EAI Endorsed Transactions
on Cloud Systems Research Article **EAI.EU**

Investigation of Security Breaches Due to Resource Sharing in Virtual Machine Migration Using Hybrid Ant Colony Optimization with ANN

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Abstract

Cloud computing is one of the active research areas in High Performance Computing. It helps to share the resources globally in a distributed manner. In this paper, hybrid ACO with ANN is designed to ensure the best and the secured VM consolidation process. Initially, the objectives constraints for power consumption, resource deterioration and the SLA parameters are modelled for the Physical Machines and Virtual Machines. The selection of VMs is explored by the concept of Ant Colony Optimization that select the best VMs by the predefined SLA parameters. Also, the eavesdropping attack is also modulated in the cloud shared environment. The proposed hybrid ACO with ANN is implemented in CloudSim and it's compared with the honeybee with GA and PSO with GA. The simulation results have proved the efficiency of the VMs consolidation process with the security constraints in terms of time-related on uptime and downtime of the servers.

Keywords: Cloud computing; Security breaches; Resource provisioning; Optimization; CloudSim; Artificial Neural networks ; Virtual Machines.

Received on 05 April 2022, accepted on 01 June 2022, published on 07 June 2022

doi: 10.4108/eai.7-6-2022.174150

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1. Introduction

The rapid advancements of cloud computing have revolutionized the growth of Information Technology (IT) and its services. Despite its support for many years, the challenges in data security and trusted computing are still prevailing in the current applications using cloud computing technologies [1]. The exploration and exploitation of the technologies will take computer generations to the next level.

Cloud computing is one of the recent technologies that offers different storage and management services related to the business's requirements. In simpler terms, it provides 'computer resources as a service' to its registered users. Data security is a concern for all technologies, but it is particularly difficult in an uncontrolled environment like cloud computing.. The assessment of organizing, managing and storing the data at the remote server is easily done by data services model. Though it can manage the data, the security of the data at the remote server has become a complex task.

Most researchers have stated the scope of the data security from different aspects for different real-time applications. However, an end-to-end solution is not achieved by the suggested data placement models. The cloud users outsource the data to the cloud infrastructure which develops data vulnerability than the conventional infrastructure. These vulnerabilities are prevailing from three aspects, namely, a) outsourced data is preserved at the infrastructure of the service providers; b) different users share similar infrastructure and c) easy access of the data. In order to gain more profit, the efficiency of the storage system has to be focused. In some cases, the probability of data duplication is highly prevailing in the cloud storage systems. It slows down the efficiency of the cloud storage process.

Load balancing is one of the challenging issues that determine the performance of the system applications. Load balancing is defined as the distribution of the tasks among the machines placed at the Data Centres (DCs) (Panda et al, 2018). In general context, the concept of cloud computing is to share the resources by means of the internet on the basis of demand. It consists of several interlinked computers in which the files and applications are hosted in a multi-fashion manner. It combines with the distributed and parallel computing that offers the resources such as software, hardware and files (xue et al, 2016). The overloaded DCs are resolved by the concept of virtual machines.

Virtual Machines (VMs) are the processing units residing in the cloud that offer computing and sharing the resources during the execution of the tasks. It makes use of a large number of VMs which perform in a preemptive and non- preemptive manner. However, it is observed that the resources are not shared in a well -distributed manner (Kumar and Sharma, 2017). As a result, some VMs are idle in nature. When the task is being submitted in the cloud, it takes the help from VMs to run in a faster manner. The concept of scheduling has been introduced in the tasks allocated to the VMs. The task assigned in the scheduler is equally distributed over the VMs. Some VMs are overused (or) underused. Thus, it initiates the concept of load balancing which is the prime focus of this study. The placed scheduler should take the responsibility of equalizing the tasks in the cloud.

The paper is organized as follows: Section 2 presents the Related work; Section 3 presents the Research Methodology; Section 4 presents the Experimental Results and Discussion and Section 5 presents the Conclusion.

