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A Pragmatic Evaluation of Performance Testing for E-commerce Web based Applications

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Abstract : Web Applications have become a necessity for all kinds of businesses and enterprises. It is important that these Web-Applications and Websites work as expected and satisfy the users. This makes it very important for the companies to test and analyze web-applications as the performance of these web-applications play a significant role in deciding the inclusive performance of the company in the market. In order to effectively analyze the performance of web-applications by which we can manage the time as well as their quality, a performance evaluation is performed under some performance evaluation criteria. The objective of this research is to review state-of-the-tools for performance evaluation of web applications. Also, to study various approaches and methods which can be adopted for web application Evaluation. Performance evaluation and analyses of three E-Commerce Websites in India namely, Amazon.in, Flipkart.com and Ajio.com has also been done and the results obtained have been compared.

IndexTerms - E-Commerce Web Applications, Web Application Testing Tools, Performance Testing, Apache JMeter.

I. INTRODUCTION

One of the industries that has had tremendous growth in recent years, particularly during the Covid 19 Pandemic for essential goods, is e-commerce. Every individual with an internet connection becomes a potential customer of these e-commerce websites because the majority of shopping applications are also designed as web-based programs, making it crucial for these websites to function as intended without any delays or errors. Some of the characteristics that help the user choose the finest e-commerce platform are serviceability, products, services, and advantages, timeliness of delivery and return policies, tracking visibility, and platform reviews. An e-commerce website's performance is the main factor that determines how many users it will have as customers, how much money it will make, and where it will stand in the competitive market. Therefore, before being used for its intended purpose, these e-commerce web apps must be evaluated under real-world circumstances. This is because software defects might result in temporary and human losses. By carrying out various sorts of tests and quality assurance activities, which take up between 40% and 70% of the software development life cycle, it is possible to analyse these web apps. One of these activities is performance testing. [1]–[5].

Web application performance testing is the foundation for evaluating an e-commerce website's performance. Performance testing is the process used to determine how well or how the web application behaves under a specific load in terms of responsiveness and dependability. Performance testing tries to measure variables including throughput, reaction time, concurrent users, dependability, resource consumption, and workload efficiency. The process of testing might be carried either manually or automatically. While automated testing uses software testing tools to test the web application by developing scripts, manual testing is done by hand without the use of any tools. Automation testing assists in cutting costs associated with web application quality assurance, testing time, time to market, and other related factors [6]–[9].

Tools like Apache JMeter, Kinsta AMP, WebLOAD, LoadNinja, NeoLoad, StormForge, LoadView, LoadUI Pro, Silk Performer, AppLoader, Galting, BlazeMeter, k6, Rational Performance Tester, Eggplant, Loadster, Akamai CloudTest, Parasoft Load Test, Locust, Grinder, Loader.io, LoadStorm, Solar-Winds, and Taurus are used in the market. The two most popular tools among these utilized for performance testing by the testers of top IT Companies are Apache JMeter and Load Runner. Numerous studies have made extensive use of web-based automated testing tools, which enhance tool performance and produce superior outcomes. These tools can be used independently or in conjunction with other tools to address a variety of problems and challenges in the field of web application testing. [10]–[12].

Web application testing makes ensuring that a website's functionality and performance standards are being met. It helps find system errors and defects so they can be fixed before the program is made available to the general public. Making sure the web application functions as intended avoids potential security breaches, improves the web application's overall quality, and enhances the user experience. A better user experience will draw more and more users, which is crucial for boosting e-commerce enterprises' sales. Before an online application is made accessible to its potential users, it is tested to help find any potential problems with the user interface, security, performance, and other aspects of web testing. By addressing these issues, developers can improve the reliability and functionality of web application [2, 13, 14].

II. LITERATURE REVIEW

We have talked about earlier studies on web application testing in this part. E. Pelivani et al.'s analysis of and comparison of automated testing technologies for web application testing is the main emphasis of [4] and emphasizes the significance of

software testing in the software development life cycle. By modeling real-world scenarios, Selenium and Katalon Studio have been examined and compared on actual web applications. In [5], the author placed more than 1,00,000 artificially generated users under heavy load on the Indian Railways, and the results demonstrate how the web application performance can be improved by increasing internet bandwidth and using high-end hardware to enable the website to support more users and process the requests quickly. I. Ushakova et al.'s recommendation in [7] to expand the use of open-source testing tools for performance evaluation seeks to improve the quality of web applications.

The author of [12] has talked about the value of performance testing for e-commerce websites and how it can be done with the use of load generators and cloud servers. The author has also highlighted a number of problems, testing methods, and difficulties encountered during cloud testing. The author of [8] places special focus on load testing, one type of performance testing. The author has described how variables like request time and response time affect how well a web application performs. When it comes to load testing online applications, both the speed of the internet and the number of concurrent users have a significant role. [20] compares and presents some automated web application testing technologies. Different university websites in Punjab were tested for usability using tools like GTMetrix, Website Grader, Site Speed Checker, and Pingdom, and the results were compared based on factors like performance, speed, load time, page size, request time, security, mobility, etc.

Using Apache JMeter as a testing tool, [8] researchers were able to identify two student admission online systems' reliability and performance-related bugs. Response time, system scalability, capability, and throughput parameters have been developed in consideration of a specific burden placed on the systems. The author also comes to the conclusion that as the load increases, the server response time also does. S. Paz et al. in [21] use web platform testing technologies like The Grinder, Gatling, Apache JMeter and Apache Flood to analyze and optimize the performance of search engines like Google, Bing, Ask, and Aol Search. The author also came to the conclusion that Apache JMeter stands out above all the other tools due to several benefits it offers, such as the development of more virtual load in the same amount of time. For performance testing of an API used to convey data to many users and consumers of a telecommunications business of a firm employing CSV files as a source of bulk data, the author in [11] optimized the use of JMeter. According to the author, ramp-up time, user or customer count, and loop count of particular tool properties would all decrease with time in order to achieve target throughput, error rate of 0%, and response failures. In [22], the author discusses the significance of web application quality assurance, particularly for e-commerce platforms.

With the use of the Apache JMeter tool and spike testing on the DiTenum website, performance metrics have been assessed in [10] along with hypothesis tests on each test result. The website has undergone effective optimization in terms of load time, but the tester saw that the error rate rose as a result of the increased load in terms of the number of active visitors. [14] Place focus on the value of online application evaluation and various performance testing techniques. Testing is a process used by the author to identify flaws in functionality, usability, performance, capacity, security, etc. Performance tests can be used to evaluate responsiveness, dependability, throughput, stability, and other characteristics. The JMeter tool has been used to improve web application performance. One method for identifying problems in a web application and deciding on the optimal platform for its development is through performance modeling. [23] describes how to evaluate the performance of a web application by adding JavaScript code to the page of the web site where the tests need to be run. The simulation results provide details on the problems as well as other web application performance metrics.

II. METHODOLOGY

3.1 Criteria for Performance Evaluation of E-Commerce Web Applications

For performance evaluation of e-commerce web applications parameters like average response time, throughput and %error have been considered. These parameters have been illustrated in Table 1.

Table 1: Illustration of Criteria for Performance Evaluation

S. No.	Parameters	Description
1.	Average Response Time	Response time basically measures the elapsed time from just before sending the request to just after the last response has been received. It represents the sum of response time of all the samples divided by the total number of samples.
2.	Throughput	Throughput is the measure of how many user requests are being processed. Its measure is per second or per minute.
3.	%Error	%Error represents the percentage of total requests which contain errors or which have not been processed or executed successfully.

3.2 Performance Testing using Apache JMeter

In this dissertation Apache JMeter has been used for performance evaluation of some e-commerce web applications. It is an open-source tool and is available free of cost. Some of the specifications of the tool used are given in Table 2.

Table 2: Specifications of the tool used for Performance Testing

Version	5.5
Stable release	June 14, 2022
Written in	Java
License	Apache License 2.0
Website	https://jmeter.apache.org/

3.3 Steps for Performance Testing Using Apache JMeter

In this section various steps followed for executing performance testing using Apache JMeter have been discussed.
First step is to determine the test scenarios for the web application. After that, thread Groups are formed to Configure the properties of Thread Group. These properties include Number of Threads, Ramp-Up Period, and Loop Count which have been explained in the Table 3. All the Thread Groups are configured according to a specific web application that is to be tested. Http Requests are generated for the particular web application and tests are executed. The Results obtained from various inbuilt Listeners of JMeter are than analyzed to deduce about the performance of a particular web application on the basis of different parameters and criteria chosen. These practices adopted while executing performance tests using Apache JMeter have been depicted in Figure 1.

Table 3: Properties of Thread Groups

S. No.	Properties	Description
1.	Number of Threads	Number of Threads is the properties that determine the number of visitors/users who will access the web page.
2.	Ramp-Up Period	The Ramp-Up Period determines JMeter Tool about how long to take to "ramp-up" all the threads selected.
3.	Loop-Count	Loop Count identifies execution time, looping test, gradually or so on.

