Global Journals LaTeX JournalKaleidoscope™
Artificial Intelligence formulated this projection for compatibility purposes from the original article published at Global Journals. However, this technology is currently in beta. *Therefore, kindly ignore odd layouts, missed formulae, text, tables, or figures.*

The Contemporary Affirmation of Taxonomy and Recent Literature on Workflow Scheduling and Management in Cloud Computing

V. Murali Mohan[1]

[1] Koneru Lakshamaiah Education Foundation

Received: 15 December 2015 Accepted: 2 January 2016 Published: 15 January 2016

Abstract

The Cloud computing systemspreferred over the traditional forms of computing such as grid computing, utility computing, autonomic computing is attributed forits ease of access to computing, for its QoS preferences, SLA?s conformity, security and performance offered with minimal supervision. A cloud workflow schedule when designed efficiently achieves optimalre source sage, balance of workloads, deadline specific execution, cost control according to budget specifications, efficient consumption of energy etc. to meet the performance requirements of today? svast scientific and business requirements. The businesses requirements under recent technologies like pervasive computing are motivating the technology of cloud computing for further advancements. In this paper we discuss some of the important literature published on cloud workflow scheduling.

Index terms— cloud computing, qos, resource scheduling, multi criteria decision, priority scheduling, task management, ropt, cbt

1 Introduction

loud computing [1,2] technology offers services of computing, resources etc. that enable users to execute millions of tasks simultaneously where there is no need for every users to have infrastructure individually. The cloud architecture consists of client applications and systems as front end connected to the cloud resourcescomprising of cloud systems,data and applicationsas the back end. The front end is connected to the back end by an internet or intranet network and virtualization technology is used in the deployment of software, networks and data.

The Clouds types [3] used in Cloud computing are generally of four types. Public cloud operated by a service provider and offers service to any general user holding the license to use the service. Private cloud is an organizations own cloud setup with customized applications and resources limited to their internal users. Hybrid cloud incorporates public and private cloud functionalities. Community cloud is set up by several organizations and used commonly by them for their internal requirements. specific task to specific VMs and integration of tasks and scenarios. The pricing models of cloud service providers are, ? Pay-as-you-go model has price set by the service provider which is constant. Ex. Companies such as Amazon, Microsoft, Google, Cisco etc. provide payas-you-go cloud datacenters services ? Subscription based pricing has the resource allotted for a period of time ? Usage based pricing model offers fair pricing for both the client and cloud service provider ? Auction based pricing is a model based on dynamic resource pricing in federated clouds Other pricing models generally used are, Cost based pricing, real time pricing, competition based pricing, customer based pricing, etc.

Cloud Workflow [6,7] schedules the resources and executes the tasks using algorithms based on the predefined strategies and objectives. Workflows in a group are usually similar and the differences are related to the variations in the volume and size of the tasks, data and algorithms used for computing.

The Scheduling approaches usually followed in cloud computing are, Static Scheduling, Dynamic Scheduling, Cloud Service Scheduling or scheduling at user and system level, Heuristic Scheduling, Workflow Scheduling, etc. In this paper we discuss about Workflow Scheduling.

Workflow scheduling [8,9] handles the process of task and resource scheduling for execution in the cloud service. A work flow scheduling processassigns the resources and executes the tasks with algorithms. The clouds scheduling process is identical to the workflow scheduling process in grids [10]. The resource showing better overall efficiency is selected and based on the algorithmic performance the scheduling procedure is determined.

A cloud workflow management system [11] manages the cloud system in provisioning of the resources, computation development, job scheduling, task execution on the resources and performance evaluation. The ever increasing scale of data i.e. big data workloads and the requirement to analyze highly complex computations and agile models has led to the migrating of the scientific work flow management systems of the previous environments to the Cloud senvironments. Cloud workflow management systems such as Simple Workflow (SWF) by Amazons, Blue Works exist by IBM, Nimbus by Tibco and management systems of Microsoft, HP, etc., the research based scientific workflow management systems [12] such as Swift, Vistrails, Kepler, etc offer services of managing the cloud environment and process. Cloud workflow management system has several modules. The Virtual Resource Pool (VRP) manages the resource inquiry. The Virtual Resource Manager (VRM) registers a resource request, places the request for resources with VRC and sends a resource inquiry to VRP. The Virtual Resource Client (VRC) processes resource request and manages the resource utilization with the VRP. The Virtual Resource Provider (VRP) registers and deregisters a Resource and manages the system configuration with CSM. The Cloud System Management (CSM) component manages the system configuration with the VRM and VRP. The terminology may vary with application types however the process is the same.

