slalom

LEGAL & OPEN MODEL TERMS FOR CLOUD SLA AND CONTRACTS

Guidance on including SLALOM in research

D3.5

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Contents

1. Introduction

This document presents the findings of the SLALOM support action that are relevant for the research community. During the 18 month project, we have been liaising closely with experts and market, trying to cut through the theory and discussion in order to produce practical and usable output. Preconceptions have been challenged. Varied opinions have been received. Multiple dead ends and unexpected hurdles have been discovered, and at the same time jackpots have been hit and gold dust found. The intention here is to take a critical view of the research community and feedback what has been learned into what will be done, thus shaping the future research agenda and habits.

The document reaches out principally to project coordinators, policymakers, exploitation managers and cloud research heads, in an attempt to inform and educate them about our findings, such that each can adapt their own areas of influence accordingly.

1.1 Glossary of Acronyms

Acronym	Definition
B2B	Business-to-Business
B2C	Business-to-Customer
CEO	Chief Executive Officer
CSP	Cloud Service Provider
EC	European Commission
FP7	Framework Programme Seven
H2020	Horizon 2020 research programme
HPC	High Performance Computing
IaaS	Infrastructure as a Service
IoT	Internet of Things
ISO	International Standards Organization
JTC1 SC38 WG3	ISO designation for the Joint Technical Committee, Subcommittee 38, working group 3, which focusses on cloud computing SLAs
MSA	Master Service Agreement
PaaS	Platform as a Service
QoE	Quality of Experience
SaaS	Software as a Service
SLA	Service Level Agreement
SLO	Service Level Objective

2. Relevant outcomes of the project

2.1 Relevant SLALOM results

Relationship with ISO

Slalom engaged with the standards organisation ISO at a very early stage. The project achieved liaison status specifically with JTC1 SC38 WG3, which is the body producing the 19086 family of standards on cloud computing SLAs. The project has attended both physical and remote meetings, had access to publically-restricted documentation and submitted documentation to the group.

The team initially found the process slow to initiate and it was several months before the liaison status was ratified. It became apparent that ISO has its own organisational culture formed around formal rules, formal voting, procedures and nomenclatures. Similarly there is a common organisational culture within the EC collaborative research community. The working practices and timescales between the two cultures are significantly distinct and consequently there was a learning curve for the team that engaged with this group. Nonetheless the relationship was mutually fruitful and a key project activity and is recommended to other initiatives.

The project found that the ISO working group was keen to listen to the experiences of the project partners and of the data collected during the project. The interaction was based on mutual respect and once liaison status was awarded, the involved personnel were able to play a fully participative role in the definition of the emerging standard. As a consequence, work produced in SLALOM (much of which was the consolidation of results from parallel H2020 and concluded FP7 projects from the cloud and software cluster) has influenced and in some cases directly appeared in the current drafts of what will become an international standard.

Research initiatives should consider the formal application to standards bodies such as ISO where they can make a concrete contribution to standards under development. This is an excellent way to create international impact. However, groups considering such a move should be conscious of the overhead in time and travel which is imposed by the potentially different timescales that the research and the standards groups may move at. In addition, projects looking to engage should familiarise themselves to the greatest extent possible with the organisation's culture. Ideally they should approach an individual member first who can act not only as a mentor on procedures, but also act as a sponsor within the group.

SLALOM reference model

Description

The SLALOM reference model was created with the aim to standardise the definition of SLA clauses in a manner that serves the whole lifecycle of SLAs for cloud services and overcomes the shortcomings of the few existing approaches, by eliminating ambiguities in the definition and calculation of SLA clauses and facilitating the measurement, monitoring and enforcement of SLAs to achieve non-repudiability, so that

these measurements cannot be contested. Another objective was to abstract the SLA clause definitions as much as possible so as to enable the application of metrics that allow for direct comparability of SLA clauses among providers.

The SLALOM reference model is ISO-compliant, utilising the classes and parameters of the ISO 19086-2 metric model, but further allows for the instantiation of a Sampling class for concretely defining the sampling process of the SLA clause. What is more, all SLA clauses defined via the SLALOM model are machine understandable.

In order to prove the applicability of the SLALOM model in a wide range of real world scenarios, a number of SLA clauses directly stemming from commercial cloud providers were successfully mapped to the SLALOM model.

For more details on the SLALOM reference model please refer to [2].

Value to research community

The SLALOM reference model can be used by the research community for the direct definition of technical SLA clauses or the translation of legal terms into a technical clauses and in all cases that this information must be exchanged among components, services and stakeholders.

By concretely defining the sampling process when defining SLA clauses via the SLALOM model, the clauses are clear, well-defined and can be measured in a non-repudiable manner, i.e. the measurement cannot be contested by any party.

What is more, the definition of an SLA clause via the SLALOM model is abstracted as much as possible. The clause is built up gradually as a summation of internal building elements (samples, metrics and sub-metrics, thresholds and conditions), each of which are clearly and well defined and identifiable. This significantly aids the application of metrics [3] for the comparable evaluation of SLAs among providers as well as the automation of relevant tasks.

Furthermore, by creating being directly machine understandable SLA clauses many processes and tasks throughout the lifecycle of cloud services can be automated, as is explained in more detail in the following sections of this document.

SLALOM example SLA clauses

Description

Through a survey conducted by the SLALOM project [4], feedback was collected from various stakeholders, which was used in order to prioritize cloud related SLA metrics according to their importance. Based on this prioritization, we provided example definitions for the key SLA clauses, which were expressed via the SLALOM reference model.

The defined SLALOM example SLA clauses provide usable definitions for a) availability, b) elasticity, and c) response time. More examples of SLA clauses will be released by the end of the project in SLALOM deliverable D3.6 “SLA specification and reference model - c”, due June 2016.

Value to research community

The example SLA clauses are represented in JSON format, which is both human and machine understandable, and can greatly help researchers and the other various stakeholders understand how to apply the SLALOM reference model in their own SLA clauses.

They further serve as a basis, without any modifications or with the incorporation of the desired changes (e.g. in the definitions of metrics and sub-metrics and the thresholds of values), for the definition of simple or more complex SLA clauses to be used by the research community to test newly introduced mechanisms (under research or development) for the SLA lifecycle.

SLALOM legal model

The SLALOM legal model is a complete contract for use between a cloud user (adopter) and their provider. It is set out as a Master Service Agreement (MSA) document, following a common industry approach, with specific service levels (privacy, technical service levels) and other issues (such as consideration) as annexes. The contract is ready to use. It can provide a starting point for creating new contracts or a benchmark for comparing existing ones. It has been designed to be extendible or modifiable as it is appreciated that each provider, and for larger clients, each customer, will frequently require a bespoke contract.