2. Related work

This section presents the review of existing studies from the aspects of objectives, techniques designed, merits and the demerits. The theme of load balancing is to allocate the input tasks among the placed VMs in a uniform distribution manner. And also, it re-allocate the tasks between the overloaded VMs and the under loaded VMs. These processes are carried out to assure the efficacy and the fair resource provisioning on cloud-based applications services. Recently, the concept of optimization and load balancing are predominantly employed to overcome the posed challenges of load balancing and task scheduling concepts. Several researchers have sorted out the issues of unbalanced load by means of neural network and optimization approaches. Security concept imbibes with the load balancing was examined under a distributed environment (Ezumalai et al,2010).
Three methodologies were designed namely, (i) architecture for mobile agents that covers the mobile nodes counts; (ii) architecture to neutralize the loads among the mobile nodes; (iii) architecture for providing security to the mobile agents. Similar study was extended by (Malarvizhi and RhymendUthariaraj, 2009) which provided a hierarchical computing model for all jobs in the grid environment. Based on the information given by the present nodes, the input tasks were allocated. The designed system has reduced response time of node allocation in the grid environment. In line with that, minimal completion time and arrival time were also achieved. (Krishna, 2013) was suggested a honey bee behaviour based load balancing model that allocated the tasks in an independent manner.

The other task scheduling algorithms such as weighted round robin, FIFO, and dynamic load balancing were evaluated under the performance of throughput, waiting time and the task prioritization (Deng and Lau, 2014). The performance of dynamic load balancing in a virtual environment has developed a heat diffusion among the placed machines. By the use of convergence threshold, it has minimized the response time with a maximized network traffic. In the cloud environment, an improved particle swarm optimization (Zhu et al, 2016) was designed to balance the loads in the cloud network. It has enhanced the task implementation time.

In order to minimize the data searching complexity in PSO, a tabu search algorithm was also suggested to effectively manage the cloud resources (Larumbe and Sanso, 2013). The three decisive parameters like cost, deadline and optimal findings are the major factors that predict the efficiency (Alam et al, 2014). It resolved the issues by the concept of task prioritization and task grouping. By means of tabu search, the locations of the data placement in cloud data centers was also optimized by improving the routing process. Load balancing algorithm (Alharbi & Rabigh,2012) was explored to increase the utilization of the resources with an increased lifespan. It also minimized the flow time to complete the tasks. In the case of handling data placement in multiple data centers, a fuzzy logic (Toosi & Buyya, 2015) was designed to efficiently balance the loads with the minimized costs and energy. It has assisted to balance the loads via an offline system. It mapped the cloud data using the fuzzy logic inference systems.

In the case of distributed file systems, the network traffic was maximized and thus, loads are balanced using optimization algorithms (Hsiao et al, 2013). Fully distributed load rebalancing algorithm (Deng et al, 2016) was designed with the base of Lyapunov optimization. A centralized approach was designed for all scheduling and power management. Honey bee algorithm was also designed to improve the Quality of Experience (QoE) (Vasudevan et al,2016) in cloud environment. Prioritization of the tasks was rebalancing the cloud server using self-learning randomized optimization (Papadopoulos et al, 2016).

While assigning the tasks towards the cloud data centers, the utilization of energy was improved by proper allocation of the resources (Moganarangan et al, 2016) using Enhanced Exponentially Weighted Moving Average algorithm. Then, a soft computing technique was also employed to resolve the issues of dynamic load balancing in the cloud data centers (Mondal & Choudhury, 2015). Homogeneous and heterogeneous cloud environments were explored under resource allocation tasks (Mishra, 2018). It has improved the power and the cloud data placement during dynamic resource allocation. With the help of static information, the cloud nodes were clustered, so as to improve the capability. In order to improve the stability of the load balanced tasks, an improved weighted round robin algorithm has been introduced (Devi & Rhymend,2016). By altering the load values, the throughput performance of the distributed file system was studied. Several scheduling algorithms related to big data processing (Selvi and Aruna, 2016) were also studies on the homogeneous and heterogeneous cloud networks (Jena et al, 2020).

