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Software Load Balancers in Cloud: An Analysis

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***Abstract*—**A load balancer is a software or hardware component that mediates between a client's requests and the servers in the cloud. It ensures the proper distribution of the resources to the client's requests by avoiding the situation of overutilization and underutilization of a server. Load balancer plays a very important role in the fair distribution of the requests to the servers which has a direct impact on the performance of the cloud. There are many free(limited) and opensource load balancers available in the market. This paper performs an analysis of various existing load balancers in the terms of performance, usage, and applications. In addition to that, a comparative analysis of these load balancers is also discussed.

***Index Terms*—**Load Balancer, Performance, Overutilization, Under Utilization.

I. INTRODUCTION

A Load Balancer acts as a mediator between the pool of servers and incoming client's requests and routes the requests to the available servers. By distributing the load efficiently, the load balancer ensures maximum utilization of the resources and also minimizes the execution time and waiting time. It also ensures that no server is overloaded or underloaded with the incoming requests. If one of the servers in not functioning properly, then the load balancer takes care of redirecting the load to another server which is in functioning state. And the incoming requests are also rerouted to the newly added servers in the cloud. The working of Load Balancer is represented in "Fig.1". A load balancer can be a virtual machine (VM) or a standalone server that efficiently manages the on growing incoming traffic. Load balancers can be of two types: software load balancer and hardware load balancer.

A. Hardware Load Balancer

It is a physical or hardware device that acts as a mediator between the client's requests and the servers. It is equipped with a separate operating system to distribute the network traffic to the resources. It also requires a separate set up for configuring, updating the license and also requires manual resources to maintain the balancer. It does the load balancing efficiently but it should be combined with another server like this in order to avoid the single point of failure, and provide high availability. All these makes this load balancer expensive to maintain. It cannot be scaled with the sudden spike of requests from clients.

B. Software Load Balancer

It is a software that can be installed directly on the servers or the VMs without any external hardware. This software is configured according to the needs of the servers. It is easy to maintain and update and requires no manual personnel. This load balancer also provides on demand scalability, and can be auto scaled in real time. It is less expensive and easier to maintain. Due to its ease, and flexibility the software balancers are used more now-a-days.

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The basic classification of the load balancers consists of two types: hardware, and software. This classification is represented in "Fig.2". This figure displays the basic two types of load balancers and a few examples of them.

II. SOFTWARE LOAD BALANCERS

Software load balancers reduce the amount of workload on a single server and also increases the overall performance. It is easy to install and also produces fast response due to concurrent transmissions of the requests to the servers. Various software load balancers are discussed and are comparative analyzed as follows:

A. NGINX Load Balancer

It is an open source load balancer which is used as a web server load balancer. It can perform load balancing, health check of the servers, and also monitors the activities. To use this load balancer, it needs to be installed first and configured. After configuration the load balancer is restarted and enabled. The modules required for this balancer are loaded dynamically. It also provides session persistence along with load balancing. The load balancing algorithms used in this balancer are roundrobin, ip hash, least connections. [7] [8] This balancer is compatible with windows, linux, mac-os. Many companies like Netflix, Starbucks, McDonalds use this load balancer.

B. HAProxy

It is an open-source software load balancer that focuses on the speed and performance of the load distribution. It performs load balancing, analysis and generates the reports for the sum of the requests, average request and response time, information about the abrupt end of any session, and also session stickiness. The load balancing algorithms used in this balancer are round-robin, least connection, source, and least pending requests. This load balancer can be integrated with other load balancers for layer7 load distribution. But it cannot support load distribution in a multi-datacenter and integration with other load balancers is expensive and more prone to error
[14].

C. Kemp Load Balancer

It is an open-source software load balancer that provides secure transmission of data over the network and also high availability. It performs the load balancing in layer4 as well as layer 7. It will run Linux/Unix-based platforms. This load balancer comes with pre-configured templates and a huge collection of libraries for applications that can be directly deployed on VMs, bare metal, or public clouds. The key features of this load balancer are the compression of data during the transmission, content caching for serving future requests, and high performance. It also ensures secure data delivery of the workloads, the network during the communication is monitored, and any illegitimate packet in the network is identified and eliminated from the network. The source of this illegitimate packet is blocked for further communication. The load balancing algorithms used in this load balancer are DNS round-robin and least connections [15].

