Increasing scalability and resource utilization in Cloud Computing with load management via Docker

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Abstract

This research aims to study and develop an approach to **increase scalability** and **resource utilization** within cloud computing systems by implementing **Docker** for **load management**. The study will focus on analyzing the efficacy of **Containerization** techniques for application isolation and the utilization of robust load balancing mechanisms to ensure optimal consumption of cloud resources . The methodology includes practical testing in a simulated environment to compare the performance of Docker-based load management against traditional approaches. The expected outcome is the derivation of a concrete framework and best practices guidelines that enable cloud service providers and users to significantly enhance operational efficiency and reduce costs. The findings reveal that the **Containerization** management techniques developed in this study significantly reduce system vulnerabilities, enhance data security, and improve the efficiency of server administration. These outcomes contribute positively to supporting digital learning initiatives within the university.

The research involved a diverse group of respondents who completed a satisfaction assessment questionnaire. This group included 1,600 university students from Rajabhat University Suan Sunandha during the first semester of the academic year 2023, along with 25 staff members from the General Education Office. Most participants were students, constituting 98.46% of the total respondents, while staff members comprised 1.54%. Satisfaction Assessment: The study assessed user satisfaction with various aspects of the cloud-based question and answer repository technology. The evaluation criteria covered essential factors related to system performance, usability, and service provision. The results, as presented in Table 2, demonstrated consistently high levels of satisfaction across all evaluated criteria. The average scores ranged from 4.44 to 4.68, with standard deviations of 0.47 to 0.50. Overall, the users expressed "Very Satisfied" levels of satisfaction, with an impressive overall satisfaction score of 4.52.

Keywords: Docker, Load management

1. Introduction

Suan Sunandha Rajabhat University (SSRU), Thailand, is a public university located in the downtown area of Bangkok, the capital city of Thailand. The university, originally a palace about one hundred years ago, is not only an academic institution but also an archaeological site and an attraction in its own right. Each year, SSRU's main campus in Bangkok attracts numerous visitors and students alike (Chopvitayakun S.,2019).

A primary requirement is the efficient management of fluctuating workloads, which presents a significant challenge in maximizing both scalability and resource utility. **Docker**, as a containerization platform, has gained substantial popularity due to its capability to create

lightweight, portable, and rapidly deployable application environments. This technology is essential for modern education, offering flexibility, improved resource management, and fostering a collaborative learning environment. (Chanhom, C. et al., 2024).

The General Education and e-Learning Innovation Office at Suan Sunandha Rajabhat University faces the challenge of managing its server infrastructure to support the growing demand for digital learning and online services. Traditional server management methods often lack the security and flexibility required to address these needs effectively. This underscores the necessity of adopting advanced tools and techniques, such as SSH, to enhance server accessibility while maintaining robust security standards (Kaewsaiha, C & Kaewsaiha, P, 2020).

This research is driven by the necessity to integrate Docker technology with cloud load management strategies to address issues of improper resource allocation (underutilization or over-provisioning). These problems directly impact system performance and operational costs. The core objective is to propose a load management method that allows cloud systems to flexibly scale application services based on the actual, dynamic demands of users. this research aims to empower IT personnel to improve the efficiency and security of server operations, ultimately contributing to the university's mission of delivering high-quality digital education (International College, Suan Sunandha Rajabhat University, 2018).

2. Research Objectives

This research study was aimed:

1) To study and analyze the fundamental principles of **Docker Containerization** and **Load Management** within the context of cloud computing.
2) To develop and propose effective mechanisms for SSH-based load management that enhance the scalability and resource utilization of cloud infrastructure.
3) To evaluate the **efficiency** and **effectiveness** of the developed mechanisms under various load scenarios (e.g., peak load, continuous varying load).
4) To establish a practical manual or guideline for the implementation of **Docker-based Load Management** in real-world cloud environments.

3. Conceptual Framework

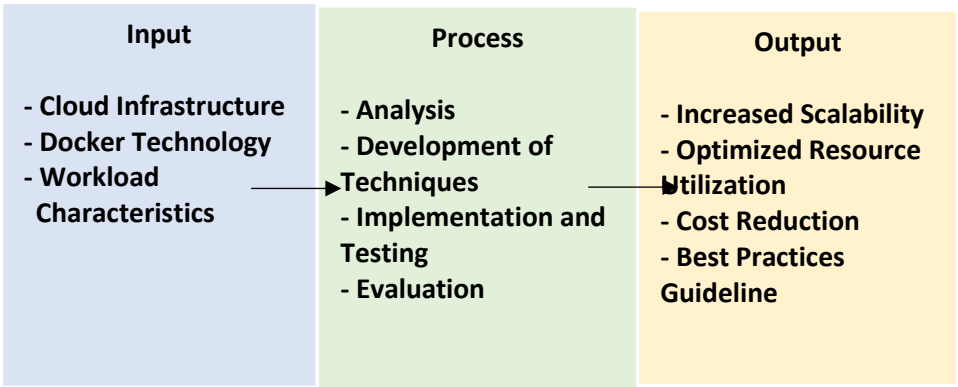

Figure 1. Conceptual Framework of the Study

1) The conceptual framework illustrated in Figure 1. focuses on **Docker Containerization** and **Load Management** within the context of cloud computing. The framework is structured into three key components: **Input**, **Process**, and **Output**, as outlined below:

Input

Cloud Infrastructure: Existing cloud systems (e.g., VMs, bare metal servers).

Docker Technology: Docker platform and associated tools (e.g., Docker Compose, Swarm, Kubernetes).

