

SLA: A Comprehensive Survey

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Abstract: *To organize and bring together resource providers and consumers in cloud environment to meet a common goal, support for negotiation is required to set up an agreement that clearly states the QoS necessary, limitations on resource utilization and penalties during violation of the objective. In this paper we discuss SLA foundations with use cases. We also propose SLA lifecycle in detail with eight steps which gives more detailed and comprehensive finegrained information.*

Key Words: *SLA, customer satisfaction, negotiation, penalties.*

I. UTILITY COMPUTING

Utility computing is a service provisioning model in which a service provider makes computing resources and infrastructure management available to the customer as needed, and charges them for specific usage rather than a flat rate[1]. Utility Computing makes efficient usage of resources with minimum costs. Utility computing is also known as pay per use or metered services and is used for enterprise computing and sometimes for consumer market, internet service, file sharing and many other applications. Grid, cloud and service oriented computing are some of the utility computing paradigms. In this paper we will give comprehensive survey on different types of SLA in cloud computing paradigms. SLA is Service Level Agreement that is signed between service provider and service consumer to ensure the quality of service. In computing systems different QoS parameters should be satisfied to increase the customer satisfaction level. The need of SLA has been in telecommunication companies has been realized in 1980. So different types of computing like service oriented grid computing started using SLA as necessity. SLAs have to be monitored and assured properly[4]. Recently cloud has been emerged as new computing platform to provide on demand services. Cloud computing provides infrastructure, platform and software as service by many business companies anywhere, anytime in the world. In cloud computing SLAs are used to ensure the service quality as both the request arrival rate and availability of resources change constantly. According to Sun Microsystems Internet Data Center Group's report [2], a good

SLA sets boundaries and expectations of service provisioning and provides the following benefits:

1. Increases customer satisfaction level: A clearly and concisely defined SLA helps providers to focus on the customer requirements.
2. Improved Service Quality: Each item in an SLA corresponds to a Key Performance Indicator (KPI) that specifies the customer service within an organization.
3. Improved relationship between two parties: A clear SLA indicates the reward and penalty policies of a service provision. The consumer can monitor services according to Service Level Objectives (SLOs), which are QoS items specified in the SLA.

II. SLA FOUNDATIONS

This section describes the SLA definition in subsection 2.1, SLA components in subsection 2.2 and SLA lifecycle in subsection 2.3.

A Definitions of SLA

Since SLA has been used since 1980s in a variety of areas, most of the available definitions are contextual and vary from area to area. Service Level Agreements (SLA)s are signed between two parties for satisfying clients, managing expectations, regulating resources and controlling costs. Some of the main SLA definitions in Information Technology related areas are given in Table 1:

Cloud consumers migrated their business functions onto the entrusted cloud. So they must be ensured the quality, availability, reliability and performance of their resources on cloud as they do not have control over the underlying computing resources. The web service delivery is ensured through Service Level Agreements (SLAs) that act as an agreement between the providers and consumers. Different cloud offerings (IaaS, PaaS, SaaS, and DaaS) will need to define different SLA metaspecifications. Also advanced SLA mechanisms need to constantly incorporate user feedback and customization features into the SLA evaluation framework.

B SLA components

An SLA defines the delivery ability of a provider, the performance target of consumers' requirement, the scope of guaranteed availability, and the measurement and reporting mechanisms [8]. Jin et al. [9] provided a comprehensive description of the SLA components (Figure 2):

- Purpose: Objectives to achieve by using an SLA.
- Restrictions: Necessary steps or actions that need to be taken to ensure that the requested level of services are provided.
- Validity period: SLA working time period.
- Scope: Services that will be delivered to the consumers, and services that will not be covered in the SLA.
- Parties: Any involved organizations or individuals involved and their roles (e.g. provider and consumer).
- Service-level objectives (SLO): Levels of services which both parties agree on. Some service level indicators such as availability, performance, and reliability are used.
- Penalties: If delivered service does not achieve SLOs or is below the performance measurement, some penalties will occur.
- Optional services: Services that are not mandatory but might be required.
- Administration: Processes that are used to guarantee the achievement of SLOs and the related organizational responsibilities for controlling these processes.

