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Cost-Benefit Evaluation of Service Level Agreement in Cloud Environment – Dynamic Monitoring Interval Tool

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Abstract

In cloud computing, Service level agreement (SLA) is an important issue. The terms of SLA is a agreement between cloud provider and customer in terms of the quality of cloud service (QoS). The SLA monitoring tools is unpreventable to evaluate the agreed SLAs at operation time and sense any possible SLA violations. The cost and benefit value of SLA monitoring systems is an issue in cloud computing environment. The interval value of monitoring system has a direct impact to the cost and benefit values of monitoring system. Certain monitoring interval is appropriate for specific kind of cloud service in a cloud environment. This paper proposes the dynamic monitoring interval (DMI) to make a balance between cost values and benefit value of SLA monitoring system in different ESs. The DMI adapts interval value based on proposed formula by measuring the cost and benefit of the cloud service monitoring system at run time. The results shows that DMI can adapt with all environment scenario and make a trade-off between cost and benefit value. Indirectly, cloud provider gained benefit in terms of reduce SLA violation and reduce penalty cost.

Keywords: Service Level Agreement, Dynamic Monitoring Interval, Cost, Cloud Computing

1. INTRODUCTION

The definition of Service Level Agreements (SLA) is related to the functional and non-functional characteristics of the cloud services that is agreed by both the cloud customer and the cloud provider [1]. When a cloud service provider is not capable to meet the terms stated in the SLA agreement, a violation of SLA occurs. For example, an IaaS cloud service provider may promise a minimum response time from a VM, minimum storage space, reliability of data, etc. However the SLA is violated, if a customer does not get the wanted response time, runs out of virtual disk space or is met with frequent errors. The SLA also defines a penalty model to pay off the customer in case of SLA violations [2, 3] SLA monitoring tools is inevitable to evaluate agreed SLAs at the operation time and detect any possible SLA violations [3]. Both cloud service provider and cloud customer need to observe the quality of service (QoS) to be sure about SLA validation.

'Interval' is clearly defined as a non-overlapping interval of time within the time space of the communication. High number of intrusiveness may influence the overall system performances negatively, while low frequency of instrument may cause a big number of SLA violations. The clarification of the intervals value is still an open research issue. For example,[6] proposed requires the pre-set of the interval of data collection by domain experts in the monitoring infrastructure of cloud services. This method deeply depends on the experience of the experts with a lacking of rationality and accurateness. The billing system THEMIS is another related work [7,10], in which the monitoring report could be presented to cloud customers when they require the monitoring the quality of services. In suggestion of optimal measurement interval for detecting SLA objectives violations at operation time, the two factors are discussed: (i) cost of measurements; and (ii) the benefit of SLA violation detection [3,4]. The suitable trade-off between these two factors defines the optimal measurement interval. The cost and benefit of SLA monitoring systems are a concerned issue in cloud environment [3]. SLA monitoring systems require resources utilization consisting CPU, Memory, and Storage for execution. is the cost of SLA evaluation is related to the amount of consumed resources by monitoring system. In contrast, SLA monitoring systems can make benefits by detecting SLA violations since cloud service provider after that can adapt the infrastructure to avoid more numbers of SLA violations and avoid the penalty amount. The cost of missing SLA violation detection increases as the measurement interval increases. This is caused by the fact that the higher measurement interval, the lower the number of measurements made and the higher the number of missed SLA violations. Failure to detect SLA violations earnings costly SLA penalties for the cloud provider and unfortunate performance of the application. The need for fine-tuning of monitoring systems in the whole set of experiments demonstrated to the specific requirements of cloud services. On the other hand, different services have needs for different value of measurement intervals, and even though some services are more established than other in terms of resource requirements.

