Checkpoints and Requirements Based Cloud Service Ranking

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Abstract. Cloud computing and the services offered by cloud computing in the field of Information and Communication Technology has impacted the enterprises and is stimulating at a more prominent pace in the recent years. Various studies have been conducted in the field to meet the client's requirements and raise the quality of services offered. Based on the client's requests and integrating it with load balancing as one of the challenges of cloud computing to be addressed the cloud services are ranked. In order to offer better services to the clients and to maintain the trust, load balancing as one of the criteria in real time scheduling is adopted. In order to attain ranking, different services are required to be invoked in the cloud, the requirement factors and the ranking criteria for each factor has been considered to rank them using entropy analysis of Shannon Furthermore, a framework has been proposed to rank them based on the weights attained by the requirements and the ranking criteria.

Keywords: Checkpoints · Service ranking · Load balancing · Scheduling

1 Introduction

The technological advancements in the field of Information and Communications Technology has brought tremendous changes and has changed the daily life of the customers by enabling him to store, manage and access data from different machines connected through internet and is termed as a cloud. Different models of cloud like private, public and hybrid offer services based on the named functionality and are charged based on the policy pay-as-you use. The Cloud Service Provider (CSP) are responsible for the management of the resources based on the types of services offered by the respective service model like Software as a Service, Platform as a Service and Infrastructure as a Service. Resources could be processing devices, storage devices, specialized tools to perform tasks etc.

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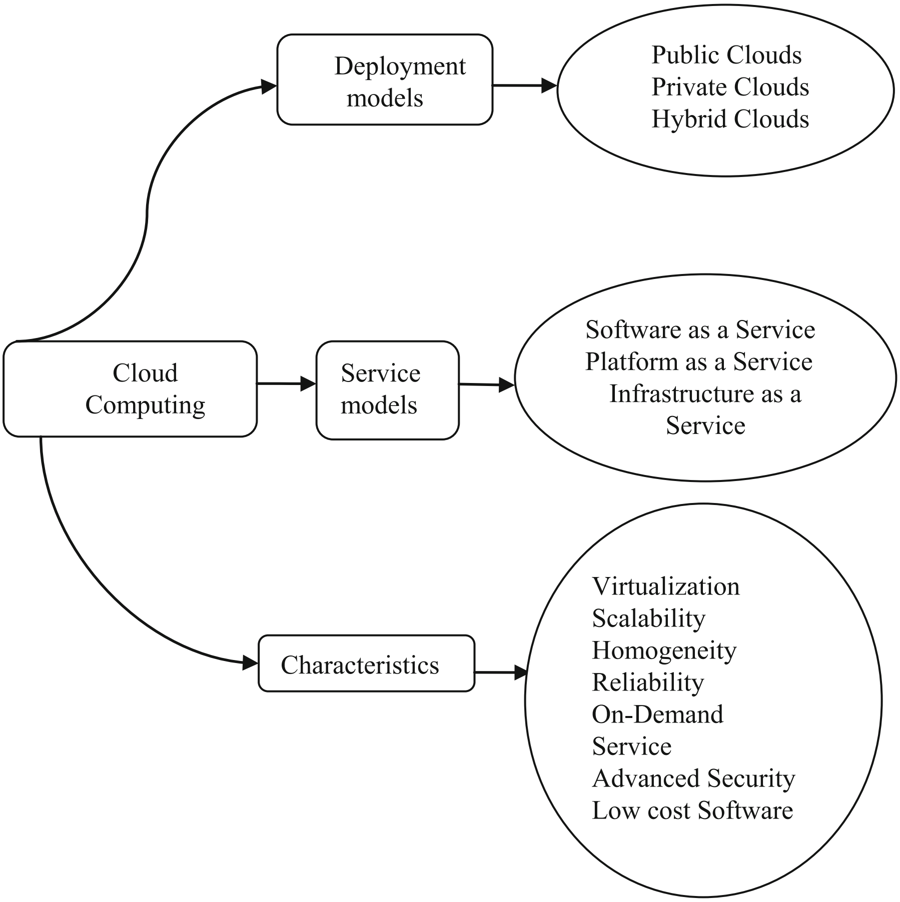

Fig. 1. Cloud computing overview [15].

