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Marco Comuzzi, Guus Jacobs, Paul Grefen

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Clearing the Sky - Understanding SLA Elements in Cloud Computing

Authors: Marco Comuzzi[1,*], Guus Jacobs[2], Paul Grefen[1]

[1]Eindhoven University of Technology, Eindhoven, The Netherlands
[2]PricewaterhouseCoopers Accountants N.V., Eindhoven, The Netherlands
* Corresponding Author (m.comuzzi@tue.nl)

Abstract: Issues characterizing cloud computing such as security, interoperability, and vendor lock-in are likely to act as inhibitors of the widespread adoption of cloud computing in organizations. These issues call for relational and contractual mechanisms to articulate the desired outcomes of service provisioning and acceptable behavior of service recipients and providers. In this paper we focus on the contractual mechanisms for this purpose and, more specifically, Service Level Agreements (SLA). We have conducted a qualitative study interviewing industry experts to understand the extent to which SLA specifications in traditional IT services outsourcing can be applied in cloud computing, identifying elements becoming redundant or not applicable, and new elements capturing the specificity of the business relationships entailed by cloud computing. Our study results in a detailed SLA specification for different cloud computing deployment models, i.e. private and public cloud, and in a framework investigating the role of SLA elements in the decision making process for cloud computing outsourcing.

Keywords: cloud computing, SLA, deployment model, IT outsourcing, contract.

Word count (main text): 7211

Introduction

The year of birth of commercial Cloud Computing (CC) is 2009, with cloud vendors introducing browser-based enterprise applications (Pallis 2010). CC is increasingly becoming a part of information processing in organizations. Numbers in a recent survey show that 24% of the interviewed IT directors and staff of potential customers of a cloud vendors' panel are currently using CC and another 61% is experimenting or waiting for CC to mature (North Bridge 2011). Forrester Research (2011) forecasts that the global market for CC will grow from $40.7 billion in 2011 to more than $241 billion in 2020.

There are many uncertainties surrounding CC, however, which may hinder this growth. Issues such as security, interoperability, vendor lock-in, and compliance are considered to be inhibitors of the adoption of CC (North Bridge 2011, Marston et al. 2011). These issues are no strangers even in traditional Information Technology Outsourcing (ITO) and are usually considered within contracts between parties in IT outsourcing engagements.

Economic and organizational theory, in fact, states that outsourcing relationships require, next to relational governance (i.e., unwritten, practice based mechanisms), formal controls, (i.e., contracts) in which the relationship is specified (Goo 2010). The early work of Jaworski (1988) defines the role of formal contracts as mechanisms of formal control which articulate acceptable behavior toward desired outcomes in the form of written rules and regulations. In ITO, the formal contract is drafted in the form of a Service Level Agreement (SLA), which describes the specifics of the service(s) to be delivered and the engagement expectations of the service recipient (SR) and service provider (SP). In this context, one can ask whether CC changes the relationship specifics between SRs and SPs and, as a consequence, their engagement expectations, i.e., the elements of the SLA.

In CC, we can identify the core of the relationship between SRs and SPs which is not likely to change when compared to traditional ITO: party A requests a service to party B, who can provide this. The properties that CC features, however, form the base for differences in outsourcing relationships that are observed in practice. CC features, such as rapid scaling, pay-per-use, and lower IT upfront investments are beneficial for companies, but also cause situations that did not occur in traditional ITO relationships.

Examples of such situations are discussed by Paquette et al. (2010): "In a period of less than 60 days, Apple MobilMe, Google Gmail, Citrix, and Amazon S3 all reported outages or periods of unavailability from 2 to 14 hours; in March 2009, Microsoft Windows Azure was down for 22 hours" (p. 249), "A cell phone provider that stored customer data in a Microsoft subsidiary-provided cloud became unavailable when the provider lost that data. Customers had to wait for days to be informed that a possibility (but no guarantee) existed that their data may be able to be restored. However, the extent of data recovery, the level of data integrity, and the timeline to restore remain to be seen" (p. 250).

The above examples show that the often unilateral nature of the relationship in CC results in the SR being more dependent on the SP when compared to traditional ITO. Moreover, it is often unclear in CC what will happen to the SRs' data when power outages occur or when data are lost.

Another critical aspect concerns interoperability and migration, that is, unforeseen events causing a SR to retract the service from one SP and transfer it to another SP. The issues created by this transfer, in particular about data, are likely to be more relevant in CC than in traditional ITO: "As cloud offerings spread, there will be ongoing challenges with interoperability, portability, and migration. […] Cloud users can face severe constraints in moving their data from one cloud to another and find themselves locked in" (Hofmann and Woods 2010, p.91).

Eventually, differences between ITO and CC are also to be found in the cardinality of the relationship between the SP and the SRs. In CC this ranges from a one-to-many 'anonymous' relationship in case of a *public* cloud, traditionally referred to as the multi-tenancy model in the SP perspective, to a one-to-one 'close' relationship in a *private* cloud. The one-to-many case, in particular, is often not relevant in traditional ITO. Although the outsourced services in traditional ITO can run on the same software instance, e.g. in time-sharing mainframes or in the Application Service Provider (ASP) paradigm, the SP usually offers a dedicated infrastructure for each SR at least for what concerns data, i.e. a separate database instance for each customer. In a multi-tenant cloud solution, the SRs do not have any guarantee from SP even on having a dedicated database instance.

In this paper we investigate the CC outsourcing decision process and the related content of SLAs in CC outsourcing. About the outsourcing decision process, we present a framework analyzing the structure of such a process, identifying decision points and the information elements required in those. About SLAs, we analyze and define the list of elements required in a SLA regulating the relationship between a SR and a SP. In particular, we show how the content of the SLA in CC should differ from the one of SLAs in traditional ITO, which we retrieve from an analysis of the literature.

Our conceptual framework and analysis of SLA content in CC represent a contribution to research and practice. From an academic perspective, we provide a basis for understanding the content of SLAs in CC and their relationship with different cloud deployment models, filling a gap in the literature and providing a foundation for future research. From a practitioner perspective, SRs may use our framework as a guide (checklist) during the creation of specific SLAs with cloud providers, whereas SPs, during service design, may use our work as a tool to develop standard capabilities supporting the required SLA elements.

The paper is organized as follows. In the next section we discuss the research method that we have adopted in our study. Then we discuss related work, identifying the literature gap regarding SLA content in CC. The results of our investigation are then introduced in the next two sections and critically reviewed. Eventually, we draw our conclusions and discuss future work in the last section.

Research Method

The aim of this research is to improve the understanding of SLA related practice and content in CC, rather than testing or confirming hypotheses involving specific research constructs. In other words, we take an exploratory approach in our research (Hair jr., et al. 2011).

For what concerns data sources, the substantial lack of comprehensive SLA specifications in CC, makes it impossible to rely on secondary data. Hence, this research uses primary data, directly and purposefully collected. Because of the exploratory nature of the study, we adopt semi-structured interviews, collecting feedback from respondents on the intermediate output of our research and narrative qualitative data to validate and possibly improve such output.

We developed a three-staged research method, which is shown in Figure 1.

