Proposed Methods for Establishing Load Balancing in Fog Computing: A Survey

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ABSTRACT:
Activating application programs among millions of devices in the Internet of things in fog computing needs edge networks. Cloud and data fog computing provide computation, storage and application service for end-users. One of the significant features of fog computing is its closeness to end-users, its geographical distribution and user stimulus support. The main goals of fog computing are performance improvement, decrease in data transfer to cloud for computing, analysis and storage. It may be used for security issues as well as other situations. However, fog computing is a suitable solution for stable development in the Internet of things, but there is a large amount of unsolved problems. One of the significant challenges of fog computing is load balancing which needs equal distribution of work load in all nodes to achieve user satisfaction, high fair resource allocation rate and performance of resource computing. In this paper, we have investigated some recommended methods to generate load balancing in fog computing and have provided a category for parameters, advantages and disadvantages of load balancing evaluation.

Keywords: Cloud computing, Fog computing, Load balancing, Internet of things, Virtual Machines.

1. INTRODUCTION

A large number of information is generated by the development of Internet of things which influences storage capacity and cloud computing. The application of Internet of things is growing day by day. Therefore, delayed of data and application program transfer into cloud and then returning to end-user is not always acceptable [1]. In other words, a large number of works such as health supervision system and emergency systems need high speed operation rate. To overcome these limitations, cloud computing is proposed where cloud services can operate speedily and ensure user satisfaction by offering less delays, user stimulus support and navigation services. Fog computing is a virtual platform which provides computation services, storage and networking among end devices and cloud platforms [2]. Figure 1 illustrates a fog computing system [3]. Cloud computing as a

central layer communicates directly with users. Fog ensures security, confirmation area, reliability and delays. A few challenges must be met like fog services distribution, resource allocation and load balancing to achieve entire potential of fog systems and Internet of things in analyzing in real time. Load balancing is an effective process in work load operation of distribution systems on computing resources. The goal of load balancing among all available resources is high well performance and less cost than in traditional models. In addition to, in Virtual Machines some functions of high work load are skipped and added to low work load machines [2]. Load balancing algorithms are used to optimize the system operation, maintain consistency of the system, generate error tolerance system by using baking and be cost efficient. A large number of different algorithms are offered to achieve load balancing with so many advantages and disadvantages which according to system capacity, they can distribute work load. In this paper, we have evaluated some ways to ensure load balancing. This survey has examined challenges while load balancing and provided some parameters to do so. In the second section, a distinction between fog computing and cloud computing, in section three load balancing in fog computing environment, in section four some issues related to research writing and the last part are provided conclusion.

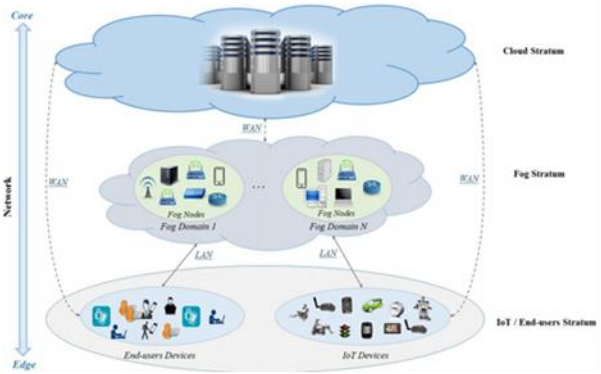

Fig.1.Fog Computing System [3]

Table 1.fog and cloud computing parameters comparison

Parameters	Fog Computing	Cloud Computing
Node Location	in the edges of local network	in the Internet
Delay	Low	High
Delay Frequency	Low	High
Security	almost High	Low, Indefinite
Navigation	Yes	No
vulnerability	Low	High
Geographical Distribution	Dense	Focused
Node Number	Very High	Low
Mobility	Supports	Limited
Reliance on the Internet	Medium	High

2. THE DISTINCTION BETWEEN FOG AND CLOUD COMPUTING

Fog computing is responsible for data storage in a large extent, computation, communication and cloud computing network close to end machines. Since fog computing nodes unload computation and cloud data center storage, cloud computation is an applicable solution for resource limitation. However, the amount of delays is decreased, but the reliability of cloud computing services is more optimal. Another significant distinction is that cloud computing tries to optimizes the resources in all over the world whereas it manages local network. Fog computation optimizes general system operation.

