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Research on secure workload execution scheme in heterogeneous cloud environment

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ABSTRACT

The increasing demand for the hardware, software and infrastructure is playing a big role in the information technology domain towards the need of customer's specific requirements. Cloud computing is a major backbone for providing such services over the internet. It includes the services such as applications, storage, network, scalability, sharing, virtualization, confidentiality, security, authentication, and integrity. A large number of data intensive workflow applications uses heterogeneous cloud environment for communication and computation operation. An intruder/attacker will utilize these environments for their benefit by flooding malicious links, unwanted information and others. In cloud environment, detecting a malicious device/packet during workflow execution is a critical and challenging task. The various workflow method with security, service level agreement (SLA) and quality of service (QoS) have been modelled in recent time; However, these models are not efficient in detecting malicious users and maintaining high level of QoS or workflow applications. This article focus is on addressing research future direction, issues and challenges of work in meeting secure and efficient workflow execution model for heterogeneous cloud environment.

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1. INTRODUCTION

To run the organizations smoothly and efficiently the information systems are used for the business operations. A type of information system is workflow system which is current being used because of the cloud computing architecture. The workflow systems have grown due to the high development of the distributed computing. This workflow system has been shifted to the cloud computing-based workflow systems as it is currently being used to support the services of the cloud [1]. In the current situation of the COVID-19, many employees are currently working in their homes and due to this there is a huge demand of cloud services to store the data. The workflow system is an important element in the cloud services which helps in many fields such as the projects of the smart city, different kind of e-commerce applications and even helps in the educational field. The cloud services are used to transfer the information between the sender device and the receiver device, or to do some sensitive operations on the data. There is a chance that the cloud services can be hacked or the data may get leaked. To protect the data from getting leaked or hacked there are several security measures which can be used. Hence for the workflow system to work in the correct manner, it must be ensured that only the approved users have the access to the current task of the workflow and all the operations performed

are achieved by them. This process can be ensured by giving appropriate access to different users with the respective tasks having proper integrity which can give an assurance that there is no misuse of the data [2].

The Figure 1 is discussing difference cloud services in workflow environment. The current research work is being done on the authorization of the workflow which mainly emphases on the static workflow. In the static workflow, the order which is arriving at the workflow makes the different tasks in a fixed sequence, and attempts to search a feasible workflow which meets all the constraints. In the real-world applications, the routing of the task is not determined, instead the pattern or the probability distribution is used that may be estimated using the previous values. For example, if an item which needs to be processed does not get approved then it will go back to the cart or else it will be shipped to the appropriate user. As the sequence of the task here is not determined, it may lead to low performance in the workload and it can disturb the user's workload. To overcome this problem, the workflow setting executes some operations on the constraints such as the utilization of the user and the waiting time for the order. In this example, the constraint on the utilization can decrease the time of the user for that particular task. If the rate of the utilization exceeds to a given threshold value, it can decrease the performance of the whole system and there may be a risk that the system would get crashed. Hence, the item being ordered should be ordered in a given particular time period, which helps to maintain the efficiency of the workflow system. In the static task-scheduling algorithms (STSA) [3], a VM mapping is developed to execute the entire sub task once, whereas in the dynamic task-scheduling algorithm (DTSA), the VM executes the entire sub task during the runtime [4]. The execution of the VM in the DTSA depends on the execution of the workflow and the present state of the system. The benefit of the STSA is that they have best optimization methods, can produce good-quality schedules using the level of the workflow and can compare the different optimized solutions before selecting the best solution. The flexibility of the STSA is worst than the DTSA. The task-scheduling algorithms have many advantages but have many security issues [5].

