Cloud Resource Price System

Sururah A.Bello
Computer Science & Engineering Department
Obafemi Awolowo University
Ile-Ife, Nigeria
sbello@oauife.edu.ng

Claudia Lüthje, Christoph Reich
Cloud Research Lab
Furtwangen University
Furtwangen, Germany
{claudia.luethje, christoph.reich}@hs-furtwangen.de

***Abstract*—Cloud Resource pricing has been known to be static. The rapid nature of resource deployment gave the impression that differential pricing might not be possible. This study shows how various factors (e.g., Social User Status, Cloud Provider Reputation, SLA Type, etc.) can be greatly used to achieve a dynamic pricing system in Cloud provisioning. An architecture of a resource price expert system has been developed, that combines mathematical relations, IF-clauses and Neural Networks to achieve a resource price model for cloud systems. Based on use cases the effectiveness of this solution is shown.**

Keywords*—*Cloud Computing; Price Models; Expert System

I. INTRODUCTION

No doubt, the PC and the Internet brought about an information revolution by making information universally accessible and affordable.

Cloud computing is a computation revolution, that gives users the possibility to access and utilize massive amounts of processing power and computer resources [1]. For example Amazon offers currently a machine with 613MB RAM [2] for 2 cents per hour, and there exist even cheaper offers from other providers. These prices are very small compared to the cost of a computer system. Thus cloud computing enables large computation affordable and universally accessible.

However, the computation revolution has to be realized with appropriate business models that will make the economic case prevail and thus make cloud computing a consumer commodity. Payment for Internet services has traditionally favored the flat pricing mechanism [3], which is basically monthly and lately hourly subscription (pay-per-use). According to [4], this static model of pay-per-use and subscription pricing allows easy prediction of payments. However Lai [5] found that dynamic pricing policies could achieve more economically efficient allocations and prices for high-value services. The ability of cloud providers to attract more cloud users by employing dynamic pricing through the offering of customized pricing models for the same product for different customers could translate into more income for the providers.

In this paper, a new concept of building a pricing model will be shown. Also the use of additional fuzzy information about the customer will be investigated as input parameters for the fair and economical price model. To create such an dynamical pricing model, artificial intelligence offers various techniques. An evaluation of neural networks has brought out to be the best solution. This method has been proven to be successful in the past.

After discussing related work in the next section, the remainder of this paper is structured as following. Section III will discuss what is influencing the price of a cloud resource in general. Section IV gives a detailed description of the architectural design of the price module, which is evaluated by use cases in section V. In section VI, a conclusion is drawn.

II. RELATED WORK

The current static pricing in Cloud Computing basically employs consumption patterns for pricing i.e., a fixed price for a fixed quantity per hour. Even though a number of variations are being introduced, like Amazon offering the opportunity to reserve machines in advance with an upfront payment which then grants an discount during usage, the basic model remains static.

Strømmen-Bakhtiar has discovered that there is a tendency for customers to think that paying the same price as in th beginning after a period is not cost effective. Perceived fairness in pricing significantly relates to emotions, and emotions similarly affect behavioral responses. This means perceived unfairness can lead to distrust and diminished shopping intentions both off and on the Internet. When consumers perceive price unfairness they feel negative emotions like anger, outrage, disappointment and may not repeat purchase.

Lai delivered, with an empirical study, evidence that various types of differential pricing tactics can have a significant impact on consumers' perception of price fairness. In addition it has been shown that employing dynamic pricing through offering customized pricing for the same product for different customers could translate into more income [5]. Differential pricing strategy involves charging varying prices for the same product based on some characteristics of the customer or the product.

Miyazaki [7] identified some differential pricing tactics that are available to Internet stores: buyer identification, time of purchase, purchase quantity, and asset/usage. In an other paper [8] this was extended to pricing of Cloud Computing since Cloud Computing is also a business transacted over Internet infrastructure like the Internet stores. No doubt there is a need to develop appropriate business models that will continuously make Cloud Computing more attractive to users. Therefore business models have to be created which transform cloud computing to a pure consumer commodity. In this paper we present a further pricing scheme for a customer specific business model. Against four factors proposed in [8], a number of factors have been considered here to be influential

 ISBN: 978-1-61208-357-5

in developing customer centric Business model for Cloud Computing.

