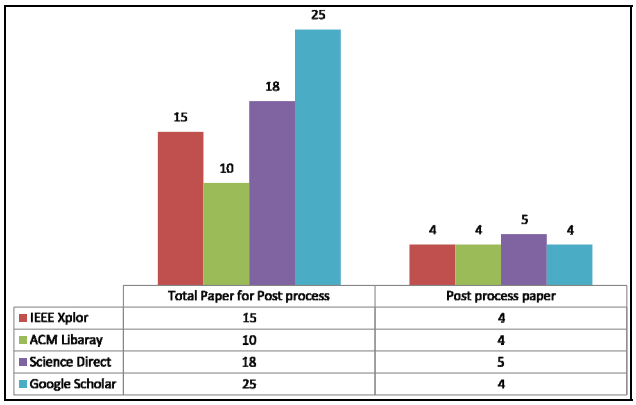


Table 1 Summary of papers

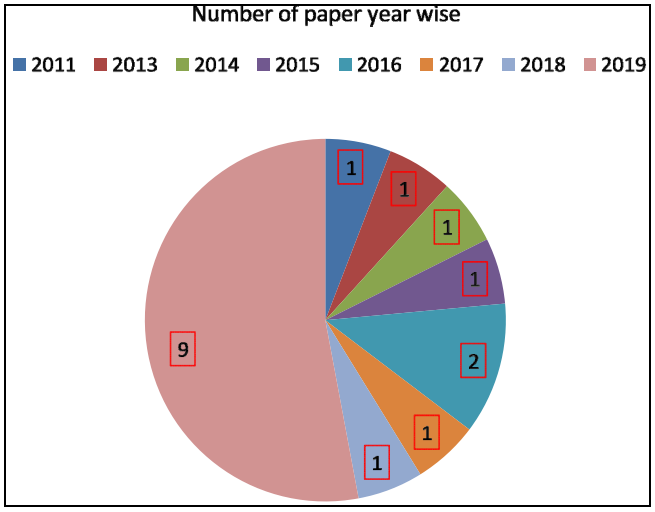
No.	*Author*	*Year*	*Algorithm*	*Technique*	*Load balancing area*
1	Agostinho et al.	2011	BAT	Load balancing	VM
2	Dasgupta et al.	2013	BAT	Load balancing	VM
3	Szczypta and Shao	2014	BAT	Load balancing	VM
4	Kavousi et al.	2015	BAT/ hybrid	Load balancing	VM
5	Abdullahi and Ngad	2016	BAT/ hybrid	Task scheduling	VM
6	Sharma et al.	20016	BAT	Task scheduling	VM QOS
7	Madni et al.	2017	BAT/ hybrid	Task scheduling	VM QOS
8	Zafar et al.	2018	BAT	Resource allocation	VM
9	Priya et al.	2019	Hybrid BAT	QOS	VM
10	Varshney et al.	2019	Hybrid BAT	Resource scheduling	Load balancer
11	Ullah et al.	2019b	BAT	Load balancing	VM
12	Pattanaik et al.	2019	BAT	Task	Load balancer
13	Jian	2019	BAT/ hybrid	Task scheduling	VM QOS
14	Krishnadoss and Jacob	2019	Hybrid BAT	Task	VM
15	Pan and Dao	2019	Hybrid BAT	Energy	VM
16	Priya et al.	2019	BAT	QOS	VM
17	Li et al.	2019	Hybrid BAT	QOS	VM

Figure 15 shows all those paper which are selected for post process which are mentioned in Table 1. Total 58 papers are selected for post process in which just 17 papers are important for this study which are listed in Table 1 with references.

In Table 1 mention all those paper about BAT algorithm which are used for load balancing purpose in cloud computing. The table shows the author name, year, technique and in which section they are used.

Figure 16 shows the total number of papers which are used load balancing purpose using BAT algorithm.

Figure 16 Yearwise paper (see online version for colours)



7 Conclusions

In this paper we collected all those papers about BAT algorithm which are used for improvement in load balancing technique for cloud computing. In the preliminary section we discuss about cloud computing, type and main element about cloud computing. In that section we define algorithm along with brief discussion about BAT algorithm. After the depth study about BAT algorithm using for improvement in load balancing technique more of the researchers used in VM improvement policy. BAT algorithm is used for improvement in cloud computing for improvement in QOS, energy management, resource scheduling and load balancing. Most of the researchers try to improve BAT algorithm selection site it is used for arranging the load among various VMs. Infrastructure layer is used for modification in the network. By using selection policy most of the researchers used these two sections in the network. Fewer researchers used transform method for optimisation in cloud computing.

References

Abdullahi, M. and Ngadi, M.A. (2016) 'Hybrid symbiotic organisms search optimization algorithm for scheduling of tasks on cloud computing environment', *PloS One*, Vol. 11, No. 6, p.e0158229.