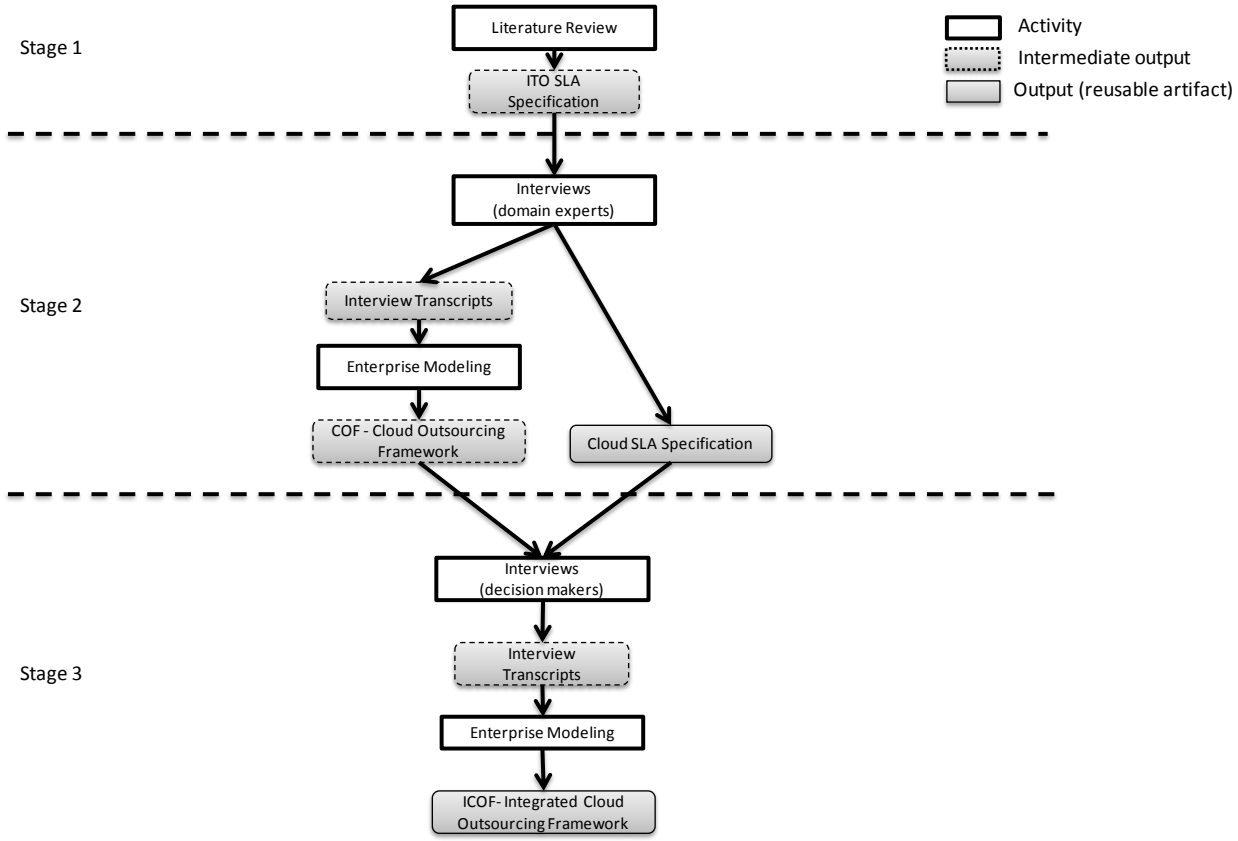

Figure 1 - Research Design

The first stage S1 is constituted by a literature review, through which we analyze current published work on SLAs in traditional ITO. The output of this phase is a comprehensive specification of SLA in traditional ITO.

In the second stage S2 we conduct interviews with experts in the domain of CC outsourcing. The objective of the interviews is twofold. First, we extend and customize the specification of SLAs in traditional ITO to the context of CC outsourcing. This leads to the Cloud SLA specification, which addresses a gap in the literature on CC. To the best of our knowledge, in fact, the Cloud SLA specification is the first example of a comprehensive specification of the content of SLAs in CC.

Second, using an enterprise modeling approach (Zachman 1987), we exploit the coding of the interviews to design the first version of the Cloud Outsourcing Framework (COF). The COF is an instrument to support the CC outsourcing decision making process, decomposing it along the two enterprise dimensions of control flow (process) and decisions flow.

The potential interviewees in stage S2 are selected from the Cloud Computing taskforce within the Business Assurance Services (BAS) department at PwC Eindhoven, The Netherlands. Out of the 11 experts in CC identified among group leaders at BAS, 6 agreed to participate in our study. Each interviewee has a minimum of 7 years experience in ITO and/or CC, with an average experience of 13.7 years. Interviews were semi-structured with a duration between 45 and 60 minutes. The content of the interviews is analyzed using grounded theory (Yancey, Martin and Turner 1986). Because our study started with an existing theory, i.e. SLAs elements in traditional ITO, grounded theory could be used to enhance the theory, widening its scope, but not to falsify it (Urquhart et al. 2010). This is consistent with the objective of our study, that is, to widen the scope of SLA theory in traditional ITO in the context of CC. The content of the interviews is analyzed using directed content analysis (Hsieh and Shannon 2005), using both codes pre-determined from theory and codes derived from interview content.

Interviews and theory building in stage S2 imply a certain degree of subjectivity in our findings. Therefore, in stage S3 we validate the output of stage S2. The objective of the validation is to assess the clarity, completeness, and usability in practice of the Cloud SLA specification and the COF framework. Validation is performed by interviewing experts with experience in practice about IT outsourcing and CC. The interviewees are selected among the members of the Dutch CIO platform[1], an independent association of CIOs and IT directors from Dutch private and public organizations. We conducted interviews with 4 experts, with an average experience of 16.5 years. We provided the preliminary version of the framework and SLA content analysis beforehand to the interviewees. Then, we conducted face-to-face, semi-structured interviews of 60 to 90 minutes. The content of the interviews is coded to identify the sections of our framework raising concerns about clarity, completeness, or usability.

For what concerns the Cloud SLA specification, the validation did not lead to substantial criticism. Therefore, we maintain the cloud SLA specification as an output of our research and use the feedback collected in the interviews to identify opportunities for future work. Conversely, the interviews in stage S3 identified substantial improvements of the COF. Revising the COF using the collected feedback requires a second iteration of enterprise modeling, which leads to the second version of our COF that we named the Integrated Cloud Outsourcing Framework (ICOF). The ICOF is therefore the second output of our research.

Literature review (Stage S1)

In this section we first present a working definition of cloud computing, and then we discuss related work in the area of ITO and CC SLA content specifications.

A definition of Cloud Computing

[1] http://www.cio-platform.nl/

Although several authors have attempted to come up with a comprehensive definition of cloud computing (Vaquero et al. 2009, Geelan 2009; Stanoevska-Slabeva et al. 2010, Grandison et al. 2010), in this paper we consider the working definition provided by Meel and Grance (2011) of the National Institute of Standards and technology (NIST).

According to NIST:

"Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This Cloud model promotes availability and is composed of five essential characteristics (On-demand self-service, Broad network access, Resource pooling, rapid elasticity , and Measured service), three service models (Software as a Service, Platform as a Service, and Infrastructure as a Service), and four deployment models (Private Cloud, Community Cloud, Public Cloud, and Hybrid Cloud)."

Given the exploratory nature of our work, in this paper we will consider only the most common cases of the deployment models: the Private and Public Cloud. In the public cloud, the organization providing cloud services owns the cloud infrastructure and makes it available to the general public or a large industry group. In the private cloud, the cloud infrastructure is operated by the providing organization solely for one specific recipient. It may be managed by the selling organization or a third party and may exist on- or off- the user premises or off-premises. The results of our work can be easily combined to address the need of intermediate deployment models, i.e. Hybrid and Community clouds. Given its exploratory nature, our study does not focus explicitly on the differences among different service models. The analysis of CC service models specificity in drafting SLAs is left to future work.