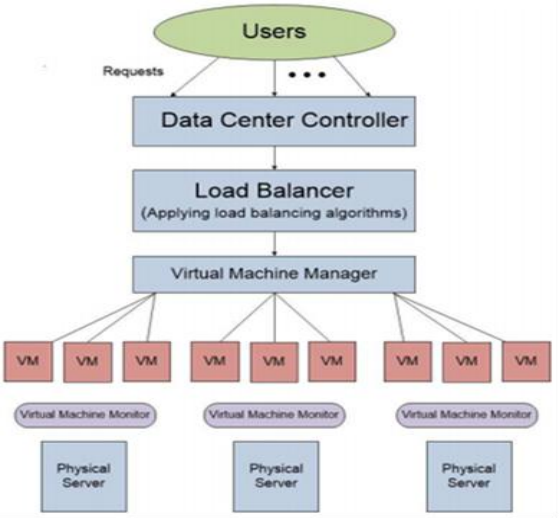

Fig. 2. Load Balancing Mechanism on the Data Centers

3. LOAD BALANCING IN FOG COMPUTING

Load balancing is a new challenge which optimize system performance by load distribution among operators. Figure 1has illustrated load balancing mechanism on the data centers. In this figure, end-users sent requests to data centers. Data center controller routes the requests on a suitable server in

which load balancing algorithm allocates the requests on settled Virtual Machines effectively [4].

4. RELATED ISSUES

Different techniques have been presented in load balancing domain in fog computing but a few of them which are performing better, up to date and optimum are taken into account.

4.1. LOAD STABILIZING IN FOG COMPUTING ENVIRONMENT

The article [5] has provided a modern method for load stabilizing in fog computing environment by using load balancing algorithm and load balancing process evaluation. In the proposed work, for load balancing it has been used four algorithms including: Throttled Algorithm, Round Robin, Particle Swarm Optimization (PSO) and Active Virtual Machine Load Balancing Algorithm.

4.2. MODIFIED SHORTEST JOB FIRST FOR LOAD BALANCING

To manage the load between different Virtual Machines (VMs) on Fog servers a new load balancing algorithm Modified Shortest Job First (MSJF) is proposed in this survey [6]. The performance of proposed algorithm is evaluated through different performance parameters. e.g. Processing Time (PT), Response Time (RT) and cost.

4.3. EFFECTIVE LOAD BALANCING STRATEGY (ELBS) FOR REAL-TIME FOG COMPUTING ENVIRONMENT USING FUZZY AND PROBABILISTIC NEURAL NETWORKS

Another paper [7] has presented an effective load balancing strategy for real-time fog computing environment using fuzzy and probabilistic neural networks. This paper has investigated a new Effective Load Balancing Strategy (ELBS) for FC environment, which is suitable for Healthcare applications. ELBS tries to achieve effective load balancing in Fog environment via real-time scheduling as well as caching algorithms. ELBS is composed of five modules namely: (i) Priority Assigning Strategy (PAS), (ii) Data Searching Algorithm (DSA), (iii) External Data Requesting Algorithm (EDRA), (iv) Server Requesting Algorithm (SRA), and (v) Probabilistic Neural Network based Matchmaking Algorithm (PMA). PAS assigns a priority to each incoming Process (P) by considering three predefined parameters, which are; Predefined Priority (PP), Deadline Time (DT), and Task Size (TS). All those parameters are the inputs to a fuzzy inference system to assign the process priority.

4.4. A HEURISTIC VIRTUAL MACHINE SCHEDULING METHOD FOR LOAD BALANCING

The survey [8] has examined a heuristic offloading method in fog-cloud computing. To be more specific, an offloading framework for deep learning edge services is built upon centralized unit (CU)-distributed unit (DU) architecture. Then, the appropriate offloading strategy has been acquired by the origin-destination ECN distance estimation and heuristic searching of the destination virtual machines for accommodating the offloaded computation tasks.

