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Laravel, Lumen, Guzzle, Leaf, Slim REST API Performance Evaluation Using ANOVA

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ABSTRACT

The rapid advancement of technology has increased the importance of selecting the right framework for RESTful API development. This study compares the performance of five popular PHP frameworks—Laravel, Lumen, Guzzle, Leaf, and Slim—in terms of response time, CPU usage, memory usage, throughput, and error rate. Using Apache JMeter as the testing tool, load testing was conducted across various endpoints with simulated virtual users (up to 75 users). The methodology involved designing a RESTful API with a PostgreSQL database, implementing it using the five frameworks, and performing load tests to measure the defined performance parameters. Statistical analysis using One-Way ANOVA was conducted to determine significant performance differences among the frameworks. The results indicate that each framework has distinct strengths and weaknesses under specific conditions. Frameworks like Lumen and Guzzle demonstrated superior performance in terms of response time and CPU usage, while Slim performed better with higher throughput under certain scenarios. These findings provide critical insights for developers and decision-makers in selecting the most efficient framework based on project requirements.

Keyword: RESTful API, PHP frameworks, performance analysis, load testing, Apache JMeter, One-Way ANOVA.

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1. INTRODUCTION

The rapid development of technology has many benefits for society in various fields. In the industrial sector, technological advances can help companies increase production [1]. Internet users in Indonesia are approximately 73.7% of the total population, this figure is the result of a survey conducted by APJII (Association of Indonesian Internet Service Providers) for the 2019-2020 period [2]. Web services as an evolution and collaboration of various technologies in the past that were created to overcome various obstacles in their predecessor technologies, web services can provide benefits for software developers in designing and creating a system so that it can interact between one system and another. Web service is a software that will bridge data traffic between systems by providing services that can be used by new systems. In addition, web services are also not affected by differences in the types of devices used [3].

Representational State Transfer (REST) is an architecture of communication methods that use the HTTP protocol for data exchange where this method is often applied in application development. RESTful is one of the API architectures that is quite popular. In making the RESTful API, there are many programming languages and frameworks that can be used [4]. The choice of technology in the development of the RESTful API is very important because it can affect performance on the server both in response time, CPU usage and memory usage. Therefore, in

developing the RESTful API, it is necessary to choose the right programming language and framework so that the RESTful API server can handle requests from clients properly [5]. The choice of technology in the development of RESTful API is very important because it can affect the performance of the server both in response time, CPU usage and memory usage. Therefore, in developing the RESTful API, it is necessary to choose the right programming language and framework so that the RESTful API server can handle requests from clients properly [5].

Framework is a collection of commands that are united in classes and functions with different functions with the aim of helping developers in calling without having to retype because the program syntax used is the same so that it can save time [6]. Framework is a library of a group of modules or program components that are organized and structured so that they become a unit that can help in building a web-based application. One of the factors that many people use frameworks in designing a website is because of their ease of operation. [7]. Laravel, Lumen, Guzzle, Leaf, and Slim are some PHP frameworks that are widely used to build web-based applications and RESTful APIs. Each framework has different characteristics and features, which can affect the performance of applications developed using the framework. There are several reasons why performance comparisons between Laravel, Lumen, Guzzle, Leaf, and slim frame works are important, especially in the context of RESTful API development, including the following.

Aspects of Choosing the Right Framework, in software development, choosing the right framework is very important. Performance comparisons help developers and project owners to understand the extent to which each framework can meet their project-specific needs. RESTful API Performance Optimization Aspects, especially in the context of RESTful APIs, good performance is essential to maintain a smooth user experience. Conducting a performance comparison between frameworks helps identify the most efficient framework in handling API requests and responses. The purpose of this research is to conduct a performance comparison analysis between several popular PHP frameworks, namely Laravel, Lumen, Guzzle, Leaf, and Slim, specifically in the context of RESTful API development. Apache JMeter was chosen as a performance testing tool to measure the extent of each framework's ability to handle certain workloads and provide fast responses.

