Suitability of Virtualization and ABC Algorithm in the SEAFORM Approach

Dr.R.Sundar Raj[1], S.Jaganathan[2] , M.Geetha[3]

[1,2,3]Assistant Professors, Department of Computer Science,
Kongu Arts and Science College (Autonomous), Erode-638 107, Tamilnadu, India

ABSTRACT

The Cloud service generally starts from the Cloud Service Provider (CSP) and ends up at the user level. The cloud resource usually gets ordered by the user who may be an individual or an enterprise. In most of the cases, the resources are dispatched to the user with an utmost speed and with a least latency. This is carried out in order to keep up the customers in a satisfactory level, but this may lead to the problem of mishandling of resources with least security measures. Once the resource is given to the users, the usage starts and that is utilized by the real customers. Then after, the CSP would not interfere much in the usage of the resources, since it is a pay per use service and due to the Service Level Agreements (SLAs) agreed. In some cases, these resources are used illegally by the intruders who may get in to the system due to mismanagement of resources at many levels like host, network or application. To handle the highly valuable cloud resources the Virtualization and a metaheuristic Artificial Bee Colony (ABC) Algorithm contribute well with their suitability especially in SEAFORM.

Keywords: *Virtualization, ABC, SEAFORM, EVMM, Physical Machines, Virtual Machines.*

1. INTRODUCTION

Cloud Computing is a collection of computing software and services available from a decentralized network of servers. There are many popular services and web sites already used by the people without being aware that they are cloud-based. Social networking sites like Twitter, Facebook, etc., Web-based email clients like Yahoo, Gmail, Hotmail etc., Messengers like WhatsApp, Telegram, Hike etc., Peer-to-Peer networks like Skype, Bit Torrent etc., Informational Sources such as Wikipedia, Online Encyclopedia, Online news etc., Video watching sites such as YouTube, Video Cafe etc., and even more. These applications blend well with the daily routine of common public as the well-known and frequently used cloud services [1,2]. There is no need for the centralized location or organization that controls these cloud services, and nothing is required to utilize them besides a Web browser and an Internet connection in the host computer. Instead of purchasing and installing the physical infrastructure necessary to run software programs, a business is carried out by providing the services as per the need.

2. VIRTUALIZATION – THE BACKBONE OF CLOUD

2.1 Importance of Virtualization

Cloud Computing has been used in most of the diversified fields, and merging Virtualization with cloud provides a good support to achieve the aim of Cloud Computing to its fullest. Virtualization is the key enabler technology of a converged infrastructure and to deal with the essential requirements of cloud. The features such

as, on demand sharing of resources, security by isolation, etc., are made possible through the concept of Virtualization [3].

Virtualizing a data center's IT resources can have certain consequences related to the physical infrastructure. If these impacts and consequences are ignored, the broad benefits of Virtualization and Cloud Computing can be limited or compromised, and in some cases it may experience severity. Virtualization brings many advantages on the manufacturing system reliability, by allowing full system backups and quick recovery in case of failures, as well as providing built-in redundancy [4,5]. Virtualization software enables to break the single application server into fractional replicas called VMs. In the year 1970, with the development of the mainframe computer system called System/360 by International Business Machines (IBM) Corporation the technology of Virtualization was initially introduced, not in the level it is now.

The important specialty features of Virtualization are:

- Faster data recovery
- Facility of service migration
- Cached reuse of frequently used resources
- Consolidation of many server machines time to time
- Normalization of hardware resources
- Independence of applications from Physical Machines (PMs)
- Measured service dispatch
- Widened access of the network with Rapid method of elasticity

2.2 Hypervisor

The Hypervisor, otherwise called as Virtual Machine Monitor (VMM) is a software that is able to run all the copies of the virtual elements and ensure that the users do not share the same resources simultaneously among one another. It is also a junction of abstracting the hardware and is encapsulated with Kernel and operating system for monitoring VMs and to enforce rules. Hypervisor allows the sharing of resources between the Host Machines (HMs) and Virtual Machines (VMs).

