

# 1 Related work on Service Level Agreements Approaches

## 1.1 A framework for SLA-based cloud services verification and composition

In [1], the authors propose a framework for dynamic specification of SLAs. The focus of their approach is on a SLA-based model for the verification and composition of the services. Their approach starts from the dynamic SLAs negotiation, then the verification and composition process, until the agreement. The framework is composed by three components: (i) *A Third-Party Cloud Directory* is the intermediary between the costumers and providers. Providers should sign up with the directory and customers can search and initiate a negotiation with a selected provider. Customers define their SLOs using WSOL; (ii) *The Cloud providers* expose their infrastructure as web services. During a SLA negotiation, the provider search for candidate concrete services that realizes the customers' requirements. After that the provider asks for the composition broker to come up with the optimal service SLA with the requirements; and (iii) *A Trusted Composition Broker* uses the E<sup>3</sup>-MOGA genetic algorithm to find the optimal cloud services composition.

- I miss how and why they choose this algorithm. There is no evaluation or comparison.
- The strongest aspect of the framework is that it enables the client to change his SLOs at runtime (but in fact, it is not clear in the paper how it works). There is no example to illustrate neither simulation/tests in order to know if the framework is efficient or not.
- Perhaps other QoS parameters should be considered in their SLA. Not only throughput, response and cost (these parameters can be included in our SLA model).
- The verification process is interesting. Different from the others approaches which normally search for SLA violations during run-time, it verifies (in a step before the end of the negotiation) if the provider fits the QoS requirement that it is proposing.

## 1.2 Service Level Agreement for Distributed Services: A Review

In [3], a review about SLAs is presented. The authors are interested in challenges associated to trust, SLA management and cloud computing (in my opinion, they focus on frameworks for SLA and on cloud computing definition). To examine/analyze this challenges, the definition of cloud computing is discussed and an analysis of the use of SLAs for different domains (web services, grid computing and cloud computing) is performed. They also discussed challenges regarding SLAs in cloud computing (this paper doesn't have a model proposal, but it can be used for background.)

## 1.3 A Survey on SLA and Performance Measurement in Cloud Computing

[4] is an extended version of [3]. The authors added to the previous research a survey on performance measurement models in different domains (such as SOA, distributed systems, grid computing and cloud services) in order to develop a general trust model for cloud community. As result, they presented challenges concerning SLAs in cloud computing (the same results from the previous work) and performance models cloud computing (this paper doesn't have a model proposal, but it can be used for background).

## 1.4 Automated Control for SLA-Aware Elastic Clouds

[14] presents (early) research ideas for a automated control for SLA-aware elastic clouds. The SLA aware Service model integrates QoS and SLA to the cloud, enabling the consumer to transparently compare service levels before choosing the adequate one for him (the idea is to propose a new cloud model and not a new SLA model). The need for an automated dynamic elasticity of the cloud to is also highlighted. The objective is to meet QoS (performance and availability) while reducing the cost (There is no more information about the model). The author discusses research directions in this context such as *online observation and monitoring of the cloud* (automatically capture variations in cloud usage and workload to detect SLA violation and trigger reconfiguration if necessary), *modeling the cloud* (to create a model capable of rendering the nonlinear variation of workloads) and *automated control of the cloud* (to build dynamic cloud reconfiguration that meets QoS preferences in SLAs while reducing costs). Different challenges for this scenario are presented: definition of scalable and optimal control algorithms for the cloud; handling of different QoS requirements; monitoring of the distributed system; and proposal of techniques for online cloud reconfiguration. (in general, it seems to be far from our research.)

## 1.5 Cloud SLAs: Present and Future

In [9], the authors presented a description of the elements present in a cloud provider SLA. SLAs from five different service providers were compared (Amazon, Rackspace, Microsoft Azure, Terremark vCloud Express and Storm on Demand) in order to identify which are the elements missing and common that should be part of SLA for the cloud services in the future. The work identified that performance based SLAs are missing in these providers and also all of them leave the responsibility of providing evidence for SLA violation on the customer. They also ask for a standardization of SLAs in order to make easy comparisons between the SLAs of different cloud providers.