III. Cloud Resource Price Influence Factors

Several factors have been identified which influence the price of cloud services. For this a classification in fixed and variable factors was created. As an fixed factor things like the cost of operating the data center can be seen. Examples for variable factors are; Social Category of a User, Cloud Providers Reputation, Type of Service Level Agreement (SLA), the Reputation of a User, Availability of Monitoring Services, Public Review and Type of Co-Cloud Users. An overview of these factors can be seen in Fig. 1. Subsequently, the respective factors are described in more detail.

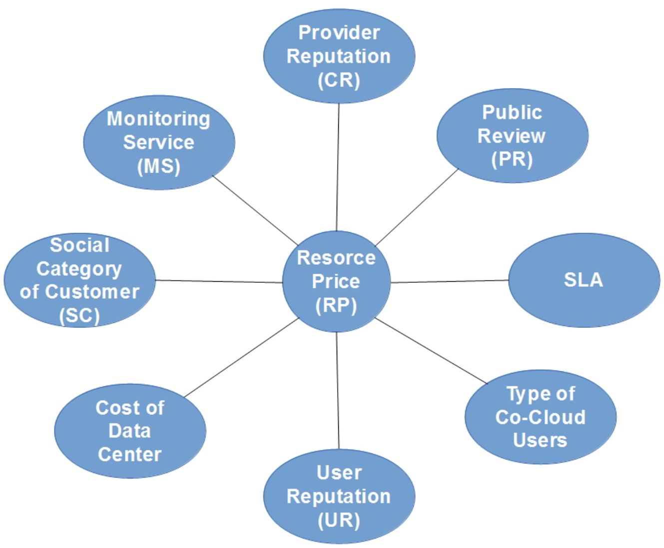

Fig. 1: Factors Influencing the Price of Cloud Resources

A. Cost of Data Center

According to [9], the following entities make up the cost of the data center. The cost of real estate, power from the grid, backup power (generators and batteries) maintenance of backup power, cooling resources, maintenance of cooling resources, security, network connectivity and fire safety. The cost may vary from location to location but are fixed for a particular location.

B. Social Category of Customers (SC)

A fair price should be charged to everyone. But the price should be adjusted for the different needs thus medical doctors may charge different fees to different patients [10]. Thus it is established that a price differential may be on account of the social status of a consumer. Social classifications of users is done here and presented with corresponding pricing scenarios. An adjusted price may be proffered for a cloud user perceived to be in need, in this case classified as a poor user. Classification can be based on the location of the consumer. The pricing of a hotel room in a downtown area might be different from a similar room in a resort. In countries like Nigeria if a company is situated in the nation's capital, it is perceived to be a rich company. Hence location could be used to classify cloud users. The year of operation can also be used to determine the stability hence the ability of a company. Magazine publishers offer price promotions to new subscribers to enhance their purchase intention. So a company that has existed for some years can be seen to be stable hence classified as being rich. Thus the year of operation is employed for social status in this work. A company of less than 2 years is categorized as *New*, those between 2 and 4 years as *Middle* and above 4 years are taken as *Old*.

C. Cloud Provider's Reputation (CPR)

Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another. A single violation of trust can destroy years of slowly accumulated credibility. There are a number of ways to establish online trust [11]. Reputation is a component of online trust [12] and it also measures reliability. Reputation is the belief by the community of an entity's stand. Using Cloud infrastructure for critical business computation necessitate that the reputation of the Cloud provider is well established. A single publicized unethical activity could create uncertainty that could tarnish a longterm reputation. The Amazon botnet is a major compromise of a cloud provider. Company's reputation could be in terms of success rate of transactions [13] and confidentiality of user's data. Record of Cloud providers experience could serve as certificate of credibility for future patronage. Hence, a Cloud Provider's reputation can be greatly used to negotiate prices for cloud services. Provider's Reputation could be quantified using: Record of Past Experience and Record of Compensation in case of problem. This study uses these two to express the reputation of Cloud Providers.