SLAs in IT services outsourcing

Lacity et al. (2009) review the ITO literature identifying the degree (size) of the outsourcing, contractual governance, and relational governance as the main determinants of ITO success. These are very broad categories of determinants meant to capture the practices associated with management commitment, evaluation processes, contracts, and supplier relationships. In this work we focus on contractual governance.

According to Goo (2010), the role of a contract in ITO is fulfilled by the SLA, which "describes the products or services to be delivered, sets SP's and SR's expectations, identifies contacts for end-user problems, and specifies the metrics by which the effectiveness of various contracted services and lower-level activities, functions, and processes will be measured, examined, changed and controlled" (p. 186).

The literature on ITO often considers SLAs only as one of the constructs, besides for instance security and performance (Hofmann and Woods 2010, Patel et al. 2009), size of outsourced IT (Misra and Mondal 2011), or IT failure and performance degradation (Marques et al. 2009),

determining the success of outsourcing relationships. Only very few research contributions analyze in depth the content of SLAs in ITO.

Jin et al. (2002) provide an overview of ten components that an SLA should have in traditional outsourcing: purpose, parties, validity period, scope, service-level objectives, penalties, optional services, exclusions, restrictions, and administration. Goo (2010) provides a more elaborate overview of eleven elements that should be included in a SLA divided among three categories: *foundation elements*, *change management*, and *governance* characteristics. The identification of elements within categories is supported by theories of relational exchange (MacNeil 1980), transaction cost economics (Williamson 1979), and control theory (Kirsch 1997).

We argue that all the SLA elements identified by Jin et al. can be mapped to elements of Goo's framework. This mapping is shown is reported in Figure A in the Appendix. There are two elements considered by Goo, however, that receive no attention in Jin et al's work: *Feedback Plan* and *Communication Plan*. Both are related to the interaction between the SR and the SP after the outsourcing relation has been established. Since, according to our mapping, Goo's elements represent a superset of Jin et al.'s, we select the former as our ITO SLA specification (see Figure 1), i.e. the starting point of our specification of SLAs in CC.

Research work on SLAs in CC tends to focus only on a subset of the typical content of SLAs in traditional ITO, such as non-functional characteristics (Villegas and Masad 2011, Alhamad et al. 2010a, Patel et al. 2009), low level resources metrics (Emekahora et al. 2010), SLA negotiation protocols (Di Modica et al. 2009, Alhamad et al. 2010b), or reputation and trust assessment of the cloud SP (Alhamad et al. 2010b, Wang and Ren 2010).

Given the novelty and rapid evolution of cloud technology, contracting aspects in CC have not yet received the same level of attention as in traditional ITO. The fragmentation of related work on SLA specification in CC calls for more research in the area of SLA contract design (Marston et al. 2011). Furthermore, from the legal point of view, the legal practice in the US and the EU to hold organizations liable for the activities of their subcontractors is still an open issue in CC (Schnjakin et al. 2010).

A framework for the specification of SLAs in Cloud Computing

This section presents the result of stage S2 of our study (see Figure 1). We first present the codes obtained from the literature review and the analysis of the interviews with domain experts. These have been the basis to inform the development of the COF and the Cloud SLA specification.

We use two sources for coding our interviews: codes derived from the SLA literature discussed in the previous section and codes derived directly from of the interviews of stage S2. The application of codes to the transcriptions enables the structural comparison of the interview content. As discussed in the literature review, we choose Goo's SLA framework as traditional ITO SLA specification. Hence, the first set of code shown is Table 1 is directly derived from the Goo's SLA framework. In order to show their applicability to our analysis, for each code we provide an example quote obtained in our interviews.

Table 1 - Codes from SLA literature review

Category	Abbreviation	Theme	Example quote
Service Level Objectives	*SLO*	High level relational aspects (goals, objectives)	*"I think you have to describe your relationship goals, whether it still is an actual cooperation in the Public Cloud is questionable though"*
Service Level Contents	*SLC*	Service characteristics (service levels, service descriptions)	*"The average business will say: My email has to work always. The 99,5% that is offered by the provider is something that could not be guaranteed in traditional SLAs"*
Process Ownership	*PO*	Process owners and their roles and responsibilities	*"Ownership could be a topic of dispute, or at least something to look at"*
Future Demand Management	*FDM*	Management of changes in future demand (capacity, licenses)	*"Scalability becomes more an issue of the provider and less of the recipient. The provider has to provide numbers on what is possible and what is not"*
Anticipated Change	*AC*	Unforeseeable changes (conflicts of interest)	*"It is nearly impossible to estimate who is involved and after that it is the question to understand what issues can arise"*
Innovation	*Inno*	Structure and processes for innovation	*"In a Private Cloud you can influence innovation development and implementation. In Public Clouds, however, I wouldn't know how to do this"*
Feedback	*Feed*	Feedback processes	*"If you look at Office 365 for example, this is not a topic of interest"*
Communication	*Comm*	Communication flow	*"You have to make the right agreements and if these are not met you should speak to him about it"*
Measurement	*Meas*	Measurement of the relationship	*"KPIs are important to include otherwise there is no way to measure the performance of the provider"*
Conflict Arbitration	*CA*	Involvement of third parties in conflicts	*"The arbitration of third parties in conflicts is comparable to traditional ITO. This will be the same in Cloud Computing SLAs as traditional ITO SLAs"*
Enforcement	*Enf*	Penalties and incentives	*"You arrive at the attributable character of the Cloud. In the case of a Public Cloud this will be more difficult"*

The second set of codes, directly derived from the content of our interviews, is shown in Table 2. In the remainder of this section we will show how the codes have been exploited to (i) derive a conceptual framework to interpret the typical decision process leading to the drafting of a SLA in CC (COF) and (ii) specify in detail the content of such SLAs, modifying and extending Goo's framework for SLA in traditional ITO.

Table 2 - Codes obtained from the interviews of stage S2

Category	Abbreviation	Theme	Example quote
Data Location	*DL*	Data storage location specifics	*"When you are active in a market that prohibits the storage in certain countries you should include in the SLA that these countries are excluded from possible storage locations"*
Compliance	*Comp*	Law and legislation requirements	*"Several instances require you to keep data in your records for up to 7 years. I can understand that a vendor after 3 year of inactivity thinks that he can delete it because the data became redundant"*
Public vs Private Cloud	*PuPri*	Similarities/differences between Private and Public Cloud	*"There are differences between Public and Private Cloud in the sense that a Public Cloud will have a standard SLA"*
Negotiation	*Neg*	Power to negotiate SLA terms	*"In the Public Cloud the service provider will work from the principle: Take it or leave it"*
ITO vs Cloud Computing	*ITOCC*	Similarities/differences between traditional ITO and Cloud Computing	*"In traditional ITO you have a reasonable insight into the whereabouts of the outsourced services. In Cloud Computing, however, you are faced with custom-build Cloud software that inhibits this"*
Risk Assessment	*Risk*	Assessment of risk that	*"You first have to make a risk assessment about the*

		determines scope for outsourced services	*extent to which it is permitted by law and to what extent the data is sensitive to privacy"*
Customizability	*Cust*	Customizability of a outsourced service	*"The question arises whether it is at all possible to personalize or customize a service for your organisation"*
Perception	*Perc*	Perception of delivered service	*"The current economy is all about 'perception'. Perception is actually what it is all about. And factually a SLA is this perception in written form"*
Transparency	*Trans*	Transparency of delivered services and provider	*"The transparency disappears for a large part in Cloud Computing"*
Exit Strategy	*EX*	Protocols/procedures for exit from vendor	*"Actually, the most important element of a SLA is how get out of the relationship when necessary"*