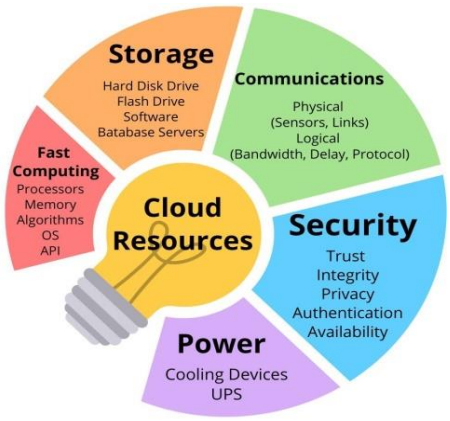

Figure 1. Workflow in the cloud services

The task scheduling method uses the data which is divided into sub-tasks depending on the transference of data between the VMs in the multi-tenant clouds [6]. This method gives the malicious users to attack on these kinds of data very easily. The data which is divided has some security measures such as confidentiality, availability and integrity. The workflow system of the cloud is stores the divided sub-tasks data mainly because of the following reasons [7]. The first reason is that the researches may require that data to re-analyze the data or to perform a method on the sub-tasks data. The second reason is to share the data from one place to another among the researchers and the sub-task data can be reused for various researches. And finally, the stored sub-task data can easily restore the execution of the workflow if there is a crash in the workflow. The VMs are usually used to store the divided data in the workflow system of the cloud [8]. If any of the VM fails, then the divided data may be lost. So, the divided data is more important than the whole data as it helps to restore the VMs [9]. The divided data helps to maintain the confidentiality, availability and integrity even when the data gets attacked by the malicious user [10]. Even if the malicious users get the data, then the content of the whole data cannot be obtained [11]. The integrity of the divided data is very important and should be able to detect whether the data has been hacked or tampered by any other user [12]. Thus, it is important to provide an effective workflow execution that meets application security requirement such as availability, confidentiality, and integrity and also application quality of service (QoS) requirement such as energy efficiency, processing time [13]. here a deep-rooted survey of various workload scheduling is conducted for identifying research challenges for heterogeneous cloud computing framework.

National Institute of Standard Technology (NIST) has defined five necessary components of a cloud computing platform: On demand self-service, one of best service provided by the cloud computing vendors is to offer the on-demand self-service which allows users to scale up the required infrastructure for their specific host operation. Resource pooling, with the help of resources are pooled multiple users are served by the same physical hardware which provides more efficient and effective use through resource virtualization. Rapid elasticity, cloud computing provide the cloud user where they can vary their needs of storage space and resources. Vertical scaling, cloud computing allows for changing the computing capacity assigned to resources which in turn helps to keep many numbers of constant physical machines.

The Figure 2 is deleborate the components of cloud computing. The term cloud computing helps us to identify various benefits which includes, online storing the data, processing, analytics, and other services, online because it is not dependent on local hardware. The cloud user needs a cloud computing environment where the of infrastructure like server, storage, network and operating system which can be provided by the infrastructure as a service (IaaS) which is known as on-demand service. There are different types of scheduling to deal cloud computing tasks. Cloud work flow scheduling helps to execute the workflow task with meeting the QoS requirements. Apart from this scheduling is having a different criterion. The following are the scheduling criteria used in the cloud scheduling algorithms. Heuristic scheme is this type of scheme algorithms implanted provides the solution of an optimized problem solution in a less amount of time, some of the algorithms include, heterogeneous earliest- finish-time (HEFT), partial critical paths (PCP), MIN-MIN, MAX-MIN. some of the Meta-heuristic scheme algorithms include, ant colony optimization (ACO), particle swarm optimization (PSO), genetic algorithm (GA), and ABC. Hybrid scheme is a combination of heuristic scheme, Meta-heuristic scheme algorithms [14].

Some of the algorithms include, list scheduling (LS) and GA, hybrid heuristic scheduling based on GA (HSGA). This section discusses about the tools or the methodologies used in the cloud computing workflow scheduling techniques. There are various types of simulation tools are available to implement the scheduling algorithm, some of the most commonly used scheduling algorithm simulation tools are. CloudSim, CLOUDS Lab developed one of the most popular free and open-source frameworks, which is useful in simulating the cloud computing services and infrastructure. This tool is written using java programming language. It also used for the simulating and modelling the cloud computing domain for evaluating a hypothesis before the software development to reproduce the tests and result. Workflowsim, to help and simulate large scale scheduling and clustering a PhD student name Weiwei Chen from university of southern California (under Apache License version 2.0) developed workflowsim simulation tool. This tool is the extended simulation form cloudsim which provides the higher layer of workflow management in the heterogeneous cloud computing environment. Other such as CloudAnalyst, Gridsim, iCanCloud, GreenCloud is the simulation tools used in the cloud computing domain [15]. The survey which is specifically focused on addressing security problems of workload execution in cloud platform. The survey identifies challenges specific to security, efficiency, and reliability need of workflow.