C SLA Lifecycle

Ron, S. et al. [3] define SLA lifecycle in three high level phases, which are the 'creation phase', 'operation phase', and 'removal phase' shown in Figure 2. We have extended the mentioned SLA lifecycle by adding five more phases in it. So in our proposed SLA lifecycle there are following eight phases:

1. Determine who provides the service :Every consumer has its own requirements according to which service providers are located.
2. Describe SLA: This phase describe the services, parties involved , penalty policies and QoS parameters.
3. Negotiate: In this step the two parties reach a mutual agreement.

4. Set up an agreement: In this phase an SLA pattern is established and filled in by specific agreement.

5. Commit: The parties started to commit to the agreement.

6. Examine SLA violation: In this phase service provider's delivery performance is measured against to the agreement.

7. End SLA: In this phase SLA ends.

8. Impose penalties: In this phase if any party violates the terms and conditions of SLA then impose penalties according to the service violation. These phases are shown in figure 3. The mapping between three high level phases and six steps of SLA lifecycle is shown in Table 2 . Mapping between two types of SLA lifecycle. The 'creation' phase of three phase lifecycle maps to the first four steps of our proposed lifecycle. In addition, the 'operation' phase of three phase lifecycle is the same as the fifth and sixth step of the other lifecycle. Removal phase is same as the seventh and eighth phase.

Table 2 Mapping of three phases of SLA Lifecycle into eight stages Lifecycle

| Three Phases | Eight Steps |
|--------------|-------------|
| 1 | 1.2.3.4 |
| 2 | 5.6 |
| 3 | 7.8 |

The eight steps SLA lifecycle is more practical and provides comprehensive finegrain information, because it includes important processes, such as negotiation and violation control. The negotiation process maintains balance between consumer expectation and service provider a consumer. The result of these processes set up an agreement and then commit to that agreement. Step six is missing in three phase lifecycle but impose penalties phase is important because it motivates parties to stay to pursue the contract. We think that the eight steps formalization of the SLA life cycle provides a better classification of the phenomenon .

III CLOUD SLA ARCHITECTURE

A Cloud SLA Architecture

The two main components of Cloud SLA architecture are cloud consumer and cloud provider. A cloud provider is a company or vendor that offers economically efficient cloud services using the hardware and software resources provisioned from

other providers or supplied from within its own data centers. Cloud customers can be either software/application service providers who have their own service consumers or end users (e.g., organization or businesses) who use cloud computing services directly. Negotiation is a process in which proposals are put forward to maintain balance between consumer expectations and service provider. SLA document is the result of negotiation process between provider and consumer to provide various management services, condition evaluation services, management services and accounting services. Figure 4 shows the Cloud SLA architecture:

B Use Cases

Tables and Figures

Table 1 Summary of the SLA definitions in various areas:

| Area | Definition | Source |
|------------------------|--|---|
| Internet | “SLA constructed the legal foundation for the service delivery. All parties involved are users of SLA. Service consumer uses SLA as a legally binding description of what provider promised to provide. The service provider uses it to have a definite, binding record of what is to be delivered”. | Internet NG [5] |
| Data Center Management | “SLA is a formal agreement to promise what is possible to provide and provide what is promised”. | Sun Microsystems Internet Data Center group [6] |
| Web Services | “SLA is an agreement used to guarantee web service delivery. It defines the understanding and expectations from service provider and service consumer”. | HP Lab [7] |

In this section, we present industry use cases in Cloud computing environments.

Industry Use Cases: In this section, we present how Cloud providers implement SLA. Important parameters are summarized in Table 3. All elements in Table 3, are original from formal published SLA documents of Amazon EC2 and S3 (IaaS provider), and Microsoft Azure Compute and Storage (IaaS/PaaS provider).

Table 3: From users’ perspective SLA Use Cases of Cloud Provider follows eight steps SLA lifecycle[10][11][12][13].