The Cloud Outsourcing Framework (COF)

The objective of the COF is to understand the implications of the nature of the SLA on the decision making process leading to CC outsourcing. To reach our objective, we take an enterprise modeling approach (Zachman 1987). The enterprise modeling approach decomposes the modeling of a complex system or issue such as an enterprise in perspectives and aspects, providing a different model of the enterprise for each aspect-perspective combination. Similarly, in our COF we consider a single perspective and multiple aspects. The perspective is the one of the decision maker in the SR organization. The aspects that we consider are:

- Process: the steps involved in the CC outsourcing decision making. We use a process model (flowchart diagram) to model this aspect;
- Decisions: the decision points involved in CC outsourcing decision making. We use a decision tree to model this aspect;

While introducing the two models, we discuss their dependencies, identifying in which stages of the decision making process certain decisions are required. Our exploratory study aims at making a first step towards a complete characterization of the CC outsourcing problem. More aspects and perspectives should be added in the future as more empirical data become available. We elaborate on possible extensions of the framework later while concluding the paper.

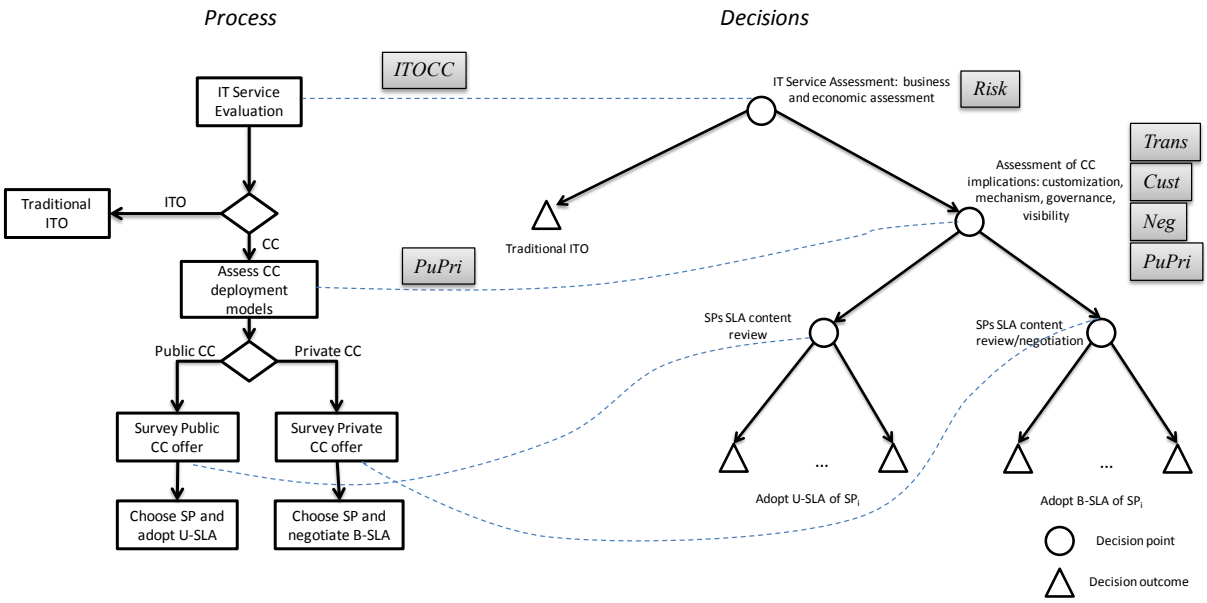

Figure 2 - The COF (Cloud computing Outsourcing Framework)

The COF is shown in Figure 2. The figure shows the two models, their dependencies and, where possible, the codes we used to derive specific elements in the models. Note that, since it is specific to CC, the codes used in the conceptual framework belong to set of codes directly derived from the interviews (see Table 2). The codes derived from the SLA literature survey will be used for the analysis of SLA content in CC.

The first step in the decision making process for the SR concerns deciding between traditional IT outsourcing and CC outsourcing (see the code *ITOCC* in Table 2). We argue that this decision is not driven by the nature of the SLA in the two outsourcing options. SR organizations decide to outsource their IT services to cloud SPs for economic reasons, i.e. to reduce IT costs or at least transform IT investments costs into fixed operative operational costs (Alford and Morton 2009. Iyer and Henderson 2010), and business-related reasons, e.g. achieving more agile IT services, which can scale and be reconfigured on-demand (Armbrust et al. 2009).

Once CC is chosen, the implications of the nature of the SLA start coming into play. The SR organization, in fact, needs to consider the implications of the CC deployment models on the possible SLA that they will be able to establish with the SP (*PuPri*). According to our analysis, the different SLAs for public and private CC should be analyzed along (i) the degree of customization allowed by the SLA (*Cust*), (ii) the *mechanism* to obtain the SLA with the SP provider (*Neg*), (iii) the expected *governance* model of the SLA (that derives directly from the choice of the public or private deployment model, *PuPri*), and (iv) the degree of *visibility* that the SR expects on its outsourced IT services entailed by the SLA (*Trans*).

The public cloud CCO is thus characterized by a *standard* SLA, based on a *take it or leave it* agreement mechanism (no negotiation allowed), for which decisions, i.e. governance, are managed *unilaterally* by the SP, resulting in the *opaque*, i.e. non-transparent, visibility of the outsourced service for the SR. The private cloud CC is characterized by a *customizable* SLA,

based on a SLA *negotiation* process allowing for *bilateral* governance, resulting in a more *transparent* outsourced service.

When a company decides that its IT services, or a part of them, are suitable to be outsourced to a specific CC provider, they have to explicitly accept the above described CC characteristics. In traditional ITO the SLA is drafted by the involved parties and signed when consensus is reached on its content. In public cloud outsourcing, however, the SP drafts a standard SLA that is usually downloadable from its website. There is no active role for the SR other than agreeing to the SLA. We label this type of SLA, typical of public cloud outsourcing, the U-SLA (Unilateral SLA). The bilaterally drafted SLA in the private cloud is renamed to B-SLA (Bilateral SLA) to underline that it remains a negotiable document.

In the SR perspective, the U-SLA and B-SLA serve different type of objectives:

An SR in public cloud outsourcing uses a U-SLA to:

- *Create internal awareness*: The SR could systematically assess the company's internal IT services that can be potentially outsourced against the content of the U-SLA. This will raise internal awareness of opportunities to adopt CC outsourcing;
- *Compare SPs*: Based on the description of the elements in the U-SLA, the SR can compare the offers of different service providers, along the extent to which they can support the outsourcing requirements. If a gap remains after analyzing the SP offer, the SR can still implement internal arrangements (e.g., a local backup of data) to support the requirements that are not covered by SP;
- *Monitor performance*: The SR can use the metrics formulated in the U-SLA to monitor the performance of the service provider. These can range from metrics that represent the specifics of a service (e.g., uptime, availability, latency) to desired procedures for resolving issues or providing feedback.

The objectives of the B-SLA are comparable to the ones of SLAs in traditional ITO. The specificity of the B-SLA, in fact, relies in its content, which is analyzed later in this section. In addition to the objectives of the U-SLA, the B-SLA, being drafted bilaterally, can be used to better define the relationship between the SR and SP. This results in the following additional objectives for the B-SLA:

- *Structure the relationship*: The relationship is formally structured through formulating and agreeing upon the expectations and responsibilities of both parties about the outsourcing engagement. This underlines the bilateral nature of agreements in the private cloud;
- *Negotiate the service provisioning*: The B-SLA enables the SR and the SP to negotiate the SLA about the outsourced service(s). The SP will then customize its cloud service to support these specifics.

