

A Study on Extremal Optimization Based Load Balancing Techniques

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ABSTRACT: In the running generation of world, cloud has become the most lightening and powerful term. Cloud computing is a term that expands on many years of research in virtualization, distributed computing, utility computing, systems administration, web and software services. It emerged as the most popular distributed computing paradigm out of all others. It gives on-demand access to shared pool of resources in a self-benefit, progressively adaptable and metered way with ensured Quality of service to clients. Extremal Optimization is implemented in processor load balancing in execution of distributed programming used in cloud computing. It is a nature-inspired meta-heuristic technique. This algorithm finds an optimized strategy of task migration. EO simply based on betterment of single solution representation with low memory and operational complexities focused with requirements of load balancing problems. In this paper it has also discussed the comparison of various technologies related to cloud computing based on various parameters i.e. speed up, migration cost etc. the overall objective of this paper is that EO gives better convergence of the calculation, less number of task migrations to be done and reduced execution time of utilization.

KEYWORDS: Extremal Optimization, Distributed programming, Task Migration, Load Balancing, Parallel Computing, Multicore Computing, Processor scheduling

1. INTRODUCTION:

Cloud computing is a term that expands on many years of research in virtualization, dispersed registering, utility figuring, additionally systems administration, web and programming administrations. By utilizing distributed computing expense of support and obtaining framework is being eliminated. It permits clients to utilize resources as per their needs. It empowers clients to have helpful and on-request access of figuring resources on pay per utilize premise.

Distributed computing has risen as the most well known appropriated distributed computing out of all others. It gives on-request access to shared pool of assets in a self-benefit, progressively adaptable and metered way with ensured Quality of service to clients. The issue of mapping jobs on clearly boundless computing assets in distributed computing has a place with a classification of issues known as NP-hard problems. Computing turn out to be these days vital and continually expanding the measure of information to trade and putting away also. This measure of putting away and changing information builds the load of the processors over the system.

So load balancing is the term utilized for adjusting the load over the processors of changing and putting away information. By balancing the load over the processors it will minimize the execution time of projects and output will be gotten quick and effective. Load balancing is one of the administer issues identified with distributing computing. Load Balancing is computer systems administration to disperse work load into number of various systems to get most extreme throughput, minimum execution time, ignore over-loading. Fundamentally it is a term used to disperse different jobs over different systems. Utilizing various segments of load adjusting expands unwavering quality rather than single part. Load balancing is the fundamental issue identified with cloud computing. It is implied for bunch of multicore processors interconnected by message passing system. It permits efforts to oversee application or workload requests by dealing assets among various PCs, systems or servers. Load in itself can be characterized as memory, CPU limit work.