2. LITERATURE REVIEW

Current monitoring infrastructures lack appropriate solutions for adequate SLA monitoring since SLA metrics are usually defined by cloud providers and can comprise various user-defined attributes, [3,4]. The challenge in monitoring system is to facilitate mapping of several metrics by low level value to high level value of SLAs [8,11]. Another issue is to determine appropriate monitoring intervals value at the application level to keep the trade -off between the early stage of detection of possible SLA violations and system intrusiveness of the

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monitoring system [3,4]. Several services are executed in cloud environment at the same time for numerous users. Each service should be monitored at the run-time to evaluate related SLA. Accordingly, SLA monitoring systems face several monitoring targets with different SLAs. Adaptability of SLA monitoring tools is a difficult issue in cloud computing to manage the monitoring threads effectively based on services status. Current monitoring systems have often constant interval value and individual monitoring process for all services and SLAs which it decrease the adaptability and increase the cost of monitoring systems [9,12]. The long interval value leads a few numbers of SLA evaluation repetitions; on the other hand, the short interval value causes a lot of repetitions for SLA evaluations. Although the short interval value makes the monitoring loop faster and can detect more number of probable SLA violations, it increases the cost value of SLA monitoring tools. The high interval value has a low overhead cost but it can detect a few numbers of probable SLA violations. Consequently the determination of suitable interval is a challenge issue and the static monitoring interval cannot make a balance between cost and benefit of SLA monitoring tools.

The life cycle of SLA in cloud computing consist of SLA negotiation, SLA evaluation, and SLA expiration. The SLA is contracted after SLA negotiation between service provider and consumer. Agreed service is deployed and the related SLA is evaluated periodically. SLA report shows the quality of service and the number of SLA violations. Finally, agreed service is terminated when the SLA duration is expired. This study is concentrated on SLA evaluation phase. The raw data is composed from resources and the low level value are mapping to high level attributes of SLA. If measured attributes exceed from agreed SLO, the SLA violation is occurred and it should be reported. The main parts of SLA evaluation models consist of raw-data collecting, mapping the low-level metrics to high-level attribute, and run-time operation evaluation. The costs value and benefits value of SLA monitoring tools is the main focus of paper. Interval value of SLA monitoring system is the focused issue in cloud computing area since it has a high impact on cost and benefit of monitoring tools. SLA monitoring systems currently settled a static interval value for instance: interval value of CASViD is set by 10 seconds to detect SLA violations in cloud applications; interval value of QUATSCH is set by 5 minutes to monitor the availability and execution time of web services. According to Emeakaroha et al. [3,4] different services will needs the dissimilar measurement intervals. To verify an optimal interval value, the targeted service is monitored by certain intervals for instance 10s, 15s, 20s, 25s, 30s, 60s, and 120s. The measurement cost and the missing violation detection cost are considered based on the number of detected SLA violations and the overhead of monitoring system. After analysing the results, the affordable interval value is selected as an optimal monitoring interval for specific application.

3. METHODOLOGY

In cloud computing, it is suggested to use the trustable SLA monitoring model to access SLA validation. Three actors such as Service Provider (SP), Trusted Party (TP) and User are included into the proposed trustable SLA monitoring model. Before SLA monitoring process, the negotiation process between SP and user is done by TP cooperation. For run time monitoring activities, the decided SLA is then logged in TP database. TP installed the monitoring engine in SP center to collect the raw data for accessing the decided SLA attributes.

SP does not have the permission to access or influence the collected data by monitoring engine even though the monitoring engine is located in SP center. Monitoring engine located in SP center for data collection purposes, certainly, is a part of trusted. The SLA monitoring system can be economized through dynamic monitoring interval (DMI). When the agreed service is working normally, DMI targets to reduce the overhead of monitoring system. Hence, agreed SLAs can be monitored using SLA monitoring tools that are developed through proposed DMI. Figure 1 depicts the developed SLA monitoring tools during the run time. Processor, memory and storage usage value of employed VMs are monitored. The forms of total consumption and VMs consumption represented each resource usage. Any SLA violations detected and its violated attribute value are displayed in a column. During run time, the cost and benefit of monitoring tools are measured and these are used in monitoring the interval adaptation process. The variations of interval value are shown in Interval TextBox.