Evidently, the SLALOM legal model can be used by the research community for its intended purpose, i.e., as a contract in the case of the project delivering on demand services. Beyond that, the model serves to research projects that are working on legal issues in a particular market vertical. For instance, where research is developing new services for public administrations, or new services involving and analysing specific legal requirements on the actors, building the research on top of the SLALOM baseline provides a guaranteed way of starting from an independent and comprehensive base. Similarly, if research projects identify a need to establish a legal model for a new technology field – such as data sharing, in many cases SLALOM can be adapted to the new technology, again forming a neutral and comprehensive base. This could be the case for example, with the Free Flow of Data initiative.

SLALOM represents common/best industry practice and hence reflects established risk profiles, behaviours and roles. Deviation from the status quo is often costly and slow. Thus beyond legal research, the model allows projects to situate their business models in a legal framework, or to appreciate the constraints that the legal framework may have on the use of their work. Consequently, if the SLALOM model would require substantial changes or contradicting to fit a proposed business model, it is a signal that the market will need a very strong value proposition from the research project in order to accept it.

Last but not least, SLA legal terms when transformed to SLA technical clauses (e.g., using the SLA reference model) can help the research community identify the missing technology for fulfilling the SLA (see SLA lifecycle research projects).

2.2 The needs of each stakeholder

The project has identified project coordinators, policymakers, exploitation managers and cloud research heads as the key stakeholders for this document.

Project coordinators

Project coordinators are those in charge of collaborative research projects (e.g., H2020) independently of whether they are technical managers or project managers, as a proxy for the highest level of project decision making. Project coordinators may not be experts in all fields of the project they oversee, and in particular here legal and technical service levels.

In relation to SLALOM, project coordinators should be aware of the way the market is operating on a legal and SLA base, the priorities and attitudes of the commercial sector with relation to these fields, and the potential impact creation through standards organisations.

Policymakers

The term “policymakers” refers to those in charge of deciding both the funding areas and funding rules for research budgets, whether European, national or private, as well as aspects of regulation and law-making.

Policy makers in the research world should be aware of the correlation between research output and market requirements, to ensure that what is funded meets the need of industry, but also of the feedback SLALOM has received in reaching out to industry with regard to previously (underexploited) research results.

Policy makers working on regulation should be aware of the market feedback SLALOM has gathered, some of which refers to the concept of regulating the cloud contract, and in other cases on particular issues in the contract / SLA.

Exploitation managers

The term “Exploitation managers” refers to those individuals charged with creating impact within a collaborative project, and of ensuring that the results are viable for use by industry. Those in charge of outreach, standards and collaboration can also be considered in this category.

After project coordinators, it is these individuals who most directly have the ability to ensure alignment of the research with the market. They need to be aware of the role of standards bodies in creating impact, of industry attitudes and priorities and the methods used in SLALOM.

Cloud research heads

Finally, this category refers to those who oversee a portfolio of research initiatives, who may set cross project policy within their organisation, mark strategies to follow and can reap synergies from multiple research projects.

Cloud research heads need to know how to prioritise research into SLAs, and how to effectively leverage participation in standards bodies across projects.

3. Critical appraisal of current SLA research

As part of the analysis conducted in SLALOM and as part of the discussions held across a wide range of the market - including role (sales, technical, procurement, etc.), company size (micro-company upwards) and company position (CEO downwards) - SLALOM is in position to highlight some of the main messages revealed. This analysis targets at allowing research community (and overall cloud stakeholders) to understand the current status of the area and focus on the missing technology rather than on technology that is already available (at least partially).

3.1 What is changing in the cloud and/or SLA market?

A maturing market –commoditisation of IaaS

IaaS is becoming ever more a commodity. Commoditisation is driven by technical and business maturity and consolidation in turn driven by significant economies of scale and ever higher barriers to entry (capital outlay). Indeed, some analysts are comparing the market to that of energy or financial markets, and suggesting the same level of scrutiny and regulation.

The effect for users of this commoditisation is an increasing focus on value for money – price and performance. Being “cloud” is no longer enough. Working “well” is no longer enough. Buyers are requesting higher performance, specified more explicitly. The suggestion of common SLA metrics was overwhelmingly positively received from all quarters. Providers complained to the project that they spent significant time educating customers. Buyers complained that they couldn’t make objective comparisons between providers due to complete misalignment in the way that performance was measured. Whilst the general market may still be fixating on the headline figures offered by a provider (e.g., 99.9% availability), the more wily are already aware that not everybody’s’ 99.9 means the same.

At the same time, the shift to cloud has widened the range of individuals involved in cloud procurement. Whereas once it was all centralised by an IT department, now many different individuals from the same organisation, each with different perspectives and backgrounds, may now be responsible for some procurement (indeed this ‘liberation’ for department heads is one of the selling points of public IaaS). Providers have commented to SLALOM that purchasers of “cloud” may be much more demanding than those of similar services before the advent of cloud.

All in all, SLALOM has detected a rising demand for some level of standardisation or harmonisation in Cloud performance definition. There is more scrutiny of performance metrics and there is a high expectation on delivering the promised performance.

Divestment in IaaS and a shift to PaaS – a radical shift in interest

Due to the above, many companies are divesting of datacentres, switching to outsourcing. Some are exiting pure-IaaS markets and are seeking growth and profit through value-added services in the PaaS layer. In many cases the mid-term company strategy looks not at creating value on top of its own IaaS,

but rather creating value from combining their own and third-party services regardless of the underlying IaaS provider(s).

This has created a significant volte-face from the commercial sector with regards to the decade or so of output from the advanced SLA research community (e.g., that was financed through FP6 to H2020 under grid, cloud and software services research challenges, particularly with reference to SLA monitoring, agent-based SLA negotiation and SLA comparison).

Previous industry commentators, operating in the pre-cloud managed operations market, have stated that the SLA was seen as part of the contract negotiation, archived once complete and never dusted off save for the highly unlikely event of the dispute making it to court. Problems were dealt at a lower level. That it "just worked" was what mattered, and dissatisfied customers would go elsewhere.

Now, the next generation of individuals in the equivalent role, in the same companies, are extremely excited to hear about the potential for such SLA innovations. End customers are requesting, and examining SLAs like never before. Procurement decisions increasingly depend on the SLA offered and most of all, in a complex web of composable services from multiple third parties, both the main provider and the (larger) customers require both technical tools and legal models which allow clear monitoring and accounting of real time performance and the ability to establish multiple different configurations from a common catalogue and to interchange services with minimal disruption.

