Survey on Performance and Energy – Aware Task Scheduling over Big Data in Cloud Computing

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Abstract: Task Scheduler is responsible of assigning an infrastructure resource to execute the task taking into account data locality, task constraints and the workload of each resource. The information required for the scheduling is provided by the Data Info provider, which tracks the locations of the different versions and replicas of the application data, and the Resource Manager, which provides. Scheduling in cloud computing environments, in order to minimize the cost incurred by using a set of resources and total execution time. Scheduling the big data workflow is meeting the specified deadline in such a way that the monetary cost and energy consumption are minimized. In this article many efficient scheduling techniques are analysed for the purpose of reducing the energy consumption. Analysis of these techniques has able to generate new improvements in this sector. Hence, we present a brief survey of 75 techniques. These techniques are taken from the standard publishers in the year of 2010 to 2018. Here, we are categorised techniques based on the year. Moreover, addressing of these techniques are determine the significance of their methods so that the new enhancement of task scheduling in cloud computing can be more attainable for the analysers. Finally, few of the research problems are also addressed to precede the further research on the same area. In this article the researches have made a survey about these better and early termination algorithms for the new coding standard.

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1. Introduction

Cloud computing is an extremely successful paradigm of service oriented computing, and has revolutionized the way computing infrastructure is abstracted and used. Three most popular cloud paradigms include: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) [76]. Cloud computing delivers an

infrastructure, platform, and software (applications) as services that are made available to consumers in a pay-as-you-go model [79]. The current technology, cloud computing have all intended to access large amounts of computing power by aggregating resources and offering a single system view. Among these technologies, cloud computing is becoming a powerful architecture to perform large-scale and complex computing. Cloud computing is associated with new paradigm for the provision of computing infrastructure and big data processing method for all kinds of resources [77].

In cloud computing applications, data, platform, and other resources are provided to users as services delivered over the network. The cloud computing enables self-service with no or little vendor intervention [78]. This is essential for ensuring that the future growth of Cloud computing is sustainable. Otherwise, Cloud computing with increasingly pervasive frontend client devices interacting with back-end data centers will cause an enormous escalation of the energy usage. Cloud resources need to be allocated not only to satisfy Quality of Service (QoS) requirements specified by users via Service Level Agreements (SLAs), but also to reduce energy usage [79].

Big data is defined as large amount of data which requires new technologies and architectures so that it becomes possible to extract value from it by capturing and analysis process. Due to such large size of data it becomes very difficult to perform effective analysis using the existing traditional techniques. Big data due to its various properties like volume, velocity, variety, variability, value and complexity put forward many challenges [81]. Big data is not only becoming more available but also more understandable to computers. Big data can be defined as data that exceeds the processing capacity of conventional database systems. It implies that the data count is too large, and/or data values change too fast, and/or it does not follow the rules of conventional database management systems [78].

Cloud computing provides a scalable and cost efficient solution to the big data challenge; although largely ill-defined. While some of the concepts behind cloud computing, such as distributed systems, grid computing and parallelised programming are not new, one of the primary enablers for cloud is virtualisation technology [80]. It is well known that processing big graph data can be costly on Cloud. Processing big graph data introduces complex and multiple iterations that raise challenges such as parallel memory bottlenecks, deadlocks, and inefficiency [81]. The collection of interconnected computers that consists of more than one united computing resource is known as the Cloud. In recent years, the advancement of cloud computing has helped simulate the quick arrangement of inter-connected data centers that are geographically dispersed for offering high

quality and dependable services. If the jobs are not scheduled correctly, performance reduces because the cloud processes a huge amount of data. Thus, the scheduling mechanism plays a vital role in cloud computing.

A scheduling algorithm is utilized to plan the task with greatest evaluated gain or benefit and execute the task [82]. A good scheduling techniques help production costs to decrease by efficiently taking advantage of the available resources. On certain occasion is providing a reliable scheduling framework that is able to deal with a very high volume of jobs per time unit [83]. Big Data applications lies in many scientific disciplines like astronomy, atmospheric science, medicine, genomics, biologic, biogeochemistry and other complex and interdisciplinary scientific researches. Web-based applications encounter Big Data frequently, such as recent hot spots social computing (including social network analysis, online communities, recommender systems, reputation systems, and prediction markets), Internet text and documents, Internet search indexing. Big Data problems arises in commerce and business, society administration and scientific research fields [84].

2. Task Sheduling Framework

Task scheduling plays a crucial part in managing and sharing cloud resources with different cloud users. Therefore, task scheduling is a major research topic in the area of cloud computing. In this survey paper, we have analyzed the concept of task scheduling published in the literature between 2010 and 2018. We selected articles from scientific journals from publishers such as IEEE, Elsevier, Springer, and other international journals. During this period, a huge number of studies have on scheduling been conducted and different techniques to solve problems related to scheduling. Here, we have analyzed more than fifty research works which have different applications such as task scheduling, resource allocation, and load balancing. It is found that a variety of scheduling algorithms work on different scheduling criteria and that all algorithms are efficient in one way or another. Each method has advantages and disadvantages. Therefore, there is every possibility of continuing and enhancing previously completed work in this field. Each algorithm has some limitations such as maximum scheduling time, overloaded, computation complexity and delay.

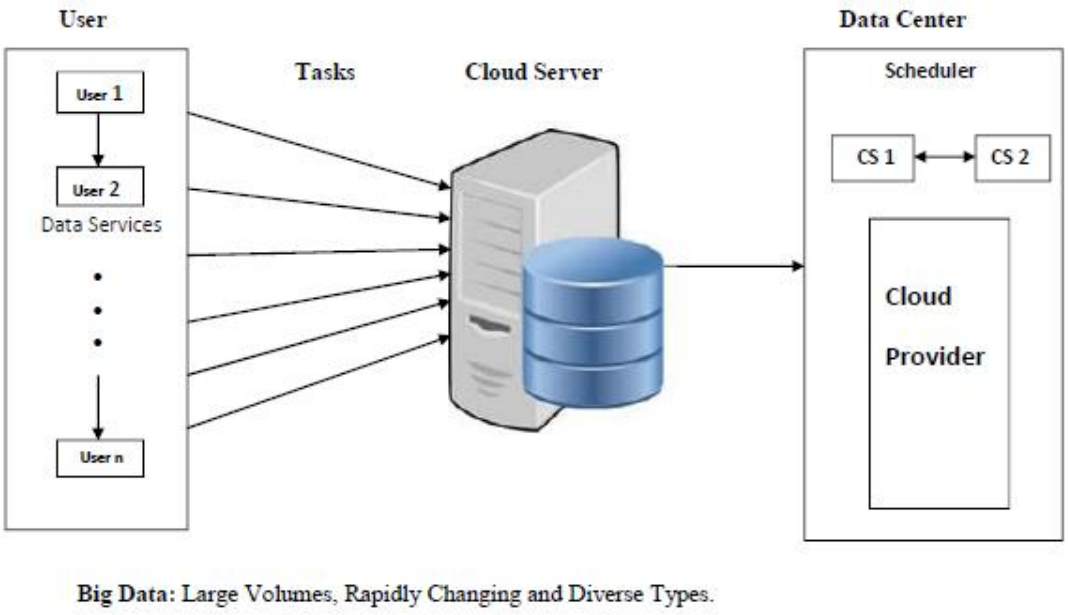

Fig.1. Framework of Task Scheduling in Cloud

F**ig.1**. Shows the task scheduling framework in cloud computing. In this framework, the user provides a data's. The data units are further divided into small tasks to be transmitted in to the cloud server. Information Service keeps the details of resource utilization and other log information to help scheduler to schedule a task to a CS in a data center. The scheduler accepts the task unit from the user portal and uses Information Service to choose the appropriate CS in a cloud data center. After the task unit is complete its execution, the result and the new status of the resource will be sent back to the Data Service for another scheduling.

3. Syrvey Of Task Sheduling In Cloud Computing

Articles from 2010 to 2011

In internets, cloud computing is the new method for hosting and delivering services. Cloud computing is famous for business owners as it removes the uses for users to plan ahead for provisioning, and allows enterprises to start from the small and increase resources only when there is a rise in service demand. The cloud computing provides large amount of opportunities to the IT industry, the development of cloud computing technology is currently at its infancy, with many issues still to be addressed**. Qi Zhang** *et al.* [1] have presented an approaches and architectural principles of cloud computing. The main aim of their article was clear presentation of a better understanding of the design challenges of cloud computing and determine the important research directions in that increasingly important area.