Agostinho, L., Feliciano, G., Olivi, L., Cardozo, E. and Guimaraes, E. (2011) 'A bio-inspired approach to provisioning of virtual resources in federated clouds', in *2011 IEEE Ninth International Conference on Dependable, Autonomic and Secure Computing*, IEEE, December, pp.598–604.

Alakeel, A.M. (2010) 'A guide to dynamic load balancing in distributed computer systems', *International Journal of Computer Science and Information Security*, Vol. 10, No. 6, p.153.

Beloglazov, A., Buyya, R., Lee, Y.C. and Zomaya, A. (2011) 'A taxonomy and survey of energy-efficient data centers and cloud computing systems', in *Advances in Computers*, Vol. 82, No. 8, pp.47–111, Elsevier.

Buyya, R., Ranjan, R. and Calheiros, R.N. (2009a) 'Modeling and simulation of scalable cloud computing environments and the CloudSim toolkit: challenges and opportunities', in *2009 International Conference on High Performance Computing & Simulation*, IEEE, June, pp.1–11.

Buyya, R., Yeo, C.S., Venugopal, S., Broberg, J. and Brandic, I. (2009b) 'Cloud computing and emerging IT platforms: vision, hype, and reality for delivering computing as the 5th utility', *Future Generation Computer Systems*, Vol. 25, No. 6, pp.599–616.

Calheiros, R.N., Ranjan, R., Beloglazov, A., De Rose, C.A. and Buyya, R. (2011) 'CloudSim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms', *Software: Practice and Experience*, Vol. 41, No. 1, pp.23–50.

Chansombat, S., Musikapun, P., Pongcharoen, P. and Hicks, C. (2018) 'A hybrid discrete BAT algorithm with Krill Herd-based advanced planning and scheduling tool for the capital goods industry', *International Journal of Production Research*, Vol. 57, No. 21, pp.6705–6726.

Cheng, X. and Bounfour, A. (2016) 'Performance analysis of public cloud computing providers', in *MCIS*, September, p.25.

Coello, C.A.C., Lamont, G.B. and Van Veldhuizen, D.A. (2007) *Evolutionary Algorithms for Solving Multi-Objective Problems*, Vol. 5, pp.79–104, Springer, New York.

Cui, D., Peng, Z., Ke, W., Hong, X. and Zuo, J. (2018) 'Cloud workflow scheduling algorithm based on reinforcement learning', *International Journal of High Performance Computing and Networking*, Vol. 11, No. 3, pp.181–190.

Dasgupta, K., Mandal, B., Dutta, P., Mandal, J.K. and Dam, S. (2013) 'A genetic algorithm (GA) based load balancing strategy for cloud computing', *Procedia Technology*, Vol. 10, pp.340–347.

Fister, I., Fister Jr., I., Yang, X.S. and Brest, J. (2013) 'A comprehensive review of firefly algorithms', *Swarm and Evolutionary Computation*, Vol. 13, pp.34–46.

Fox, A., Griffith, R., Joseph, A., Katz, R., Konwinski, A., Lee, G. and Stoica, I. (2009) *Above the Clouds: A Berkeley View of Cloud Computing*, Department Electrical Eng. and Comput. Sciences, University of California, Berkeley, Rep. UCB/EECS, Vol. 28, No. 13.

Gangadhar, P., Hota, A.K., Rao, M.V. and Rao, V.V. (2019) 'Performance of memory virtualization using global memory resource balancing', *International Journal of Cloud Applications and Computing*, Vol. 9, No. 1, pp.16–32.

James, H.G. (1985) 'The ELF spectrum of artificially modulated D/E-region conductivity', *Journal of Atmospheric and Terrestrial Physics*, Vol. 47, No. 11, pp.1129–1142.

Jian, C., Chen, J., Ping, J. and Zhang, M. (2019) 'An improved chaotic BAT swarm scheduling learning model on edge computing', *IEEE Access*, Vol. 7, pp.58602–58610.

Kapgate, D. (2014) 'Efficient service broker algorithm for data center selection in cloud computing', *International Journal of Computer Science and Mobile Computing*, Vol. 3, No. 1, pp.355–365.

Kaur, R. and Luthra, P. (2012) 'Load balancing in cloud computing', in *Proceedings of International Conference on Recent Trends in Information, Telecommunication and Computing*, ITC, December.

Kaushik, S. and Gandhi, C. (2020) 'Capability based outsourced data access control with assured file deletion and efficient revocation with trust factor in cloud computing', *International Journal of Cloud Applications and Computing*, Vol. 10, No. 1, pp.64–84.