3. Research Methodology

This section presents the working of the hybrid Ant colony optimization with Artificial Neural Networks (ANN). The proposed phases are:

3.1 System Model

Let us assume a data center that contains a trove of Physical Machines (PMs) runs many applications and a trove of Virtual Machines (VMs) that supports the PMs by observing the CPU and memory of the running applications. In order to minimize the consumed power, data centers play a vital role for ensuring better environmental sustainability. The wiser utilization of the cloud resources assures the minimized energy consumption rate. Henceforth, dynamic VM consolidation and it's security are focused in this study. The proposed focus is achieved by reducing the energy consumption of idle physical machines and also proper selection of virtual machines. Virtual Machines selection process is done by the concept of optimization and neural network approaches. In this approach, we have used the resources such as CPU utilization, RAM, migration time and Service Level Agreement (SLA) violations. Depending on the CPU performance, the PMs are categorized in terms of Million of Instructions per Seconds (MIPS). The similar consolidation is performed on the set of different virtual machines that satisfies the constraints the CPU utilization, MIPS, network bandwidth and RAMs.

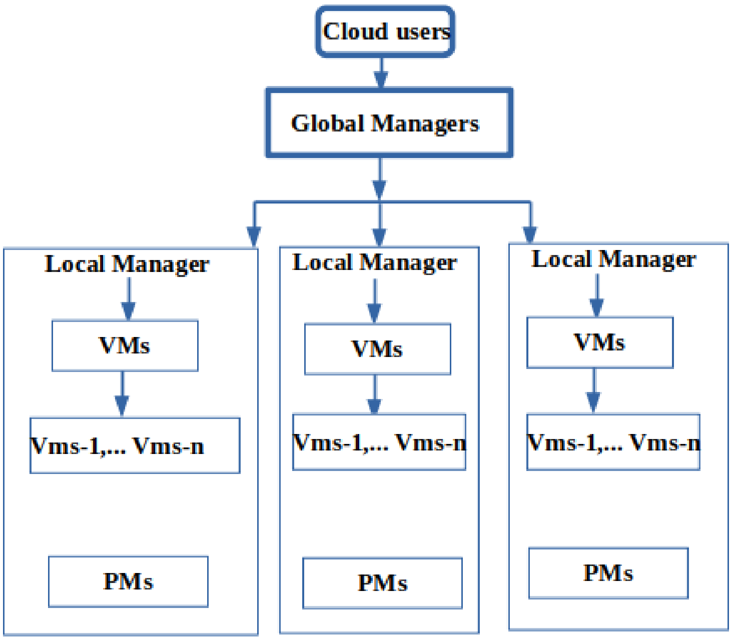

Fig. 1. System model for proposed work

The system model contains two core components, viz, a) Global manager and b) Local manager. The role of global manager is to wisely decide and proportionate the resources for the VMs based on the availability of PMs. It is triggered by the predefined characteristics of SLA. The role of local manager is to take action on placing the VM based on the service availability and the latency time by means of Ant Colony Optimization (ACO). Additionally, the security of the VM placement is also considered by proposing an Artificial Neural Network (ANN). Henceforth, both the managers play a significant role in the architecture of the data center.

3.2 Modelling of Data centers

The predefined characteristics and the SLA parameters of the cloud data centers containing virtual machines and physical machines are modelled in this phase. They are presented as follows:

a) Power consumption analysis:

It is analyzed by the utilization of CPU. Pertaining to it, a linear relationship between power consumption and the CPU utilization is expressed as,

$$P_{server} = \{\left(P^{busy}_{server} - P^{idle}_{server}\right) \times U^{P}_{server} + P^{idle}_{server}\,;\ {}^{CPU}_{server} \geq 0\} \text{ ------------(1)}$$

Else

$$P_{server} = \{0 \;\;,\quad otherwise\} \text{ ----(2)}$$

Where,

P^{busy}_{server} & P^{idle}_{server} are the average power constants, server denotes idle and busy states.

In general context, the threshold values of these variables are defined to 160 and 210 respectively.

b) Resource deterioration analysis:

The resource deterioration of the server is analyzed as,

$$RD_{server} = \frac{\left|NR^{CPU}_{server} - NR^{memory}_{server}\right| + \epsilon}{NU^{CPU}_{server} + NU^{memory}_{server}} \qquad \text{------------(3)}$$

Where,

NR^{CPU}_{server} denotes the regularized remained CPU power;

NR^{memory}_{server} denotes the regularized remained memory;

NU^{CPU}_{server} and NU^{memory}_{server} denotes the regularized CPU and memory.

