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# 2015 Information Technologies in Innovation Business Conference (ITIB)

## Proceedings

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# Survey of Major Load Balancing Algorithms in Distributed System

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**Abstract**— The classification of the most used load balancing algorithms in distributed systems (including cloud technology, cluster systems, grid systems) is described. Comparative analysis of types of the load balancing algorithms is conducted in accordance with the classification, the advantages and drawbacks of each type of the algorithms are shown. Performance indicators characterizing each algorithm are indicated.

**Keywords**— load balancing algorithm, distributed system, throughput, resource utilization, capacity

## I. INTRODUCTION

Due to a massive spread of distributed computing systems the problem of their effective use has become urgent. One aspect of this problem is the effective planning and task allocation within a distributed computing system in order to optimize resource utilization and reduce the computation time. Quite frequently the situation arises, where a part of the processing resources is idle, while the other part of the resources is overloaded and a large number of tasks are waiting for execution in the queue.

To optimize the use of resources, reduce the time of service requests, horizontal scaling (dynamic addition / removal of devices), as well as to provide fault tolerance (backup) the method of a uniform distribution of tasks between multiple network devices (e.g. servers) is used, which is called load balancing.

When a new task appears the software realizing balance should decide on which computing node the calculations associated with a new task should be performed. In addition, the balancing involves the transfer of parts of computing from the most loaded compute nodes to less loaded ones. When performing tasks, processors exchange communication messages among themselves. In the case of low-cost communication, some processors may be idle while others are overloaded. Also, high costs of communication are inexpedient. Consequently, the balancing strategy should be such that the computing nodes were loaded uniformly enough, but also the communication environment should not be overloaded.

In the scientific literature a lot of attention is paid to the load control in the distributed systems. Theoretical studies and development of fundamentals of the load distribution, creation of the mathematical apparatus, models and management methods for load balancing in the distributed systems were

considered by such scientists as Hisao Kameda, Lie Li, Chonggun Kim, Yongbing Zhang [1], H. Mehta, P. Kanungo, M. Chandwani [2], V. Cardellini, M. Casalicchio, E. Casalicchio [3,4], Y.S. Hong, J.H. No, S.Y. Kim [5], Martin Randles, David Lamb, A. Taleb-Bendiab [6], Nayandeep Sran, Navdeep Kaur [7]. Such scientists as S. Keshav [8], O. Elzeki, M. Reshad, M. Elsoud [9] were developing and improving load balancing algorithms, depending on the task completion time on the computer. Brute force algorithms and those based on statistical data were considered by such scientists as H. Chen, F. Wang, N. Helian, G. Akanmu [10], Y. Hu, R. Blake, D. Emerson [11], Jing Liu, Xing-Guo Luo, Xing-Ming Zhang, Fan Zhang, Bai-Nan Li [12], Shamsollah Ghanbari, Mohamed Othman [13]. Algorithms based on biological phenomena were considered by Ratan Mishra, Anant Jaiswal [14], Dhinesh Babu L.D., P. Venkata Krishna [15].

The problem of the computational load balancing of the distributed application appears for the following reasons:

- the structure of the distributed application is non-uniform, various logical processes require different computing capacities;
- the structure of the computing complex (e.g. the cluster) is non-uniform, i.e. different computing nodes have different performance;
- the structure of inter-node communication is non-uniform because links connecting nodes may have different bandwidth characteristics.

The purpose of this work is to study the basic load balancing algorithms of distributed systems, their classification, on the basis of which it is possible to make representation analysis of algorithms with the description of their advantages and shortcomings, as well as a comparative analysis of the basic algorithms for different performance metrics.

## II. CLASSIFICATION OF LOAD BALANCING ALGORITHMS

The load balancing helps in fair allocation of computing resource to achieve a high user satisfaction and proper resource utilization. High resource utilization and a proper load balancing help in minimizing the resource consumption. It helps in implementing fail over, scalability, and avoiding bottlenecks [16, 17].



The load balancing is a technique that helps networks and resources by providing a maximum throughput with minimum response time. The load balancing divides the traffic between all servers, so data can be sent and received without any delay with the load balancing.

The major goals of the load balancing algorithms are:

- **Cost effectiveness:** The load balancing helps to provide better system performance at lower cost.
- **Scalability and flexibility:** The system for which the load balancing algorithms are implemented may be changed in size after some time. In this way the algorithm must handle situations of these types and must be flexible and scalable.
- **Priority:** Prioritization of the resources or jobs needs to be done. So higher priority jobs get a better chance to be executed.

Load balancing algorithms can be classified into several types [17, 23]:

#### A. Depending on the system state

##### a) Static algorithm

The current state of the node is not taken into account, a prior knowledge base is required about each node statistics and user requirements, not flexible, not scalable, not compatible with changing users' requirements and load. It is used in a homogeneous environment.

