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An Extensive Survey on QoS in Cloud computing

N.Ani Brown Mary[#1], K.Jayapriya[*2]

[#]*Software Engineer, Vin Solutions ,Tirunelveli, Tamilnadu, India*

[*]*Chief Executive Officer, Vin Solutions , Tirunelveli, Tamilnadu, India*

***Abstract*— Cloud computing provides consumer an inclusive software atmosphere. In the midst of the escalation of Cloud computing, additional companies are offering diverse Cloud services. Commencing the consumer's point of view, it is constantly complex to make a decision on choosing the services depending on QoS requirements. QoS requirements have to be satisfied by both service providers and consumers. In this paper, we have presented a widespread survey on QoS in Cloud computing with respect to their implementation details, Strong Points and Limitations.**

***Keywords*— Quality of Service, Cloud computing, Service Level Agreement**

I. INTRODUCTION

Cloud Computing arisen as a successful computing paradigm, because it allows hiring resources without caring of maintenance costs and adds some new features for clients, such as the possibility of scale-up and scale-down resources dynamically depending on punctual requirements[1]. Cloud computing is almost certainly the most cost efficient method to use, maintain and upgrade. Cloud is a disruptive force and has the potential for broad long-term impact in most industries. A set of applications managed and hosted externally by a specialist partner and delivered over a secure high quality network and it is available anywhere with an internet connection, even when on the move. Service provisioning in the Cloud relies on Service Level Agreements (SLAs) representing a contract signed between the customer and the service provider including non-functional requirements of the service specified as Quality of Service (QoS). SLA considers obligations, service pricing, and penalties in case of agreement violations.

The on-demand service provision model in Cloud computing necessitates the use of well-established SLA. A SLA is a part of a service contract between the consumer and provider that formally defines the level of service. In Cloud computing, SLAs are obligatory to control the use of computing resources. Therefore, a main issue for Cloud computing is to build a new layer to maintain a negotiation phase between service providers and consumers to establish SLAs between them. Negotiation can be viewed as a bargaining process by which a joint decision is made by two parties, service provider agent and service consumer agent in the context of Cloud computing environment. The negotiating agents bargain with each other and move towards a final agreement. During such a negotiation process, the decision making model plays a critical role.

During the service negotiation or renegotiation, a consumer exchanges a number of contract messages with a provider in order to reach a mutual agreement. Furthermore, SLA violation enforce penalties to motivate parties adhere to follow the contract. Quality of Service is the knack to provide diverse priority to different applications, consumers, or data flows, or to guarantee a certain level of performance. QoS criteria are abundant and is highly reliant of the application. The key benefit of having copious servers in Cloud computing is the system performance increases efficiently by reducing the mean queue length and waiting time than compared to the conventional approach of having only single server so that the consumers need not wait for a long period of time and also queue length need not be bulky[3].

*2.*QUALITY OF SERVICE IN CLOUD COMPUTING

Cloud computing aims to distribute a network of virtual services so that consumers can access them from anywhere in the world on payment at competitive costs depending on their Quality of Service (QoS) requirements[6]. Cloud computing systems may flock thousands of internationally dispersed consumers at any given time. These consumers may access diverse types of services that have varying requirements depending on the type of consumers, services and resources involved[7].

Saravanan et al[2] proposed a novel framework for ranking and advanced reservation of cloud services using Quality of Service (QoS) attributes. In some situations, due to the vast number of requests, the providers are not able to deliver the requested services within requested time. To avoid this scenario, ranking technique is very much useful. All QoS characteristics are explained. But for implementation all QoS characteristics are not used.

Performance evaluation of server farms is an important aspect of cloud computing which is of crucial interest for both cloud providers and cloud customers. Hamzeh Khazaei et al.[3] have proposed an analytical technique based on an approximate Markov chain model for performance evaluation of a Cloud computing center. Here response time only is considered as a major factor. If there is burst arrivals of requests then this method is not suitable.

Ani[4,5] considers only few QoS constraints, such as deadline, budget, file size, penalty rate ratio and requested length. Deadline is the maximum time consumer would like to wait for the result. Budget is the amount consumer wishes to pay for the resources. Penalty Rate Ratio is a ratio for consumers compensation if the SaaS provider misses the deadline. Input File Size is the size of input file provided by users. Request Length is the Millions of Instructions (MI) required to be executed to serve the request.