In cloud computing different types of scheduling methods are used in different scenarios howevera model for work-flow scheduling that is widely used is the New Berger model. The scheduling strategy of tasks and resources and execution is based on choosing tasks priority wise and assigning to available processors and computer machines to meet predefined goals. In dynamic cloud scheduling improving the efficiency of task scheduling with load balanceis the main criteria which however lead to task and load im balance. The New Berger model is based on a fair distribution of the tasks to the resources. In this approach first the tasks are allotted to the resources to avoid uneven resource mapping and overloading. The main criteria or priority is fairness in resources distribution to the tasks instead of driving the scheduling process to find an efficient solution or limiting the cost. The strategy of finding an efficient solution in terms of single criteria of cost or time may result in load imbalance affecting the overall QoS solution path finding process. So the necessity is maintaining a balance between performance and cost **??**13, 14, and 15] which is the basis for New Berger model. The design of the workflow should provide necessary benefit first and next the user required cost control with fairness can be achieved.

The newer techniques of synthetic workflows, algorithms, virtual machine, simulation technologies etc., with improved scheduling strategies can leverage the balance between fairness and efficiency with benefit. Several models of workflow scheduling based on the New Berger model have been successful in allocation of resources to tasks in diverse scenarios without workload imbalance and achieve QoS preferences.

The remaining sectionsare "Systematic literature review" evaluating contemporary cloud computingre search work, followed by the Survey "Conclusion"and finally the "References".

2 II.

3 Taxonomy

A general taxonomy of the process of cloud workflow comprises of essentially four stages that are, i) Workflow Scheduling, ii) Work-Flow Execution and iii) Performance Evaluation Workflow scheduling process is the automation of tasks and integration of resources into your applications and tools. The process involves scheduling of the applications and the resources based on Quality of Service factors and also on the Workflow Constraints such as, ? The QoS factors of scheduling [16] Matlab etc. ? The scalability strategy to be followed especially in case of dynamic scheduling and real time applications ? Establishing the performance monitoring metrics of reliability, threshold, throughput, fault tolerance and failover criteria ? Selection of the strategy for performance evaluation and the metrics for the assessment The work-flow factors above are dynamic factors constantly affecting the cloud workflow and scheduling process. A task flow mapped to a resource set undergoes several changes due to the real time requirement changes of other task flows. So a workflow process should consider several factors in designing, integrating and execution of the schedule into the Cloud workflow for the success of cloud computing. The workflow process with sub steps and the techniques and strategies followed in each stage is, ? A resource pool is formed by the scheduler from a collection of virtual machines manually or automatically ? A virtual machine that is newly included into the pool is allocated a name and an IP address? A unified pool is configured comprising of VM sand

Applications with parameters such as memory and total number of tasks

? The tasks nature and compatibility with the VMs and Application in terms of OS and scalability is checked ? The dependencies between the individual VMs and VMs of different pools is established ? A schedule of the total tasks executable in a VM is created defining the rules for tasks and associated data to be executed ? The rules defining tasks priority, task priority change criteria, the task execution time, the failover criteria, maximum retries for a task, etc. are set. The scheduling policy is generally an approach of managing the scheduling process that does not modify or influence the individual task scheduling set of rules ? Task scheduling mapping specific tasks according to preset rules and configurations to the required type of resource ? Resources parameters are mapped to the user task parameters. Resource scheduling allocates virtualized data center resources such as systems, servers, networks and data in different geographical positions into a resource pool through virtual technology and with mirror service for allocation on a global scale to the task ? The Schedulers allocate the cloud resources to the tasks and after the task completion call back the resources.

The scientific workflow problems of vast computational complexities may comprise of thousands or more tasks [17] mapped to million or more possible workflow schedules with variations in resources, time, and cost and execute dusing simulation tools for several days in generating an optimal result.

Workflow Execution is the algorithmic execution of tasks on each resource as per the SLAs. A simulation of the scheduling strategy can be done with tools such as Cloud Sim, Matlab etc. A cloud simulator simulates the scheduling, execution of even huge cloud computing tasks of scientific scale virtually with functionality of scaling up and down the process for further analysis and optimized result set. The process of work flow execution involves in stages such as, ? The tasks mapped to resources and the tasks and resources mapped to the task scheduling algorithms, based on the task priority and execute dalgorithmically on the resources ? The dynamically scale-up or scale-down of resources in real time for meeting the variations in the applications user requirements ? A task if not mapped due to unavailability of resources the scheduler reclassifies the tasks by updating the training set ? The task is checked for completion before the expectation time