- There is no model proposal, but they discuss about the SLA elements and we can use this to create our model
- Their analysis is based on public cloud providers only... perhaps in private providers, the SLAs are different
- It seems also to be a good reference for the background

## 1.6 A Conceptual Framework for Cloud Computing

A conceptual framework for cloud computing is presented in [2]. The authors focus on the designing step of the SLA in cloud computing. Functional and non-functional requirements of IaaS, PaaS and SaaS cloud services were analyzed/identified to build the framework. In their proposed framework, the SLA parameters are specified by metrics which defines how the parameter can be measured and specifies values for the measurable parameter. They defined metrics for each type of service (IaaS, ...) based on the most important parameters that consumers can use to create a reliable negotiation model.

- Several SLA metrics proposed by them could be used in our model: scalability, geographic location, security, privacy, recovery, backup, transferring bandwidth, availability, and others.
- They have specified metrics for each type of services (IaaS, PaaS, SaaS and Storage as a service) with different metrics and also metrics commons between them that should make part of a general SLA. That can be used as basis for our model.
- It is still missing the implementation and simulation experiments in order to validate our framework.

The authors in [8] presented a generic SLA model that includes management capabilities as a service which are agreed and negotiated in contracts. These management capabilities (elasticity, high availability, scalability and on demand provisioning) are performed by management services called Pcloud services that are defined in order to achieve application requirements (specified as SLOs by users). The idea is to help the user to choose the appropriated providers that fits his requirements. In the approach, the provider offers four levels of SLA contract which is created in the negotiation phase. First, the user chooses the SLA level and specifies his requirements. Then, the provider exposes the Pcloud services according to the SLA level and the usage services based on the QoS requirements. After that the user can choose the services that fits its need. As non-functional aspects in their model, they consider availability, delay, capacity and reliability. There is no implementation and experiments.

[7] is an extended work of [8]. This work proposes an efficient SLA management by introducing a self-control service component. It uses the approach explained above but it does not focus on the SLA (schema, model...). It seem out of our context.

[11] presented a approach for cloud security service level agreements on hybrid clouds. The author focus on two parts of the proposed method: the lifecycle of a security SLA and a framework for a cloud security mechanism to include SLA. The lifecycle is composed by six steps: *publishing*: phase in which the providers will design their security SLA templates; *negotiation*: the customer and provider agree in the security SLA. The resulting SLA is composed by a set of security requirements stated by the customer and offered by the provider. Then, the provider will match the agreed SLA with other service provider who can provide the service meeting the security requirements. The result of this phase will be a contract between the customer and the provider; and possibly contracts between the provider and other service providers; *commitment*: the security SLAs are digitally signed in this phase; *provisioning* step to configure and reach the security mechanisms; *monitoring*; and *termination*. The security requirements are defined based in a framework for security mechanisms in SLA for cloud services. The mechanisms suggested are: secure resource pooling, secure elasticity, access control, audit, verification and compliance and incident management and response. A case study is presented and also some challenges are discussed.

## 1.7 Security as a Service Using an SLA-based Approach via SPECS

In [28], the authors proposed an approach called SPECS to add security mechanisms and to manage the SLA life cycle considering these mechanisms. The approach assumes that security aspects are included in the SLA, **but there is no description of the parameters related to security that should be present in the SLA**. Three interaction models are proposed, **but none of them have been implemented yet**: (i) SPECS can work as a intermediate between the user and provider offering security services, but the provider is not aware of SPECS; (ii) a provider can use SPECS in to improve its security mechanisms; and (iii) a single user can use the platform to manage security aspects over remote services;

**I don't think this work is close to our idea. I miss the clauses of their SLA, but I like the idea of having a service to manage the SLA and also flexible to be used in different scenarios (interaction models).**

These are the other papers I have read but I did not make a summary yet [12, 17]. Analyzing the SLA models, most of the proposals do not have even a small example and implementation, experiments/simulations of the proposed approaches are still missing. There is need for a standard way of writing the SLA in order to be capable to compare SLAs from different providers.