Table 3: From users’ perspective SLA Use Cases of Cloud Provider follows eight steps SLA lifecycle[10][11][12][13].

| Cloud provider | Service Type | Step 1 Determine who provides the service | Step 2 Describe SLA | Step 3 Negotiate | Step 4 Set up an agreement | Step 5 Commit | Step 6 Examine SLA violation | Step 7 End SLA | Step 8 Impose penalties |
|-------------------------|------------------|---|-----------------------|----------------------------|--------------------------------------|-----------------------|---|---|----------------------------------|
| Amazon EC2 | IaaS (Computing) | Determine automatically (e.g. via web site) | Pre-defined SLA terms | Pre-defined QoS parameters | Pre-defined SLA document by provider | Pre-defined agreement | Can use third party monitor systems (e.g. CloudWatch) | By user, or provider programmatically or manually | Service Credit given by provider |
| Amazon S3 | IaaS (Storage) | Determine automatically (e.g. via web site) | Pre-defined SLA terms | Pre-defined QoS parameters | Pre-defined SLA document by provider | Pre-defined agreement | Can use third party monitor systems (e.g. CloudWatch) | By user, or provider programmatically or manually | Service Credit given by provider |
| Microsoft Azure Compute | PaaS | Determine automatically (e.g. via web site) | Pre-defined SLA terms | Pre-defined QoS parameters | Pre-defined SLA document by provider | Pre-defined agreement | Can use third party monitor systems (e.g. CloudWatch) | By user, or provider programmatically or manually | Service Credit given by provider |
| Microsoft Azure Storage | PaaS | Determine automatically (e.g. via web site) | Pre-defined SLA terms | Pre-defined QoS parameters | Pre-defined SLA document by provider | Pre-defined agreement | Can use third party monitor systems (e.g. CloudWatch) | By user, or provider programmatically or manually | Service Credit given by provider |