It gets associated well with Network Interface Controller (NIC), operating system, and also with the end user applications. It acts as a functional layer that performs the operations in an inter-relational way [6,7].

2.3 Virtual Machines

Virtual Machines (VMs) are used to run multiple core machines independently with the property of isolation among the applications. These machines create an illusion among the users that they are using the systems with a whole sole access. They are also essentially needed for applying this concept of Virtualization [8,9,10]. The fundamental types of Virtual Machines are shown in the Fig. 2.1.

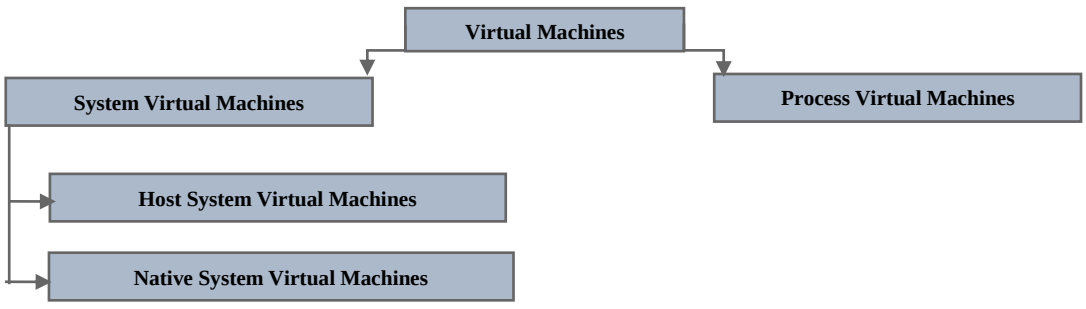

Fig. 2.1 Types Of Virtual Machines

2.4 Virtual Machine Migration

Migration of VMs is a process that is carried out within two or more servers deployed either over a Local Area Network (LAN) or Wide Area Network (WAN) in which a VM is moved from one machine to another. With day to day advancements and arising need for the huge data storage in the processing and networking of applications, VMs and their migrations are becoming major needs of any business of present state [11,12,13]. Hence, VM Migration becomes an essential factor when there is a need to share the resources among other users.

2.5 Approaches Of Virtualization

Generally, in an environment that supports traditional methods, the concept of physical switch is used along, by connecting with the physical servers. The organizations that use it can receive details about the traffic that goes between the servers and the connected switch. In VMs, the virtual switch has links from the physical switch through the physical NIC. The eye is kept away from this and may cause some lag related to the safeguard measures and efficiency in performance. Thus it is essential to keep track on the major approaches related to the Virtualization [14,15]. The popular approaches are shown as follows:

2.5.1 Hypervisor Based Virtualization

Hypervisor is a program running on the host, that facilitates simultaneous access of resources. The nature of it depends upon the application code. Hypervisor turns riskier when the volume and complexity of the application code increases. A Trusted Platform Module (TPM) in the host helps to create a trust relationship with the Hypervisor [16]. The user while using this approach should be very cautious, because if failure occurs even at small point, chances are high for the intruder to get into the system and may cause attacks. Controlling the attacks after its occurrence is also somewhat difficult [17,18].

2.5.2 Application Based Virtualization

Applications running in virtual systems would possibly run on a thin client. This comprises of few resident programs and can access many of them in a connected server [19,20,21]. Application based Virtualization follows each VM containing its own guest operating system and related applications. Even though this approach is simpler in usage, it is not commonly used in commercial environments and has a moderate level of security issues.

2.5.3 Operating System Based Virtualization

OS acts as an interface between the user and the hardware of the system. This method of OS based Virtualization, completely rules over the virtualized machines. This approach supports the different virtualized guests on a single physical server. These act according to the property in which all the individual machines are on the common roof of operating system's central core Kernel. Some external support on the infrastructure of hardware would be offered to them. Security issues of this approach are similar to Application based systems. A brief overview on the three above mentioned approaches of Virtualization based on its characteristics in various factors is presented in the Table 2.1.