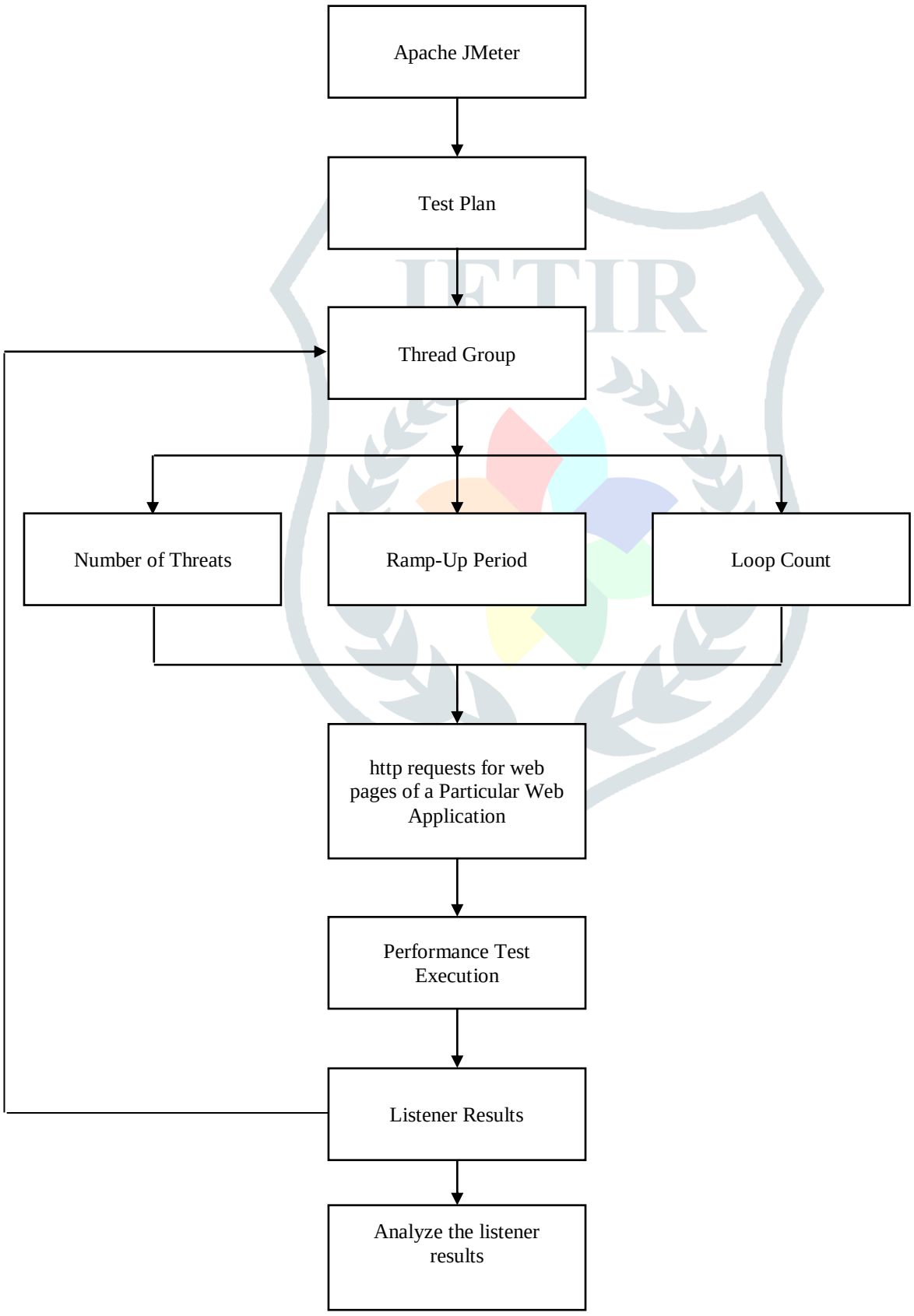

Figure 1: Performance Testing Practices adopted using Apache JMeter

3.4 E-Commerce Web Applications for Performance Testing

This section constitutes criteria considered for choosing 3 web applications of India dedicated towards E-Commerce for Performance Evaluation. Some of the factors like MAU, Bounce Rate, Pages/Visits, and Visitors have been considered and described in the Table 4.

Table 4: Criteria for selecting E-Commerce Web Applications for Performance Evaluation

S.No.	Factors	Description
1.	MAU	MAU stands for Monthly Active Users. It represents the number of customers visiting the web application in a month.
2.	Bounce Rate	Bounce Rate represents an estimate of the website's average bounce rate, or percentage of visitors that leave the website after viewing just one page.
3.	Pages Visited	Pages Visited is an estimate of how many pages (on average) a person visits in one session on the website.
4.	Visitors	Visitors/users on a web application in a particular month.

In this dissertation the data for these factors have been taken as of November 2022. Figure 2-5 show the values of these factors for various Web Applications in India.

