Towards a Comprehensive Purchasing Model for Cloud Services[⋆]

Octavio Martín-Díaz, Pablo Fernandez, José María García, and Antonio Ruiz-Cortés

Dpto. Lenguajes y Sistemas Informáticos
ETS. Ingeniería Informática – Universidad de Sevilla
41012 Sevilla, España – Spain
omartindiaz@us.es, pablofm@us.es, josemgarcia@us.es, aruiz@us.es

Abstract. The Cloud Service Market has evolved into a complex landscape that challenges the decision making of users as they develop their purchasing process. In particular, we explore the case of cloud infrastructure (IaaS) providers as an example of heterogeneous variety of purchasing options and discounts; this variability represents an important drawback during the decision making process where there is a need to compare and select the best option. In this work, we define a common model to describe purchasing models from different providers taking into account such heterogeneity. This purchasing model represents a first step towards the automated support of decision making problems during the purchasing process. In order to illustrate our approach we apply the model in a real case study of IaaS purchasing.

Keywords: Cloud Services, Purchasing Options, Decision Making

1 Introduction

In the last years, the proliferation of cloud services is gathering pace as the Software-as-a-Service model is becoming the predominant architectural paradigm. Amongst these services, the Infrastructure-as-a-Service (IaaS) case is one of the most successfull cases where providers compete to offer competitive purchasing options. Specifically, IaaS purchasing aims to obtain virtual processing and storage resources from a Cloud provider, as a cheaper alternative for the procurement of on-premise, private computer infrastructures. In the typical purchasing scenario, the providers offer their purchasing options, so that the users' goal is to search and select "*the best one*" for their requirements.

Purchasing options put together configurations and their price for using for a period of time. It may include volume storage, data transfer, security, IP and load

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balancing, together with a myriad of other properties. This results in a highly configurable service, since the actual number of combinations can be overwhelming [5]. Moreover, the purchasing options have a high degree of variability since most of providers publish their own purchasing options in different ways. As a consequence, such a variability represents a challenge to purchasing, monitoring, and billing in order to get the total price to charge, that should take into account the different configurations purchased, the purchasing dynamics themselves (when and how the purchase was developed), and the potential discounts that should be applied.

In this context, in order to assist the purchasing process and estimate the potential costs there is a need of techniques and tools to support the great deal of variability amongst different providers. Currently, there are some tools implementing the search of an optimal configuration like CloudScreener[1] or several configurations for independent instances, like Cloudorado[2]. However, these tools provide a simplified comparison that does not include a comprehensive purchasing options but a subset of it (e.g. they do not include any discount modeling).

In this paper, we define a comprehensive model of purchasing options to find a commonality in different providers in order to provide support for a complete comparisons amongst IaaS offerings; this model represents a first step towards an automated support of the purchasing process.

The remaining text is organized as follows. Sect. 2 introduces the purchasing process, in order to characterize the problem. Next, Sect. 3 and 4 present the purchasing model for automating the purchasing process and a case of study for illustrative purpose. Later, Sect. 5 comments the related work. Finally, Sect. 6 presents our conclusions and future work.