D. Citrix ADC

It acts as a layer3 and layer7 load balancer. To use this software, it should be configured before use. It first configures VMs according to the required load balancing specifications. Then binds each application/service to separate VMs. When the client sends the request, this software acts as a virtual server, accepts the request, and sends it to the appropriate server based on the application requested. This load balancer initiates a separate connection to the server to route the incoming requests from client to server. It uses various types of IP addresses and also provides a monitor to check whether the request is routed to the appropriate server. The load balancing algorithms

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used in this balancer are round-robin, least connection, URL hash, Domain hash, etc., [16].

E. Loadbalancer.org

It is also one of the popular software load balancers that provide high availability and scalability. This load balancer can be used for both Layer4 and Layer 7. The configuration and maintenance of this load balancer are very easy. It provides many important features like security, SSL offloading, report generation, report monitoring, etc, . Security in this load balancer is provided by identifying and avoiding malicious requests and contents. The load balancing algorithms used in this load balancer are Direct routing, Network address translation, HAProxy, and SSL termination [17].

An overall comparison of the various above-mentioned load balancing algorithms is represented in Table 1. It includes various factors like features of the load balancer, algorithms used, companies using that load balancer, supporting operating systems, and also whether it is a layer 4 or layer 7 load balancer.

III. CONFIGURING SOFTWARE LOAD BALANCER

The software load balancer provides high availability, and performance by distributing the workload equally across the pool of resources. The configuration of the load balancer is done at the server end. The prerequisites for installing the software load balancer at server's end are given as follows:

- The load balancer and the server should be connected through the same LAN.
- An IP address must be available for the load balancer.
- The load balancer should be able to ping the servers to get the status.

After checking the required prerequisites, the load balancer software is installed/configured to manage the requests coming from the clients. The brief process of configuring the software load balancer is given in the following steps:

- A port number is allocated to the load balancer during the process of configuration. This port number is used for further communication purposes.
- To this configured port, servers are added.
- The configured servers are validated and checked for the availability status by sending a ping/request to the IP address of the server.
- Once everything is configured and checked for validation, a Virtual IP (VIP) is provided to the load balancing server that represents the actual server in the resource pool. This load balancer acts as a virtual server that accepts the request from the user and routes it to the appropriate server.

IV. RELATED WORKS

The software load balancers discussed so far give an efficient functionality in cloud domains. (Yu et al., 2017) [9] designed a software load balancer for fog and edge computing that is 4 to 10 times faster and consumes 50 percent less than the traditional load balancers. This load balancer used a minimal perfect hashing algorithm to distribute the tasks to the servers. It operates in both stateful and stateless modes. In stateful mode, every packet is assigned with an Id and the packet is hashed. In stateless mode, a random Id is given to the packet and it is hashed to provide a route to the packet. (Shi et al., n.d.) [10] proposed a stateful load balancing algorithm that improves the performance, throughput and also consumes less memory. This algorithm is applicable to both cloud and edge computing. The minimal perfect hashing algorithm is used for load balancing. This load balancer will have a virtual IP address (VIP) which is connected to the direct IP address DIP of the servers. It maintains an array to hold the incoming requests

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from the user and the same will be directed/connected to the DIP. However, this load balancer is not applicable to mobile devices. [11] Maglev is a google network load balancer that is reliable and fast. It is also cost-effective while processing a huge amount of requests. Session stickiness is provided in this balancer with the help of connection tracking and Maglev hashing. (Poddar et al., 2015) [12] introduced a load balancer called Haven that uses the best capabilities of both software and hardware load balancers. It provides high performance like hardware load balancer and provides autoscaling like a software load balancer. Haven can be easily implemented and used in multi-tenant clouds. In the multi-tenant scenario, the status of the resource usage along with auto-scaling algorithms is considered for load balancing. It uses the terms and functionality of a software load balancer and performs as a hardware load balancer. When the hardware and software load balancers are compared, software load balancers suffer from high latency and low capacity which in turn results in performance degradation. To overcome that (Gandhi et al., 2015) [13] introduces a hybrid load balancer by deploying the load balancers in the switch. These commodity switches will have spare resources that support the programming capability. This allows the load balancer to function efficiently with less latency and high performance. The proposed model is able to improve the functionality of the load balancer 10 times faster than the traditional load balancers.

