SLA Negotiation and Renegotiation in Cloud SLA Management: Issue and Challenges

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Abstract. Service-level agreement (SLA) is the commitment between consumers and providers. Service providers commit the consumers to assure the quality, availability and responsibility. SLA renegotiation is negotiation between consumers and providers to improve the quality of service. Cloud computing service provided by providers can be guaranteed with SLA. Therefore, SLA renegotiation is vital to service and profit of both providers and consumers. This article presents some detailed analysis of previous papers and the comparison of components of theirs. In this paper, an improved framework is proposed to solve the existing problems of traditional SLA renegotiation process. In the end, limitation and future work are concluded.

Keywords: SLA · Cloud computing · SLA violation · Service level agreement · SLA renegotiation

1 Introduction

With technology getting advanced, more individuals and companies tend to use cloud services to help organise their files and data. Cloud computing offers a wide range of services from hardware, to readymade software and a platform to build customised software. These services classified into three main models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). A consumer and a provider when agreed on services they form an agreement called as service level agreement (SLA). Before forming an SLA, both parties pass through multiple steps of negotiation [1].

SLA negotiation can be defined as the process of establishing a commitment between consumers and service providers by specifying the nature of the required service and the level of quality of service (QoS) which must be guaranteed to the customer [2]. SLA is playing an important role for the service provider as it controls the quality of provided services in the cloud-based system. The cloud environment is dynamic in nature, and the SLA parameters need to be reviewed frequently to fulfil requirements. Therefore, it is critical to adjust SLA during service operations so that there is a satisfactory level of service continuity for all parties [3]. When there are any discrepancies, then both parties get back to reconsider different service level objectives (SLOs), and the process

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W. Hussain and M. A. Jan (Eds.): IoTaaS 2021, LNICST 421, pp. 159–170, 2022.
https://doi.org/10.1007/978-3-030-95987-6_11

of renegotiation started. Therefore, SLA negotiation and renegotiation are the processes that help to improve the quality of contracts between a consumer and a provider [4, 5]. Majority of the earlier studies presume that the SLA cannot be adjusted once it has been modified, but we suggested that the 'no-win' situation should be changed into a 'win–win' one with the help of an automated renegotiation method. The purpose of introducing the renegotiation method is to create an innovative SLA that restricts the losses on both sides.

In this paper, we analysed existing approaches to discuss SLA negotiation and renegotiation in the cloud environment. We have categorised existing approaches into three classes – trustable model-based framework, proactive detective SLA framework and QoS monitoring frameworks. We further critically evaluate existing approaches, identified gaps and proposed our framework. The rest of the paper is organised as follows. Section 2 discusses the related literature. In Sect. 3, we present a critical analysis of existing approaches. Section 4 highlights gaps in existing literature, Sect. 5 we present our proposed framework and Sect. 6 concludes the paper with future direction.

2 Related Work

Renegotiation is one of the most important things in SLA. Existing researches are very valuable to our study. These articles are reviewed and analyzed to comprehend the principle and frameworks about renegotiation of SLA. In this section the brief reviews of these papers are presented. After the studying and reviewing of several articles, we categorize them into three different forms as presented in Fig. 1:

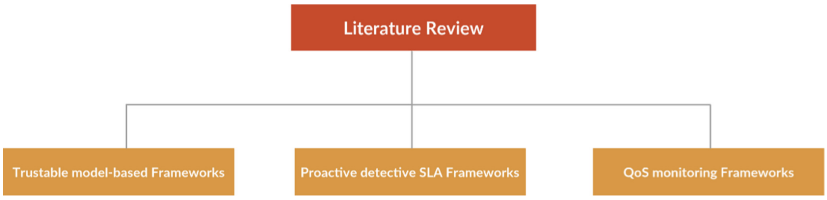

Fig. 1. Literature review

- Trustable Model-based Frameworks.
- Proactive Detective SLA Frameworks.
- QoS Monitoring Frameworks.