Razvan I. Dinita *et al.* [2] have presented an optimised and novel approach to an Autonomous Virtual Server Management System in a 'Cloud Computing' environment. The main advantage of that system was to enhance the hardware power consumption via autonomously moving virtual servers over a network to balance out hardware loads. That was the major problem of sustainability with both energy efficiency and economic viability. Another important advantage of that method was enhancement of the overall end-user experience for services within the Cloud. That have addressed via a cloud-computing test-bed rig.

M. Mezmaz *et al.* [3] have presented a new parallel bi-objective hybrid genetic algorithm. Their algorithm was used to reduce the completion time (makespan) without paying much attention to energy consumption. They were mainly focused on the island parallel model and the multi-start parallel model. They were also present a new method that was based on the dynamic voltage scaling (DVS) to minimize energy consumption. In terms of energy consumption, their achieved output performs better than the previous scheduling methods. In terms of completion time, the achieved schedules were also smaller than that of other algorithms. But their method was not supported for the potential of DVS.

High Performance Computing (HPC) was used for the commercial and consumer IT applications. The high scalable end computing capabilities were needed for HPC users. The computing infrastructure was delivered by using data centers due that HPC users can process the cloud applications and data. Those have increased the energy consumption of data centers that was a major issue of cloud computing. The high energy consumption was reduced the profit margin of Cloud providers and also increased the high energy cost. To overcome those issues the **Saurabh Kumar Garg** *et al*. [4] have presented near-optimal scheduling policies. They include some energy efficiency factors such as energy cost, carbon emission rate, workload, and CPU power efficiency. Depending on their area, architectural design and management system was varied for various data centers. Their carbon/energy based scheduling policies have able to obtain on average up to 25% of energy savings in comparison to profit based scheduling policies leading to higher profit and less carbon emissions.

The main aim of cloud computing was to arrange only truly wanted cloud resources. Many of the mechanisms support only simple resource utilization indicators. Due to that, the **Mao** *et al.* [5] have presented an approach called a new auto-scaling mechanism. That mechanism was used for the basic computing elements are virtual machines (VMs) of various sizes/costs, jobs are specified as workflows, users specify performance requirements by assigning (soft) deadlines to jobs, and the

goal is to ensure all jobs are finished within their deadlines at minimum financial cost. The major goal of their article was dynamic allocation/deallocation of virtual machines VMs and arranging tasks on the most cost-efficient instances. They also calculate their approach in four representative cloud workload patterns and their results shows cost savings from 9.8% to 40.4%.

The distributed computing, grid computing and virtualization are used to made a cloud computing. Hence cloud resources task have various cost and clouds traditional scheduling task was not same as in traditional scheduling methods. The goal of their article was to schedule task groups in cloud computing platform for different resource costs and computation performance. Due to job grouping, communication of coarse-grained jobs and resources optimizes computation/communication ratio were caused. For that, the **Selvarani, S., and G. Sudha Sadhasivam** [6] have presented an algorithm named as an improved cost-based scheduling algorithm based on both costs with user task grouping. That was used for creating an efficient mapping of tasks to available resources in cloud.That algorithm evaluates both resource cost and computation performance and also enhance the computation/communication ratio by grouping the user tasks according to a particular cloud resource's processing capability and sends the grouped jobs to the resource.

Large amounts of application data need to be stored in distributed data centres in cloud workflow. To effectively store those data, a data handler must intelligently select data centres in which those data would reside. This is, however, not the case for data which must have a fixed location. When one task needs several datasets located in different data centres, the movement of large volumes of data becomes a challenge. Due to that the **Dong Yuan** *et al.* [7] have presented a matrix based k-means clustering strategy for data placement in scientific cloud workflows. The strategy consists of two algorithms that group the existing datasets in k data centres during the workflow build-time stage, and dynamically clusters newly generated datasets to the most appropriate data centres – based on dependencies – during the runtime stage. Their Simulations result shows their algorithm could effectively reduce data movement during the workflow's execution.

Warneke *et al.* [8] have discussed the opportunities and challenges for efficient parallel data processing in clouds opportunities and challenges for efficient parallel data processing in clouds. They have presented a Nephele. Nephele was nothing but the first data processing framework to explicitly exploit the dynamic resource allocation offered by today's IaaS clouds for both, task scheduling and execution. Particular tasks of a processing job could be arranged to various types of virtual machines that

were automatically instantiated and terminated during the job execution. Based on that new framework, they were process extended evaluations of Map Reduce inspired processing jobs on an IaaS cloud system and compare the results to the popular data processing framework Hadoop.

Cloud infrastructures have recently become a center of attention. They can support dynamic operational infrastructures adapted to the requirements of distributed applications. As large-scale distributed systems reach enormous sizes in terms of equipment, the energy consumption issue becomes one of the main challenges for large-scale integration. Due to that the **Lefèvre, Laurent, and Anne-Cécile Orgerie** [9] have discussed about energy issue by analyzing how much energy virtualized environments cost. They present an energy-efficient framework dedicated to Cloud architectures and they also calculate via various experimentations on a modern multi core platform. Their result shows a realistic example that their infrastructure could save 25% of the Cloud nodes' electrical consumption.

Young Choon Lee *et al.* [10] have discussed about the problem of scheduling precedence-constrained parallel applications on multiprocessor computer systems. They have present two energy-conscious scheduling algorithms using dynamic voltage scaling (DVS). A number of recent commodity processors are capable of DVS, that able to processors to operate at various voltage supply levels at the expense of sacrificing clock frequencies. In the context of scheduling, that multiple voltage facility implies there is a trade-off between the quality of schedules and energy consumption. To effectively balance those two performance goals, they were devised a novel objective function and a variant from that. The main difference between the two algorithms is in their measurement of energy consumption. The extensive comparative evaluations conducted as part of their work shows that the performance of their algorithms is very compelling in terms of both application completion time and energy consumption.

Stylianos Zikos *et al*. [11] have analyzed about the three local resource allocation policies. Those policies were based on shortest queue, in a cluster with heterogeneous servers. Two of them were optimized for performance and the third one is optimized for energy conservation. They were consider that there a two types of processors in the cluster, with different performance and energy characteristics. They also consider that service times of jobs are unknown to the scheduler. Their simulation result was used for calculate the performance and energy behaviour of the policies. Their simulated result shows the variations among the policies depend on system load and there is a trade-off between performance and energy consumption.

Energy consumption has many benefits in minimal computation, such as

environment protection, cost savings, etc. An important research problem was the energy aware task scheduling for cloud computing. For many diverse computers in a typical cloud computing system, great energy reduction can be achieved by smart optimization methods. The aim of energy aware task Scheduling was to efficiently complete all designed tasks to reduce energy consumption with various constraints. Genetic Algorithm (GA) was a popular and effective optimization algorithm. But operating speed of that algorithm was lower than other traditional search algorithms such as heuristic algorithm. Due to that the **Shen** *et al.* [12] have presented a shadow price guided algorithm (SGA) to enhance the performance of energy aware task scheduling. Their experimental result shows, that their energy aware task scheduling algorithm using the new SGA is more effective and faster than the standard GA.

Jayant Baliga *et al.* [13] have presented an analysis of energy consumption in cloud computing. Their research assigns both public and private clouds, and comprises energy consumption in switching and transmission as well as data processing and data storage. They also shows that energy consumption in transport and switching can be a significant percentage of total energy consumption in cloud computing. Cloud computing could allow more energy-efficient use of computing power, especially when the computing tasks are of low intensity or infrequent. In some cases, cloud computing could consume more energy than conventional computing where each user performs all computing on their own personal computer (PC).

Minimizing power consumption has been an essential constraint for Cloud resource providers not only to decrease operating costs, but also to enhance the system reliability. Due to that **Nawfal** *et al.* [14] have presented a task scheduling algorithm. That has able to lowering the power consuming and reducing the total data center load. That algorithm was used to for the distribution of task deadline and VM load based on the load and also used for the calculation of scheduling algorithm. The main aim of their article was to reduce the problem of minimizing power consuming in data centers hosts and enhancing their load balancing simultaneously. Cloud computing based on the approach of offering services going to be executed on data centers. Those data centers need huge amount of power if they are in the peak load or the tasks are not distributed efficiently in their machines.