As part of this, machine understandable SLAs which can be consumed by legacy or new systems and mechanisms, are becoming the main vehicle for enabling automation of relevant processes throughout the lifecycle of SLAs, aiding the composition of advanced cloud services and the emergence of new business opportunities covering the current needs of stakeholders and society.

The clients/adopters of cloud services can express their needs and requirements in terms of service level objectives by taking and using (with or without adaptations) the predefined SLALOM example clauses or by defining their own new ones via the SLALOM model. Cloud service providers can also describe their value proposition SLA terms via the SLALOM model. In any case and as explained in the previous sections of this document, all these clauses defined via the SLALOM reference model are clearly and well defined, non-repudiable, abstracted and machine understandable.

In the service composition phase, third parties like brokers of cloud services and entities dealing with monitoring and auditing of SLA contracts can utilise these machine understandable SLA clauses in order to offer evolutionary services that were previously non-existent or less developed, and play an important role in the cloud ecosystem. This becomes particularly useful in the case of composite services that consist of chains of services with varying client requirements for each sub-service in terms of e.g. availability, response time and security, which can be combined among providers. Cloud service brokers will be able to easily offer end-to-end cloud solutions by automatically combining services from different providers and pricing their final offering.

During the evaluation phase of cloud tenders, the definition of SLA clauses via the SLALOM reference model allows the adopter to easily apply comparable metrics, such as SLA strictness levels [3] for

performing custom comparative evaluations of the SLAs offered by various cloud providers, as follows. First, the parameters of importance for the given domain or application are identified within each SLA clause and their importance is defined by assign them a weight and/or a normalisation factor. Then, these parameters are mapped to an arbitrary function, which allows for comparative ranking of the SLA clauses of the different providers. The can be performed easily, since, according to its definition, the higher the SLA strictness function output value for a provider, the more appropriate their SLA for the given purpose and needs.

During the contract monitoring and evaluation phase, a trusted third-party stakeholder (i.e. broker) can utilise the machine understandable SLA clauses descriptions in order to non-repudiably monitor the offered service levels and keep track of violations of the agreed clauses. Another stakeholder could perform relevant measurements and then calculate SLA success ratios [3] of various providers in the course of time, i.e. the ratio of successful SLA clauses vs. total SLA clauses, and offer this information to interested stakeholders, e.g. to adopters for reasons of comparability of providers, and to providers for reasons of performance management and improvement of business processes, service levels and customer satisfaction levels.

New areas for SLALOM development

As part of the community discussions, three broad areas for further SLALOM development have been identified:

Increased definition of the general cloud contract and SLA

SLALOM has deliberately been vague about whether it is applicable to B2B or B2C, to IaaS, PaaS, SaaS. Parts of the work may be more applicable to one or the other. Some aspects were avoided because they become too specific or convoluted, and would detract from the overall pragmatic nature of the results. In other cases, they were specifically commented on, for example the rulings on unfair contracts can vary substantially depending on whether it is B2B or B2C. Demand for further specification of this exists among the community. Furthermore, extension of both the contract and the SLAs in order to increase the resale of services was a subject demanded: the main contractor has their own supply chain of providers, and the counterpart may themselves be interested in reselling capacity on.

Verticalisation of the legal and technical SLA

During the activities certain industry verticals, most particularly health, finances and public administration leapt out as vertical markets with a need for specific clauses. In all three, this is related to sector specific laws and regulation, and in the latter case, also due to established procedures (some of which are enshrined in law). All three sectors reflect significant variation across jurisdictions which are not present in other markets.

Application of SLALOM to new technology fields

Finally, whilst SLALOM focused on cloud, the technology areas of devices, sensors, supercomputing and advanced networks are all facing similar issues around a common “fair and neutral” legal model for various interactions: be it the interchange and access to data from devices and sensors, or the sharing of physical or virtualized resources. There are calls from some quarters for a similar result in these fields.

3.2 What is already available and what is missing in the market

Based on [1], [5] and further SLALOM analysis of public deliverables of cloud and SLA related projects (e.g., SLA ready [8], SPECS [9], A4Cloud [10], MUSA [11]), Table 1 summarises the current landscape of mechanisms that may enhance the adoption of clouds and transform SLAs into a tool rather than just a contract that cannot be validated. More detailed information with respect to the mechanisms referred hereafter can be found in the above referenced documents.

As one can easily notice through Table 1, there are many mechanisms and studies related to "Service modelling", "Service instantiation and management" and "SLA enforcement and monitoring" phases of an SLA lifecycle. Contrarily, little can be found for the phases of "Service use", "SLA template definition" or even nothing for "SLA conclusion". Overall, there are SLA specifications and machine readable formats to facilitate automated processing of SLAs including re-negotiation mechanisms but little of them have been exploited in e.g., evaluation and SLA violation detection mechanisms ("SLA enforcement" phase), or accounting/billing and revenue sharing in multi-cloud environments ("SLA conclusion" phase). Therefore, questions such as a) what mechanisms can be built to facilitate e.g., the revenue sharing among the providers in a multi-provider environment when the SLA is terminated? b) what are the mechanisms that may allow the secure data transfer from one provider to another? c) what are the offered mechanisms to easily calculate the discount to be applied to users when their SLA has been violated (e.g., based on the type of failure, its impact to the user, the type of the user and the time period that the SLA was not served)? and others remain open.

On the other hand, the fact that the mechanisms of Table 1 do exist, does not ensure that they can effectively capture all the needs of the market in terms of metrics or cloud environments. For example, mechanisms "Automatic Root Cause Analysis for scalability problem" and "Proactive SLA violation detection" have been developed to identify the causes or the patterns of an SLA violation in a simple cloud environment. But are they capable to also address requirements posed by a multi-cloud/ multi-provider environment? What are the changes imposed when referring to an Internet-of-Things (IoT) cloud service? In order for SLALOM to identify the current market needs, a SLALOM conducted survey focused on the components and the metrics proposed by ISO and asked stakeholders to indicate their importance to them. Based on the received feedback, section 6 in [1] summarizes the views of the cloud providers and the cloud adopters. The overall prioritization of the key metrics is as follows:

1. Availability
2. Elasticity
3. Response time
4. CPU performance
5. Disk space
6. Memory size
7. Simultaneous cloud service connections
8. Cloud service bandwidth
9. Cloud service throughput
10. Data portability
11. Service monitoring

12. Information security methods
13. Information security authentication
14. Customer data backup methods
15. Notification of service termination
16. Cloud service support methods
17. Cloud service support costs
18. Cloud service incident notification/reporting
19. Law enforcement access
20. Cloud service governance

Researchers or new project consortiums should take this information into account before moving on with their next project. Depending on the cloud environment that is investigated or the metrics to be considered, projects should either a) exploit some of the existing mechanisms (and complement them with missing technologies), or b) enhance their functionality based on the market demands or even c) combine and integrate them into more "complete" sets of mechanisms that would cover all the phases of an SLA lifecycle instead of specifying new (already available) mechanisms and specifications, which would further add to the already *excessive*[1] number of SLAs defined by ISO and the ECP. Such an approach would lead to the removal of one of the main barriers for cloud adoption, i.e., the extended but incomplete state-of-the-art, and bridge the gap between research and the market in the cloud SLA area.