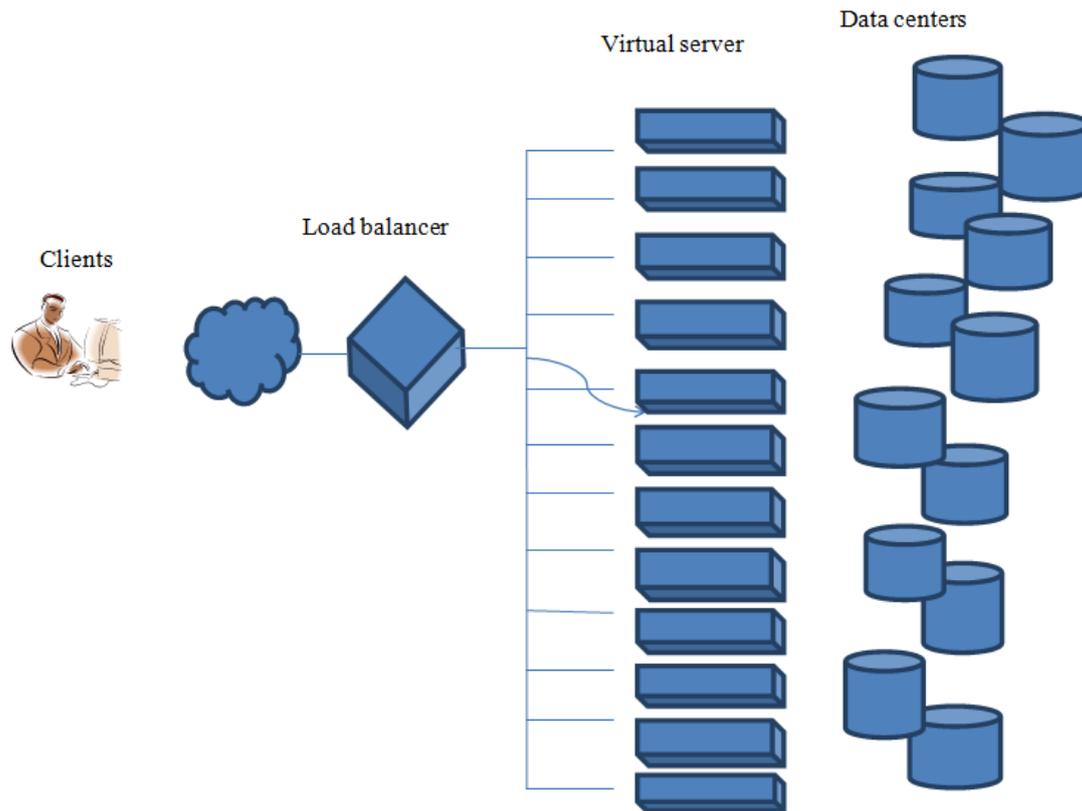


Figure 1

Fig 1 depicts the load balancing criteria in cloud computing[11].

- **Load Balancer:** Nowadays websites work by using load balancing. If there are various instances running on different machines. Clients do not send requests directly on that machines. Thus they send requests to the another machine that is Load Balancer. It is a device that acts as backup and divides network or application traffic among different servers. It is used to enhance capability and reliable ness. It helps to make the improvement of the quality of work that was having a huge load.
- **Virtual Servers:** It is a server that deals with hardware and software resources with other operating systems against devoted servers. They are cost effectual. It provides better resource control.
- **Data Center:** It is a huge group of networked computer servers that used by constitutions for remote storage processing or dispersion of huge amount of data.

Parallel and distributed system focus on high performance network for efficient execution. There are principally two sorts of load balancing algorithm in distributed computing:

- **Static Algorithm:** In static algorithm load is similarly partition among numerous processors or servers. Choice of partitioning the load not relies upon current situation of system but rather it requires the learning of system assets. It is accurately connected on that system whose load variety is less[11].
- **Dynamic Algorithm:** From the entire system among which has lightest server it is connected on that. It isolates the load among processors or a server relies on the current situation of the system[11]. Load balancing issue emerge in numerous applications, it assumes an essential part in conveyance of parallel and distributed computing system. Extremal Optimization(EO) is broadly useful nearby research heuristic based a long way from balance wonders as far as self-sorted out basically. It is inspired by simulated annealing or genetic algorithm. It is a purely new meta-heuristic technique based on evolutionary science notion.

2. TECHNOLOGIES USED:

In running generation of world, cloud computing has become most powerful that lighten up the technology. IT world has changed their way to buy and design hardware through this technology. Cloud computing is internet based computing. It is usually defined as activity of using computer hardware and software. Load balancing is one of the concern that is to be explored for its perfect awareness. Without balancing load it is too much hard to manage cloud computing.

2.1 GENETIC ALGORITHM:

Genetic algorithm has been utilized as a delicate computing approach in distributed computing. Genetic algorithm are heuristic and enhancement strategy that mimic procedure of characteristic development [2]. Genetic algorithm increased tremendous fame over a years ago. It is simple versatile inquiry strategy. These algorithms commonly used with two scheduling algorithms:

- a. FCFS (First Come First Serve): In distributed system, computers are not same sort that have not same setup so that some computer complete their work prior and sit perfect which debase the execution of multicomputer framework. For proper load balancing a new algorithm is developed that is first come first serve algorithm[13]. It is the least complex scheduling algorithm. It is easy to right and get it. The significant disadvantage is that its normal time is so long.
- b. RR (Round Robin): It is one of the least complex techniques for broadcasting customer asks for over a gathering of servers. The round-robin stack balancer advances a client request to each server in turn. The fundamental advantage of round-robin load balancing is that it is to a great degree easy to implement. Genetic algorithm is suitable for load balancing system[13]. It is very complicated and time consuming algorithm. Genetic algorithm is based on principles of evolution and natural genetics works from database of points simultaneously, climbing many peaks in parallel. Two main attraction of genetic algorithm technique are point to point simplicity of operation and power of effect. It operates on huge number of possible solutions. It proposed for load adjusting issues to accomplish better execution and proficient outcomes.

