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Load Balancing Techniques for Server Clustering in Cloud Environment: Systematic Literature Review

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Abstract
The rapid development of cloud computing has a significant impact on increasing the workload on resources, which is often excessive and a major challenge in computing environments. Load balancing is key to avoid overloading or underloading virtual machines, given the high user demand for service availability. There are several types of load balancing techniques, and this diversity poses its own challenges in selecting the optimal technique to address workload issues. This research presents a systematic literature review with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to identify various load balancing techniques for server clustering in a cloud computing environment. The purpose of this research is to review previous research on load balancing techniques for server clustering in cloud computing by categorizing based on problems, solutions, research methods, objects, and research results. Research that uses the experimental method will be reviewed again to categorize the research results based on the load balancing matrix, namely response time, make span, resource utilization, migration time, fault tolerance, throughput, and cost. Various publishers, such as IEEE, Elsevier, Springer, Wiley, MDPI and Hindawi were explored as data sources. The research conducted generates more information about load balancing techniques for clustering servers in cloud computing and allows other researchers to fill the current research gap.
Keywords: Cloud Computing; Clustering Server; Load Balancing; Systematic Literature Review

Introduction
Cloud Computing is a fast-growing internet technology in the advancement of communication technology that provides services for customers with various needs by using computing resources available online (Afzal & Kavitha, 2019). One of the challenges in a cloud environment is the issue of Load Balancing (LB). LB deals with load distribution across different elements of the system, such as servers, network links, disks, and CPUs. The goal is to maximize system throughput, resource usage, and device performance. LB algorithms in cloud systems are used for efficient use of resources (Shahid et al., 2020).

There are various load balancing methods that are often used to improve Cloud Computing (CC) performance. These methods can be grouped into three main types based on their basic characteristics: static, dynamic, and nature-inspired methods (Shafiq et al., 2022). Each load balancing method has advantages and disadvantages that can be measured by load balancing parameters. It is important to know, what method should be used when implementing load balancing on server clustering.

This research presents a systematic literature review that aims to identify various existing load balancing techniques and categorize them based on problems, solutions, research methods, objects, and research results. Research that uses experimental methods will be reviewed to evaluate their effectiveness based on the load balancing performance matrix, namely response time, make span, resource utilization, migration time, fault tolerance, throughput, and cost. The results of this systematic literature review can be used to fill in the gaps of current research.

Literature Review
In the world of cloud computing, load balancing is a crucial issue that requires spreading the workload evenly across all nodes to maximize resource utilization. One emerging solution is server clustering that integrates multiple servers as a single hosting entity with uniform IP addresses and hostnames, increasing system security. In general, the concept of cloud computing provides computing resource services over the internet, such as infrastructure and storage.

Research (Panwar et al., 2022) developed an OpenFlow-based cluster server, which is the most common SDN (Software-Defined Networking) protocol. The researchers proposed a new load balancing algorithm, called dynamic weighted random selection (DWRS), which considers server load in real-time when dispatching requests to servers. They also improved system performance by modifying the packet handling flow in the Floodlight controller, which is an open source SDN platform. They used multi-threaded techniques to utilize the parallel processing capabilities of multiple cores, which accelerated the processing of packet-in messages when selecting a destination server. Experimental results show that DWRS with multi-threaded implementation outperforms other policies, especially in heterogeneous environments.

Another study (Ahmad & Khan, 2018) performed traffic classification for efficient load balancing in server clusters using deep learning techniques. The researchers used load balancing metric parameters (reaction time, fault tolerance, scalability, throughput, etc.) to evaluate the performance of existing techniques for comparison. They also discussed cloud virtualization and its types for optimal resource utilization. They proposed a deep learning classification model based on the characteristics of incoming traffic and server status, which is strengthened by extended labeling using a correlation-based approach. The experimental results of the proposed classification model show significant performance improvement in terms of classification size and request waiting time compared to existing machine learning models.