This performance analysis is expected to provide deep insight into the strengths and weaknesses of each framework, so that developers and project owners can make better decisions in choosing the framework that best suits their project needs, especially in the context of RESTful API development with Apache JMeter as a performance testing tool. Therefore, the author proposes research with the title “ANALYSIS OF PERFORMANCE COMPARISON OF LARAVEL, LUMEN, GUZZLE, LEAF AND SLIM FRAMEWORK ON REST API USING ONE WAY ANOVA”.

2. METHODS

This study employs a quantitative experimental approach to compare the performance of five PHP frameworks (Laravel, Lumen, Guzzle, Slim, and Leaf) in REST API development. Data is collected through load testing using Apache JMeter, simulating 25, 50, 75 virtual users (VUs) across four API endpoints (Create Employee, Average Salary by Position, Get Employee Attendance, and Employee Overtime Record). Hardware/software configurations are standardized (PHP 8.1, PostgreSQL 14.8), and resource metrics (response time, throughput, CPU/RAM usage, error rate) are recorded via the PerfMon plugin. Statistical analysis applies one-way ANOVA ($\alpha = 0.05$) with post-hoc Tukey HSD tests to identify significant differences, following methodologies from prior studies on web service performance [5] and load testing frameworks [9]. The experimental design aligns with best practices for API performance evaluation [9], ensuring reproducibility and scientific rigor.

3. RESULTS AND DISCUSSION

Researchers will create a Rest API application from the Public Database, the data records used are dummy data. The data has a sql (Structured Query Language) format. After the data is obtained, then create a Rest API script with php along with 5 frameworks that will be used to configure the database and migrate data from the PostgreSQL database. Next, create endpoints from each database that will be tested.

3.1 One Way Anova Test Results

3.1.1 Response Time

Descriptives

response time mac

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
laravel	15	19808.60	5717.147	1476.161	16642.55	22974.65	12386	28045
lumen	15	17201.47	4296.019	1109.227	14822.41	19580.52	11349	22201
guzzle	15	11125.27	2425.095	626.157	9782.29	12468.24	7869	14638
slim	15	11953.33	2678.715	691.641	10469.91	13436.76	8325	15032
leaf	15	26739.93	7888.830	2036.887	22371.24	31108.62	16716	38247
Total	75	17365.72	7535.197	870.090	15632.03	19099.41	7869	38247

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
response time mac	Based on Mean	8.462	4	70	<.001
	Based on Median	6.632	4	70	<.001
	Based on Median and with adjusted df	6.632	4	46.140	<.001
	Based on trimmed mean	8.640	4	70	<.001

ANOVA

response time mac

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2431615570.587	4	607903892.647	24.041	<.001
Within Groups	1770045082.533	70	25286358.322		
Total	4201660653.120	74			

Robust Tests of Equality of Means

response time mac

	Statistic[a]	df1	df2	Sig.
Welch	21.486	4	33.819	<.001

a. Asymptotically F distributed.

Figure 1 Result Anova One Way Response Time New Employee Mac

In the figure 1, the One-Way Anova test results show significant differences in response time between frameworks (Laravel, Lumen, Guzzle, Slim, Leaf). Laravel Framework has the highest average (19,808.60 ms), while Guzzle Framework has the lowest average (11,125.27 ms). ANOVA test ($F=24.041$, $p<0.001$) and Welch Test ($p<0.001$) confirmed significant differences, although the variance between groups was not homogeneous.