Table 2.1 Comparison Of Virtualization Approaches

Factors	*Hypervisor based approach*	*Application based approach*	*Operating system based approach*
Common features	Web based remote control Migration within hardware nodes Data backup Root access		
Principle behind	Complete OS is running in a VM	Concentrates on the guest OSs that runs its related applications	One kernel installed and gets run on the hardware node, with several VMs (as a partial OS) installed on top of it
Operating System	Flexible and allows multiple OS at a time	Can be used in a single OS at a time	Chosen when not more than an OS is needed
Set up	Longer set up phase depending on OS Takes minutes to hours	Medium level set up Takes some minutes	Very Quick Fully automatized set up by provider Takes some seconds
Remote access	Available before OS boot Provides remote console and keyboard functionality	Available after OS boot Depend on applications	Available after OS boot Depend on OS shell access or remote desktop connection
Management of resources	VM needs to get shut down when new resources are to be allocated	Consumes application related resources	Provides elasticity- (i.e.) resources are added whenever necessary without any shut down or volume resizing
License	Separate license costs for OS and VM	License for applications is enough	All in one included
Pros	Free choice Full control on OS and parameters Full control on version and upgrade of OS Full dedicated resources Quality of Service (QoS) is a commitment Convenient to consolidate physical servers on a single hardware node	Can incorporate changes easily Runs variety of applications QoS is moreover essential Application level updation is allowed	More efficient Kernel upgraded by provider Low overhead Less charged and more economical QoS is a best try Provider lends managed service
Cons	More costly Higher overhead per VM Full Maintenance is customer's responsibility Less VM can run on a hardware node	Not used in commercial based environment more commonly Has some security issues	No control on Kernel Provider has control on version and upgrades on kernel Only one kernel can run on hardware node Mix of OS impossible

3. ARTFICIAL BEE COLONY (ABC)

3.1 Importance of ABC

Researches can be carried by the inspiration of many sources. Among those sources, Nature plays a very important role and has the capability to inspire research mob in a greater way. Most of the important inventions came into reality by the inspiration created by nature.

Artificial Bee Colony (ABC) algorithm with global search ability is one of its kind, designed based on a stochastic technique. This algorithm is adopted into the cloud resource management portion of the proposed

work. Swarm Intelligence, which is based on the restrained collective behavior of social insect colonies or animal societies that interact with each other for making up a decision, is the foundation for this ABC algorithm. This algorithm was first published by Dr. Dervis Karaboga, in the year 2005 with the agenda of solving numeric based optimization algorithm. It was recognized as a powerful, robust, global optimization algorithm, capable of dealing the unimodal and multimodal, non-differentiable, nonlinear objective functions effortlessly. Inspite of several efforts have been made by researchers across different disciplines to enhance the performance and efficiency of the algorithm, the original version itself stands stronger.

3.2 ABC In Cloud – The Reason For Choice

ABC still remains a promising and interesting algorithm, which would continue to be extensively used by the researchers. It has been used across diverse fields, but not widely in the area of Cloud Computing's resource management, which is evident through the Literature review. Although the performance of ABC algorithm can be improved by integrating additional heuristics, the standard version is used in this research work since it is still in a potent form. Chiefly, the motivation of bringing out this kind of search and swarm based bio-inspired iterative algorithmic technique, is made out by the keen observation made on the intelligent foraging behaviour of honey bees in their colony. The complexity of the algorithm is also O(n). The construct of this algorithm is very simple, but with robust characteristics. The algorithm is comparatively flexible by having less control parameters such as Limit, Swarm size, the Count of employed bees that occupies first half of the swarm, the Count of onlookers that occupies next half of the swarm, and the Count of scout bees. This algorithm also works very well with the pattern matching algorithms.