D. SLA

As guarantees for service delivery SLAs are negotiated between the Cloud Providers and Cloud Consumers. Most often SLAs are dictated by the Cloud Providers [14]. Providers usually have fixed templates of SLAs where cloud users are expected to pick from. There is opportunity to also negotiate SLA online as reported in [15], where cloud user could be allowed to specify customized SLA at a price. Therefore the type SLA could be used to influence the price to charge.

E. Users Reputation

The nature of multi-tenancy in Cloud Computing demands that users should have a positive reputation. Sniffing programs, Trojans, Ill motive, Attacker and Hackers from the users end can endanger the Cloud [16]. Social engineering attacks remain effective - one exploit tried to convince Amazon Elastic Compute Cloud (EC2) users to run malicious virtual machine images simply by giving the image an official sounding name, such as "fedora core". It's apparent that not only the data and software is worth protecting in the Cloud but also the activity patterns. Activity patterns could constitute confidential business information [1]. Users reputation could be quantified with the physical address (UPL), the police records of criminality (UCR) and also users bank details (UBR) of financial stability as banks don't give credit to bankrupt customers. This study considered the three of users reputation.

F. Availability of Monitoring Services (MS)

Few Cloud Providers have the confidence to provide customers with monitoring tools for service availability. Rackspace Inc., GoGrid or ZOHO are offering 24/7 customer support for free. However, Microsoft or Amazon is more inclined to provide paid customer support. Google's attitude is more likely: "Cloud it on your own" towards customers. Independent monitoring is largely missing except for Gomez Inc. and Hyperic Inc. that offer services for monitoring providers, SLA compliance and elasticity. Hence a good means for negotiating customer friendly pricing could be availability of proper monitoring devices. Monitoring services could either be from the provider itself or a third party.

G. User's Recommendation, Feedback and Public Review(PR)

Commoditization of Cloud services must emphasize users rights to have a voice. Public reviews on issues such as downtime, phishing [17], data loss, password weakness can be valuable in pricing of cloud services. User ratings is employed in this study, as done by Airline Operators (from 1 to 5): *1-Excellent*, *2-Very Good*, *3-Good 4-Fair* and *5-Bad*

H. Co-Cloud Users

The nature of multi-tenancy in a Cloud could enable competitive companies to use the same Cloud platform. There may emerge clash of interest, fear of possible leakage of confidential business information, loss of privacy, risk of data theft [12]. Multi-tenants on cloud infrastructure has introduced non-obvious threats as a result of sharing physical resources between VMs [18]. Hence information about co-tenants in the Cloud can be used to influence service price. No matter how cheap the cloud service is, the presence of a business competitor may scare off similar companies. In the same vein, a cloud provider may offer a high cost in exchange for a deal not to host a competitive company.

IV. ARCHTECTURE OF THE CLOUD PRICE MODULE

To get a most variable price solution for the customer and the provider, a number of data has to be collected and evaluated. The information is combined as shown in the following Figure.

There are two major interfaces: The *customer interface* and the *provider interface* to supply the information, from which the price is determined. On both interfaces the parameters are divided into fixed and variable cost parameters. The interface of the customer requires information about which resources the customer requires, which are fix parameters like the storage size, CPU and RAM and variable parameters like the storage place and runtime. Also the provider interface has input values. There the fix costs are CPU and RAM and the variable costs are defined as categories and reputation. This means the variable costs directly depend on the status of a customer. At the *customer interface* different parameters are influencing the price for Cloud. SLA specific parameters are modelled as XML using the Adaptable Service Level Objective Agreement (A-SLO-A) language [15].