4.5. A TIME EFFICIENT THERSHOLD BASED ANT COLONY SYSTEM FOR CLOUD LOAD BALANCING

The article [9] has examined a time efficient threshold based ant colony system for cloud load balancing. A combination of two scheduling techniques, Ant Colony Optimization System coupled with Threshold implemented Load Balancer algorithm has been designed in the survey. The proposed Threshold based ACO system has been used to select a virtual machine. In this paper, it has been investigated whether work allocation to the selected virtual machine is less than threshold or not.

4.6. METAHEURISTIC-BASED VIRTUAL MACHINE TASK MIGRATION TECHNIQUE FOR LOAD BALANCING IN THE CLOUD

A metaheuristic-based virtual machine task migration technique for load balancing in the cloud [10] by using particle swarm optimization (PSO) technique achieves migration of overloaded VM. The excessive workload on some virtual machines (VM) in cloud computing environment is detected by the proposed method and the workload is given to other machines. Cost functions are designed to model the actual cost of performing task migration. The VM task migration technique utilizes an ineffective discriminate function to identify overloaded VM. In this paper, a new discriminate function has been designed to identify actual overloaded VM. A particle swarm optimization (PSO) technique is proposed to search for efficient task migration strategies.

4.7.FOG COMPUTING FOR ENERGY-AWARE LOAD BALANCING AND SCHEDULING IN SMART FACTORY

A quantitative energy-aware model is established on edge nodes and an optimization function aiming at the load balancing of manufacturing cluster is formulated [11]. Then, the improved particle swarm optimization algorithm is used to obtain an optimal solution.

4.8.EFFICIENT LOAD BALANCING ALGORITHM FOR TASK PREPROCESSING IN FOG COMPUTING ENVIRONMENT

The objective of this work [12] is to evenly distribute the load across the available fog nodes and reduce the response time of the task processing. The results have been verified that the response time has optimized to a large extent in which the proposed approach is offered.

4.9.INTEGRATION OF CLOUD-FOG BASED PLATFORM FOR LOAD BALANCING USING HYBRID GENETIC ALGORITHM USING BIN PACHING TECHNIQUE

In this survey [13], a multilayer framework has been used for resource allocation. In this model, genetic algorithms, round robin and Throttle has been used in load balancing for creating packing technique and allocating resources.

4.10.SECURE AND SUSTAINABLE LOAD BALANCING OF EDGE DATA CENTERS IN FOG COMPUTING

This article [14] has proposed a novel load balancing method for validating edge data centers and detecting lightly loaded data centers for work allocation. The results have shown that the method has increased load balancing efficiency in addition to establishing security by target data centers validation.

Table 2. A Comparative Analysis of Proposed Methods for Establishing Load Balancing in Fog Computing

Parameter	Year	Technique	Advantages	Disadvantages
Method [5]	2018	particle swarm optimization	response time improvement	low wait time
Method [6]	2018	modified shortest job first	processing time improvement, response time and cost	low work completion time
Method [7]	2019	fuzzy and probabilistic neural networks	deadline time and total work scale improvement	low response time
Method [8]	2018	heuristic virtual machine scheduling	total response time improvement	low operation rate
Method [9]	2018	ant colony	optimal resource allocation	low wait time
Method [10]	2019	particle swarm optimization algorithm	low cost	work completion time is not improved
Method [11]	2018	particle swarm optimization algorithm	total response time, data center service time	total work scale is not considered
Method [12]	2019	task preprocessing	low task processing response time	low work completion time
Method [13]	2018	using hybrid genetic algorithm using bin packing technique	optimal resource allocation	low operation power rate
Method [14]	2018	edge data centers validation	detecting lightly loaded data centers	low response time

Table 2 demonstrates a comparative analysis of proposed methods for establishing load balancing in fog computing environment.

5. CONCLUSION

Fog computing has developed rapidly as a modern technology which has been challenged several times. Load balancing is one of the significant challenges in fog computing. Several techniques have been proposed for load balancing so far which each of them are suitable for specific conditions. In this article, various recent techniques for load balancing have been evaluated, then advantages and disadvantages of these algorithms have been compared. Adequate information has been provided for researchers to be used in further studies for discovering solutions to problems in load balancing which have not been detected.