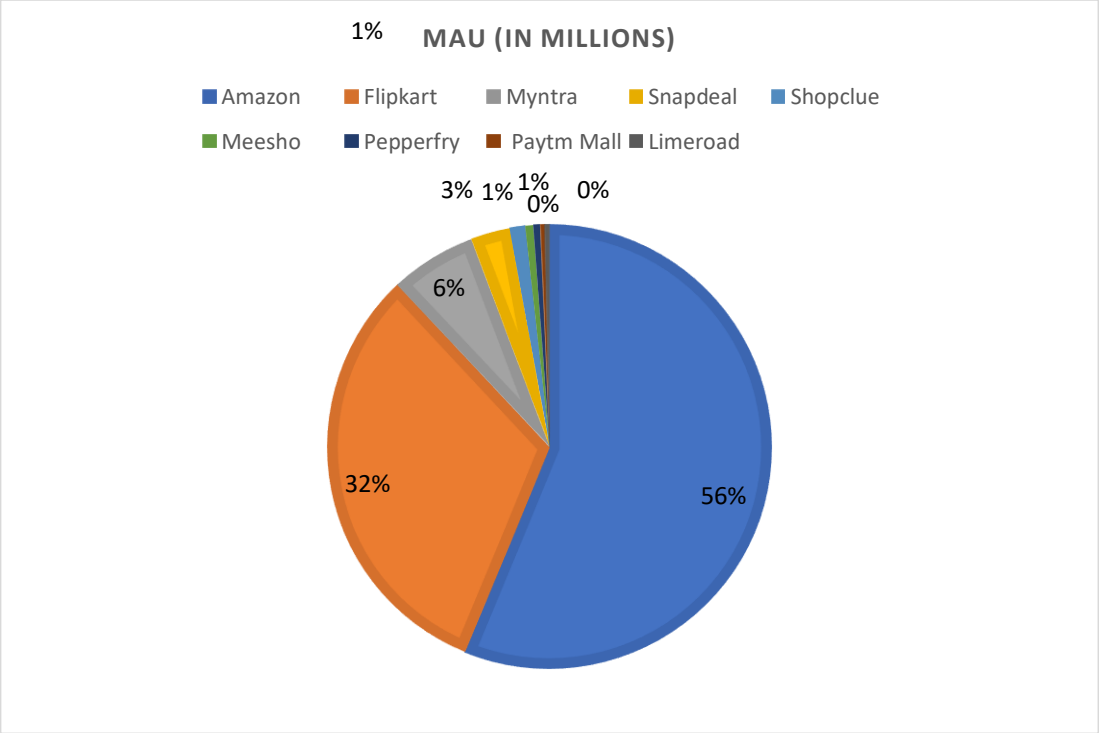

Figure 2: Monthly Active Users for various Web Applications in India

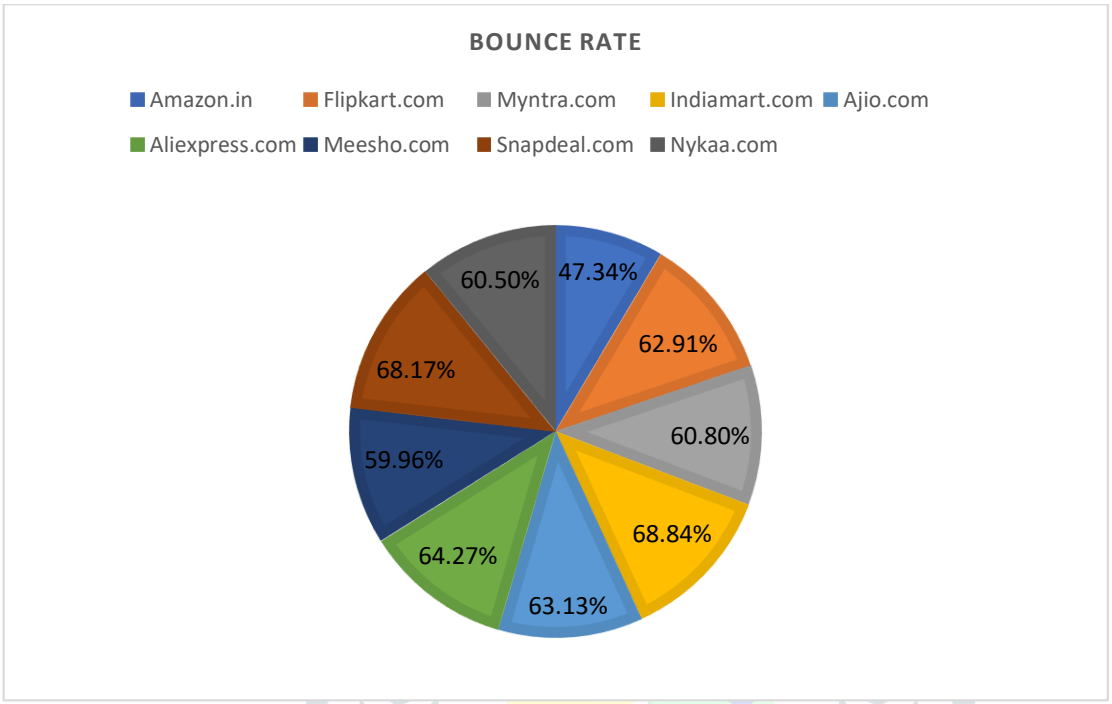

Figure 3: Bounce Rate for various E-Commerce Web Applications in India

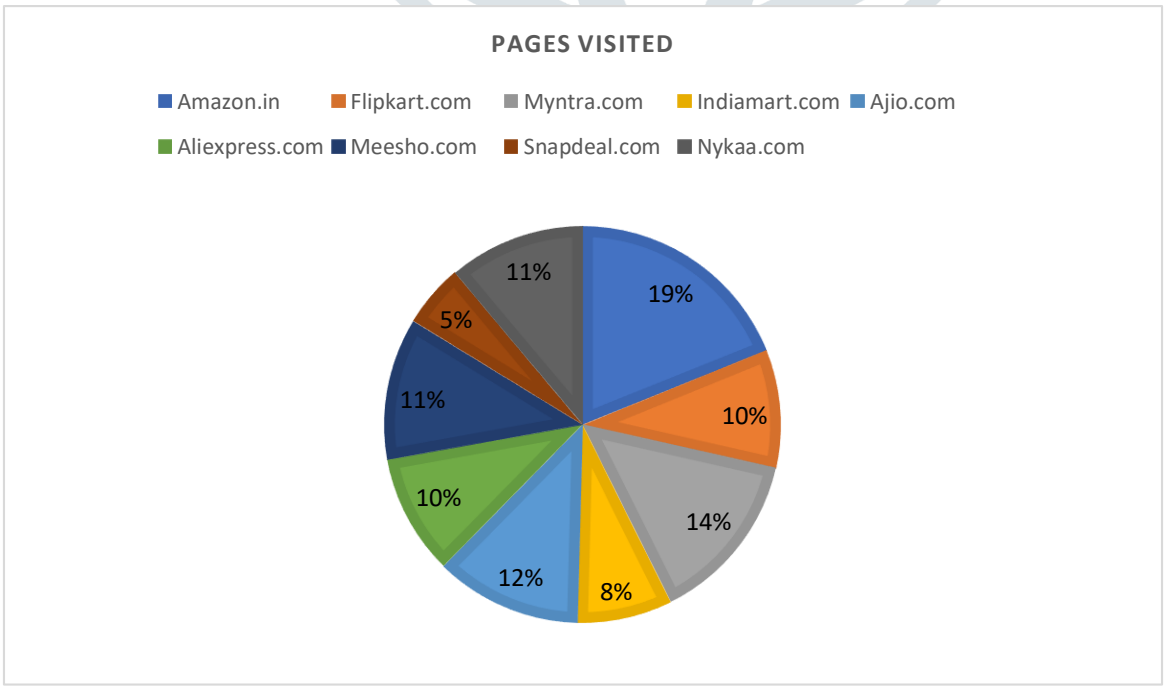

Figure 4: Pages Visited for various E-Commerce Web Applications in India

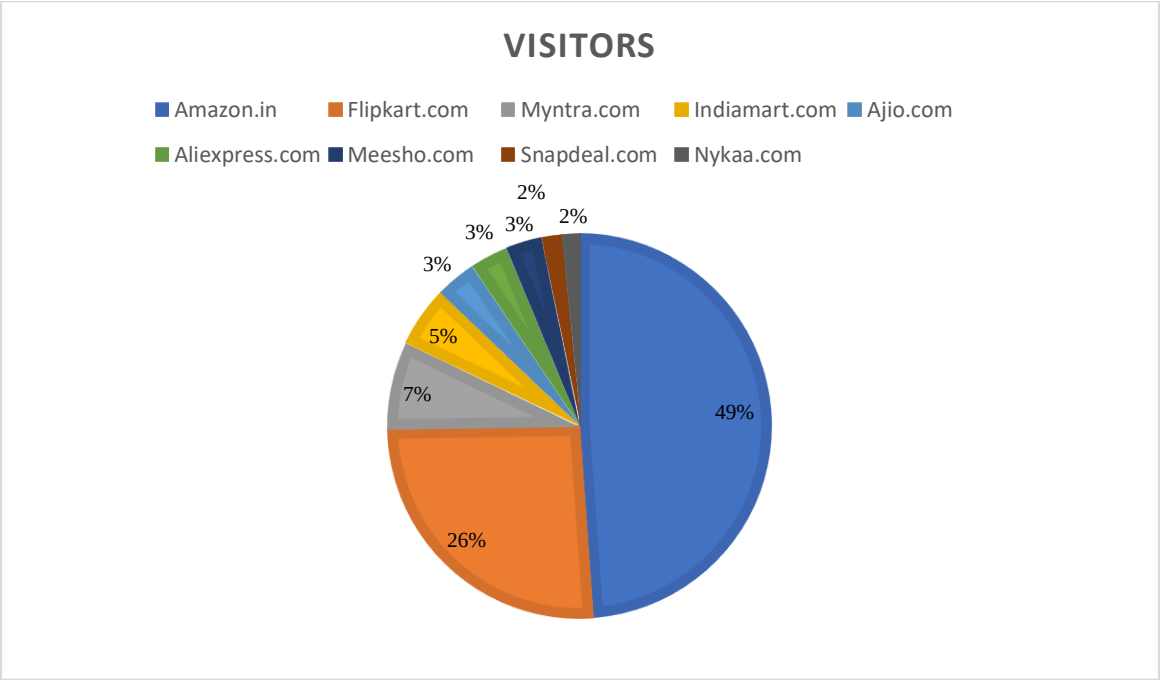

Figure 5: Visitors in a particular month for various Web Applications in India

After considering the data in the pie charts three E-Commerce Web Applications have been chosen for Performance Evaluation in this dissertation. These Web Applications are given in the Table 5.

Table 5: E-Commerce Web Applications for Performance Testing

S. No.	E-Commerce Website	Official URL
1.	Amazon.in	https://www.amazon.in/
2.	Flipkart.com	https://www.flipkart.com/
3.	Ajio.com	https://www.ajio.com/

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III. RESULTS

4.1 Performance Test Results for E-commerce Web Applications

This section depicts the test results for performance testing executed on e-commerce web applications using Apache JMeter. Apache JMeter has various inbuilt listeners for analyzing the test results attained but for our analysis we have depicted the test results using two listeners Aggregate Report and Graph Results. The Aggregate Report is one of the primary indispensable listeners offered by Apache JMeter. It gives parameters like min, max, average, %error, throughput, median, KB/Sec, 90% line, 95% line and 99% line. 90% Line (90th Percentile) signifies that this time was the average for 90% of the samples. It took at least as long to complete the 10% remaining samples. 95th Percentile or 95% Line denotes that 95% of samples took no longer than this amount of time. Min represents the quickest turnaround time a sample can achieve for a given label. Max shows the longest time a sample needs to process a particular label. Average signifies the average time of a set of results. Median represents a value that divides samples into two equal parts. Half of the samples are higher than the median and half of them are smaller. %Error displays the HTTP requests that failed. Throughput indicates how many requests are handled each second. KB/Sec is used to display the typical quantity of data that was obtained from the server while the Test Plan was being executed. In Graph Results, the graph's lines display the number of samples per minute (throughput), the average response time (Average), the median response time (Median), the variance in response time (variance), and the response time for each request individually (Data). The graph's bottom portion displays the condensed data.

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4.1.1 JMeter Test Results for Amazon.in

For ramp-up period as 1 second and loop count as 1 Figure 6 shows the Aggregate Report and Figure 7(a) and 7(b) represent the Graph Results for Amazon.in under 1000 Threads.

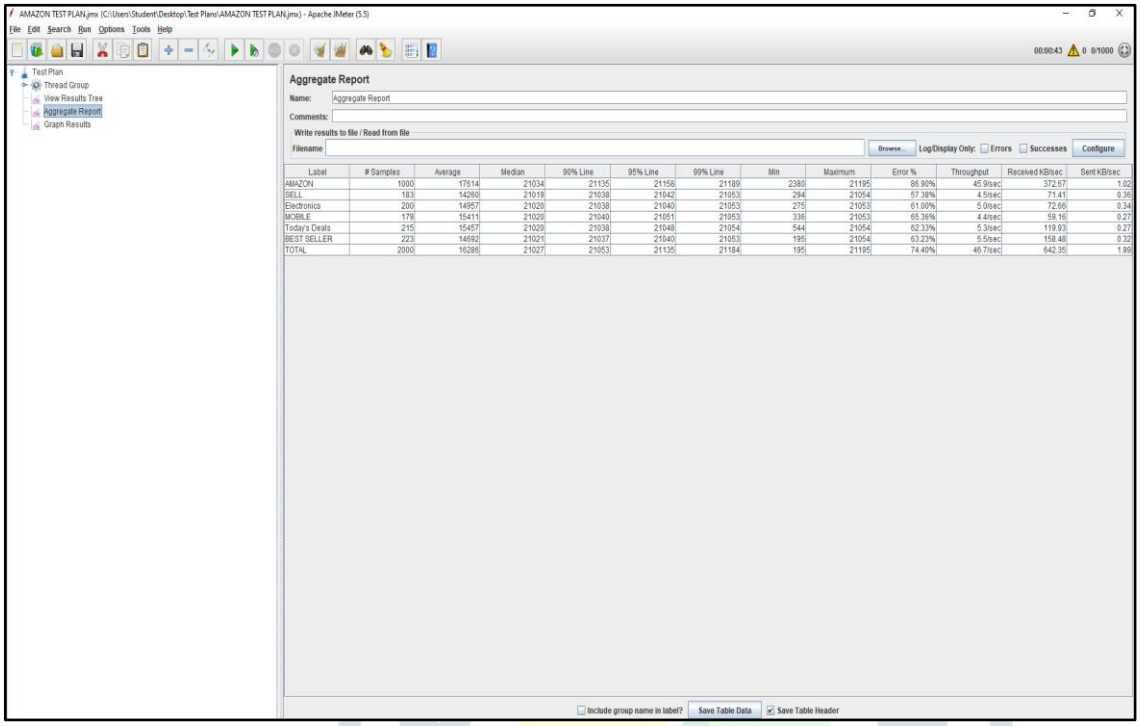

Figure 6: Aggregate Report for Amazon.in with ramp-up period and loop count as 1.

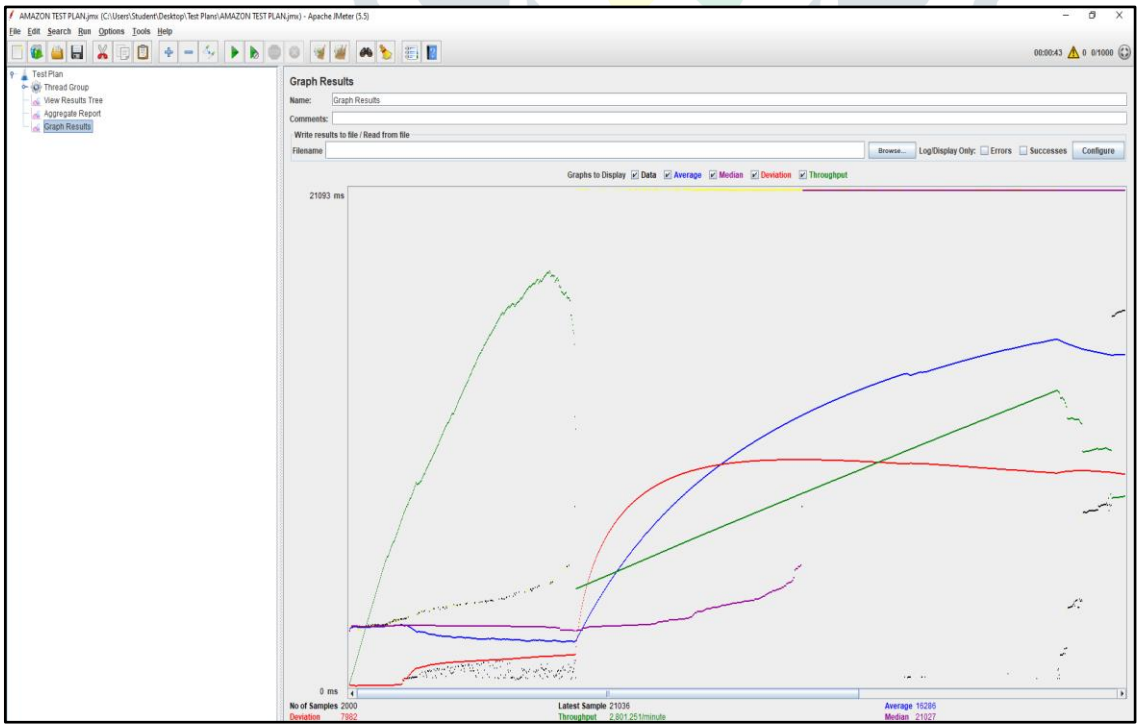

Figure 7(a): Graph Results for Amazon.in with ramp-up period as 1 second and loop count as 1.

