**Surveys on Task Scheduling Algorithms in Cloud computing**

**ABSTRACT**

Cloud computing is defined as a model that follow client-server architecture in which a pool ofcomputing resources (network, operating system,storage,server,application,data,middleware,run-time,virtualization) are provided to the end user over the internet on demand. Distributed computing environment has grown-up to be a novel technology to perform wide-ranging applications and Cloud computing is one of these technologies. To draw on capabilities of distributed system successful and proficient task scheduling is needed . Task scheduling is a NP-hard optimization problem. Taskscheduling is used to diminish the turnaround time , progress the resource utilization , accurate provision of tasks to the resources , minimize the make span and maximize the CPU utilization by view of deadline constraints and QoS. The idea of this paper is to analyze different task scheduling algorithms to address the task overhead exertion in cloud environment

**Keywords**: Cloud computing; Task scheduling, Cost, Time and QoS.

**1. INTRODUCTION**

“Cloud computing model enablesubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”. A Cloud is the collection of interconnected computer that are provided by one or more unified computing resources” [1] Cloud computing environment shares multiple virtual machines (VMs) with physical resources (CPU, memory, and bandwidth) on a single physical host and multiple VMs can share the bandwidth of a data centre by using network virtualization. Because many users and applications essentially share system resources, a proper task- scheduling scheme is required to improve resource utilization and system performance. Many system parameters, such as processor power, memory space, and network bandwidth, affect the efficiency of task scheduling.

Three main services are provided by the Cloud computing architecture according to the needs of IT customers [1]. Firstly, Software as a Service (SaaS) provides access to complete applications as a service, such as Customer Relationship Management (CRM) [2]. Secondly, Platform as a Service (PaaS) provides a platform for developing other applications on top of it, such as the Google App Engine (GAE) [3]. Finally, Infrastructure as a Service (IaaS) provides an environment for deploying, running and managing virtual machines and storage. Technically, IaaS offers incremental scalability (scale up and down) of computing resources and on-demand storage [1].

Cloud computing serves on demand requests of the users with self managedvirtual infra-structure and efficient resources utilization. Growth of cloud computing slower down the efficiency, throughput and utilization of resources for which cloud computing need to be evolved. Apart from many ways to enhance the throughput and efficient resource utilization one way is the cloud task scheduling. Through task scheduling we can manage the resource utilization which in turn increases the throughput of the system. Scheduling refers to the mapping or assigning a task to a specific VM, such that resource utilization increases. An efficient task scheduling algorithm improves the overall system performance and helps service provider to providegood quality ofservices (QoS).

**2. TASK SCHEDULING**

In order to offer better Quality of Service (QoS), have to implement asuitable task scheduling algorithm which maintains a high-qualitysense of balance between resource utilization to enable efficiency, lesser make span, concurrent task scheduling, proper resource utilization and management.

Scheduling of tasks and allocation of resources are theimportant quality of the cloud environment which directlyinfluences the concert of a system. In order to attain highthroughput, various task scheduling algorithms have beenintroduced by the researchers for scheduling and scaling ofresources. The adaption of the appropriate algorithm decidesthe performance of the system.In cloud computing, proper task scheduling is necessary so as to progress the efficiency and to minimize the execution time. The reason behind task scheduling is to identify a particular resource from all the available resources so that run the effectiveness of the computing environment increases [4] .The task scheduling is a key issue in data centres.Application scalability is the primary benefit of moving toclouds. Unlike grids, scalability of cloud resources allowsreal-time provisioning of resources to congregate applicationrequirements. Cloud services like compute, storage andbandwidth are available at substantially lower costs.Scheduling process in cloud can be widespread into three stages namely [5] 1. Resource discovering and filtering datacentre broker discovers the resources present in the networksystem and collects status information related to them. 2.Resource selection – Target resource is selected based oncertain parameters of task and resource. This is deciding stage.3. Task submissions – Task is submitted to resource selected.Types of scheduling [6].

There are two categories for task scheduling; static and dynamic. In dynamic scheduling, schedules create duringrun time and no knowledge of task is

in hand until it arrives. While in static scheduling, schedules are created before run time and cannot change. Similarly, asks must all be known in advance. In other style a static task scheduling algorithm schedules a set of tasks with known processing and communication characteristics on processors to optimize some performance metric, such as Make span and CPU utilization. In this paper, focused on static scheduling.The main lead of job scheduling algorithm is to attain a high performance computing and the best systemthroughput. The obtainable resources should be utilized efficiently without distressing the service parameters of cloud. Scheduling process in cloud can be categorized into three stages they are Resource discovering and filtering, Resource selection, and Task submission [7]. In resource detection datacentres broker (DCB) discovers the resources present in the network system and collects status information related to them using Cloud Information Centre (CIC). During resource selection process target resource is selected based on certain parameters of task and resource. Then during task submission task is submitted to the selected resource. Figure 2.1 Scheduling in Cloud

User

DCB

CIC

VM1

M

VM2

VM3

Data Centre

**3. Problem Definition**

Cloud processing isdeveloped through the current progressions in equipment, virtualization innovation, disseminated figuring, and administration conveyance over the Internet. While Cloud figuring may not include a considerable measure of new advancements, it absolutely speaks to another method for overseeing IT. Cost reserve funds and adaptability can be exceedingly accomplished from cloud registering. In cloud figuring, legitimate assignment booking is required in order to enhance the productivity and to limit the execution time. The reason behind errand planning is to indicate a specific asset from all the accessible assets to run the effectiveness of the processing condition increments. Schedule length is likewise one of the fundamental criteria which cost for execution. Hence, a rank based function for limiting the length of schedule is proposed which overcomes task scheduling overhead problem.Two rank capacities such as upward and downward ranking functions are utilized