2 Purchasing in IaaS

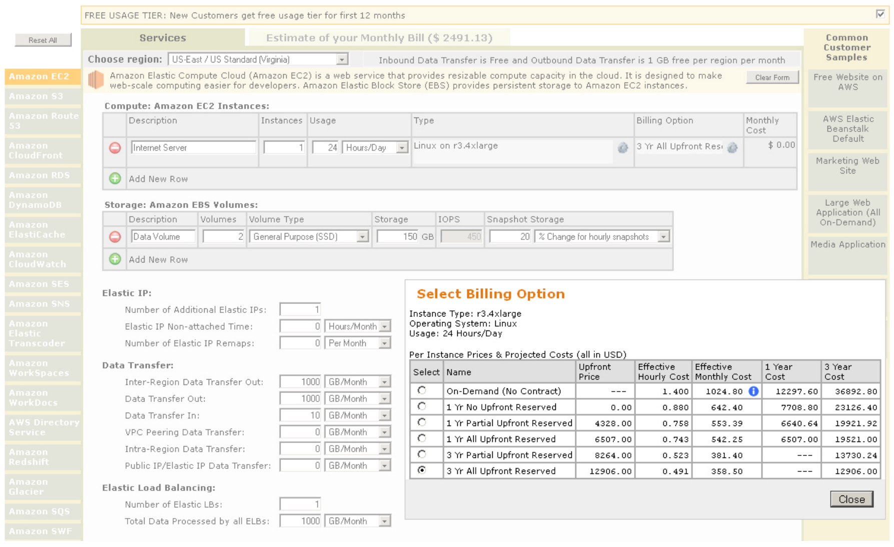
The purchasing process of cloud services consists of several steps: First, a user searches for the information published from different providers, going through the pricing they offer for purchasing different instance configurations. Next, once the provider is selected, the user purchases a number of instances in order to support its own business process. Periodically, the user is charged for the usage of the purchased instances, so that some discounts may be applied if certain conditions are fulfilled. In addition, payments in advanced and commitment to use a number of instances may make the user be eligible for much greater discounts.

The most common type of purchasing is on demand (i.e. the user only pays for the actual usage) without obligations or contractual relationship[3]. Pricing is usually specified as follows: (i) the configuration of instances includes properties such as the CPU number and type, the size of and storage, the operating system,

[1] See `http://www.cloudscreener.com/` for details.

[2] See `http://www.cloudorado.com/` for details.

[3] There are other types of purchasing, which are out of scope of the paper. As an example, Amazon also offers (i) spot instances, (ii) dedicated instances, and (iii) reserved instances.



FREE USAGE TIER: New Customers get free usage tier for first 12 months

Estimate of your Monthly Bill ($ 2491.13)

Choose region: US-East / US Standard (Virginia)

Inbound Data Transfer is Free and Outbound Data Transfer is 1 GB free per region per month

Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers. Amazon Elastic Block Store (EBS) provides persistent storage to Amazon EC2 instances.

Compute: Amazon EC2 Instances:

Description	Instances	Usage	Type	Billing Option	Monthly Cost
Internet Server	1	24 Hours/Day	Linux on r3.4xlarge	3 Yr All Upfront Res	$ 0.00

Storage: Amazon EBS Volumes:

Description	Volumes	Volume Type	Storage	IOPS	Snapshot Storage
Data Volume	2	General Purpose (SSD)	150 GB	450	20 % Change for hourly snapshots

Elastic IP:

Number of Additional Elastic IPs:	1	
Elastic IP Non-attached Time:	0	Hours/Month
Number of Elastic IP Remaps:	0	Per Month

Data Transfer:

Inter-Region Data Transfer Out:	1000	GB/Month
Data Transfer Out:	1000	GB/Month
Data Transfer In:	10	GB/Month
VPC Peering Data Transfer:	0	GB/Month
Intra-Region Data Transfer:	0	GB/Month
Public IP/Elastic IP Data Transfer:	0	GB/Month

Elastic Load Balancing:

Number of Elastic LBs:	1	
Total Data Processed by all ELBs:	1000	GB/Month

Select Billing Option

Instance Type: r3.4xlarge
Operating System: Linux
Usage: 24 Hours/Day

Per Instance Prices & Projected Costs (all in USD)

Select	Name	Upfront Price	Effective Hourly Cost	Effective Monthly Cost	1 Year Cost	3 Year Cost
○	On-Demand (No Contract)	---	1.400	1024.80	12297.60	36892.80
○	1 Yr No Upfront Reserved	0.00	0.880	642.40	7708.80	23126.40
○	1 Yr Partial Upfront Reserved	4328.00	0.758	553.39	6640.64	19921.92
○	1 Yr All Upfront Reserved	6507.00	0.743	542.25	6507.00	19521.00
○	3 Yr Partial Upfront Reserved	8264.00	0.523	381.40	---	13730.24
●	3 Yr All Upfront Reserved	12906.00	0.491	358.50	---	12906.00

Fig. 1. Snapshot of the Amazon EC2 calculator

or the region on which the instance is executed, and (ii) the pricing is given in a tabular form whose columns are the configuration properties. Each row corresponds to a configuration and its basic price for a unit of time, either an hour or a month. Most of providers have a calculator in order to help users to select their preferred configurations. As an example, Fig. 1 depicts the case of the EC2 Calculator that is provided by Amazon in order to estimate the cost of a particular purchasing option (note the number of properties, denoting a highly configurable service).