Research (Chakrabarti et al., 2020) on load balancing techniques implemented in cloud data centers classifies load balancing techniques into three categories: static, dynamic, and adaptive. The researchers presented several evaluation metrics to measure the performance of load balancing techniques, such as response time, throughput, overhead, and resource utility. They suggest that adaptive load balancing techniques are more suitable for heterogeneous and dynamic cloud environments.

Gabi et al., (2015) provide a comprehensive exploration of load balancing metrics in cloud computing. The research covers crucial parameters such as Response Time, Performance, Resource Utilization, Throughput, Overhead Cost, Scalability, Fault Tolerance, and Migration Time. These metrics collectively contribute to the evaluation of system efficiency during load balancing implementation. The study emphasizes the importance of minimizing waiting times, optimizing resource utilization, and achieving high throughput for improved system performance. Additionally, it underscores the significance of fault tolerance and scalability in maintaining effective load balancing, even in dynamic and challenging cloud environments. The comprehensive examination of these metrics offers valuable insights for understanding and enhancing load balancing practices in cloud computing systems.

Furthermore, a study (Chinedu et al., 2022) on hybrid load balancing algorithms in cloud computing environments explains that hybrid methods inherit the properties of both static and dynamic load balancing techniques and attempt to overcome the limitations of both algorithms. The researchers studied various hybrid load balancing algorithms in cloud computing environments and compared their performance using several parameters, such as execution time, throughput, and computational cost. They found that the most efficient hybrid load balancing algorithms are Genetic Algorithm and Ant Colony Optimization.

Materials & Methods

The method to be used is a literature study using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, repeatability, and scientific rigor. The stages carried out in this study are developing a review protocol, explaining article selection criteria, search strategies, data extraction, and data analysis procedures (Georgopoulos et al., 2023).

Eligibility Criteria

Screen the literature found based on the specified inclusion criteria, namely:
IC1: The year of the article used is only the last 5 years, namely 2019-2023.
IC2: The relevance of the article topic used is Load Balancing on Cloud Computing.
IC3: Articles used must use English.

Data Sources

The literature used in this research was obtained from various scientific databases, such as IEEE, Elsevier, Springer, Wiley. MDPI and Hindawi Articles that could not be accessed by the author were eliminated. Search results using predetermined keywords resulted in more than twelve thousand articles. Next, articles that did not meet the inclusion criteria were eliminated. Finally, the top 30 articles were selected for further review.

Study Selection

The articles collected through this research were screened through a series of selection stages. First, a systematic literature search was conducted using relevant keywords, such as "load balancing", "server clustering", and "cloud environment". After that, an exploration and selection stage of article titles, abstracts, and keywords was conducted with reference to the predetermined eligibility criteria. The identified articles were then read in whole or in part to determine whether they were eligible for inclusion in the review, according to the eligibility criteria established in the previous stage. Finally, the reference lists of the articles were also reviewed to look for related studies that could complement this literature review. Thus, the article selection process was systematic and structured to ensure the inclusion of only relevant and high-quality articles in this literature review.

Data Analysis

Extracting data from the 30 selected literatures, by categorizing them based on problems, solutions, research methods,

objects, and research results. Then the results will be visualized with diagrams made with the help of excel tools. Comparative analysis is also conducted on articles that use experimental methods for their research.

Results and Discussion

With a literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method has provided various important findings around Load Balancing techniques or algorithms in Server Clustering in Cloud Environment. Researchers conducted a systematic review of the literature to compare various Load Balancing algorithms used to distribute workloads or tasks evenly among available resources, such as servers or virtual machines. More than 60,000 papers were found through the search. Then 30 papers that fit the inclusion criteria and were included in the final evaluation were selected for full-text analysis after removing duplicates and filtering titles and abstracts.