2.2 EXTREMAL OPTIMIZATION (EO):

Numerous nature inspired techniques are utilized to adjust load among distributed programs. Extremal Optimization is another enhancement technique. It is stochastic search system. Fundamental components utilized as a part of this method are stochastic change of most exceedingly awful segments of issue's answer. It identifies improved methodology of undertaking movement that minimize program execution time. It speaks to technique for NP-Hard combinatorial and physical optimization issue. Extremal optimization was motivated by Bak-Seneppen model of biological evolution. In this model species situated on destinations of grid and have a related wellness esteem somewhere around 0 and 1 [15]. It is proposed to guide errands making up a client application in lattice situations.

Extremal optimization has some distinguished features which are Low Operational and Memory Complexities. These features help to make it good for online dynamic load balancing. In parallel strategies for extremal upgrade associated in processor load balancing in execution of scattered activities, the parallel part portrays iterative execution of EO in parallel branches. In Extremal Optimization, we use two fitness functions for computation of tasks. These strategies are utilized to support load adjusting of processor in execution of distributed projects. Two functions are used in extremal optimization:

- I. Local fitnessfunction is essential for evaluating specific states of local entities. It demonstrates how much computational heap of nodes execute jobs surpasses the normal computational heap of nodes. Local fitness function is also known as per- component fitness of tasks [15].
- II. Global fitness function is impact of total extremal communication between tasks on quality of given mapping. This is to be defined the communication between tasks placed on different nodes [15].

For better efficiency, distribution of partitioning of threads/tasks among processors in critical and important concern. It helps to increase the performance of system. If all the processors are active at the same time by distributing the tasks, it will save the power consumption of the processors. Workload is to be distributed among different processors using some algorithm. Due to this overload of Jobs and program balanced, Execution time and response time increases. Load Balancing is used to find reduced mean and standard deviation of response time and under heavy load. As this technique is new in field as compared to other techniques like Ant Colony Optimization, Genetic Algorithms, Particle Swarm Optimization.

There is a huge scope to use this meta-heuristic technique. Grid is decentralized heterogeneous multisite framework which accumulated multipurpose assets spread over various spaces. It makes single intense collective problem solving environment. Mapping of extremal optimization is multi-objective problem. It can be beneficially presented by utilizing approach in light of idea ofpareto-optimal set. With this optimal solutions emerges with no one consider to be better than any other in same set. In this the inadequately performing arrangements are replaced by irregular ones. Execution of EO demonstrates that it is fit for finding close ideal arrangement proficiently to a large portion of test issues.

Extremal optimization is used to find out the best job for migration and for guided selection for better processor to get migrated task. To diminish the complexity for migration Guided state Extremal optimization proposed. Guided EO calculation is a two stage random determination all through the arrangement advancement in view of two fitness functions. These capacities estimated the relations amongst projects and official equipment. This calculation describes great measure-ability for the raising number of employments and controlling units appearing in load adjusting issue.

- Algorithm: Extremal Optimization with guided state changes (EO-GS)[15] :

EO algorithm with guided state changes (EO-GS)

Initialize configuration X at will

$X_{best} \leftarrow X$

While total number of iterations N not reached do

Evaluate α_i for each variable x_i of the current solution S

Rank the variables x_i based on their local fitness α_i

Choose the rank y according to $y^{-\beta}$ so that the variable x_j with $j = \Omega(y)$ is selected

Evaluate $\forall x_i$ for each neighbour $X_u \in \text{Neighbor}(X, x_j)$, generated by changing x_j in the current solution X

Rank neighbours $X_u \in \text{Neigh}(X, x_j)$ based on the target function α_i

choose $X' \in \text{Neighbor}(X, x_j)$ according to the exponential distribution

accept $X \leftarrow X'$ unconditionally

If $\alpha(X) < \alpha(X_{best})$ then

$X_{best} \leftarrow X$

end if

end while

Return X_{best} and $\alpha(X_{best})$

2.3 MODIFIED EXTREMAL OPTIMIZATION (MEO):

It is the regular expansion of extremal optimization. It finds more optimal solutions than other existing heuristics. Only one individual evolves in it, its major drawback is that it is not possible to explore the whole search space [5]. In EO there are some performance issues defined that is the convergence speed is slow and it takes large computation time to get optimal solutions. Therefore to overcome these issues Modified Extremal Optimization is proposed.