In the COF, therefore, when SRs choose for a public cloud solution, they have to evaluate the U-SLA defined by candidate SPs and choose the one that better fits their own expectations. When the private cloud is chosen, the process of choosing the SP resemble one of traditional ITO, since the SLA would be the outcome of a negotiation between the SR and SP.

Stage 2: Cloud SLA Specification

In this section we analyze the content of SLAs in CC. Specifically, the first part of our content analysis aims at comparing SLAs in CC to SLAs in traditional ITO. The second part of our content analysis aims at understanding the differences in SLA content for CC in different deployment models, i.e., public vs. private cloud CC.

Regarding the comparison between SLAs in traditional ITO and CC, interviews with domain experts revealed that the SLA specification in traditional ITO (see Goo's framework in Figure A in the Appendix) is also applicable to outsourcing in CC. This is demonstrated by the fact that the codes from the literature review could be easily used to code the content of the interviews (see quotes Table 1).The extent to which the SLA specification in ITO can be applied in CC, however, depends on the deployment model under consideration. The private cloud CC shares more similarities with traditional ITO and, therefore, it is not surprising that all traditional ITO SLA elements are applicable in the B-SLA. In the case of the U-SLA for public cloud CC, the interviewees identified two traditional ITO SLA elements that are redundant, and one that is partly redundant.

The two redundant contractual elements and the argumentation for their redundancy are discussed hereafter.

- *Innovation Plan*: There are two possible scenarios for innovations in the Public Cloud, i.e. incremental innovations that are rolled out in the background or innovations that are announced and rolled out at a specific moment in time (Marston et al. 2011). The SR has no influence on the service content in both scenarios; the SP determines the number and the nature of service innovations. Therefore there is no need for the SR to include the Innovation Plan element in a U-SLA;
- *Anticipated Change Plan*: in the public cloud the SP controls unilaterally the innovation of its services and such control applies also to unforeseen changes. Therefore, procedures to cope with unforeseen changes do not belong to the U-SLA. Interviews also revealed that the technology and market of CC is not mature yet for enabling the SPs to specify contractually binding change plans. When unacceptable unforeseen changes for the SR occur, the SR can invoke the Exit Strategy Plan element of the SLA, which is a new contractual element for the U-SLA defined later in this section.

The element that is only partly adopted in the U-SLA is the Enforcement Plan:

- *Enforcement Plan*: in traditional ITO the Enforcement Plan includes the exit strategy and reward/penalty specifics. In public cloud CC the penalty/reward specifics are not negotiable and are usually downloadable by the SR from the SP website. Therefore they cannot become part of a U-SLA. Being very important for both U-SLAs and B-SLAs, we decided to include the Exit Strategy as a new and independent element in our Cloud SLA specification. As a result, the Cloud SLA specification includes the Enforcement Plan element only for the B-SLA, whereas the U-SLA will only include the Exit Strategy element.

The characteristics of CC entail the definition of two new SLA elements, which are analyzed in the following:

- *Data Code of Conduct*: The Cloud inherently causes processes to become opaque (in public cloud CCO to a larger extent than in private cloud CCO). SPs are not or to some extent able

to state the specifics of data policies. Compared to traditional ITO, where this was clear and did not require a separate contractual element, this must receive close attention. The Data Code of Conduct element includes the specification of boundaries for data storage locations (e.g., Europe only, exception for USA), and the identification of data access, change and deletion authorizations;

- *Exit Strategy Plan*: The exit strategy receives more attention in the CC SLA specification than it does in traditional ITO SLAs. In the Cloud it is paramount to ensure the seamless subtraction of SRs data from the SP, allowing SRs to restore data at a different location/provider. The increased importance lies in the fact that data in the cloud are almost always intertwined with other customer data and their exact location is often unknown. This can cause issues when the SR wants to terminate the relationship. The element Exit Strategy Plan includes the specification of roles and responsibilities for the involved parties, time schedules for exit strategy activities, and conditions that cause the exit strategy plan to be invoked.

As a summary, the Cloud SLA Specification is reported for the U-SLA and the B-SLA in Table A and Table B in the Appendix, respectively, where for each element we indicate the objective and we specify the content of the element in practice, i.e. with example clauses.

The main differences between the content of the U-SLA and B-SLA result from the nature of the relationship between the SR and the SP.

Regarding the foundation characteristics part of the SLA, in the public cloud outsourcing, the SR has no influence on the features of the service provided by SP. Therefore, SLA elements Service Level Objectives and Content or Communication plan will contain only the point of view of the SP on the outsourcing relationship.

Another difference concerns other SLA elements defining the role of the SR in the outsourcing relationship, i.e. the elements of the governance characteristics. Since the SP drafts the U-SLA unilaterally, in a U-SLA such elements can only contain the *desiderata* of SP or, in other words, a specification of the behavior that the SP expects from the SR. In a B-SLA, on the contrary, governance characteristics reflect the bilateral agreement obtained during the SLA negotiation.

Eventually, regarding the Change Management characteristics, as previously discussed the U-SLA does not include Anticipated Change and Innovation Plan, since change and innovation can only be controlled unilaterally by the SP. Moreover, similarly to the governance characteristics, while the U-SLA change management elements represent the expectations of the SP, in a B-SLA change management characteristics reflect the joint interests of the SR and the SP, as agreed during the negotiation.

Towards the Integrated Cloud Outsourcing Framework (Stage S3)

This section describes the validation of the output of stage S2, that is, the validation of the Cloud SLA specification and the COF. As discussed in the presentation of our research method, we

have conducted four interviews with CIOs to investigate whether the COF and the Cloud SLA specification are understandable, complete, and usable in practice.

All interviewees considered the COF and Cloud SLA specification relevant and useful in a SR's perspective. Regarding usability, completeness, and clarity, the answers collected during the interviews resulted into conceptual and presentation-related comments. The conceptual comments are about the usability in practice of the framework and its improvement and possible extensions in the future. The presentation-related comments are mainly about the clarity of the framework and SLA specification and their understandability in practice. Therefore, these comments can be used to improve the quality of the data collection process through interviews with domain experts, but they do not modify conceptually the COF as presented in Figure 2. The conceptual comments have been used to improve and extend the COF, resulting in the Integrated Cloud Outsourcing Framework (ICOF, see Figure 3). In the remainder of this section, we address more in depth the comments received in each one of the above mentioned categories, i.e. usability in practice, clarity and completeness. Then, we discuss how conceptual comments have been integrated to obtain the ICOF.

Usability
The members of the CIO platform acknowledge that they, as a platform, are working towards a checklist to assist companies in taking the necessary steps to be ready for the Cloud. The COF and SLA specification can provide a valuable starting point for such a checklist. They furthermore indicate that companies currently are struggling with the exact characteristics of services in CC and what the implications are for SLAs and contracts in general. The framework and SLAs can provide more insight into this issue. The companies that cooperated in the interviews explicitly mentioned that they will distribute our Cloud SLA Specification internally.

Clarity
Three presentation-related comments were identified pointing out ways of improving the understandability of the output of stage S2. Specifically, the use of abbreviations and technical jargon cause the COF and SLA specification to be better understandable by business stakeholders rather than by IT managers. Adding a description to the SLA's categories (foundation-, change management- and governance characteristics) improves the understandability and therefore readability of the SLAs.