V. CONCLUSION

Many organizations are looking forward to using a software load balancer for the load distribution as it is easy to configure, maintain, and also does effective load distribution. Few software load balancers that are already in use have been discussed. The main focus of this paper is to analyze the software load balancers that are used currently and widely in the present day and also to find out the load balancing algorithms used for the same. The effectiveness of the load balancer mainly depends on the load balancing algorithm used. Almost all the software load balancers are using round-robin, least connections algorithms for the effective distribution of the load. As future research, an empirical study can be conducted on these load balancing algorithms to compare the effectiveness and impact of each algorithm on the load balancing.

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TABLE I
COMPARISION OF VARIOUS SOFTWARE LOAD BALANCERS

Balancer	Features	Load Balancing Algorithms	Supporting OS	Companies Using	Layer 4	Layer 7
NGINX	Healthchecks,Acti Monitoring	Round-robin, IP hash, Least weighted connnections	Windows, Linux, Mac-OS	Netflix, StarBucks, McDonalds [3]	Yes	Yes
HAProxy	Session Stickyness, Generation and summarization of reports, Information about abrupt session	Round-robin, Least connections, Source , Least pending	Linux	JPMorgan, Salesforce, Tableau [4]	Yes	Yes
Kemp Loadbalancer	Security, Availability, Preconfigured templates, Huge collection of Libraries, Data compression	DNS round-robin, Least connections	Linux, Unix	Square one, Intellinet, Federal emergency management Agency [5]	Yes	Yes
Citrix ADC	Routes data packets to the servers, Establishes connection to the server	Round-robin, Least Connections, URL Hash, Domain Hash	-	Genpact, Walgreens, Standard Bank Group [6]	No	Yes
Load balancer.org	Security, SSL offloading, Reportgenerationa Monitoring	NAT,SSLTermina Direct Routing	-	-	Yes	Yes

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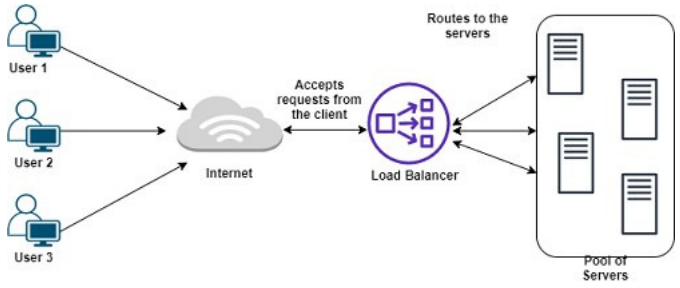

Fig. 1. Working of Load Balancer [1]

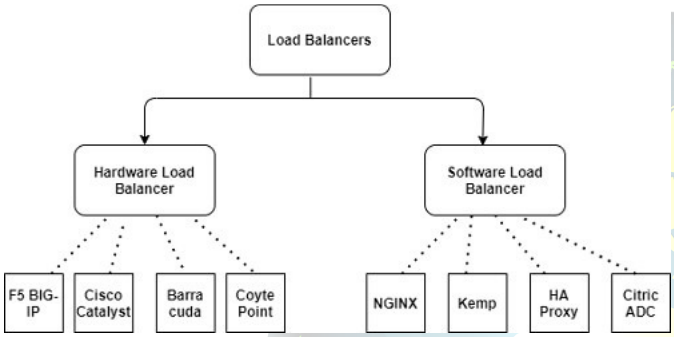

Fig. 2. Types of Load Balancers [2]