Kavousi-Fard, A., Niknam, T. and Fotuhi-Firuzabad, M. (2015) 'A novel stochastic framework based on cloud theory and θ-modified BAT algorithm to solve the distribution feeder reconfiguration', *IEEE Transactions on Smart Grid*, Vol. 7, No. 2, pp.740–750.

Knepper, R. (2017) *Shifting Modalities of Use in the XSEDE Project*, Doctoral dissertation, Indiana University.

Krishnadoss, P. and Jacob, P. (2019) 'OLOA: based task scheduling in heterogeneous clouds', *International Journal of Intelligent Engineering and Systems*, Vol. 12, No. 1, pp.114–122.

Li, C., Liao, X. and Jin, H. (2019) 'Enhancing application performance via DAG-driven scheduling in task parallelism for cloud center', *Peer-to-Peer Networking and Applications*, Vol. 12, No. 2, pp.381–391.

Madni, S.H.H., Latiff, M.S.A., Abdullahi, M. and Usman, M.J. (2017) 'Performance comparison of heuristic algorithms for task scheduling in IaaS cloud computing environment', *PloS One*, Vol. 12, No. 5, p.e0176321.

Mandal, A.K. and Sarkar, A. (2019) 'A novel meta-information management system for SaaS', *International Journal of Cloud Applications and Computing*, Vol. 9, No. 3, pp.1–21.

McClelland, J.L., Rumelhart, D.E. and PDP Research Group (1986) *Parallel Distributed Processing. Explorations in the Microstructure of Cognition*, Vol. 2, pp.216–271.

Milani, A.S. and Navimipour, N.J. (2016) 'Load balancing mechanisms and techniques in the cloud environments: systematic literature review and future trends', *Journal of Network and Computer Applications*, Vol. 71, No. 1, pp.86–98.

Mishra, P., Pilli, E.S., Varadharajan, V. and Tupakula, U. (2017) 'Intrusion detection techniques in cloud environment: a survey', *Journal of Network and Computer Applications*, Vol. 77, No. 3, pp.18–47.

Mushtaq, M.F., Akram, U., Khan, I., Khan, S.N., Shahzad, A. and Ullah, A. (2017) 'Cloud computing environment and security challenges: a review', *International Journal of Advanced Computer Science and Applications*, Vol. 8, No. 10, pp.183–195.

O'Driscoll, A., Daugelaite, J. and Sleator, R.D. (2013) ''Big data', Hadoop and cloud computing in genomics', *Journal of biomedical informatics*, Vol. 46, No. 5, pp.774–781.

Pan, J.S. and Dao, T.K. (2019) 'A novel improved BAT algorithm based on hybrid parallel and compact for balancing an energy consumption problem', *Information*, Vol. 10, No. 6, p.194.

Pattanaik, A., Sagnika, S., Das, M. and Mishra, B.S.P. (2019) 'Extractive summary: an optimization approach using BAT algorithm', in *Ambient Communications and Computer Systems*, pp.175–186, Springer, Singapore.

Premkamal, P.K., Pasupuleti, S.K. and Alphonse, P.J.A. (2020) 'Efficient escrow-free CP-ABE with constant size ciphertext and secret key for big data storage in cloud', *International Journal of Cloud Applications and Computing*, Vol. 10, No. 1, pp.28–40.

Priya, V., Kumar, C.S. and Kannan, R. (2019) 'Resource scheduling algorithm with load balancing for cloud service provisioning', *Applied Soft Computing*, Vol. 76, No. 5, pp.416–424.

Rimal, B.P., Choi, E. and Lumb, I. (2009) 'A taxonomy and survey of cloud computing systems', in *2009 Fifth International Joint Conference on INC, IMS and IDC*, IEEE, August, pp.44–51.

Sharma, S., Luhach, A.K. and Sinha, S.A. (2016) 'An optimal load balancing technique for cloud computing environment using BAT algorithm', *Indian Journal of Science and Technology*, Vol. 9, No. 28, pp.1–4.

Szczypta, J., Łapa, K. and Shao, Z. (2014) 'Aspects of the selection of the structure and parameters of controllers using selected population based algorithms', in *International Conference on Artificial Intelligence and Soft Computing*, Springer, Cham, June, pp.440–454.

Tang, X. and Chanson, S.T. (2000) 'Optimizing static job scheduling in a network of heterogeneous computers', in *Proceedings 2000 International Conference on Parallel Processing*, IEEE, August, pp.373–382.

Ullah, A. and Nawi, N.M. (2020) 'Enhancement to dynamic load balancing technique for cloud computing using HBATAABC algorithm', *International Journal of Modeling, Simulation, and Scientific Computing*, Vol. 8, No. 6, pp.215–227.

Ullah, A., Nawi, N.M., Shahzad, A., Khan, S.N. and Aamir, M. (2017) 'An e-learning system in Malaysia based on green computing and energy level. JOIV', *International Journal on Informatics Visualization*, Vol. 1, Nos. 4–2, pp.184–187.