Chitra et al.[8] have established a new-fangled monitoring system called Cloud Monitoring System(CMS) that is used to enhance QoS during SLA negotiation. The negotiation between consumers and cloud Service providers periodic polling is conducted and reports are generated in a absolute process. After detecting the local changes, each network element has to emit alarms in order to ensure that global parameters are not violated. With monitoring, the failed node can be noticed and it gradually increases the efficiency of the cloud environment and attract the consumers. More QoS parameters can be considered.

Xiao Liu et al.[10] have proposed a generic QoS framework for Cloud workflow systems. This framework consists of four components such as QoS requirement specification, QoS-aware service selection, QoS consistency monitoring and QoS violation handling. However the data communication and knowledge sharing between the components for different QoS dimensions is not suitable for solving complex problems such as multi-QoS based service selection, monitoring and violation handling.

Zibin Zheng et al.[14] have proposed a QoS ranking prediction framework for Cloud services by taking past service usage experiences of consumers. This framework is to avoid the time-consuming and expensive real-world service invocations. This framework requires no additional invocations of Cloud services when making QoS ranking prediction. Collaborative filtering method is used to predict QoS for web services only, it can be used for cloud services also. Here Pearson Correlation Coefficient is used to calculate the similarity between users.

Saurabh Kumar Garg et al.[15] have proposed a framework to measure the quality and prioritize Cloud services. This framework makes significant impact and creates healthy competition among Cloud providers to satisfy their Service Level Agreement (SLA) and improve their Quality of Services (QoS). They proposed an Analytical Hierarchical Process (AHP**)** based ranking mechanism which can evaluate the Cloud services based on different applications depending on QoS requirements. This proposed technique is used only for quantifiable QoS attributes such as Accountability, Agility, Assurance of Service, Cost, Performance, Security, Privacy, and Usability. It is not suitable for non-quantifiable QoS attributes such as Service Response Time, Sustainability, Suitability, Accuracy, Transparency, Interoperability, Availability, Reliability and Stability.

Sonal Dubey et al.[16] have investigated the crisis of choosing an optimal progression of infrastructure resources to outline an lengthwise path for QoS provisioning in Cloud computing location. The authors embrace amplification of QoS aware services model and recitation two resourceful algorithms for selecting an optimal sequence of infrastructure resources for lengthwise QoS provisioning. The main optimization focus for Cloud service provisioning is how to make up a progression of service components from virtualized services into the Cloud service and afford it to consumers. It is a time consuming process.

Li Pan[19] proposed a software agent based automated service negotiation framework for on-demand Cloud service provision. Here autonomous agents act as half of service providers and consumers to participate in negotiations in automated and professional way. They proposed bilateral multi-step monotonic concession negotiation protocol for service negotiation in Cloud computing environments. Cloud service providers publish their services in the Cloud marketplace by registering them into the service registries maintained by the matchmaker. The lack in this framework was multiple interactions was not available.

Xiong et al.[20] have proposed a Queueing network model with infinite queue to find the relationship among the maximal number of customers. Then explained QoS guaranteed services to find the highest level of services with minimal service resources. Here response time is a major factor. With the help of response time they calculate, what level of QoS services can be guaranteed for given service resources, then for a given number of customers, how many service resources are required to ensure that customer services can be guaranteed. For given service resources, how many customers can be supported to ensure that customer services can be guaranteed in term of the percentile of response time. They also developed an approximation method for computing the Laplace transform of a response time distribution in the cloud computing system.

Buyya et al.[22] have proposed some algorithms for resource allocation for SaaS providers to balance the cost of hardware and SLA violations. This proposed algorithm takes certain QoS parameters such as response time and service initiation time for satisfying the customers while minimizing the use of hardware resources. Theses algorithms are proposed to reuse the already created VMs in order to minimize cost, but it may create security problems for customers as the residual information in the VMs can be used against them.

Emeakaroha et al.[23] have presented a scheduling heuristic that takes multiple SLA parameters for application deployments in the Cloud. The attributes considered in this application includes CPU time, network bandwidth and storage capacity for deploying applications. These parameters have limited application in real world systems as they need to be considered only during deployment. Once the applications have been ready for consumer access, the consumers would be more interested in performance parameters such as response time, processing time etc. Hence this heuristic may not have much practical significance in real world business environments.