3.3 Chief Components

The chief components of this nature inspired approach ABC, that carries out the remarkable and dedicated tasks on their own, are enlisted below:

3.3.1 Foraging Bees

The residents of the hive or colony which may be employed or unemployed depending upon the situation are the Foraging Bees

(i) Employed Foragers

These are comprised within the preceding or beginning portion of the hive. These are linked to number of food sources equal to their count. The information carried by the Employed bees are Distance from the Food Source and Direction, Quality and Profitability of the Food Source.

(ii) Unemployed Foragers

These are comprised within the succeeding or ending portion of the hive. They are continually at look out for a food source to exploit that takes care of the recruitment of Food Source. They are classified into two sub categories:

(a) Onlookers

Onlookers waits at dance area and keenly watches the dance pattern of Employed Foragers in order to select the food source. It also carries out the exploitation process in the search space.

(b) Scouts

Scouts make a random selection of new food sources and controls the exploration process in the search space that are characterized by a low average in food source quality. The employed bees would turn in to Scouts once if solution of food source is not improved by a pre-determined number of trials and its food source has been exhausted.

3.3.2 Food Source Or Solution Vector

Food Source may be rich or poor in terms of quality in nature, but the objective is to select the high quality of resources. Factors determining the high quality of the Food Source are the Proximity to the hive, Richness or Concentration of energy, Easiness in extraction.

4. ANALYSIS OF ABC'S BEHAVIOR AND ALGORITHM

4.1 Classification Of Behaviors

The significant behaviors of ABC components are listed in the Table 4.1 as follows:

Table 4.1 Behaviors In ABC – Classification

BEHAVIOR	SIGNIFICANCE
Automized organization	Dynamic mechanism that sets up the rules of interaction which is based on the observation of local patterns
Distributive labor	Allocative mechanism that are given to the specialized individuals of the group in order to respond regarding the changes that occur in the search space during the search cycle
Collective Intelligence	Decisive mechanism that are derived as a result of the search cycle by the exchange of information in order to take a vigilant decision

4.2 Fundamental Stages

Various stages of ABC are depicted in Fig.4.1 as follows:

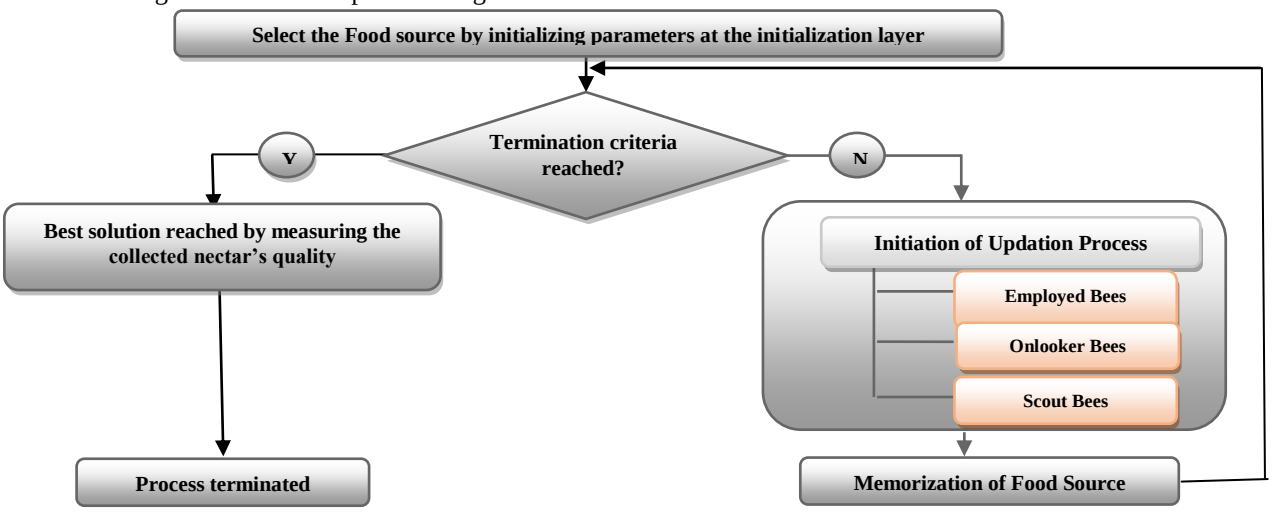

Fig. 4.1 Fundamental Stages Of ABC Algorithm

4.3 Feedbacks Obtained

The common feedbacks obtained from ABC are tabulated in Table 4.2 as follows:

Table 4.2 Feedbacks From ABC

FEEDBACK	CIRCUMSTANCE
Positive	Returned when employing or allocating foraging bees to rich food sources
Negative	Returned when employing or allocating foraging bees to poor food sources
Fluctuate	Returned as a result of the search cycle by the exchange of information
Multiple interactional	Returned when employed bees performs different dance patterns

4.4 Search Cycle

The processes of search cycle in ABC are mentioned as follows:

- **Local Selection Process -** Carried out by onlooker bees
- **Global Selection Process -** Carried out by onlooker bees and scouts
- **Random Selection Process -** Carried out by scouts with the help of neighbor searching mechanisms

4.5 Procedure Of ABC

The procedure of ABC is presented Phase wise in Fig. 4.2, 4.3, and 4.4. and general scheme in the Fig. 4.5.

Employed Bee Phase In Artificial Bee Colony (ABC) Algorithm

```
for j=1.....PS do
    for i=1.....N do
        x'(i) = x_j(i) ± r(x_i(j) – x_k(i))
        ∀_k ∈ (1, 2, ... ..PS), k ≠ j and r~ (0,1)
    end for
  calculate f(x_i)
  if (f(x') ≤ f(x_i)) then
    x_i = x' ;  f(x_i) = f(x')
   end if
 end for
```

Fig. 4.2 Employed Bee Phase - Pseudocode

Onlooker Bee Phase In Artificial Bee Colony (ABC) Algorithm

```
for i=1.....PS do
     r~ (0,1)
     sum_prob = 0
     j = 0
     while (sum_prob ≤ r) do
       sum_prob = sum_prob + p_j
       j = j + 1
      for k=1.....N do
          x'(j) = x_j(k) ± r(x_j(k) – x_j(m))
          ∀_m ∈ (1, 2, ... ..PS)
       end for
     calculate f(x_j)
  if (f(x') ≤ f(x_j)) then
     x_j = x'_j ;  f(x_j) = f(x'_j)
  end if
 end for
```

Fig. 4.3 Onlooker Bee Phase - Pseudocode

Scout Bee Phase In Artificial Bee Colony (ABC) Algorithm
for i=1.....VS do *if (scout(i) = limit) then* *generate* x_j *where,* $x_j(i)=LB_i + (UB_i - LB_i)\times r$ *end if* *end for*

Fig. 4.4 Scout Bee Phase - Pseudocode

The general scheme of ABC Algorithm is given below:

Artificial Bee Colony (ABC) Algorithm
Step 1 : *Initialize the ABC by sending the scouts to Food Source* ***Step 2 :*** *Initialize the parameters of the optimization problem* ***Step 3 :*** *Initialize the Food Source Memory* *Loop* *Assign the employed bees to the food sources* *Employee bee Phase begins* *Determine the nectar amount* *Assign the onlookers to the select the food source* *Onlooker bee Phase begins* *Calculate the probability value of the food sources* *Send the scouts to the select other possible food sources* *Scout bee Phase begins* *Best food source is stored in Memory* *Until* *(Termination stage is reached by meeting out the requirements of the hive)*

Fig. 4.5 Artificial Bee Colony (ABC) Algorithm – General Scheme

5. SEAFORM APPROACH

5.1 Self Evaluative ABC adapted Federated networks with Optimized Resource Management (SEAFORM)

The proposed approach is named as **S**elf **E**valuative **A**BC adapted **F**ederated networks with **O**ptimized Resource **M**anagement (SEAFORM). In the proposed work that is entitled as Enhanced Cloud Resource Management System Inspired by Artificial Bee Colony Algorithm (ABC), the metaheuristic algorithm ABC has been incorporated in the resource management sector with the efforts for carrying out the simpler and easier resource locator activities. Specifically improvised mapping approach that is suitable for federated networks has been fused into the system with least latency.