Based on the Research Problem

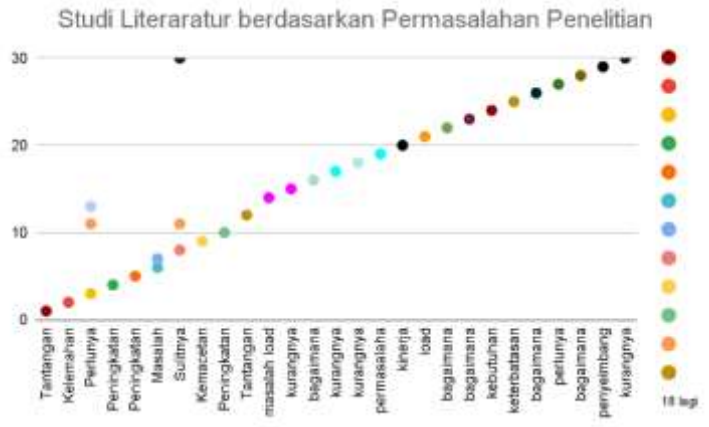

Figure 1. Literature Study based on Research Problems

Of the 30 papers, there are two main types of paper problems that appear significantly. The first three papers emphasize the urgency of the need for an effective Load Balancing strategy to improve cloud services along with the rapid technological developments in the cloud environment. These papers highlight the importance of adopting an appropriate Load Balancing strategy to ensure optimal service availability amid rapid changes in cloud technology.

On the other hand, there are three other papers that illustrate the difficulty in maintaining load balance among resources due to heterogeneous distribution. These papers highlight the challenges faced in achieving even load distribution in cloud environments that have a non-uniform variety of resources. They emphasize how factors such as differences in capabilities or characteristics between resources can become obstacles in creating an effective Load Balancing strategy.

Based on the Research Solution

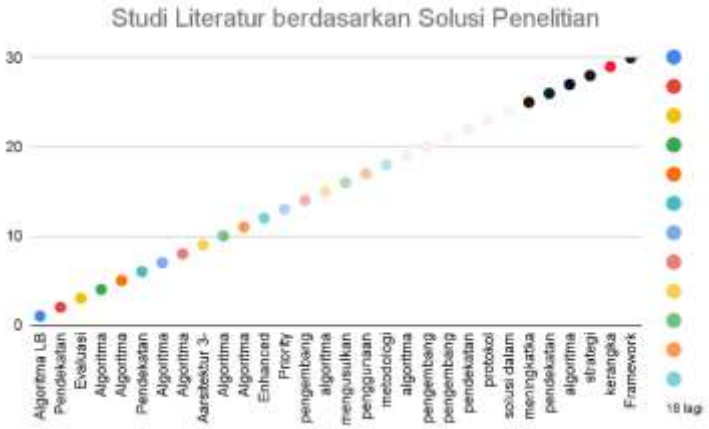

Figure 2. Literature Study based on Research Solutions

In 30 papers focusing on diverse research solutions related to Load Balancing in cloud environments, various innovative approaches have been proposed. Most of these studies explored the use of various algorithms, ranging from classical algorithms such as Particle Swarm Optimization (PSO), Round Robin (RR), and hybrid strategies to more recent approaches such as Inspired Lion Optimization Algorithm (ILOA), Adaptive Dragonfly Algorithm (ADA), and Enhanced

Firefly Algorithm. Some studies focus more on specific strategies, such as proactive fault tolerance algorithms that aim to improve reliability by tolerating virtual machine CPU faults. In addition, there are studies that highlight the use of bio-inspired technologies, such as approaches that integrate osmotic behavior with metaheuristic techniques, as well as fuzzy-based algorithms to improve resource scheduling efficiency in cloud computing environments. Other solutions include the development of intelligent load balancers capable of recognizing technical characteristics to improve performance, decentralized approaches for IoT service deployment, and dedicated routing protocols for IoT networks. There are also efforts in improving network performance through the use of efficient Load Balancing techniques in Software-Defined Networking (SDN) as well as a stochastic congestion game approach for coordinatorless multi-cloudlet edge computing systems. In addition, there is research that proposes a fault tolerance framework in Load Balancing and an intermediate node-based task allocation strategy for load balancing in edge computing. All in all, the development of these solutions paves the way for innovation in addressing the increasingly complex challenges of Load Balancing in cloud computing environments.