**4. Literature Survey**

Assignment scheduling calculation is a strategy by which undertakings are coordinated, or designated to server ranch assets. Because of contradictory scheduling destinations for the most part no completely consummate scheduling calculation exists. A decent scheduler actualizes an suitable trade off, or applies mix of scheduling calculations as indicated by various applications. An subject can be comprehend in seconds, hours or even years relying upon the calculation connected. The efficiency of a calculation is assessed by evaluation of time which is important to execute it. The execution time of a calculation is expressed as a period multifaceted nature capacity relating the information There are a few sorts of time unpredictability calculations that show up in the writing[11]. In the event that an issue has a polynomial time calculation, the issue is tractable, doable, effective or sufficiently quick to be executed on a computational machine. In computational intricacy hypothesis, set of issues can be dealt with as multifaceted nature class taking into account a specific asset [11].

Class P is the course of action of decision issues that are sensible on a Deterministic Turing Machine in polynomial time, which infers that an issue of Class P can be picked quickly by a polynomial time computation. Class NP is the course of action of decision issues that are resolvable on a Nondeterministic Turing Machine in polynomial time, yet a candidate plan of the issue of Class NP can be attested by a polynomial time count, which infers that the issue can be affirmed quickly.

Class NP-finish is the course of action of decision issues, to which all other NP issues can be polynomial transformable, and a NP-finish issue must be in class NP. When in doubt, NP-finish issues are more troublesome than NP issues. Class NP-hard is the game plan of streamlining issues, to which all NP issues can be polynomial transformable, yet a NP-troublesome issue isn't as per usual in class NP. Yet most by far of NP-finish issues are computationally troublesome, some of them are handled with commendable adequacy. There are a couple of counts, the running time of which isn't simply constrained by the measure of commitment of a representation, moreover by the best number of the cases. Undertaking planning issue is the issue of organizing errands to different courses of action of benefits which is formally conveyed as a triple (T, S, O) where "T" is the game plan of assignments, each of which is an event of issue, the game plan of possible game plans is "S" and the objective of the issue is 'O'. Booking issue can be additionally orchestrated into two sorts as streamlining issue and decision issue in light of target O. In the real environment generally hundreds and thousands of resources hosting many tasks and at the same time the system is keep on receiving the batches of task service requests. For allocating a batch of incoming requests, one can find few target servers. It can fulfil a batch of incoming service requests. The total number of resources available is ‘R’ and the number of batch of service requests is ‘T’ then allocating the tasks to resources there are RPT possible permutations of making the problem combinatorial. Complexity class of the task scheduling problem categorizes as NP-complete relating extremely large search space with correspondingly huge number of potential solutions [9] and it takes longer time to get the optimal solution. By considering the load balancing issue in dynamic task scheduling is an NP-hard problem

Scheduling algorithms can be characterized according to many polices as immediate and batch scheduling, pre-emptive and non-pre-emptive scheduling, static and dynamic scheduling [10]. In Immediate mode, tasks are scheduled when enter the computing environment, while in the batch mode, first tasks are grouped into a batch; that is a set of meta-tasks would be allocated at times called mapping events. In Static Scheduling, Tasks are pre-Schedule, all information are known about existing resources and tasks in sophisticated and a task is assigned once to a resource. In Dynamic Scheduling, Jobs are offered dynamically for scheduling over time by the scheduler. It is more resilient than static scheduling, to be able of formative run time in advance. In Pre-emptive Scheduling allows each task to be intermittent during execution and a task can be migrated to another resource by leaving its originally allocated resource, available for other tasks. If constraints like priority are measured then this scheduling scheme is more ready to lend a hand [11]. In Non Pre-emptive Scheduling scheme, resources are not being allowed to be re-allocated until the running and scheduled job finished its execution [11].

Selective algorithm [46] performs better than Min-Min and Max-Min while reducing the make span and increasing the average resource utilization and load balancing level. Later Weighted Mean Time Min-Min Max-Min Selective (WMTS) [47] achieves least make span and medium resource utilization. To optimize make span and increasing the resource utilization Memetic algorithm [48] with Ant Colony Optimization as local search by considering load balancing effectively. Load Balanced Max-Min [49] achieves better performance than the Max-Min. Improved Max-Min [50] algorithm which is inherited from Min-Min, Max-Min and RASA reduce the make span. To improve the resource utilization and reduce the response time of tasks ECMM [51] algorithm has studied for many tasks by maintaining task status table and virtual machine status table in load balancer.Comparative study of Most Fit, Max-Min and Priority algorithm [52], Max-min achieves minimum make span and maximum resource utilization. Better make span and load balancing Mim-Mim [53] algorithm has derived from Min-Min and Max-Min.Hybrid Avg Task –Min and Max-Min [54] algorithm also strive for achieving minimum make span. NMOMXSS [44] algorithmperformed better than Min-Min and Max-Min for deriving good make span.By prioritizing small tasks MXFT [55] algorithm with Service Level Agreement for large sized tasks can consider.