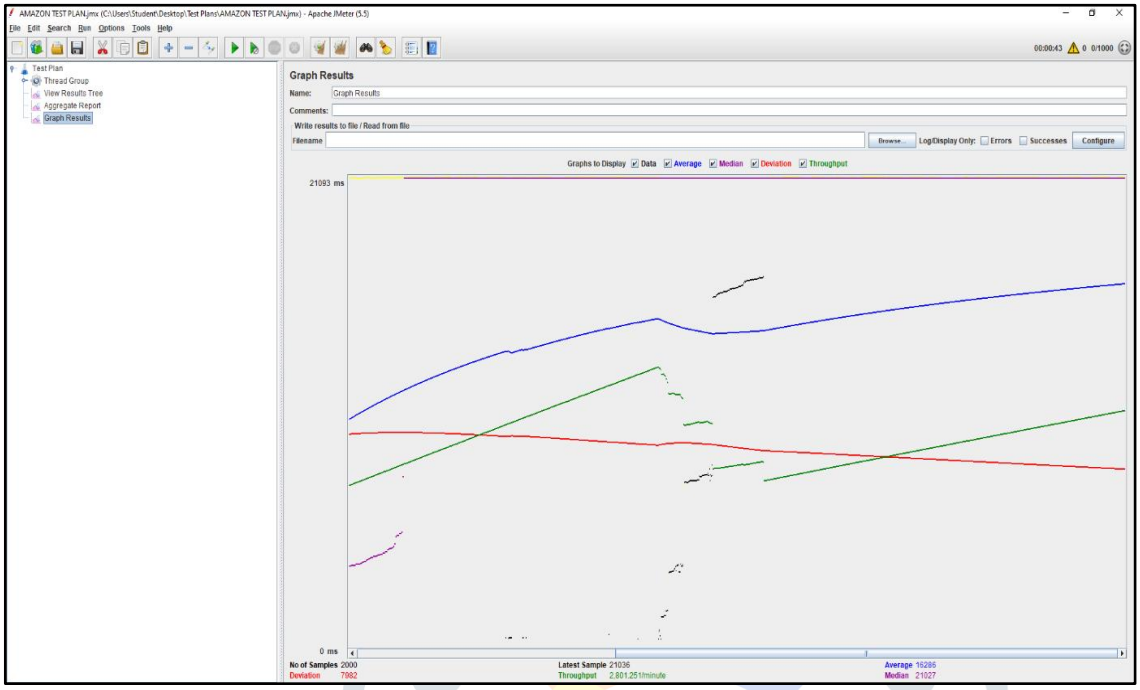

Figure 7(b): Graph Results for Amazon.in with ramp-up period as 1 second and loop count as 1.

For ramp-up period of 10 seconds and loop Count 2 Figure 8 signifies the Aggregate Report and Figure 9(a) and 9(b) signifies the Graph Results for 1000 users on Amazon.in.

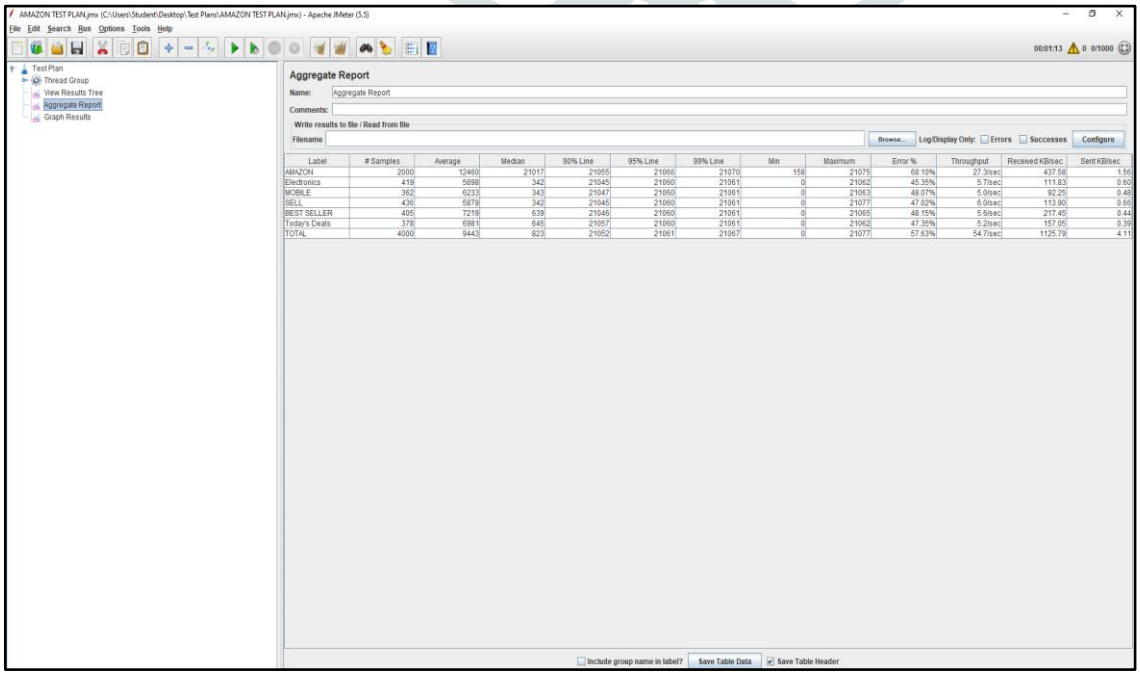

Figure 8: Aggregate Report for Amazon.in with ramp-up period as 10 second and loop count as 2.

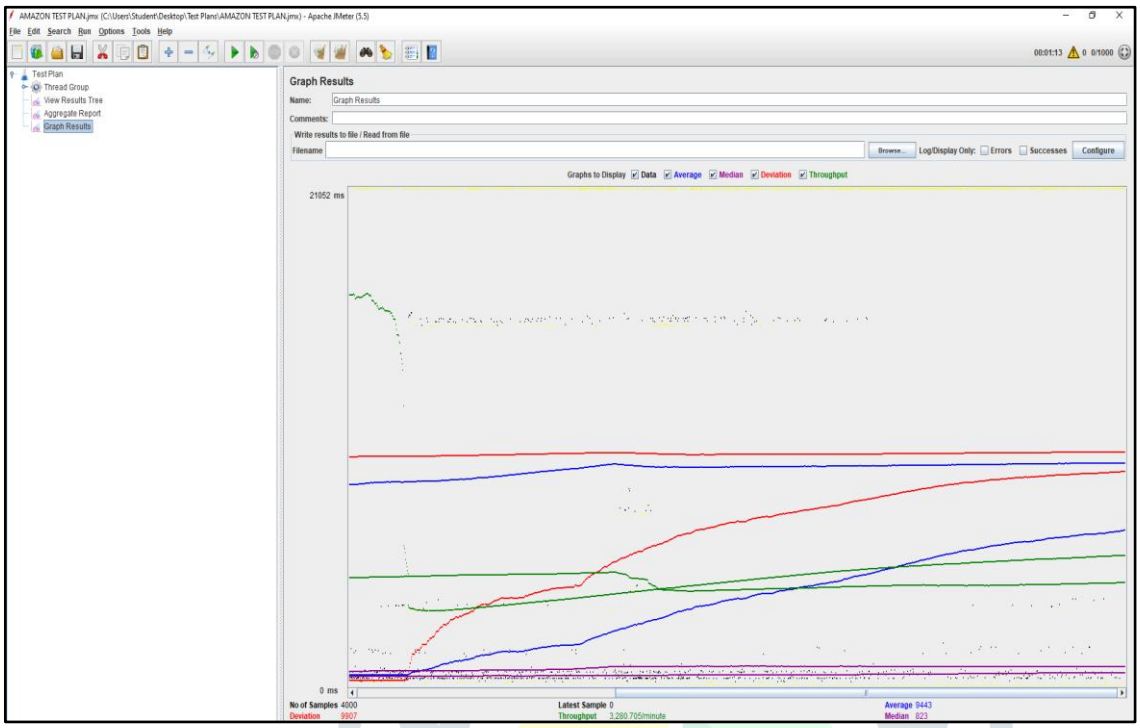

Figure 9(a): Graph Results for Amazon.in with ramp-up period as 10 second and loop count as 2.

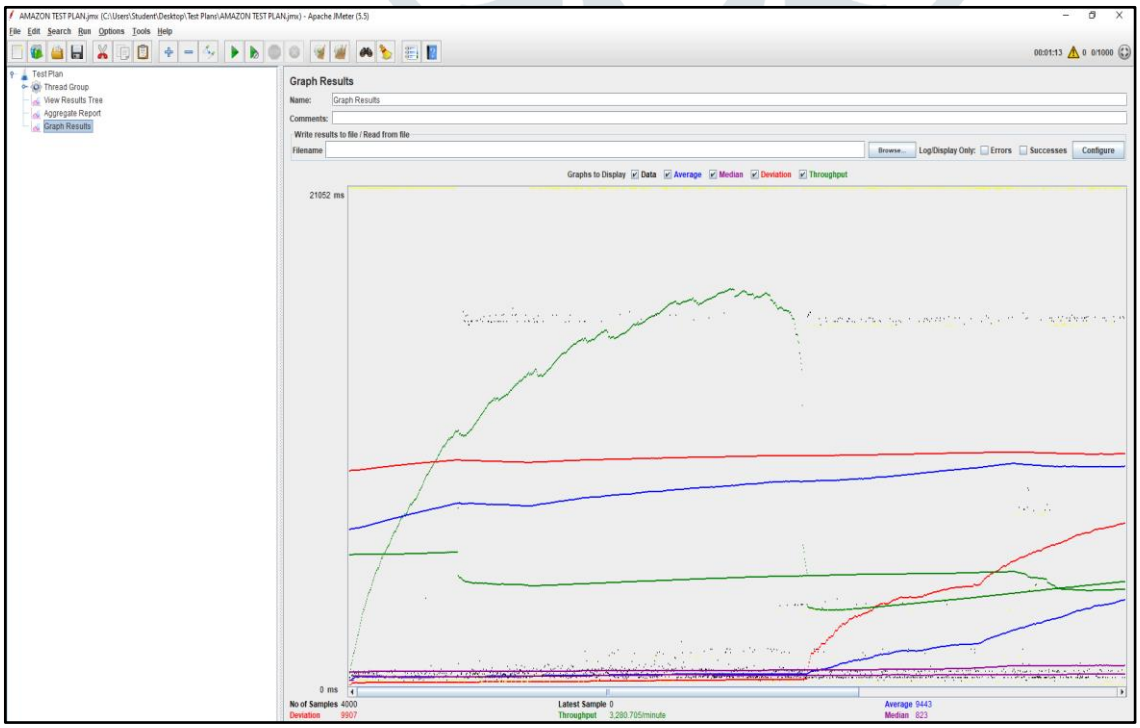

Figure 9(b): Graph Results for Amazon.in with ramp-up period as 10 second and loop count as 2.