Figure 1 gives an overview of cloud computing, showing the various deployment models, services offered and the characteristics of cloud computing. There are different regular qualities of Cloud like the virtual processing, extensibility of the machines, though heterogeneous systems are connected showing the homogeneous nature, dependability, wide accepted on demand service, high level security, affordable cost etc. Unmistakable of those are Service level understanding, Sharing of load, safety and security, Quality of service in cloud administrations, costs, and so forth [14].

Figure 2 shows how the tasks are assigned to each Virtual Machine. The point where the system is stable and the data is consistent is called a checkpoint. Point in time (PIT) permits the VMs to roll back to a stable state to meet the client's demand. There are two types of checkpoints as programmed and manual [5]. Programmed checkpoints are taken consistently at regular intervals or as right on time as would be prudent, which are crash reliable and are helpful amid recuperation. Manual checkpoints can be explicitly set at a specific time like at a non-peak hour so as not to effect the user's trust [10]. Therefore, the client has an alternative to do PIT recuperation utilizing manual checkpoints routinely. Executing the checkpoints makes the framework be in a reliable state. Checkpoints are advantageous in an environment where there is non pre-emption along with implementing load balancing.

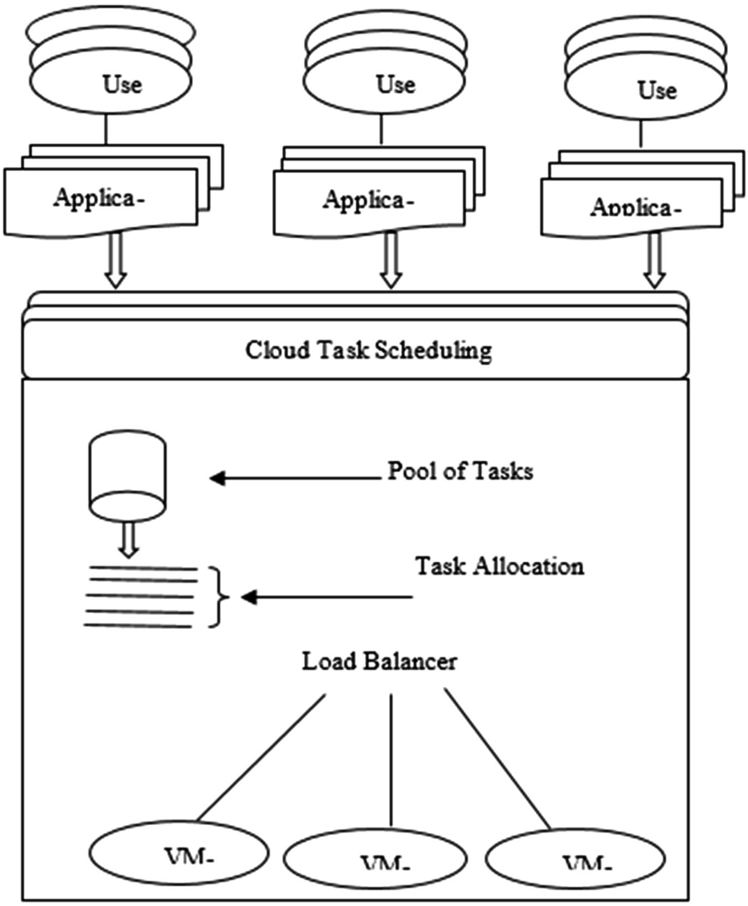

Fig. 2. Cloud architecture for load balancing.

2 Related Work

Various authors have ranked the cloud services using different methodologies. Some have taken the user requirements as a base to rank the cloud service, and some others have made the criteria to rank it [8].

The cloud services being offered by various cloud service providers, there is no standard way to evaluate and select an appropriate service provider. A framework and a mechanism were proposed in order to measure the quality and prioritize the service needed showing its impact on to satisfy the SLA and improve the QoS [6].

In [18], the authors have taken after multi specialist framework (MAS) in cloud computing, keeping in mind the goal to adjust the heap. This framework is an inexactly combined system with the product specialists in order to address the issues which couldn't be settled utilizing singular limit [1]. Creators utilized diverse parameters for load adjusting which are dependability, reconfigurability and capacity to alter [2].

Agreeable Checkpointing talked about in was contrasted and occasional checkpointing with a trial examination which demonstrates the helpful checkpointing helps the application or a procedure to continue promote under a few gathering of disappointment appropriations. Likewise, the agreeable checkpointing is utilized to enhance the unwavering quality procedures like QoS, adaptation to non-critical failure in this manner making the framework strong and increment the execution [12].