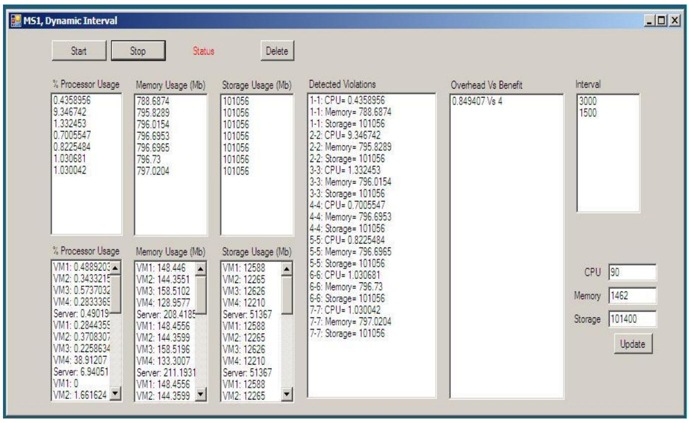

Figure 1: SLA monitoring tools

Furthermore, The SLA violations should be detected when the quality of agreed service go beyond the defined quality value in SLA. The number of missed SLA violation should be reduce. The DMI formula is to adapt the interval value based on the cost and benefit of monitoring tool. Monitoring Cost (MC) is the summation of needed Storage, Memory and Processor consumption which are consumed by monitoring tool in run time. The cost of each resource consumption are measures by multiply the value of resource usage in the cost unit of the resource. The main function of SLA monitoring tool is to prevent further SLA violation by suitable reaction. It reduces the total of penalty amount which should be paid to the customer. The Violation Detection Benefit (VDB) is the benefit of monitoring tool where it measured by multiply the penalty cost in the number of detection SLA violations.

$$Monitoring\ Interval\ (I) = \begin{cases} \frac{I}{2}, & MC < VDB \\ I\ , & MC = VDB \\ I + \frac{I}{4}, & MC > VDB \end{cases}$$

$$Monitoring\ Cost\ (MC) = \sum_{i=0}^{n} (S * SCU + M * MCU + P * PCU)$$

$$Violation\ Detection\ Benefit\ (VDB) = \text{PC} * \sum_{i=0}^{n} DV$$

S: Storage usage
SCU: Storage cost unit
M: Memory usage
MCU: Memory cost unit
P: Processor usage
PCU: Processor cost unit
PC: Penalty cost
DV: Detected Violation
n: number of monitoring iterations

Consumed CPU, memory and storage resources for SLA monitoring execution are taken into consideration in calculating the cost of SLA monitoring. Cost calculation relies on defined formula. To access the spend cost, the amount of each resource usage is multiply on the predefined price per value. The formula for cost assessment formula is as follow:

$$C = St * SCU + Me * MCU + CP * CCU$$

Monitoring cost is represented by C. While St, Me and CP are storage, memory and CPU resources accordingly. SCU, MCU and CCU are the cost units for storage, memory and CPU respectively.

4. RESULTS AND DISCUSSION

The proposed dynamic interval and four constant intervals are applied on developed SLA monitoring system to be executed in a cloud environment. The SLA monitoring system is executed in different situations of cloud service consists of without any SLA violation, with always SLA violation, with managed SLA violation, and actual situation. SLA monitoring system checked the image rendering service to evaluate predefined SLA attributes. Developed monitoring system is executed by setting certain interval values and execution of proposed dynamic interval method. Table 1 shows the number of detected SLA violations in different situations by setting different interval values. The SLA violation is exceeding of at least one SLA attribute in each iteration of SLA monitoring.