Completeness
Comments about the completeness have been interpreted as suggestions for possible improvement and extension of the framework and the Cloud SLA specification. The interviewees identified missing aspects in the framework regarding the deployment (community and hybrid) and service models (SaaS, PaaS, IaaS) that are part of Cloud Computing, according to Mell and Grance (2011) definition. During interviews, however, it also became clear that the research scope included only two deployment models (Public and Private) and did not explicitly take the service models into consideration. With this in mind, the interviewees considered the study complete within its scope, with two exceptions related to including industry specific aspects and the position of the CC outsourcing decision in the COF.

The interviewees suggested that the SLA specification should take into account the specificity of the industry where the SR is operating. SRs in highly regulated industry, for instance, are more likely to focus their SLAs on security aspects, whereas providers of critical services will be interested in the performance and possible resilience of the cloud SP.

A second important suggestion that emerged during interviews was to possibly delay the outsourcing decision point in the COF. Often, in fact, the decision to opt for a private cloud solution may be taken after a preliminary survey of possible SLAs offered by public cloud SPs.

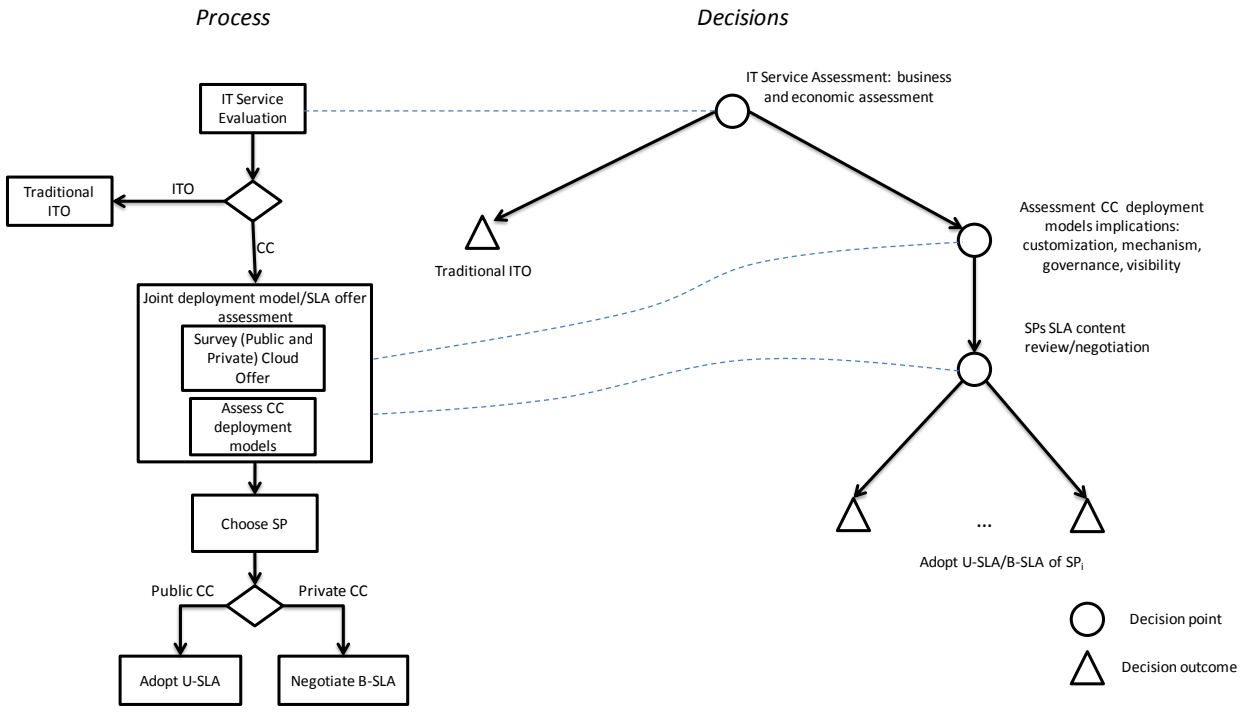

Figure 3 - The ICOF (Integrated Cloud computing Outsourcing Framework)

Elaborating the results of interviews of stage S3 using the same enterprise modeling approach described in Section 4, we obtained the improved and extended version of our framework, i.e. the ICOF, which is shown in Figure 3.

Regarding the decision process, the ICOF considers survey of candidate public and private CC solutions as an activity which precedes the actual SP selection. If the public CC deployment model is chosen, then the SR can only adopt the SLA of the chosen SP since the evaluation of possible alternatives has already occurred. If the private CC deployment model is chosen, then the SLA will be negotiated by the SR and the SP.

Discussion

Based on the results of our study, it can be concluded that the SLAs defined for traditional ITO are applicable in CC only to a certain extent. The nature of the relationship in CC requires a different mindset in establishing relations. In particular, this mindset entails the need for SLAs to support more intensively trust building of the SR towards the SP. Furthermore, given the often opaque nature of CC-based service provisioning, the SLA content analysis should help the SR understanding that SLAs in CC can cover only a smaller set of aspects than in traditional ITO.

Regarding deployment models, the Public Cloud results in the largest change for SLAs compared to traditional ITO. In Public Cloud solutions it is (nearly) impossible to change the characteristics of the service, i.e. providers adopt a *take it or leave it* principle. The services are standard and the corresponding SLAs are fixed and only to be agreed upon by the SR, who cannot negotiate them. Therefore, from the SR perspective, SLAs in the Public Cloud become a unilateral document, i.e. an U-SLA.

The Private Cloud requires less significant adjustments of SLAs compared to traditional ITO. In Private Cloud solutions it is possible to customize services based on SR's requirements. The providers adopt an 'agreement' principle in which the SR and SP discuss the specifics of the services and corresponding SLAs. Both parties can negotiate requirements of the included services. The purpose of the SLAs drafted in collaboration between SR and SP does not change in the case of Private Clouds, when compared to traditional ITO. The Private Cloud SLA remains a bilateral document, i.e. a B-SLA.

Cloud Computing, inherently causes services to become opaque due to the used technologies, e.g., virtualization, and characteristics, e.g., resource pooling. This occurs to a larger extent in Public Clouds when compared to Private Clouds. SPs can provide no or limited guarantee to where the data is stored and next to whom your data is stored. Therefore, an important addition to the traditional ITO SLA elements is the element regarding the treatment of data, i.e. Data Code of Conduct (DCC). This element specifies the boundaries for data storage locations and the identification of data access, change, and deletion authorizations.

Furthermore, the traditional element 'Enforcement Plan' treats the exit strategy plan in its contractual clauses. From the interviews it became clear that this topic requires more attention than in traditional ITO. For a SR it is of paramount importance to be able to discontinue the relationship with his SP without this threatening business continuity or resulting in the loss of (critical) data. Therefore, an important addition to the traditional ITO SLA elements specific to CC regards the exit strategy, i.e. Exit Strategy Plan. This element specifies exit roles and responsibilities for the involved parties and includes time schedules and conditions under which the exit strategy may be invoked.

Implications for research

Our work did not explicitly consider the impact of different service models (e.g., SaaS, PaaS, IaaS) on the content of SLAs in CC. There are, however, indications from the interviews that the different service models do influence the characteristics of SLAs. For instance, SaaS models may

trigger further analysis of the SLA elements capturing policies about data management, i.e. data code of conduct and exit strategy. While IaaS and PaaS models usually consider data at a limited level abstraction, i.e. database instance, SaaS model introduce higher levels of aggregation, e.g. business objects in enterprise systems. Further investigation is therefore required to understand how to relate the management of low level database records to higher level entities, such as business objects, when services are retracted by the SR. The U-SLA and B-SLA analyzed in our work can be used as a starting point for extending our work to include the service models as well.