Ruozhou et al.[24] proposed a QoS-aware service selection algorithms for composing different services offered by a Cloud. Different types of resources need to be virtualized as a collection of Cloud services using virtualization technology. End-users in the Cloud are usually provided with customized Cloud services that involve not only different kinds of computing services but also the networks interconnecting those computing services. Therefore, a set of Cloud computing services and the networking services has been modeled as a composite customized Cloud service.

Sharma et al.[26] have proposed a Cloud resource pricing model balancing QoS requirements and higher profits. This model uses the realistic valuation for underlying resources using the age of resources. The proposed model does dynamic configuration not include utilization in computing the cost. Hence it may lead to inaccurate projections. Utilization is a major factor that has to be considered always for all computational cost calculation.

Conversely, composing suitable service components into a Cloud service that congregates multiple QoS requirements is a challenging optimization issue since such a quandary can be basically addressed as Multi-Constraints Path problem (MCP), which is known to be NP-hard [27]. To handle this problem, much research progress has been made toward designing efficient algorithms recently. Xue et al. [29] distinct a dissimilar version of MCP and presented a set of ballpark figure algorithms for each problem, which are known as the best among the mentioned results. Huang et al. [30] gave a heuristic for Multi-Constrained Optimal Path (MCOP) selection, in which a nonlinear combination procedure and a geographical version of a well-known procedure in solving Delay Constrained Least Cost (DCLC) were established. The results obtained, show that the proposed heuristic can achieve a good substitution between execution time and quality of the path, and it requires less time to work out a path compared with Xue's algorithm in [28].

Buyya et al. [32] have presented the first framework, SMICloud to methodically compute all the QoS attributes proposed by Cloud Service Measurement Index Consortium (CSMIC). They have concentrated on some key challenges by designing metrics for each quantifiable QoS attribute for measuring precisely the service level of each Cloud provider. They also have proposed an Analytical Hierarchical Process (AHP) based ranking mechanism which can appraise the Cloud services based on diverse applications depending on QoS requirements. Their proposed mechanism also addressed the challenge of different dimensional units of various QoS attributes by providing a uniform way to evaluate the relative ranking of Cloud services for each type of QoS attribute.

Iosup et al. [33] analyzed the performance of many-task applications on Clouds. Correspondingly, many performance monitoring and analysis tools are also proposed. By utilizing these tools the authors can use the data to rank and measure the QoS of various Cloud services according to consumers' applications. Other works such as CloudCmp [34] proposed frameworks to compare the performance of different Cloud services such as Amazon EC2, Windows Azure and Rackspace. These works again focused on comparing the low level performance of Cloud services such as CPU and network throughput.

Even supposing the evaluation and qualified ranking of various Cloud services is moderately new in the Cloud computing region, it is an mature concept in other areas such as web services. The most interrelated work in this region is done by Tran et al. [35]. This exertion proposed a Analytical Hierarchical Process (AHP) based ranking performance. Conversely, this algorithm was designed for web services and thus did not consider various performance parameters such as VM capacity which are specific to Cloud computing. Therefore, the main challenge in this paper is how to assign weights to each of the attributes when they are not quantifiable. The authors have assigned for both essential and non essential elements.

Buyya et al. [36] have proposed the exploration of mock-up applications and correlations between workloads, and endeavour to build performance models that can facilitate exploring the trade-offs between QoS and energy savings. This knowledge has been used to develop workload-aware resource allocation algorithms, which can be incorporated into energy-efficient resource management strategies in data centers to achieve more optimal allocation of resources. For resource providers, the optimal allocation of VMs will result in higher utilization of resources and therefore reduced operational costs. Consumers will benefit from decreased prices for the resource usage. Knowledge of the efficient combination of different types of workloads will advance resource management strategies in energy-aware computing environments, where consolidation of VMs is one of the most productive energy saving techniques.

Guitart et al. [37] encompasses the autonomic enforcement of a distinct Business Level Objectives (BLO) for maximisation of the revenue. They defends the idea that revenue can be maximized by establishing a bidirectional data flow between market and resource layers. Market brokers can perform negotiations that are more profitable if they use resource-level data, and the resource manager can help maximising the revenue if it manages the SLAs by considering this BLO. They proposed the improvement of SLA Negotiation and management in Cloud Computing markets by means of bidirectional communication between market brokers and resource managers. They also introduced several rules for maximising revenue in a Cloud Provider, and demonstrates their validity by means of several experiments.