None of the models is related to data integration, but they can help to identify: the SLA measures could be related to data such as storage scalability, backup, recovery, privacy, security, etc [2]; and the measures associated to the different types of cloud delivery model: IaaS, PaaS and SaaS.

## 2 Related work on data integration and cloud services

In [22], a cloud-based data management and integration system called Fusion Tables is presented. It enables data sharing, integration and collaboration between different and multiple users. Users, that can be non-IT experts, can visualize and manipulate their data in the web in a easy way. The system enables users to (i) uploading of data files from different formats; (ii) visualizing the data in different ways; (iii) integrating data from different sources belonging to multiple users. The integration process consists in a join between tables; (iv) sharing and controlling data in at levels; and (v) interacting with data in a web interface or through an API. The authors described the design foundations of Fusion Tables (such as integration with the web, easy of use, incentives for sharing and facilitate collaboration) and some examples of applications that can take advantages from the system.

The summaries for data integration are the ones I used in the first version of the related works on our paper [16, 20, 27, 30, 32]. I have no summaries of the data integration approaches I read before (I recently started doing the summaries), but this is the complete list I have read [5, 6, 10, 13, 15, 18, 19, 23, 24, 26, 29, 31, 33]. Considering these papers, most of them are frameworks/systems for data integration. Excepting the articles concerning the Google fusion tables [21], none of the works until now presented (clearly) how they integrate data (there is only a superficial description of the approach). The works focus on data quality aspects such as cost, privacy, protection and security of their integration approach. In [25], a theoretical perspective of data integration is presented, focusing on aspects such as modeling data integration applications, inconsistencies between sources, reasoning on queries and query rewriting.

## References

- [1] Asma Al Falasi and Mohamed Adel Serhani. A Framework for SLA-based cloud services verification and composition. In *2011 International Conference on Innovations in Information Technology*, pages 287–292. IEEE, April 2011.
- [2] Mohammed Alhamad, Tharam Dillon, and Elizabeth Chang. Conceptual SLA framework for cloud computing. In *4th IEEE International Conference on Digital Ecosystems and Technologies*, pages 606–610. IEEE, April 2010.
- [3] Mohammed Alhamad, Tharam Dillon, and Elizabeth Chang. Service Level Agreement for Distributed Services: A Review. In *2011 IEEE Ninth International Conference on Dependable, Autonomic and Secure Computing*, pages 1051–1054. IEEE, December 2011.
- [4] Mohammed Alhamad, Tharam Dillon, and Elizabeth Chang. A survey on sla and performance measurement in cloud computing. In *Proceedings of the 2011th Confederated International Conference on On the Move to Meaningful Internet Systems - Volume Part II*, OTM’11, pages 469–477, Berlin, Heidelberg, 2011. Springer-Verlag.
- [5] Sattam Alsubaiee, Alexander Behm, Raman Grover, Rares Vernica, Vinayak Borkar, Michael J. Carey, and Chen Li. Asterix: Scalable warehouse-style web data integration. In