[1] As concluded from the feedback from the market conducted by SLALOM in March 2015 [7].

Table 1. Existing cloud/SLA technology

SLA Lifecycle phase	Project	Mechanism	Metrics/ Cloud Environment
Service Use	EGI	Service catalogue	Federated environment
	Helix Nebula	Common catalogue of Services	Multi-tenant, multi-provider cloud infrastructure focusing on trust, security and privacy
	IRMOS	Application SLA	SLAs at different levels
	VISION Cloud	Content-related terms in SLAs	Focussing on content-centric services across disparate administrative domains
Service modelling	4CaaSt	Blueprint	PaaS Cloud platform, multi-tier applications – service dependencies within and across the cloud layers
	CloudScale	Scalability specification	Enriches existing SLAs with scalability aspects
	CONTRAIL	SLA specification and quality model	Elastic PaaS services over a federation of IaaS clouds, introduces Quality of Protection terms (data locality, protection, replication, etc.)
	OPTIMIS	Service manifest	Focus on automatic externalization of services and application to trustworthy and auditable cloud providers
	PrestoPRIME	SLA specification for preservation services	Service management infrastructure for the long-term preservation of audio-visual digital media objects, programmes and collections
	Q-ImPrESS	QoS-oriented SLA specification	Focus on performance, reliability and maintainability
	SERSCIS	Service dependability	Focus on secure, resilient and highly available information systems
	SLA@SOI	SLA(T)	Functional and non-functional characteristics of a service
	PHOSPHOROUS	Term language	Advanced reservation of optical network links
	SmartLM	Software licenses in SLAs	Enriches existing SLAs with the software license usage during the provision of a service
	SLA-Ready	SLA-Ready common reference model	A model for the common understanding of SLAs for cloud services , integrating SLA components like terminology, SLA attributes, and Service Level Objectives (SLOs), guidelines and best practices
	SPECS	Security SLA model	A model to define SLOs via security metrics expressed through a declaration of security controls that the service provider adopts and applies on the services protected by the SLA.

	A4Cloud	Accountability model, also reflecting on SLAs	The accountability model highlights 'what' needs to be implemented. Within the model, accountability mechanisms are instances of tools and techniques supporting accountability practices and focus on the core aspects of accountability (e.g. remediation, notification and risk assessment), which are expected to be used in conjunction with separate privacy and security mechanisms
	MUSA	SLA-driven Methodology to Set-up Security Capabilities on Top of Cloud Services	The MUSA framework aims to support security-aware multi-cloud application life cycle management, thus promoting security by design practices in the development and embedding security mechanisms in the application
SLA Template definition	4CaaSt	eMarketplace	PaaS Cloud platform, multi-tier applications
	Cloud-TM	SLA definition and enforcement in transactional data stores	Data-centric PaaS on top of Transactional Memory platform, deals with response time and abort rate in transactional data stores
	ETICS	Business-enhanced SLA template	Different business or charging models
	OPTIMIS	API for developing, importing and exporting the service manifest	Focus on automatic externalization of services and application to trustworthy and auditable cloud providers
	plugIT	Recommendation system	Ordered list of SLA templates that meet the user's requirements
SLA Instantiation and Management	4CaaSt	Blueprint	PaaS Cloud platform, multi-tier applications – service dependencies within and across the cloud layers
	CloudScale	Elasticity management	Focus on scalability aspects
	Cloud4SOA	Agreement Negotiation functionality of "Dynamic SLA Negotiation and Enforcement" mechanism	Multi-cloud paradigm at PaaS level (multiplatform matchmaking and unified applications), interoperable framework for PaaS developers – automatic negotiations for business dynamics and changing customer needs
	CONTRAIL	Multi-level SLA interaction model and SLA Management for cloud federations	Elastic PaaS services over a federation of IaaS clouds – QoS, SLA management, security, interoperability and scalability – automated SLA offer generation from cloud federation
	EGI	Federated service management	Federated IaaS cloud infrastructure
	GEYSERS	Converged SLA Management for composed virtual infrastructures	End-to-end service delivery, dependencies between physical and virtual resources

	IRMOS	Technical SLA (SLAs at Different Levels), Dynamic SLA re-negotiation and Mapping High-level to low-level attributes	Efficient integration of interactive real-time applications
	MCN	Distributed SLA Management	Decentralised computing and smart storage in one atomic service with on-demand, elastic and pay-as-you-go characteristics – composite services, combined and joint management of the multiple SLAs
	MODA clouds	Runtime re-negotiation	Multi-clouds with guaranteed quality of services
	OPTIMIS	Automated SLA negotiation	Federated and multi-cloud deployment
	SERSCIS	Layers of decision making in federated interconnected systems	Focus on secure, resilient and highly available information systems
	SLA@SOI	SLA negotiation across multiple layers	Considered tiers: business, software and infrastructure layers
	Initiated by SLA@SOI and supported by Open Grid Foundation (OGF)	Open Cloud Computing Interface (OCCI)	Interactions between service and infrastructure clouds, API for managing cloud service resources
	SPECS	SLA Negotiation module	Managing the SLA negotiation and renegotiation phases. It manages the creation of the SLA, by analysing the End-user requirements gathered trough the SPECS application until its signature. It encapsulates the components: SLO Manager, Supply Chain Manager, Security Reasoner
	A4Cloud	Cloud Offerings Advisory Tool (COAT)	Aiding the execution of the cloud service selection process by filtering the variety of offers being presented to the user based on the a set of security and privacy requirements. The tool acts as an independent web-based broker that checks and gathers user requirements (some functional and mostly security and data protection requirements, matches offers by cloud service providers, compares these offers, explains the terms of offerings, suggests best offerings that match the user requirement, and gives general guidance to users on service