? The tasks if completed the resources are called back and allotted to the tasks next in the priority ? The algorithms find a best result of mapping the resources to the user tasks The cloud scenarios with varied usage pattern and QoS constraints requires automated provisioning techniques. Scheduling algorithms are required to implement the workflow scheduling strategies and also for automating the process of scheduling [1]. The automated provisioning of resources are offered by cloud service providers such as, ? The Amazons EC 2 service with a simple APIs offers scalability of services with variations of user requirements with complex algorithmic and statistical calculations ? Open Nebula [19] is a Cloud Infrastructure service provider for automatic resource provisioning ? The Wrangler system is an automatic provisioning tool for VMs and other resources allocation ? The Context Broker [20] of project Nimbus is able to allocate huge virtual clusters in simple steps by the users The algorithmic execution of workflows is done if the tasks to be executed are of huge number. The algorithms based on heuristics and meta-heuristics offer better optimized search of resource and incur less cost compared to non-heuristics based algorithms. The Scheduling algorithms [21] are based on the best-effort service or based on QoS constraints and a candidate instance selected is further improved with enhanced algorithmic approaches. The algorithms generally used are, Genetic Algorithm (GA), Simulated Annealing (SA), AA or Agent based, PETRI Network, Partial Critical Path (PCP), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), etc.

? The GA algorithm [22] is based on the chromosome survival tactics. Here individual instances efficiency in mapping the resources over others is replicated over and over again incorporating the incremental developments taking place every time. The process is repeated till a single instance is found offering the most optimized QoS solution according to the set constraints. ? Agent Task Scheduling [23].is based on agent approach in the cloud systems. The cloud architecture comprises of various clusters of computers made up of layers of nodes. A node in a cluster carries the information of the resource in a proxy that is distributed to the other clusters in several places which achieves high performance and extends the network with additional resources ? Simulated Annealing (SA) [24] algorithmic approach is based on solutions with lesser probability of success in the search process.

An initial schedule is prepared on annealing i.e. system temperature and. at the end of iteration the make span is evaluated and depending on probability a poorer make span is included. This inclusion however decreases for successive iterationsas per the QoS requirements for achieving an optimized solution in problems of global scale ? Cost Scheduling [25] based on optimizing the cost of cloud computing that virtualizes various cloud resources such as network or bandwidth, CPU capacity, storage, data transfer times with different price models. The task scheduling based on cost criteria achieves a cost effective solution The combination of various algorithms also gives very good results. For example the GA based algorithm when combined with the Ant Algorithm gives better search results quickly. Another example is task scheduling in cloud computing based on genetic algorithm with simulated annealing.

A performance evaluation helps in designing complex scheduling approaches involving multiple QoS requirements based on time, cost, and resource. If the target is a high QoS, various scheduling approaches are run in terms of the QoS values set individually for each of the criteria. If a scheduling approach gives an optimized result in terms of execution time then the algorithm is further tuned for optimizing the performance in terms of other criteria i.e. cost and resource for overall QoS value.

Work-Flow Performance Evaluation finds solutions for work flow shaving complexities of modeling the tasks, resources, data etc. study by Schad et al. [26] states, Amazon's EC2 cloud processor has performance variations of 24%. Performance Monitoring is done by integrating the interface into a monitoring system for observing factors such as, ? Thresholds monitored in real time enable start-up of new virtual machines and shut down of unnecessary services ? Throughput or performance of task scheduling is monitored in real time for enhancing the process ? Fault tolerance is monitored to avoid possible failures in real time ? Reliability of the system can be established in various real time scenarios The performance of a cloud scheduling is evaluated by the execution of a wide range of scenarios involving diverse infrastructure models, applications, synthetic workflow ensembles based on diverse user defined and operational constraints. A performance evaluation helps in evaluating and overcoming the problems of workflow such as, ? the impact of the infrastructure sharing and virtualization ? the non-virtualized hardware complexities ? The delays of startup, data transfer times, VM boot time variations etc.

? the problems of selecting the initial pool of resources are overcome ? improving the resource model to handle resources spread across various locations geographically considering the data transfer costs and time ? the algorithms problems of finding the critical shortest paths between the resources in scheduling tasks and resource ? the algorithm delay of converge in finding an optimal solution is overcome ? the application performance tested with other algorithms not evaluated ? The design complexities of scheduling approaches involving multiple QoS requirements based on time, cost, and resource. ? the scalability requirements of the applications ? the scheduling problems of the application execution in real-time The challenges of workflow scheduling [27]are in the form of cloud system, management of tasks, resources, data, integration of above and meeting the expected criteria in which the managing the resources and scheduling are the most complex tasks above all. These different challenges are, The research work of cloud computing technology is facing a lot of problems of diverse nature and a lot of work has to be done in this field for the technology to be fully available with the desired qualities. In the next section we review some of the important research work done in this field.?