The authors proposed a calculation in [20] for decreasing the time taken for migration of the tasks between virtual machines as the faster this process happens so will be the processing. Taking in to consideration the factors like throughput, benefit, misfortune a reproduction is done to demonstrate the non-preemptive ongoing planning checkpointing diminishes the execution time [7].

For keeping the security dangers in distributed computing, the authors in [9] proposed a plan of inside movement checkpoint demonstrate. The proposed model considered three segments which are utilized to distinguish and avoid dangers to make the cloud assets secure. The load balancing techniques alongside the measurements are talked about, addressed the problems in categorizing different types of load calculations are ordered in light of framework load and framework topology [4].

The authors in [11] have proposed another ongoing booking calculation for distributed computing whose point is to have a most extreme utility of the assets utilizing the time utility capacity. Two-time utility capacities in particular benefit and punishment have been utilized as a part of their work. The punishment was utilized to rebuff the assignments that have missed due dates and the benefit was utilized to compensate the errands which have met the due dates.

A preemptive cloud booking calculation was utilized as a part of with a settled need appointed to each assignment keeping in mind the end goal to enhance the QoS [25]. Two variations of preemptive booking calculations were numerically ended up being fit for administration situated errands. In the evaluation process, a dispatcher assumes the part of appropriating the low need errand when a high demand assignment lands with less overhead and keeping up optimality to accomplish QoS [22].

The authors in [13] considered load is adjusting as the primary test alongside accomplishing green processing with the different studies. Given the exponential increment of the distributed computing, the requirement for the server farms expanded which thus is bringing about the abundance of carbon outflows polluting the earth. Different measurements to assess the heap adjusting calculations alongside Carbon discharge and vitality utilization measurements were utilized to show which calculation is productive [17].

Stack Balancing in conjunction with accessibility is examined in alongside with a Hospital Data Management framework. All things considered review the information of a patient should be gotten to by various specialists, nurture internationally from various frameworks when the data of the patient is accessible [24]. An asset director is in charge of the entire operations like observing, accessibility and execution.

The privacy issue and an important challenge in cloud computing is the protection of data. Data being a basic and important element of any organization need to be protected and kept secured. And its security is more important and complicated when it is kept in the cloud as security plays an important role in cloud computing when compared with the traditional way of storing the data [3]. Though encrypted information is a solution to keep the data protected still it is not free from other vulnerable attacks for the reason that it is transmitted over web.

3 Methodology

This study employed a practical descriptive survey and the required data for determining the sample size provided by the decision team. We prepared a list of twelve experts who somehow deals with cloud service and provided four different questionnaires to each to pursue the following:

- Questionnaire 1: was prepared to confirm the proposed structure.
- Questionnaire 2: was developed based on a nine-level scale of Saaty [19] and its aim was the comparison of each two criteria and determining the preference among them.
- Questionnaire 3: was designed as an open-ended which required the respondents to establish the weight of each criterion to its pair from the same group.
- Questionnaire 4: was prepared to implement the interview and its design was based on the computing need and related literature. The level of each criterion graded and identified in a ten-point ranking scale.

In the paired comparison method, as each factor should estimate by the other factors, it assures the consideration of all. Consequently, questionnaires have somehow a logical content validity that is linked with a method used. In the paired comparison method, all factors should be evaluated to each other which remove all the possibilities of not being considered for each criterion. Also, in another used questionnaire, all criterions were assessed and reviewed. Therefore, they also reject the possibility of not considered for being measured. Moreover, the validity and content of the questionnaires were confirmed by the experts and decision teams. Hence it can be said that the used data collection tools in this study have been proved of the content validity.

The theory of Dempster-Shafer is recognized as the most used methods for uncertainty reasoning, modeling, and efficiency of intelligent systems with unstructured data. Dempster founded it, and then Shaffer introduced it as a theory [23]. Besides, uncertainty measurement of a particular situation is one of the most important roles of entropy as a primary concept of big data.

The reliability measure in this study doesn't benefit from the quantitative methods however the reliable estimation of evaluators considers as a factor for analysis of reliability. Nonetheless, the compatibility rating can evaluate the reliability for questionnaire's paired comparison that used Saaty's system.