References

[1] Li, C., Zhuang, H., Wang, Q., & Zhou, X. (2018). Sslb: **Self-similarity-based load balancing for large-scale fog computing.** *Arabian Journal for Science and Engineering*, *43*(12), 7487-7498.

[2] Shooshtarian, L., Lan, D., &Taherkordi, A. (2019). **A Clustering-Based Approach to Efficient Resource Allocation in Fog Computing.** In *International Symposium on Pervasive Systems, Algorithms and Networks*, 207-224.

[3] Mouradian, C., Naboulsi, D., Yangui, S., Glitho, R. H., Morrow, M. J., &Polakos, P. A. (2017). **A comprehensive survey on fog computing: State-of-the-art and research challenges.** *IEEE Communications Surveys & Tutorials*, *20*(1), 416-464.

[4] Bukhsh, R., Javaid, N., Ali Khan, Z., Ishmanov, F., Afzal, M. K., &Wadud, Z. (2018). **Towards fast response, reduced processing and balanced load in fog-based data-driven smart grid.** *Energies*, *11*(12), 3345.

[5] Abbasi, S. H., Javaid, N., Ashraf, M. H., Mehmood, M., Naeem, M., &Rehman, M. (2018). **Load Stabilizing in Fog Computing Environment Using Load Balancing Algorithm.** In *International Conference on Broadband and Wireless Computing, Communication and Applications*, 737-750.

[6] Nazar, T., Javaid, N., Waheed, M., Fatima, A., Bano, H., & Ahmed, N. (2018). **Modified shortest job first for load balancing in cloud-fog computing.**In *International Conference on Broadband, Communication and Applications*, 63-76.

[7] Talaat, F. M., Ali, S. H., Saleh, A. I., & Ali, H. A. (2019). **Effective Load Balancing Strategy (ELBS) for Real-Time Fog Computing Environment Using Fuzzy and Probabilistic Neural Networks.** *Journal of Network and Systems Management*, 1-47.

[8] Xu, X., Liu, Q., Qi, L., Yuan, Y., Dou, W., & Liu, A. X. (2018). **A Heuristic Virtual Machine Scheduling Method for Load Balancing in Fog-Cloud Computing.**IEEE International Conference on High .

[14] Puthal, D., Obaidat, M. S., Nanda, P., Prasad, M., Mohanty, S. P., &Zomaya, A. Y. (2018). **Secure and sustainable load balancing of edge data centers in fog**

Performance and Smart Computing (HPSC) and IEEE International Conference on Intelligent Data and Security (IDS), 83-88.

[9] Banerjee, C., Roy, A., Roy, A., Saha, A., & De, A. K. (2018). **A Time Efficient Threshold Based Ant Colony System for Cloud Load Balancing.**In *International Conference on Computational Intelligence, Communications*, 206-219.

[10] Megharaj, G., &Kabadi, M. G. (2019). **Metaheuristic-Based Virtual Machine Task Migration Technique for Load Balancing in the Cloud.**In Integrated Intelligent Computing, Communication and Security, 435-446.

[11] Wan, J., Chen, B., Wang, S., Xia, M., Li, D., & Liu, C. (2018**). Fog computing for energy-aware load balancing and scheduling in smart factory.**IEEE Transactions on Industrial Informatics, 14(10), 4548-4556.

[12] Manju, A. B., &Sumathy, S. (2019). **Efficient Load Balancing Algorithm for Task Preprocessing in Fog Computing Environment.** In Smart Intelligent Computing and Applications, 291-298.

[13] Zubair, M., Javaid, N., Ismail, M., Zakria, M., Zaheer, M. A., &Saeed, F. (2018). **Integration of Cloud-Fog Based Platform for Load Balancing Using Hybrid Genetic Algorithm Using Bin Packing Technique.**In International Conference on P2P, Parallel, Grid, Cloud and Internet Computing, 279-292

computing. *IEEE Communications Magazine*, *56*(5), 60-65.