##### b) Dynamic algorithm

This type of algorithms operates according to the dynamic changes in the nodes state, i.e., these algorithms collect, store and analyze information about the system state. Because of this, they are characterized by large loads balancing overhead. It is necessary to take into account the location of the processor to which the load is transferred by an overloaded CPU, the load estimation, limitation of the migrations number. If some node has failed, it will not stop the work of the entire network, but it will influence the system performance. It is used in a heterogeneous environment.

#### B. Depending on who initiated the process

- **Initiated by a sender:** a sender defines that the number of nodes is large and a sender initiates the execution of the load balancing algorithm.
- **Initiated by a receiver:** the load balancing requirement can be identified by a receiver/server in the distributed system, and then the server initiates the load balancing algorithm execution.
- **Symmetric:** This is a combination of the sender initiated and receiver initiated types.

The dynamic load balancing approach is divided into two types: distributed and undistributed (centralized) approaches. They are defined in the following way:

##### a) in the non-distributed approach:

one node or group of nodes are responsible for the management and distribution of service information throughout the system. Other nodes do not distribute tasks and do not operate management functions, therefore this type of algorithms is not fault tolerant, the central decisions making processor can be overloaded. They are useful in small networks with a low load;

##### b) in the distributed approach:

each node builds its load vector independently. All processors in the network are responsible for the load distribution and content of their own local database for taking effective decisions of load balancing. This causes large communication costs and complexity of algorithms. They are useful in large and heterogeneous networks.

The load balancing can have two forms at the distributed approach: cooperative and non-cooperative ones. At the cooperative approach the nodes operate side-by-side for a common goal, such as the overall response time perfection. At the non-cooperative approach the node operates independently of the purpose, such as perfection of the execution time of local problems.

The nodes are constantly interacting with each other and generate more messages at the distributed approach. Sending messages between the nodes to share information about updates of the system can cause the decrease in the system performance [1]. One node or a group of nodes solves the problem of the load balancing at the undistributed approach, which obtains two forms, namely: centralized and semidistributed ones.

In the centralized algorithms one unit is exclusively responsible for the load balancing of the whole system and it is called the central node. It is used in small networks. In the semi distributed algorithms a cluster is formed by the system group of nodes, the load balancing occurs in each cluster by the centralized type. The central node initiates the load balancing among the group of nodes in the cluster. Semidistributed algorithms exchange a lot of messages compared to the centralized ones.

The algorithm for selection of communication tasks defines the task to transfer. When selecting a task to send the algorithm one must take into account that the overhead associated with sending the tasks should be minimal, the complexity of the task should be large, the number of links in the problem with local resources should be minimal.

The algorithm of choosing a partner is responsible for the selection of a suitable node for the balancing operation. A common technique in the distributed algorithms is nodes polling. The poll can be serial or parallel, it can use the results of the previous polls.

In the centralized algorithms the node applies to a specialized coordinator to determine a suitable partner for balancing. The coordinator collects and maintains up to date information about system components capacity, and the partner search algorithm uses this information.



The data collection mechanism collects information about the system capacity, defines sources of the information, the time of capacity data collection, storage space. There are several classes of the data collecting mechanism.

- Data collection on the need. In this class the distributed algorithms are used to collect information about the capacity when a node needs the load balancing.
- Periodic data collection. The algorithms of this class can be both centralized and distributed. Depending on the data collected, the algorithm initiates the load balancing.
- Data collection on change of state. In systems that implement algorithms of this class, the nodes themselves are spreading information about changing capacity when changing the internal state. In the case of the distributed algorithms data are sent to neighboring nodes, in the case of the centralized algorithms data are sent to the coordinator.

Classification of the load balancing algorithms is shown in Figure 1.

### III. ANALYSIS OF LOAD BALANCING ALGORITHMS

There are many algorithms for load balancing, due to which higher throughput and improved response time in distributed systems is achieved. Each algorithm has both advantages and shortcomings [9-23].

Table 1 presents a comparative analysis of different load balancing algorithms by various efficiency metrics. The efficiency of the load balancing algorithms is determined by several indicators, which are listed below [20-21]:

#### a) Throughput

This indicator is used to assess the total number of tasks that are successfully completed. High bandwidth is required for the overall system performance.

#### b) Overhead

Overhead is associated with the operation of any load-balancing algorithm, and it indicates the cost of the processes involved in the task and redistribution process. Overhead should be as low as possible.