3.1 Research Process

First, by extensive research in library and literature reviews, the cloud service ranking based on requirements and criteria in a load balancing environment were recognized. Then we used them to create our new conceptual framework which consists of eight requirements factor which is in a cycle with eight ranking criteria. The structure of the proposed new conceptual framework is displayed in Fig. 3. Then we ranked each factor using entropy analysis of Shannon [21].

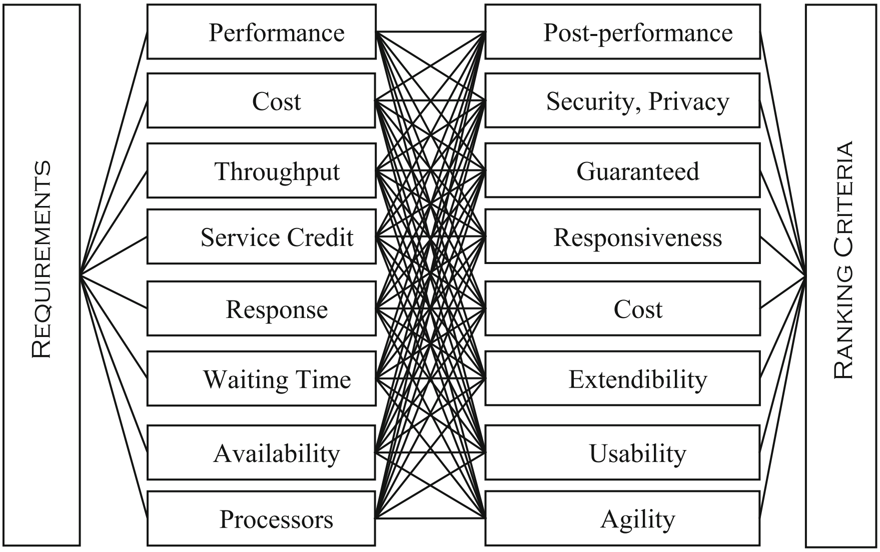

Fig. 3. Cloud service ranking evaluation mapping in load balancing environment.

By developing specific matrices to each questionnaire, we could accomplish a valid result. Due to the formation of multiple matrices, to obtain the final matrix we had to use the geometric mean for the variable of each matrix and calculated the compatibility rank which is used as an input for entropy Shannon and computed the final weight of each variable.

The ranking of cloud service should be evaluated based on requirements and criteria in load balancing environment. By collecting the acknowledged data from the fourth questionnaire to be used as input in fuzzy functions, the next level starts which is data analysis and evaluation of final decision. Remarking that the method used at this stage is proposed by [26]. Uncertainty is a primary motivation for the fuzzy sets. By achieving the rank of each factor, it is time to combine factors in the same rank. Therefore, we reduce the factors to increase the certainty given to each. Dempster-Shafer theory revised the combination conflict. Given that this study contains some conflicts, the averaging method of Murphy [16] is used to overcome the conflicts. Murphy recommended that if all shreds of evidence are available concurrently, calculate the weight average and determine the final weight by joining the averaged values several times. Therefore, using this method, we prevent the over-dependence to a section of conflicting evidence.

3.2 Proposed Algorithm

The following section explains computation of the cloud service ranking using checkpoint based load balancing and then considering the various requirement factors and the criteria to rank the services. The following formulae are used to evaluate the node correspondence value, value for the preferred node and the priority value for a service at a node. The correspondence value of node is evaluated by Eq. (1):

$$\mathrm{CV}(\chi, y) = \frac{a - b}{n(n-1)/2} \tag{1}$$

Where n is total services, a is a total number of consistent pairs and b is a total number of variant pairs among two lists, $n(n-1)/2$ are the total number of pairs in the cloud with n services. Preferred nodes among the correspondent nodes are selected by subtracting the ranks of services.

$$\mathrm{P}(\chi, y) = S_\chi - S_y. \tag{2}$$

Where $\mathrm{P}(\chi, y)$ = prefer value among node x and y, S_χ = rank of node x's service, S_y = rank of node y's service. The greater prefer value indicates that the service is more reliable than the other service.

$$\mathrm{PV} = \sum\nolimits_{y \in S} \mathrm{P}(\chi, y) \tag{3}$$

Where PV = priority value of service x. The system then arranges the list having services with greater priority values higher in the list. To improve the accuracy of rank prediction of services the system prefers the higher priority values of implicit services which the user has already accessed.