2.1 Trustable Model-based Frameworks.

It was asserted by the authors [4] that the in latest SLA, there is the need to have a greater number of trustworthy service providers, especially in the health and medical-related fields [6]. Service terms are one of the trusted factors that are usually described in the Service Level Agreement that the providers and their customers both have to

follow. The authors proposed proactive SLA renegotiation while providing the service. This is to ensure that customers continue to trust cloud providers. The article discussed requirements and critical aspects for renegotiation, including determining SLA violation and examining service level limitations [7]. Certain properties are included in the renegotiation framework, for example, proactive actionability, the predetermined SLA and other related areas. This kind of negotiation framework can increase the trust levels, specifically in medicinal and health-related clouds. In addition, customers are also prevented from relocating their resources. The framework is also likely to play a part in research pertaining to resource optimisation, Autonomic Computing and SLA management. The authors in the article [8, 9] stated that managing service of quality in complex environment cloud service is a big challenge. The study introduced that there are three main components in rSLA framework: the rSLA language, the rSLA services and a set of Xlets. Authors proposed the rSLA language, which is designed and applied in the Ruby Language and Xlets configuration with a detailed description. Two scenarios presented to testify the performance of the rSLA model, the first one is tested by a PaaS application. The second scenario focuses on its usage at the IaaS level in the real pilot. The results show that the rSLA framework allows the dynamic setup of service quality management in a short period of time frame at a low cost. According to authors [10, 11], for an SLA to be successful and acceptable, it should be trusted and securely monitored. An SLA framework put forward in this article which includes negotiation and creates secure monitoring method that includes a third-party to improve the security and trust in the SLA. Implementation a case development of an SLA for cloud computing mechanisms presented in this article. Secure monitoring of the SLA is put forward through the involvement of a third party. The general theme of the WSLA has been adopted by the suggested SLA framework, which was initially designed for Web Services. The SLA between the consumer and the cloud provider created before the use of services. The provider determines the SLA parameters for any service, and the customer can negotiate them. Those SLA parameters signify the quality of service parameters. The main question the article talked about is that trust management in cloud computing is more significant than previously. Since cloud always acts dynamically, trust attributes need to be monitored continuously to assure SLA can work well. A trust model should be created to guarantee service-level agreement can work well in cloud computing. The authors in. attempted to build a cloud trust management model to evaluate the trust attributes of cloud service. The model should be user-side based and consider more of users' trustworthy. The model should have adaptability as well and can be used to make decisions. Statistics were used to analyses trust attributes and trustworthy attributes. Different kinds of calculation applied to the whole process of experiment [12]. Comparing is used as well to see the difference of performance among simple trust model, fuzzy trust model and cloud-trust data and fitting curve. Attributed based trust management is designed to assure SLA cloud services. Authors in [6] state that due to the possibility of the long term commercial relationship between consumers and providers, it is necessary to design a brokerage service level agreement (bSLA) to benefit all parties in the business, consumer and Cloud Anchor platform. This article introduced the basic concepts of service level agreement (SLA), brokerage service level agreement (bSLA), resource service level agreement (rSLA) and explained the typical

relationship between these terms in a successful service scenario. The authors presented a new SLA renegotiation mechanism which ensures that the most trusted businesses get the lowermost resource prices and brokerage fees. To design a new approach to the issue, the authors analysed four other SLA renegotiation models from existing study and found the advantages and disadvantages of each of these models. This article focused on the financial perspective of the service level agreement instead of technical value, such as availability and bandwidth value. The authors only discussed the situation of services that providers delivers services via third party platform.

2.2 Proactive Detective SLA Frameworks.

Service level agreement. However, it is not possible to adjust such SLA during operations. A real-time and proactive SLA renegotiation framework discussed to facilitate the dynamic character of cloud-based systems [13]. Besides, a new method is put forward to determine and forecast service violation, which helps in guaranteeing proactive renegotiation. According to the authors [14], profit-recognising scheduling decisions should be made by the providers while allocating client requirements to virtual resources [15]. The SLA that has been decided should be adhered to during decision-making. Since the cloud environment is extremely dynamic, it is possible that due to unforeseen events, the preliminary scheduling plans may be affected, leading to unexpected SLA violations. Therefore, there may be a 'no-win' situation for the provider and the client. When there is an SLA violation, the possibly high penalty that has been decided in the original SLA to be paid by the provider. However, from the perspective of the customer, when there is an SLA violation, a business-critical job may be cancelled, and the loss faced by the client cannot be compensated by an SLA penalty alone. In addition, when there are increasing SLA violations, the provider's reputation may also deteriorate, leading to a decrease in the number of potential clients. The new method decreases the provider's loss in profit and reduces the number of cancelled jobs faced by the client, in contrast to implementing the original SLA. The degree of customer satisfaction in utility computing mechanisms is critical, because of which SLAs become extremely important. The main goal is to manage SLAs, including management of SLA autonomy or trade-off between various Quality of Service (QoS) parameters [16]. However, no classification exists on the whole for these extensive solutions [17]. The purpose of the article is to comprehensively analyses the way SLAs are developed, managed and implemented in utility computing settings. The key ideas of SLA and the two kinds of SLA lifecycle have been discussed in this article. The WS-Agreement signifies a language and a Web service protocol that is developed for establishing service-level agreements (SLAs) on the basis of preliminary offers, and for supervising those offers during runtime. This description of WS-Agreement is quite general and does not consider the view that an agreement may be altered at runtime [18]. The WS-Agreement is mainly used to generate the SLA between agreement parties, and it comprises of three sections: a plan for defining an agreement, a plan for defining an agreement template, and various kinds of ports and operations used to supervise the agreement life cycle from production to termination and supervising the agreement states between them. The key component of this WS-Agreement implementation is the negotiation manager (NegMgr), which performs negotiations between SLAs and system-external contractors. To be addressable by

