SLA-Based Reputation Life Cycle

Kahina Hamadache

Department of European Projects, Singular Logic S.A. Athens, Greece
khamadache@singularlogic.eu

Abstract. Establishing and managing reputation has become a critical issue for Cloud Computing. In this paper we investigate this issue and propose our conception for the management of Reputation in Cloud Computing. This conception is based on the extensive use of SLA through the whole life cycle of the reputation. With this objective in mind we focus on defining and describing the close relations that exist between the establishment of reputation and the management of SLA. In this perspective we identify key aspects and mechanisms to develop a truly efficient Reputation management based on the use of SLAs.

Keywords: Service Level Agreement, Reputation Management, Service-Oriented and Cloud Computing, Reputation Life Cycle.

1 Introduction

Cloud Computing advocates the outsourcing of more and more complex services, providing a way to virtualize entire ecosystems. Given this trend, companies are facing the choice of migrating their system to the cloud or keeping their infrastructure. But with this new paradigm come new issues to tackle.

Entrusting an unknown or unevaluated entity in providing a reliable, secure, legally sound and efficient service is clearly impossible. Besides, the cloud computing paradigm implies that even if you deal with a service provider, you cannot know or control if the provider will not call services of other third parties. In this perspective, and as intensively suggested by the recent researches, one of the main issue to tackle for the adoption of this paradigm is the management of trust and reputation inside and outside Clouds. Given this inevitable requirement for a better and faster adoption of Cloud Computing, numerous researches have been conducted in this direction. However, there is no consensus on how trust and reputation has to be handled.

Service Level Agreement is a term that refers to the general idea that someone or something that wants to use a service offered by a provider may want, or need, to sign a legal contract with this provider in order to ensure that a certain level of performance (according to some parameters) will be delivered. Thus, Service Level Agreement is really a legal contract binding the consumer and provider to a set of duties, responsibilities and penalties/bonuses in case of under/over-performance. However, and as we will demonstrate in this paper, the conception of SLA for service-oriented computing, goes beyond the simple notion of legal contract, it can be used as a real basis for the collaboration by describing meaningful characteristics and be used to drive and support reputation mechanisms.

R. Meersman et al. (Eds.): OTM 2013, LNCS 8185, pp. 377–394, 2013.

This paper is organized as follows: we will first introduce a state of the art on SLA-Based reputation. In the third section we present our SLA-based reputation life cycle. Finally we conclude by discussing our research and by giving some perspectives of our future work.

2 Related Work

This research focuses on the management of Reputation for Cloud Computing by relying on SLA. Hence, the investigation we had to conduct involved looking into the life cycle of Cloud Computing, Management of Reputation and use of SLA.

2.1 Existing Cloud Computing Life Cycles

Due to its complex multi-faceted nature, Cloud Computing has to be described with a more complex life cycle than "usual" service-oriented computing. Conway and Curry [3] proposed a cloud life cycle that can be used for the migration and the ongoing management of public and also for cloud-based services. Their cloud life cycle is divided into four phases that are further divided into nine steps. The four phases and the nine steps are:

- *Architect*: Investigate, Identify, Implementation Strategy and Business design;
- *Engage*: Select, Negotiate;
- *Operate*: Operational Roll-out, Manage the Supply Chain;
- *Refresh*: Review.

This nine-stepped process gives an interesting overview of the cloud life cycle, as it provides an organization and milestones helping the consideration of the cloud.
In [5] the authors described a Service Cloud Life Cycle; it consists of six main stages and 3 looped activities:

- *Deployment*: collection of all information about a service in a service description;
- *User Requirements*: Service Requirements stage;
- *Matchmaking*: Identification of Services fulfilling user requirements;
- *Negotiation*: Service Negotiation;
- *Execution*: Service Consumption
  - *Monitoring, Analyzing, Adjusting*: are looped through during the execution;
- *Ending*: costs for the service execution are billed, and the service is rated by the consumer.

This work is interesting in the perspective that it describes relatively precise life cycle since the deployment stage until the rating task.

Just with these two examples the main aspects of the cloud life appears clearly: a first phase consisting of the service design, deployment, user requirement and service selection; a second phase relying on the negotiation; a third phase consisting of the service execution/operation and a final phase with billing and rating. However, if we consider these works in the perspective of the reputation management, they don't give information about how it could be handled and processed throughout the life cycle.

2.2 Reputation Management

Reputation Management in massively distributed systems has been a particularly hot topic for many years. With the rapid emergence of Peer-to-Peer computing and Service-Oriented Computing, the need for trust and reputation mechanisms has been considered of major importance. Indeed, relying on third parties that you don't always know to support a part of your business (even a small part) is far from being easy. Still, this need was not completely identified by all the players of the market. Within a few years, Cloud Computing has grown tremendously, and almost every large company is considering this technology for a part of its business. But with the possibility to virtualize every component of your system, and then completely virtualize your business, the question isn't any more whether or not you need to have access to Reputation information, the question is how reliable is this information, what has been used to estimate this reputation, how does it live through the Cloud life.

In [9] the authors are presenting an overview of the Reputation and Trust management in service-oriented computing, from the perspective of Service Selection. Among the different remarks they make on the reputation and trust management, they notice that still few work exists on the decentralized management of trust, mainly because of the inherent complexity of such system, and probably because of the need for such system to build a credibility model on top of the reputation model in order to evaluate the credibility of the reputation source, meaning that Reputation information becomes harder to trust due to the potential lack of information on the provenance of feedbacks, leading to a great uncertainty.