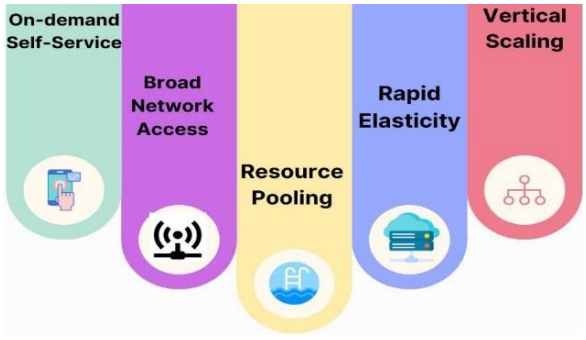

Figure 2. Cloud computing components

2. LITERATURE SURVEY

Role-based access control mechanism, cloud computing technology has attracted many users since a long time. The cloud provides the resources for computing on demand and it also depends on the sharing of the resources rather than having a local server. The existing models have not clearly explained the need for the requirement of the security in their models. Hence, in it explains the security goals required for an efficient reputation-based model. This model has good security and executes the different operations done in the cloud in a minimal execution time. The results of the model show that the model can be used in the real cloud

activities which provide good security, performance, and less execution time. In an algorithm has been proposed for the usage of the resources in the cloud. In this model the task required for the computation are represented using the nodes, and the associations of the tasks is represented using the workflow dependency [16]. The results show that the model uses the resources for the computation efficiently and the workflow dependency executes in very less time. In different algorithms have been reviewed for the scheduling and to make the different strategies in the cloud. The analysis on the different strategies using various metrics has been performed. Using this study, they have proposed a model for the efficient scheduling in the clouds. As the popularity for sharing the files on the cloud is increasing, the security and privacy of the data has become a major problem. For this problem, a framework has been proposed using the ABAC/XACML and CP-ABE. This framework provides the encryption of the file on the basis of the algorithm proposed [17]. The algorithm generates an optimal solution for the encryption of the files which contains small elements and reconstructs the vector. To reduce the errors made by this algorithm an improved scheme CP-ABE-L has been proposed. In this section we study different recent workload execution and security framework presented for workflow execution.

The Figure 3 is shows the workflow scheduling schemes which can be differentiated. Reputation-based secure workload execution scheme: As the internet of things (IoT) devices are increasingly used, there is a huge requirement of the cloud storage. Since the IoT gives architecture for the development of various new systems, the cloud computing services have become universal. Though, because of the various computing and storage problems in the IoT systems, the cloud platform is used to resolve the issue by increasing the storage.

The Table 1 is shows the acronyms and their interpretations used in the forthcoming section of this article. To provide the storage, the security and trust problems arise during the transference of the data. Therefore, a trust model for both the trust and the security has been proposed. In this model the evaluation of the trust is performed so that it ensures the security of the cloud in the IoT device [18]. The security method of the model provides the security measures for all the resources and services given by the cloud. To ensure the security in the trust model, the ratings of the feedback on the value of the services given by the cloud have been exploited. The results show that the trust-based method works effectively and efficiently in the real-world services provided by the cloud.