Based on Research Methodology

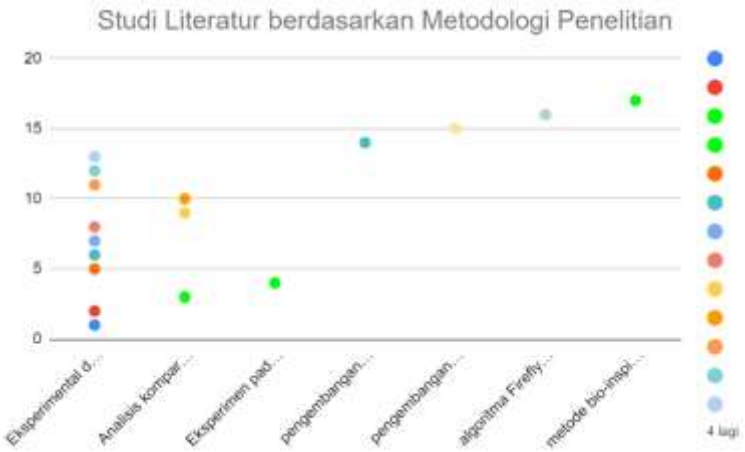

Figure 3. Literature Study based on Research Methodology

Of the 30 papers, there are 9 papers that focus on experiments with simulation using CloudSim and comparative analysis as the main research methodology. This simulation involving CloudSim involves structured steps. First, through the use of the CloudSim simulation framework, the cloud environment is virtually replicated to facilitate the experiment. Within this simulation, various load balancing techniques, such as Round Robin or other specialized algorithms, are implemented to distribute the workload among the available resources, such as servers and virtual machines. During the simulation process, data covering system performance parameters, such as response time, resource utilization, throughput, and other metrics, are collected in detail for each load balancing technique tested. After the simulation was completed, a comparative analysis was performed on the collected data. This analysis allows comparison of the effectiveness and relative performance of the various load balancing techniques tested, considering aspects such as efficiency, scalability, resource usage, and reliability. The experimental approach with CloudSim simulations allows researchers to test a number of techniques without the need for actual physical infrastructure, providing the ability for repeatable experiments with more controllable costs and obtaining more reliable results.

Based on the Object of Research

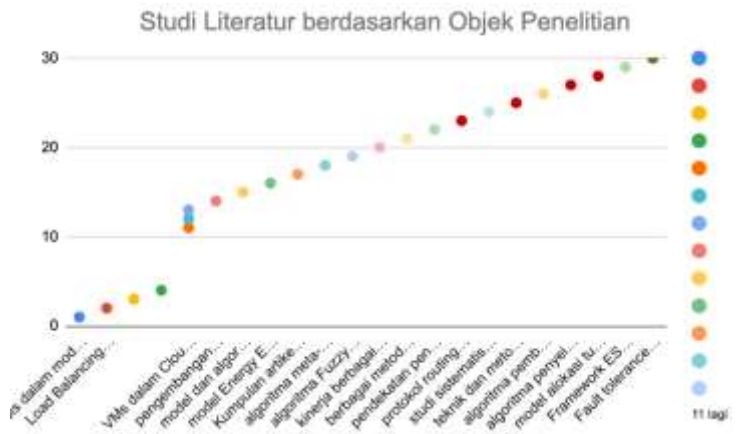

Figure 4. Literature Study by Research Object

In the literature collection, four papers specifically expanded on research related to task scheduling on demand for resource utilization. These papers discuss the same object and highlight the metrics of response time, makespan, and resource utilization. It directly focuses on the effectiveness of the object.