Effective monitoring architecture which increases the internal profitability has also been followed, with efficient management of resources without affecting the local accessibility. This has been made to go well with supportive security buildup systems that could render the service even more cheaper with lesser administrative burden. The scheduling and allocation processes together is meant as provisioning, further carrying out monitoring, optimizing and security support together constitutes the management with respect to the SEAFORM.

5.2 Incorporation Of ABC To Resource Management In Cloud

In the proposed work related to cloud resource management, the Artificial Bee Colony (ABC) algorithm is adopted. There are several reasons for incorporating ABC into the proposed approach. They are as follows:

- The unresolved problems taken for this research highly demanded this technique, in order to carry out the cloud resource management in an effective manner.
- It is evident from the past researchers that it has outperformed and has been proved as a prominent one by comparing the other available optimization algorithms like Particle Swarm Optimization (PSO) Algorithm, Particle Swarm inspired Evolutionary Algorithm (PS-EA), Genetic Algorithm (GA) and Differential Evolution (DE).
- It is possible to turn into a hybridized model and could work well with pattern recognition and matching algorithms, which is important to be compatible with SBIDS+SMIPS.
- It has variety of applications such as the analysis of protein structure, engineering designs, information technologies, numeric oriented solutions, etc., that shows its wider scope.
- It is a well proven concept that gives optimized results when applied on several bench marking problems which are evident with the review of literature and with comparison of results.

5.3 Depictions Of Operating Components – ABC Vs SEAFORM

Being inspired by Artificial Bee Colony (ABC) algorithm, the important components of it are incorporating to the proposed approach SEAFORM. These vital considerations are illustrated in the Table 5.1, as the portrayal of key components of SEAFORM matching to the important metaheuristic factors of ABC.

Table 5.1 ABC Vs SEAFORM –Portrayal Of Key Components

In ABC	In SEAFORM
Hive	With improvisations it is treated as the Enhanced Virtual Machine Monitor (EVMM) of Base Network
Honey Storage Cells	Cloud Resource Pool
Food Sources	Cloud Resource Instances
Employee Bees	Cloud Resource Fetchers that is associated with the Mapping Phase
Onlooker Bees	Cloud Resource Optimizer that also does Local Resource Monitoring and is associated with the Embedded Resource Management Phase
Scout Bee	Cloud Resource Scheduler that also does Remote Resource Monitoring is associated with the Targeting Phase
Dance Area	Cloud Provenance Interface
Waggle dance	Notification about the Current Status of the Resource with its Availability
Delay by Waggle dance	Latency
Solution Space	Range of the Cloud System
'Limit' in Food Source	Abandoned/ Engaged Cloud resources
Collected Nectar	Resource Population Size as Packets
Nectar quality, distance etc.,	Control Parameters
Neighborhood search	Local Selection with Proactive Static Provisioning
Random or Outer area search	Global Selection with Reactive Dynamic Provisioning
Choices made by Onlookers	Considered as Positive/Negative/ Fluctuate/ Multiple Interactional Feedbacks
Association between Food Sources and Hive	Federated Cloud Virtual Network
Position of Food sources	Mapping between resources and tasks carried out by CSPs
Bees' Flying potential	Velocity to determine the speed and direction of the resources
Chosen Food Source	Optimal Solution
Nectar removal	Ready-to-Dispatch Cloud Resources

5.4 Strategy Implemented

The strategical view is essential for any proposed approach to get implemented. Understanding the importance of this factor, the strategy that has been followed in SEAFORM is presented as follows:

- The ABC has been adapted to the resource allocation Phase at the level of Virtual Machine Monitor (VMM) by converting it as Enhanced Virtual Machine Monitor (EVMM) for which the need of supporting toolkits has been minimized