Buyya et al. [39] have considered multiple IaaS providers and admission control in this paper. Procuring from multiple IaaS providers brings mammoth amount of resources, various price schemas, and flexible resource performance The authors used an innovative cost-effective admission control and scheduling algorithms to maximize the SaaS provider's profit. Their proposed solutions are able to maximize the number of accepted consumers through the efficient placement of request on VMs leased from multiple IaaS providers. They used various customer's QoS requirements and infrastructure heterogeneity. At platform category, Projects such as InterCloud [40] and Sky Computing [41] investigated the technological advancement that is required to aid the deployment of Cloud services across multiple infrastructure providers. On the other hand, research at the SaaS provider level is still in its infancy, because many works do not consider maximizing profit and guaranteeing SLA with the leasing scenario from multiple IaaS providers, where resources can be dynamically expanded and contracted on demand.

CONCLUSIONS

Cloud computing has been the hypothesis shift in distributed computing due to the way the resource provisioning and charging. Managing QoS is a crucial task in making such an innovative technology to a larger consultation. Several researchers have put forward their ideas for new and innovative solutions for handling this imperative area is resource management. In this paper, we have carried out a decisive review of the most recent work carried out in this area. The findings of the authors in terms of the Strong points and Limitations of the proposed work has been presented in a table for easy reference. This extensive survey in QoS paper will be very much helpful for researchers to do research in QoS.

TABLE I
SUMMARY OF STRONG POINTS AND LIMITATIONS OF PROPOSED TECHNIQUES AND FRAMEWORKS

Effort	**Techniques**		
	Proposed	**Strong Point**	**Limitation**
2	Framework for ranking using AHP	All QoS characteristics are mentioned	All QoS requirements are not implemented
3	An approximate Markov chain model	Provides high degree of accuracy	Not suitable for burst arrivals
8	Cloud Monitoring System for QoS	periodic polling is conducted and reports are produced	Failed to calculate communication cost
9	Optimal resource allocation replica for maximizing revenue	Logically derived and performs superior than heuristics	Not suitable for sensitive QoS applications
10	Generic QoS framework for Cloud workflow systems	Demonstrated system implementation and appraised effectiveness of performance framework	Complex problems such as monitoring and violation handling occurs
14	Personalized QoS ranking prediction framework	Outperformed rating based approaches and greedy method	Accuracy of ranking method has to be considered
15	AHP based ranking mechanism	QoS attributes are explained for both consumers and providers	Non quantifiable QoS attributes are not used
18	Cloud Monitoring System for Virtualization	Increases QoS by monitoring System	Single QoS Parameter is considered
19	Software agent based automated service negotiation framework	Proposed a bilateral multi-step monotonic concession negotiation protocol for service negotiation	Multiple interactions are not possible
20	A Queueing network model with infinite queue	Service performance is calculated with high accuracy	Only response time is considered as a major factor.
22	Algorithm for resource allocation	Reduces cost of service provider	Security problems occurs
23	A scheduling heuristic with multiple parameters	Considers deployment attributes cpu time, network bandwidth and storage capacity	Response time and performance parameters are not used
24	QoS-aware service selection algorithms	Different resources has been virtualized using virtualization technology	Service Provisioning problems are not overcomed
26	Profit Balancing and pricing model for QoS	Realistic Values are used as a major constraint	Utilization is not considered for computational cost
27	Multi-Constraints Path problem	Multiple QoS requirements are optimized	NP-Hard problem occurs
30	Delay Constrained Least Cost (DCLC)	A good substitution between execution time and quality of the path	QoS constraints are not used
32	AHP hierarchy using SMI architecture	Creates healthy competition among Cloud providers to satisfy SLA and improve QoS	Ranking Algorithms can be deployed to rank infrastructures
33	A framework for performance monitoring and analysis tools	Have analyzed the performance of many task applications on Clouds	After analyzing the services can be ranked
34	A framework to compare the performance of different Cloud services	Focused on comparing low level performance of Cloud services such as CPU and network throughput	Authors must deployed more constraints for comparison
35	AHP hierarchy for web services	Ranking relative weights for Cloud services	VM capacity parameter is not used
36	Energy efficient resource allocation and scheduling algorithms	Energy efficiency is improved under dynamic workload scenarios	QoS parameters are not considered as a major constraints
37	Business Rules for maximising the revenue of Providers	Revenue is maximized by using resource data	Consumers are not satisfied without QoS Requirements
39	Admission Control and Scheduling algorithm	Profit is maximized for service providers	Only fewer QoS constraints are considered