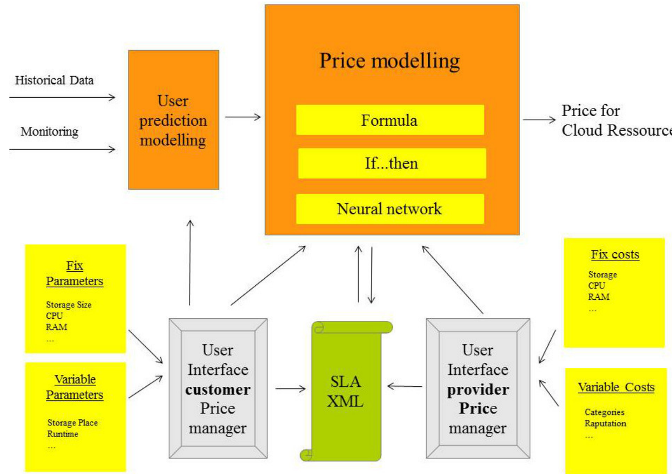

Fig. 2: Architecture of the Cloud Resource Price System

A. Mathematical Model

First of all the fixed costs or parameters are calculated by mathematical formulas. Then the costs based on the input parameters will be added:

- Costs of Power
- Costs of Hardware (CPU, RAM, Storage)
- Costs of required SLA

For example, cost-power + cost-hardware + cost-sla = cost-total

This cumulative costs will be shown to the customer, to support them, to find a suitable solution

B. Rule Based Model

The model is described using IF-THEN rulesets to specify the options available. For the SLA factor, the rule based design is shown in Fig. 3. The SLA level is used to influence price for a service. The provider has three distinct SLA templates for the user to choose from; GOLD_TEMPLATE, SILVER_TEMPLATE and the PLATINUM_TEMPLATE, each of which is accompanied by its price. The user has also the opportunity to negotiate a new SLA, specifically designed for its needs as it has been established that SLA can be negotiated online.

C. ANN Model

The artificial Neural Network Resource Price (RP) system was developed to further illustrate the concept. Four steps were adopted in training of the neural network. First assemble the training data, second create the network neurons, third train the network and fourth run the neural network. The feed-forward neural network with back propagation was used because of their simplicity. The ANN structure is as shown in Fig. 4 with one layer of hidden neurons followed by an output layer. The inputs are Public Review (PR), Monitoring Service (MS), Cloud Provider's Reputation (CPR), Type of SLA (SLA), User Physical Location (UPL), User Bank Record (UBR), User

```
SLA_TEMPLATE
    IF
    SLA_TEMPLATE== GOLD _TEMPLATE
    THEN GOLD_PRICE
    IF
    SLA_TEMPLATE== SILVER_TEMPLATE
    THEN SILVER_PRICE
    IF
    SLA_TEMPLATE==PLATINUM_TEMPLATE
    THEN PLATINUM_PRICE
    ELSE
    USER_SLA_TEMPLATE==USER_DEFINED
    PRICE NEW_SLA_PRICE
```

Fig. 3: Knowledge Represented as Rules

Criminal Record (UCR) and the Social Category of user (SC). As shown in Fig. 5, different combinations of the inputs where used for the training of the neural network.

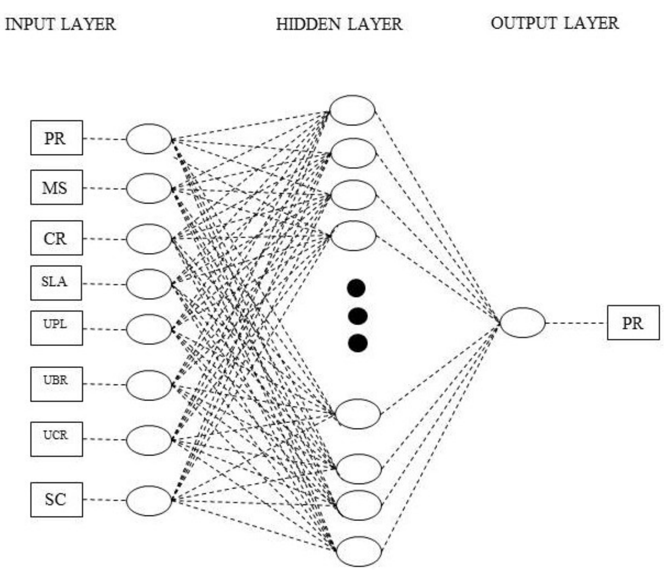

Fig. 4: Knowledge Represented with ANN

The function newff was used to create the ANN. For the initial network, the following command was used and the ANN network object called "CloudNet" was created.

```
CloudNet = newff(minmax(input_combination),
    [100,1],
    {'tansig','purelin'},'traingdx');
```