- The design layers of cloud resource management have been strengthened up and the facilitations have been made to work well in federated networks
- Customization of resource monitoring and management have been made possible with simple steps and are fine-tuned for ensuring the effective utilization of resources with an elaborated view of the proposed approach by incorporating ABC components into the Phases of SEAFORM
- The compatibility of the approach with the other proposed security supportive systems SBIDS + SMIPS have been verified to ensure that the resources are dispatched only after tightening the network security
- The focus has been given for the global access of resources to make it perform better in all kinds of host systems, where Hybrid clouds can also be facilitated for the usage
- Workflow execution time has been minimized which would facilitate faster service and the bandwidth estimation has been comparatively made simpler
- The concentration has also been shown towards both load balancing and resource monitoring of dynamically changing VMs that could be managed with least costs
- The possibility of making the struggles lesser in diversified federated environments is seen through and the resource underutilization problems have been addressed
- The approach has focused on scalability services by handling large scale of resources with least efforts
- Mapping a network at virtual level to the network at base level has been efficiently carried out

7. CONCLUSION

The main objective of the proposed approach is to overcome the cons of the existing methods to carry out resource management in a better way and by adapting ABC at the level of VMM by enhancing it as EVMM. This would outperform the existing works with its unique approach towards resource allocations, scheduling and monitoring, by strengthening the process at foundation level itself. '**S**elf **E**valuative **A**BC adapted **F**ederated networks with **O**ptimized Resource **M**anagement' (**SEAFORM**) approach. From the analysis it is clear that to handle the highly valuable cloud resources the Virtualization and a metaheuristic Artificial Bee Colony (ABC) Algorithm contribute well with their suitability especially in SEAFORM.

REFERENCES

1. Anup H. Gade. (2013). A Survey paper on Cloud Computing and its effective utilization with virtualization. *International Journal of Scientific and Engineering Research*, 4(12), 357-363.
2. Asaju La'aro Bolaji, Ahamad Tajudin Khader, Mohammed Azmi Al-Betar Mohammed A. Awadallah. (2013). Artificial Bee Colony Algorithm, its Variants and Applications: A Survey. *Journal of Theoretical and Applied Information Technology,* 47(2), 434 - 459.
3. Ashish Prosad Gope and Rabi Narayan Behera. (2014). A Novel Pattern Matching Algorithm in Genome Sequence Analysis. *International Journal of Computer Science and Information Technologies*, 5(4), 5450-5457.
4. Brototi Mondal, Kousik Dasgupta, Paramartha Dutta, Kalyani and Visva. (2012). Load balancing in Cloud Computing using Stochastic Hill Climbing-A Soft computing approach. *Elsevier, Science Direct- Procedia Technology, Bharati University,* 4(1), 783-789.