From the purchasing dynamic perspective, Fig. 2 shows a simplified model in BPMN for the billing cycle that specify the different activities that correspond with charges or monitoring processes joint with the different events that are relevant. During a billing cycle, the monitoring of usage to be charged is usually done by counting hours or minutes, so that the total price to be charged is computed according to such usage; in some cases, providers define a minimum period of usage to be charged (e.g. Google establishes 10 minutes). In all the studied cases, the billing cycle duration corresponds with one month but there is a certain variability depending on the billing day, which could correspond with either a natural day (i.e. a given day on the calendar, usually the first), or the anniversary day (i.e. the day of the month in which the user began the contractual relationship).

In this billing cycle model, the events are associated with three different charges: First, on the contract event, one-time payments in advance may be charged (e.g. Rackspace prepayments, or Amazon reservation upfronts); next, on the billing cycle begin event, recurring payments in advance may be charged

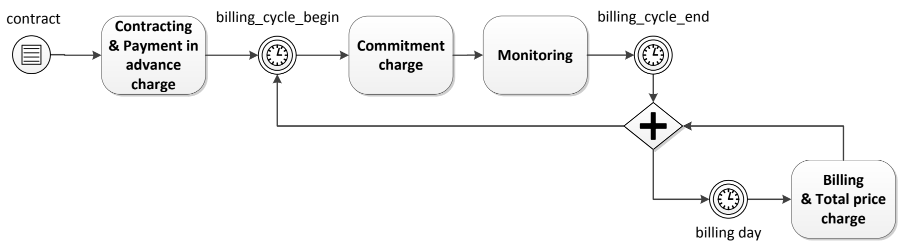


Fig. 2. Simplified purchasing process with regards to the billing cycle

(e.g. Rackspace commitments); finally, on the billing cycle end event (or billing for short), the total price is usually charged.

In addition to the base prices of the purchasing options, providers may offer a variety of different discount programs. In order to exemplify the variability of the discounts models, in the following we describe three different cases:

- Amazon offers the *reserve instance volume discounts* program[4]. On purchasing a large amount of reserved instances, if the total list price exceeds a given threshold, the user will be eligible for savings (on both upfronts and base prices) in the reservations of instances above such threshold. The total list price is the expected expense obtained by summing up the costs due to (1) the current purchasing, and also (2) all non-expired reservations, including both upfronts and monthly charges.
- Google offers the *sustained use discounts* program[5] based on the actual usage of instances. The user is eligible for incremental discounts according to the usage thresholds which had been reached.
- Rackspace offers up to three discount programs[6]: (i) Volume discount, i.e. *spend more and save*. On billing, savings are applied according to the current charge; (ii) Commitment discount, i.e. *commit to a term, save even more*. The user commits to spend an amount for a term, being eligible for greater savings, according to the commitment amount and the duration of term. On the beginning of each billing cycle, the user is charged for the commitment amount, being savings applied (if any). On billing, the user is monthly charged the spent over, that is to say, the exceeds over the commitment amount. Volume discounts can be in turn applied on spent over, provided that conditions are fulfilled. (iii) Prepayment discount, i.e. *prepay for the entire term, save the most*. The user prepays the total amount com-

[4] See `http://aws.amazon.com/ec2/purchasing-options/reserved-instances/` for details on Amazon reserved instances volume discounts.

[5] See `https://cloud.google.com/compute/pricing` for details on Google sustained use discounts.

[6] See `http://www.rackspace.com/cloud/servers/discounts` for details on Rackspace discounts for cloud servers.

mitted for a term, being eligible for greatest savings. On billing, the user is monthly charged the spent over, that is to say, the exceeds over the commitment amount. Volume discounts can be in turn applied on spent over, provided that conditions are fulfilled. In all cases, savings are set by means of a logarithmic scale according to the total amount which is being charged.