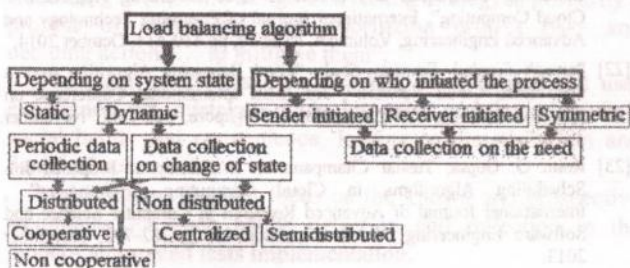


Fig. 1. Classification of load balancing algorithms

TABLE I. COMPARATIVE ANALYSIS OF DIFFERENT LOAD BALANCING ALGORITHMS ON VARIOUS EFFICIENCY INDICATORS

Algorithms/ Metrics	Throughput	Overhead	Fault tolerance	Migration time	Response time	Resource Utilization	Scalability	Performance
Task Scheduling based on LB [13, 18, 21, 22]	+	+	-	+	+	+	+	+
Opportunistic LB (OLB) [18, 21-22]	+	+	+	-	-	+	+	+
Round Robin [8, 18, 21]	+	+	-	-	+	+	-	+
Weighted Round Robin [8, 18, 23]	+	+	+	+	-	+	-	-
Randomized [18-19]	+	+	+	-	-	+	-	+
Min-Min [9, 10, 17-18, 21]	+	+	-	-	+	+	-	+
Max-Min [9, 16-18, 21]	+	+	-	-	+	+	-	+
Honeybee Foraging Behavior [18, 21]	+	-	-	-	-	+	+	+
Active Clustering [18, 23]	-	+	-	+	-	+	-	-
Compare and Balance [11, 18, 23]	+	+	+	+	+	-	+	+
Lock-free multiprocessing solution for LB [12, 18, 21]	-	+	+	-	-	-	-	-
Ant Colony Optimization [14-16, 18]	+	+	-	-	-	+	+	+
Shortest Response Time First [12, 17, 22]	-	+	-	+	+	+	-	+
Based Random Sampling [20, 22]	+	-	-	-	-	-	-	+
The two phase scheduling LB [13, 16, 22]	+	+	-	-	+	+	-	+
Active Clustering LB [11, 16, 22]	-	+	-	+	-	+	-	-
ACCLB [22]	+	+	-	-	-	+	+	+
Decentralized content aware [22]	+	+	-	+	+	-	+	+
Server-based LB [22]	-	-	+	+	+	+	+	+
Join-Idle-Queue [22-23]	+	+	-	+	+	-	+	+
Token Routing [19]	-	+	-	+	-	-	+	-
Central queuing [18]	-	+	-	+	+	+	-	+
Connection mechanism [12, 19, 23]	+	+	+	-	-	+	+	-

#### c) Fault tolerance

This indicator measures the ability of the algorithm to perform the load balancing uniformly in the event of any failure. The good load balancing algorithm must be very insensitive to faults.

#### d) Migration time

It is defined as the total time of transition of a task from one node or resource to another. It should be minimized.



### e) Response time

It is measured as the time interval between sending a request and receiving a response. It should be minimized in order to improve overall performance.

### f) Resource utilization

The indicator is used to ensure the appropriate harnessing of all the system resources. This indicator must be optimized for efficiency of the load balancing algorithm.

### g) Scalability

It is the ability of the algorithm to perform uniform load balancing in the system according to the requirements upon increasing the number of nodes. The preferred algorithm is highly scalable.

### h) Performance

It may be defined as the system efficiency. This indicator should be improved at a reasonable overhead, for example, reducing the response time and preserving an allowable delay.

## Conclusion

The most used load balancing algorithms of distributed systems are classified according to different types in this work. Based on the performed analysis of classification types of the load balancing algorithms the scope of each type of algorithms is indicated, the algorithms types necessary operation requirements are defined, defaults of each type of algorithms are shown. In this way one can select a particular type of the load balancing algorithm based on the specifics of a particular project or executable task, and the goals to be achieved. The description of the main features of load balancing algorithms, analysis of their advantages and defaults are also presented in this work. A comparative analysis of different load balancing algorithms on various performance metrics is carried out, i.e., the efficiency indicators are shown for each algorithm used in it. It is planned to realize a comparative analysis of the load balancing algorithms with different capacity in a variety of distributed systems: cloud, cluster and grid systems.