The scope of this research is restricted to the Public and Private Cloud deployment models. The interviews, however, have revealed that there is a practical need for the inclusion of the Community and Hybrid deployment models as well. Since these models derive from a combination of the two models that we considered in this paper, the results of our study should be applicable also to the other two deployment models with only limited further investigation. In particular, we argue that the Community deployment model can be assimilated to the Public Cloud model, provided that the SP has sufficient bargaining power to offer a U-SLA to the community of SRs. In the Hybrid deployment model, more attention has to be put on the analysis of those SLA elements that may cross the boundaries of individual clouds bound together in the hybrid model. The data code of conduct, for instance, should be drafted in such a way that data management policies become homogeneous across the SLAs established for each individual cloud entity.

Another point for improvement emerged from the validation is the structure of our framework. In our framework, the choice of deployment model, in particular, appears at the beginning of the flow and is based on the data and process assessment. The validation interviews suggest that this choice could be deferred along the process. Furthermore validation showed a specific interest in the criteria to determine the choice for a certain CC solution. Such criteria, being out of the scope of this research, have to be further examined, extending our framework with literature on vendor selection and management theory to enhance its completeness.

Implications for practice

The framework and SLA content analysis provide insights for practitioners in the aspects playing a role in determining possible Cloud solutions for a company and the corresponding elements to be covered in the SLA. Currently, companies do not have a clear view on what these aspects and elements should be. We therefore recommended companies to use our framework and SLA content analysis as a tool for investigating Cloud solutions and for the drafting of SLAs.

The framework and SLAs provide an overview of the relevant aspects of Cloud Computing for drafting an SLA and the elements that should be included in a Public or Private Cloud SLA. Companies, moreover, should critically take into consideration the specificity of their industry, since our validation interviews stressed that this can have important implications for CCO decisions and the content of the SLA.

The influence of industry on the structure and content of the SLA, however, should not change on the basis of the type of outsourcing decision, i.e. ITO or CC. Industry such as finance or healthcare may require more attention to aspects as privacy, authorization, and security, whereas SLAs in e-retailing solutions may require more attention service availability and guarantees on

performance. Our study stresses that, once CC is chosen, some aspects are more critical than others to be captured in a SLAs. In CC, obtaining guarantees on data management-related issues, such as privacy or authorization, can be more critical, particularly in a Public cloud deployment model, than negotiating performance-related aspects.

Concluding Remarks and Outlook

Because of well known economic and business drivers, CC is becoming increasingly relevant for a number of companies. Recent developments on sustainability, e.g., carbon footprint reduction, and the emerging centrality of new way of working, e.g., flexible working times and telecommuting, also push modern companies towards more flexible IT service implementation, often achieved through the adoption of CC. The lack of commonly understood frameworks for SLAs, however, makes companies often skeptical over engaging in CC relationships. By providing companies with a framework to understand the CC outsourcing decision and the related specification of the SLA content, we claim that companies will gain insight in the forces at work in Cloud Computing and required knowledge for the SLAs.

The work presented here can be extended along several lines. From the research method perspective, our exploratory approach should evolve into theory building and hypotheses testing as more empirical data about CC adoption become available. From the research output perspective, we are currently working on extensions regarding different service and deployment models, the relative importance of SLA elements as related to industry-specific features, and new aspects and perspectives in the enterprise modeling of the CC outsourcing decision.

While we envision that considering different service models will have an impact mainly on the foundation characteristics of the SLA, e.g., the content of service level objectives, but will not disrupt its structure, considering industry-specific features will introduce the concept of relative importance among SLA elements. This will also impact the CC outsourcing decision making process, since only the more important SLA elements are likely to drive the deployment model and the SP selection processes. About the enterprise modeling approach, we want to extend the SR perspective considered in this paper looking also at the perspective of the SP and, most importantly, the possible role of the arbitrator in the process of drafting the (B-)SLAs.

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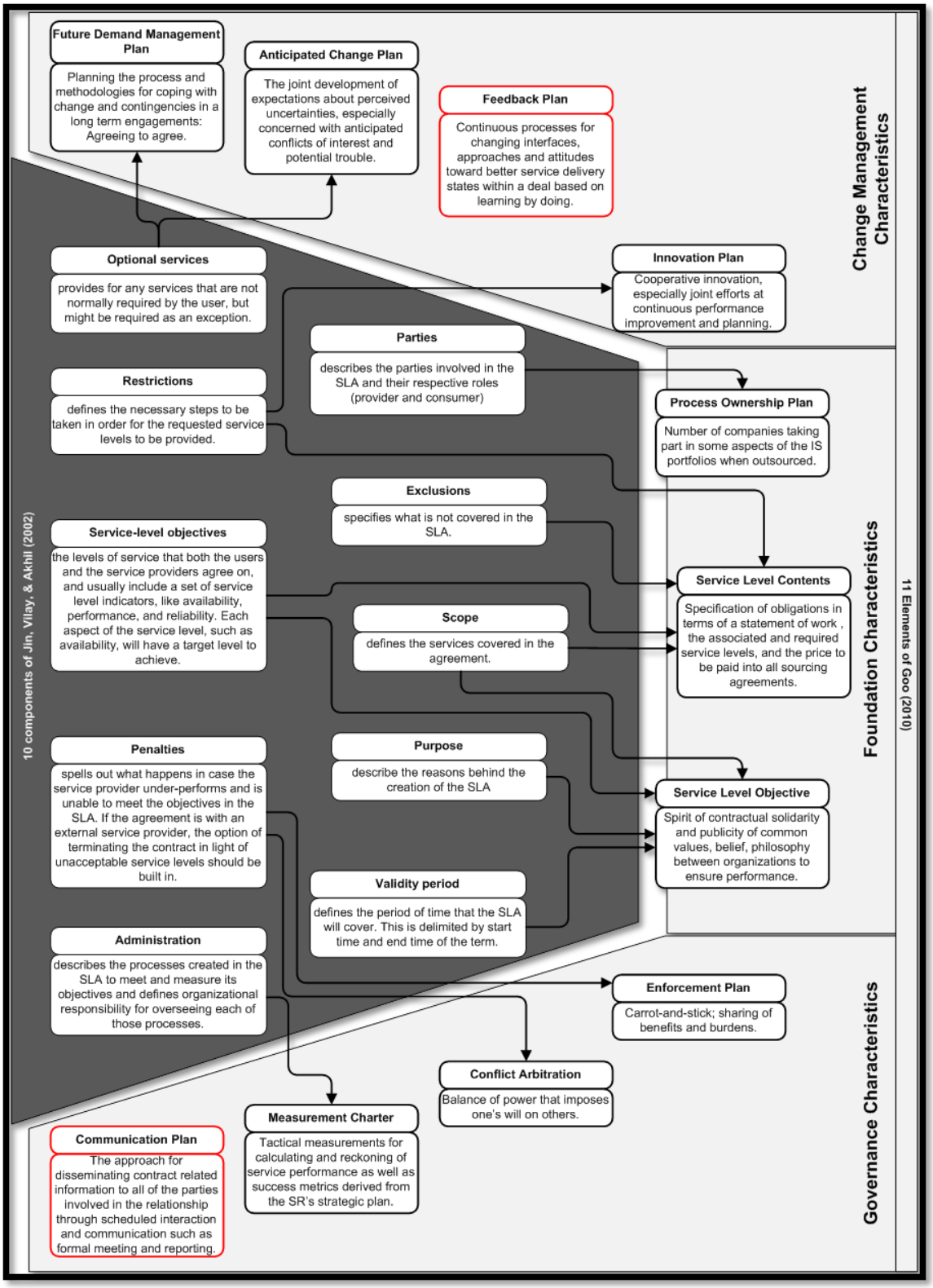