3 Purchasing Model

Figure 3 shows our purchasing model consisting of five different modules: configuration, pricing, monitoring, billing, and discounts. These modules and their interdependencies support the whole purchasing process, as described in Sec. 2.

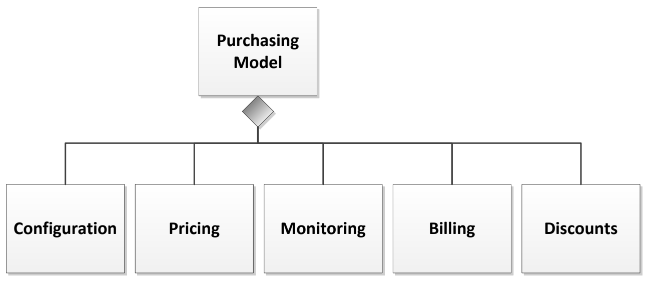


Fig. 3. Simplified model for purchasing model

The configuration module provides facilities to describe computational characteristics of cloud services, so that we can define which particular IaaS instance we are interested in with respect to its instance type (i.e. CPU, memory, storage and other computational features), its operating system, and the region to be deployed in, among other characteristics. Depending on the instance configuration, the pricing module can be used to describe all the pricing options offered by a cloud service provider, whereas the monitoring module registers the actual usage of that instance, and hence enabling the total pricing to be computed. Figure 4 shows a conceptual global view of these three modules, including the relationships between the main concepts of those modules, depicted with a gray background. Empty arrows represent *is-a* relationships (e.g. a Base Price is a Price), diamonds associate a compound with its components (e.g. Configuration is composed of Instance Type, Region and Operating System), and filled arrows show uni-directional dependencies (e.g. the Total Pricing depends on the Base Pricing, the Extra Price, and the Usage Time).

Focusing on the pricing module, the Base Pricing for purchasing instances relates an instance Configuration and a Purchasing Option with a Base Price. The Base Price Rate, which establishes how often the Base Price is charged,