**Table 1: Task Scheduling Algorithms based on Ranking**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No/Year/Author | Title | Usage of Algorithm  | Performance Metrics | Advantages | Limitations/Future Work |
| [12]2003Henan Zhao and Rizos SakellariouElsevier | An Experimental Investigation into the RankFunction of the Heterogeneous Earliest FinishTime Scheduling Algorithm | HEFT uses DAG to a limited number of heterogeneousMachines. | 1.weight for the nodes and edges of the graph2. Upward rank and downward rank | Upward ranking is better than downward ranking | scheduling process can improve  |
| [13]2012Saurabh Kumar Garg a, Steve Versteeg b, Rajkumar Buyyaa | A framework for ranking of cloud computing services |  CSMIC framework ,AHP ranking mechanism and (SLA). | Service response time,Sustainability, Suitability, Accuracy ,Elasticity , Performance And Security | Cloud Services are improved. |  fuzzysets, The quality model to non-quantifiable QoSAttributes.  |
| [14] 2015Kuo-Chan Huang · Ying-Lin Tsai ·Hsiao-Ching Liu | Task ranking and allocation in list-based workflowscheduling on parallel computing platform | List-based workflow schedulingtop bottom rank is a dual mechanism | two task-ranking mechanisms and oneTask allocation method for the two major steps in list-based workflow scheduling.workload and hybrid ranking,bottom amount rank | The proposed approaches were evaluated extensively with a series ofsimulation experiments and compared to existing widely used task-ranking and allocationMethods. | further research efforts to develop advanced or hybrid approaches for achieving better performance in more situations, |
| [15]2013Yuanjun Laili a, Fei Tao a, Lin Zhang a,\*, Ying Cheng a, Yongliang Luo a, Bhaba R. Sarker b | A Ranking Chaos Algorithm for dual scheduling of cloud service andcomputing resource in private cloud |  (DS-CSCR) is  (SCOS) and (OACR)To deal with large-scale DS-CSCR problem- Ranking Chaos Optimization (RCO)is used. | Ranking Selection Operator | DS-CSCR is high efficient and low cost resource sharing | Private cloud can consider and also QoS and optimization problems.  |
| [16]2016Kuo-Chan HuangMeng-Han Tsai | Task Ranking and Allocation Heuristics for Efficient Workflow Schedules | List-based workflow scheduling. | task ranking andallocation heuristics and min-max OCT | Better schedules for workflows of higher CCR values. | better performance across differentWorkflow characteristics and computing environments. |
| [17]2017R. W. Bunney | Comparing Rank Methods in HEFTScheduling | The Heterogeneous Earliest-Finish-Time (HEFT) algorithm is list-scheduling algorithm with upward rank to each task. | Execution time  And Make span | Ranking sort is an improvement over a standard topo-logical sort. | Improving the HEFT algorithm with cost values in the ranking method. |
| [18]2017Kalka Dubey a, Mohith Kumar b, S.C Sharma a,b | Modified HEFT Algorithm for Task Scheduling in Cloud Environment |  Modified HEFT algorithm distributes the workload among the processors. | Make span time | Overcome the load balancing problem with better make span time.  | Make span time can be further reduced. |

**Table 2 : Task Scheduling algorithms based on Priority**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No/Year/Author | Title | Usage of Algorithm  | Performance Metrics | Advantage | Limitations/Future Work |
| [19]2012Shamsollah Ghanbari , Mohammed Othman | A Priority Based Job Scheduling Algorithm in Cloud Computing | Algorithm based on multiple criteria decision making model | Complexity ,Consistency and finish time | reasonable Complexity derived | Make span time can still reduce. |
| 202013Ajay Jangra#1, Anil Kumar#2 | Dynamic Prioritization Based Efficient TaskScheduling for Grid Computing | Adaptive Ranking TaskScheduling (ARTS) algorithm in gridEnvironment. |  completion time ,Organization rank (OR)  | minimize theAverage completion time. | real grid applications and Modified ARTS to precedence relations in real-life situation.  |
| [21] 017Dr.D.I. George AmalarethinamS.Kavitha,  | Priority based Performance ImprovedAlgorithm for Meta-task Scheduling inCloud Environment | Priority based Performance ImprovedAlgorithm. | Make span, resource utilization. | Minimum make span and better resource utilization | the real time periodic tasks in cloud environment |

**Table 3 : Task Scheduling Algorithms based on Energy Consumption**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No/Year/Author | Title |  Usage of Algorithm  | Performance Metrics | Advantage | Limitations/Future Work |
| [22]2014Zhuo Tang · Ling Qi · Zhenzhen Cheng ·Kenli Li · Samee U. Khan · Keqin Li | An Energy-Efficient Task Scheduling Algorithmin DVFS-enabled Cloud Environment | Energy-saving scheduler DEWTS based on dynamic voltage/frequency scaling algorithm. | Resource Utilization, Average Execution time and Energy Consumption Ratio | Obtain significant energy reduction andmaintains QoS using the pre-set deadlines. | For parallel applications on heterogeneous environment can apply.Further system reliability , communication overhead, the voltage/ frequency switching overhead  |
| [23]2016Leila Ismaila,∗, Abbas FardounElsevier | EATS: Energy-Aware Tasks Scheduling in Cloud ComputingSystems | EATS used for heterogeneous environment by taking performance and energy optimization. | a non-linear programming model take scheduling decisions. | A non-linear programming model takes scheduling decisions. | Implementing EATS for exploitation in a Cloud computing environment to calculate its performance. |
| [24]2017Jagadeeswara Rao. GG. Stalin Babu | Energy Analysis of Task Scheduling Algorithms inGreen Cloud | green cloud scheduling algorithm | Multi-Tenancy, Server Utilization , Data centre Efficiency | Utilizing less Power than Round Robin,Random ,green and HEROS Schedulers | Time is required for a server to do operation |
| [25]2016Daljinder Singh, Mandeep Devgan , Shashi Bhushan | Tasks Scheduling with Lessen Energy Usage over a Cloud Server using Hybrid Adaptive Multi-Queue Approach | Improved Adaptive Min-Min Scheduling Algorithm | Energy Consumption, Green Cloud Computing, Adaptive Min-Min Scheduling and Multi-Level Back Queue Scheduling Algorithm. | Reduce energy consumption of larger heterogeneous cluster systems for green cloud. | Can extend for cloud computing |