Also the weights and biases of the network had to be initialized. The following function transfers tansig from input layer to hidden layer and purelin from the hidden layer to output. The training function is used for the back-propagation traingdx. Several trainings were carried out and the CloudNet parameter that gave the best performance is shown below (see Figure 5):

```
CloudNet = newff(minmax(input_combination),
    [100,1],
    {'tansig','purelin'},'traingdx');
CloudNet.trainParam.show = 50;
CloudNet.trainParam.lr = 0.01;
CloudNet.trainParam.lr_inc = 1.05;
CloudNet.trainParam.epochs =1200;
CloudNet.trainParam.goal = 1.63;
[CloudNet, tr] = train(CloudNet,
    input_combination,
    target_output);
```

PR	MS	CR	SLA	UPL	UBR	UCR	SC	Input Combination	Output (RP)
1-Excellent	1-Cloup Provider	1-Good	1- Gold	1-Good Physical Location	1-Good Bank Record	1-Good Police Record	1-New Company	1,1,1,1,1,1,1,1 1,2,2,2,2,2,2,2	24 20
2-Very Good	2-3rd Party	2-Moderate	2-Silver	2-Moderate Physical Location	2-Moderate Bank Record	2-Moderate Police Record	2-Middle Age Company	2,2,2,2,2,2,2,2 2,1,1,1,1,1,1,1 3,2,2,3,2,2,2,2	20 24 19
3-Good	3-Not Available	3-Poor	3-Platinum	3- Bad Physical Location	3-Poor Bank Record	3-Poor Police Record	3-Old Company	3,3,3,3,3,3,3,1 3,3,3,3,3,3,3,3	26 23
4-Poor			4-User Defined					4,3,2,4,1,2,2,2 1,3,2,2,2,2,2,2	25 18
5-Bad								5,1,1,3,2,2,2,2 3,1,2,3,3,1,1,3	23 21
								3,3,3,3,3,3,3,3 2,2,3,1,1,2,2,2	25 22
								5,3,3,4,3,3,3,3	24
								5,1,3,1,1,1,1,1	20

Fig. 5: Sample Data for the RP ANN System

The ANN was simulated using the command `sim(CloudNet, input_combination)` and the CloudNet being the network object and different input combination were tried. The network simulation was static because the sequence or timing of the inputs is not important. The training type is incremental because the effect of the input on the network is not the same. The RP ANN system was implemented with Artificial Neural Network toolbox of Matlab. The codes were deposited in an m-file. The codes are shown in Figure 6.

```
%% NEURAL NETWORK DESIGN FOR RESOURCE PRICE SYSTEM
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
clc;
input_combination =[1 1 2 2 3 3 3 4 1 5 3 3 2 5 5 5 1 3 4 2 1;
 1 2 2 1 2 3 3 3 3 1 1 3 2 3 1 1 1 1 2 3 1;
 1 2 2 1 2 3 3 2 2 1 2 3 3 3 3 3 1 1 2 2 1;
 1 2 2 1 3 3 3 4 2 3 3 3 1 4 1 3 4 2 3 3 4;
 1 2 2 1 2 3 3 1 2 2 3 3 1 3 1 1 1 1 2 2 1;
 1 2 2 1 2 3 3 2 2 2 1 3 2 3 1 1 1 1 2 2 1;
 1 2 2 1 2 3 3 2 2 2 1 3 2 3 1 1 1 1 1 2 1;
 1 2 2 1 2 1 3 2 2 2 3 3 2 3 1 1 1 3 2 2 1];
target_output = [24 20 20 24 19 26 23 25 18 23 21 25 22 24 20 15 17 17 18 17
25]

CloudNet = newff(minmax(input_combination), [100,1],
{'tansig','purelin'},'traingdx');
CloudNet.trainParam.show = 50;
CloudNet.trainParam.lr = 0.01;
CloudNet.trainParam.lr_inc = 1.05;
CloudNet.trainParam.epochs =1200;
CloudNet.trainParam.goal = 1.63;
[CloudNet, tr] = train(CloudNet, input_combination, target_output);

SIMOUTPUT2 = sim(CloudNet, input_combination);
SIM = round(SIMOUTPUT2)
Error = SIM - target_output
%**********************************************************************
```