Algorithm 1. Proposed Algorithm
Input: A set of service S, x is a cloud service and π stacks in the ranking.
Output: ranked service list x
Step 1: for each service from 1 to n
Step 2: calculate correspondence value of each service based on user's requirements using eq. (1)
Step 3: end for
Step 4: for each service from 1 to n
Step5: calculate prefer value of each service using eq. (2)
Step 6: end for
Step 7: R=S;
Step 8: for each service from 1 to n
Step 9: rank each service by checkpoints and the load balancing, present on the cloud,
x = max rank in S,
π(x) = S-R+1;
R=R-x;
Step 10: end for
Step 11: for each service from 1 to n
Step 12: Calculate the priority value of each service using eq. (3)
Step 13: rank the services by their priority values,
R=μ(i)
a= max rank in priority value set, μ(i),
π(x) = μ(i)-R+1,
R=R-x,
Step 14: prioritize the implicit services with greater rank.
Step 15: update the service set S with the ranked services and save it in ranked service list x
Step 16: end for

4 Analysis and Results

In this section, we brought just some sample results due to the high volume of outputs. According to the decision matrix, we calculated the weight of each requirement factors as shown in Table 1:

Table 1. The weight of requirement's factors.

Factors	Entropy value	Uncertainty value	Factor's weight	Intellectual weight	Adjusted weight
A1	0.533	0.145	0.143	0.132	0.113
A2	0.422	0.137	0.063	0.086	0.136
A3	0.539	0.135	0.106	0.193	0.105
A4	0.544	0.118	0.139	0.16	0.127
A5	0.441	0.123	0.161	0.066	0.091
A6	0.432	0.093	0.091	0.103	0.145
A7	0.59	0.144	0.173	0.118	0.155
A8	0.499	0.105	0.124	0.142	0.128

Similarly, we gained the weight of each ranking criteria as shown in Table 2:

Table 2. The weight of ranking criteria

Factors	Entropy value	Uncertainty value	Factor's weight	Intellectual weight	Adjusted weight
B1	0.542	0.118	0.063	0.174	0.113
B2	0.414	0.091	0.107	0.071	0.136
B3	0.517	0.128	0.129	0.124	0.105
B4	0.538	0.154	0.116	0.179	0.127
B5	0.523	0.113	0.175	0.063	0.091
B6	0.556	0.152	0.153	0.154	0.145
B7	0.436	0.103	0.169	0.091	0.155
B8	0.474	0.141	0.088	0.144	0.128

Based on Tables 1 and 2 and after calculating the mean of entropy, uncertainty values, factor's weight with intellectual and adjusted weight, we found that almost all the sixteen factors have near rating and similarities which are shown in Fig. 4.

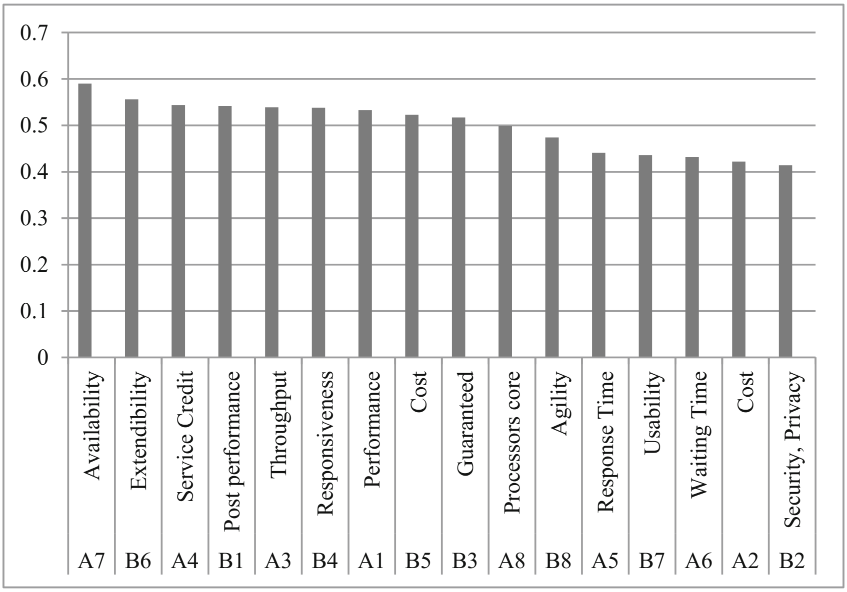

Fig. 4. Cloud service ranking based on requirements and criteria in load balancing environment.