**Table 4: Task Scheduling based on Heterogeneous Distributed System**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No/Year/Author | Title | Usage of Algorithm  | Performance Metrics | Advantage | Limitations/Future Work |
| [26]2014Xiao long Xu, Lingling Cao, and Xinheng Wang, *Senior Member* | Adaptive Task Scheduling Strategy Basedon Dynamic Workload Adjustment forHeterogeneous Hadoop Clusters | a novel adaptive task schedulingstrategy based on dynamic workload adjustment (ATSDWA) isPresented. | Resource utilization, CPU utilization and Memory utilization. | Algorithm create heterogeneous Hadoop clusters stable,Scalable, efficient, and load balancing. | Pertinent to homogeneous and heterogeneous clusters and progressuniversal task throughput rate of cluster without bringing extraLoad to task trackers. |
| [27]2016Anubha Chauhan1, Smita Singh2, Sarita Negi3, Shashi kant Verma4 | Algorithm for Deadline based Task Scheduling InHeterogeneous Grid Environment | Improvised Prioritized Deadline scheduling algorithm(IPDSA): | Arrival of tasks,Dynamism and deadline constraint of each processed task. |  IPDSA better than over *EDF* and *PDSA*  | Communicationlatency. |
| [28]2016Hidehiro Kanemitsu, *Member, IEEE,* Masaki Hanada, *Member, IEEE,*and Hidenori Nakazato, *Member* | Clustering-based Task Scheduling in a LargeNumber of Heterogeneous Processors | Clustering for Minimizing the Worst Schedule Length (CMWSL) to minimize the schedule length in a large number of heterogeneous processors | Schedule Length and Efficiency | CMWSL achieve betterPerformance than the list-based and clustering-based task schedulingAlgorithms. |  reduce the effect onCommunication overhead in a data-intensive DAG. |
| [29]2016Shaikhah AlEbrahim1 · Imtiaz Ahmad1 | Task scheduling for heterogeneous computing systems | A new task scheduling algorithm based on Prioritization phase and Selection phase. | make span, communication costs and processing time of each processor | Helped to prioritize tasks without giving the larger tasks higher priorities than smaller tasks. | task duplication ,communications between processors , memory constraints or energy-aware data allocation and task scheduling consumption |
| [30]2017Ashish GuptaRitu Garg | Workflow scheduling inHeterogeneous computing systems : aSurvey | workflow structures, scheduling criteria’s, scheduling strategiesin heterogeneous systems. | Make span, load balancing , Energy efficiency ,Security and cost | Survey of various task scheduling in algorithm |  Scalability,Multi-objectivity,Security |