4 III.

5 Systematic Literature Review

The research work related to the cloud scheduling of workflows, the research criteria and affirmation of its relevance to the latest scenarios, is reviewed in this section.

The criteria of the literature reviewed in this paper are various cloud workflow constraints discussed in the taxonomy section and are assessed on its relevance to present and future research work. The recent literatures relevant to the field of cloud computing and specific approaches of cloud work-flow scheduling are reviewed here.

The previous research work in the field of grids and clusters that have relevance to the cloud computing however have faced problems are, A Workflow scheduling algorithm by Lin and Lu [28] for service-oriented systems is capable of dynamic resource provisioning which is not possible with algorithms of grid environments. The approach fails in cloud environments implementation as it does not consider the cost of the resources required.

A workflow scheduling algorithm by Shi and Dongarra [29] for clusters environments is applicable to the cloud environments if the cloud infrastructure is allocated unconditionally. The algorithms however are unable to accurately assess the number of machines required for cost minimization so are inapplicable for scalable cloud environments dependent on manageable cost as per use.

The above methods mostly concentrated on reducing the task runtime based on the availability of limited number of resources without considering the cost factor involved in the process of execution and are not suitable for clouds environments.

A job scheduling algorithm for cloud environments by Baomin Xu et al. [30] is structured on the Berger model categorizes the user tasks according to QoS parameters as well as defines the criteria of resource selection for resource allocation. The approach succeeds in QoS specific task execution however leaves out valid scheduling criteria such as improving server performance and security.

A model for utilizing Cloud environment in addition to desktop Grid resources projected by C. J. Reynolds, S. Winter, G. Z. Terstyanszky, T. Kiss, P. Greenwell, S. Acs and P. Kacsuk [31] uses the cloud environment for executing specific slow tasks. The approach does not improve performance in terms of time or cost factors and without assurance runs on detecting tasks consuming time.

A dynamic scheduling strategy for multiple workflows in Clouds by Mao and Humphrey [32] based on assumption of the existence of various VM models of diverse specifications of cost, proposes to reduce the cost of task execution. This technique though robust does not assure cost minimization and is only a probable solution.

A scheduling approach FAIR for cloud environments by Riktesh Srivastava [33] for multiple users is a node feedback based approach that identifies nodes ready for computation for allotting the tasks in queue. Though the response time is enhanced in case of simple tasks and ensures resources allocation in case of big tasks, FAIR is not based on criteria such as increasing the overall performance, localization of information and quality of service.

A fault tolerant scheduling algorithm FTWS for cloud environments by J. Nirmala, S. Bhanu, S. Jaya divya in 2010 [34] based on tasks resubmission and replication, is tested with several workflow types with diverse time constraints and different faults, performs efficiently in comparison to scheduling algorithms not based on fault tolerance. The proposed algorithm on execution however shows high failure rate. An scheduling algorithm based on heuristic of PSO by S. Pandey, L. Wu, S. M. Guru and R. Buyya, [35] for cloud environments optimizes workflow scheduling process to minimize the execution cost and for distributing as well as balancing the tasks load over the resources. For cost reduction, the execution time is further extended and though this may be viable in nonelastic environments like cluster or a grid, however in clouds where scalability is a prime criterion the approach however requires a more detailed schedule.

The scheduling problem for cloud environments based on the PSO technique by Z. Wu, Z. Ni, L. Gu, and

X. Liu et al [36] under deadline and budget limitations for diverse nature of resources, similar to the work in [35]. However it supposes the existence of cloud resources i.e. VMs prior to the execution and is not scalable as required by public clouds.

The approaches [29], [36] are designed for executing workflows, allotting resources, implementing the tasks, managing the scheduling process and for evaluating the execution or the results. The approaches however are devoid of a regulated QoS based framework and require detailed research activities as well as community collaboration.

An algorithm by M. Rahman, X. Li, and H Palit [37] for hybrid Clouds utilizes minimal resources at very less cost and with greater performance management.

A scheduling algorithm PBTS for clouds by E.-K. Byun Y.-S. Kee, J.-S. Kim, and S. Maeng, [38] assigns tasks to resources assuming the availability of a particular cloud resource in allocation and scheduling. The approach however is based on a specific category of VM and does not address the divergent environments of computing resources.

Cloud Workflow algorithms by S. Abrishami, M. Naghibzadeh, and D. Epema [39] optimize workflows for cost reduction, adhering to the user defined time limits. The two different algorithms proposed however are not based on the number of times the data is assigned in the process of resources mapping as well asscheduling that result in automatic escalation of the cost of running the tasks.

The scheduling approaches developed by Mao et al [32], S. Pandey et al, [35], Wu, et al [36] are specific scheduling algorithms that are based on the characteristics unique to the cloud computing systems. The research work of recent times given below by Reynolds et al [31], Rahman et al [37], Byunet al [38] and Abrishamiet al [39], concentrated on the developing algorithms based on the complex factors associated with cloud environments.