5. B Rahul. Diwate and Satish J. Alaspurkar. (2013). Study of Different Algorithms for Pattern Matching. *International Journal of Advanced Research in Computer Science and Software Engineering*, 3(3).
6. Chirag Modi, Dhiren Patel, Bhavesh Borisaniya, Hiren Patel, Avi Patel and Muttukrishnan Rajarajan. (2013). A survey of intrusion detection techniques in cloud, *Elsevier, Journal of Network and Computer Applications*, 36(1), 42-57.
7. Dervis Karaboga and Bahriye Akay. (2009). A comparative study of Artificial Bee Colony algorithm. *Elsevier, Journal of Applied Mathematics and Computation*, 214(1), 108-132.
8. Dhinesh Babu L. D and P. Venkata Krishna. (2013). Honey bee behavior inspired load balancing of tasks in cloud computing environments. *Elsevier, Applied Soft Computing*, 13(1), 2292-2303.
9. Fouad Bahrpeyma, Ali Zakerolhoseini, Hassan Haghighi and Shahid Beheshti. (2014). Using IDS fitted Q to develop a real-time adaptive controller for dynamic resource provisioning in Cloud's virtualized environment. *Elsevier, Applied Soft Computing*, 26(1), 285-298.
10. Junaid Arshad, Paul Townend and Jie Xu. (2013). A novel intrusion severity analysis approach for clouds. *Elsevier, Future Generation Computer Systems*, 29(1), 416-428.
11. Raj, R Sundar; Bhaskaran, Dr. V Murali. (2014). Technical Guidance to Overcome the Issues on Cloud Computing. *Journal of NanoScience and NanoTechnology*, 2(6), 725-727.
12. Raj, R Sundar; Bhaskaran, Dr. V Murali. (2015). A Roadmap to Virtualization Approach in Cloud Computing. *International Journal of Advanced Research in Data mining and Cloud Computing*, 3(1), 33-37.
13. Raj, R Sundar; Bhaskaran, Dr. V Murali. (2015). An Empirical study on revolutionizing approach in Cloud Computing paradigm. *International Journal of Contemporary Research in Computer Science and Technology*, 1(6), 187-198.
14. Raj, R Sundar; Bhaskaran, Dr. V Murali. (2016). Improved Cloud Security Mechanism with a Self-Monitored Intrusion Prevention System. *International Journal of Advance Research in Science and Engineering*, 5(12), 20-32.
15. Raj, R Sundar; Bhaskaran, Dr. V Murali. (2017). Comparative Analysis of Cloud Tools to Implement Automated Resource and Security Management. *Indian Journal of Engineering (An International Journal)*, 14(35), 20-32.
16. Raj, R Sundar; Bhaskaran, Dr. V Murali. (2017). Securing cloud environment using a string based intrusion detection system. *Advanced Computing and Communication Systems (ICACCS), 20174th International Conference on*, 1-13.
17. Raj, R Sundar; Bhaskaran, Dr. V Murali. (2018). Security Intelligence in Cloud with Intrusion Detection and Prevention Enhancements. *International Journal of Advance Research in Science and Engineering*, 7(2), 454-467.
18. Rodrigo N. Calheiros, Rajiv Ranjan, Anton Beloglazov, C´esar A. F. De Rose and Rajkumar Buyya. (2010). CloudSim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms. *CLOUDS Laboratory*, 41(1),.23–50.
19. Suraj Pandey, LinlinWu, Siddeswara Mayura Guru and Rajkumar Buyya. (2008). A Particle Swarm Optimization-based Heuristic for Scheduling Workflow Applications in Cloud Computing Environments. *The University of Melbourne, Australia*.

20. Weiwei Kong, Yang Lei and Jing Ma. (2016). Virtual machine resource scheduling algorithm for cloud computing based on auction mechanism. *Elsevier, Journal of Optik*, 127(1), 5099–5104.
21. UCI Repository – https://archive.ics.uci.edu/ml/support/Cloud
22. European Union Open Data Portal
    - https://data.europa.eu/euodp/en/data/dataset/yUBHDpCh8MDqL9Gub8Qmq

AUTHORS' BIOGRAPHY

Dr.R.Sundar Raj, Assistant Professor in Computer Science of Kongu Arts and Science College (Autonomous), Erode, Tamilnadu, India has received his B.Sc in Computer Science and MCA degree from Bharathiar University and has secured University I Rank in both the degrees. He has also published research papers in International journals. He has secured Highly Commended in his Ph.D programme from Bharathiar University with his area of research as Cloud Computing. He has six years of teaching experience and has received Best Teacher awards twice.

Mr.S.Jaganathan, Assistant Professor in Computer Science of Kongu Arts and Science College (Autonomous), Erode, Tamilnadu, India has received his B.C.A from Bharathiar University and MCA degree from Anna University. He has also published research papers in International journals. He has secured M.Phil. from Bharathiar University with his area of research as Data Mining. He has eight years of teaching experience.

Ms.M.Geetha, Assistant Professor in Computer Science of Kongu Arts and Science College (Autonomous), Erode, Tamilnadu, India has received her B.Sc in Computer Science from Bharathiar University and MCA degree from Periyar University. She has also published research papers in International journals. She has secured M.Phil. from Mother Teresa University with her area of research as Data Mining and Networking. So far, She has guided six M.Phil. Scholars. She has fifteen years of teaching experience and has received Best Teacher award.