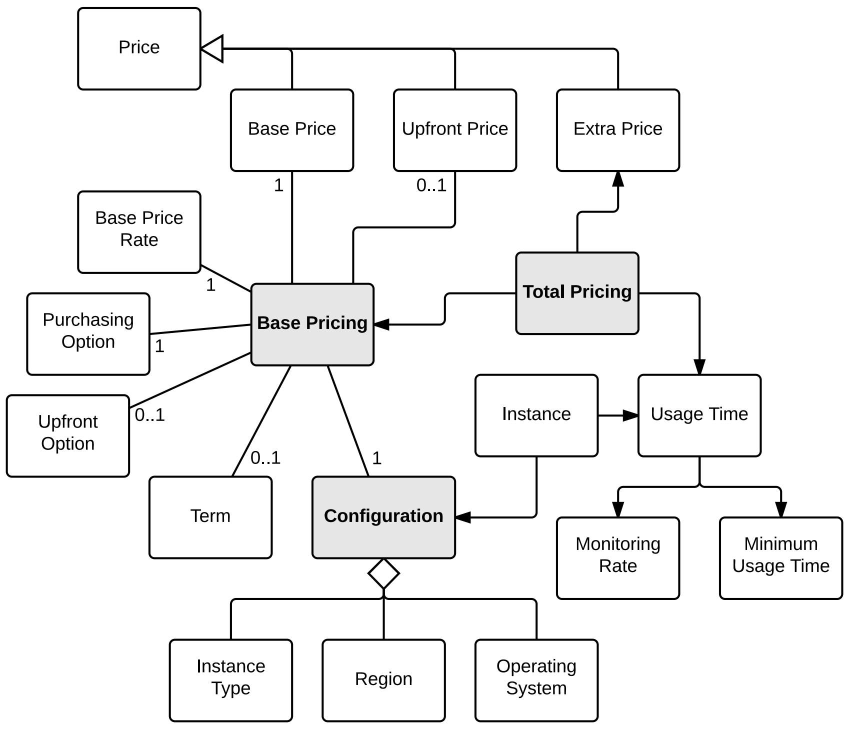


Fig. 4. Conceptual model for configuration, pricing, and monitoring

is also specified, since some purchasing models offer different prices for each available rate. Optionally, depending on the purchasing option chosen (e.g. *on demand* or *reserved* in Amazon EC2), an Upfront Price can be established, which will depend in turn on the actual Upfront Option chosen (e.g. one can choose from none, partial or total upfront payment in Amazon EC2) and on the contract Term (i.e. the number of months or years that the contract will last). Extra price refers to those properties which are not included in the configuration by all providers, such as region or operating system, but their prices are given apart.

Monitoring can be carried out either hourly or minutely, and a minimum time charged can be added. For each instance, the number of hours or minutes of usage is monitored. This usage time, along with the base pricing applied plus the extra costs are used to compute the total pricing that will be billed.

Although not shown in Fig. 4, the billing module describes the billing cycle period, which is usually a month, so that the billing day can be either a natural day or the anniversary day. Different kinds of charges can be identified. First, the total price obtained from the monitoring module, which is the payment per usage at the end of a billing cycle. Second, a payment in advance, which is a one-time or recurring payment that corresponds to a flat rate per usage. And finally, a commitment charge, which is not properly a payment, but a obligation to make it in due time. The events when these charges can be applied are (1) the contract, (2) the begin of the billing cycle, and (3) the end of the billing cycle, or simply billing event.

Finally, the discounts module uses several types variables obtained from previous modules, such as the monitored usage of instances, the expected expense, the different charges, and the savings for discounts to be applied. We define the discounts by means of ECA rules (event, condition, action rules), as shown in the example in Fig. 5. Each ECA rule consists of:

- The event of a billing cycle which triggered it, in order to define the instant in which the discount is to be set, or applied, or both.
- The condition on variables to be fulfilled for the action to be effective.
- The action can consist of (1) setting the savings (on contract), or (2) applying the savings (on the current charge), or (3) both.

ON RESERVATION
IF TOTAL_LIST_PRICE >= $500000
THEN SET SAVINGS = 5% **FOR** USER

ON RESERVATION
IF TOTAL_LIST_PRICE >= $4000000
THEN SET SAVINGS = 10% **FOR** USER

Fig. 5. ECA Rules for Amazon discounts

4 Case of Study

In order to illustrate the purchasing process, we introduce the following case of study of a user with demanding requirements of computing which purchases some Amazon EC2 reserved instances according to the following scheduling:

- On January the 15th, the user reserves 10 instances of the "d2.8xlarge" configuration for a year. It is published in the website to have 36 virtual CPUs, 116 ECUs (EC2 computed unit), memory of 255 GiB, storage of 24 per 2000 Gb HDD, with Linux operating system, deployed in the East US Region. Its reservation has an all upfront of $23616 and monthly price of $0, for a full amount of $236160.
- On March the 15th, the user reserves another 20 instances of the "d2.8xlarge" configuration for a year, for a full amount of $472320.