4.1.2 JMeter Test Results for Flipkart.com

Figure 10 denotes the Aggregate Report attained for performance testing on Flipkart.com for 1000 users and ramp-up period as 1 second along with loop count of 1. The Graph Results have been shown in the Figure 11(a) and 11(b).

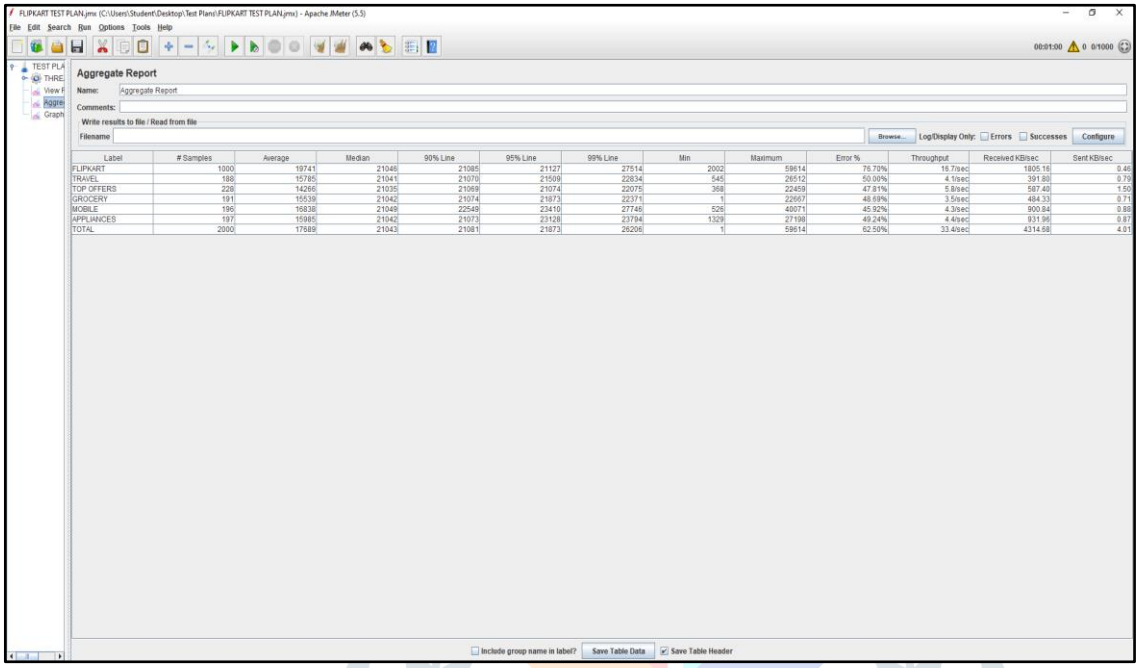

Figure 10: Aggregate Report for Flipkart.com with ramp-up period and loop count as 1.

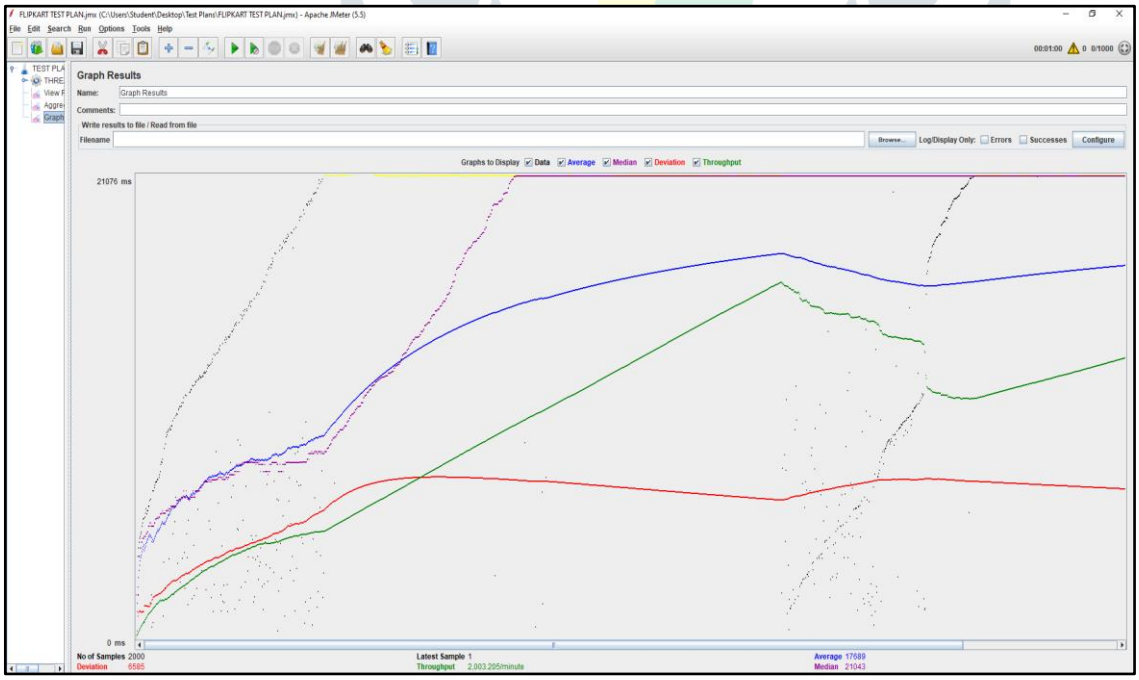

Figure 11(a): Graph Results for Flipkart.com with ramp-up period and loop count as 1.

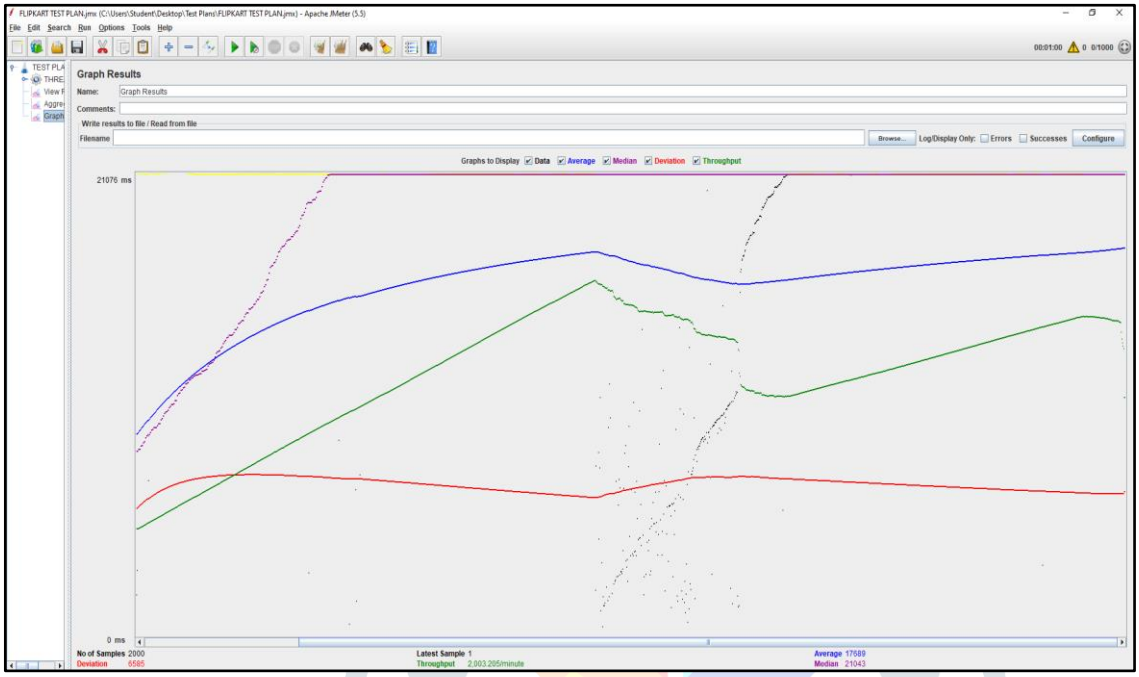

Figure 11(b): Graph Results for Flipkart.com with ramp-up period and loop count as 1.

Setting the ramp-up period as 10 seconds and loop count as 2 for 1000 users for Flipkart.com gives the aggregate report as shown in Figure 12. Graph Results for the same have been depicted in Figure 13(a) and 13(b).

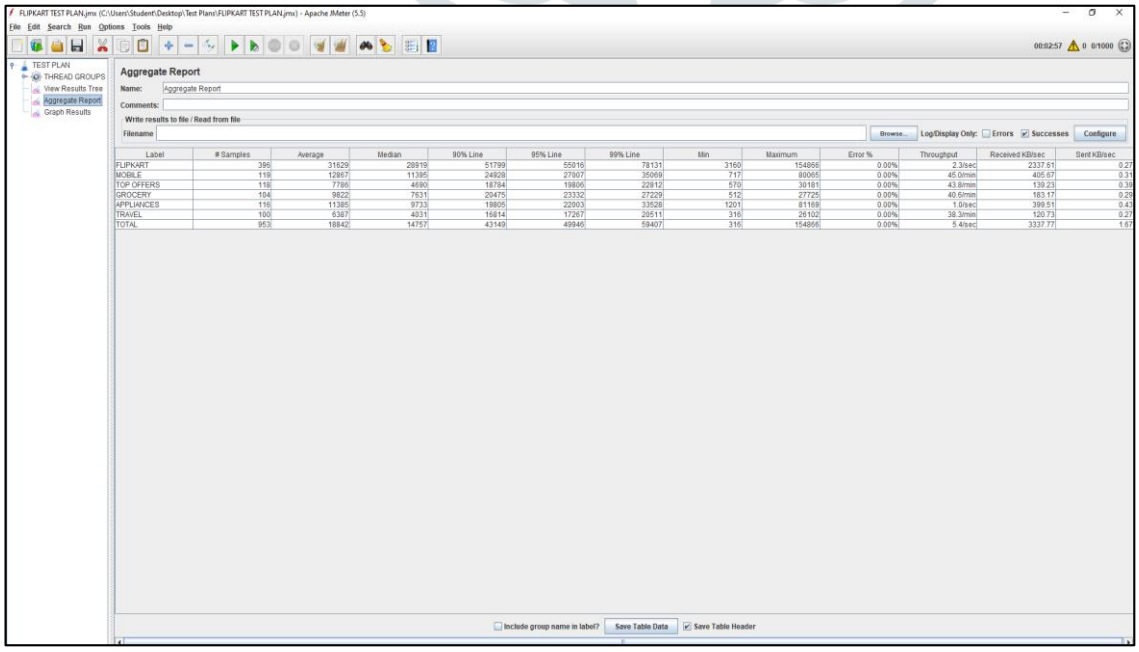

Figure 12: Aggregate Report for Flipkart.com with ramp-up period as 10 second and loop count as 2.