Fig. 6: Neural Network Design for Resource Price System

V. USE CASES

To illustrate the applicability of our *Cloud Resource Price System* a simple use case is introduced. As a precondition the

Cloud user has to fill in a web form with all required data, like the fix and variable parameters. Some information depend on input by the cloud provider, other by the cloud customer. The following information has to be provided by the Cloud Provider:

- The state and the location of the data centers, to determine their individual fix costs. All fix costs will be handled by the providers price manager. Assume a data center in Germany based on the total cost of ownership of a VM (2 Core, 2G Mem, 100G storage) has a fixed price of 8.50€.
- The SLA templates for *BRONZE*, *SILVER*, *GOLD* and for each offered QoS selectable for the customer has to be factored by the price manager of the provider.
- The Cloud Provider Reputation (CR) is expressed based on the availability of Past Experience or Compensation Records. Suppose the provider has both a "Record of Success" and a "Record of Compensation", then its reputation is *Good* =>, which will result in no change in the price.

The following information has to be provided by the Cloud customer:

- If the customer wants to define individual QoS, the price for each QoS is determined using information of user, who predicts his usage of the resource. If heavy usage is predicted during working hours it will costs more, than during the night. A detailed discussion about this can be found in the paper "Cloud Utility Price Model" [8]. So for example a customer has chosen *GOLD* (HA, backup every day, restore time < 2h, etc.), this could result in an increase of the price by 20$.
- The customer has to check in the template the type of monitoring services that are available. Monitoring service can be available from the provider itself or from a third party or may not be available. If no monitoring is selected => then there is no change in the price.
- The user reputation is measured using the "Physical Address", the "Bank Details" and the "Police Record". The particular option selected will determine the price to give. A user with a bad police record is a high risk user, hence the user has to pay higher price than others. In our example we assume being *Good* for all three reputations attributes.

After that, all information is fed into the price model, building the final price for the cloud service. First, all fix cost will be calculated with the mathematical formula and other information like state and location will be evaluated by the if then rules. Next step is the determination of information like reputation or customer behavior where the neural networks will predict the estimated price.

The provider itself has a provider price manager, where he can add and change the fix and variable costs. All these informations are used by the price modeling module, which calculates the price for the cloud resources. The user also checks the review from the public on this provider. Though the review does not affect the price heavily, but it has an influence.

VI. Conclusion

The price of a Cloud resource is influenced by many factors. It has been shown how a variety of static and dynamic factors like hardware price, data center location, provider or user reputation could be used to adapt the price of a cloud resource. To keep up with the dynamicity of the factors influencing the price, an adaptable Cloud Resource Price Model has been developed. By using a combination of mathematical formula, IF-THEN rules and a Neural Network this has been realized. A simple use case was introduced to show how useful this approach can be.

Acknowledgment

The study was carried out in the Cloud Research Lab of HFU. The support of the TWAS_DFG Cooperation Visit is appreciated. The research is supported by the German Federal Ministry of Education and Research (BMBF) through the research grant number 03FH046PX2.

References

[1] B. Singh, M. Kaur, and C. Batra, "A review of new about cloud computing security," INTERNATIONAL JOURNAL OF COMPUTERS & TECHNOLOGY, vol. 4, no. 2b1, 2013.