Here, a regularization operator is employed to calculate the amount of used resources to the aggregate resources. The resource wastage modelling aims to achieve a balance of the residual resources along different dimensions of resources considered.

c) Service Level Agreement (SLA) modelling:

Here, two SLA parameters are modelled, viz, server availability and the server latency.

- Server availability: It is also known as uptime assessment. It is expressed as,

$$Availability_{server} = \frac{Uptime}{Uptime + downtime} \text{ -----(4)}$$

- Server latency: It measures the speed of data being transferred. It helps to find out the overloaded (or) under loaded PMs for the betterment process of VM migration. It is measured in milliseconds (ms).

3.3 Virtual Machines consolidation process

VMs consolidation process is the major key focus of this study that contains two processes, namely, VMs selection and the secured VMs prediction.

3.3.1 Formulation of VMs

Consider a set of v virtual machines $v \epsilon V$ that locate in p physical servers $s \ \epsilon \ S$. The placement of the VM is processed by the optimal mapping solutions. The placement of VMs v is to map onto p physical servers with a specified set of constraints. The above objective functions aim to reduce the total power consumption and resource deterioration. With the help of objective functions, the creation and the allocation of VMs are mathematically expressed as,

$$\sum_{s=1}^{p}[y_s \times ((P_s^{busy} - P_s^{idle}) \times \sum_{v=1}^{n}\left(allocate_{vs} R_{cpu}^{v}\right) + P_s^{idle})] \text{ ------(5)}$$

$$min \sum_{s=1}^{p} RW_s = \sum_{s=1}^{p}[y_s \times \frac{|(latency_{cpu}^{s} - \sum_{v=1}^{n}(allocate_{vs} - R_{cpu}^{v})) - (latency_{mem}^{s} - \sum_{v=1}^{n}(allocate_{vs} - R_{mem}^{v}))| + \epsilon}{\sum_{s=1}^{n}\left(allocate_{vs}\, R_{cpu}^{v}\right) + \sum_{v=1}^{n}(allocate_{vs}\, R_{mem}^{v})} \text{ -----(6)}$$

Subject to,

$$\sum_{s=1}^{p} allocate_{vs} = 1 \quad , \quad \forall_v \in V \text{ -------(7)}$$

$$\sum_{s=1}^{n} R_{cpu}^{v}\, allocate_{vs} \leq latency_{cpu}^{s}\, y_s \,, \quad \forall_s \in S \text{ -----------(8)}$$

$$\sum_{s=1}^{n} R_{memory}^{v} allocate_{vs} \leq latency_{memory}^{s} y_s \quad , \forall_s \in S \text{ --------(9)}$$

$$y_s, allocate_{vs} \in \{0, 1\} \quad , \quad \forall_s \in S \quad \forall_v \in V \text{ ------------(10)}$$

3.3.2 Virtual Machines (VMs) selection using ACO

With the help of above objective constraints, the deployment of Ant Colony Optimization (ACO) is designed to select the best VMs from a pool of VMs. The working of ACO is presented as follows:

a) Initialization:

This is the first step used to construct the pheromone matrix. Here, the count of virtual machines and physical machines; CPU utilization; Resource utilization; network latency and the uptime and downtime of servers are collected. It is expressed in matrix form and thus, the regularized matrix form is given as,

$$P(S_O) = \sum_{s=1}^{p} \frac{P_S}{P_S^{max}} \text{ -----(11)}$$

b) Solution framing process:

The fundamental principle behind the VM migration is done via an iterative process. Therefore, the solution framing begins on ants that hold the set of VMs and its organized servers. For each server s at vector S, the ants select the VMs to locate in the appropriate position. It is done by:

$$\Omega_a(s) = \{v \in \{1 \ldots\ldots n\} | (\sum_{u=1}^{p} allocate_{vu} = 0) \wedge ((\sum_{u=1}^{n} allocate_{us} \times R_{cpu}^{u}) + R_{cpu}^{v}) \leq latency_{cpu}^{s})$$

$$\wedge ((\sum_{u=1}^{n} allocate_{us} \times R_{memory}^{u}) + R_{memory}^{v}) \leq latency_{memory}^{s}) \text{ ----------(12)}$$