Based on Research Results

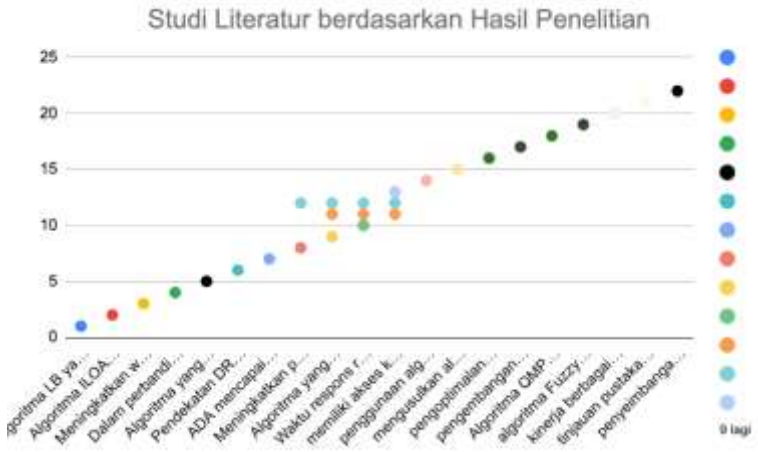

Figure 5. Literature Study based on Research Results

Research papers have good results on resource utilization which is a very good result to improve the performance of load balancing techniques. and some papers also focus on response time, and others.

Comparative Analysis based on Load Balancing Metrics

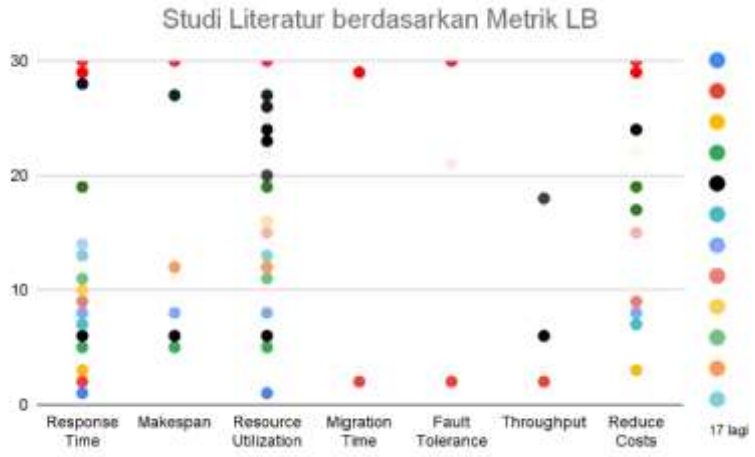

Figure 6. Comparative Analysis by Load Balancing Metrics

In the 30 papers related to load balancing in the cloud environment reviewed, there are 17 papers, prioritizing the use of resource utilization metrics as the main focus in performance analysis. These papers consistently use metrics such as CPU utilization, memory utilization, network utilization, and storage utilization to evaluate the effectiveness of the proposed load balancing strategy. By relying on these metrics, these studies emphasize the importance of balanced workload allocation to ensure resources in the cloud environment are optimally utilized, prevent overloading of key components, and maintain stable system performance. These resource utilization metrics provide a strong foundation for researchers to assess the reliability and efficiency of their proposed load balancing strategies in the context of cloud environments.

Conclusions

In a literature review using the PRISMA method, the research identified the importance of effective Load Balancing techniques in optimizing cloud services in line with technological developments. Two main issues were found: the emphasis on the need for strategies that match technological developments and the difficulty in maintaining load balance on heterogeneous resources. More than 15 innovative approaches are proposed, including various Load Balancing algorithms and specialized strategies. Nine of the 30 papers focus on experiments with simulations using CloudSim, enabling the analysis of the effectiveness of Load Balancing techniques in a cost-controlled manner. Several studies

expanded the focus on task scheduling, highlighting performance improvements, especially in resource utilization. Resource utilization is the main focus in more than 15 papers, with metrics such as CPU utilization and storage utilization used to evaluate the effectiveness of Load Balancing strategies. Overall, this literature provides a comprehensive insight into the problems and solutions in the domain of Load Balancing in cloud computing, and evaluates the load balancing techniques used based on load balancing metrics.

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