- Proceedings of the Ninth International Workshop on Information Integration on the Web, IIWeb '12*, pages 2:1–2:4, New York, NY, USA, 2012. ACM.
- [6] Mohammed Abdullatif ALzain and E Pardede. Using Multi Shares for Ensuring Privacy in Database-as-a-Service. In *2011 44th Hawaii International Conference on System Sciences*, pages 1–9. IEEE, January 2011.
  - [7] Tatiana Aubonnet and Noemie Simoni. Self-Control Cloud Services. In *2014 IEEE 13th International Symposium on Network Computing and Applications*, pages 282–286. IEEE, August 2014.
  - [8] Ines Ayadi, Noemie Simoni, and Tatiana Aubonnet. SLA Approach for "Cloud as a Service". In *2013 IEEE Sixth International Conference on Cloud Computing*, pages 966–967. IEEE, June 2013.
  - [9] Salman A. Baset. Cloud slas: Present and future. *SIGOPS Oper. Syst. Rev.*, 46(2):57–66, July 2012.
  - [10] S. Benkner, C. Borckholder, M. Bubak, Y. Kaniovskyi, R. Knight, M. Koehler, S. Koulouzis, P. Nowakowski, and S. Wood. A Cloud-Based Framework for Collaborative Data Management in the VPH-Share Project. In *2013 27th International Conference on Advanced Information Networking and Applications Workshops*, pages 1203–1210. IEEE, March 2013.
  - [11] Karin Bernsmed, Martin Gilje Jaatun, Per Hakon Meland, and Astrid Undheim. Security slas for federated cloud services. *2012 Seventh International Conference on Availability, Reliability and Security*, 0:202–209, 2011.
  - [12] Karin Bernsmed, Martin Gilje Jaatun, and Astrid Undheim. Security in service level agreements for cloud computing. In Frank Leymann, Ivan Ivanov, Marten van Sinderen, and Boris Shishkov, editors, *CLOSER 2011 - Proceedings of the 1st International Conference on Cloud Computing and Services Science, Noordwijkerhout, Netherlands, 7-9 May, 2011*, pages 636–642. SciTePress, 2011.
  - [13] Bin Lu and Wei Song. Research on heterogeneous data integration for Smart Grid. In *2010 3rd International Conference on Computer Science and Information Technology*, volume 3, pages 52–56. IEEE, July 2010.
  - [14] Sara Bouchenak. Automated control for SLA-aware elastic clouds. In *Proceedings of the Fifth International Workshop on Feedback Control Implementation and Design in Computing Systems and Networks - FeBiD '10*, pages 27–28, New York, New York, USA, April 2010. ACM Press.
  - [15] Reinhard Braumandl. *Quality of Service and Optimization in Data Integration Systems*. PhD thesis, University of Passau, 2002.
  - [16] Gianluca Correndo, Manuel Salvadores, Ian Millard, Hugh Glaser, and Nigel Shadbolt. SPARQL query rewriting for implementing data integration over linked data. In *Proceedings of the 1st International Workshop on Data Semantics - DataSem '10*, page 1, New York, New York, USA, March 2010. ACM Press.
  - [17] Shirlei Aparecida de Chaves, Carlos Becker Westphall, and Flavio Rodrigo Lamin. SLA Perspective in Security Management for Cloud Computing. In *2010 Sixth International Conference on Networking and Services*, pages 212–217. IEEE, March 2010.