With the help of above constraints, the migration problem of VMs from the VMs v to the host server s is strategized by the motion of ants. Selecting the right VM v for the host server s rely on the heuristic and the pheromone data at the present state. Thus, the heuristic information is expressed as η_{vs} and the pheromone information is expressed as τ_{vs}. The role of heuristic information is to offer the choice of selecting the VMs v to place in the current server s. Therefore, the mapping of v to s is expressed as,

$$\eta_{vs1} = \frac{1}{\epsilon + \sum_{i=1}^{S} (\frac{P_i}{P_i^{max}})} \text{ ----(13)}$$

$$\eta_{vs2} = \frac{1}{\epsilon + \sum_{i=1}^{S} RW_i} \text{ ------(14)}$$

$$\eta_{vs} = \eta_{vs1} + \eta_{vs2} \text{ ------(15)}$$

Finally, the v to s mapping element that has highest heuristic and pheromone information is selected by the ant to place VM in the current server.

c) Pheromone Trial Update:

A complete analysis of VMs to PMs has been analyzed. However, the local update of pheromone values for each ant motion is expressed as,

$$\tau_{vs} = (1 - \rho_{trail}) * \tau_{vs}\,(t-1) + \rho_{trail} * \tau_O \text{ ----(16)}$$

Where,

$\rho_{trail} \in \{0,1\}$ denotes the pheromone decay coefficient

τ_0 is the initial value of the pheromone.

Once after the solution is being constructed, the global update of the pheromone values are further calculated by following the below three equations.

$$\tau_{vs}(trail) = (1 - \rho_{global})\, \tau_{vs}\,(trail - 1) + \rho \Delta\tau_{vs}^{best} \text{ ----(17)}$$

$$\tau_{vs}^{best} = \frac{\lambda}{QS_{best}} \text{ ------(18)}$$

$$\lambda = \frac{CA}{trail - CD_s + 1} \text{ -----(19)}$$

Where,
CA denotes the count of ants
CD denotes the count of epochs
λ denotes the adaptive coefficient parameters that control pheromone updation.

If the present iteration is not ruled by other solutions, then the current iteration solution is preserved and the pheromone value of the current solution gets updated.

3.3.3 Secured Virtual Machine prediction using ANN

The previous process happens in the cloud shared environment i.e public channel. Hence, security constraints need to be addressed for the efficiency of cloud- based applications. Eavesdropping is an eminent attack that rules the distributed network environment. The failures of VM allocation represents an unusual behavior of the system when the attributes of the systems correlates with observed and expected values. In order to improve the selection rate of VMs placement, the occurrence of the failure rate in cloud systems needs to be minimized. Predictive analytics is introduced to exploit the data based on the security trends. Initially, collecting the data from the diverse sources from VMs and PMs, determined neuron and weighted connections. Let us define the ANN parameters, input layer $I = \{I_1 \ldots . I_n\}$ with connection weights $W = \{w_1 \ldots . w_n\}$. The proposed ANN consists of two phases and thus, combinedly expressed as,

$$A = \sum_{i=1}^{n} i_i \times w_i \text{ ---(20)}$$

The value obtained from A and the transfer function values are used to represent the states of the neuron. Then, the obtained value is transferred to the hidden neurons. Here, sigmoid transfer function is applied on the proposed objective constraints. These calculations have an effect over the migration and selection of VMs to enhance the security performance of PMs. Bssed on the available server information, the proposed ANN predicts the next possible failure of VMs. The non- availability of VMs will urge the global manager to re-compute those VMs to the next available VMs. The evaluation of obtained information of VMs and PMs are processed on the basis of interpolation modules. And also, the selection of optimized VMs will help to trade-off the main cause of server non-availability. The proposed ANN module operates continuously to enhance the VMs selection and also maximize the response time by eliminating the VM migration delays.