REFERENCES

[1] R. Buyya, C. S. Yeo, and S. Venugopal, “Market-oriented Cloud computing: Vision, hype, and reality for delivering it services as computing utilities”, published in the Proceedings of High Performance Computing and Communications, 10th IEEE International Conference on, vol. 0, pp. 5–13, 2008.

[2] Mr.K.Saravanan and M.Lakshmi Kantham, “An enhanced QoS Architecture based Framework for Ranking of Cloud Services", published in the Proceedings International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue4- April 2013.

[3] Hamzeh Khazaei, Jelena and Vojislav, "Performance Analysis of Cloud Computing Centers Using M/G/m/m+r Queuing Systems", Published in the IEEE Transactions on parallel and Distributed systems, Vol. 23, No. 5, may 2012.

[4] N.Ani Brown Mary, "Profit Maximization For Saas Using SLA Based Spot Pricing in Cloud Computing", published in the Proceedings of the International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, An ISO 9001:2008 Certified Journal, Volume 3, Special Issue 1, January 2013).

[5] N.Ani Brown Mary, "Profit Maximization for Service Providers using Hybrid Pricing in Cloud Computing" published in the Proceedings of the International Journal of Computer Applications Technology and Research Volume 2, Issue 3, 218 - 223, 2013.

[6] R. Buyya, C. Yeo, S. Venugopal, J. Broberg, I. Brandic, "Cloud computing and emerging IT platforms: vision, hype, and reality for delivering computing as the 5th utility", Published in ELSEVIER of Future Generation Computer Systems 25 (6) (2009) 599–616.

[7] Mohamed Firdhous, Suhaidi Hassan , Osman Ghazali", A Comprehensive Survey on Quality of Service Implementations in Cloud Computing", Published in International Journal of Scientific and Engineering Research, volume 4, Issue 5, May 2013.

[8] B.Chitra, M.Sreekrishna, A.Naveenkumar", A Survey on Optimizing QoS during Service Level Agreement in Cloud", Published in International Journal of Emerging Technology and Advanced Engineering Volume 3, Issue 3, March 2013.

[9] Guofu Feng, Saurabh Garg, Rajkumar Buyya and Wenzhong Li, "Revenue Maximization Using Adaptive Resource Provisioning in Cloud Computing Environments", Published in ACM/IEEE 13th International Conference on Grid Computing 2012.

[10] Xiao Liu, Yun Yang, Dong Yuan, Gaofeng Zhang, Wenhao Li and Dahai Cao, " A Generic QoS Framework for Cloud Workflow Systems", Published in Ninth IEEE International Conference on Dependable, Autonomic and Secure Computing 2011.