			offerings. The tool may also be used by cloud providers for identifying and selecting a third party CSP for (complementary) operating a cloud service
	MUSA	An SLA-driven approach for creating multi-cloud applications taking into account their security requirements together with functional and business requirements	An automated deployment environment that, based on an intelligent decision support system, will allow for the dynamic distribution of the components according to security needs
SLA enforcement – monitoring and evaluation mechanisms	Cloud4SOA	Agreement enforcement functionality of "Dynamic SLA Negotiation and Enforcement" mechanism	Multi-cloud paradigm at PaaS level (multiplatform matchmaking and unified applications), interoperable framework for PaaS developers – Supervise all SLAs are respected
	Cloud-TM	SLA definition and enforcement in transactional data stores	Data-centric PaaS on top of Transactional Memory platform, self-optimization and self-tune of the infrastructure resources based on QoS metrics
	IRMOS	Adaptable monitoring and Evaluation	Efficient integration of interactive real-time applications - monitoring and evaluation in both application and infrastructure levels, adaptable in terms of monitoring intervals
	MUSA	SLA-driven monitoring of multi-cloud resources security and performance	Monitoring application runtime to mitigate security incidents, so multi-cloud application providers can be informed and react to them without losing end-user trust in the multi-cloud application.
SLA enforcement – Monitoring mechanisms	CumuloNimbo	SLA enforcement for transactional systems	Focusing on scalability and elasticity aspects for transactional systems
	MODA clouds	Unified monitoring across different cloud layers	Multi-clouds with guaranteed quality of services
	mPlane	Network monitoring for SLAs	SLA definition according to OSI layer
	SLA@SOI	Scalable SLA-driven monitoring	Functional and non-functional characteristics of a service
	Stream	Scalable and efficient monitoring	Focus on scalability issues when processing data/event streams
	SPECS	SLA Monitoring module	Orchestration of the entire process of service monitoring by gathering raw monitoring information from the target

			services, translating it into events and into alerts or violations which need to be managed. It encapsulates the components: Event Hub and Adapter, Metric Aggregator, (MoniPoli)Filter, Archiver, CTP Explorer: Server and Adaptor
SLA enforcement – Evaluation mechanisms	Cloud-TM	Performance estimation and workload prediction	Data-centric PaaS on top of Transactional Memory platform – mechanism for identifying the optimum resources and deployment patterns
	Q-ImPrESS	Trade-off analysis and SLA prediction	Focus on performance, reliability and maintainability – assesses the risk for potential SLA violations
	SPECS	SLA Enforcement module	Orchestration of the actions needed in order to implement a signed SLA and ensure its fulfilment. It has to translate End-user's security requirements specified in a signed SLA into a set of acquisition, allocation and configuration parameters. Moreover it has to provision the needed resources and apply the requested security mechanisms. It encapsulates the components: Planning, Implementation, Diagnosis, remediation, Broker.
SLA enforcement – SLA violation detection mechanisms (inc. proactive violation detection)	Cloud4SOA	Violation recovery functionality of "Dynamic SLA Negotiation and Enforcement" mechanism	Multi-cloud paradigm at PaaS level (multiplatform matchmaking and unified applications), interoperable framework for PaaS developers – suggests the most appropriate recovery action (e.g., warning messages, stop or migration of the application, etc.) based on the policies defined by the software developer
	CloudScale	Automatic Root Cause Analysis for scalability problem	Identifies the causes of the SLA violation when services do not scale as expected
	VISION Cloud	Proactive SLA violation detection	Content-centric services across disparate administrative domains – identifies repetitive patterns in the monitoring information with respect to SLA violations

4. Recommendations (Dos and Don'ts)

This section provides the principle recommendations for the targeted stakeholders discussed initially. A simplified version of these DOs and DON'Ts has been circulated to the community.

a. DO target metrics that are directly comparable between providers. This is a major user issue.

This is one of the core motivations for the technical track (WP3) of the project and early market research instantly identified this as a correct assumption. Buyers are becoming increasingly wise to the variations and leeway that (poorly written) clauses allow.

b. DO consider directly machine understandable descriptions through standardized templates

Machine understandable descriptions allow for the adoption of mechanisms for the automation of processes which pertain to all the phases of SLA lifecycle (service composition, tenders negotiation and evaluation, service levels monitoring and violation management), with positive impact on the efficiency of processes and the potential of offering advanced new services for covering the emerging market needs. . Standardized templates allow for interoperability among the developed mechanisms and services and for the providers.

c. DO look into the ISO 19086- series of standards (under development[2] and adopt if applicable.

ISO JTC1/SC38 Working group 3 (of which SLALOM is a liaison body) is currently producing this series of standards. SLALOM believes that they are fully adequate for use within the European research community, and alignment to this international standard - if not to the compatible and more extensive ISO-based SLALOM model - will ensure greater chances of uptake by industry. In some cases, it is simply one of reducing divergence and not reinventing the wheel, in others of extending the applicability of the work to a broader user base. Being SLALOM compliant will further ensure that the sampling process is concretely defined and SLAs are machine understandable, hence aiding comparability of the SLAs and enabling the automation of relevant processes.

d. DO think outside the narrow Cloud box. With the advent of *aaS and the emergence of IoT, SLAs may refer to services external to the data center

We have touched on this before. Network, IoT, big data and HPC services are increasingly becoming part of the cloud ecosystem. SLA and legal research should take a step back from the simple cloud situation and consider what requirements non-human or non-cloud service consumers may require. What clauses may be floated up from data producers? What level of quality, performance, service guarantees, security and disaster recovery might be need for end-users building critical systems with smart cities,

[2] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=601355

wearables, driverless cars and the such like? How can new services comply with the market status quo and still permit innovation? To this end, SLALOM project in collaboration with COSMOS project have designed a survey [6] the purpose of which is to investigate aspects of Cloud (or in general service oriented) SLA metrics that would be more appropriate for the IoT domain, select the highest ranking of these metrics and create example metric descriptions following the SLALOM reference model. This way, the applicability of the SLALOM model in the IoT domain will be proved or, if unsuccessful, recommendations for improvements will be provided.

e. DO consider composite services that may create chains of SLAs and their interdependencies. This is critical for guaranteeing response time to service support services: consider downstream (reseller) and upstream (e.g. provider's subcontractors) actors, their requirements and the need to 'float' SLA clauses down the chain.