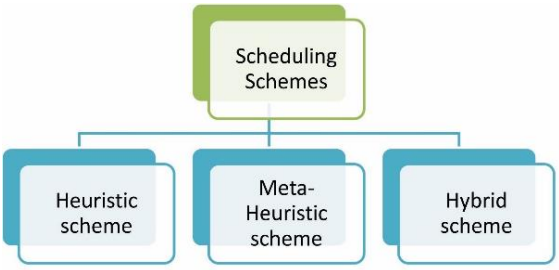

Figure 3. Schemes of workflow scheduling

Table 1. Acronyms used for cloud scheduling

Abbrev	Interpretation	Abbrev.	Interpretation
WFS	Workflow scheduling	CPU	Central processing unit
PaaS	Platform as a service	ABAC	Attribute based access control
IaaS	Infrastructure as a service	IDA	Ideal distribution algorithm
SaaS	Software as a service	XACML	Extensible access control markup language
QoS	Quality of service	NFV	Network functions virtualization
SLA	Service level agreement	ACO	Ant colony optimization
STSA	Static task-scheduling algorithms	BA	Byzantine algorithm
VM	Virtual machine	SDN	Software-defined networking
PVM	Physical virtual machine	QRAS	Qos Resource Allocation scheduling
DAG	Directed acyclic graph	SWS	Secured workflow scheduling
LSTM	Long short-term memory	FCFS	First come frist served
RBAC	Role-based access control	IOT	Internet of things
GA	Genetic algorithm	CP-ABE	Cipher-text-policy attribute based encryption
LIGO	Laser interferometer gravitational wave observatory	ANN	Artificial neural networks
SIPHT	Srna identification protocol using High Throughput technology	IDS	Intrusion detection system
PSO	Particle swarm optimization	CSP	Cloud service provider

3. METHODS

Data integrity through fusion mechanism: In the domain of information technology IoT is playing a major role and a new idea. There are number of data gadgets which can shape start to complete the joins with the help of server through suitable similar forms some of the examples are, Bluetooth, ZigBee, Wi-Fi, and ultra-wideband, in this manner enhancing applications in the domains of smart technology and in-home care, industrial monitoring, among others. By consolidating the IoT with cloud computation domain, and at a greater extent of the executives can likewise be elaborated functionally [19]. With respect to cloud computational environment or IoT, a distributed system has three immense consequences, like independent failures, no global clock, and concurrency. This hub can be handily assaulted by the intruder. Hence, a compelling security algorithm is required. In such a situation powerful agreement algorithm utilizing byzantine algorithm (BA). Byzantine algorithm is a considered as issue tolerant technique. In cited the significant illustration of concurrence among the officers of the byzantine empire concerning assaulting their challenges and used this idea for the development of byzantine algorithm [20].

Machine and deep learning-based security framework: The flexibility of the software defined networking (SDN) have been utilized underway by characterizing the SDN based security systems. The extra functions given by the SDN innovation empower coordination of an original security instrument like the filtering of the traffic. While in the network function virtualization (NFV) scope, a couple of assessment papers focused on evaluating the presentation and believability of running virtual security machines on the edge using holders like IDS and firewalls [21]. Yet this light virtualization development showed exceptional productivity, it ended up being testing representing the asset obliged IoT devices. In fact, the high measure of the traffic represents high energy consumption and CPU utilization, along these lines influencing the gadget's convenience. An elective way to deal with secure IoT frameworks is to utilize machine learning strategies. Various arrangements that influence SDN innovation and ML strategies for empowering network interruption recognition frameworks have been recommended in. In have proposed an answer for the prediction of the city transport area using a deep learning approach. In this method, the long short-term memory (LSTM) neural network has been used for the prediction of the location and the data rate [22]. In they have proposed an answer for the blockchain adaptable IoT frameworks. In they have a recommendation for the correspondences between IoT gadgets and the mobile edge computing (MEC). This method is used to distinguish the possibility of the delivery and the service composition. In research on the usage of the articial neural network (ANN) for the identification of the malicious network traffic is done [23].

Secure Workload execution scheme: In cloud computing, the most significant concept is the workflow scheduling (WFS). This concept reduces the cost, energy, and increases the QoS in the cloud applications [24]. As each of the user and the provider set their own constraints for the security, the cloud computing applications need a universal security measure for all the intermediate information [25]. The security measure is called as the secured workflow scheduling (SWS). In this scheduling, the security of the data is done during the execution of the workflow. This security measure shows that the application having inter-dependent data should be protected when the execution of the workflow is happening in the different cloud VMs. Adding the security measure during the execution of the workflow increases the execution time which may lead to the decrease in the QoS which decreases the efficiency of the model. In a survey on some current models of the cloud computing for the secure workload scheduling (SWS) has been done, where the different factors which are used to measure the secure workflow have been used to clarify the security domains. The different sources of security threats and the solution for each problem have been discussed. They have proposed an algorithm on the basis of the components of the cloud computing. There are various applications of workflow being used in different domains such as prediction, astrophysics, disaster modeling and bioinformatics. As the workflow application solves complex problems using various algorithms, it requires more storage to execute these problems. With the help of the clouds, the workflow applications can easily execute the complex scientific problems and the tasks performed by the workflow applications depend on each other because the output for a given task is taken as an input for another task. In a method to manage the workflow efficiently has been proposed using the GA.