**Table 5: OtherTask Scheduling Algorithms**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No/Year/Author | Title |  Usage of Algorithm  |  Performance Metrics | Advantage | Limitations/Future Work |
| [312012 Brototi Mondal a\*, Kousik Dasgupta a , Paramartha Dutta b |  Load balancing in Cloud Computing using Stochastic Hill Climbing- A Soft Computing Approach |  A soft computing based local balancing approach.Compared FCFs and Round Robin | Cloud Analyst | The results are quite encouraging |  Both algorithms have to studied further  |
| [32]2015 Anqi Xu , Yang Yang , Zhenqiang Mi, Zenggang XiongIEEE |  Task Scheduling algorithm based on PSO in cloud environment | QoS-DPSO AlgorithmBerger Model for Particle Swarm Optimization |  Response time and transmission costs are considered.Multidimensional QoS | Task execution time , User satisfaction and System fairness evaluation are enhanced | Learning factor and reliability. |
| [33] 2015Mala Karla a, Sarbjeet Singh b,\* | A review of metaheuristic scheduling techniquesin cloud computing | The recent research efforts are done in the direction of energy-aware scheduling as data centres | Met heuristic based techniques have been proved to achieve near optimal solutions within reasonableTime |  reduce energy consumption of data centres withoutdegrading performance and violating SLA constraints |  Can attempt for reducing energy consumption. |
| [34]2015Atul Vikas Lakraa, Dharmendra Kumar Yadavb | Multi-Objective Tasks Scheduling Algorithm for Cloud ComputingThroughput Optimization | Multi-objective task scheduling algorithm with SLA and SaaS environment. | execution time, cost, bandwidth of user | better than priority and FCFSwith minimum execution time and increasedThroughput. | Can apply for other QoS parameters |
| [35]2015Dzmitry Kliazovich · Johnatan E. Pecero Andrei Tchernykh · Pascal Bouvry ·Samee U. Khan · Albert Y. Zomaya | CA-DAG: Modelling Communication-Aware Applicationsfor Scheduling in Cloud Computing | Communication-Aware –Directed Acyclic Graph  | Task Completion time , Bandwidth and Data Size | Efficiency is improved. | Concentrate ondeveloping novel communication-aware resource allocation solutions  |
| [36]2016Shubham Mittal,Avita Katal | An Optimized Task Scheduling Algorithm in CloudComputing | Optimized Task Scheduling Algorithm with distribution and scalability characteristics of cloud resources. | Make span, Minimum/MaximumExecution Time, Minimum/Maximum Completion Time, LoadBalancing. | system itself adapts the optimized Task Scheduling schemewithintelligent computational technique  | Scalability, stability, availability can improve. |
| [37]20161Abdul Razaque,2Nikhileshwara Reddy Vennapusa,3Nisargkumar Soni,4Guna Sree Janapati,5khilesh Reddy Vangala | Task Scheduling in Cloud Computing | Task scheduling algorithm with non linear programming model | Network bandwidth |  For independent tasks execution time and resource consumption has reduced. | Dependency between the tasks can improve |
| [38]2016Moïse W. Convolbo1 · Jerry Chou2 | Cost-aware DAG scheduling algorithms for minimizing execution cost on cloud resources | Cost-aware DAG | Resource usage, make span and cost. | decrease the cost of other cost-unaware scheduling algorithms by 20–50 % | Still cost can be reduced. |
| [39] 2017Haitao Yuan*, Student Member, IEEE*, Jing Bi*, Member, IEEE*, Wei Tan*, Senior Member, IEEE*, and Bo Hu Li | Temporal Task Scheduling With Constrained ServiceDelay for Profit Maximization in Hybrid Clouds | profit maximization algorithm (PMA) and Simulated annealing PSO(SAPSO) algorithm | Memory and CPU utilization and running time | improves theThroughput and the profit of a private cloud without the service delay bound. | multiple different tasks which require heterogeneous resources withBandwidth and storage. |
| [40]2017Haitao Yuan, *Student Member, IEEE*, Jing Bi, *Member, IEEE*, Wei Tan, *Senior Member, IEEE*,MengChu Zhou, *Fellow, IEEE*, Bo Hu Li, and Jianqiang Li, *Senior Member* | TTSA: An Effective Scheduling Approach forDelay Bounded Tasks in Hybrid Clouds |  TTSA is derived from A simulated-annealing andparticle-swarm-optimization  | throughput and cost of private CDC and delay bounds of all theTasks. | Reduce the cost and throughput is enhanced in private CDC | Dispatching timeand execution delay  |
| [41]2017Danlami Gabi,Anazida Zainal,Abdul Samad Ismail and Zalmiyah Zakaria | Scalability-aware Scheduling OptimizationAlgorithm for Multi-Objective Cloud TaskScheduling Problem | Cloud Scalable Multi- Objective Cat Swarm Optimization Based Simulated Annealing (CSM-CSOSA) | Executiontime, executioncost of processing task. | better performance and returned better scalability value withan acceptable range of 0 <ψ < 1. | Making more efficient for cloud task scheduling |
| [42]2017Danlami Gabi,Anazida Zainal,Abdul Samad Ismail and Zalmiyah Zakaria | Cloud Scalable Multi-Objective Task SchedulingAlgorithm for Cloud Computing Using Cat SwarmOptimization and Simulated Annealing | Multi-Objective QoS modelCloud Scalable Multi-Objective Cat Swarm Optimization (CSO) based SimulatedAnnealing (SA) (CSM-CSOSA) algorithm is | execution time andexecution cost criteria | Theresults obtained shows proposed method has achieved aRemarkable performance by returning good QoS. | Execution time and cost can be furtherimprove |
| [43]2017Chi-Yeh Chen | Task Scheduling for Maximizing Performanceand Reliability Considering Fault Recovery inHeterogeneous Distributed Systems | Heterogeneous allotment aware scheduling -HAAS algorithm | reliability, precedence constraints | Communication-intensive and computation-intensive application can be used | Performed better than other algorithms in terms of SLR, reliability and speedup. |
| [44]2017YoungJu Moon1†, HeonChang Yu1†, Joon‑Min Gil2† and JongBeom Lim3\*† | A slave ants based ant colonyoptimization algorithm for task schedulingin cloud computing environments | SACO algorithm | diversification and reinforcementStrategies with slave ants. | Derives Optimal solution without pre-processing overheads. | Heterogeneous clusters.  |
| [45]2017P.K. Suri1 and Sunita Rani2 | Design of Task Scheduling Model for CloudApplications in Multi Cloud Environment | Cloud Scheduling Model (CSM)  | Average waiting time, turnaround time,Completion time and make span.SJF, FCFS and LPTF are compared. | Minimized average waiting time , Turnaround time , Execution time and make span | Can compare for other algorithms |