The Cloudwatch-2 project and Helix Nebula initiative are good examples of research activities that have drawn attention on the need to compose value chains of multiple providers and resellers in a true commodity-based market. As discussed previously, the market is catching up and focusing ever more intensely on PaaS marketplaces of value added 3rd party services. It is a grave error to consider that the SLA or the contract pertain just to two parties. Clauses in the SLA you provide to your client will have to be reflected in the SLA they have with their client, and so forth, or else a risk mismatch is created which will be reflected in pricing. Compliance with de jure or de facto standards, in definition, and industry practice in terms of service level are a way to reduce the risk of potential providers overlooking you in favour of less risky providers. Ultimately this is a decision that requires significant strategic consideration and should not be overlooked. Researchers should be aware of the way that risks they pass on to their customers are propagated through supply chains and may impede uptake.

f. DO consider resource management as a key part of the SLA upkeep and analysis process

The management of cloud resources plays a key role in the satisfaction of the services user, including their perceived level of services. Although the offered service levels (e.g. amount of RAM, number of VCPUs) may well be within the agreed upon limits, described the SLA, the perceived (real) experience may be significantly lacking, e.g. if more of the virtual resources sharing the same physical resources are utilized at the same time. Keep this in mind when managing and allocating resources or negotiating the value of key metrics. The research community should also consider such issues when studying SLA mechanisms.

g. DO consider complementary mechanisms that would allow providers, resellers (e.g., offering a service over a cloud infrastructure that is not theirs) and users to easily monitor the SLA in a common and understandable way (for non-experts as well)

SLA monitoring is of key importance for all stakeholders of the cloud services ecosystem. For users to identify SLA violations and request compensation, but also as a mains of pushing providers to maintain the needed service levels, for providers to fine tune their services, minimize their expenses and increase adopters' satisfaction and for resellers to rank their collaborating service providers and appropriately

choose and price an autonomous or composite service before proposing it to their clients. One would expect that SLA monitoring is done by the providers, but in most cases it is not, and even if it is, the results are not widely available. The outcomes of SLALOM project greatly help towards the creation and usage of mechanisms for automated and understandable monitoring of SLAs and management of violations. SLALOM has found that market interest and uptake of monitoring is variable, across both user and providers, as well as in a state of flux (see above). Assumptions should not be made regarding the desirability of specific monitoring solutions.

h. DON'T consider that offered terms are equivalent, even if they originally seem to refer to the same SLO. Always check the fine print for differences in how metrics are actually calculated

One provider's 99.9 is not the same as another's. Researchers working in this area need to carefully analyse the wording of the SLAs they consider. Tools to monitor SLOs need to either define a common metric, aware that this diverges from the terms actually offered by the provider, or else build in this heterogeneity. Brokers, recommenders and other sophisticated tools used to compare providers must match the complexity of the market and not just take the published 'headline' figures for granted. The SLA definition model proposed by SLALOM aims at lifting such differences and thus removing this barrier.

i. DON'T consider that SLAs are monitored by providers.

SLAs are not usually monitored by the provider. Often both notification of the breach and the burden of proof required to establish that breach are responsibilities placed on the client. Automated brokers and marketplaces must consider this. Providers who currently do not monitor SLAs or provide data on SLA compliance may be reticent to accept new technology that does so.

j. DON'T leave end-users out of the loop. Understandability and clarity of an SLA (or its relevant metric) for non-experts should be a key target. Translate your metrics into plain English if necessary.

This recommendation is both common sense, and not that common. It is a mistake to consider that cloud adopters are technical experts. Often purchase decisions are made by a procurement department based on an initial set of requirements passed on from a technical specialist. Hence it is in the interest of a provider to ensure that the non-expert procurers can see the value in the SLA and terms they are provided with. Selling points should be made clear. Complex SLA descriptions may impede uptake of research results.

k. DON'T limit yourself to popular metrics (e.g., availability) in SLAs. Users are also interested in more generic QoE indexes such as stability

There are headline metrics, of which availability is clearly one. However, the users are looking for more general peace of mind, security and stability. Providers should choose a limited number of SLAs around which their value proposition is based. Both the C-SIG on SLAs and the ISO working group defined an

extensive list of SLA metrics, running to forty or more. SLALOM market research showed this to be considered excessive by both sides of the market. This is particularly relevant for marketplaces, brokers and recommenders: the SLAs which are chosen for decision making should be assessed for relevance and commonality, should be as numerous as necessary to permit objective and holistic evaluation, yet few enough to be pragmatic for both sides of the market. SLALOM deliverable D4.1_5.1 [7] presents this market research and D3.2 [1] summarizes the prioritization of the ISO metrics based on the stakeholders' feedback.

l. DON'T expect the market to bend for you: fit in to current practice to the maximum extent and if not possible, hone your value proposition

The results of both the SLALOM technical track and the SLALOM legal track are a good benchmark for current industry practice. The former is fully compatible with the emerging international standard. The latter is a complete contract that weighed up multiple company practices, user considerations, regulations in multiple jurisdictions and EU countries (Italy, Greece, UK); and is the result of consensus in the market. Divergence from this established industry practice implies risk, uncertainty and cost for the actors concerned. Consequently, all proposed business models from related research should evaluate if they fit within this status quo, and if not, whether their value proposition is really strong enough to convince commercial actors to change their established practices – knowing that to do so involves more departments and more senior individuals to become proponents of the changes. Who will bear the risks and are they adequately compensated for it?

5. Recommendation / stakeholder matrix

The table below provides a quick cross-reference of the SLALOM recommendations and their importance to the four stakeholders identified.

	Project Coordinator	Policymaker	Exploitation Manager	Research Head
Observations				
Relationship with ISO	X	X	X	X
What is changing in the cloud and/or SLA market?	X	X	X	X
What is already available and what is missing in the market	X	X	X	X
DOs				
DO target metrics that are directly comparable between providers. This is a major user issue.	X	X	X	X
DO consider directly machine understandable descriptions through standardized templates	X	X		X
DO look into the ISO 19086- series of standards (under development and adopt if applicable.	X		X	X
DO think outside the narrow Cloud box. With the advent of *aaS and the emergence of IoT, SLAs may refer to services external to the data centre	X			X
DO consider composite services that may create chains of SLAs and their interdependencies. This is critical for guaranteeing response time to service support services: consider downstream (reseller) and upstream (e.g. provider's subcontractors) actors, their requirements and the need to 'float' SLA clauses down the chain.		X	X	
DO consider resource management as a key part of the SLA upkeep and analysis process		X		X
DO consider complementary mechanisms that would allow providers, resellers (e.g., offering a service over a cloud infrastructure that is not theirs) and users to easily monitor the SLA in a common and understandable way (for non-experts as well)		X		X
DON'Ts				
DON'T consider that offered terms are equivalent, even if they originally seem to refer to the same SLO. Always check the fine print for differences in how metrics are actually calculated	X		X	
DON'T consider that SLAs are monitored by providers.	X	X	X	X
DON'T leave end users out of the loop. Understandability and clarity of an SLA (or its relevant metric) for non-experts should be a key target. Translate your metrics into plain English if necessary.	X		X	
DON'T limit yourself to popular metrics (e.g. availability) in SLAs. Users are also interested in more generic QoE indexes such as stability	X		X	X
DON'T expect the market to bend for you: fit in to current practice to the maximum extent and if not possible, hone your value proposition	X	X	X	X