The topics of managing multiple workflows executions or multi-tasking workloads on Clouds has been of great interest for researcher as reviewed below, A scheduling approach for multiple large scale grid workflows application by R. Duan, R. Prodan, and T. Fahringer [40] is based on a simple game centric optimization approach. Itis effective for enhancing the performance and simultaneously reduces cost.

A powerful cloud resource provisioning and task scheduling approach by Smith, Siegel and Maciejewski [41] focuses on allocation of resources in workflows with specific criteria of QoS in distributed environments.

The methods discussed in [34], [40] [41] did not consider or study in detail the system efficiency and the varying criteria of scheduling profiles or policies in minimizing implementation time, cost and balancing load.

Workflow models developed specifically for the criteria of energy consumption, tried to minimize the levels of energy consumption as reviewed below, A cloud scheduling approach for reducing the power consumption by Q Zhu J Zhu and G Agrawal [42] effectively executes the workflow without affecting the other criteria involved.

A ”RC2” scheduling algorithm for the cloud systems by Lee and Zomaya [43] is designed for effectively finishing the given tasks specifically for hybrid cloud. An initial schedule based on the resources of a private cloud or the organization is calculated for effectively reducing the resource utilization in cloud execution.

A cloud systems scheduling model that is energy efficient, by Peng Xiao, Zhi-Gang Hu, Yan-Ping Zhang [44] schedules workflows with heavy data loads that are executable with virtual data centers. The approach based on a unique technique, Minimal Data-Accessing Energy Path, proposes to reduce the energy consumption while accessing huge data.

The above approach though is an algorithm for optimizing scheduling time, cost and is energy aware, fails in efficiently managing the power utilization and preventing scheduling mismatch causing wastage.

The scheduling of huge scientific workflow in the areas such as bioinformatics, astronomy, geosciences, physics etc. executed on grids, clusters or supercomputers till recently are changing to cloud systems for the increasing performance requirements in terms of big-data workloads and huge complexity of the tasks.

A multi-tenant cloud workflow model based on BPEL standard language by Bhaskar Prasad Rimal, Mohamed A. El Refaey [45], use two workflow approaches based on the semantic and policy criteria for clouds computing of scientific workflows with different cloud setups. Though effective in performance, the approach did not consider the varying scheduling profiles or policies for minimizing implementation time and cost and has system efficiency implementation complexities of separating data and managing security. A framework for scientific workflows in dynamic resource allocation in the cloud environment by T. T. Huu, G. Koslovskiet al. [46] automatically allocates, deploys and executes the resources. The approach is based on a model of cost appraisal and optimization using cloud managed virtualized network and machines. However the algorithms adaptation to the cloud process is difficult as its performance in terms of time and safety is unsatisfactory and also incurs high costs.

The security issues of unknown as well as known kind have been studied in the established grid computing environment. In the clouds, security for workflow scheduling, finds greater relevance, A workflow schedule with security factors is studied by Liu, H., A. Abraham, V. Sná?el et al. [47] who proposeda solution of PSO based scheduling algorithm. The scheduling strategy by Ko?o dziej, J., F. Xhafa [48], shows the probability of failure in batch processing. The approach quantifies the independent tasks behavior in terms of security and reliability of resources.

The simulation tests and performance0 of the above algorithms in terms of execution time and security is better compared to other similar approaches, however they do not consider the costs associated and thus are inapplicable for direct use in the scheduling of cloud workflow systems. With the advances in applications of cloud computing, security aspect of workflow scheduling has been further studied, A cloud scheduling approach of multidimensional QoS optimization, by Sun, D. W., G. R. Chang, F.Y.Li etal., [49]schedules the resources by quantifying the user's application requirements with animmune clone optimization based algorithm approach. However the approach has difficulties of insufficient depiction of the security functionality, the security attributes like fuzziness and randomness and the quantitative strength.

A scheduling algorithm for cloud systems based on PSO by Li, J et al. [50]for computing vast scale of data, reduces scheduling time as well as cost of the cloud service. The approach however does not address the unfamiliar security threats associated with cloud computing platform. A hierarchical scheduling approach for systems of cloud computing based on scheduling the service layer and the task layer by Wu, Z., et al [51] is wholly customer centric. In the cloud environment, the appropriate resources for the workflow tasks are allotted with service layer scheduling while the execution time and cost are reduced by task scheduling.

The algorithms discussed above in a cloud workflow scheduling system, while meeting the security constraints of execution, insufficiently address the QoS requirements of execution time and cost.

IV.