**Table 6 : Min –Max Task scheduling Algorithm**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S.No/Year/Author’s Name | Name of Algorithmand | Performance Metrics | Advantages | Limitations/Future Work |
| [46]2007Kobra EtminaniProf. M. NaghibzadehA Min-Min Max-Min Selective Algorithmsfor Grid Task Scheduling | Selective Algorithm by calculating Standard deviation. | Make span,Average resource utilization rate and Load balancing level | Selective algorithm performs better than Min-Min and Max-Min. | Deadline of each task, cost of execution on each resource, and communication cost can extend.  |
| [47]2010Sameer Singh Chauhan\* and R. C. Joshi\*\*A Weighted Mean Time Min-Min Max-MinSelective Scheduling Strategy for IndependentTasks on Grid | Weighted Mean Time Min-Min Max-Min Selective(WMTS) By considering Standard deviation and Weighted Mean time.  | Make span,Average resource utilization rate and Load balancing level | WMTS performs better than Min-Minand Max-Min  | Deadline of task, QoS of task, execution cost on each resource and , communication cost are future research.  |
| [48]2011M. H. Kashani,R. SarvizadehA Novel Method for Task Scheduling in Distributed Systems Using Max-Min AntColony Optimization |  Memetic algorithm with Ant Colony Optimization as local search by considering load balancing efficiently. | Make span and CPU utilization | minimizes make span and maximizes averageof CPU utilization.Performs better than GA | Still make span can reduce |
| [49]2012Tarun Kumar Ghosh, Rajmohan Goswami, Sumit Bera and Subhabrata BarmanLoad Balanced Static Grid SchedulingUsing Max-Min Heuristic | Load Balanced Max-Min algorithm | Waiting and running time of job for FCFS and Max-Min algorithm | Gives better performs than Max-Min.  |  For low and high machine heterogeneity and task heterogeneity can be extended. |
| [50]2013S.DEVIPRIYAC.RAMESHIMPROVED MAX-MIN HEURISTIC MODEL FORTASK SCHEDULING IN CLOUD. |  Improved Max min algorithm derived from Min-Max , Max-Min and RASA algorithm | Number of resources and tasks | Reduce make span. |  Scalability, availability, stability parameters and to achieve better make span using genetic algorithm (ga) and genetic programming (gp). |
| [51]2014Xiao fang Li1, Yangchow Mao2, Xianjian Xiao1, Yanbin Zhuang1An Improved Max-Min Task-Scheduling Algorithmfor Elastic Cloud | ECMM algorithm for many tasks in consecutive batches by maintains task status table and Virtual machine status table inside a load balancer | Average task, Pending time and Response time | improve theResource utilizationand reduce the response time of tasks. | Still average task pending time can be reduced. |
| [52]2015Bhawna TanejaAn Empirical Study of Most Fit, Max-Min andPriority Task Scheduling Algorithms in CloudComputing | Most Fit, Max- Min and Priority algorithm.  | Scalability, Makespan and average resource utilization and priority to cloudlets. | Max-Min algorithm givesthe lowest make span. andMaximum average resource utilization. And Most Fit is better than Priority algorithm | The task scheduling policies in inter-cloud environment can implement. |
| [53]2015S. Vaaheedha KathleenDr. M. Nazreen BanuMiM-MaM: A New Task Scheduling Algorithm forGrid Environment | MiM-MaM  | Make span and load balancing | achieves better make span and loadBalancing. | The deadline of each task, arriving rate of the tasks, cost of the task execution on each resource, cost of the communication can be considered. |
| [54]2015Santhosh B,Manjaiah 0 HA Hybrid Avg Task-Min and Max-MinAlgorithm For Scheduling Tasks In CloudComputing |  Hybrid Algorithm by clubbing of Max Min and Enhanced MaxMin algorithms which decrease the possibility of larger job allotted to slower resource.  | Availability of resources,make span and minimum execution time | Performed better than Max-Min and Enhanced Max Min in reducing Makespan. | Improved by considering the completion time. |
| [55]2016Vatsal Gajera*∗*, Shubham*†*, Rishabh Gupta*‡*, Prasanta K. Jana*§*, *IEEE Senior Member*An Effective Multi-Objective Task SchedulingAlgorithm using Min-Max Normalization in CloudCom\*puting | Normalized Multi-Objective Min-Min Max-Min Scheduling (NMOMXS). | Make span, Resource utilization. | NMOMXS Better than Min-Min and Max-Min algorithm  | apply for large as well as small tasks,  |
| 562017Paul Moggridge, Na Helian, Yi Sun, Mariana Lilley, Vito VenezianoRevising Max-min for Scheduling in a CloudComputing Context | Max min Fast Track (MXFT) withService Level Agreements (SLAs),  | Consumer speed and Task Size | MXFT better than Max Min by prioritizing small tasks | Size of the Fast Track can increase.  |

New booking system named effective area and reproduction mindful planning (ELRAS) incorporated with an independent replication conspire (ARS) to improve the information territory and perform reliably in the heterogeneous condition. ARS freely picks the data dissent to be duplicated by considering its popularity and empties the multiplication as it is sit out of apparatus. The outcomes demonstrate the proficiency of the calculation for heterogeneous bunches and workloads [57].

**4. Conclusion**

Cloud computing is a parallel and distributed system containing a number of dynamically interconnected virtualized machines. The scheduling issue is illuminated over the iterative choice of a sub issue and the provisional task of an answer for that sub issue. Since the greater part of the scheduling issues is NP-finished or NP-hard, finding an answer for those issue imperatives could require exponential time in the most pessimistic scenario. A task scheduling algorithm for heterogeneous multi-

cloud environment that is based on Min-Min and Max-Min will be used with ranking functions .This scheduling algorithm is executed with two phases and tested synthetic and benchmark data sets.

 **References:**

[1] Kaur, P.D., Chana, I. Unfolding the distributed computing paradigm, In: [1] International Conference on Advances in Computer Engineering, pp. 339-342 (2010)

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

[3] M. Cusumano, Cloud computing and SaaS as new computing platforms,

Communications of the ACM 53 (4) (2010) 27–29.

[4]Maryam Masoudi Khorsand, Mehdi Effatparvar and Mahdi Kanani, “A survey of Scheduling Algorithms in Grid Computing,” *International Journal ofResearch in Computer Applications and Robotics, ISSN 2320-7345, Volume 2, Issue 2, Pg. 118-126,February 2014.*

[5]C. ChandraSekhar and C. S. Rao, “Secure network connectivity in the cloud computing environment,” International Journal of Innovative Research Computer and Communication Engineering, vol. 2, no. 3, pp. 3535–3545, 2014.

[6] M. K. Deshmane and M. B. Pandhare, “Survey on scheduling algorithms in cloud computing,” International Journal of Emerging T rend in Engineering and Basic Sciences (IJEEBS), 2014.

[7] Shu-Ching Wang, Kuo-Qin Yan, Shun-Sheng Wang, Ching-Wei Chen, "A Three-Phases Scheduling in a Hierarchical Cloud Computing Network", IEEE, 2011

8. M. Sipser. *Introduction to the Theory of Computation*. International Thomson Publishing, 1st edition, 1996.

9. Hefny, HA. and Khafagy, MH., and Ahmed, MW. (2014). Comparative Study Load Balance Algorithms for MapReduce environment. International Journal of Applied Information Systems (IJAIS), 106(18), 41

[10]Xiaofang Li, Yingchi Mao, Xianjian Xiao, Yanbin Zhuang,” An Improved Max-Min Task-Scheduling Algorithm for Elastic Cloud” IEEE International Symposium on Computer, Consumer and Control, 2014.