Table 1 : Detected Violations In Sit1 For Different Situation And Intervals

Situation \ Interval value	500ms	2500ms	5000ms	7500ms	10000ms	Dynamic Interval
Number of Detected SLA Violation in Sit1	0	0	0	0	0	0
Number of Detected SLA Violation in Sit2	300	284	145	83	47	285
Number of Detected SLA Violation in Sit3	241	195	117	78	58	163
Number of Detected SLA Violation in Sit4	159	144	89	61	45	156

SLA monitoring system detected the different number of SLA violations by setting the different interval values. Shorter interval detects more number of violations. Dynamic interval did not detect the most number of SLA violations; but, the cost-benefit assessment of monitoring system in different situations is the main criteria for intervals comparison.

The Benefit-Cost Analysis For Sit1

In Sit1, SLA monitoring system is executed when the image rendering service was run without any SLA violations. This section shows the benefit-cost assessment of SLA monitoring system. The cost is measured based on needed CPU, memory and storage resources for execution of monitoring system. The benefit is measured based on the number of detected SLA violations.

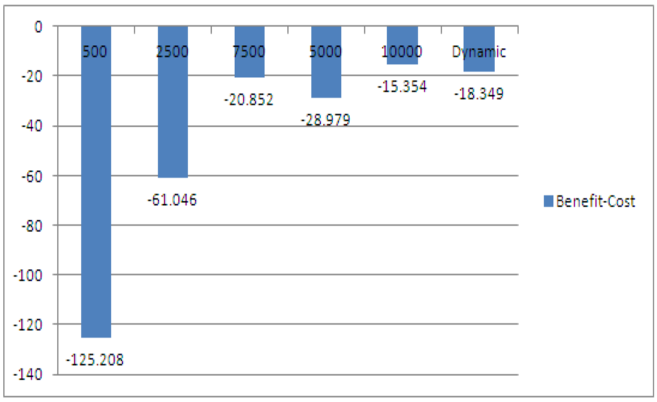

Figure 2 : The cost-benefit assessment for Sit1

Figure 2 illustrates the cost-benefit assessment of SLA monitoring system for certain intervals when there is no any SLA violation. SLA monitoring system does not have any benefit in this situation because no SLA violation is detected; that is why the cost-benefit assessment presents negative values. SLA monitoring system consumed further resources when the interval value is 500 ms so the monitoring cost for 500 ms interval is higher than other intervals. The costs of other interval employments are presented in Fig. 2. 10000 ms interval has the minimum cost for SLA monitoring system in this scenario. The initial value of proposed dynamic interval was 3000 ms. The dynamic interval is changed based on the number of violation and it assigned the minimum value after few minutes running time in without violation scenario; that is why the dynamic interval cost is close to the minimum cost.

The Benefit-Cost Analysis For Sit2

This section presents the benefit-cost assessment of monitoring system by settled intervals. Table 2 and Figure 3 illustrate the result of cost-benefit analysis.

Table 2: Detected Violations In Sit2 For Different Situations And Intervals

Analysis \ Interval	500ms	2500ms	5000ms	7500ms	10000ms	Dynamic Interval
Benefit	240	224	116	64	56	228
Cost	65.905	61.560	31.488	17.707	15.328	64.343
Profit	174.094	162.439	84.511	62.292	40.671	163.656

In always violation situation, the shorter interval value has more benefits because the monitoring system can detect higher number of SLA violations. Although the cost of smaller interval is also more than higher interval, the benefits is more than cost in this situation. SLA monitoring system achieved the maximum profit (174 $) by setting 500 ms interval while 10000 ms interval gained 40$ profit. The proposed dynamic interval changed the interval value based on the detected violations so it increased the interval value in always violation scenario; that is why proposed interval value achieved high profit as well as 500ms and 2500 ms interval values.

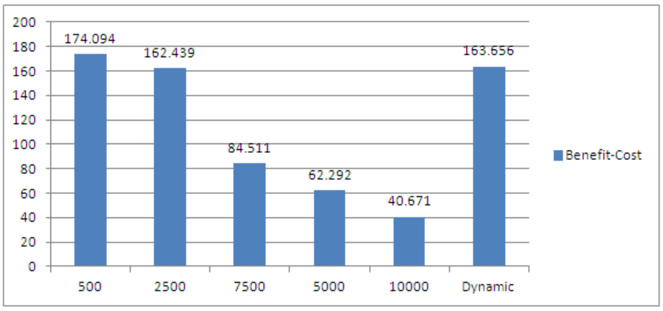

Figure 3: The cost-benefit assessment for Sit2

The Benefit-Cost Analysis for Sit3

In Sit3, an intrusion disruption is performed to create periods of SLA violations. SLA monitoring system detected the SLA violations. This section describes the cost-benefit assessment of SLA monitoring system for different interval value.