Xiangzhen Kong *et al.* [15] have presented an efficient dynamic task scheduling scheme for virtualized data centers. Including the availability and responsiveness performance, the general model of the task scheduling for virtual data centers is generated and formulated as a two-objective optimization. A graceful fuzzy prediction method was given to

model the uncertain workload and the vague availability of virtualized server nodes, by using the type-I and type-II fuzzy logic systems. An on-line dynamic task scheduling algorithm named SALAF was presented and calculated. Experimental results show their algorithm could enhance the total requirements of the virtualized data center while providing good responsiveness performance.

Articles from 2012 to 2013

In computing resources, data centers of cloud computing were famous. The cost and operating expenses of data centers have skyrocketed with the increase in computing capacity. Several governmental, industrial, and academic surveys indicate that the energy utilized by computing and communication units within a data center contributes to a considerable slice of the data center operational costs. Due to that the **Kliazovich** *et al*. [16] have presented an energy aware simulation of data centers in cloud computing environment. The simulator was assigned for the evaluation of energy consumption in components of data centers. The simulation results received for two-tier, three-tier, and three-tier high-speed data center architectures generates the effectiveness of the simulator in utilizing power management schema, such as voltage scaling, frequency scaling, and dynamic shutdown that are applied to the computing and networking components.

Energy consumption in data centers, for a considerably large slice of operational expense. The state of the art in data center energy optimization is aim to only on job distribution between computing servers based on workload or thermal profiles. Due to that the **Kliazovich, Dzmitry** *et al.* [17] have presented a scheduling approach for energy consumption in data centers and network awareness, termed DENS. The DENS methodology balances the energy consumption of a data center, separate job performance, and traffic demands. Their approach was optimizes the trade-off between job consolidation and distribution of traffic patterns.

Jiayin Li *et al*. [18] have presented a mechanisms named as resource optimization. Their mechanisms were utilized for a pre-emptable application in federated heterogeneous cloud systems in federated heterogeneous cloud systems. They also presented. Two novel online dynamic scheduling algorithms were DCLS and DCMMS, for this resource allocation mechanism. Their experimental result shows that the DCMMS outperforms DCLS and FCFS. During the fierce resource contention situation the dynamic procedure with updated information provides significant enhancements. The energy-aware local mapping in our dynamic scheduling algorithms could significantly reduce the energy consumptions in the federated cloud system.

In their article an architectural framework and principles for energy-efficient Cloud computing was addressed. For that, the

Beloglazov *et al.* [19] have presented a resource provisioning and allocation algorithms. Their algorithm was utilized for energy-efficient management of Cloud computing environments. Their energy-aware allocation heuristics provision data center resources to client applications in a way that enhances energy efficiency of the data center, while delivering the negotiated Quality of Service (QoS). They also manage a survey of research in energy-efficient computing and also presented an architectural principles for energy-efficient management of Clouds, energy-efficient resource allocation policies and scheduling algorithms considering QoS expectations and power usage characteristics of the devices; and number of open research challenges, addressing which can bring substantial benefits to both resource providers and consumers. Their result shows that the Cloud computing model have immense potential as that offers significant cost savings and demonstrates high potential for the improvement of energy efficiency under dynamic workload scenarios.

Minimal operating costs, increasing system reliability, and environmental respect were achieved from the minimal energy consumption of high end computing. The main goal of their article was to generate scheduling heuristics and to present application experience for reducing power consumption of parallel tasks in a cluster. For that the **Lizhe Wang** *et al.* [20] have presented a Dynamic Voltage Frequency Scaling (DVFS) technique. In their article formal models were presented for precedence-constrained parallel tasks, DVFS-enabled clusters, and energy consumption. Their article presented a study of the slack time for non-critical jobs, extends their execution time and reduces the energy consumption without increasing the task's execution time as a whole. Moreover, Green Service Level agreement is also considered in their article. By increasing task execution time within an affordable limit, in their article develops scheduling heuristics to reduce energy consumption of a tasks execution and discusses the relationship between energy consumption and task execution time. Models and scheduling heuristics are examined with a simulation study. Test results justify the design and implementation of presented energy aware scheduling heuristics in their article.

Si-Yuan Jing *et al.* [21] have presented a cloud computing deteriorates from different challenging issues related to security, software frameworks, quality of service, standardization, and power consumption. Efficient energy management was one of the most challenging research issues. The core services in cloud computing system are the SaaS (Software as a Service), PaaS (Platform as a Service), and IaaS (Infrastructure as a Service). For that, they address state-of-the art techniques and their article related to power saving in the IaaS of a cloud computing system,that consumes a huge part of total energy in a

cloud computing system. At the end, some feasible solutions for building green cloud computing were presented. The major to provide a better understanding of the design challenges of energy management in the IaaS of a cloud computing system.

Energy efficiency in cluster computing has two main constraints such as Operational costs, and system reliability. Energy consumption excess heat, lower operational costs, and improve system reliability were reduced by using cluster systems. Based on the energy-power relationship, and the fact that energy consumption can be reduced with strategic power management, So the **Giorgio Luigi Valentini** *et al.* [22] have concentrated on the characteristic of two main power management technologies such as static power management (SPM) systems that utilize low-power components to save the energy, and dynamic power management (DPM) systems that utilize software and power-scalable components to optimize the energy consumption. They presented also the current state of the art in both of the SPM and DPM techniques, citing representative examples. The survey is concluded with a brief discussion and some assumptions about the possible future directions that could be explored to improve the energy efficiency in cluster computing.

Uddin *et al.* [23] have presented energy efficiency and low carbon enabler green IT framework. Their presented frame work was used for the large and complex server farms to save consumption of electricity and reduce the emission of green house gases to lower the effects of global warming. Their framework uses latest energy saving techniques like virtualization, cloud computing and green metrics to obtain greener data centers. That comprise of five phase to properly implement green IT techniques to obtain green data centers. Their framework was logically splits data center components into various resource pools and then applies green metrics like Power Usage Effectiveness, Data Center Effectiveness and Carbon Emission Calculator to measure performance of individual components so that benchmarking values could be achieved and set as standard to be followed by data centers.

Xiao *et al.* [24] have presented a dynamic resource data center of virtualization technology. Their technology was based on the application demands and support green computing by optimizing the number of servers in use. They also presented a approach named as skewness. That approach was used to evaluate the unevenness in the multidimensional resource utilization of a server. By minimizing skewness, in their article they could combine different types of workloads nicely and enhance the overall utilization of server resources. They were generating a set of heuristics that prevent overload in the system effectively while saving energy used. Trace driven simulation and experiment results

demonstrate that their algorithm obtains good performance.

Maheshwari *et al.* [25] have analysed energy conservation for clusters of nodes. That was used for run Map-Reduce jobs. That algorithm dynamically reconfigures the cluster based on the current workload and turns cluster nodes on or off when the average cluster utilization rises above or falls below administrator specified thresholds, respectively. They calculate their algorithm using the Grid Sim toolkit and their results shows that their algorithm obtains an energy reduction of 33% under average workloads and up to 54% under low workloads.

Virtualization helps to encapsulate Web-based applications or HPC jobs in virtual machines (VMs) and see them as a single entity which can be managed in an easier and more efficient way. **Íñigo Goiri** *et al.* [26] have presented a new scheduling policy. Their scheduling policy was utilized for models and manages a virtualized data center. That was mainly concentrated on the allocations of VMs in data center nodes according to multiple facets to optimize the provider's profit. In particular, that includes energy efficiency, virtualization overheads, and SLA violation penalties, and supports the outsourcing to external providers. Their approach was compared with other common scheduling policies, demonstrating that a generator can enhance that benefit by 30% and save power while handling other challenges.

Wang *et al*. [27] have presented a new energy-efficient task scheduling model. They were also presented forward an effective genetic algorithm with practical encoding and decoding methods and specially designed genetic operators. That was used for the process of their scheduling model. For the time with a view to accelerating those algorithm's convergent speed as well as Improving that's searching ability, a local search operator was introduced. Finally, their experimental results show their presented algorithm was effective and efficient.