- [18] Christopher Duffy, Lorne Leonard, Gopal Bhatt, Xuan Yu, and Lee Giles. Watershed Re-analysis: Towards a National Strategy for Model-Data Integration. In *2011 IEEE Seventh International Conference on e-Science Workshops*, pages 61–65. IEEE, December 2011.
- [19] Schahram Dustdar, Reinhard Pichler, Vadim Savenkov, and Hong-Linh Truong. Quality-aware service-oriented data integration: Requirements, state of the art and open challenges. *SIGMOD Rec.*, 41(1):11–19, April 2012.
- [20] Ghada ElSheikh, Mustafa Y. ElNainay, Saleh ElShehaby, and Mohamed S. Abougabal. SODIM: Service Oriented Data Integration based on MapReduce. *Alexandria Engineering Journal*, 52(3):313–318, September 2013.
- [21] Hector Gonzalez, Alon Halevy, Christian S. Jensen, Anno Langen, Jayant Madhavan, Rebecca Shapley, and Warren Shen. Google fusion tables: Data management, integration and collaboration in the cloud. In *Proceedings of the 1st ACM Symposium on Cloud Computing*, SoCC '10, pages 175–180, New York, NY, USA, 2010. ACM.
- [22] Hector Gonzalez, Alon Y. Halevy, Christian S. Jensen, Anno Langen, Jayant Madhavan, Rebecca Shapley, Warren Shen, and Jonathan Goldberg-Kidon. Google fusion tables: Web-centered data management and collaboration. In *Proceedings of the 2010 ACM SIGMOD International Conference on Management of Data*, SIGMOD '10, pages 1061–1066, New York, NY, USA, 2010. ACM.
- [23] Xin Hong and ChunMing Rong. Multiple Data Integration Service. In *2014 28th International Conference on Advanced Information Networking and Applications Workshops*, pages 860–865. IEEE, May 2014.
- [24] Herald Kllapi, Dimitris Bilidas, Ian Horrocks, Yannis E. Ioannidis, Ernesto Jiménez-Ruiz, Evgeny Kharlamov, Manolis Koubarakis, and Dmitriy Zheleznyakov. Distributed query processing on the cloud: the optique point of view (short paper). In Mariano Rodriguez-Muro, Simon Jupp, and Kavitha Srinivas, editors, *Proceedings of the 10th International Workshop on OWL: Experiences and Directions (OWLED 2013) co-located with 10th Extended Semantic Web Conference (ESWC 2013), Montpellier, France, May 26-27, 2013.*, volume 1080 of *CEUR Workshop Proceedings*. CEUR-WS.org, 2013.
- [25] Maurizio Lenzerini. Data integration: A theoretical perspective. In *Proceedings of the Twenty-first ACM SIGMOD-SIGACT-SIGART Symposium on Principles of Database Systems*, PODS '02, pages 233–246, New York, NY, USA, 2002. ACM.
- [26] Asfia Mubeen, Mohd Murtuza Ahmed Khan, and Sana Mubeen Zubedi. Web Service Integration Using Cloud Data Store, 2012.
- [27] Tiezheng Nie, Guangqi Wang, Derong Shen, Meifang Li, and Ge Yu. Sla-based data integration on database grids. In *Computer Software and Applications Conference, 2007. COMPSAC 2007. 31st Annual International*, volume 2, pages 613–618, July 2007.
- [28] Massimiliano Rak, Neeraj Suri, Jesus Luna, Dana Petcu, Valentina Casola, and Umberto Villano. Security as a Service Using an SLA-Based Approach via SPECS. In *2013 IEEE 5th International Conference on Cloud Computing Technology and Science*, volume 2, pages 1–6. IEEE, December 2013.
- [29] Andreas Thor and Erhard Rahm. Cloudfuice: A flexible cloud-based data integration system. In Sören Auer, Oscar Díaz, and GeorgeA. Papadopoulos, editors, *Web Engineering*, volume 6757 of *Lecture Notes in Computer Science*, pages 304–318. Springer Berlin Heidelberg, 2011.

- [30] Yuan Tian, Biao Song, Jimuping Park, and Eui-Nam Huh. Inter-cloud data integration system considering privacy and cost. In Jeng-Shyang Pan, Shyi-Ming Chen, and NgocThanh Nguyen, editors, *Computational Collective Intelligence. Technologies and Applications*, volume 6421 of *Lecture Notes in Computer Science*, pages 195–204. Springer Berlin Heidelberg, 2010.
- [31] Yanxia Wang. Research on web data integration framework based on cloud computing. In *2012 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet)*, pages 2823–2826. IEEE, April 2012.
- [32] S.S. Yau and Yin Yin. A privacy preserving repository for data integration across data sharing services. *Services Computing, IEEE Transactions on*, 1(3):130–140, July 2008.
- [33] Peng Zhang, Yanbo Han, Zhuofeng Zhao, and Guiling Wang. Cost Optimization of Cloud-Based Data Integration System. In *2012 Ninth Web Information Systems and Applications Conference*, pages 183–188. IEEE, November 2012.