In [1] the authors proposed a trust model for Cloud Computing based on the usage of SLA. They describe the requirements and benefits of using SLA for trust modeling in cloud environment, provide a high level architecture capturing major functionalities required, and provide a protocol for the trust model. Their model consists of SLA agents, cloud consumer module and cloud services directory. The SLA agent is the core module of the architecture as it groups the consumers in classes based on their needs, designs SLA metrics, negotiates with cloud providers, selects the providers based on non-functional requirements such as QoS, and monitors the activities for the consumers and the SLA parameters. Cloud consumer module requests the external execution of one or more services. Cloud services directory is the one where the service providers can advertise their services and consumers seek to find the providers who meet their functional requirements such as database providers, hardware providers, application providers etc. The authors have proposed only the model and no implementation or evaluation has been developed or described. Every module will have to be evaluated for its functionality and the effectiveness and finally the overall model will have to be evaluated for its effectiveness.

2.3 Existing SLA Life Cycles and Uses

Service Level Agreement (SLA) is a formal contract negotiated between a service consumer and a service provider for the service. It outlines the relationship between parties to understand each other's needs, preferences and expectations. It should

include how to perform future service delivery including QoS levels required, performance-tracking techniques, performance reports, managing problems and conflicts, security and termination. During service delivery, SLA requires real-time verification. If violation occurs, appropriate action (e.g., penalty, conflict resolution) should be taken. Ron et al [2] defined SLA life cycle in three high level phases: the creation phase, operation phase and removal phase. Sun Microsystems Internet Data center Group defined a more detailed SLA life cycle in six steps:

1. *Discover service providers*: where service providers are located according to consumer's requirements.
2. *Define SLA*: includes definition of services, parties, penalty policies and QoS parameters. In this step it is possible for parties to negotiate to reach an agreement.
3. *Establish agreement*: an SLA template is established and filled in by specific agreement, and parties are starting to commit to the agreement.
4. *Monitor SLA violation*: the provider's delivery performance is measured against to the contract.
5. *Terminate SLA*: SLA terminates due to timeout or any party's violation.
6. *Enforce penalties for SLA violation*: if there is any party violating contract terms, the corresponding penalty clauses are invoked and executed.

This life cycle provides some insight on how the SLA will be handled during the use of a service. However, it does not define the entanglements between SLA life and actual service steps.

Indeed, in addition to traditional use of SLA, many research activities are extending the reach of SLA to use them as the base for more and more tasks inside the service and cloud computing paradigms. In [4] an approach to manage Cost and Business Risk Awareness within SLA is proposed. This work is particularly interesting as it demonstrates the potential use of SLA to help monitoring the Business constraints.

SLA appears to be a more and more active topic in recent research on Cloud Computing. This trend is natural. Indeed, Cloud Users are requesting guarantees before diving into the Cloud, and the only way they have to obtain these guarantees is to sign an SLA with the providers. In the following section we will present how our conception of the relations between SLA and Reputation can lead to the use of SLA to drive the creation of accurate Reputation information, simplifying the life of consumers and providers as they can refer to a single document for the management of their relations.

3 Our Approach

As it is our main focus for this article we will make an in-depth investigation of SLA through the whole life cycle of service computing and reputation. Before diving into the life cycle however, we have to more precisely define the concept of SLA that we adopt for our work. Indeed, if the notion of Service Level Agreement can seem self-descriptive and relatively unambiguous, it is in fact necessary to clarify what is an SLA, how it has to be described, what can/could/should be described in SLA.

3.1 Service Level Agreement for Reputation Management

Service Level Agreement is everything except just a simple legal contract. Yes it is a legal contract; in fact, it is the only piece of information indicating what a service has to provide a consumer. Without SLA, service-oriented computing is more or less like a jungle, you can try to eat an unknown fruit, but you cannot have any insight about the consequences. Signing an SLA is a bit like having the list of excipients and consequences on an exotic fruit: you're informed beforehand, but in some cases you don't understand completely the effects. However in the case of SLAs, you can discuss with the different trees you have at your disposal in order to find the fruit that suits you best. In addition, if one of your co-adventurers in the jungle has already tasted such a fruit and has shared his opinion and a "feedback" on the effects of eating one of them, it becomes a bit simpler to choose one fruit or another. An efficient way for those adventurers to evaluate the fruits is simply to comment the effects announced on the fruits according to the expectations and real experience. In the service-oriented computing it corresponds to the evaluation of SLA parameters. And the fact of sharing and dispatching this evaluation become the reputation of the fruits/service.

Exotic fruits have obviously nothing to do with service-oriented computing. However, the analogy made here serves to illustrate the simple fact that SLAs are powerful supports for the reputation. They describe what is expected, while reputation gives information about what was expected and what was finally delivered. Besides, as we will see in the remainder of the section, SLAs are useful throughout the whole life cycle of the service.

Our conception of SLAs relies on some clear assumptions that are required to correctly consider the life cycle itself. One of the basic needs for the construction of SLAs is to ensure that all parties are using the same accurate and understandable terminology. To this extent, we advocate the fact that SLAs have to be represented according to a shared ontology, an ontology of SLAs. In addition, SLAs should be the base of the feedbacks that will be collected and will later become part of the reputation. Thus, Feedbacks should rely on and extend the SLA ontology.

With these precisions given, we can dive into the main part of this section and consider the life cycle of service-oriented computing and identify the key points of SLA and Reputation.

3.2 SLA-Based Reputation Life Cycle Main Phases

The design of an SLA-based Reputation Life Cycle for Cloud Computing requires the exploration of most of the steps of the Cloud from the Reputation perspective, and the consideration of the use of SLA in this perspective. Our consideration of the Cloud Computing Life Cycle is organized in 4 major phases as depicted on Fig. 1.