Cloud computing and task scheduling were the major principles of issues. It was the main challenging problems during energy consumption**,** traditional make span criteria and users QoS as objectives. **Changtian, Ying** and **Yu Jiong** [28] have analysed about the independent tasks scheduling in cloud computing as a bi-objective minimization problem with make span and energy consumption as the scheduling criteria. In their article, they were utilized a Dynamic Voltage Scaling (DVS) for the minimization of energy consumption. They were propose two algorithms, those two algorithms were used for the methods of unify and double fitness to define the fitness function and select individuals. In their article, reasonable scheduling scheme was achieved by applying the genetic algorithm. Their simulation result shows that the two algorithms could efficiently determine the right

compromise between make span and energy consumption**.**

Xiaomin Zhu *et al.* [29] have presented a scheduling strategy named as an adaptive energy-efficient scheduling (AEES). Their scheduling strategy was used for periodic and independent real-time tasks on heterogeneous clusters with dynamic voltage scaling. The main goal of their work was to adaptively change voltages with respect to the workload conditions of a cluster, thereby making the best trade-offs between energy conservation and schedule ability. If the cluster was heavily loaded, their strategy takes voltage levels of both new tasks and running tasks to meet tasks' deadlines. AEES aggressively reduced the voltage levels to conserve energy while maintaining higher guarantee ratios. They also we directed extensive tasks to compare their strategy with an existing algorithm – MEG, as well as two baseline algorithms – MELV, MEHV. Their experimental result shows that AEES significantly enhanced the scheduling quality of MELV, MEHV and MEG.

Sharifi, Mohsen *et al.* [30] have presented a four model named as the target system model, the application model, the energy model, and the migration model. The utilization of their models was to determine the operation of interferences between processor and disk utilizations and the costs of migrating VMs. They presented a consolidation fitness metric for the calculation of the merit of consolidating a number of known VMs on a PM based on the processing and storage workloads of VMs. In their article an energy-aware scheduling algorithm also presented for the power consumption of PMs in the whole data center. Their empirical results show nearly 24.9% power savings and nearly 1.2% performance degradation when their scheduling algorithm was used compared to when other scheduling algorithms were used.

Articles from 2014 to 2015

Wu *et al.* [31] have presented a scheduling algorithm for the cloud data center with a dynamic voltage frequency scaling technique. Their scheduling algorithm has able to increase resource utilization; thus that can minimize the energy consumption for executing jobs. Their experimental results shows that their scheme can reduce more energy consumption than other schemes do. The performance of executing jobs was not sacrificed in our scheme. They have also a green energy-efficient scheduling algorithm using the DVFS technique for Cloud computing data centers.

Xiaomin Zhu *et al.* [32] have presented a novel rolling-horizon scheduling architecture. Their architecture was used for a real-time task scheduling in virtualized clouds. Then a task-oriented energy consumption model was given and addressed. Based on their scheduling architecture, they generate a novel energy-aware scheduling algorithm named EARH for real-time, a periodic, independent tasks. The EARH employs a rolling-horizon optimization policy and can

also be extended to integrate other energy-aware scheduling algorithms. Moreover they also proposed two strategies in terms of resource scaling up and scaling down to make a good trade-off between task's schedule ability and energy conservation. Extensive simulation experiments injecting random synthetic tasks as well as tasks following the last version of the Google cloud trace logs were conducted to validate the superiority of their EARH by comparing it with some baselines. Their experimental results show that EARH significantly enhances the scheduling quality of others and that was fit for real-time task scheduling in virtualized clouds.

Mihaela-Andreea Vasile *et al.* [33] have presented a resource-aware hybrid scheduling algorithm. That was used for various applications such as batch jobs and workflows. Their algorithm considers hierarchical clustering of the available resources into groups in the allocation phase. Two phases of tasks were conducted in their article such as tasks are assigned to groups of resources and a classical scheduling algorithm was used for each group of resources. Their presented algorithm was suitable for Heterogeneous Distributed Computing, especially for modern High-Performance Computing (HPC) systems in which applications were modelled with various requirements (both IO and computational intensive), with accent on data from multimedia applications. They were calculate their performance in a realistic setting of Cloud-Sim tool with respect to load-balancing, cost savings, dependency assurance for workflows and computational efficiency, and investigate the computing methods of these performance metrics at runtime.

Diamantoulakis *et al.* [34] The smart electricity grid enables a two-way flow of power and data between suppliers and consumers in order to facilitate the power flow optimization in terms of economic efficiency, reliability and sustainability. That infrastructure permits the consumers and the micro-energy producers to take a more active role in the electricity market and the dynamic energy management (DEM). The reduction of power cost was the important challenge in a smart grid (SG).Thus the robust data analytics, high performance computing, efficient data network management, and cloud computing techniques were critical towards the optimized operation of SGs. That research aims to highlight the big data issues and challenges faced by the DEM employed in SG networks.

Lena Mashayekhy *et al.* [35] have presented an Energy efficiency enhancing framework for MapReduce applications. In their article they were, first represent the problem of energy-aware scheduling of a single MapReduce job as an Integer Program. Then they presented two heuristic algorithms named as energy-aware Map Reduce Scheduling Algorithms (EMRSA-I and EMRSA-II), that find the assignments of map and reduce tasks to the machine slots in order to reduce the energy consumed when executing the

application. We perform extensive experiments on a Hadoop cluster to find the energy consumption and execution time for several workloads from the HiBench benchmark suite including TeraSort, PageRank, and K-means Clustering, and then use that data in an extensive simulation study to analyze the performance of the presented algorithms. Their results shows that EMRSA-I and EMRSA-II are able to determine near optimal job schedules consuming approximately 40% less energy on average than the schedules obtained by a common practice scheduler that reduces the makespan.

Weiwei Lin *et al.* [36] have presented a bandwidth-aware algorithm for divisible task scheduling in cloud computing environments. A nonlinear programming model for the divisible task-scheduling problem under the bounded multi-port model was presented. By solving that model, the optimized allocation scheme that determines proper number of tasks assigned to each virtual resource node was obtained. On the basis of the optimized allocation scheme, a heuristic algorithm for divisible load scheduling, called bandwidth-aware task-scheduling (BATS) algorithm was proposed. The performance of algorithm was evaluated using CloudSim toolkit. Their experimental result shows that, compared with the fair-based task-scheduling algorithm, the bandwidth only task-scheduling algorithm, and the computation-only task-scheduling algorithm, their proposed algorithm (BATS) has better performance.

Fei Taoa *et al.* [37] have presented a more comprehensive and accurate model for OSCR was defined. In their model, the cloud computing environment was considered to behighly heterogeneous with processors of uncertain loading information. Along with makespan, the energy consumption was considered as one of the optimization objectives from both economic and ecological perspectives. To provide more attentive services, the model seeks to find Pareto solutions for this bi-objective optimization problem. On the basis of classic multi-objective genetic algorithm, a case library and Pareto solution based hybrid Genetic Algorithm (CLPS-GA) was proposed to solve the model. The major components of CLPS-GA include a multi parent crossover operator (MPCO), a two-stage algorithm structure, and a case library. Their experimental results have verified the effectiveness of CLPS-GAinterms of convergence, stability, and solution diversity.

The cloud phenomenon is quickly becoming an important service in Internet computing. Infrastructure as a Service (IaaS) in cloud computing is one of the most significant and fastest growing field. In that service model, cloud providers offer resources to users/machines that include computers as virtual machines, raw (block) storage, firewalls, load balancers, and network devices. One of the most pressing issues in cloud

computing for IaaS was the resource management. Resource management problems include allocation, provisioning, requirement mapping, adaptation, discovery, brokering, estimation, and modeling. Resource management for IaaS in cloud computing offers following benefits such as scalability, quality of service, optimal utility, reduced overheads, improved throughput, reduced latency, specialized environment, cost effectiveness and simplified interface. **Manvi** *et al.* [38] have analysed about the important resource management techniques such as resource provisioning, resource allocation, resource mapping and resource adaptation. That brings out an exhaustive survey of such techniques for IaaS in cloud computing, and also put forth the open challenges for further research

Wang *et al*. [39] have presented a new multi-objective bi-level programming model. Their model was based on the MapReduce. That was used to improve the energy efficiency of servers. In their article First, the variation of energy consumption with the performance of servers was taken into account; second, data locality can be adjusted dynamically according to current network state; last but not least, considering that task-scheduling strategies depend directly on data placement policies, they were define the problem as an integer bi-level programming model. In order to solve their model efficiently, specific-design encoding and decoding methods were introduced. Based on those, a new effective multi-objective genetic algorithm based on MOEA/D is proposed. As there are usually tens of thousands of tasks to be scheduled in the cloud,that was a large-scale optimization problem and a local search operator was designed to accelerate convergent speed of their proposed algorithm. Finally, numerical experiments indicate the effectiveness of their proposed model and algorithm.