6. Actions carried out

The strategy to support the Research and Scientific community has been underpinned on:

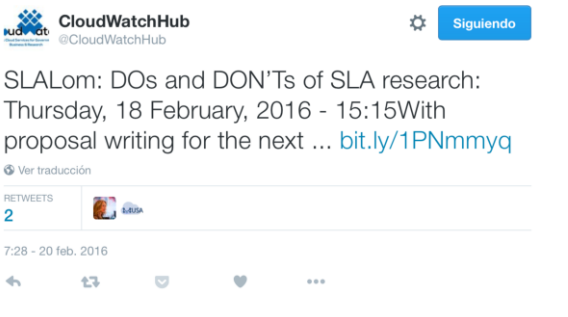
a) generating materials to facilitate the understanding of SLALOM outcomes and the benefits;
b) participating in events in which leverage visibility; and
c) engaging the community by producing live sessions in which this community might be interested, such as webinars, and by having one-to-one contacts with interested stakeholders.

We now cover the most relevant ones.

Publication of the Dos and don'ts flyer – February 2016

The team created "*SLALOM best practice DOs & DON'Ts Guide on Cloud SLAs for Project Researchers: The 12 DO's & DON'Ts of SLA Research*" which are lessons learned from our experience and contacts bridging research, EC initiatives, industry and ISO in SLA Standardization. They are explained in this document in more detail. The flyer version of these recommendations (http://bit.ly/1SxyCXe) was circulated to the community in February 2016, using established channels such as the SLALOM mailing list, SLALOM and 3rd party websites, like CloudWatch Hub, and social media channels to share as much as possible within the scientific and research community.

This was particularly promoted with reference to the then upcoming call for proposals in cloud computing, so that the recommendations would be factored into the design of future projects.



Dissemination Kit: Posters, flyers and online materials

The project created a Dissemination Kit that includes relevant materials to share with stakeholders. This has especially important in our participation in events and concertation meetings in which SLALOM members have used, and shared, posters used flyers to generate visibility for the project.

All these materials have been continuously updated according to the phase of the project during the whole life of the project. The **SLALOM Dissemination Kit** includes materials such as SLALOM in a Nutshell (http://bit.ly/SLALOMinanutshell), an introduction to the Project, webinars materials, and versions of the outcomes of the Project, to facilitate understanding of the project scope and its benefits.

Figure 1 SLALOM Poster

Figure 2 SLALOM Flyer

DPSP Event 23 February 2016

The Data Protection, Secrutiy and Privacy (DPSP) in the Cloud Cluster is a group of an EU-funded projects with key objectives on data protection, security and privacy in the cloud. SLALOM established contact with this cluster and collaborated with the organization of the DPSP Workshop 2016 in Napoli (Italy), on 23rd February 2016. This workshop addressed some of the key issues of cloud security and privacy related with EU Digital Single Market strategy as well, and in particular: security level agreements, data sharing agreements, reactive cloud applications, data localization, security of cloud-based public services, secure communication and processing in cloud platforms.

In this regards, SLALOM had an excelent opportunity to present its outcomes in this context. SLALOM was respresented by Gian Marco Rinaldi (Senior Legal Advisor on Cloud SLAs from Bird & Bird) who participated as panelist in the DPSP event discussing on the Challenges for (multi-)cloud-based services in Digital Single Market, particularly from the benefits that SLALOM's legal perspective can put on the table. SLALOM was also represented by David Bicket (Senior Advisor on Cloud SLAs from CIF). The project delegats established conversations with projects like SPECS, SERECA, MUSA, COCOCLOUD, and CLIPS. It is workth mentiniong here that contacts with MUSA project wre initiated here that led to more concrete actions (detailed later).

Closed workshop with DG-DIGIT and DG-CNECT 7 March 2016

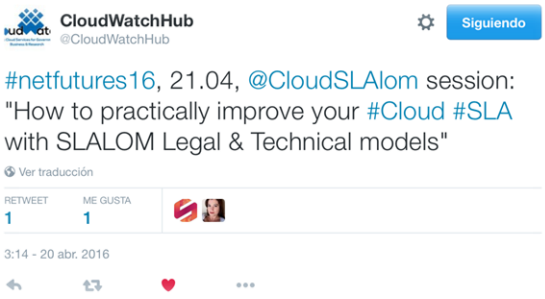
SLALOM and PICSE had a closed, all day workshop with key members of DG-CNECT and DG-DIGIT where an open and frank discussion regarding the experience from the EC on its recent cloud tender process was discussed. SLALOM was presented and the two sides explored how the project could enable the Commission to improve future tenders. In particular the technical track material was considered highly appropriate for use in future tenders.

CloudScape 8-9 March 2016

The project attended this conference, attended by many prominent members of the cloud research community and had the opportunity to present the work and recommendations of SLALOM, both to the audience and through informal discussion.

Cloud Expo London 6-7 Abril 2016

The project presented the project results to the audience in one of the seminars, as well as distributing information via the CIF stand. Although the public were largely commercial in nature, some of the attendees come from the research community.



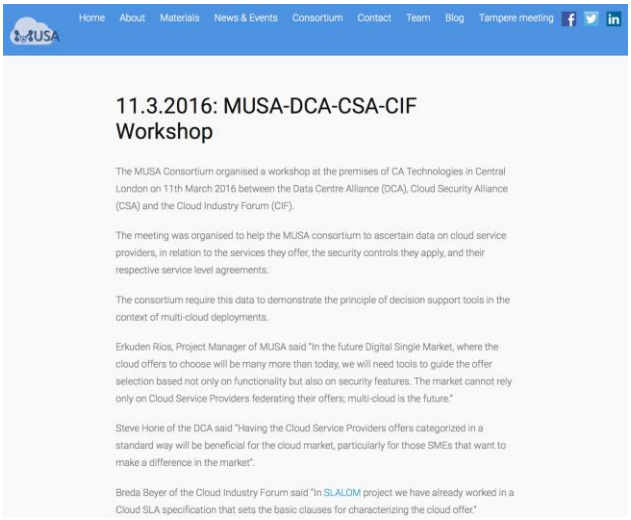
Net Futures 20-21 Abril 2016

The project interacted with delegates across the Future Internet research agenda through the Data Protection, Security and Privacy (DPSP) cluster booth, and through informal discussions.