## References

- [1] Hisao Kameda, Lie Li, Chonggun Kim, Yongbing Zhang, "Optimal Load Balancing in Distributed Computer Systems," Springer, Verlag London Limited, London, 1997. p. 238.
- [2] H. Mehta, P. Kanungo, M. Chandwani, "Decentralized content aware load balancing algorithm for distributed computing environments," ICWET '11 Proceedings of the International Conference & Workshop on Emerging Trends in Technology, N-Y, 2011, pp. 370-375.
- [3] V. Cardellini, E. Casalicchio, M. Colajanni, "A performance study of distributed architectures for the quality of web services," Proceedings of the 34th Conference on System Sciences, Vol. 10, 2001, pp.213-217.
- [4] E. Casalicchio, M.Colajanni, "A client aware dispatching algorithm for web clusters providing multiple services," Proceeding of the 10th International Conference on WWW, 2001, pp.535-544.
- [5] Y.S. Hong, J.H. No, S.Y. Kim, "DNS-based load-balancing in distributed web- server systems," Proceeding, in: Fourth IEEE Workshop on Software Technologies for Future Embedded and Ubiquitous Systems (WCCIA 2006), 2006, pp. 251-254.
- [6] Martin Randles, David Lamb, A. Taleb-Bendiab, "A Comparative Study into Distributed Load Balancing Algorithms for Cloud Computing," IEEE 24th International Conference on Advanced Information Networking and Applications Workshops, 2010, pp.551-556.
- [7] Nayandeep Sran,Navdeep Kaur, "Comparative Analysis of Existing Load Balancing Techniques in Cloud Computing", International Journal of Engineering Science Invention, vol 2, 2013, pp.60-63.
- [8] S.Keshav, "An Engineering Approach to Computer Networking," Addison-Wesley, Reading, MA, 1997, pp. 215-217.
- [9] O. Elzeki, M. Reshad, M. Elsoud, "Improved max-min algorithm in cloud computing," International Journal of Computer Applications, vol. 50 (12), 2012, pp. 22-27.
- [10] H. Chen, F. Wang, N. Helian, G. Akanmu, "User-priority guided min-min scheduling algorithm for load balancing in cloud computing," National Conference Parallel Computing Technologies (PARCOMPTECH), 2013.
- [11] Y. Hu, R. Blake, D. Emerson, "An optimal migration algorithm for dynamic load balancing," Concurrency: Practice and Experience 10 (6), 1998, pp. 467-483.
- [12] Jing Liu, Xing-Guo Luo, Xing-Ming Zhang, Fan Zhang and Bai-Nan Li, "Job Scheduling Model for Cloud Computing Based on Multi-Objective Genetic Algorithm", IJCSI International Journal of Computer Science, Issues, January 2013.
- [13] Shamsollah Ghanbari, Mohamed Othman, "A Priority based Job Scheduling Algorithm in Cloud Computing", International Conference on Advances Science and Contemporary Engineering (ICASCE), 2012.
- [14] Ratan Mishra, Anant Jaiswal, "Ant colony Optimization: A Solution of Load balancing in Cloud", International Journal of Web & Semantic Technology (IJWesT), Vol.3, No.2, pp.335-338, April 2012.
- [15] Dhinesh Babu L.D., P. Venkata Krishna, "Honey bee behavior inspired load balancing of tasks in cloud computing environments", Applied Soft Computing, Volume 13, Issue 5, pp. 2292-2303, May 2013.
- [16] Mayanka Katyal, Atul Mishra, "A Comparative Study of Load Balancing Algorithms in Cloud Computing Environment", International Journal of Distributed and Cloud Computing, Volume 1, Issue 2, pp.6-14, December 2013.
- [17] Dharmesh Kashyap, Jaydeep Viradiya, "A Survey Of Various Load Balancing Algorithms In Cloud Computing", International Journal Of Scientific & Technology Research, Volume 3, Issue 11, pp. 115-119, November 2014.
- [18] Rajwinder Kaur, Pawan Luthra, "Load Balancing in Cloud Computing", DOI: 02.ITC.2014.5.92 Association of Computer Electronics and Electrical Engineers, 2014, pp.374-381.
- [19] Soumya Ray, Ajanta De Sarkar, "Execution analysis of load balancing algorithms in cloud computing environment", International Journal on Cloud Computing: Services and Architecture (IJCCSA), Vol.2, No.5, pp.2657-2664, October 2012.
- [20] N. S. Raghava, Deepti Singh, "Comparative Study on Load Balancing Techniques in Cloud Computing", Open journal of mobile computing and cloud computing, Volume 1, Number 1, pp.18-25, August 2014.
- [21] Kalyani Ghuge, Prof. Minaxi Doorwar, "A Survey of Various Load Balancing Techniques and Enhanced Load Balancing Approach in Cloud Computing", International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 10, pp.410-414, October 2014.
- [22] Priyank Singhal, Sumiran Shah, "Load Balancing Algorithm over a Distributed Cloud Network", 3rd IEEE International Conference on Machine Learning and Computing, Singapore, pp.37-42, November 2011.
- [23] Rohit O. Gupta, Tushar Champaneria, "A Survey of Proposed Job Scheduling Algorithms in Cloud Computing Environment", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 11, pp.782-790, November 2013.



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