Ibrahim Abaker Targio Hashem *et al.* [40] have analysed about the rise of big data in cloud computing. They were presented a classification for big data, a conceptual view of big data, and a cloud services model. Their model was combined with various representative big data cloud platforms. They were also addressed about the Hadoop technology framework and core components of Hadoop technology such as MapReduce and HDFS. They analysed some of the big data processing challenges such as volume, scalability, availability, data integrity, data protection, data transformation, data quality/heterogeneity, privacy and legal/regulatory issues, data access, and governance. But their technique was not fully supported for the issues of big data in cloud.

The rapid growth in demand for computational power has led to a shift to the cloud computing model established by large-scale virtualized data centers. Such data centers consume enormous amounts of electrical energy. Cloud providers must ensure that their service delivery was

flexible to meet various consumer requirements. However, to support green computing, cloud providers also need to minimize the cloud infrastructure energy consumption while conducting the service delivery. For that the **Abbas Horr** *et al*. [41] have presented an approach need as novel QoS-aware VMs consolidation. That has combined the approach based on the resource utilization history of virtual machines. Their presented approach was simplified and calculated by applying CloudSim simulator. Their Simulation result shows that enhancement in QoS metrics and energy consumption as well as demonstrates was a trade-off between energy consumption and quality of service in the cloud environment.

Wanchun Dou *et al.* [42] have presented a privacy-aware cross-cloud service composition method such as HireSome-II (History record-based Service optimization method). Their presented method was based on the previous version HireSome-I. The main aim of their method was to improvement the credibility of a composition plan, the calculation of a service is promoted by some of its QoS history records, rather than its advertised QoS values. For that, the k-means algorithm was presented in their method. Their result shows that HireSome-II could protect cloud privacy, as a cloud was not achieved to unveil all its transaction records. But their method has time complexity of developing a cross-cloud service composition plan as only representative ones are recruited, which was demanded for big data processing.

Xue Lin *et al*. [43] have analysed about the scheduling tasks in MCC environment. In their article the scheduling issues were addressed based on their steps such as in first step, offloading tasks in cloud was determined, in second step, remaining task were mapped in to the mobile device cores. In final step, all the tasks were scheduled in the core part. For that a novel algorithm was presented, which starts from a minimal-delay scheduling solution and subsequently performs energy reduction by migrating tasks among the local cores or between the local cores and the cloud. A linear-time rescheduling algorithm was proposed for the task migration. Their simulation result shows that the proposed algorithm could obtain a maximum energy reduction by a factor of 3.1 compared with the baseline algorithm.

Energy consumption has become a significant concern for cloud service providers due to financial as well as environmental factors. As a result, cloud service providers were seeking innovative ways that allow them to reduce the amount of energy that their data centers consume. They were calling for the development of new energy-efficient techniques that were suitable for their data centers. The services offered by the cloud computing paradigm have unique characteristics that distinguish them from traditional services, giving rise to new design challenges as well as opportunities

when that comes to developing energy-aware resource allocation techniques for cloud computing data centers. For that **Mehiar Dabbagh** *et al.* [44] have discussed about resource allocation challenges, and they presented some potential solutions to reduce cloud data center energy consumption. Special focus was given to power management techniques that exploit the virtualization technology to save energy.

Ehab Nabiel Alkhanak *et al.* [45] have presented an approach called as Cost-aware Workflow Scheduling (WFS). Their algorithm was mainly focused on task allocation to achieve the desired workload balancing by pursuing optimal utilization of available resources. At the same time, relevant performance criteria and system distribution structure must be considered to solve specific WFS problems in cloud computing by providing different services to cloud users on pay-as-you-go and on-demand basis. The main objective of their paper was to facilitate researchers in selecting appropriate cost-aware WFS approaches from the available pool of alternatives. To obtaining their objective, they conducted an extensive review to investigate and analyze the underlying concepts of the relevant approaches. The cost-aware relevant challenges of WFS in cloud computing are classified based on Quality of Service (QoS) performance, system functionality and system architecture, which ultimately result in a taxonomy set.

Huangke Chen *et al.* [46] have discussed about the key challenges and opportunities for saving energy in cloud data centers. In their method, more servers were converted in to smaller power states from that they were achieved an energy savings. That was achieved from the uses of the already active ones. In their article they were addressed about three various approaches, that was used to obtain a savings such as workload prediction, VM placement and workload consolidation, and resource over commitment and some potential ways that exploit virtualization to address those challenges were also explained with the aim of making cloud data centers more energy efficient.

T. Baker *et al.* [47] have presented an algorithm named as, a network-based routing algorithm for the processing and storing of big data in cloud data center. The goal of their article was, to determine an energy efficient path in cloud data center. Their method has able to evaluate the energy efficient path in any manner. Their algorithm was modelled by applying linear, goal and dynamic programming approaches and their algorithm was calculated in contrast to shortest path baseline algorithm with min number of node traversed by applying a real Italian ISP physical network topology. In their article, shortest path energy efficient path was different from other energy efficient methods. Transferring and receiving, process causes node failure can generates different energy and power consumption.

As such, the numbers of intermediate nodes, capacity and power consumption of each node between the user and the cloud data centre have a direct impact on ETsend and ETrecv, as shown in their experimental results. But their method has some issues such as requires high energy and high computation time.

Cloud computing was the important technology. Cloud computing was operated via commodity hardware only at anytime and anywhere. Those generate high performance gain to the user and provide advantages to cloud service provider (CSP). Load balancing was one of that, which helps the CSP to meet the QoS requirements of the users. To balance the load in cloud the resources and workloads must be scheduled in an efficient manner. A variety of scheduling algorithms were used by load balancers to find that backend server to send a request to. The selected server allocates resources and schedules the job dynamically on some virtual machine (VM) located on the same physical machine. That was also responsibility of the provider to dynamically reallocate or migrate the VM across physical machines for workload consolidation and to avoid over utilization or under utilization of resources. **Shaw** *et al.* [48] have analysed about the different algorithms. That presented to overcome issue of load balancing and task scheduling in Cloud Computing. In their article they also explained about load balancing problems in detailed manner.

Xue Lin *et al.* [49] have addressed the scheduling task issues in the MCC environment. In their aarticle scheduling issues were involved in some steps such as, finding the tasks to be offloaded onto the cloud, mapping the remaining tasks onto local cores in the mobile device, determining the frequencies for executing local tasks, and scheduling all tasks on the cores (for in-house tasks) and the wireless communication channels such that the task-precedence requirements and the application completion time constraint are satisfied while the total energy dissipation in the mobile device was minimized. In their article a novel algorithm was presented, thats starts from a minimal-delay scheduling solution and subsequently performs energy reduction by migrating tasks among the local cores and the cloud and by applying the dynamic voltage and frequency scaling (DVFS) technique. The author also presented a linear-time rescheduling algorithm for the task migration. Their Simulation results demonstrates significant energy reduction with the application completion time constraint satisfied

Cloud computing has become a buzzword in the area of high performance distributed computing as that generates on-demand access to shared pool of resources over Internet in a self-service, dynamically scalable and metered manner. One of the important research issues which need to be focused for that's efficient performance was scheduling. The aim of scheduling was to map tasks to

appropriate resources that optimize one or more objectives. Scheduling in cloud computing belongs to a category of problems known as NP-hard problem due to large solution space and thus that makes a long time to find an optimal solution. There are no algorithms which may produce optimal solution within polynomial time to solve those problems. In cloud environment, that was preferable to find suboptimal solution, but in short period of time. Metaheuristic based techniques have been proved to obtain near optimal solutions within reasonable time for such problems. **Kalra** *et al*. [50] have presented an algorithm for cloud named as an extensive survey and comparative analysis of various scheduling algorithms. In their work three famous metaheuristic techniques were utilized for the grid environment such as Ant Colony Optimization (ACO), Genetic Algorithm (GA) and Particle Swarm Optimization (PSO), and two novel techniques: League Championship Algorithm (LCA) and BAT algorithm.

Mateusz Guzeka *et al*. [51] have presented three algorithms such as based on state-of-the-art MOCell, NSGA-II and IBEA algorithms. The main aim of their article was to cure the multi-objective precedence constrained application scheduling problem on a distributed computing system, and that have also two main goals such as the creation of general algorithms to solve the problem and the examination of the problem by means of the via analysis of the results returned by the algorithms. The first aim was achieved in two steps such as adaptation of state-of-the-art multi-objective evolutionary algorithms by designing new operators and their validation in terms of performance and energy. Their second goal was accomplished by performing an extensive number of algorithms executions on a large and diverse benchmark.