 [11]Saeed Parsa, Reza Entezari-Maleki,” RASA: A New Grid Task Scheduling Algorithm” International Journal of Digital Content Technology and its Applications Volume 3, Number 4, December 2009.

[12]. Zhao, H., & Sakellariou, R. (2003, August). An experimental investigation into the rank functions of the heterogeneous earliest finish time scheduling algorithm. In *European Conference on Parallel Processing* (pp. 189-194). Springer, Berlin, Heidelberg.

[13].Garg, S. K., Versteeg, S., & Buyya, R. (2013). A framework for ranking of cloud computing services. *Future Generation Computer Systems*, *29*(4), 1012-1023.

14. Huang, K. C., Tsai, Y. L., & Liu, H. C. (2015). Task ranking and allocation in list-based workflow scheduling on parallel computing platform. *The Journal of Supercomputing*, *71*(1), 217-240.

[15].Laili, Y., Tao, F., Zhang, L., Cheng, Y., Luo, Y., & Sarker, B. R. (2013). A ranking chaos algorithm for dual scheduling of cloud service and computing resource in private cloud. *Computers in Industry*, *64*(4), 448-463.

[16].Huang, K. C., & Tsai, M. H. (2016, December). Task ranking and allocation heuristics for efficient workflow schedules. In *Computer Symposium (ICS), 2016 International* (pp. 515-519). IEEE.

[17].Bunney, R. W. (2017). Comparing Rank Methods in HEFT Scheduling.

[18].Dubey, K., Kumar, M., & Sharma, S. C. (2018). Modified HEFT Algorithm for Task Scheduling in Cloud Environment. *Procedia Computer Science*, *125*, 725-732.

[19].Ghanbari, S., & Othman, M. (2012). A priority based job scheduling algorithm in cloud computing. *Procedia Engineering*, *50*, 778-785.

[20].Jangra, A., & Kumar, A. (2013, December). Dynamic prioritization based efficient task scheduling for grid computing. In *Information Management in the Knowledge Economy (IMKE), 2013 2nd International Conference on* (pp. 150-155). IEEE.

[21].Amalarethinam, D. G., & Kavitha, S. (2017, February). Priority based Performance Improved Algorithm for Meta-task Scheduling in Cloud environment. In *Computing and Communications Technologies (ICCCT), 2017 2nd International Conference on* (pp. 69-73). IEEE.

[22].Tang, Z., Qi, L., Cheng, Z., Li, K., Khan, S. U., & Li, K. (2016). An energy-efficient task scheduling algorithm in DVFS-enabled cloud environment. *Journal of Grid Computing*, *14*(1), 55-74.

[23].Ismail, L., & Fardoun, A. (2016). Eats: Energy-aware tasks scheduling in cloud computing systems. *Procedia Computer Science*, *83*, 870-877.

[24] Rao, G. J., & Babu, G. S. (2017, February). Energy analysis of task scheduling algorithms in green cloud. In *Innovative Mechanisms for Industry Applications (ICIMIA), 2017 International Conference on* (pp. 302-305). IEEE.

[25].Daljinder Singh, Mandeep Devgan, Shashi Bhushan (2016). Tasks Scheduling with Lessen Energy Usage over a Cloud Server using Hybrid Adaptive Multi-Queue Approach

[26].Xu, X., Cao, L., & Wang, X. (2016). Adaptive task scheduling strategy based on dynamic workload adjustment for heterogeneous Hadoop clusters. *IEEE Systems Journal*, *10*(2), 471-482.

[27].Chauhan, A., Singh, S., Negi, S., & Verma, S. K. (2016, October). Algorithm for deadline based task scheduling in heterogeneous grid environment. In *Next Generation Computing Technologies (NGCT), 2016 2nd International Conference on* (pp. 219-222). IEEE.

[28].Kanemitsu, H., Hanada, M., & Nakazato, H. (2016). Clustering-based task scheduling in a large number of heterogeneous processors. *IEEE Transactions on Parallel and Distributed Systems*, *27*(11), 3144-3157.

[29].AlEbrahim, S., & Ahmad, I. (2017). Task scheduling for heterogeneous computing systems. *The Journal of Supercomputing*, *73*(6), 2313-2338.

[30]Ashish Gupta Ritu Garg (2017). Workflow scheduling in Heterogeneous computing systems: a Survey

[31]. Mondal, B., Dasgupta, K., & Dutta, P. (2012). Load balancing in cloud computing using stochastic hill climbing-a soft computing approach. *Procedia Technology*, *4*, 783-789.

[32].Xu, A., Yang, Y., Mi, Z., & Xiong, Z. (2015, August). Task scheduling algorithm based on PSO in cloud environment. In *Ubiquitous Intelligence and Computing and 2015 IEEE 12th Intl Conf on Autonomic and Trusted Computing and 2015 IEEE 15th Intl Conf on Scalable Computing and Communications and Its Associated Workshops (UIC-ATC-ScalCom), 2015 IEEE 12th Intl Conf on* (pp. 1055-1061). IEEE.

[33].Kalra, M., & Singh, S. (2015). A review of Metaheuristic scheduling techniques in cloud computing. *Egyptian informatics journal*, *16*(3), 275-295.

[34].Lakra, A. V., & Yadav, D. K. (2015). Multi-objective tasks scheduling algorithm for cloud computing throughput optimization. *Procedia Computer Science*, *48*, 107-113.

[35].Dzmitry Kliazovich · Johnatan E. Pecero · Andrei Tchernykh · Pascal Bouvry (2015)· Samee U. Khan · Albert Y. ZomayaCA-DAG: Modelling Communication-Aware Applicationsfor Scheduling in Cloud Computing

[36].Mittal, S., & Katal, A. (2016, February). An optimized task scheduling algorithm in cloud computing. In *Advanced Computing (IACC), 2016 IEEE 6th International Conference on* (pp. 197-202). IEEE.