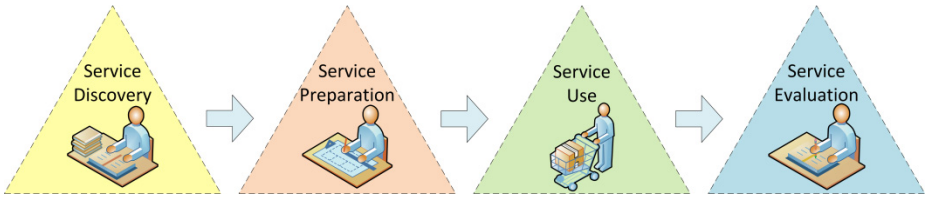

Fig. 1. Cloud Computing Life Cycle Overview

The first phase of this general conception is the *Service Discovery*. This initial phase starts at the very beginning of the Cloud Service life; when consumer and provider aren't known of each other and when the Cloud Service does not exist yet. For these phases, we have to consider that there is no direct relation between the service provider and the service consumer. During this phase, the service provider is building the service and publishing it on a repository. From the consumer perspective, this phase includes several steps, from the service requirement description and SLA drafting, to the service search and selection.

The second main step of the Cloud Service life cycle is the *Service Preparation*. This phase is used by the service consumer and provider to negotiate the terms of the service level agreement. Once these terms have been negotiated and agreed upon, service provider and consumer have to effectively setup their environment for the consumption of the service. On the provider part it may include customization or configuration of the service or/and environment. On the consumer side it requires the integration of the service into the rest of its system. Only when these steps have been completed can the actual use of the service occur. Our first consideration for the overall representation of the Cloud Service Life Cycle was to design a 3-phased cycle based on a simple "*past-present-future*" conception, which in the perspective of Service-Oriented Computing would be mapped as something like "before the use of the service", "during the use of the service" and after the use of the service". However, even if this conception is a valid one, we argue it has to be a bit more detailed to be both relevant and accurate. Indeed, the *service discovery* phase is asynchronously done by provider and consumer; they don't have to know each other or to communicate to operate. It is only at the end of this phase that the communication between them will start as they will undergo the *service preparation* phase.

Once the *service preparation* is completed on each side and the parties are ready, the actual *service use* (or consumption) can take place. During this complex phase, many different elements, entities and action will be involved, spanning from the actual deployment of the service until the monitoring and reporting of SLA violations. More details on this phase will be provided in the reminder of this article.

The fourth phase we have defined is related to the end of use of the service. Once the consumer wants to put an end to its service consumption, or if the ending date of the SLA has been reached. Important actions have to be taken in this regarding the feedback provided by the different entities that where involved in the Service Use.

Now that we have presented the general view of our conception of Service-Oriented Computing we will go into details for each phase and identify the key points for reputation and SLA.

3.3 Service Discovery

Fig. 2 describes the different steps in the first phase of the life cycle.

Service Creation: the very first element in the life of the service is the creation of the service itself, according to a wish of the provider to offer such service to its future clients. This step contains several sub-steps that won't be detailed in this paper as they correspond to service development steps and can vary according to different elements. However, it is important to notice that even at this step we have to consider the reputation and SLAs. We have to consider the reputation at this step, because the development of the service can imply the use of external services and will then induce that a part of the service reputation will be linked to the reputation of these external services. At this stage we have to take SLAs into account for three reasons: first, as we will see in the following phases, we argue that reputation of a service has to be closely related to its respect of SLAs, thus the consideration of external services implies the consideration of the SLAs that have been signed with them in the past; secondly we need to consider the currently signed SLAs with these external service to be able to estimate the boundaries of the envisaged service. Finally we need to consider SLA because when developing the service, depending on its intended use, the service provider will make development choices that will give him limits for the use of its service and then limits in some of the SLA parameters that he will be able to agree on.

Service Publication is the second step, it occurs when the service has been created and is deployed to be used by consumers.

Service Indexing immediately follows the publication, it is done at the initiative of the provider and the service is indexed and referenced in a service registry held by a third party. As it will be evoked later, this kind of registry can be useful not only to simply index the service, but also potentially to aggregate and provide additional data on the service and can then be seen as an advertisement support. At this point in the process, the job of the provider is done and he has to "wait" for consumers to contact him in order to use its service.

From the consumer perspective the steps are completely different. The ***Service Description*** is the first step in the consumer process in using a service. For this step the future consumer will describe the service is looking for in term of functionality. Most probably he will also want to start at least drafting the SLA he's expecting to sign with the service provider he wants to find.

Once the consumer has finished describing the service he's looking for he will effectively make the ***Service Search*** and contact registries to find the adequate service matching his description. In practice this step can be ensured by a Service Broker that will manage the search on behalf of the consumer. In such a case it can be essential for the consumer to draft the SLA as it will simplify the exchanges between the parties and fasten the general process of looking for a service.