Modified EO is basically a EO based solver. The methodology of generating solutions is improved by MEO and makes local modifications. An individual has several elements in EO. Each element has a state and its local modifications are executed by changing the state of element. But in Modified EO it generates multiple individuals to each element. Worst fitness value of the element is selected by EO first and then changes the state of that selected element. But in modified EO it does not select only element with worst fitness value for changing state. It uses a roulette selection to select an element.

2.4 POPULATION-BASED MODIFIED EXTREMAL OPTIMIZATION (PMEO):

It is an extension of extremal optimization. It is used to solve multi-objective population based extremal optimization. In this approach results may be sometimes occurs in local optima. Once in a while nearby wellness allotted to segment of arrangement in light of Pareto mastery regard to set of expected destinations. It is unable to maintain the diversity at the end of alternation of generation. PMEO outperforms MEO [6].

2.5 DISTRIBUTED MODIFIED EXTREMAL OPTIMIZATION (DMEO):

The word 'distributed' or 'distributed computing' or 'distributed programming' mentioned in computer programming where single computer physically distributed over some geographical areas. Distributed systems can solve large computational problems [16]. These systems feasible like individual systems to normal users, but only the hardware and software components are distributed only. Distributed Modified Extremal Optimization (DMEO) is essentially a novel bio-inspired heuristic approach using island model. DMEO is hybrid of PMEO and DGA using island model. Islands stabilize many types of individuals at end of alternation of generation. So DMEO stabilize more heuricity than PMEO.

2.6 SIMULATED ANNEALING LOAD BALANCING:

Simulated annealing algorithm is a new tremendous execution technique to cover the dynamic load adjusting issues. It is not just conceivable to discover the solution of the issue additionally in proficient time. It is used to balance the load of cloud architecture. It simulates behaviour of systems in thermal equilibrium [13]. In simulated annealing load balancing strategy grid computing is concerned with coordinated resource sharing and problem solving in multi-departmental virtual organizations. To achieve the promising potentials of tremendous resource distribution, competent algorithms that can efficiently utilize resource are fundamentally important. An efficient load balancing strategy avoids the situation where some resources are idle while others have multiple tasks queued up[1].

By developing strategies that could map these tasks to resources with suitable load balancing results in less processing time with improving utilization of resources. Simulated Annealing to cover Load Balancing in framework condition is a load balancing strategy based on simulated annealing algorithm that is appropriately arranged and created whereby optimal or near optimal job allotments can evolve throughout the operation of the network framework.