MUSA-DCA-CSA-CIF Workshop 11 April 2016

The MUSA Consortium organised a workshop at the premises of CA Technologies in Central London on 11th March 2016 between the Data Centre Alliance (DCA), Cloud Security Alliance (CSA) and the Cloud Industry Forum (CIF).

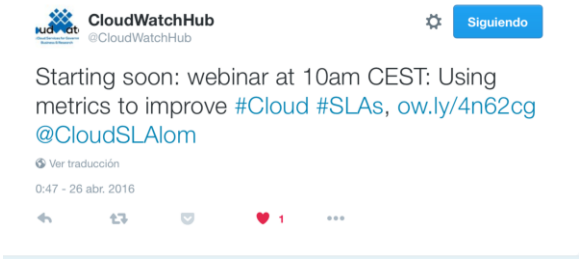
During this workshop SLALOM outcomes were presented to the MUSA consortium

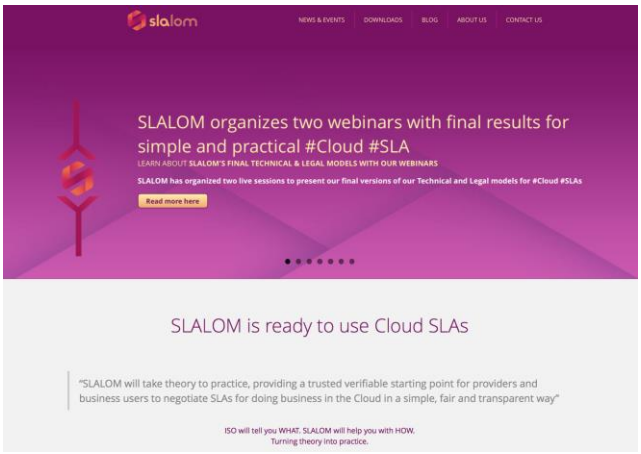


Webinars

SLALOM also organized two live webinar sessions to present our final versions of our final versions of our models for Cloud SLAs.

The first webinar called **"Using metrics to improve Cloud SLAs"** presenting SLALOM Technical Specifications was held on April 26th. The second webinar, **"Ready to Use Cloud Master Agreement for SLAs"**, will present more about our Legal Model Terms and will be held on May 27th. Both provide examples showing how to practically apply SLALOM to improve current practice in the industry and support development of cloud computing metrics, especially for Data Protection and eProcurement. They have also been actively announced and promoted within EU Research and Scientific communities, paying special attention to show best practice for research projects adopting and using the outcomes of the project. The first webinar had an external audience of 12 people.





Bilateral communications: SUNFISH, PICSE & MUSA

As the result of our promotion activities (participation in events and workshops, production of webinars and online activity) SLALOM has established various conversations with various projects during this period.

We were contacted by MITA, which is one of the Consortium partners for the **SUNFISH project** [12], which stands for "*SecUre iNFormatIon SHaring in federated heterogeneous private clouds*". SUNFISH, is a recently approved Research and Innovation proposal presented under the first H2020 call dedicated to *ICT*, particularly to *Advanced Cloud Infrastructure and Services*. Today the European Public Sector Players lack the necessary infrastructure and technology to allow them to integrate their computing clouds. Furthermore, legislative barriers often make it difficult to use available commercial technological solutions. The SUNFISH project aims to provide a specific and new solution to face these issues. SUNFISH will enable the secure federation of private clouds based on the Public Sector needs: federated private clouds belonging to different Public Sector Entities will be able to share data and services transparently, while maintaining required security levels. The SUNFISH project will develop and integrate software enabling secure cloud federation as required by European Public Sector bodies. The project will achieve this by meeting firstly the specific challenges faced by the Maltese and Italian Ministries of Finance, as

well as by the UK Regional Cyber Crime Units, the three SUNFISH selected use cases. For further details you may check http://www.sunfishproject.eu/

In the SUNFISH project, MITA is in charge of the SLA definition language, and conversations were established with SLALOM's technical team in order to better understand how we might employ SLALOM, since SUNFISH is currently considering to opt for the utilisation of SLALOM.

Another project that we currently have initiated conversations is MUSA Project (already mentioned above). Contacts were initiated with our participation in the DSDP workshop, and both projects agreed to organize a session in which SLALOM could participate during the project workshop held in London, to show the project scope and outcomes to all members of this project. During this workshop SLALOM outcomes were presented to the MUSA consortium and it was discussed to establish an initial assessment to consider how to adopt SLALOM outcomes within this project, with a basic set of clauses for characterizing the cloud offer, which is really well aligned with MUSA objective. Conversations are still on-going, and are expected to be continued after SLALOM concludes its formal period, since MUSA project is still at a very early stage.

PICSE

The European Open Science Cloud envisages a trusted, open environment for storing, sharing and re-using scientific data and results and supporting Open Science practices. How procurement practices, cloud contracts and SLAs affect the establishment of such environment? The PICSE (Procurement Innovation for Cloud Services in Europe) [13] and SLALOM projects created a collaboration and have been working to answer this question. Some synergies were found and have been shared in presentations and speeches as best practice of using SLALOM outcomes applied to a concrete context.

Other initiatives with which a strong interaction has existed include: SLA-Ready, A4Cloud, SPECs, Cococloud, ARTIST and COSMO.

Proposals

H2020-2016 Research grant proposals – The flyer version of these recommendations (DOs and DON'Ts) was circulated well before the 2016 April call for proposals on cloud research in order to allow all community proposals to benefit from the SLALOM work. Proposals from consortium partners follow the recommendations here, and additionally several proposals (e.g., SUNFISH) contemplate work building on SLALOM results.

7. Conclusions

This document provides a summary of the main recommendations of the SLALOM project to the cloud computing and SLA community. They are formulated as DOs and DON'Ts, based on the experiences and feedback of the consortium during the project.

In the research community, he recommendations are targeted at project coordinators, policy makers, exploitation managers and cloud research department heads.

The document also charts some of the outreach activities performed in order to make the target stakeholders aware of these recommendations. The response from the research community is encouraging in validating the overall approach taken by SLALOM and opens doors for continuing collaboration.

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