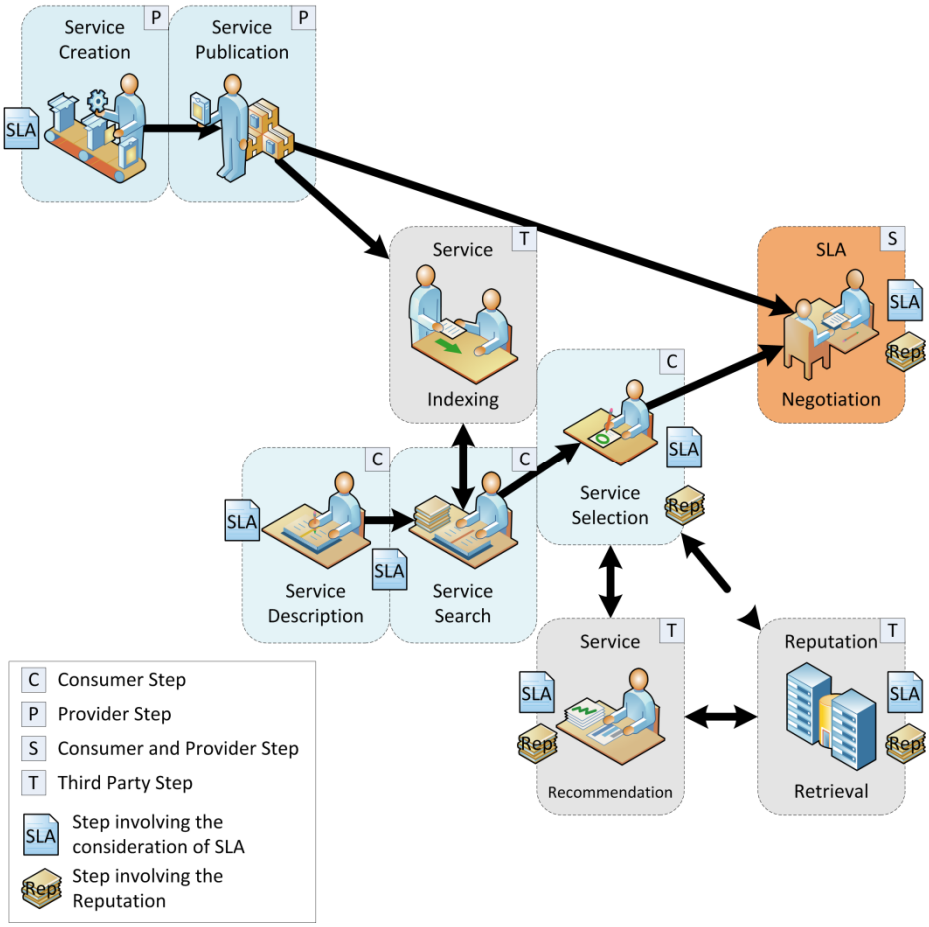

Fig. 2. Cloud Service Discovery Phase

In return registries will provide to the consumer a list of services that match the description he has provided. This will give the consumer the opportunity to choose the service he wants to use, thus he will perform a ***Service Selection***. The selection process has to be done according to the differences between services and the preferences of the consumer. As it is rarely possible to be able to have an opinion or previous experiences of use of all the services proposed and thus make an educated choice, the service selection step is often linked to the ***Service Recommendation***. The recommendation of a service can take several forms and involve different entities of the ecosystem. In our conception we consider that the service recommendation has to reflect past experiences of use of the service. Thus the recommendation has to be influenced by past experience reports, usage feedbacks and be adapted to the final needs of the user. Thus, in our conception, the service recommendation has to be fed by experiences/reputation registries, and provide customized information to the user. Hence, Service Recommendation implies the ***Reputation Retrieval*** from a reputation

repository. Such recommendation can be collected directly by the user or can pass through a Service Broker in order to simplify the selection. On the selection and recommendation steps it is important to consider reputation of the service according to past SLAs and the expected SLA for this use, as it will drive a part of the selection process.

3.4 Service Preparation

Once the selection of the service is done and the consumer knows with which provider he wants to deal with, he will contact this provider and initiate the ***SLA Negotiation***. This step links together the first and the second phases of the life cycle. As depicted on Fig. 3.

During the SLA Negotiation, consumer and provider discuss and exchange about the different terms of the SLA on which they want to agree. Given the fact that past experience can provide hints about the expectable SLA, it is of prime importance to accurately consider the reputation of the service (and service provider). This step includes multiples interactions, mainly between the consumer and provider, but also with third parties that will be involved in the service such as service auditors, contractors, service brokers, etc. In the process of the SLA Negotiation between the consumer and the provider, ***Contractor SLA Renegotiation*** can also be involved. For this optional and specific step the service provider may want to reconsider the SLA he has signed with its contractors in order to be able to agree to some of the parameters the consumer is willing to have a specific level of performance. This renegotiation will then potentially imply a customization of the service. After the SLA negotiation between consumer and provider, two outcomes are possible: no agreement on SLA parameters is reached and one of the parties breaks the negotiation. In such a case the consumer will go back the Service Selection step of the Discovery Phase. The second possible outcome is where an agreement is reached by the two parties and an SLA is signed, this corresponds to the ***SLA Signing*** milestone. After reaching an agreement and signing the SLA, the provider may have to undergo an extra two extra steps: customization and redeployment of the service.

The ***Service Customization*** step is done by the service provider, when after signing an SLA with a customer he has to tailor the service that he will deliver in order to match consumer's expectations and ensure the respect of the terms of the SLA. Depending on the level of customization needed, the provider may also go through a ***Service Deployment*** phase. During the Service Customization of the provider, he will also communicate with the consumer to notify him if changes in the use of the service arise. This will drive the consumer for his next step: the ***Service Integration***. Indeed, while issues regarding provider's technical challenges on service development, adaptation and management and consumers difficulties regarding service discovery, selection are often discussed or at least mentioned in researches, we also have to consider the simple fact that the consumer has to integrate its consumption of the service within its own system.