3.1.2 Throughput

Descriptives

throughput mac

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
laravel	15	.45727	.117874	.030435	.39199	.52254	.069	.569
lumen	15	.52327	.062224	.016066	.48881	.55772	.459	.614
guzzle	15	.72747	.073417	.018956	.68681	.76812	.627	.833
slim	15	.68353	.076392	.019724	.64123	.72584	.591	.788
leaf	15	.37340	.065814	.016993	.33695	.40985	.298	.459
Total	75	.55299	.156536	.018075	.51697	.58900	.069	.833

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
throughput mac	Based on Mean	.157	4	70	.959
	Based on Median	.164	4	70	.956
	Based on Median and with adjusted df	.164	4	35.094	.955
	Based on trimmed mean	.165	4	70	.955

ANOVA

throughput mac

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.347	4	.337	50.518	<.001
Within Groups	.467	70	.007		
Total	1.813	74			

Figure 2 Result Anova One Way Throughput Time New Employee Mac

In the figure 2, the One-Way ANOVA test results show significant differences in throughput between frameworks (Laravel, Lumen, Guzzle, Slim, Leaf). Framework Leaf has the lowest average throughput (0.37340), while Slim has the highest average throughput (0.68353). ANOVA test with results ($F = 50.518$, $p < 0.001$) confirmed a significant difference, with homogeneous variance between groups ($p > 0.05$).

3.1.3 Error Rate

ANOVA test cannot be performed on the error rate metric because all the frameworks tested showed 0% error.

3.1.4 CPU Usage

Descriptives

cpu mac

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
laravel	15	.03819	.005010	.001294	.03542	.04097	.033	.054
lumen	15	.03341	.008505	.002196	.02870	.03812	.028	.063
guzzle	15	.13993	.012736	.003288	.13288	.14699	.120	.153
slim	15	.21853	.006937	.001791	.21469	.22237	.208	.234
leaf	15	.06747	.004882	.001261	.06476	.07017	.059	.079
Total	75	.09951	.071565	.008264	.08304	.11597	.028	.234

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
cpu mac	Based on Mean	6.592	4	70	<.001
	Based on Median	3.395	4	70	.013
	Based on Median and with adjusted df	3.395	4	45.099	.016
	Based on trimmed mean	6.191	4	70	<.001

ANOVA

cpu mac

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.374	4	.094	1411.101	<.001
Within Groups	.005	70	.000		
Total	.379	74			

Robust Tests of Equality of Means

cpu mac

	Statistic[a]	df1	df2	Sig.
Welch	1862.964	4	34.284	<.001

a. Asymptotically F distributed.

Figure 3 Result Anova One Way CPU Usage Time New Employee Mac

In the figure 3, the One-Way Anova test results show significant differences in CPU Usage between frameworks (Laravel, Lumen, Guzzle, Slim, Leaf). Slim framework has the highest average cpu usage (0.21853), while Lumen framework has the lowest average cpu usage (0.03341). ANOVA test ($F=1411.101$, $p<0.001$) and Welch Test ($p<0.001$) confirmed significant differences, although the variance between groups was not homogeneous.

3.1.5 Ram Usage

Descriptives

memory mac

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
laravel	15	.04650	.003120	.000806	.04477	.04823	.041	.050
lumen	15	.07694	.004242	.001095	.07459	.07929	.071	.083
guzzle	15	.03412	.004990	.001288	.03136	.03688	.026	.047
slim	15	.05507	.035156	.009077	.03560	.07454	.034	.150
leaf	15	.03341	.008505	.002196	.02870	.03812	.028	.063
Total	75	.04921	.022772	.002629	.04397	.05445	.026	.150

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
memory mac	Based on Mean	13.048	4	70	<.001
	Based on Median	2.870	4	70	.029
	Based on Median and with adjusted df	2.870	4	16.174	.057
	Based on trimmed mean	8.275	4	70	<.001

ANOVA

memory mac

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.019	4	.005	17.746	<.001
Within Groups	.019	70	.000		
Total	.038	74			

Robust Tests of Equality of Means

memory mac

	Statistic[a]	df1	df2	Sig.
Welch	195.297	4	33.532	<.001

a. Asymptotically F distributed.