This method categorizes the valuable data and non-valuable data using the algorithm which gives a scheduler for the most valuable data required for the workflow. The algorithm shows a good performance with respect to the time and cost when compared with other methods. In an updated version of the genetic algorithm has been proposed, GA-PSO, which allocates the different tasks to the resources. The main aim of this algorithm was to reduce the cost, makes pan, and to balance the work of the different tasks in a cloud environment. This algorithm proposes an optimal solution with a better performance when compared with the similar techniques. As to resolve the problem of the resource scheduling in a business cloud, an algorithm using the trust method has been proposed. The algorithm first divides the cloud resource scheduling into two, the user scheduling and task-scheduling. After that the trust method is implemented into the task-scheduling so that it can prevent the malicious attacks. When the trust method is completely implemented in the task scheduling then the users are selected for the given task. This reduces the cost and provides more security to

the model when implemented in the cloud. Another method has been proposed to assign different tasks to the machines having huge work scheduling problems using a modified PSO method. In this method the algorithm gives an optimal solution for the job scheduling in the clouds and reduces the security risk in the job scheduling problems. To manage the workflow of the cloud a survey has been done and using the survey an algorithm has been proposed for the scheduling of the workflow in the clouds. This algorithm has improved the existing algorithms like PSO, GA and ACO using the combination strategy for the scheduling enhancement of the workflow in a cloud environment. Another method for a reliable scheduling of the workflow has been presented to reduce the cost, time needed for the execution and to increase the security in a cloud environment. This method aims for the better performance and security of the model during the execution of the task in the workflow scheduling. It also aims to avoid the attacks from the malicious users. An algorithm has been proposed for the workflow application in the cloud. In this algorithm various existing methods and algorithms have been used for the deployment of the workflow application which is more reliable, has less cost and also has good security solutions. The results show that the model performs better when compared with the two existing scheduling algorithms.

Service level agreement (SLA) based workload execution scheme: the cloud provides different services such as IaaS, PaaS and SaaS. The users can have the access to these resources by paying the service they require. The providers of the cloud have to optimize the different resources given to the users using the SLA. As the demand for the cloud is constantly increasing, the providers have to ensure the workload resource allocation for each user as it can affect the QoS. Hence, it requires a strategy which can help to increase the availability, scalability, utilization and elasticity for the allocation of the cloud storage. Therefore, for the task scheduling to be performed in the clouds, an efficient method for the resource scheduling has to be implemented so that the tasks can be distributed correctly to the required virtual machines. An algorithm using the ACO for the resource scheduling has been proposed. The main objective of this algorithm was to reduce the time for the execution and the cost. The results show that this algorithm can increase the efficiency of the resource scheduling in the cloud environment. To attain more resources having a secure workflow, a method has been proposed. The method uses swarm-based ACO to give accurate results. The results show that the model has a better performance in terms of QoS. In the current situation of the pandemic, many business operations are done in the cloud. As the business operations have complicated task to be performed which is divided into sub task for the execution to be done, each sub task has an intermediate data which is required for the processing.

4. RESULT AND DISCUSSION

In this section issues and challenges involved for workload execution in cloud computing environment. Energy efficiency workflow execution, for the deployment of the cloud services, it requires a variety of different servers. The power consumption of these servers is very high and to buy these servers it is very expensive. The power required by the servers can damage the environment. Furthermore, the visualization process in the cloud increases the management of the tasks using the parallelism method in the cloud environment.