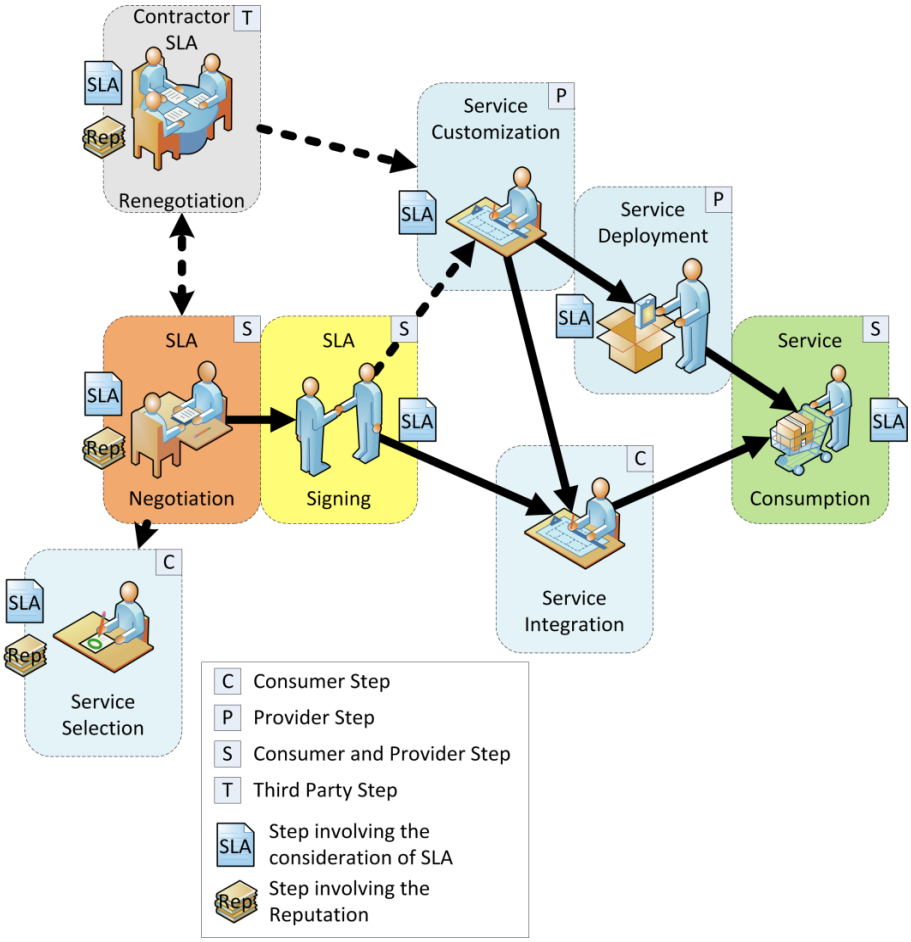

Fig. 3. Cloud Service Preparation Phase

3.5 Service Use

Upon completion of the service integration and service deployment, consumer can finally start the main activity of the life cycle: ***Service Consumption***. The beginning of this activity marks the end of the Service Preparation Phase and the start of the *Service Use Phase* as illustrated on Fig. 4.

Service Consuming itself is the simple fact for the consumer to call the service of the provider. The service use phase includes much more interactions between the parties.

In addition to the simple deployment of a service, the provider has to ensure the efficiency and well-being of the service by supporting the monitoring of his service. This can simply be called ***Service Monitoring*** and has to be considered as a continuous activity during the whole use of the service. This activity allows the service

provider to keep its awareness on the state of his service and detect potential issues or needs. The monitoring of the service is closely related to the ***Service Adaptation***. Indeed, while the monitoring task has in charge to collect information regarding the state of the service, the service adaptation allows triggering specific management activities in case a need for change is detected. In such a case, the service adaptation that will occur may take several forms: it can be an adaptation of the execution environment, an adaptation of the contractors (providers) of the provider or an adaptation of the underlying infrastructure used to support the service deployment. In any case, this adaptation has to preserve or improve the respect of the SLA. Once adaptation is done, the provider may have to go through a ***Service Deployment*** step in order to take into account some of the adaptations made. In an ideal world, it would be possible to only have a monitoring of the service from the provider. However, an ideal world takes time to build, and it would be unreasonable to consider that we already live and work in such a place. Thus, in order to be able to somehow trust a provider, we need to ensure that trust by auditing the provided service. This task, the ***Service Auditing*** can be performed either by the service consumer itself, but in order to gather more reliable information and ensure the objectivity of the audit it is preferable to let this activity be performed by a third party entrusted by both consumer and provider. Typically, the identity and the method of auditing can be parts of SLA terms.

Then, the Service Auditing will consist in monitoring and evaluating the respect of performance indicators and other specific parameters of the service. Hence in our conception it would be almost natural to consider that the most important parameters to consider (but not the only ones) for the audit are the one of the agreed SLA. Such a mechanism is naturally suited to handle the task off detecting SLA Violation. Given this possibility, the Service Auditor can, in addition to the ***Service Reporting*** that would generate reports to be used in the last phase of the process, handle the ***SLA Violation Reporting*** activity that will be communicated to the provider (and the consumer) in order to alert him of the need for adaptation of the service. Both Service Auditing (consumer side) and Service Monitoring (provider side) possess common concerns: *Performance Monitoring* to ensure the performance of the service (CPU availability, average response time, network speed, etc.), Security Monitoring (encryption, protocol, access control, etc.), Business Monitoring (when possible and upon applicability of the concept) and Legal Monitoring (for example ensuring that data do not transit in some countries that would not respect the same privacy rights as the one desired by the consumer). Even if there are common items between the two activities, there are also differences. Service Monitoring will also incorporate monitoring and awareness of external resources (external to the service, for example resources dedicated to another service in use) in order to be able to optimize resource usage. SLA Violation and the different monitoring activities have a direct impact on the reputation of the service and its provider, as they will quantitatively and qualitatively reflect the respect of the SLA.

It is also noticeable that using a service can be based on a pay-on-use model, requiring the consumer to have a ***Cost Monitoring*** activity.

Finally, we have to mention the possibility for one party or the other (or both) to ask for an ***SLA Modification***. Indeed, the provider may ask for a modification of SLA

parameters because he isn't able to provide the agreed level (with the risk of losing the trust of the consumer) or on the contrary because he wants to improve the SLA. The consumer on his side may want to modify the SLA for different reasons (for instance if one of the parameters that they did not agreed upon is disturbing the consumer's business, or if the requirements of the consumer have evolved).