Articles from 2017 to 2018

Gai *et al.* [52] have presented an Energy-Aware Heterogeneous Cloud Management (EA-HCM) model. In their article, they were utilizing a Heterogeneous Task Assignment Algorithm (HTA2) as a main algorithm. The main aim of their article was to reducing the total energy cost of the mobile heterogeneous embedded systems by a novel task assignment to heterogeneous cores and mobile clouds. They were mainly focused to analyse the energy-saving problem and consider the energy wastes when tasks were assigned to remote cloud servers or heterogeneous core processors. Their experimental calculations have proved their approach was an effective to save energy when deploying heterogeneous embedded systems in mobile cloud systems.

Duan *et al.* [53] have presented a new scheduling approach named Pre Ant Policy. Their approach contains a prediction model based on fractal mathematics and a scheduler on the basis of an enhanced ant colony algorithm. Their approach was used to determine the

scheduler execution by applying virtue of load trend prediction, and the scheduler was responsible for resource scheduling while minimizing energy consumption under the premise of guaranteeing the Quality-of-Service (QoS). Their performance result shows that their approach exhibits excellent energy efficiency and resource utilization. Moreover, that approach offers an effective dynamic capacity provisioning model for resource-intensive applications in a heterogeneous computing environment and can reduce the consumption of system resources and energy when scheduling is triggered by instantaneous peak loads.

Service provisioning requires facto approach from the cloud computing on internet. That processes relying on a pool of shared computing resources available on demand and usually hosted in data centers. Assessing performance and energy efficiency of data centers becomes fundamental. Industries use a number of metrics to assess efficiency and energy consumption of cloud computing systems, focusing mainly on the efficiency of IT equipment, cooling and power distribution systems. However, none of the existing metrics was precise enough to distinguish and analyze the performance of data center communication systems from IT equipment. **Fiandrino** *et al.* [54] have presented a framework of new metrics able to assess performance and energy efficiency of cloud computing communication systems, processes and protocols. Their presented metrics have been calculated for the most common data center architectures including fat tree three-tier, BCube, DCell and Hypercube.

Juarez *et al*. [55] have presented a real time dynamic scheduling system. Their scheduling system was used to execute efficiently task-based applications on distributed computing platforms in order to minimize the energy consumption. Scheduling tasks on multiprocessors was a well know NP-hard problem and optimal solution of those problems was not feasible, they also present a polynomial-time algorithm that combines a set of heuristic rules and a resource allocation technique in order to get good solutions on an affordable time scale. Their presented algorithm reduces a multi-objective function that combines the energy-consumption and execution time according to the energy-performance importance factor provided by the resource provider or user, also taking into account sequence dependent setup times between tasks, setup times and down times for virtual machines (VM) and energy profiles for different architectures. A prototype implementation of the scheduler has been tested with different kinds of DAG generated at random as well as on real task-based COMPSs applications. They have evaluated a different size instances and importance factors, and have calculated that combination generates a better solution and energy savings in each case. Moreover, They were also calculated the

introduced overhead by measuring the time for getting the scheduling solutions for a different number of tasks, kinds of DAG, and resources, concluding that our method was suitable for run-time scheduling.

Qiu et al. [56] have presented a novel hybrid on-chip SPM. Their method contains a static random access memory (RAM), a magnetic RAM (MRAM), and a zero-capacitor RAM for CMP systems by fully taking benefits each type of memory. To reduce memory access latency, energy consumption, and the number of write operations to MRAM, the also presented a novel multidimensional dynamic programming data allocation (MDPDA) algorithm to strategically allocate data blocks to each memory. Their experimental result shows that the proposed MDPDA algorithm can efficiently reduce the memory access cost and extend the lifetime of MRAM.

Wei *et al.* [57] have presented a cloud resource allocation model. Their model was based on the Stackelberg game (CSAM-IISG) utilizing a hidden Markov model (HMM) in a cloud computing environment. CSAM-IISG was used to increase the profit of both the resource supplier and the applicant. First, they were used the HMM to predict the service provider's current bid using the historical resources based on demand. Via predicting the bid dynamically, an imperfect information Stackelberg game (IISG) was established. The IISG motivates service providers to choose the optimal bidding strategy according to the overall utility, achieving maximum profits. Based on the unit prices of different types of resources, a resource allocation model was presented to guarantee optimal gains for the infrastructure supplier. Their mode has able to support synchronous allocation for both multiservice providers and various resources. The simulation results demonstrated that the predicted price was close to the actual transaction price that was lower than the actual value in the game model. Their presented model was shows to increase the profits of service providers and infrastructure suppliers simultaneously.

Chen *et al.* [58] have presented a Parallel Random Forest (PRF) algorithm. Their algorithm was used for the analysis of big data on the Apache Spark platform. Their algorithm was optimized based on a hybrid approach combining data-parallel and task-parallel optimization. A vertical data-partitioning method was used to minimized the data communication cost effectively, and a data-multiplexing method was performed to allow the training dataset to be reused and diminish the volume of data. From the perspective of task-parallel optimization, a dual parallel approach was carried out in the training process of RF, and a task Directed Acyclic Graph (DAG) was created according to the parallel training process of PRF and the dependence of the Resilient Distributed Datasets (RDD) objects. Then, different task schedulers were invoked for the tasks in the DAG.

Moreover, to improve the algorithm's accuracy for large, high-dimensional, and noisy data, we perform a dimension-reduction approach in the training process and a weighted voting approach in the prediction process prior to parallelization. Their experimental results shows that the superiority and notable benefits of the PRF algorithm over the relevant algorithms implemented by Spark MLlib and other studies in terms of the classification accuracy, performance, and scalability.

Wang *et al.* [59] have presented a prototype software system named as a pips-cloud. Their method was used for high performance cloud computing for RS. The main purpose of their article was to combine current cloud computing and HPC techniques. The HPC technique has able to process the RS data processing system as on-demand real-time services. The advantages of cloud computing models were ubiquity, elasticity and high-level of transparency. In their work encapsulation and web interfaces were achieved from the dynamic environment of the massive RS data managing and data processing. An optimal query and access of RS imageries, RS data products, interim data's were employed by applying a Hilbert-R + based data indexing mechanism. They were also presented a parallel file system for massive high-dimensional RS data and offers interfaces for intensive irregular RS data accessing. Furthermore, they also provided an adaptive RS data analysis workflow manage system for on-demand workflow construction and collaborative execution of distributed complex chain of RS data processing, such as forest fire detection, mineral resources and coastline monitoring.

The data security and privacy in cloud computing has many critical problems and restricts in cloud applications. One of the major issues in the cloud computing was caused the security and privacy was caused by that the cloud servers can easily obtain sensitive data. **Li** *et al.* [60] have presented an intelligent cryptography approach. The major aim of their work was to reduce the security and privacy issues in cloud computing. By using their approach, the cloud servers cannot able to obtain a partial data directly. Their approach first splits the data and the spitted data were stored in the distributed cloud servers. They also presented a scheme named as a Security-Aware Efficient Distributed Storage (SA-EDS) model. Those schemes was supported by an intelligent cryptography approach and also contains an alternative Data Distribution (AD2) Algorithm, Secure Efficient Data Distributions, (SED2) Algorithm and Efficient Data Conflation (EDCon) Algorithm. But their work has high computational time.

The goal of private cloud server was to obtain a maximum profit from intelligently scheduling tasks during the service delay bound of delay-tolerant tasks. **Yuan** *et al.* [61] have presented a profit maximization algorithm (PMA) to

determine the temporal changes of prices in hybrid clouds. The PMA could provide the temporal task scheduling and that ahs able to arrange all incoming tasks used to perform the public and private cloud. Some of the issues were occurred in the PMA during the iteration those problems were solved by applying a hybrid heuristic optimization algorithm, simulated annealing particle swarm optimization (SAPSO).

Li *et al*. [62] have presented a computation partition model for stateful data. That was used to enhance the performances on the dynamic environment. In their work first they were generated a stateful data streaming model and learn the computation partitioning method in a dynamic environment. They generated describe about a segmentation scheme evaluations and directions and also contains single frame data flow, task scheduling and executing efficiency. Second, they were presented a computation partitioning method. That was used for the dataflow of single frames. They find the data parameters for the application model, computation partitioning scheme and task, work order data steam model. In their article, the effectiveness of face recognition was verified by applying a mobile cloud computing platform prototype system.