Workload Characteristics: The nature of fluctuating load and traffic patterns.

Process

Analysis: Analyzing current limitations in scalability and resource utilization.

Development of Techniques: Developing Docker-based auto-scaling and load distribution mechanisms.

Implementation and Testing: Apply the proposed techniques in a controlled environment to assess efficiency, scalability, and security.

Training and Documentation: Deploying the mechanisms in a controlled test environment and testing performance under varying loads.

Evaluation: Evaluating performance by comparing key metrics with baseline methods.

Output

Increased Scalability: A system capable of scaling resources more effectively.

Optimized Resource Utilization: Maximized and appropriate use of computing resources.

Cost Reduction: Lowering the operational expenditure of the cloud system.

Best Practices Guideline: A practical guide for implementing Docker-based load management.

The conceptual framework emphasizes focuses on **Docker Containerization** and **Load Management** within the context of cloud computing.

4. Methodology

The study employs a rigorous, multi-stage methodology to evaluate containerized load management. It begins with the **Environment Setup** of a cloud infrastructure utilizing Docker Engine and a Container Orchestration tool (e.g., Kubernetes or Docker Swarm). Subsequently, the **Load Management Development** phase involves packaging application services into Docker Containers and implementing a specific load balancing policy. **System Testing** is then conducted by simulating varying workloads and rapid load spikes to assess the scaling capabilities. Throughout testing, **Data Collection** focuses on key metrics, including resource utilization (CPU/RAM) and Response Time. Finally, **Statistical Analysis** is performed to compare the performance of the proposed Docker-based system against traditional methods, substantiating the efficacy of the techniques.

5. Result

The study, titled " Increasing scalability and resource utilization in Cloud Computing with load management via Docker " yielded several noteworthy results.

Satisfaction evaluation

The research involved a diverse group of respondents who completed a satisfaction assessment questionnaire. This group included 1,600 university students from Rajabhat University Suan Sunandha during the first semester of the academic year 2023, along with 25 staff members from the General Education Office. Most participants were students, constituting 98.46% of the total respondents, while staff members comprised 1.54%. Satisfaction Assessment: The study assessed user satisfaction with various aspects of the cloud-based question and answer repository technology. The evaluation criteria covered essential factors related to system performance, usability, and service provision. The results, as presented in Table 2, demonstrated consistently high levels of satisfaction across all evaluated criteria. The average scores ranged from 4.44 to 4.68, with standard deviations of 0.47 to 0.50. Overall, the users expressed "Very Satisfied" levels of satisfaction, with an impressive overall satisfaction score of 4.52.

These findings highlight the success and effectiveness of Increasing scalability and resource utilization in Cloud Computing with load management via Docker for managing computer servers, emphasizing their efficiency, reliability, user-friendliness, and the high level of service provided by both the system and staff members. The research outcomes have been actively utilized to Increasing scalability and resource utilization in Cloud Computing with load management via Docker for managing computer servers for the General Education Office. These improvements aim to facilitate convenient and efficient information retrieval for users. Impact of Workflow Changes: The research has brought about notable changes in workflow processes. Students have gained the ability to independently search for information, streamlining the information retrieval process. Additionally, it has provided clear and unified directions for General Education Office staff, leading to a reduction in errors related to information responses and an overall enhancement in work efficiency. Challenges encountered during the research implementation, such as data accuracy and the approval process, were acknowledged and addressed. The reliance on data from the Educational Services department necessitated careful consideration and approval from departmental heads and deputy directors to ensure the accuracy and completeness of information, ultimately facilitating swift and efficient use by students.

Table 1 Participants

Category	Number	Percentage
Student	1,600	98.46
Staff	25	1.54
Total	**1,625**	**100**

Table 2 Satisfaction results

Evaluation Criteria	Satisfaction Level	Average Score	Standard Deviation
1. System efficiency, modernity, and reliability	4.57	0.50	Very Satisfied
2. Stability, security, and accessibility of the system	4.49	0.50	Very Satisfied
3. Currency of data in the system	4.52	0.50	Very Satisfied
4. User-friendliness of the system	4.52	0.50	Very Satisfied
5. Benefits derived from the system	4.44	0.50	Very Satisfied
6. Accuracy and speed of service provision	4.51	0.50	Very Satisfied
7. Clarity and promptness of guidance for system use	4.48	0.50	Very Satisfied
8. Convenience of system use	4.46	0.50	Very Satisfied
9. Accuracy and speed of service provision by staff	4.56	0.50	Very Satisfied
10. Knowledge and ability of staff to provide system services	4.68	0.47	Very Satisfied
Overall Satisfaction	**4.52**	**0.50**	**(Very Satisfied)**

6. Conclusion

This research is anticipated to provide valuable insights into leveraging Docker for enhanced cloud load management. The findings will significantly benefit the development of future cloud computing technologies by promoting systems that are both highly scalable and highly efficient to enhance the operational efficiency of the General Education Department. The researchers successfully implemented and tested the system among 1,600 students and 25 staff members during the first semester of the academic year 2025.

The results indicated a high level of satisfaction among both students and staff, with an overall satisfaction score of 4.52. This suggests that Increasing scalability and resource utilization in Cloud Computing with load management via Docker for managing computer servers of The Office of General Education and Innovative Electronic Learning Suan Sunandha Rajabhat University significantly contributed to the improvement of operational efficiency within the General Education Department.

The implementation of the system led to streamlined question management for students and facilitated convenient use for both students and staff. The collaboration and knowledge exchange fostered by the system resulted in a sense of unity among different departments, promoting a cooperative learning environment.

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