The Table 2 shows the comparative study and novelty of various proposed sections of methodology and by noticing the above existing works, there are many works which have been done to address the given constraints, execution time, execution cost and makespan. But there have been very few research works which have presented the QoS constraint while meeting all the above constraints. Resource forecasting and workload execution: During the execution of the workflow, the tasks are executed which do not consider the load on the resources. Moreover, selecting an appropriate cache and processing element to execute the task without disturbing the quality of service can be considered as problem due to their dynamic nature. To overcome these problems and for the improvement of these challenges, the resource prediction is done from the workflow scheduling tasks. Considering the availability of the resources and the loads on the servers, the prediction is done to get an appropriate server at each point which can achieve an improved performance and accuracy for the given system. Using the resource prediction, the various objectives of the scheduling can be met without disturbing the QoS factor. For the execution of each task in a parallel order, a number of VMs are working in the cloud center to minimize the resources. For the minimization of the resources and energy in the cloud center, it is necessary to build an efficient virtual machine which can perform the workflow operations without reducing the quality of service.

To maximize the profit of the clouds, many efficient energy methods are used to save the energy by engaging the VMs so that it uses the available serve in the cloud data center. Workflow Fault-Tolerance and Dependability: To deal with the failure of the components, different methods of workflow systems having fault tolerance have been proposed to handle the execution of the workflow with availability and reliability but the dependance on huge data workflow process shows an increase in the complexity. Different factors like the long execution process can affect the dynamic nature of the workflow. Usually, to handle the failures it is most

important to rectify the error, identify the source, reduce the impact and then take an appropriate action so that it can recover the failure. In a big cloud data center, to achieve these tasks it is very complicated because of the different characteristics of the big data and its workflow. Security constraint: As there are many advantages of using the big data processing and cloud computing platforms, there is an issue to create a proper management system for the security and privacy in the Bigdata applications having their data in the cloud. Complete security arrangements have to be done to organize the security of information escalated tasks related with work-flow applications with the security of ever-growing developing bigdata. Moreover, in these existing works no one has addressed the issue of availability, confidentiality, integrity and security of the virtual machine. The given issue can be solved by proposing a reputation-based security model which meets the QoS and also addresses the constraints like cost, time and makespan. Furthermore, the existing works have not addressed the malicious attacks during the execution of the workflow in the virtual machines. This can be done by proposing a reputation-based security model and consensus-based security model which will detect the attack and remove the intermediate corrupted packets.

Table 2. Comparative study and novelty of existing works and possible solutions

Author	Objectives	Method	Findings	Observation
Konjaang and Xu	To propose an algorithm which can schedule the workflows, reduce the cost required for execution and ensure the workflow deadline	The proposed algorithm splits the large workflow in small and executes on the virtual machine which will help to cut down the cost and can execute the workflows faster.	The results show that the model reduced the cost of executing the SIPHT, Montage and Cybershake workflows by 32.5%, 3.9% and 1.2% when compared with the existing system.	In this work they have evaluated the results using the standard workflows such as Inspiral, Montage, SIPHT and Cybershake. The results show better outcomes when compared with the existing systems.
Konjaang and Xu	To propose an algorithm this reduces the cost, makespan and resource utilization and complete. The task of the workflow in the given deadline.	They have proposed two selection methods called MaxVM and MinVm which will help to reduce the cost and provide better makespan.	The results show that the model reduces the cost, provides better makespan and uses the resources efficiently when compared with the existing systems.	In this work, they have considered the scientific workflows, Montage, Cybershake, SIPHT and LIGO to evaluate the model and compare with the existing systems.

5. CONCLUSION

This article first outline an introduction execution of the workflow using cloud platform; and described about the various type of scheduling schemes and parameters. The workflow representations used in the implementations and further highlighted the tools or methodologies used in the development of scheduling algorithms. Also discusses on the QoS and security need for execution of the workflow in cloud platform. Then presented the deep-rooted survey of various security and workflow execution framework it is under the cloud computing environment. Identify the various issues and challenges of workload execution in achieving secure and efficient manner. The future work can be extended for developing an efficient security and QoS constraint of workflow execution under heterogeneous cloud computing environment.

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