Bui *et al.* [63] have presented a solution for resource cloud computing named as an energy efficient solution. In their work, their presented solution first determines the upcoming period resource utilization by using the Gaussian process regression method. For every monitoring window, appropriate quantity physical servers were assigned by using t he convex optimization technique. Their quantity was evaluated to achieve a minimum number of servers with a acceptable quality of servers. Their presented method was calculated by using a synthetic data from 29-day period of Google traces and real workload from the Montage open-source toolkit. Their solution has able to reduce the energy consumption.

Shen *et al*. [64] have aimed to provide an adaptive task scheduling strategy. They were first demonstrates the perspective of the cloud task scheduling by applying the virtual machine energy. The author also presented a genetic algorithm for the performances and various energy requirements in the cloud (EPGA). Then they were, represents two various types of fitness function for the selection of next generations with various energy and performances. Their methods were used for the real cloud data centers. Their scheduling strategy proved, that the minimum total task time usually leads to low energy consumption to some extent, the price of the sacrificed performance only taking into account the energy optimization, there was always an optimal condition of energy-efficiency ratio in the cloud data center, and more importantly the specific conditions of the optimal energy-efficiency ratio can be obtained.

Poonam Singh *et al.* [65] have presented a meta-heuristics techniques.

Their technique was used for the task scheduling in cloud computing. They also presented the taxonomy and comparative review on those algorithms. Methodical analysis of task scheduling in cloud and grid computing was presented based on swarm intelligence and bio-inspired techniques. Various existing solutions of meta-heuristics methods were enhanced by hybrid approach in selecting initial population, diversity of the solution or to modifying the operators. In hybrid approach, features of existing meta-heuristics algorithms could be integrated to enhance various challenges due to multi-criteria optimization in workflow applications. Cost and time were mostly the center of attention for optimization process. Reducing the energy consumption in data centers was an important factor. However, there was a possibility of failure due to which the system may go down or crashed. Those could probably affect the performance of the applications. A system can be scalable with respect to the size of the workflow. So those issues along with scalability of the new computing standard were open issues that could be considered for future research.

Xibo Jin *et al*. [66] have presented a VM assignment and scheduling algorithms to reduce the operational cost and enhanced the performance interference in cloud data centers. They among the first to builds a joint model to capture the trade-off between the two contradictory objectives. They also generate efficient scheduling algorithms for both offline and online cases and improve them by exploiting some properties of cloud environments, such as batch arrival and resource reservation. They calculate the performance of the proposed algorithms by conducting a comprehensive set of simulations. Their results confirm that a joint optimization that takes into accounts both VM combination and life-cycle overlapping can significantly reduce the total cost as well as the performance interference in cloud data centers. The performance of the system was an important factor for the quality of service of a cloud data center.

Lin et al. [67] have presented a genetic algorithm (GA) based resource constraint project scheduling, incorporating a number of new ideas (enhancements and local search) for solving computing resources allocation problems in a cloud manufacturing system. A newly generated off spring may not be feasible due to task precedence and resource availability constraints. Conflict resolutions and enhancements were performed on newly generated off springs after crossover or mutation. The local search can exploit the neighbourhood of solutions to find better schedules. Due to those complex characteristics, computing resources allocation in a cloud manufacturing system is NP-hard. Computational results show that their presented GA can rapidly provide a good quality schedule that can

optimally allocate computing resources and satisfy users' demands.

Nir *et al.* [68] have an energy and monetary cost-aware mathematical task scheduler model. Their model extends the optimization process by including an economic element to that. Their model could allow mobile devices to offload multiple tasks to cloud resources. The results in their article were more via and more aspects of task offloading have been analysed. For instance, the model was calculated under two different resource augmentation environments for mobile cloud computing such as a local private cloud and public clouds. More precisely, the task scheduling problem was optimally solved to minimize; the total energy consumption when applied to a local private cloud, and the total energy consumption and monetary cost when applied to public clouds. Their presented model at the centralized broker-node finds optimal solutions for task assignment problem, and provides a significant reduction in the total costs compared with the task assignment by the centralized scheduler without optimization.

Asma Enayet *et al.* [69] have analysed about an optimal resource allocation architecture named as Mobi-Het for remote big data task execution in a mobile cloud environment. Mobi-Het schedules remote code execution requests to available heterogeneous cloudlet resources and allows mobile devices to run big data applications while enjoying mobility in a smart city environment. Their model has also been evaluated via test bed implementations in a dynamic mobile network environment. Their experimental results shows that Mobi-Het outperforms the state-of-the-art methods in terms of success percentage, execution time, and workload distribution.

Sura Khalil Abd *et al*. [70] have presented a DNA-based Fuzzy Genetic Algorithm (DFGA). That performs DNA-based scheduling strategies to reduce power consumption in cloud data centers. That was a power-aware architecture for managing power consumption in the cloud computing infrastructure. They also determine the performances metrics that are needed to evaluate their presented work performance. Their experimental results demonstrate that DFGA reduced power consumption when comparing with other algorithms. Their presented work deals with real time task which was not static, and concentrates on the dynamic users since they are involved in cloud.

Articles in 2016

Keke Gai *et al.* [71] have presented a novel approach called Cost-Aware Heterogeneous Cloud Memory Model (CAHCM). The goal of their article was to provision high performance cloud-based heterogeneous memory service offerings. Their CAHCM algorithm was a dynamic Data Allocation Advance (2DA) Algorithm. That was used for the utilization of genetic programming to find the data allocations on the cloud-based memories. In their presented approach, they contains a set of crucial factors impacting the performance

of the cloud memories, such as communication costs, data move operating costs, energy performance, and time constraints. Their experimental result shows that was performed better compared with various existing systems.

Abdullahi et al. [72] have presented a discrete symbolic organism search (DSOS) algorithm. Their algorithm was applied on the tasks of cloud resources for optimal scheduling. The numerical optimization issues were cured by applying a symbiotic Organism Search (SOS). In their work, the symbiotic Organism Search (SOS) was a newly generated metaheuristic optimization technique. Their simulation result shows that the DSOS was perform better than the article swarm optimization algorithm. The discrete symbolic organism search (DSOS) algorithm was suitable for large scale scheduling problems and it has able to reduce the time consumption. But their algorithm was unfit for discrete optimization problems.

Tang et al. [73] have presented a DVFS-enabled Energy-efficient Workflow Task Scheduling algorithm: DEWTS. Via merging the relatively inefficient processors by reclaiming the slack time, DEWTS can leverage the useful slack time recurrently after severs are merged. In their work first they evaluates the initial scheduling order of all tasks, and obtains the whole makespan and deadline based on Heterogeneous-Earliest-Finish-Time (HEFT) algorithm. Through resorted the processors with their running task number and energy utilization, the underutilized processors can be merged by closing the last node and redistributing the assigned tasks on it. Finally, in the task slacking phase, the tasks can be distributed in the idle slots under a lower voltage and frequency using DVFS technique, without violating the dependency constraints and increasing the slacked make-span.

Zhao *et al.* [74] have presented an energy and deadline aware task scheduling method for data-intensive applications. In their work first, the datasets and tasks are modelled as a binary tree by a data correlation clustering algorithm, in that both the data correlations generated from the initial datasets and that from the intermediate datasets have been considered. Hence, the amount of global data transmission can be reduced greatly, which are beneficial to the reduction of SLA violation rate. Second, a “Tree-to-Tree” task scheduling approach based on the calculation of Task Requirement Degree (TRD) was presented that can improve energy efficiency of the whole cloud system by optimizing the utilization of computing resources and network bandwidth. Their experimental results show that their power consumption of the cloud system can be reduced efficiently while maintaining a low-level SLA violation rate.

Wang *et al.* [75] have presented a new energy aware multi-job scheduling model based on Map Reduce. In their presented method, first, the variation of

energy consumption with the performance of servers was taken into account; second, since network bandwidth was a relatively limited resource in cloud computing, 100 % data locality is guaranteed; Finally, considering that task-scheduling strategies depend directly on data placement policies, The formulate the problem as an integer bi-level programming model. That was worth noticing that there are usually tens of thousands of tasks to be scheduled in the cloud, so that was a large-scale optimization problem. In order to solve it efficiently, a local search operator was specifically designed, based on that, a bi-level genetic algorithm presented in their article.

4. Analysis Of Various Tecnhiques

In recent years, the problem of task scheduling on a distributed environment has caught the attention of researchers. Task scheduling is considered a critical issue in the Cloud computing environment by considering different factors like completion time, the total cost for executing all users' tasks, utilization of the resource, power consumption, and fault tolerance. For that, we are categorized some techniques of task scheduling in cloud computing.