4. Results and Discussion

This section elaborates the simulation setup and the performance measures used to validate the proposed framework. Along with that, the existing techniques, honeybee with GA and PSO with GA are discussed to consolidate the designed framework. The security analysis of preventing (or) detecting the eavesdropping attack are also presented. Here, CloudSim is employed to implement the hybrid ACO with ANN. The class design of the cloudsim for the hybrid ACO-ANN is presented in the below figure. The finer details of the simulation process and the SLA parameters are discussed as follows:

a) Datacenter: It is liable for the creation of the fundamental infrastructure services that have diverse RAM, storage and bandwidth related to the PMs as well as VMs.
b) Datacenter Characteristics: It depicts the configuration data of data center resources.
c) Host: It models the physical resource that encapsulates the usage of memory and storage and the allocation policies of VMs.
d) Cloud Coordinator: It ensures the cloud federation process by coordinating with the internal resources of DCs and the load balancing process. It is configured as per the cloud provisioning policies.
e) Virtual Machine (VM): It is a class model that is managed and hosted by the cloud host component. Further, it coordinates with the SLA parameters.
f) VM allocation policy: It is used to monitor the VMs to the hosts using ACO technique.
g) VM scheduler: It is an abstract class that executes the server components related to time and CPU utilization.
h) Cloudlet: This class identifies the tasks that must be uploaded onto the cloud to be processed. Every cloudlet has a preassigned instruction length and data transfer (both pre and post fetches) overhead that it needs to undertake during its life cycle.
i) Bw provisioner: This is an abstract class that models the policy for provisioning of bandwidth to VMs. The main role of this component is to undertake the allocation of network bandwidths to a set of competing VMs that are deployed across the data center.
j) Cloudlet Scheduler: This abstract class is extended by the implementation of different policies that determine the share of processing power among Cloudlets in a VM.

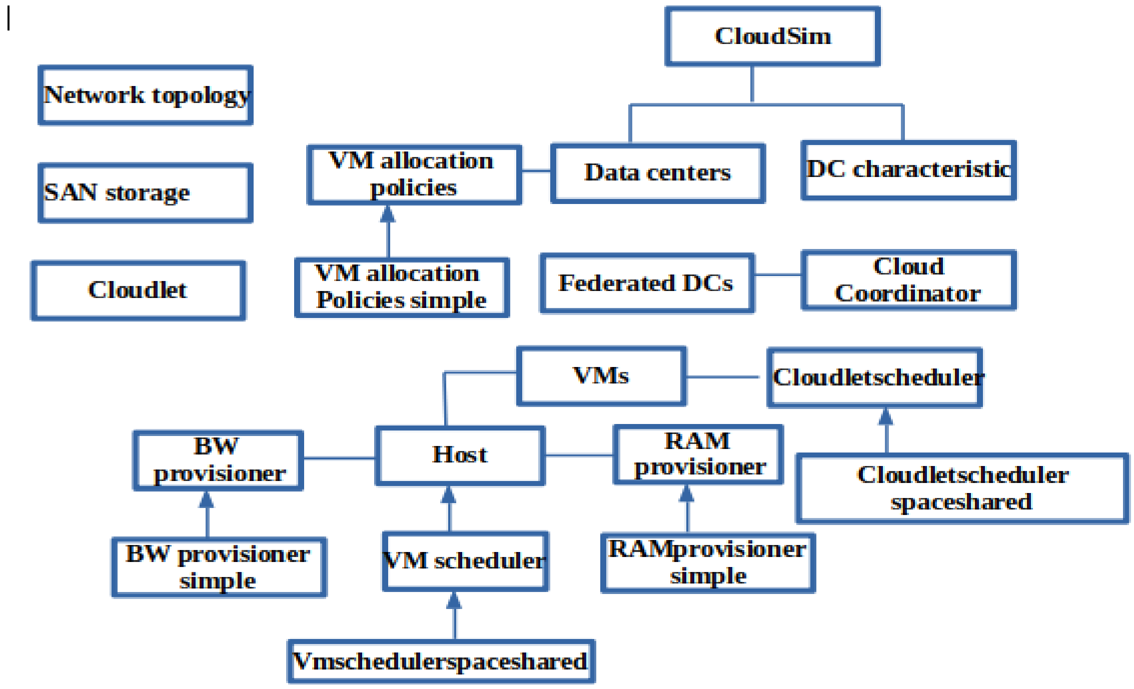

Fig.2. Class details of CloudSim tool

The hybrid ACO-ANN is compared with the existing technique, honeybee with GA and PSO with GA.