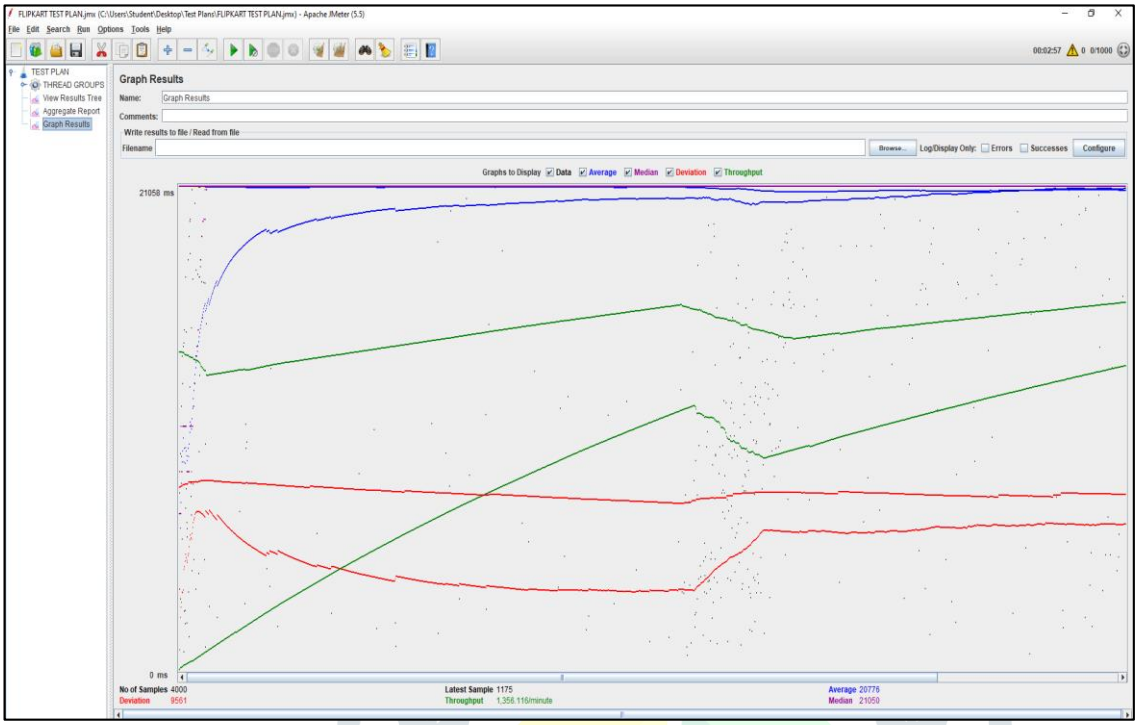

Figure 13(a): Graph Results for Flipkart.com with ramp-up period as 10 second and loop count as 2.

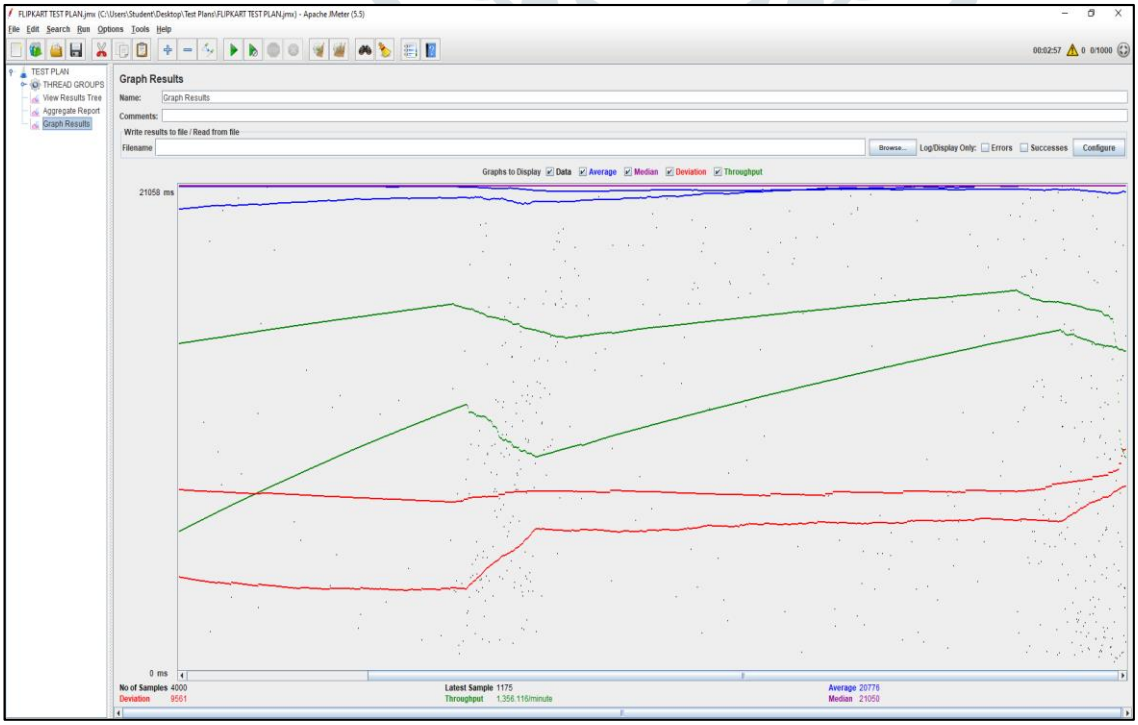

Figure 13(b): Graph Results for Flipkart.com with ramp-up period as 10 second and loop count as 2.

4.1.3 JMeter Test Results for Ajio.com

For Ajio.com the Listener Results have been represented in the Figure 14 and Figure 15(a) and (b) for ramp-up period of 1 second and loop count as 1 for 1000 users. Figure 14 depicts the Aggregate Report and Graph Results are shown in Figure 15(a) and (b).

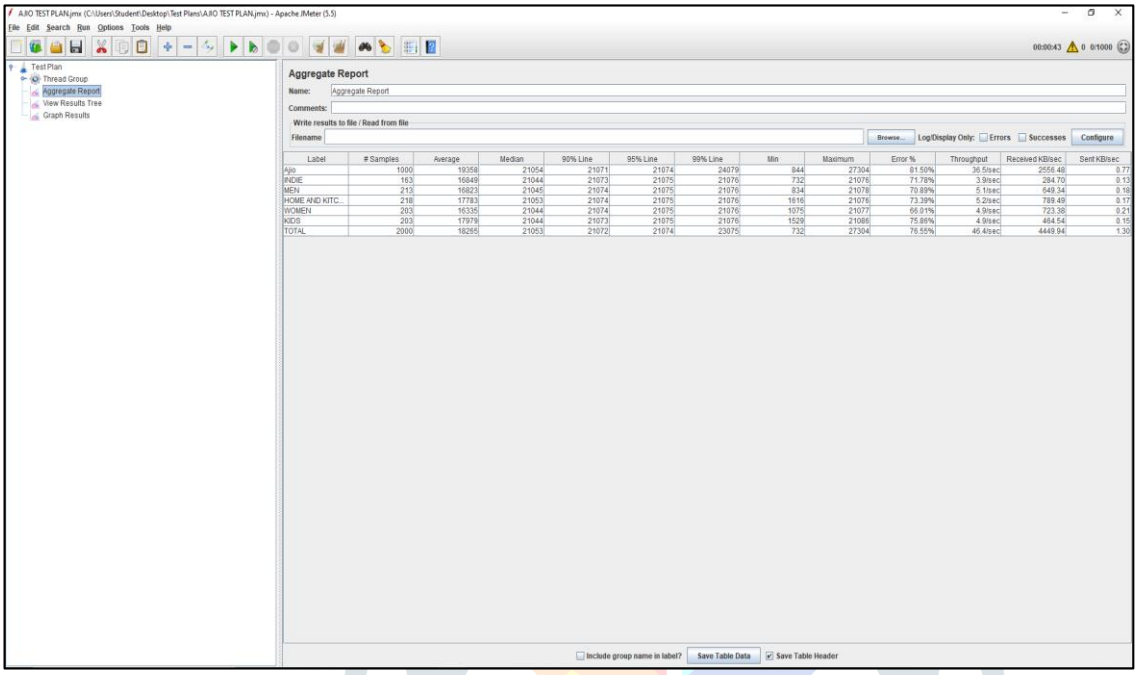

Figure 14: Aggregate Report for Ajio.com with ramp-up period and loop count as 1.

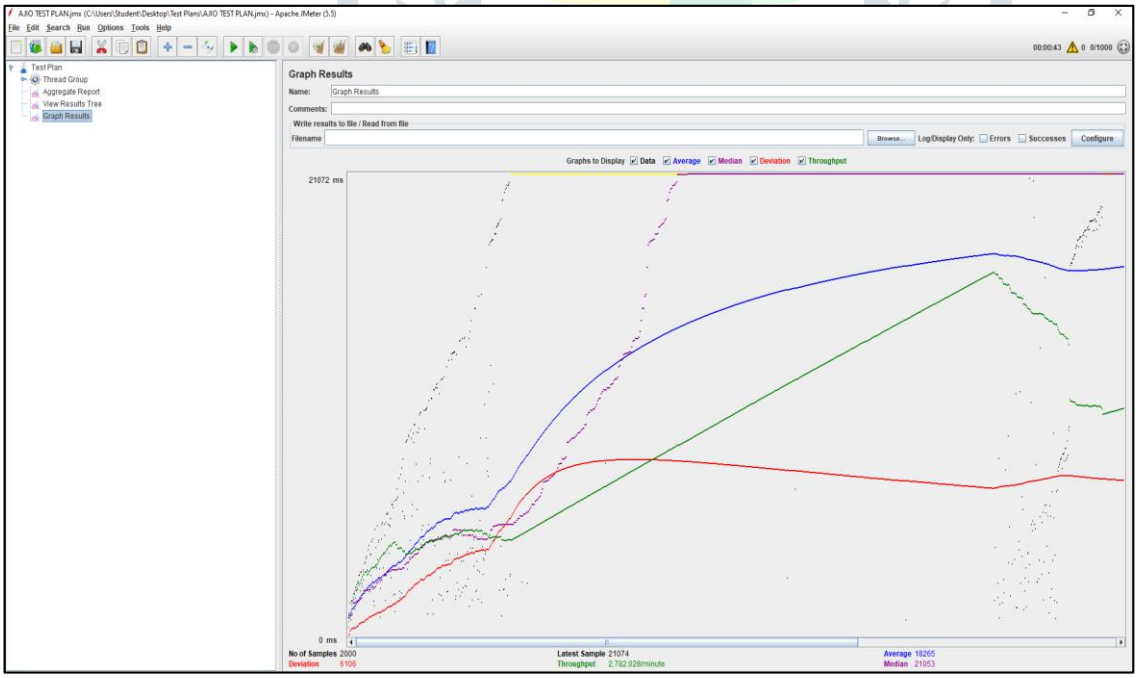

Figure 15(a): Graph Results for Ajio.com with ramp-up period and loop count as 1.