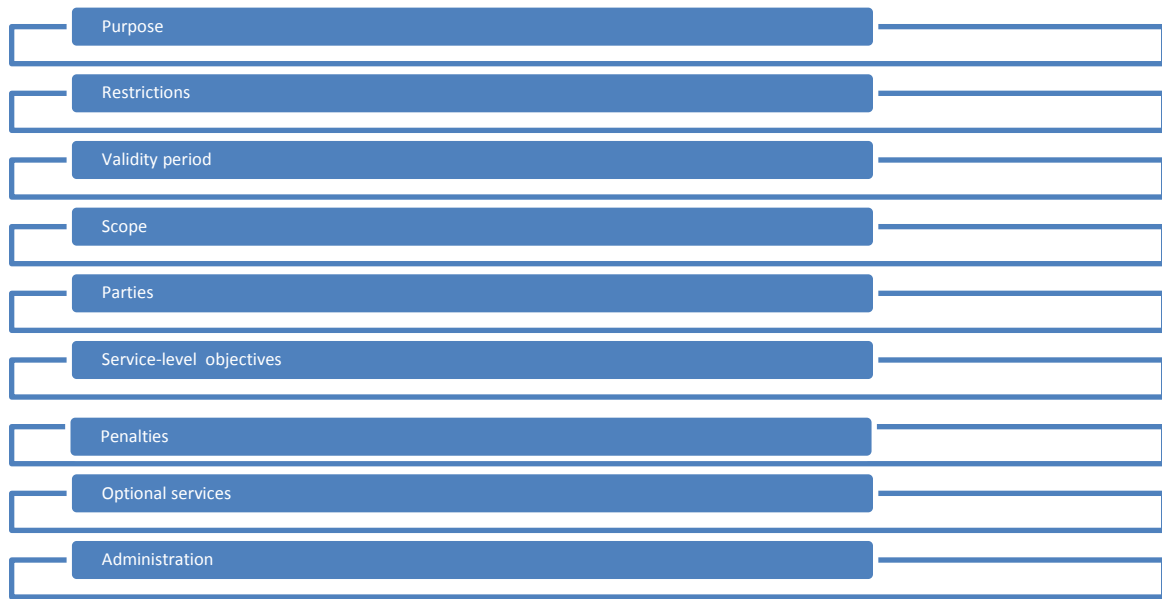


Figure 1: SLA Components

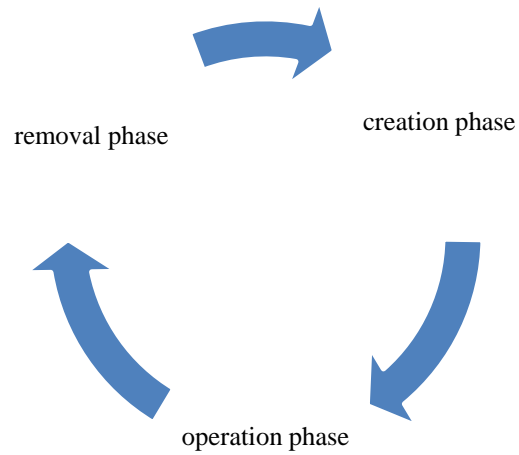


Figure 2: Three phases SLA Lifecycle



Figure 3: EIGHT PHASES OF SLA LIFECYCLE

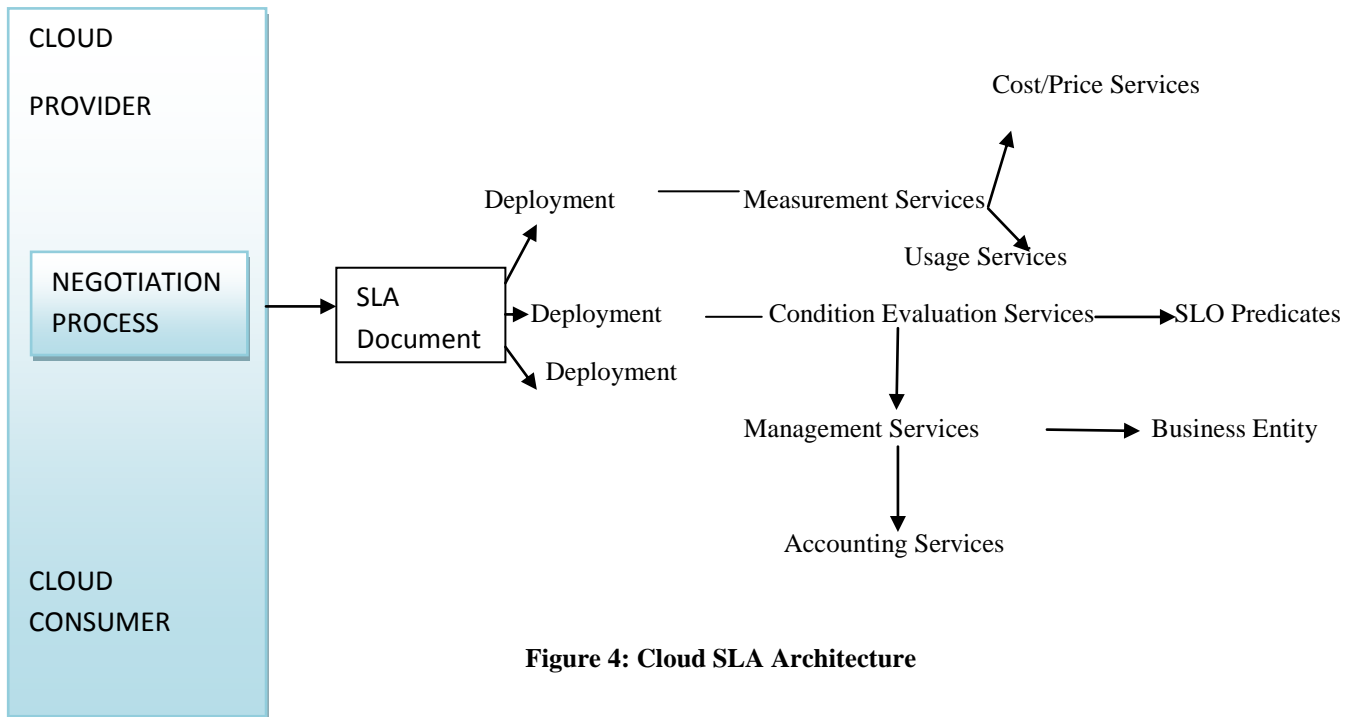


Figure 4: Cloud SLA Architecture

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