6 Conclusion

In this paper we have reviewed the taxonomy and contemporary affirmation of the benchmarking models in recent literature about works flow scheduling in cloud computing. Many of scheduling models observed in the literature. The common constraint of these many models is the generalization of the scheduling priorities or deep involvement of the experts towards customizing the scheduling order. The experiences learnt from the existing models evincing that the scheduling priorities are divergent from one context to other of the organizations, also different depend the resource availability and usage. Hence it is quite obvious to confirm that there is vast research scope to define novel Scheduling strategies for Cloud workflow management. In order to overcome the constraints observed, the custom level scheduling will be the possible criteria of the research. The lessons from the past scheduling order can help to redefine the current scheduling order, henceforth the evolutionary and machine learning strategies are highly adoptable to define robust and scalable workflow scheduling strategies [1] [2]

Figure 1:

[L I U ()] 'A b r a h a m'. H L I U , A . *Swarm Scheduling Approaches for Work-Flow Applications with Security Constraints in Distributed Data-Intensive Computing Environments. -Information Sciences*, 2012. 192 p. .

[Yuan et al. ()] 'A data dependency based strategy forinter mediate data storage in scientific cloud work flow systems'. Dong Yuan , Yun Yang , Xiao Liu , Gaofeng Zhang , Jinjun Chen . *Concurrency and Computation: Practice & Experience* 2012. 24 (9) p. .

[Fei and Lu ()] 'A Dataflow-Based Scientific Workflow Composition Framework'. X Fei , S Lu . *IEEE Transactions on Services Computing (TSC)* 2012. 5 (1) p. .

[Rahman et al. ()] 'A dynamic critical path algorithm for scheduling scientific workflow applications on global grids'. M Rahman , S Venugopal , R Buyya . *Proc. 3rd IEEE Int. Conf. e-Sci. Grid Comput*, (3rd IEEE Int. Conf. e-Sci. Grid Comput) 2007. p. .

[Bhaskar Prasad Rimal and Refaey ()] 'A Framework of Scientific Workflow Management Systems for Multi-Tenant Cloud Orchestration Environment'. Mohamed A El Bhaskar Prasad Rimal , Refaey . *Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises*, 2010.

[Zhangjun et al. ()] 'A Market-Oriented Hierarchical Scheduling Strategy in Cloud Workflow Systems'. W Zhangjun , L Xiao , N Zhiwei , Y Dong , Yun , Y . *Journal of Supercomputing* 2011.

[W U and X. L I U ()] 'A Market-Oriented Hierarchical Scheduling Strategy in Cloud Workflow Systems'. Z W U , Z X. L I U . *J. Supercomputer* 2013. 63 (1) p. .

[Xu et al. ()] 'A multiple QoS co nstrained scheduling strategy of multiple workflows f or cloud computing'. M Xu , L Cui , H Wang , Y Bi . *Proceedings of the Internati onal Symposium on Parallel and Distributed Proces sing with Applications (ISPA)*, (the Internati onal Symposium on Parallel and Distributed Proces sing with Applications (ISPA)) 2009.

[Pandey et al. ()] 'A particle swarm optimization-based heuristic for scheduling workflow applications in cloud computing environments'. S Pandey , L Wu , S M Guru , R Buyya . *Proc. 24th IEEE International Conference on Advanced Information Networking and Applications*, (24th IEEE International Conference on Advanced Information Networking and Applications) 2010. p. .

[Wu et al. ()] 'A revised discrete particleswarm optimization for cloud workflow scheduling'. Z Wu , Z Ni , L Gu , X Liu . *Proc. IEEE Int. Conf. Comput. Intell. Security*, (IEEE Int. Conf. Comput. Intell. Security) 2010. p. .

[Smith et al. ()] 'A Stochastic Model for Robust Resource Allocation in Heterogeneous Parallel and Distributed Computing Systems'. J Smith , H J Siegel , A A Maciejewski . *Proc. of IEEE Int'l Parallel & Distributed Processing Symp. (IPDPS'08)*, (of IEEE Int'l Parallel & Distributed essing Symp. (IPDPS'08)Miami, FL) 2008.

[Fang et al. ()] 'A Task Scheduling Algorithm Based on Load Balancing Cloud Computing'. Yiqiu Fang , Fei Wang , Junwei Ge . Lecture Notes in Computer Science 2010. 6318 p. .