potential contractors, it needs to offer an interface to the neighbouring world. The implementation of the Negotiation Manager is done using a Globus Toolkit 4.0 service. This service permits the use of various mechanisms offered by the toolkit, including authorisation, authentication, GridFTP and supervisory services. The research [19] states that although cloud service platforms provide consumers convenient environment to deploy applications, service level agreement management is becoming more difficult because of the increasing dynamism of application environment and different vendors of service. The authors proposed the rSLA service and language, aiming to reduce the time of setting up SLA significantly [20]. According to the authors, this rSLA service and its language are both flexible enough to instrument virtually into any environment. Also, it is agile enough to scale and SLA management as needed. The researchers started their work by discussing the system model outlining how the rSLA service deal with interfaces of a heterogeneous environment. The approach addresses the efficient specification of SLAs in a formal language. Besides that, the Xlet architecture abstractions successfully overcome the issues of heterogeneity.

2.3 QoS Monitoring Frameworks

T t is essential to have a legal agreement for negotiating and renegotiating between the two cloud parties and to describe the Quality of Service (QoS) needs of crucial service-based procedures. According to the authors [16], there isn't any model, using which, the clients can assess cloud offering and rank them based on their interests. Therefore, a method requires for fulfilling these requirements of customers. A framework was put forward in this article that would enable customers to analyse and decide between the various cloud service offerings in the market. The purpose of the suggested framework is to shape the SLA with an accurate and unambiguous explanation of services key performance indicators (KPIs) to facilitate automated negotiation and renegotiation based on an agreement between customers and providers. The purpose of presenting the approach is mainly to present a method that suggests the Cloud providers' list of services and encourages the cloud users to choose the most reliable service by combining the automatic SLA negotiation with the measurement besides the service quality factors. An innovative automated negotiation framework for the cloud was presented by the authors [21] for providing a decision-support system for customers to accomplish the required service efficiently. The decision-making system considered the existing cloud market situation, time limitations and multiple QoS factors. Strategies and decision-making procedures can also be affected by the dynamic cloud market competitions among providers. There are two main aspects of the negotiation framework: 1) multiple QoS parameters are more stable using prioritisation and that regarding user preferences. 2) the most significant provider is determined to choose the best offer based on various objectives of the different parties involved in the negotiation. Besides, the system for decision-making takes into account the existing cloud market situation, multiple QoS parameters and time limitations [22, 23]. A QoS model considers different parameters such as - price, availability, process time and time. Those dimensions are using extensively and are domain-independent.

The authors [9] proposed SLA management approach Optimised Personalised Viable SLA (OPV-SLA) framework in clouding computing which can help service provider create a better SLA to deal with SLA violations [5]. The article not only has a detailed

analysis about the existing data of SLA management in cloud computing but also provides a complete framework using three QoS parameters – throughput, availability and response time which can assist service providers in forming a better SLA.

3 Critical Analysis

In this section, we critically analysed existing SLA management approaches, as presented in Table 1. We analysed different approaches based on historical data, QoS monitoring approach, provider revenue, violation detection and multi-provider matching mechanism. The reason for selecting the mentioned parameters is because we believe that these parameters play an active role to assist cloud consumer during negotiation and renegotiation process. The critical analysis of these approaches describes below.