[11] Jong Woo Kim and Jung-Hee Jeong, “Comparison of Cloud Service Quality Information Publication Based on Cloud Service Quality Model”, published in 2012 International Conference on Information and Computer Applications (ICICA 2012).
[12] Xun Xu, “From Cloud computing to Cloud manufacturing”, Published in the ELSEVIER of Robotics and Computer Integrated Manufacturing on 28(2012)75–86.
[13] Amir Vahid Dastjerdi and Rajkumar Buyya, “An Autonomous Reliability aware Negotiation Strategy for Cloud Computing Environments”, Published in 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing 2012.
[14] Zibin Zheng, Xinmiao Wu, Yilei Zhang, Michael R. Lyu and Jianmin Wang, "QoS Ranking Prediction for Cloud Services", Published in IEEE Transactions on Parallel and Distributed Systems, vol. 24, no. 6, june 2013.
[15] Saurabh Kumar Garg, Steve Versteeg and Rajkumar Buyya, "SMICloud: A Framework for Comparing and Ranking Cloud Services", Published in Fourth IEEE International Conference on Utility and Cloud Computing in 2011.
[16] Sonal Dubey and Sanjay Agrawal, "Methods to Ensure Quality of Service in Cloud Computing Environment", Published in the International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 6, June 2013.
[17] T. A. L. Genez, L. F. Bittencourt, and E. R. M. Madeira, “Workflow Scheduling for SaaS/PaaS Cloud Providers Considering Two SLA Levels” Published in the IEEE/IFIP NOMS, Apr. 2012.243, 1996.
[18] Ruozhou Yu, Xudong Yang, Jun Huangy, Qiang Duanz, Yan Ma and Yoshiaki Tanaka, "QoS-aware Service Selection in Virtualization-based Cloud Computing" Published in the International Scientific and Technological Cooperation Program (0902).
[19] Li Pan, "Towards a framework for automated service negotiation in Cloud computing" Published in the Proceedings of IEEE CCIS2011.
[20] Kaiqi Xiong and Harry Perros, " Service Performance and Analysis in Cloud Computing " Published in the Annual SRRI Global Conference, pp. 11-20, 2012.
[21] P.S.Prakash and S.Selvan, "A Feasible Path Selection QoS Routing Algorithm with two Constraints in Packet Switched Networks", Published in the World Academy of Science, Engineering and Technology Vol:15 2008-03-22.
[22] L.Wu, S.K. Garg, and R. Buyya, "SLA-based Resource Allocation for Software as a Service Provider (SaaS) in Cloud Computing Environments", Published in the Proc. 11th IEEE/ACM Int. Symp. Cluster, Cloud and Grid Computing, pp. 195-204, 2011.
[23] V.C. Emeakaroha, I. Brandic, M. Maurer, and I. Breskovic, "SLA-Aware Application Deployment and Resource Allocation in Clouds", Published in the Proc. 35th IEEE Annual Computer Software and Applications Conference Workshops (COMPSACW), pp. 298-303, 2011.
[24] Ruozhou Yu, Xudong Yang, Jun Huangy, Qiang Duanz, Yan Ma and Yoshiaki Tanaka,"QoS-aware Service Selection in Virtualization-based Cloud Computing", Published in China-EU International Scientific and Technological Cooperation Program (0902).
[25] ´I˜nigo Goiri, Ferran Julia, J.Oriol Fito, Mario Macıas, and Jordi Guitart, " Resource-Level QoS Metric for CPU-Based Guarantees in Cloud Providers", Published in the Springer-Verlag Berlin Heidelberg 2010.
[26] B. Sharma, R.K. Thulasiram, P. Thulasiraman, S.K. Garg, and R. Buyya, "Pricing Cloud Compute Commodities: A Novel Financial Eco-nomic Model", Published in the Proc. 12th IEEE/ACM Int. Symp. Cluster, Cloud and Grid Computing, pp. 451-457, 2012.
[27] Z. Wang and J. Crowcroft, “Quality-of-service routing for supporting multimedia applications”, Published in the IEEE J. Sel. Areas. Commun., vol. 14, no. 7, pp. 1228–1234, Sept. 1996.
[28] Zibin Zheng, Xinmiao Wu, Yilei Zhang, Michael R. Lyu and Jianmin Wang, “QoS Ranking Prediction for Cloud Services”, Published in the IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS, VOL. 24, NO. 6, JUNE 2013.
[29] G. Xue, W. Zhang, J. Tang and K. Thulasiraman, “Polynomial time approximation algorithms for multi-constrained QoS routing”, Published in the IEEE/ACM Trans. Netw., vol. 16, no. 3, pp. 656-669, Jun. 2008.
[30] J. Huang, X. Huang, and Y. Ma, “An Effective Approximation Scheme for Multi constrained Quality-of-Service Routing”, Published in the Proc. IEEE GLOBECOM 2010, Miami, Florida, pp. 1–6, Dec. 2010.
[31] Alexandru Iosup, Nezih Yigitbasi and Dick Epema, "On the Performance Variability of Production Cloud Services", Published in the 11th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing 2011.