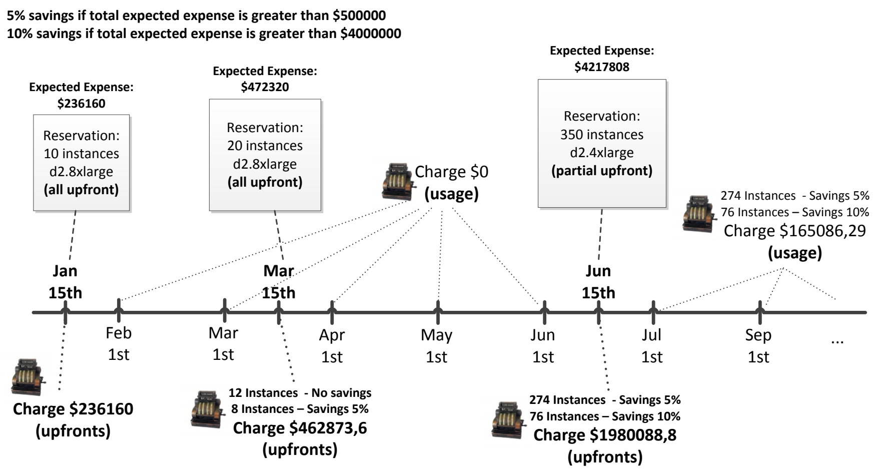

5% savings if total expected expense is greater than $500000
10% savings if total expected expense is greater than $4000000
Expected Expense: $236160
Reservation: 10 instances d2.8xlarge (all upfront)
Expected Expense: $472320
Reservation: 20 instances d2.8xlarge (all upfront)
Charge $0 (usage)
Expected Expense: $4217808
Reservation: 350 instances d2.4xlarge (partial upfront)
274 Instances - Savings 5%
76 Instances – Savings 10%
Charge $165086,29 (usage)
Jan 15th
Mar 15th
Jun 15th
Feb 1st
Mar 1st
Apr 1st
May 1st
Jun 1st
Jul 1st
Sep 1st
...
Charge $236160 (upfronts)
12 Instances - No savings
8 Instances – Savings 5%
Charge $462873,6 (upfronts)
274 Instances - Savings 5%
76 Instances – Savings 10%
Charge $1980088,8 (upfronts)

Fig. 6. Amazon discounts case of study

– On June the 15th, the user reserves 350 instances of the "d2.4xlarge" configuration for a year. It is published to have 16 vCPUs, 56 ECUs, memory of 122 GiB, storage of 12 per 2000 Gb HDD, with Linux operating system, deployed in the East US Region. Its reservation has a partial upfront of $6024 and monthly price of $502,24 for a full amount of $4217808.

In Amazon, the discount rule is only triggered on reservation (a *contract event*). The billing cycle events, as depicted in Fig. 6, occur as follows:

– On January the 15th, the reservation date, the user will be immediately charged for $236160.
  • As no threshold for discounts is reached, the rule condition is not fulfilled, then the discount rule action is not executed.
– On February and March the 1st (a pair of *billing day events*), the user will not be charged any amount since the monthly price was $0.
– On March the 15th, another reservation date, the user will be immediately charged for $462873,6 which corresponds to:
  • For the first 12 instances, the charge is for $283392. In full, the user sums up a total expected expense of $519552:
    ∗ The first threshold for discounts is reached, thus the rule condition is fulfilled. Then the discount rule action is executed so the user becomes eligible for savings of 5% in subsequent reservations (contracts).
  • For the remaining 8 instances, the user is charged for only $179481,6 after savings of 5% had been applied.
– On April, May, and June the 1st, (some *billing day events*), the user will not be charged any amount since the monthly price was $0.

- On June the 15th, another reservation date, the user will be immediately charged for \$1980088,8 which corresponds to:
  - For the first 274 instances, the charge is for only \$1568047,2 after savings 5% had been applied. In full, the total expected expense is of \$4010421,1:
    - The second threshold for discounts is reached, thus the rule condition is fulfilled. The discount rule action is executed so the user becomes eligible for savings of 10% in subsequent reservations (contracts).
  - For the remaining 76 instances, the user is charged for only \$412041,6 after savings of 10% had been applied.
- From July the 1st on (this and subsequent *billing day events*) the user will be charged monthly for \$165086,29 which corresponds to:
  - For 274 instances, the user is charged for \$130733,07 after savings of 5% had been applied.
  - For 76 instances, the user is charged for \$34353,22 after savings of 10% had been applied.