Table 1. Critical analysis of existing approaches

Author	Single provider cloud service				Multi-provider match module
	History of data analysis	QoS monitoring	Provider revenue	Violation detection	
[2]	Yes	Yes	No	No	No
[24]	No	No	Yes	No	No
[25]	Yes	No	No	Yes	No
[26]	Yes	Yes	No	No	No
[27]	No	Yes	No	Yes	No
[28]	Yes	No	Yes	Yes	No
[29]	No	Yes	No	Yes	No
[30]	Yes	Yes	No	Yes	No
[31]	Yes	No	No	Yes	No
[32]	Yes	No	No	Yes	No
[33]	Yes	Yes	No	Yes	No
[18]	Yes	Yes	Yes	Yes	No
[34]	Yes	Yes	No	Yes	No
[22]	No	No	Yes	No	No
[35]	No	Yes	No	No	No
[36]	Yes	Yes	No	No	No
[37]	Yes	Yes	Yes	Yes	No
[1]	Yes	Yes	No	Yes	No
[19]	Yes	No	Yes	No	No
[38]	Yes	Yes	No	Yes	No

(*continued*)

Table 1. (*continued*)

Author	Single provider cloud service				Multi-provider match module
	History of data analysis	QoS monitoring	Provider revenue	Violation detection	
[39]	Yes	No	No	Yes	No
[40]	Yes	Yes	Yes	Yes	No
[41]	No	Yes	No	No	No
[42]	No	No	Yes	Yes	No
[17]	Yes	Yes	No	Yes	No
[43]	No	No	Yes	No	No
[8]	No	Yes	No	Yes	No

After a thorough analysis, we found the following gaps:

- All existing researches do not consider that the consumers of cloud services can use service from more than one provider.
- Although some of these articles mentioned the revenue of cloud services providers, most of them do not present this perspective in the paper.
- Many articles consider violation monitoring function as an essential part of their models. However, none of them paying more attention to the same violations after the renegotiation agreements.

Although there are some existing frameworks focus on QoS in the process of SLA renegotiation, they did not consider the service that consumers are using. For example, consumer A uses cloud service for video meeting while consumer B uses cloud service for website server. Apparently, consumer needs a higher quality of QoS controlling and monitoring because of the higher demand for video meeting.

4 Proposed Framework

After comparing the related works from previous study [1, 3, 6, 16, 44–48] and digging out their research gaps, we designed the following framework to solve these problems. The proposed framework contains four functional modules- multi-provider match module, risk and cost management module, QoS management module and SLA violation detection module as presented in Fig. 2. The objective of this architecture is to build a high-efficiency and reliable SLA renegotiation system for cloud services users to solve their problems which exist in traditional SLA frameworks. The proposed framework gives a customer a flexible plan to choose best available option. In risk and cost management module the customers can decide which provider give them the best particular service, so customers can choose any service form different provider to reach their need and avoid risks. This step can be the first step. Multi-provider match module was created

to help user to negotiate and re-negotiate to any service form different providers. QoS management module will store history data, when a customer need a new service, it may this as a parameter. SLA violation detection module care more to monitoring any violation. The penalty will be applied if there any violation, also is can store history of violation. Below will explain more about each module:

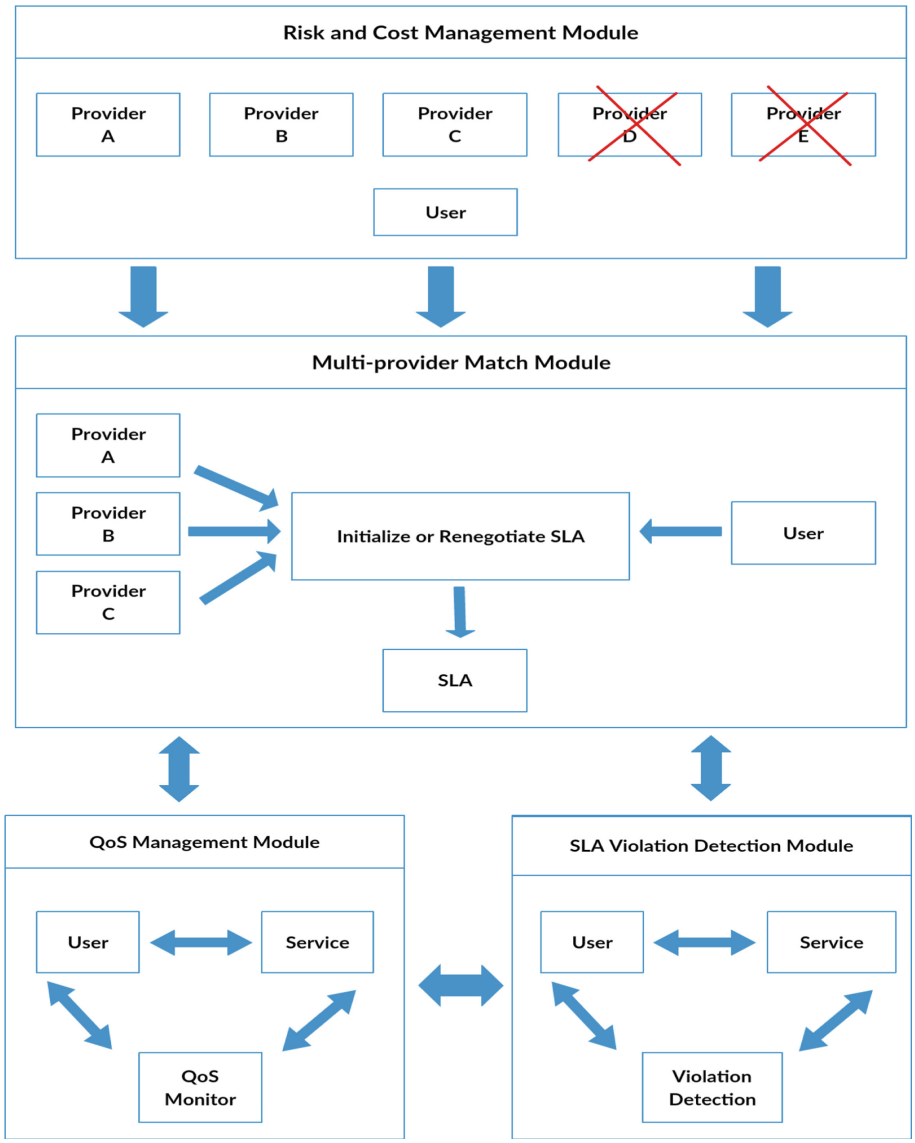

Fig. 2. Proposed framework for SLA management

1. Multi-provider match module
   Although some cloud service consumers only have one type of demand which need cloud service, many clients have more requirements on different types of business needs. For example, an international enterprise A need cloud services to support its online sale business and the need of online video meeting. In this case, one single cloud service might not be able to fulfil all the requirements due to many reasons. The multi-provider match module will present the clients a series of collocations of cloud services to meet the demands from different needs while initializing SLA or renegotiating SLA.
2. Risk and cost management module
   As mentioned in previous sections, some related study discussed about the revenue of service providers, however none of them consider the financial problem from the customer's perspective. The risk and cost management module will help cloud service users to choose the most cost-effective solution and weigh the risks with every choices by the performance of services from history.
3. QoS management module
   The reason why consumers and service providers sometimes might need to renegotiate new SLA is that because the cloud service providers updated the platform, or the consumers changed their requirements. The growing business needs of consumers is one of the most important and common reason they change their requirements. It might be lower latency and loss of packet. The QoS management module will keep monitoring the QoS performance of consumers' systems and inform the administrator while they have abnormal situations. It also could help consumers choose better service providers based on history performance when renegotiating SLA.
4. SLA violation detection module
   The SLA violation detection module is the key part of this framework. It helps cloud services users timely identify the violation and isolate the root cause. When there is a need of SLA renegotiation, this module could help decision makers analysis the advantage and risk of each services provider based on violations history and calculate the penalty.

5 Conclusion and Future Work

Recently, more and more people rely on Cloud. Most big companies offer different technical solutions over the internet. Most these services are considering about small and medium companies to help them to start their business easily and cheaper. SLA is the first step to in Cloud Computing, it is like the contract between two parties to define all rights for both parties. Most companies want to avoid any issue that may happen in the future. So, researches spend time to find a solution to negotiate and renegotiate between them to satisfy both. In this paper, we proposed a framework which contains four modules which are multi-provider match module, risk and cost management module, QoS management module and SLA violation detection module, to improve the process of SLA renegotiation for both consumers and services providers. However, the framework we proposed is mainly based on theory research. Therefore, to testify the efficiency of this frame work, we will try to take experiments in real scenarios. On the other hand,

this framework is more from the perspective of consumers of cloud services; hence we will try to consider things more from cloud services providers' perspective in the future. In the future, there is no doubt that this topic, SLA renegotiation, will be mentioned and discussed more and more frequently. It can be predicted that more and more companies will use cloud services in the future.

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