Table 3: Detected Violations In Sit3 For Different Situations And Intervals

Analysis \ Interval	500	2500	5000	7500	10000	Dynamic Interval
Benefit	189.6	155.2	91.2	60.8	43.2	128
Cost	109.484	81.304	44.447	29.636	21.714	65.386
Profit	80.115	73.895	46.752	31.163	21.485	62.613

Table 3 presents the gained cost and benefit for each interval value. SLA monitoring system provided 189$ benefits while it had 109$ cost by setting 500 ms interval. Monitoring system achieved 80$ and 21$ (maximum and minimum profits) by employing 500ms and 10000ms intervals respectively. Fig. 4 presents the profit of each interval. The SLA status is changed frequently in this scenario; subsequently, proposed dynamic interval changed the interval value as well. SLA monitoring system gained 62$ profits by employing dynamic interval.

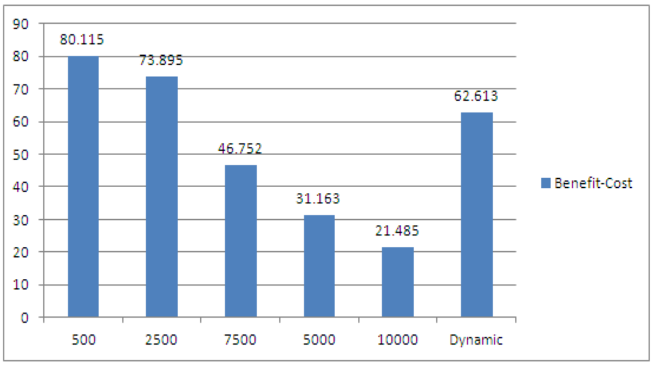

Figure 4: The cost-benefit assessment for Sit3

Figure 5 presents the trend of interval changes by proposed dynamic interval in Sit3. The red and light green areas refer to the violation and normal state of SLA during the execution time respectively. Interval value is increased when the SLA is in normal state, and it is decreased when the SLA is violated. So, the interval value is varied between 500ms and 10000ms based on SLA state. This scenario simply presents the dynamic interval behavior in unstable environment.

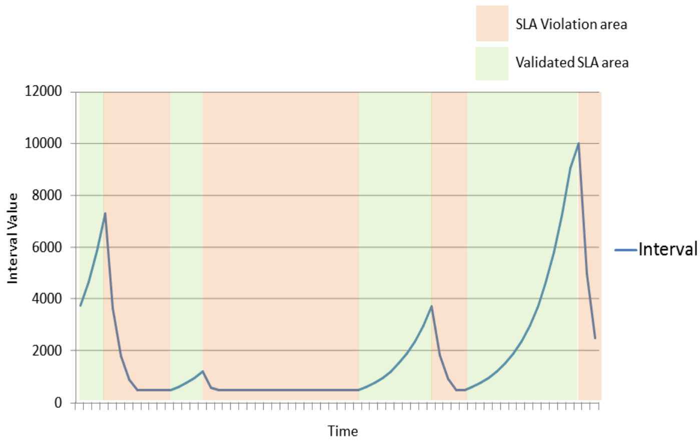

Figure 5: Trend of interval changes by proposed DMI in Sit3

The Benefit-Cost Analysis for Sit4

SLA monitoring system is also executed in a normal environment without any managed SLA violations. This section presents the cost-benefit assessment of Sit4. Table 4 and Fig. 6 illustrate the profit analysis for each interval value.