[L I and H U A N G ()] *A Task Scheduling Algorithm for Large Graph Processing Based on Particle Swarm Optimization in Cloud Computing*, J L I , Q J H U A N G , YY . 2012. 46 p. . Journal of Xi'an Jiaotong University

[Monaco] *A View inside theCloud*, A Monaco . `http://theinstitute.ieee.org/technology-focus/technology-topic/a-view-inside-the-cloud`

[Armbrust et al. ()] *Above the clouds: A Berkeley View of Cloud Computing*, M Armbrust , A Fox , R Griffith , A D Joseph . No. UCB/EECS- 2009-28. 2009. Berkerley, CA. University of California (Technical Report)

[Xiao et al. ()] 'An Energy-Aware Heuristic Scheduling for Data-Intensive Workflows in Virtualized Datacenters'. Peng Xiao , Zhi-Gang Hu , Yan-Ping Zhang . *Journal of Computer Science and Technology* 2013. 28 (6) p. .

[Mao and Humphrey ()] 'Auto-scaling to minimize cost and meet application deadlines in cloud workflows'. M Mao , M Humphrey . *Proceedings of the 2011 International Conference for High Performance Computing, Networking, Storage and Analysis (SC)*, (the 2011 International Conference for High Performance Computing, Networking, Storage and Analysis (SC)) 2011. p. .

[Juve et al. ()] 'Characterizing and profiling scient ific workflows'. G Juve , A Chervenak , E Deelman , S Bharathi , G Me , K Vahi . *Future Generation Comput. Syst* 2012. 29 (3) p. .

[Buyyaa et al. ()] 'Cloud Computing and Emerging IT platforms: Vision, Hype, and Reality for Delivering Computing as the Utility'. Rajkumar Buyyaa , Srikumar Chee Shin Yeo , James Venugopal , Ivona Broberg , Brandic . *Journal Future Generation Computer Systems* 2009. 25 (6) .

[Chai and Cao ()] 'Cloud Computing Oriented Workflow Technology'. Xuezhi Chai , Jian Cao . *Journal of Chinese Computer Systems* 2012. 33 (1) p. .

[Calheiros et al. ()] 'CloudSim: A toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms'. R N Calheiros , R Ranjan , A Beloglazov , C A Derose , R Buyya . `http://dev.opennebula.org/` *Software: Practice Experience* 2011. 41 (1) p. 19.

[Keahey and Freeman ()] *Contextualization: Providing One-click Virtual Clusters. ine Science*, K Keahey , T Freeman . 2008. 2008. Indianapolis, IN. p. .

[Malawski et al. ()] *Cost and deadline constrained provisioning for scie ntific work flow ensembles in iaas clouds*, M Malawski , G Juve , E Deelman , J Nabrzyski . 2012. SC. 22 p. 11.

[Byun et al. (2011)] 'Cost optimized provisioning of elastic resources for application workflows'. E.-K Byun , Y.-S Kee , J.-S Kim , S Maeng . *Future Generation Computer Systems* Aug. 2011. 27 (8) p. .

[Abrishami et al. (2013)] 'Deadline constrained workflow scheduling algorithms for IaaS clouds'. S Abrishami , M Naghibzadeh , D Epema . *Future Generation Computer Systems* Jan. 2013. 29 (1) p. .

[Tilak (2012)] 'Dipti Patil A Survey of Various Scheduling Algorithms in Cloud Environment'. Sujit Tilak , Prof . *International Journal of Engineering Inventions* 2278-7461. September 2012. 1 (2) p. .

[Nirmala et al. ()] 'Fault tolerant workflow scheduling based on replication and resubmission of tasks in Cloud Computing'. J Nirmala , S Bhanu , S Jayadivya . *International Journal on Computer Science and Engineering* 2010.

[Yujiage ()] 'GA -Based Task Scheduler For the Cloud Computing Systems(WISM'10)'. Guiyiwei Yujiage . *Proceedings of the International Conference on Web Information Systems and Mining*, (the International Conference on Web Information Systems and Mining) 2010. 02 p. .

[Zhang and Li ()] 'Grid Computing Resources Management Scheduling System Based on Evolutionary Algorithm'. Yinfeng Zhang , Yulin Li . *Computer Engineering* 2003. 29 (15) p. .

[Rahman et al. ()] 'Hybrid heuristic for scheduling data analytics workflow applications in hybrid cloud environment'. M Rahman , X Li , H Palit . *Proceedings of the Parallel and Distributed Processing Workshops and PhD Forum (IPDPSW)*, (the Parallel and Distributed Processing Workshops and PhD Forum (IPDPSW)) 2011.

[Srivastava ()] *Implementation of Job Scheduling Algorithms in a Cloud Computing Environment for B2C Electronic Commerce Architecture using GI/G/1 Queuing Model*, Riktesh Srivastava . 2008.

[Xu et al. ()] 'Job Scheduling Algorithm Based on Berger Model in Cloud Environment'. Baomin Xu , Chunyan Zhao , Enzhao Hu , Bin Hu . *Advances in Engineering Software*, 2011. 42 p. .