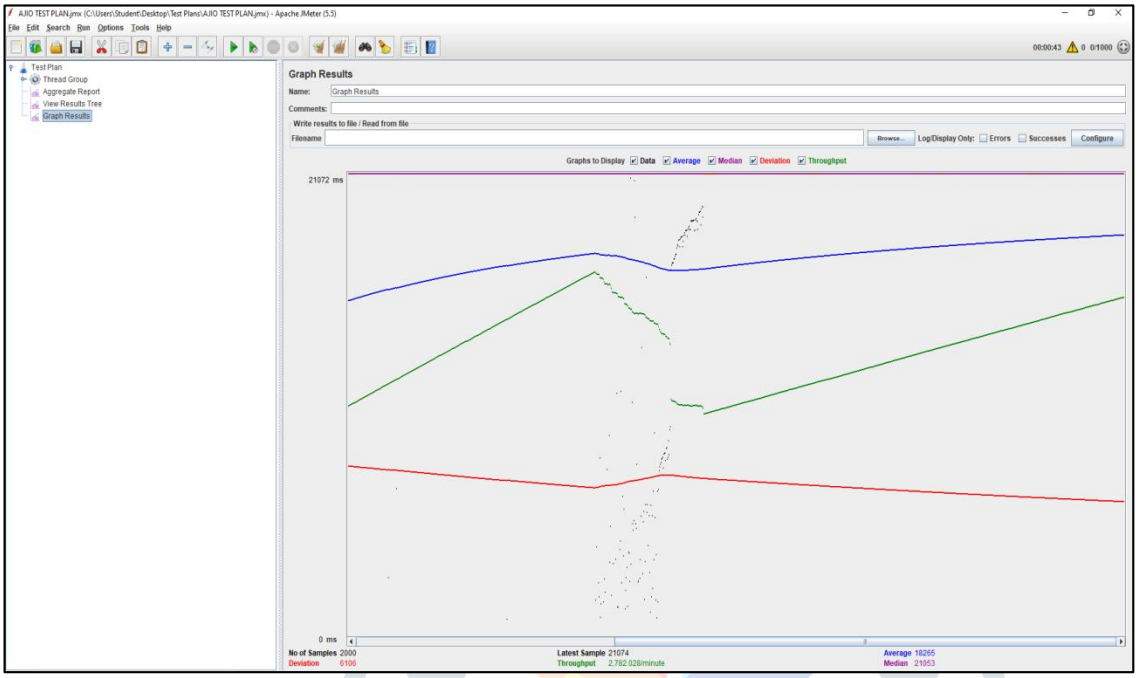

Figure 15(b): Graph Results for Ajio.com with ramp-up period and loop count as 1.

For number of users as 1000 with loop count as 2 and ramp-up period as 2 the Aggregate Report and Graph Results for Ajio.com are shown in Figure 16 and Figure 17(a) and 17(b).

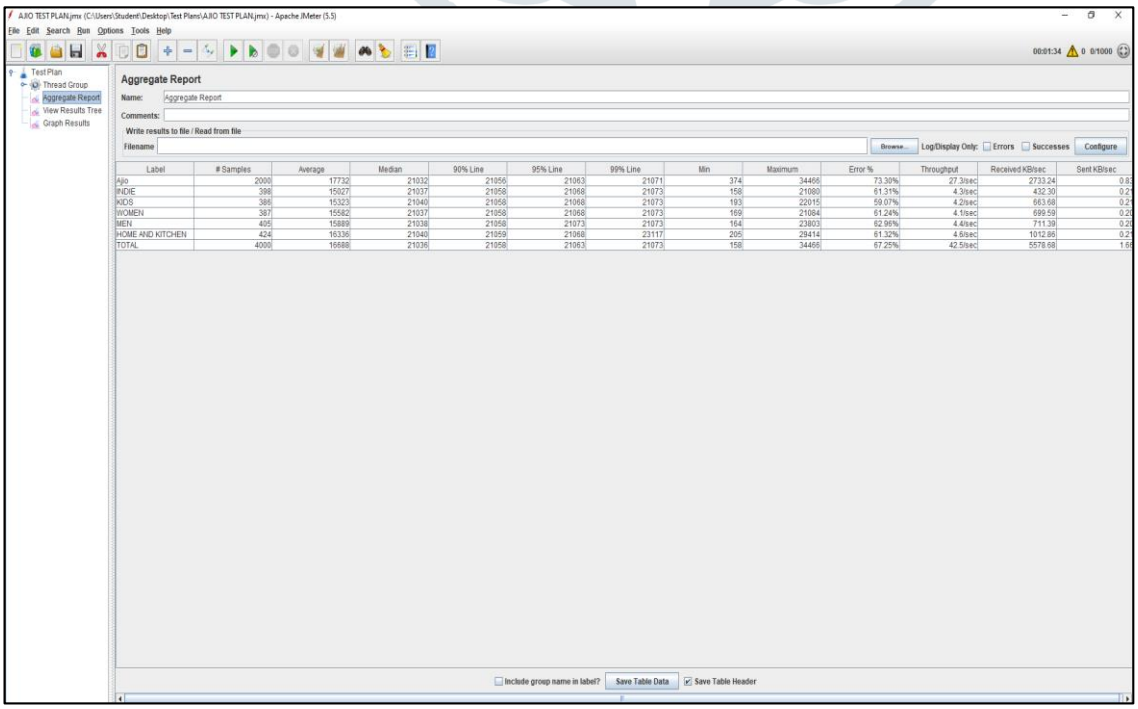

Figure 16: Aggregate Report for Ajio.com with ramp-up period as 10 second and loop count as 2.

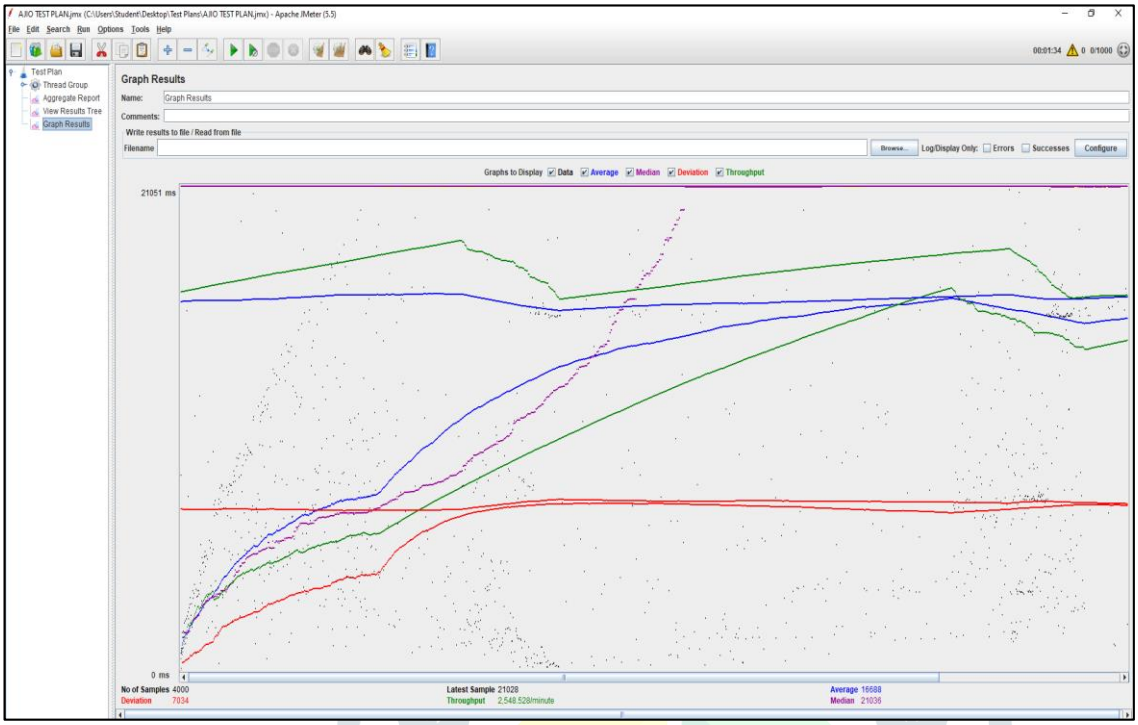

Figure 17(a): Graph Results for Ajio.com with ramp-up period as 10 second and loop count as 2.