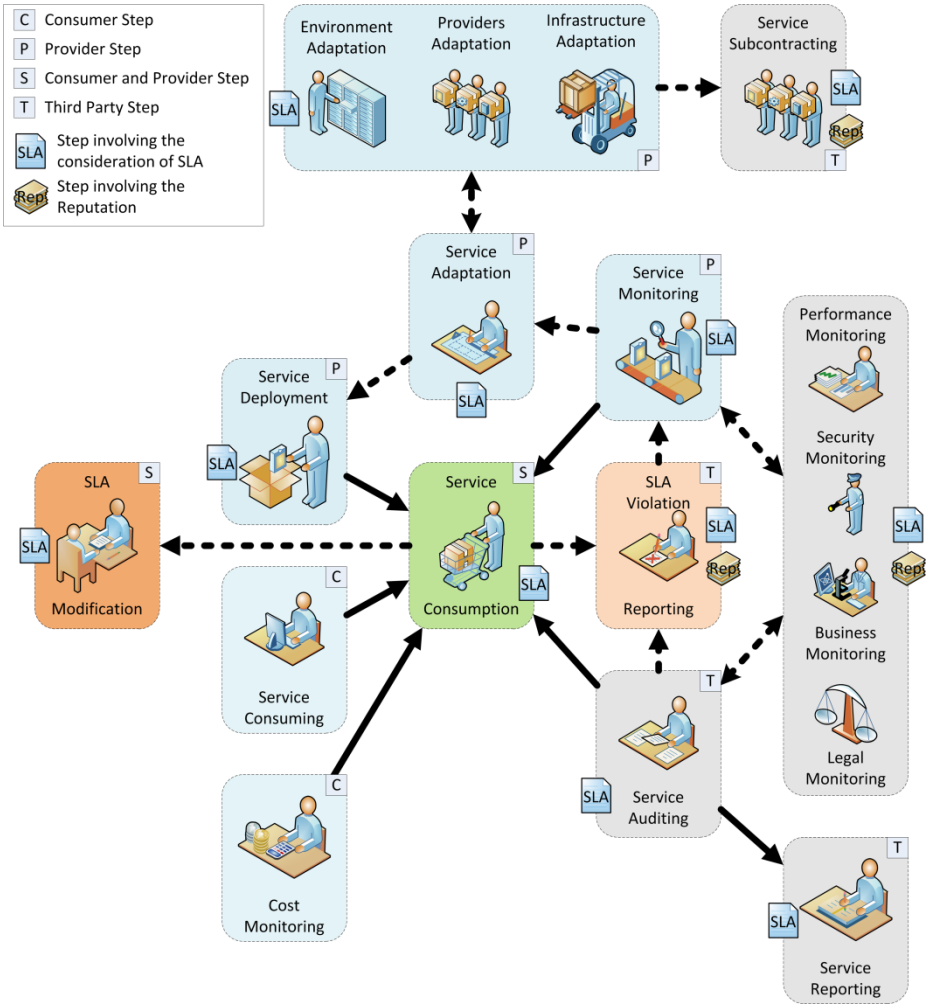

Fig. 4. Cloud Service Use Phase

3.6 Service Evaluation

The Service Use phase is followed by the Service Evaluation Phase (Fig. 5), the last of the process. After the end of the service consumption, there is a need for the entities that were involved to provide feedbacks on the use of the service. In this

perspective both service provider and consumer undergo a ***Feedback Creation*** step that will represent their general evaluation of the service consumption for their respective perspectives. In addition to this evaluation, the Service Monitoring and Service Auditing activities will produce reports through the ***Monitoring Reporting*** and ***Audit Reporting*** steps. The main difference between feedbacks and reports is to be found in the fact that reports is only based on the measured aspects of the service consumption, while feedbacks can include, in addition with information on measured aspects, information on not-measured aspects (whether they are positive or negative feedbacks).

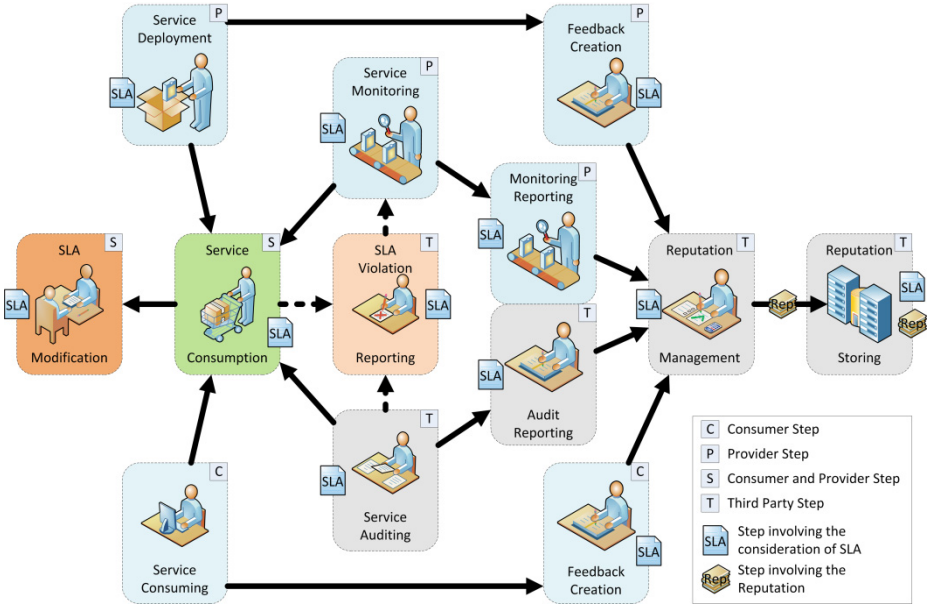

Fig. 5. Cloud Service Evaluation Phase

All those reports and feedbacks have to be the source of the reputation, and consequently have to be sent to a ***Reputation Management*** system in order for it to infer information about the reputation of the participating entities. Once processing of this information is done, it can proceed to the ***Reputation Storing*** step which will allow retrieving reputation information on a later use.