Table 4: Detected Violations In Sit4 For Different Situations And Intervals

Analysis \ Interval	500	2500	5000	7500	10000	Dynamic Interval
Benefit	124.8	115.2	70.4	46.4	36	124
Cost	76.899	58.405	32.531	21.598	16.403	53.811
Profit	47.900	56.794	37.868	24.801	19.596	70.188

Unpredictable SLA violations are detected in normal situation by SLA monitoring system. The cost of 500ms interval is higher than other longer intervals by 76$. SLA monitoring system had the minimum cost by setting 10000ms interval; but it had also the minimum profit. Proposed dynamic interval built a balance between benefit and cost of monitoring system based on the number of SLA violations. Although the benefit and cost of dynamic interval are not the maximum and minimum values respectively, the profit is the highest value compared to the constant intervals.

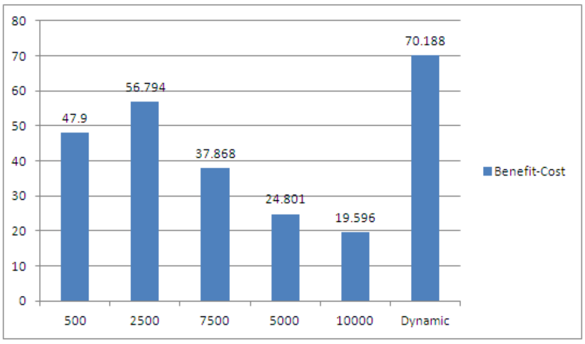

Figure 6: The cost-benefit assessment for Sit4

Comparison of Interval in Different Situation

This section compares the profit of intervals in different scenarios in Figure 7. Each constant interval is appropriate for specific scenario. SLA monitoring system had the highest profit in without violation situation by setting 10000ms interval; however, this interval had the lesser profit in other scenarios. 500ms interval delivered the highest profit in always and managed violation scenarios. The amount of provided profits by employing the 500ms and 2500ms were quite same in always, normal, and managed violation scenarios.

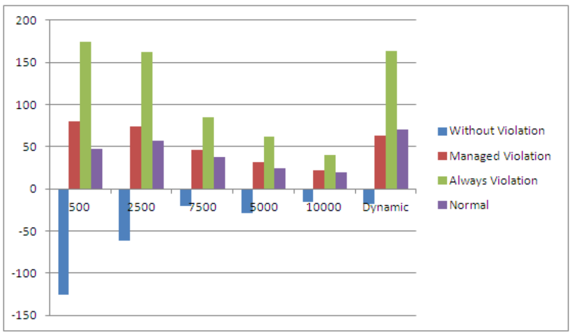

Figure 7: Profit analysis for predefined intervals in different situations

Proposed dynamic interval adopted the interval value of monitoring system based on the number of SLA violations. The comparison of results has indicated that the dynamic interval is appropriate for all situations. The profit of SLA monitoring system is close to the best value by employing the dynamic interval. In always and managed violation scenario, the gained profit by dynamic interval is close to the achieved highest value by 500ms interval. The dynamic interval profit in without violation scenario is also close to the best value gained by 10000ms. In normal situation, dynamic interval achieved the highest profit compared to constant intervals. Therefore, the proposed dynamic interval is suitable for all situations whereas each constant interval can be reasonable for specific situation.

5. CONCLUSION

Developed SLA monitoring system is executed in specific situations by employing certain interval values. The monitoring system recorded data and detected SLA violations as presented in this paper. The number of detected violations was different in different interval values. The cost-benefit analysis is described for each interval value. Each constant interval value was appropriate for specific situations. SLA monitoring system had the highest profit in always violation situation by employing 500 ms interval while this interval had the highest damage in without violation scenario. Proposed DMI adopted the monitoring periods depends on the number of SLA violations. The gained profit by employing dynamic interval was acceptable for all situations. Therefore, the comparison of cost-benefit results has proven that the proposed DMI successfully adopted the interval value to have an suitable profit in all situations.

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