[32] J.Saurabh Kumar Garg, Steve Versteeg and Rajkumar Buyya, "A framework for ranking of Cloud computing services", Published in the ELSEVIER of Future Generation Computer Systems 29 (2013) 1012–1023.
[33] A.Iosup, S.Ostermann, N.Yigitbasi, R.Prodan, T.Fahringer and D.Epema, "Performance analysis of Cloud computing services for many-tasks scientific computing", Published in the IEEE Transactions on Parallel and Distributed Systems 22 (6) (2011) 931–945.
[34] A. Li, X. Yang, S. Kandula and M. Zhang, "CloudCmp: comparing public Cloud providers", Published in the Proceedings of the 10th Annual Conference on Internet Measurement, Melbourne, Australia, 2010.
[35] V. Tran, H. Tsuji and R. Masuda, "A new QoS ontology and its QoS-based ranking algorithm for web services", Published in the Proceedings of the Simulation Modelling Practice and Theory, 17 (8) (2009) 1378–1398.
[36] Anton Beloglazov, Jemal Abawajy, and Rajkumar Buyya, "Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing", Published in the ELSEVIER of Future Generation Computer Systems 28 (2012) 755–768.
[37] Mario Macıas, J.Oriol Fito and Jordi Guitart, "Rule-based SLA Management for Revenue Maximisation in Cloud Computing Markets", Published in the Proceedings of the International Conference on Network and Service Management 2010.
[38] Rodrigo N. Calheiros, Christian Vecchiol, Dileban Karunamoorthy and Rajkumar Buyya, "The Aneka platform and QoS-driven resource provisioning for elastic applications on hybrid Clouds", Published in the Elsevier publication of Future Generation Computer Systems 28 (2012) 861–870.
[39] Linlin Wu, Saurabh Kumar Garg and Rajkumar Buyya, "SLA-based admission control for a Software-as-a-Service providervin Cloud computing environments", Published in the Elsevier publication of Journal of Computer and System Sciences 78 (2012) 1280–1299.
[40] R. Buyya, R. Ranjan and R.N. Calheiros, "InterCloud: Utility-oriented federation of Cloud computing environments for scaling of application services", Published in the Proceedings of the 10th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2010), Busan, South Korea, 2010.
[41] K. Keahey, A. Matsunaga and J.Fortes, "Sky computing", Published in the Proceedings of IEEE Internet Computing 13 (5) (2009) 43–51.
[42] Dimitrios Skoutas, Dimitris Sacharidis, Alkis Simitsis, and Timos Sellis, "Ranking and Clustering Web Services using Multi-Criteria Dominance Relationships", Published in IEEE TRANSACTIONS ON SERVICES COMPUTING.
[43] Paul Hershey, Shrisha Rao, Charles B. Silio Jr., and Akshay Narayan, "System of Systems to Provide Quality of Service Monitoring, Management and Response in Cloud Computing Environments", Published in Proc. of the 2012 7th International Conference on System of Systems Engineering, Genoa, Italy - 16-19 July 2012.
[44] Yee Min Chen and Yi Jen Peng, " A QoS aware services mashup model for cloud computing applications", Published in the Journal of Industrial Engineering and Management (JIEM) 5(2) 457-472 2012.
[45] Molood Makhlughian, Seyyed Mohsen Hashemi, Yousef Rastegari and Emad Pejman, "WEB SERVICE SELECTION BASED ON RANKING OF QOS USING ASSOCIATIVE CLASSIFICATION ", Published in the International Journal of Web Service Computing (IJWSC), Vol.3, No.1, March 2012.
[46] Muhammad Zakarya and Ayaz Ali Khan, "Cloud QoS, High Availability & Service Security Issues Solutions", Published in the IJCSNS International Journal of Computer Science and Network Security, VOL.12 No.7, July 2012.
[47] Stefan Frey, Claudia L¨uthje, Vitali Huwwa and Christoph Reich, "Fuzzy Controled QoS for Scalable Cloud Computing Services", Published in the CLOUD COMPUTING 2013 : The Fourth International Conference on Cloud Computing, GRIDs, and Virtualization.
[48] Wei Chen and Junwei Cao, " QoS-aware Virtual Machine Scheduling for Video Streaming Services in Multi-Cloud", Published in the TSINGHUA SCIENCE AND TECHNOLOGY ISSN 1007 -0214 Volume 18, Number 1, February 2013.
[49] Massimiliano Rak, Salvatore Venticinque, "QoS Management in Cloud@Home Infrastructures", Published in the Proceedings of the Simulation Modelling Practice and Theory, 17 (8) (2009) 1378–1398.
[50] Lars Kolb, Andreas Thor and Erhard Rahm, "Don’t Match Twice: Redundancy-free Similarity Computation with MapReduce", Published in the Proceedings of DanaC’13, June 23, 2013, New York, NY, USA.