Ullah, A., Nawi, N.M., Sutoyo, E., Shazad, A., Khan, S.N. and Aamir, M. (2018) 'Search engine optimization algorithms for page ranking: comparative study', *International Journal of Integrated Engineering*, Vol. 10, No. 6, pp.415–423.

Ullah, A., Nawi, N.M., Uddin, J., Baseer, S. and Rashed, A.H. (2019a) 'Artificial bee colony algorithm used for load balancing in cloud computing', *IAES International Journal of Artificial Intelligence*, Vol. 8, No. 2, pp.156–162.

Ullah, A., Umeriqbal, I.A.S., Rauf, A., Usman, O.Y., Ahmed, S. and Najam, Z. (2019b) *An Energy-Efficient Task Scheduling using BAT Algorithm for Cloud Computing*, August, Vol. 14, No. 4, pp.16–24.

Umar, S. and Baseer, S. (2016) 'Perception of cloud computing in universities of Peshawar, Pakistan', in *2016 Sixth International Conference on Innovative Computing Technology (INTECH)*, IEEE, August, pp.87–91.

Varshney, S., Sandhu, R. and Gupta, P.K. (2019) 'QoS based resource provisioning in cloud computing environment: a technical survey', in *International Conference on Advances in Computing and Data Sciences*, Springer, Singapore, April, pp.711–723.

Wang, H., Burgei, W.A. and Zhou, H. (2017) 'Interpreting dose-response relation for exposure to multiple sound impulses in the framework of immunity', *Health*, Vol. 9, No. 13, pp.1817–1842.

Wang, L.F. and Anderson, D.E. (2019) 'Viruses in BATs and potential spillover to animals and humans', *Current Opinion in Virology*, Vol. 34, No. 7, pp.79–89.

Wang, Y., Wen, J. and Zhou, W. (2019) 'A trust-based evaluation model for data privacy protection in cloud computing', *International Journal of High Performance Computing and Networking*, Vol. 14, No. 2, pp.147–156.

Wertheim, J.O., Murrell, B., Smith, M.D., Kosakovsky Pond, S.L. and Scheffler, K. (2014) 'RELAX: detecting relaxed selection in a phylogenetic framework', *Molecular Biology and Evolution*, Vol. 32, No. 3, pp.820–832.

Wheeler, A.R., Fulton, K.A., Gaudette, J.E., Simmons, R.A., Matsuo, I. and Simmons, J.A. (2016) 'Echolocating big brown BATs, *Eptesicus fuscus*, modulate pulse intervals to overcome range ambiguity in cluttered surroundings', *Frontiers in Behavioral Neuroscience*, Vol. 10, No. 6, p.125.

Willebeek-LeMair, M.H. and Reeves, A.P. (1993) 'Strategies for dynamic load balancing on highly parallel computers', *IEEE Transactions on Parallel and Distributed Systems*, Vol. 4, No. 9, pp.979–993.

Wood, T., Shenoy, P.J., Venkataramani, A. and Yousif, M.S. (2007) 'Black-box and gray-box strategies for virtual machine migration', in *NSDI*, April, Vol. 7, p.17.

Wu, J., Guo, S., Li, J. and Zeng, D. (2016) 'Big data meet green challenges: big data toward green applications', *IEEE Systems Journal*, Vol. 10, No. 3, pp.888–900.

Xiao, Z., Song, W. and Chen, Q. (2012) 'Dynamic resource allocation using virtual machines for cloud computing environment', *IEEE Transactions on Parallel and Distributed Systems*, Vol. 24, No. 6, pp.1107–1117.

Xiong, Y., Chen, Y., Jiang, K. and Tang, Y. (2017) 'An energy-aware task consolidation algorithm for cloud computing data centre', *International Journal of High Performance Computing and Networking*, Vol. 10, Nos. 4–5, pp.352–358.

Xue, W., Li, W., Qi, H., Li, K., Tao, X. and Ji, X. (2017) 'Communication-aware virtual machine migration in cloud data centres', *International Journal of High Performance Computing and Networking*, Vol. 10, Nos. 4–5, pp.372–380.

Zafar, F., Javaid, N., Hassan, K., Murtaza, S., Rehman, S. and Rasheed, S. (2018) 'Resource allocation over cloud-fog framework using BA', in *International Conference on Network-Based Information Systems*, Springer, Cham, September, pp.222–233.

Zhang, Q., Cheng, L. and Boutaba, R. (2010) 'Cloud computing: state-of-the-art and research challenges', *Journal of Internet Services and Applications*, Vol. 1, No. 1, pp.7–18.

Zissis, D. and Lekkas, D. (2012) 'Addressing cloud computing security issues', *Future Generation Computer Systems*, Vol. 28, No. 3, pp.583–592.