Figure 4 Result Anova One Way Ram Usage Time New Employee Mac

In the figure 4, the One-Way Anova test results show significant differences in Memory Usage between frameworks (Laravel, Lumen, Guzzle, Slim, Leaf). Framework Lumen has the highest average memory usage (0.07694), while Framework Leaf has the lowest average memory usage (0.03341). ANOVA test ($F=17.746$, $p<0.001$) and Welch Test ($p<0.001$) confirmed significant differences, although the variance between groups was not homogeneous.

3.2 Discussion

The One-Way ANOVA test results show significant differences in performance between PHP frameworks tested on Mac and Windows operating systems. In Response Time testing, the Leaf Framework recorded the highest response time on Mac with an average of 28,516.40 ms and on Windows at 26,682.20 ms. Meanwhile, Guzzle achieved the lowest response times on both operating systems (Mac: 11,598.67 ms, Windows: 13,785.33 ms). The ANOVA test yielded significant values with $F=51.762$ ($p<0.001$) on Mac and $F=15.880$ ($p<0.001$) on Windows. For Throughput metrics, the Leaf Framework consistently showed the lowest throughput (Mac: 0.14707, Windows: 0.355467), while Guzzle outperformed with the highest throughput (Mac: 0.45573, Windows: 0.623373). ANOVA results showed significant differences on both operating systems with $F=114.073$ ($p<0.001$) on Mac and $F=33.792$ ($p<0.001$) on Windows.

Regarding CPU Usage, the Slim Framework showed the highest usage on both operating systems (Mac: 0.21853, Windows: 0.055067). Lumen achieved the lowest CPU usage on Mac (0.03341), while Leaf was lowest on Windows (0.022867). The ANOVA test showed significant differences on Mac ($F=1,411.101$, $p<0.001$), but not significant on Windows ($F=4.360$, $p>0.001$). For Memory Usage, results varied between the two operating systems. On Mac, Lumen showed the highest usage (0.07694) with Leaf being the lowest (0.03341). On Windows, Slim recorded the highest usage (0.212533) with Leaf being the lowest (0.063853). ANOVA tests showed significant differences on both systems (Mac: $F=17.746$, Windows: $F=331.673$, both $p<0.001$). In Error Rate testing, all frameworks showed 0% error on both operating systems, therefore ANOVA testing could not be performed for this metric.

Overall, the One-Way ANOVA test results show significant differences in performance between the PHP frameworks tested on both operating systems. These findings provide important insights for developers in selecting frameworks that suit their project needs. The results also indicate that performance can vary based on the operating system used. This research opens

opportunities for further exploration regarding the influence of other factors, such as server configuration and user load, on framework performance.

CONCLUSION

This research was conducted to compare the load testing performance between Laravel, Lumen, Guzzle, and Slim Leaf Frameworks. The measurement parameters were obtained from load test scenarios using Apache JMeter. The analysis process began with the development of REST APIs with 4 endpoints for each framework using the same cloud database, with load test performance testing conducted using Apache JMeter with loads of 25, 50, and 75 virtual users. The research results showed that the Guzzle Framework excelled in two main aspects: lower Response Time and higher Throughput compared to other frameworks, while the Leaf Framework showed advantages in terms of low CPU and Memory usage efficiency, despite having higher Response Time and lower Throughput.

Although the Guzzle Framework shows advantages in Response Time and Throughput compared to other frameworks (Laravel, Lumen, Slim, Leaf), this does not mean other frameworks should not be considered for future API development. Each framework has its own strengths and weaknesses. In this research, the Guzzle Framework performed better in load testing because it uses minimal library requirements during application initialization. However, for other use cases, the Guzzle Framework does not always guarantee better load test performance than other frameworks. Suggestions for future research development include conducting comparative analysis from other aspects such as cost efficiency, development time efficiency, flexibility, and security. Research on these aspects will help application developers determine the appropriate framework for their application use cases.

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