3. RELATED WORK:

Albert Y. Zomaya, Senior Member, IEEE, and Yee-Hwei et al. 2001[14] analysed Genetic algorithm utilized to take care of the dynamic load-adjusting issue. A dynamic load-adjusting calculation was produced whereby ideal or close ideal assignment distributions can advance amid the operation of the parallel processing framework. The algorithm considered other load-adjusting issues, for example, edge strategies, data trade criteria, and between processor correspondence. The effects of these and diverse issues on the accomplishment of the inherited based load-adjusting computation as differentiated and the principle fit heuristic outlined. Hara, Natsumi, Keiichi Tamura, and Hajime Kitakami et al. 2010[5] detailed a novel modified EO (Extremal Optimization) based developmental calculation (MEOEA) for diminishing hybrids in a reconciliation graph. The proposed evolutionary algorithm was popular construct developmental calculation based with respect to MEO. We assessed MEOEA utilizing genuine information sets. The investigation came about demonstrate that MEOEA was great execution contrasted and MEO. Masoud Gharehjanloo et al. 2011[9] defined extremal optimisation is proposed for work shop scheduling. Extremal Optimization was a formative meta-heuristic strategy that consecutively substitute undesirable calculated current course of action with a self-assertive regard and advances itself toward ideal arrangement. For EO, the nature of created starting arrangement assumed an essential part in joining rate and achieving worldwide ideal. GT technique was used for starting arrangement. This algorithm executed on a few specimen issues on datasets and demonstrate that ideal arrangement can be came to rapidly on a large portion of the datasets. Keiichi Tamura, Hajime Kitakami, and Akihiro Nakada et al. 2013[16] proposed a novel bio-inspired heuristic called dispersed adjusted extremal optimization (DMEO) using the island appear. This heuristic was a creamer of masses based changed extremal optimization (PMEO) and the passed on innate computation using the island exhibit that is used for diminishing crossovers as a part of a trade-off outline. We have surveyed DMEO using authentic data sets. DMEO demonstrated better execution contrasted and PMEO. Nadia Dilawar, Muhammad Zakarya and Izaz Ur Rahman et al. 2013[10] studied A multicore CPU has more than one free preparing center on a single chip to expand throughput and execution, by adding additional center to a same chip double the execution, yet by speed of every center was slower than the single center processor. Moreover executing more guidelines expands control utilization and along these lines delivered additional high temperature. Delicate products composed for multicore stage that disperse the workload among numerous indistinguishable or diverse centers. This usefulness called string level parallelism. These specific strategies called stack adjusting instrument. Various load adjusting calculations that minimize the power utilization of multicore innovation while keeping up execution to the best level. Tushar Desai, Jignesh Prajapati et al. 2013[11] showed distributed computing is developing quickly and more clients pulled in towards utility figuring, better and quick administration should be given. For better administration of accessible great load adjusting procedure required. Furthermore, through better load adjusting in cloud, execution expanded and client improved administrations. It characterized a wide range of load adjusting procedures used to explain the issue in distributed computing environment. Shivangi Katiyar, Nipun Mehta, Ankit Gupta et al. 2015 [1] presented a heuristic technique intended to take care of the heap adjusting issue in network situations. This strategy, called SALB (Simulated Annealing to cover Load Balancing in framework environment), was a heap adjusting technique in view of re-enacted toughening calculation that is appropriately arranged and created whereby ideal or close ideal assignment portions can develop amid the operation of the matrix framework. Brototi Mondal, Avishek Choudhury et al. 2015 [13] formulated a load balancing system in light of Simulated Annealing (SA) has been proposed which adjusts the heap of the cloud foundation. To quantify the execution of the calculation, a current test system Cloud Analyst changed and the re-enactment comes about demonstrate the general execution of the proposed calculation is superior to of the current methodologies like First Come First Serve (FCFS), Round Robin (RR) and a nearby hunt calculation i.e. Stochastic Hill Climbing (SHC).

COMPARISON TABLE:

Sr. no.	Author	Title	Year	Technique	Speed Up	Migration Cost	Meta-heuristic	Load balancing
1	Min.Rong Chen	Multi-objective optimization using population-based Extremal Optimization	2007	Pareto- based algorithm	no	yes	yes	no
2	Shivangi Katiyar	Simulated Annealing based load balancing in grid	2015	Simulated Annealing	No	No	yes	yes
3	Keiichi Tamura	Distributed Modified Extremal Optimization Using Island Model for reducing crossover in reconciliation graph	2013	Distributed Genetic Algorithm	yes	no	yes	no
4	Natsumi Hara	Modified EO Algorithm for reducing crossover of Reconciliation graph	2010	Modified EO Evolutionary Algorithm	no	no	No	no
5	Akihiro Nakada	Population based EO for contact map overlap maximization problem	2013	Bio-inspired heuristic	no	yes	yes	no
6	Nadia Dilawar	Review of power efficient load balancing algorithm for multicore system	2013	Scheduling	yes	yes	No	yes
7	Brotoi Mondal	Simulated Annealing based load balancing strategy for cloud computing	2015	Simulated Annealing	No	yes	Yes	yes
8	AlbertY. Zomaya	Observations on Using Genetic Algorithms for Dynamic Load-Balancing	2001	Parallel Processing	yes	yes	Yes	yes

4. Conclusion:

In running generation of world, cloud computing has become most powerful that lighten up the technology. IT world has changed their way to buy and design hardware through this technology. Cloud computing is internet based computing. This paper has presented the comparison of various technologies related to cloud computing based on various parameters i.e. speed up, migration cost etc. But still there are some issues related to extremal optimization based on load balancing has not considered the tuning parameters. In near future we will evaluate machine learning based EO technique for efficient load balancing as well as utilize random forest algorithm to construct optimal schedulers. Also multi-objective criteria will be used to enhance the result further.