[Huu et al. ()] 'Joint Elastic Cloud and Virtual Network Framework for Application Performance-cost Optimization'. T T Huu , G Koslovski , F Anhalt , J Montagnat , P , V-B Primet . *Journal of Grid Computing* 2011. (1) p. .

[Zhao et al. ()] 'Opportunities and Challenges in Running Scientific Workflows on the Cloud'. Y Zhao , X Fei , I Raicu , S Lu . *IEEE International Conference on Cyberenabled distributed computing and knowledge discovery (CyberC)*, 2011. p. .

[S U N and C H A N G ()] 'Optimizing Multi-Dimensional QoS Cloud Resource Scheduling by Immune Clonal with Preference'. D W S U N , G R C H A N G , FY . *Acta Electronica Sinica* 2011. 39 (8) p. .

[Duan et al. ()] 'Performance and Cost Optimization for Multiple Large-scale Grid Workflow Applications'. R Duan , R Prodan , T Fahringer . *Proc. of IEEE/ACM Int'l Conf. on Super Computing (SC'07)*, (of IEEE/ACM Int'l Conf. on Super Computing (SC'07)Reno) 2007.

[Zhu and Zhu ()] *Power-aware consolidation of scientific work flows in virtualized environments*, Q Zhu , J Zhu , G . 2010. SC. p. .

[Lee and Zomaya ()] 'Rescheduling for reliable job completion with the support of clouds'. Y C Lee , A Y Zomaya . *Future Generation Computer Systems* 2010. 26 p. .

[Liu et al. ()] 'Research of "Our customers expect" task scheduling algorithm based on cloud computing'. Zhijia Liu , Tirong Zhang , Xiongchen Xie . *Popular Science* 2011. (4) p. .

[Wang and Dong ()] 'Research of a realization method of cloud computing architecture'. Peng Wang , Jingyi Dong . *Computer Engineering and Science* 2009. p. .

[Samimi and Patel ()] 'Review of Pricing Models for Grid and Cloud Computing'. P Samimi , A Patel . *Proc. IEEE Symp. on Comp. and Informatics*, (IEEE Symp. on Comp. and Informatics) 2011.

[Kllapi et al. ()] 'Scheduleoptimization fordataprocessingflowsonthec loud'. H Kllapi , E Sitaridi , M M Tsangaris , Y Ioannidis . *SIGMOD*, 2011.

[Shi and Dongarra (2006)] 'Scheduling workflow applications on processors with different capabilities'. Z Shi , J J Dongarra . *Future Generation Computer Systems* May 2006. 22 (6) p. .

[Reynolds et al. ()] 'Scientific workflow make span reduction through cloud augmented desktop grids'. C J Reynolds , S Winter , G Z Terstyanszky , T Kiss , P Greenwell , S Acs , P Kacsuk . *Proceedings of the 3 rd International Conference on Cloud Computing Technology and Science Cloud Com*, (the 3 rd International Conference on Cloud Computing Technology and Science Cloud Com) 2011.

[Lin and Lu ()] 'SCPOR: An elastic workflow scheduling algorithm for services computing'. C Lin , S Lu . *Proceedings of the International Conference on Service-Oriented Computing and Applications (SOCA)*, (the International Conference on Service-Oriented Computing and Applications (SOCA)) 2011.

[Cao et al. ()] 'Service Flow: QoS-based hybrid service-oriented grid workflow system'. Haijun Cao , Hai Jin , Xiaoxin Wu , Song Wu . *Journal of Supercomputing* 2010. 53 (3) p. .

[Mace et al. ()] 'The Case for Dynamic Security Solutions in Public Cloud Workflow Deployments'. John C Mace , Aad Van Moorsel , Paul Watson . *Proceeding of the IEEE/IFIP 41st International Conference on Dependable Systems and Networks Workshops*, (eeding of the IEEE/IFIP 41st International Conference on Dependable Systems and Networks Workshops) 2011.

[Kashani and Jahanshahi ()] 'Using simulated annealing for task scheduling in distributed systems'. M Kashani , M Jahanshahi . *Computational Intelligence, Modelling and Simulation*, 2009. 2009. p. .

[Ko?o D Z I E J ()] 'X h a f a. Integration of Task Abortion and Security Requirements in GA Based Meta-Heuristics for Independent Batch Grid Scheduling'. J Ko?o D Z I E J , F . *Computers and Mathematics with Applications*, 2012. 63 p. .

[Luo and Mu ()] 'Zhiqun Deng, et. Research of Task Scheduling in Grid Computing'. Hong Luo , Dejun Mu . *Application Research of Computers* 2005. (5) p. .