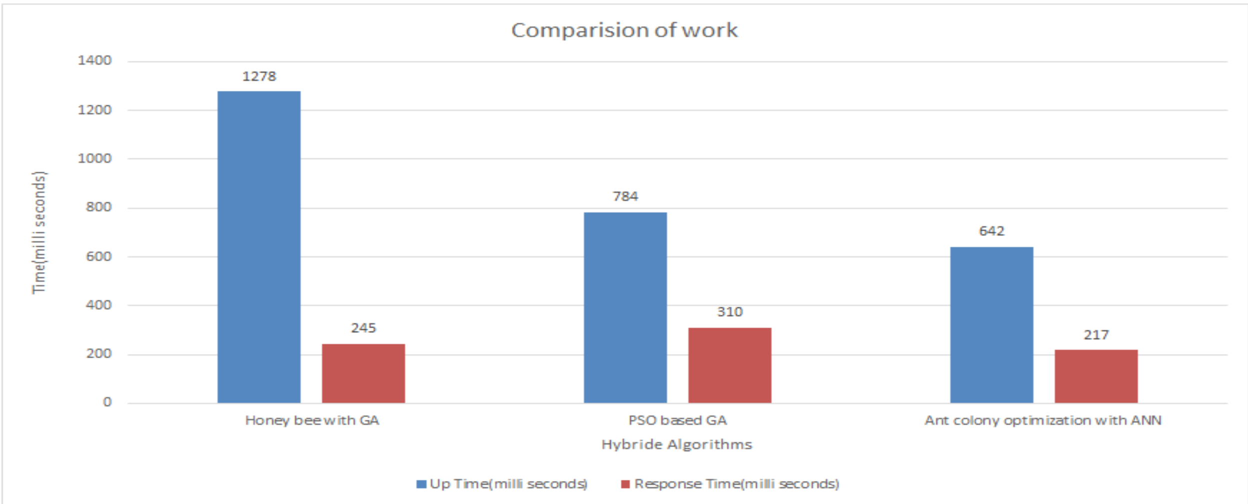

Fig. 3. Performance chart

The above fig.3 presents the performance chart of the proposed with the existing techniques. It is inferred that the proposed consumed better uptime and downtime than the other existing techniques. The comparison of cloudlet completion time, with respect to VM- CPU utilization and resource deterioration policy reveals that the number of cloudlets completing their execution with high cloudlet completion time is greater.

The fundamental improvement is that the optimized and secured VMs are eventually divided among the task units without resource deterioration and also meet the security constraints Excessive VM movement may have a negative impact on datacenter performance, As a result, the maximum CPU utilization, minimum migration time, and maximum memory space(RAM) policies address the problem of VM migration minimization while also addressing SLA violations.

The main idea for selecting physical machines from which the selected VMs will be migrated is to set a lower and upper CPU usage threshold, and it is also critical to keep the CPU utilisation of PMs between these threshold values. As a result, just a few VMs will be migrated if PM CPU utilisation exceeds the upper threshold value, while all VMs will be migrated if CPU utilisation falls below the lower threshold value. Thus, our proposed hybrid ACO with ANN takes the advantages of the CPU utilization, resource deterioration and SLA parameters.

5. Conclusion

In this paper, hybrid ACO with ANN is designed to ensure the best and the secured VM consolidation process. Data center is the major focus point of this research study. Initially, the objectives constraints for power consumption, resource deterioration and the SLA parameters are modelled for the Physical Machines (PMs) and Virtual Machines (VMs). The selection of VMs is explored by the concept of Ant Colony Optimization (ACO) that helps to select the best VMs by the predefined SLA parameters.

Along with that, the eavesdropping attack is also modulated in the cloud shared environment. In order to improve the security constraints, the formulation of Artificial Neural Network (ANN) is designed for the secured resource provisioning policies. The proposed hybrid ACO with ANN is implemented in CloudSim and it's compared with the honeybee with GA and PSO with GA. The simulation results have proved the efficiency of the VMs consolidation process with the security constraints in terms of time-related on uptime and downtime of the servers.

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