5 Related Work

A purchasing model involves a characterization of the cloud services description and the purchasing process. In this context, the problem of service description modelling has been extensively addressed in the literature from semantic driven approaches [9] to traditional interface-driven alternatives [3]; in both cases, the combination of functional and non-functional service properties and configurations have been also developed in different formal languages [1, 6]. Traditionally, the applicability of these models to different scenarios were either simplified prototypes or intra-organizational scenarios whose pricing models were simplified to a single cost property in most of cases and, to the best of our knowledge, no formal characterization of complex purchasing models has been developed. As an example, in [11], authors present a formal language for cloud services with a pricing model that does not include a variable purchasing process nor extensible discount rules. As we introduce in this work, an analysis of a real open market of services (i.e. the cloud service market) shows a complex variability of purchasing models where the processes vary and different combinations of purchasing options arise; in particular there is a rich combination of discount rules in the different providers studied. Similar limitations can be found in other related works such as [8] where authors present an initial review of different pricing models for cloud services that shows simple cost model scenarios but elements such as purchasing processes variability or discounts are not discussed.

The purchasing problem can be also analyzed from other perspectives. From an economic perspective, some studies on the cost of cloud services have been developed [2, 4, 10]; these works focus on the analysis of investments to support the decision making during the purchasing process but they do not address how the different purchasing options are formally expressed. From a quality perspective, in [7] authors provide a comprehensive model to automate the ranking of different providers but define a simplified version of cost and do not introduce a real purchasing option variability in their scenario.

6 Conclusions and Future Work

While the Cloud Computing Market is growing, the purchasing model is becoming increasingly complex. Specifically, the process of selecting and comparing offers from different providers result in a time-consuming and error-prone task. In this paper we aim to establish a first step towards the automation of the support in the purchasing process. To this end, this paper outlines a comprehensive purchasing model for Cloud Infrastructure that takes into account all the aspects included in real-world offerings.

Some consequent actions are foresight as future work, specifically: to design a concrete language to help in the modeling phase; to develop a set of tools for analyzing the model and provide an automated the comparison among different offers; finally we will study the applicability of this model as part of a more general idea of service level agreement that has being addressed by authors in previous works.

References

[1] Alain Andrieux *et al.* Web services agreement specification (WS-Agreement). In *Open Grid Forum*, volume 128, 2007.

[2] Slaven Brumec and Neven Vrček. Cost effectiveness of commercial computing clouds. *Information Systems*, 38(4):495–508, 2013.

[3] Erik Christensen, Francisco Curbera, Greg Meredith, Sanjiva Weerawarana, et al. Web services description language (WSDL) 1.1, 2001.

[4] Se-Hak Chun and Byong-Sam Choi. Service models and pricing schemes for cloud computing. *Cluster Computing*, 17(2):529–535, 2014.

[5] Jesús García-Galán, Pablo Trinidad, Omer F. Rana, and Antonio Ruiz-Cortés. Automated Configuration Support for Infrastructure Migration to the Cloud. *Future Generation Computer Systems*, 2015.

[6] José María García, Carlos Pedrinaci, Manuel Resinas, Jorge Cardoso, Pablo Fernandez, and Antonio Ruiz-Cortés. Linked USDL agreement: Effectively sharing semantic service level agreements on the web. In *IEEE 22nd International Conference on Web Services (ICWS)*, pages 137–144. IEEE, 2015.

[7] Saurabh Kumar Garg, Steve Versteeg, and Rajkumar Buyya. A framework for ranking of cloud computing services. *Future Generation Computer Systems*, 29(4):1012–1023, 2013.

[8] Sahil Kansal, Gurjeet Singh, Harish Kumar, and Sakshi Kaushal. Pricing models in cloud computing. In *ACM International Conference on Information and Communication Technology for Competitive Strategies (ICTCS)*, page 33, 2014.

[9] Carlos Pedrinaci, Jorge Cardoso, and Torsten Leidig. Linked USDL: a vocabulary for web-scale service trading. In *The Semantic Web: Trends and Challenges*, pages 68–82. Springer, 2014.

[10] Bhanu Sharma, Ruppa K Thulasiram, Parimala Thulasiraman, Saurabh K Garg, and Rajkumar Buyya. Pricing cloud compute commodities: a novel financial economic model. In *12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGRID)*, pages 451–457, 2012.

[11] Rafael B. Uriarte, Francesco Tiezzi, and Rocco De Nicola. SLAC: A formal Service-Level-Agreement Language for cloud computing. In *IEEE/ACM th Int. Conf. on Utility and Cloud Computing (UCC)*, pages 419–426, 2014.