On this final phase of the Service life, we can see that *Reputation* will be processed and stored for later use. Indeed, as we have seen in the initial phases, reputation will be used during the service search, discovery, selection and SLA negotiation steps.

3.7 SLA-Based Reputation Life Cycle

Now that we have seen the details of service-oriented computing in the light of SLA and Reputation, we can extract a minimalistic life cycle for the SLA-Base life-cycle. As depicted by Fig. 6, the core life cycle behind our research is simple. Starting from

the SLA signed by the parties, it constitutes the basis of the Feedbacks that will be given afterwards. Thus we can say that SLAs are characterizing feedbacks. On the feedbacks have been created they are aggregated and processed to feed the Reputation of the service. While we could think that the reputation is the final "form" of the influence of SLA, we have, in fact, to consider the fact that the Reputation of a Service drives a part of the establishment of future SLA. Indeed, if you now that a service performs poorly on a given SLA parameters, it is probable that you will try to reach an agreement on this parameter to avoid too many "surprises" during the use of the service.

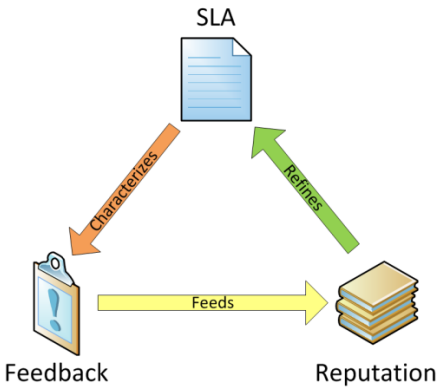

Fig. 6. SLA-Based Reputation Core

Table 1 summarizes the different key points that we have identified along our analysis of the Reputation life-cycle. The driving role of the SLA appears clearly and will help us in our future work to determiner actions to undertake.

Table 1. SLA and Reputation Key Points

Phase/Step	Entity	Element	Key Point
Service Discovery			
Service Creation	Provider, Subcontractor	Reputation	• Inheritance of Reputation from subcontracted services
		SLA	• Transitivity of SLA (SLAs signed with subcontracted services fix boundaries *de facto* to the establishment of the SLA)
		Reputation & SLA	• SLAs previously signed with external (subcontracted) services have to be considered for the reputation and the design of the SLA of the service.
Service Description	Consumer	SLA	• Drafting of SLA

Table 1. (*Continued*)

	Service Recommendation	Consumer, Broker	Reputation	• Reputation retrieval, filtering, customization
			Reputation & SLA	• Reputation has to be considered according to the intended SLA.
Service Preparation				
	SLA Negotiation	Provider, Subcontractor	SLA	• Consider previously signed SLAs • May renegotiate SLA with sub-contractors
		Consumer	Reputation & SLA	• Has to consider reputation of SLA parameters in the negotiation.
		Third Party	SLA	• Take part to the negotiation, for instance for the monitoring activity
	SLA Signing	Consumer, Provider, Third Party	SLA	• Sign the SLA, creating the legal contact
	Service Customization	Provider	SLA	• Tailor the service and its adaptation features according to the parameters of the SLA.
Service Use				
	Service Consumption	All parties	SLA	• Has to be done in respect of SLA
	Service Monitoring	Provider	SLA	• Verify the respect of the SLA and the respect of provider-specific elements
	Service Auditing	Consumer, Third Party	SLA	• Verify the respect of the SLA parameters.
	Service Adaptation	Provider, Subcontractors	SLA	• Ensure the respect of the SLA • Adapt the service execution environment according to the threats to the SLA and internal needs of the provider. • Adapt/Renegotiate with subcontractors to ensure the SLA
	Service Deployment	Provider	SLA	• Service has to be deployed in respect of the SLA parameters
	Service Reporting	Consumer, Third Party	Reputation & SLA	• Create audit reports on the respect of SLA, that will be used later to evaluate the service reputation.
	SLA Violation Reporting	Any party	Reputation, SLA	• The violation of SLA has a direct impact on the Reputation of a service and its provider.

Table 1. (*Continued*)

	SLA Modification	Consumer, Provider	Reputation, SLA	• Any request for the modification of the SLA implies a modification of the relation between the parties, and then a modification of the reputation. It will also be the start of the life of a new SLA
Service Evaluation				
	Feedback Creation	Consumer, Provider	Reputation, SLA	• When creating a feedback for the use of the service, it has to be done by taking into account the SLA. • The reputations of both consumer and providers are directly related to the feedback provided.
	Monitoring Reporting	Provider	Reputation, SLA	• Reports generated by the monitoring are done according to the SLA • Those reports will influence the Reputation.
	Audit Reporting	Consumer, Third Party	Reputation, SLA	• Reports generated by the auditing are done on the basis of the SLA • Those reports will influence the Reputation.
	Reputation Management	Reputation Manager	Reputation, SLA	• The reputation management has to be done in accordance with the SLA as it provides a basis against which the service evaluation has been done.
	Reputation Storing	Reputation Manager	Reputation, SLA	• The storage of feedbacks has to be done with a reference to the SLA

4 Discussion

In this paper we propose our conception of an SLA-Based reputation management for service-oriented and cloud computing. This conception relies on the simple principle that SLA can drive many activities during the whole life of the service, and more particularly can serve as a reference and a base for the production of feedbacks that will then feed the Reputation of the service. Management of Reputation is a hard task in open environments where any entity can enter the system and offer a service with more or less goodwill. With the new challenges and opportunities offered by Cloud Computing, it is more than ever needed to develop a robust method and mechanisms allowing a reliable collaboration between involved parties. In this perspective, our approach proposes to reuse the established process of SLA negotiation and signing. This reuse of SLA has to be completed by building a semantically coherent and meaningful ontology (inspired by work already done on this matter [7] and with the

perspective of a complete Cloud ontology [8]) to help the design, understanding and negotiation of SLAs. This ontology would also ensure the coherence and the common ground on which SLAs are built and then it will ensure the coherence of Feedbacks, and finally Reputation.