4.1 Factor's Evaluation

After calculating each factors' weight, the ranking of each factor has been evaluated based on the conducted interviews with experts. Table 3 shows the results:

Table 3. Factor's ranking

Factors	Description	Factor's ranking
A1	Performance	H
A2	Cost	VL
A3	Throughput	H
A4	Service credit	VH
A5	Response time	L
A6	Waiting time	VL
A7	Availability	VH
A8	Processors core	M
B1	Post-performance	VH
B2	Security, privacy	VL
B3	Guaranteed	M
B4	Responsiveness	H
B5	Cost	M
B6	Extendibility	VH
B7	Usability	L
B8	Agility	L

By determining the factor's score, the next step is to combine the factors of each group. For this purpose, the following five diagnosis hypotheses were considered:

$$\theta = \{(\text{VL})\ \text{Very Low},\ (\text{L})\ \text{Low},\ (\text{M})\ \text{Medium},\ (\text{H})\ \text{High},\ (\text{VH})\ \text{Very High}\}$$

Each one of these is intimating the cloud service ranking based on requirements and criteria in load balancing environment and applied as input in Dempster-Shafer Theory. Remarking, these evidence are preliminary and uncertain for the combination. Therefore, they need to be reduced first. By synthesizing evidence, almost 100% assurance allocated to an individual factor which several ways have been offered for facing such conflicts by other researchers. In this study, we used Murphy's proposed idea. The results are shown in Table 4:

Table 4. Overall evaluation of cloud service ranking based on requirements and criteria in load balancing environment

Combination of evidence	VL	L	M	H	VH	VL, L	L, M	M, H	H, VH
A1, A2, A3, A4	0.17	0.00	0.00	0.43	0.22	0.08	0.00	0.21	0.32
B1, B2, B3, B4	0.17	0.00	0.21	0.22	0.22	0.08	0.10	0.21	0.22
A5, A6, A7, A8	0.17	0.18	0.20	0.00	0.24	0.17	0.19	0.10	0.12
B5, B6, B7, B8	0.00	0.36	0.21	0.00	0.22	0.18	0.29	0.10	0.11
Average	0.13	0.14	0.15	0.16	0.22	0.13	0.14	0.16	0.19

5 Conclusion

This methodology is an extended version of the article entitled "Cloud Service ranking using Checkpoint based Load balancing in real time scheduling of Cloud Computing." A new framework is proposed to evaluate the cloud service ranking based on the requirements and criteria. In the previous work, a mathematical evaluation was proposed for evaluation and the factors affecting them were not considered. The study, by the use of interviews, expert opinions and review of previously related researches provided a new framework model which includes the requirements and criteria to evaluate the cloud service provided by CSP. Each of these considered eight sub contents in them for evaluation to prioritize a cloud service. This research prioritizes aspects of the conceptual model using modified Fuzzy Analytic Hierarchy Process.

Undoubtedly, this research can be the basis for selecting the cloud service rendered by a specific Cloud Service Provider. As all the CSPs are providing the same kinds of service by balancing the load at their end, the customer is confused in selecting a specific CSP for the service intended. Therefore this model can be a decision making tool in selection of a service with CSP. On the other hand, it helps the Cloud Service Providers to enhance themselves in the competitive market for reaching the targets and improving their businesses. Then Cloud Services ranking enables the customers to adopt the service with high raking to satisfy their requirements. The Quality of Service and optimization of resources at the data center should be improved to meet the increasing demands. Whenever the CSPs fail to meet the criteria, the enterprises always have an option to migrate to other service providers resulting in perishing the business.

6 Future Studies

Although the Cloud Computing has made the tasks easier for the enterprises, still the trust and security is a big challenge. The Service level Agreements are in its place to guarantee the enterprises regarding the performance yet still there lacks reliability and efficiency. The lack of support from the management of the enterprises also can have adverse effects on performance and usage. Furthermore, Cloud Computing needs standards to be benchmarked and provide the service to the customers. With the increasing demand of adoption of cloud, the need of protecting these resources and data against cyber attacks also increase giving scope for the researchers to propose solutions for protection.

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