[37].Razaque, A., Vennapusa, N. R., Soni, N., & Janapati, G. S. (2016, April). Task scheduling in cloud computing. In *Systems, Applications and Technology Conference (LISAT), 2016 IEEE Long Island* (pp. 1-5). IEEE.

[38].Convolbo, M. W., & Chou, J. (2016). Cost-aware DAG scheduling algorithms for minimizing execution cost on cloud resources. *The Journal of Supercomputing*, *72*(3), 985-1012.

[39].Yuan, H., Bi, J., Tan, W., & Li, B. H. (2017). Temporal task scheduling with constrained service delay for profit maximization in hybrid clouds. *IEEE Transactions on Automation Science and Engineering*, *14*(1), 337-348.

[40].Yuan, H., Bi, J., Tan, W., Zhou, M., Li, B. H., & Li, J. (2017). TTSA: an effective scheduling approach for delay bounded tasks in hybrid clouds. *IEEE transactions on cybernetics*, *47*(11), 3658-3668.

[41].Gabi, D., Zainal, A., Ismail, A. S., & Zakaria, Z. (2017, May). Scalability-Aware scheduling optimization algorithm for multi-objective cloud task scheduling problem. In *Student Project Conference (ICT-ISPC), 2017 6th ICT International* (pp. 1-6). IEEE.

[42].Gabi, D., Ismail, A. S., Zainal, A., Zakaria, Z., & Al-Khasawneh, A. (2017, May). Cloud scalable multi-objective task scheduling algorithm for cloud computing using cat swarm optimization and simulated annealing. In *Information Technology (ICIT), 2017 8th International Conference on* (pp. 599-604). IEEE.

[43].Chen, C. Y. (2016). Task scheduling for maximizing performance and reliability considering fault recovery in heterogeneous distributed systems. *IEEE Transactions on Parallel and Distributed Systems*, *27*(2), 521-532.

[44].Moon, Y., Yu, H., Gil, J. M., & Lim, J. (2017). A slave ants based ant colony optimization algorithm for task scheduling in cloud computing environments. *Human-centric Computing and Information Sciences*, *7*(1), 28.

[45].Suri, P. K., & Rani, S. (2017, May). Design of Task Scheduling Model for Cloud Applications in Multi Cloud Environment. In *International Conference on Information, Communication and Computing Technology* (pp. 11-24). Springer, Singapore.

[46]. Naghibzadeh, M., & Etminani, K. (2007). A min-min max-min selective algorithm for grid task scheduling. In *Proceedings of the 3rd IEEE/IFIP International Conference in Central Asia*.

[47]. Chauhan, S. S., & Joshi, R. C. (2010, February). A weighted mean time min-min max-min selective scheduling strategy for independent tasks on grid. In *Advance Computing Conference (IACC), 2010 IEEE 2nd International* (pp. 4-9). IEEE.

[48]. Kashani, M. H., & Sarvizadeh, R. (2011, January). A novel method for task scheduling in distributed systems using Max-Min Ant Colony Optimization. In *Advanced Computer Control (ICACC), 2011 3rd International Conference on* (pp. 422-426). IEEE.

[49]. Ghosh, T. K., Goswami, R., Bera, S., & Barman, S. (2012, December). Load balanced static grid scheduling using Max-Min heuristic. In *Parallel Distributed and Grid Computing (PDGC), 2012 2nd IEEE International Conference on* (pp. 419-423). IEEE.

[50]. Devipriya, S., & Ramesh, C. (2013, December). Improved max-min heuristic model for task scheduling in cloud. In *Green Computing, Communication and Conservation of Energy (ICGCE), 2013 International Conference on* (pp. 883-888). IEEE.

[51]. Li, X., Mao, Y., Xiao, X., & Zhuang, Y. (2014, June). An improved max-min task-scheduling algorithm for elastic cloud. In *Computer, Consumer and Control (IS3C), 2014 International Symposium on* (pp. 340-343). IEEE.

[52]. Taneja, B. (2015, May). An empirical study of most fit, max-min and priority task scheduling algorithms in cloud computing. In *Computing, Communication & Automation (ICCCA), 2015 International Conference on* (pp. 664-667). IEEE.

[53]. Kfatheen, S. V., & Banu, M. N. (2015, March). MiM-MaM: A new task scheduling algorithm for grid environment. In *Computer Engineering and Applications (ICACEA), 2015 International Conference on Advances in* (pp. 695-699). IEEE.

[54]. Santhosh, B., & Manjaiah, D. H. (2015, December). A hybrid AvgTask-Min and Max-Min algorithm for scheduling tasks in cloud computing. In *Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2015 International Conference on* (pp. 325-328). IEEE.

[55]. Gajera, V., Gupta, R., & Jana, P. K. (2016, July). An effective multi-objective task scheduling algorithm using Min-Max normalization in cloud computing. In *Applied and Theoretical Computing and Communication Technology (iCATccT), 2016 2nd International Conference on* (pp. 812-816). IEEE.

[56]. Moggridge, P., Helian, N., Sun, Y., Lilley, M., Veneziano, V., & Eaves, M. (2017, June). Revising Max-min for Scheduling in a Cloud Computing Context. In *Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE), 2017 IEEE 26th International Conference on* (pp. 125-130). IEEE.

[57] Benifa, JVB. AndDejey, Performance Improvement of MapReduce for Heterogeneous Clusters Based on Efficient Locality and Replica Aware Scheduling (ELRAS) Strategy. Wireless Personal Communications, 1-25.2017.