4.1 Categorization Based on Techniques

In the year of 2010 to 2011, there are 15 articles are addressed where 3 works are based on the energy efficient scheduling algorithm, 4 works are based on the task scheduling mechanisms, 4 study articles are presented and other approaches also presented

.

Table.1. 2010 to 2011 Articles Categorized based on techniques

Article from 2010 to 2011					
Ref. No.	**Scheduling Mechanism**	**Energy Efficient Scheduling Algorithm**	**Task Scheduling Algorithm**	**Study**	**Others**
1				**Y**	
2					**Y** [AVSMS]
3					**Y** [PBOHGA]
4	**Y**				[Near optimal]
5					**Y** [NASM]
6	**Y**				
7					**Y** [M K-MCA]
8				**Y**	
9		**Y**			
10		**Y**			
11				**Y**	
12		**Y**			
13				**Y**	

14			**Y**		
15		**Y**			

In the year of 2012 to 2013, there are 15 articles are addressed where 6 works are utilized the energy based scheduling algorithm, 4 works are utilized the DVFS algorithm, 3 works are utilized task scheduling algorithm, 2 resource optimization algorithm and 1 other approaches also presented.

Table.2. 2012 to 2013 Articles Categorized based on techniques

Articles from 2012 to 2013						
Ref. No.	**Energy Based Scheduling Algorithm**	**DVFS**	**Resource Scheduling Optimization Algorithm**	**Task Scheduling Algorithm**	**Study**	**Others**
16	**Y**					
17	**Y**					
18			**Y**			
19			**Y**			
20		**Y**				
21	**Y**					
22		**Y**				
23	**Y**					
24		**Y**				
25						**Y** [CBECN]
26					**Y**	
27					**Y**	
28		**Y**			**Y**	
29	**Y**					
30	**Y**					

In the year of 2014 to 2015, there are 21 articles are addressed where 4 works are utilized the task scheduling algorithm, 2 works are utilized the Dynamic Scheduling algorithm, 7 works are utilized scheduling algorithm, 1 energy efficient framework, 3 MCC base task scheduling algorithms and 12 other approaches are analyzed in the year of 2014 to2015.

Table.3. 2014 to 2015 Articles Categorized based on techniques

Articles from 2014 to 2015							
Ref. No.	**Task Scheduling Algorithm**	**Dynamic Scheduling Algorithm**	**Scheduling Algorithm**	**Energy efficient framework**	**MCC task Scheduling Algorithm**	**Study**	**Others**
31		**Y**					
32			**Y**				Rolling horizon
33			**Y**				
34		**Y**					
35				**Y**			
36			**Y**				
37							**Y** [CLPS-GA]
38			**Y**				
39							**Y** [MOBPM]
40							**Y** [HDFS]
41			**Y**				Privacy aware
42			**Y**				Bandwidth aware
43	**Y**				**Y**		
44			**Y**				QOS
45	**Y**						CAWFS

46					**Y**		
47							**Y** [NBRA]
48	**Y**						
49	**Y**				**Y**		Linear Time
50							ACO, GA, PSO, LCA, BAT
51							MOcell NSGA-II & JBEA

In the year of 2017 to 2018, there are 19 articles are addressed where 4 works are utilized the energy efficient scheduling algorithm, 7 works are utilized the task Scheduling algorithm, 2 works are utilized scheduling algorithm, 1 PRFA, 2 resource allocation algorithms and 5 other approaches are addressed in the year of 2017 to2018.

Table.4. 2017 to 2018 Articles Categorized based on techniques

Articles from 2017 to 2018							
Ref. No.	**Energy efficient**	**PRFA**	**Task Scheduling Algorithm**	**Scheduling Algorithm**	**Resource allocation Algorithm**	**Study**	**Others**
52	**Y**		**Y**				
53				**Y**			
54	**Y**						
55				**Y**	**Y**		
56							**Y** [NHCS]
57					**Y**	**Y**	
58		**Y**					
59							**Y** [PCPSS]
60							**Y** [JCA,

							SAEDS]
61							**Y** [PMA]
62	**Y**		**Y**				
63	**Y**						
64			**Y**				
65			**Y**				
66			**Y**				
67			**Y**				
68			**Y**				
69						**Y**	
70							**Y** [DFGA]

In the year 2016, there are 5 articles are addressed where 1 work utilized CAHCM and DSOS, 3 works are utilized the energy efficient task Scheduling algorithm, there is no study and other approaches

Table.5. 2016 Articles Categorized based on techniques

Articles in 2016					
Ref. No.	**CAHCM**	**DSOS**	**Energy efficient task scheduling**	**Study**	**Others**
71	**Y**				
72		**Y**			
73			**Y**		
74			**Y**		
75			**Y**		

The above fig.2 shows the graphical representation of overall techniques analyzed from the articles. From the graph, other indicates articles those are utilized single techniques. The articles are taken in the year from 2010 to 2018.

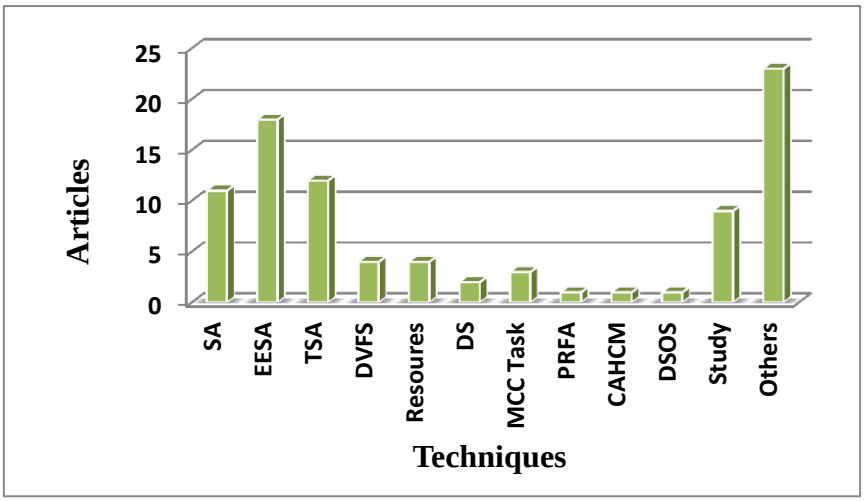

Fig.2. Analysis based on the techniques utilized in the articles

5. Future Directions

Task scheduling is one of the most important problems in cloud computing. In this section few of the issues are addressed. In order to improve popular and scheduling techniques in cloud computing, new methods need to be developed which include economic models and heuristic algorithms along with algorithms inspired by nature. By combining different approaches and considering input parameters such as running costs and deadlines, it is possible to provide a powerful approach for scheduling tasks in a cloud computing environment.

- ❖ Future direction should focus on how to effectively combine task scheduling and virtual machine consolidation strategies to further enhance the effectiveness of scheduling. In future should also pursue single objective- and multi-objective-based task scheduling using different hybridization of existing algorithms.
- ❖ Many key challenges present in the cloud computing Such as automatic resource provisioning, power management and security management.
- ❖ Handling imprecise input parameters, such as the estimation of task running time and the lag of instance acquisition are challenging issue in cloud environment.
- ❖ The data transfer between tasks is not directly considered, data uploading and downloading is part of each task and tasks communicate temporary results through a central storage. However, this may not always be the case. This is the major issues are occurred during task scheduling in cloud environment.
- ❖ In a data intensive application or computing framework, like Map Reduce, Hadoop and DryAd, data movement activities can dominate both the performance and the cost. The trade-off between data transfer performance and cost needs to be more enhancements in the cloud environment.

- Characterizing the different consistency semantics that can be provided at different scales and effective techniques for load balancing are also critical aspects of the system.
- Designing scalable, elastic, and autonomic multitenant database systems is another important challenge that must also be addressed. In addition, ensuring the security and privacy of the data outsourced to the cloud is also an important problem for ensuring the success of data management systems in the cloud.

6. Conclusion

In this survey article, we have analyzed various scheduling algorithms and tabulated different parameters used under the cloud and grid environments. In all, 75 articles associated with scheduling, from 2010 to 2018, have been analysed. The articles are categorized, technique-wise, into 5 different years of categories. They have been studied and their limitations and complexity highlighted. It is, therefore, necessary to improve the availability and reliability of task scheduling within cloud computing. Finally, specific research issues have been identified that need to be addressed in a comprehensive manner. This will provide future avenues and encourage researchers to conduct further research along these directions.

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