Figure A - SLA elements mapping

Table A - Public cloud U-SLA: SLA specification

Public Cloud U-SLA			
	Contractual element	***Specification/Objective***	***Clauses in practice***
Foundation characteristics			
1	Service Level Objectives (SLO)	*Publicizing SP's values, belief and philosophy for clarification purposes. Formulate required capabilities and expectations of a SR.*	∴ A statement of SP's business objectives from the engagement ∴ A statement of overall objectives from the contract ∴ A statement of expectations and capabilities of the SR
2	Service Level Contents (SLC)	*Specification of required service and service levels determined from business requirements.*	∴ A general description of the services required ∴ A detailed description of service categories and specific service elements
3	Process Ownership Plan (POP)	*Specification of key process owners with corresponding roles and responsibilities. Scope definition of the process owners' authority to plan, manage and evolve services.*	∴ Statement of processes directly involved by the service included in the agreement ∴ Statement of process ownership roles, authorities and responsibilities
4	Data Code of Conduct (DCC)	*Specification of boundaries for data storage locations (compliance). Identification of data access, change and deletion authorization.*	∴ Statement of data location exceptions ∴ Identification and specification of compliance aspects ∴ Statement of data access and change authorization ∴ Statement of data deletion protocols and procedures
Change Management characteristics			
5	Future Demand Management Plan (FDMP)	*Definition of planning process and desired methodologies for coping with change, innovations and contingencies that possibly influence service requirements.*	∴ Demand forecasting process ∴ Process and protocols for scheduling, costing and modifying agreements ∴ Process for technology advancements (scope improvement and technology refreshes/upgrades)
6	Feedback Plan (FP)	*Specification of desired approaches and attitudes toward better service delivery states within a deal, based on learning by doing.*	∴ Road map for an efficient feedback on predetermined parameters ∴ Desired prioritization methodology for tasks and feedbacks
Governance characteristics			
7	Communication Plan (CP)	*The desired approach for disseminating contract related information to all of the parties involved in the relationship.*	∴ Identified SR communication initiative owners ∴ Identified SR's recipients for various communication initiatives ∴ Events for communication initiation
8	Measurement Charter (MC)	*What is desired to be measured and what are the desired measurement processes.*	∴ Definition of what is to be measured ∴ Definition of processes to periodically measure the defined categories ∴ *Interfaces with Feedback Plan*
9	Conflict Arbitration Plan (CAP)	*Specification of time windows for resolving issues that threaten business continuity of the SR.*	∴ Timetables for resolving issues by the SP
10	Exit Strategy Plan (ESP)	*What are the expected roles and responsibilities for the SP in case the engagement is discontinued.*	∴ Specification of desired exit roles and responsibilities for the SP ∴ Time schedule with time window boundaries regarding exit strategy activities ∴ Specification of conditions that cause the exit strategy to be invoked ∴ *Interfaces with Data Codes of Conduct*

Table B - Private cloud B-SLA: SLA specification

Private Cloud B-SLA			
	Contractual element	***Specification/Objective***	***Clauses in practice***
Foundation characteristics			
1	Service Level Objectives (SLO)	*Spirit of contractual solidarity and publicity of common values, belief, philosophy between organizations(SR and SP) to ensure performance.*	∴ A statement of both SR's and SP's business objectives from the engagement ∴ A statement of overall objectives from the contract
2	Service Level Contents (SLC)	*Specification of obligations in terms of a statement of work, the associated and required service levels, and the price windows to be paid into all sourcing agreements.*	∴ A general description of the services required, major categories of services and specific service elements ∴ A compilation of the most common service levels completed for each service level ∴ Service-level target, time frame definition, quality statement, etc.
3	Process Ownership Plan (POP)	*Number of companies taking part in some aspect of the IS portfolios when outsourced.*	∴ Statement of processes that are delivered via the agreement ∴ Statement of processes directly affected by the service(s) included in the agreement ∴ Statement of processes that are required to manage the agreement between SR and SP ∴ Statement of process ownership roles, authorities and responsibilities
4	Data Code of Conduct (DCC)	*Specification of boundaries for data storage locations (compliance). Identification of data access, change and deletion authorization.*	∴ Statement of data location exceptions ∴ Identification and specification of compliance topics ∴ Statement of data access and change authorization ∴ Statement of data deletion protocols and procedures
Change Management characteristics			
5	Future Demand Management Plan (FDMP)	*Planning process and methodologies for coping with change and contingencies in a long term engagement.*	∴ Joint (SR/SP) demand forecasting process ∴ Assumptions made and process for updating the key assumptions that affect demand ∴ Prioritization methodology for current and future demands ∴ Process for scheduling, costing and modifying agreements
6	Anticipated Change Plan (ACP)	*The joint development of expectations about perceived uncertainties, especially concerned with anticipated conflicts of interest and potential trouble*	∴ Clear definitions of the key categories of change ∴ Roles, responsibilities and decision-making procedures for the SR and SP for each category of change ∴ Top drivers for change – reviewed regularly
7	Feedback Plan (FP)	*Continuous processes for changing interfaces, approaches and attitudes toward better service delivery states within a deal based on learning by doing*	∴ Statement of how changes will be implemented based on measurement results ∴ The road map for an efficient feedback on the identified drawbacks ∴ Prioritization methodology for current tasks and feedbacks
8	Innovation Plan (IP)	*Cooperative innovation, especially joint efforts at continuous performance improvement and planning*	∴ Process for innovation, including implementation and prioritization ∴ Process for technology advancements (scope improvement and technology refreshes/upgrades) ∴ Business-measured innovation (business process improvement)
Governance Characteristics			
9	Communication Plan (CP)	*The approach for disseminating contract related information to all of the parties involved in the relationship through scheduled interaction and communication such as formal meeting and reporting*	∴ Organizational reporting structure ∴ Identified communication initiative(s) owner(s) ∴ Identified recipients for various communication initiatives ∴ Communication schedules and media
10	Measurement Charter	*Tactical measurements for calculating and reckoning of service performance as*	∴ Statement of measurement methodology ∴ Definition of what is to be measured

	(MC)	*well as success metrics derived from the SR's strategic plan*	∴ Definition of processes to periodically measure the defined categories ∴ *Interfaces with feedback plan*
11	Conflict Arbitration Plan (CAP)	*Balance of power that imposes one's will on others*	∴ A statement of the parameters for involving third party in discussions between SR and SP ∴ Process descriptions to determine how the parties interact ∴ A schedule for regular interactions between the parties, and timetables for resolving issues between the SR and SP ∴ A statement of the practices and conduct rules to required to preserve the independence of the independent advisor
12	Enforcement Plan (EP)	*Sharing of benefits and burdens; Carrot-and-stick*	∴ Penalty/reward definitions and formula ∴ Detailed list of all penalty assumptions ∴ Detailed list of all reward assumptions
13	Exit Strategy Plan (ESP)	*Specification of exit roles and responsibilities for SR and SP including time schedule and conditions under which the exit strategy may be invoked*	∴ Specification of exit roles and responsibilities for SR and SP ∴ Time schedule with details about exit strategy activities ∴ Specification of conditions that cause the exit strategy to be invoked ∴ *Interfaces with Data Codes of Conduct*

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