[2] P. Wayner, "Cloud review: 8 public cloud services put to the test from amazon to windows azure, iaas clouds differ widely in features, complexity, and speed." InfoWorld, March 2013. [Online]. Available: http://www.infoworld.com/d/cloud-computing/cloud-review-8-public-cloud-services-put-the-test-214403?source=fssr

[3] A. M. Odlyzko, "Internet pricing and the history of communications," Computer Networks, vol. 36, no. 5/6, pp. 493–517, 2001.

[4] P. C. Fishburn and A. M. Odlyzko, "Competitive pricing of information goods: Subscription pricing versus pay-per-use," Economic Theory, vol. 13, no. 2, pp. 447–470, 1999.

[5] K. Lai, "Markets are dead, long live markets," CoRR, vol. abs/cs/0502027, 2005.

[6] A. Strømmen-Bakhtiar and A. R. Razavi, "Cloud Computing Business Models Cloud Computing for Enterprise Architectures," ser. Computer Communications and Networks, Z. Mahmood and R. Hill, Eds. London: Springer London, 2011, ch. 3, pp. 43–60. [Online]. Available: http://dx.doi.org/10.1007/978-1-4471-2236-4_3

[7] R. I. Gopalkrishnan, A. D. Miyazaki, D. Grewal, and M. Giordano, "Linking web-based segmentation to pricing tactics," Journal of Product & Brand Management, vol. 11, no. 5, pp. 288– 302, 2002.

[8] S. A. Bello and C. Reich, "Cloud utility price models." in CLOSER, F. Desprez, D. Ferguson, E. Hadar, F. Leymann, M. Jarke, and M. Helfert, Eds. SciTePress, 2013, pp. 317–320.

[9] D. Patel Chandrakant and J. Shah Amip, "Cost model for planning, development and operation of a data center," Internet Systems and Storage Laboratory, HP Laboratories, Palo Alto, Tech. Rep., 2005, hPL-2005-107(R.1).

[10] S. Maxwell, The Price Is Wrong: Understanding What Makes A Price Seem Fair And The True Cost Of Unfair Pricing. Hoboken, N.J.: John Wiley & Sons, 2008.

[11] D. Osterwalder, Trust Through Evaluation and Certification? Sage, 2001.

[12] S. Pearson and A. Benameur, "Privacy, security and trust issues arising from cloud computing," in Proceedings of the 2010 IEEE Second International Conference on Cloud Computing Technology and Science, ser. CLOUDCOM '10. Washington, DC, USA: IEEE Computer Society, 2010, pp. 693–702.

[13] M. Armbrust, A. Fox, R. Griffith, A. D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, and M. Zaharia, “A View of Cloud Computing,” Commun. ACM, vol. 53, no. 4, pp. 50–58, Apr. 2010.

[14] P. Hofmann and D. Woods, “Cloud computing: The limits of public clouds for business applications.” IEEE Internet Computing, vol. 14, no. 6, pp. 90–93, 2010.

[15] S. Frey, C. Lüthje, R. Teckelmann, and C. Reich, “Adaptable Service Level Objective Agreement (A-SLO-A) for Cloud Services.” in CLOSER, F. Desprez, D. Ferguson, E. Hadar, F. Leymann, M. Jarke, and M. Helfert, Eds. SciTePress, 2013, pp. 457–462.

[16] Y. Chen, V. Paxson, and R. Katz, “What’s New About Cloud Computing Security,” University of California, Berkeley Report No. UCB/EECS-2010-5 January, vol. 20, no. 2010, pp. 2010–5, 2010.

[17] M. Jensen, J. Schwenk, N. Gruschka, and L. L. Iacono, “On technical security issues in cloud computing,” in Proceedings of the 2009 IEEE International Conference on Cloud Computing, ser. CLOUD ’09. Washington, DC, USA: IEEE Computer Society, 2009, pp. 109–116.

[18] T. Ristenpart, E. Tromer, H. Shacham, and S. Savage, “Hey, you, get off of my cloud: Exploring information leakage in third-party compute clouds,” in Proceedings of the 16th ACM Conference on Computer and Communications Security, ser. CCS ’09. New York, NY, USA: ACM, 2009, pp. 199–212.