References

- [1] Katiyar, Shivangi, Nipun Mehta, and Ankit Gupta. "SALB: Simulated Annealing Based Load Balancing in Grid." *Int. J. of Emerging Technologies in Computer Science and Electronics*, Vol16 (2), ISSN (2015): 0976-1353.
- [2] Dalal, Surjeet, and Shilpa Kukreja. "Genetic Algorithm based Novel approach for Load Balancing problem in Cloud environment." *International Journal of Computer Science and Information Security* 14.7 (2016): 88.
- [3] Boettcher, Stefan, and Allon G. Percus. "Extremal optimization: an evolutionary local-search algorithm." *Computational Modeling and Problem Solving in the Networked World*. Springer US, 2003. 61-77.
- [4] Tamura, Keiichi, Hajime Kitakami, and Akihiro Nakada. "Distributed modified extremal optimization using island model for reducing crossovers in reconciliation graph." *Eng. Lett* 21.2 (2013): 81-88.
- [5] Hara, Natsumi, Keiichi Tamura, and Hajime Kitakami. "Modified eo-based evolutionary algorithm for reducing crossovers of reconciliation graph." *Nature and Biologically Inspired Computing (NaBIC)*, 2010 Second World Congress on. IEEE, 2010.
- [6] Nakada, Akihiro, et al. "Population-based Modified Extremal Optimization for Contact Map Overlap Maximization Problem." *Advanced Applied Informatics (IIAIAI)*, 2013 IIAI International Conference on. IEEE, 2013.
- [7] Sahoo, Bibhudatta, Sanjay Kumar Jena, and Sudipta Mahapatra. "Simulated Annealing based Heuristic Approach for Dynamic Load Balancing Problem on Heterogeneous Distributed Computing System." (2013).
- [8] A Vouk, Mladen. "Cloud computing—issues, research and implementations." *CIT. Journal of Computing and Information Technology* 16.4 (2008): 235-246.
- [9] Gharehjanloo, Masoud, et al. "Extremal optimization for solving job shop scheduling problem." *Computer and Knowledge Engineering (ICCKE)*, 2011 1st International e Conference on. IEEE, 2011.
- [10] Dilawar, Nadia, Muhammad Zakarya, and Izaz Ur Rahman. "A Review of Power Efficient Load Balancing Algorithms for Multicore Systems." *World Applied Sciences Journal* 27.9 (2013): 1175-1182.
- [11] Desai, Tushar, and Jignesh Prajapati. "A survey of various load balancing techniques and challenges in cloud computing." *International Journal of Scientific & Technology Research* 2.11 (2013): 158-161.
- [12] Patel, Niraj, and Sandip Chauhan. "A survey on load balancing and scheduling in cloud computing." *International Journal for Innovative Research in Science and Technology* 1.7 (2015): 185-189.
- [13] Mondal, Brotoi, and Avishek Choudhury. "Simulated Annealing (SA) based Load Balancing Strategy for Cloud Computing." *IJCSIT International Journal of Computer Science and Information Technologies* 6.4 (2015): 3307-3312.
- [14] Zomaya, Albert Y., and Yee-Hwei Teh. "Observations on using genetic algorithms for dynamic load-balancing." *IEEE transactions on parallel and distributed systems* 12.9 (2001): 899-911.

- [15] De Falco, Ivanoe, et al. "Parallel extremal optimization in processor load balancing for distributed applications." *Applied Soft Computing* 46 (2016): 187-203.
- [16] Tamura, Keiichi, Hajime Kitakami, and Akihiro Nakada. "Distributed modified extremal optimization using island model for reducing crossovers in reconciliation graph." *Eng. Lett* 21.2 (2013): 81-88.
- [17] Chen, Min-Rong, Yong-Zai Lu, and Genke Yang. "Multiobjective optimization using population-based extremal optimization." *Neural Computing and Applications* 17.2 (2008): 101-109.