One clear potential issue in our conception is a need for a relatively complex a highly descriptive SLA. This issue is a "natural" problem of SLA and some really promising researches are already trying to solve it ([6], [10], [11]) by simplifying or guiding the design and development of SLAs.

Many researches in the domain of Trustworthiness of services are considering primarily the Trust of an entity in another. From our point of view, the concept of trust is either insufficient, or not correctly employed. Indeed, the Reputation mechanism we rely on is using feedbacks from the different entities implied in the Cloud ecosystem the build the Reputation of entities. Then, the trust of one entity in another could be described as a sum of the feedback it provided on that second entity. And finally reputation could be considered as the consolidation of all trust of all entities of the system regarding the concerned entity. In this conception the trust of on particular entity in another becomes a simple part of the global reputation. That's the reason why we haven't explored more deeply the representation of trust; it is implicitly "included" in the Reputation.

5 Conclusion

Management of Reputation for Service-Oriented Computing has been a hot subject for many years now. The fast emergence of the Cloud Computing has generated new challenges and requires an even deeper consideration of this reputation as it may be one of the only ways to make a difference between two providers offering the same service at the same cost. Moreover, in a wider and wider network of entities collaborating more and more freely, it becomes unavoidable to be able to get information about providers in order to avoid bad surprises. In addition, we argue that providers are not the only ones that need to be evaluated. Service consumers for instance are not "external" to the system, they also need to do their part and have to correctly use services. Given this consideration, it becomes natural that reputation has to be envisaged as a characteristic of services themselves, but also a characteristic of providers of these services (some elements of the reputation have no direct relation with the service, but with the management of the service; for instance service scalability may partially be a result of the service design, but in many case it will more probably be a result of the capacity of the service provider to correctly balance load and respond to the evolution of service use). Reputation is also a characteristic of consumer of the service (as evoked, the way the service is integrated and used within the system of the consumer can lead to various results and may induce a lack of efficiency compared with the actual performance of the service). The case of third parties is a bit different, as it involves the consideration of separate SLAs. However, it is possible that in the future, third parties involved in the service life cycle will be integrated more deeply into the SLA.

In the end, SLAs have to be considered during the whole life of the service, as multiple entities, steps and activities can use them to calibrate, customize and optimize service delivery, service management, monitoring, reporting and even subcontracting. Given the natural benefits offered by SLA in the Reputation life cycle, it is clear for us that we will continue working on this perspective. The future of our research will concentrate on the description of an ontology for SLA, Feedbacks and Reputation, allowing the seamless understanding of the information, from the beginning of the service discovery, until the very last evaluation steps.

Acknowledgements. The research presented in this paper is supported by the European Union within the FP7 Marie Curie Initial Training Network "RELATE".

References

1. Alhamad, M., Dillon, T., Chang, E.: SLA-Based Trust Model for Cloud Computing. In: Proceedings of the International Conference on Network-Based Information Systems, Barcelona, Spain, September 14-16, pp. 321–324 (2010)
2. Ron, S., Aliko, P.: Service level agreements. Internet NG. Internet NG project (1999-2001), http://ing.ctit.utwente.nl/WU2/
3. Conway, G., Curry, E.: Managing Cloud Computing: A Life Cycle Approach. In: 2nd International Conference on Cloud Computing and Services Science (CLOSER 2012), Porto, pp. 198–207 (2012)
4. Jiang, M., Byrne, J., Molka, K., Armstrong, D., Djemame, K., Kirkham, T.: Cost and Risk Aware Support for Cloud SLAs. In: Proceedings of the International Conference on Cloud Computing and Services Science (CLOSER 2013), Aachen, Germany, May 8-10, pp. 207–212 (2013)
5. Moltkau, B., Thoss, Y., Schill, A.: Managing the Cloud Service Lifecycle from the user's View. In: Proceedings of the International Conference on Cloud Computing and Services Science (CLOSER 2013), Aachen, Germany, May 8-10, pp. 215–219 (2013)
6. Spillner, J., Illgen, S., Schill, A.: Engineering Service Level Agreements A Constrained-domain and Transformation Approach. In: Proceedings of the International Conference on Cloud Computing and Services Science (CLOSER 2013), Aachen, Germany, May 8-10, pp. 395–405 (2013)
7. Patel, P., Ranabahu, A., Sheth, A.: Service level agreement in cloud computing. In: Cloud Workshops at OOPSLA (2009)
8. Youseff, L., Butrico, M., Da Silva, D.: Toward a unified ontology of cloud computing. In: Grid Computing Environments Workshop, GCE 2008, pp. 1–10. IEEE (2008)
9. Wang, Y., Vassileva, J.: A review on trust and reputation for web service selection. In: 27th International Conference on Distributed Computing Systems Workshops, ICDCSW 2007, p. 25. IEEE (2007)
10. Keller, A., Ludwig, H.: The WSLA framework: Specifying and monitoring service level agreements for web services. Journal of Network and Systems Management 11(1), 57–81 (2003)
11. Rady, M.: Parameters for Service Level Agreements Generation in Cloud Computing. In: Castano, S., Vassiliadis, P., Lakshmanan, L.V.S., Lee, M.L. (eds.) ER 2012 Workshops 2012. LNCS, vol. 7518, pp. 13–22. Springer, Heidelberg (2012)