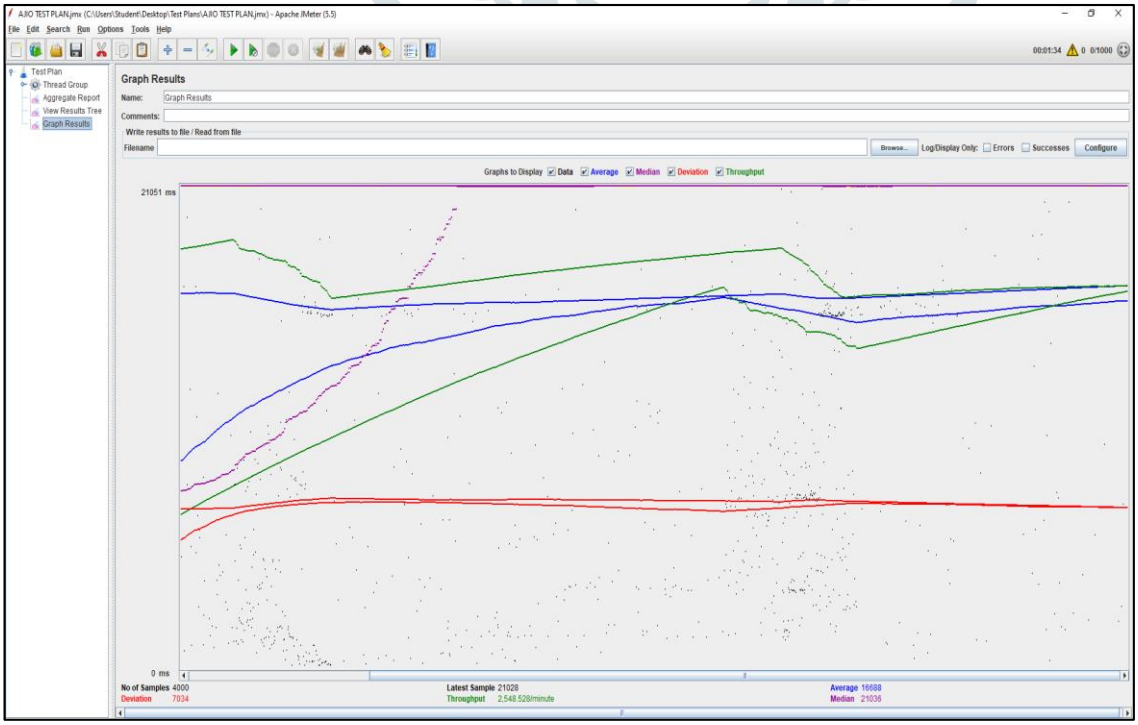

Figure 17(b): Graph Results for Ajio.com with ramp-up period as 10 second and loop count as 2.

4.2 Analysis of Performance Testing Results

Graphical representation of performance parameters shown below depicts the results of the Performance Testing on three shopping Web Applications. Each Figure analytically describes the performance parameters namely Average Response Time (Milli Seconds), %Error, Throughput (/second), with increasing number of users from 50 to 1000. The horizontal axis of each graph depicts the number of threads/users while the vertical axis represents the performance parameters. Also, the worst-case scenario as well as best case scenarios have been shown along with the average case for each parameter recorded for each test case.

4.2.1 Performance Testing Results for Amazon.in

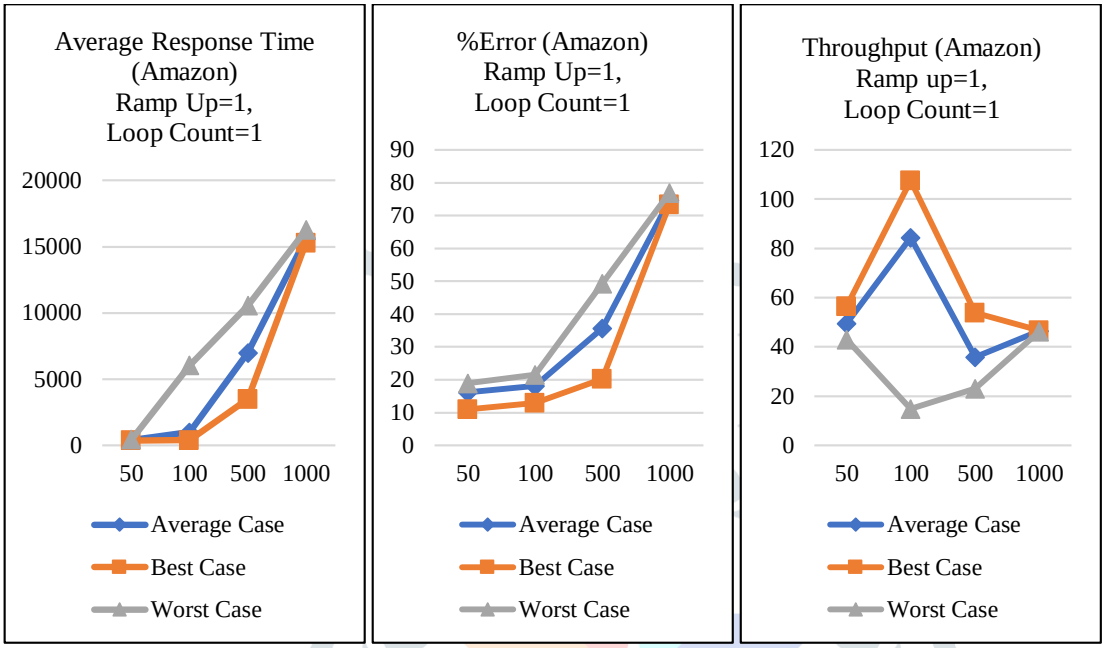

Figure 18: Performance Test results for Amazon.in with Ramp-Up Period and Loop Count as 1

Figure 18 shows the variation of average response time, %error and throughput with increasing number of users for Amazon.in when the ramp-up period and loop count are chosen as 1. It is observed that the Average Response Time and %Error increase with increasing number of users. The number of users on the website has from 50 users to 1000 users. Throughput on the other side first increases and then decreases for the average case. It is observed that the %error as well as average response time is lowest for 50 users whereas while maximum throughput is observed when the number of users was 100.

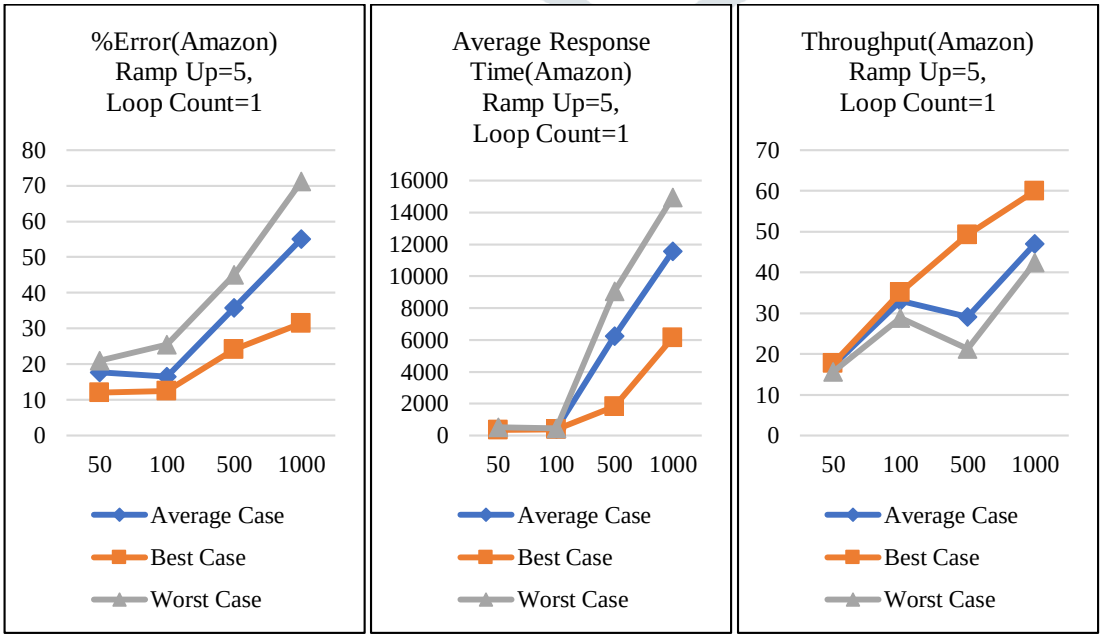

Figure 19: Performance Testing results for Amazon.in with Ramp-Up Period= 5, Loop Count=1

When the ramp up time is increased to 5 seconds and loop count remains 1, the Average Response Time increases with growing users. Throughput follows uncertain trends as observed for the average case scenario. It is highest for 1000 users. %Error as well as average response time is lowermost in case of 50 threads whereas highest throughput is observed when the number of threads reaches 1000. It can be observed in figure 19.

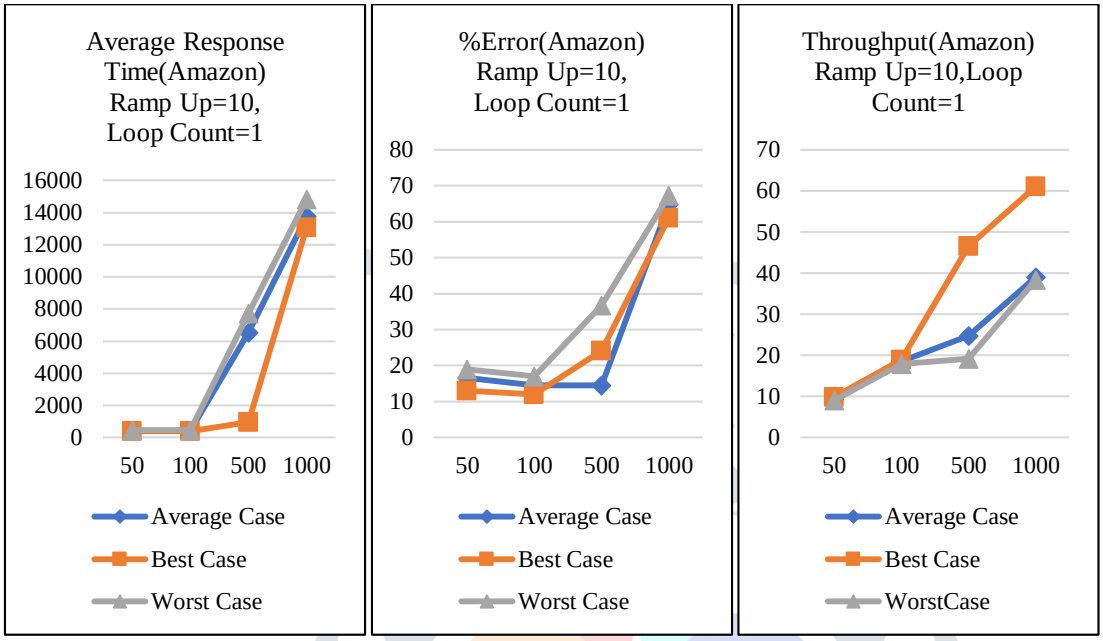

Figure 20: Performance testing results for Amazon.in with Ramp-Up Period= 10, Loop Count=1

It can be seen in Figure 20 that the Ramp Up period as 10 seconds and loop count as 1 lead to increase in the error rate when number of users rise. The Average Response Time also increases and the Throughput is higher than the throughput obtained with ramp-up time as 5 seconds and same loop count. The number of requests declined when 1000 threads are on the system whereas least %error is observed for 500 threads. Throughput value attained at 1000 threads is the maximum. With number of threads as 50 the average response time recorded is minimum.

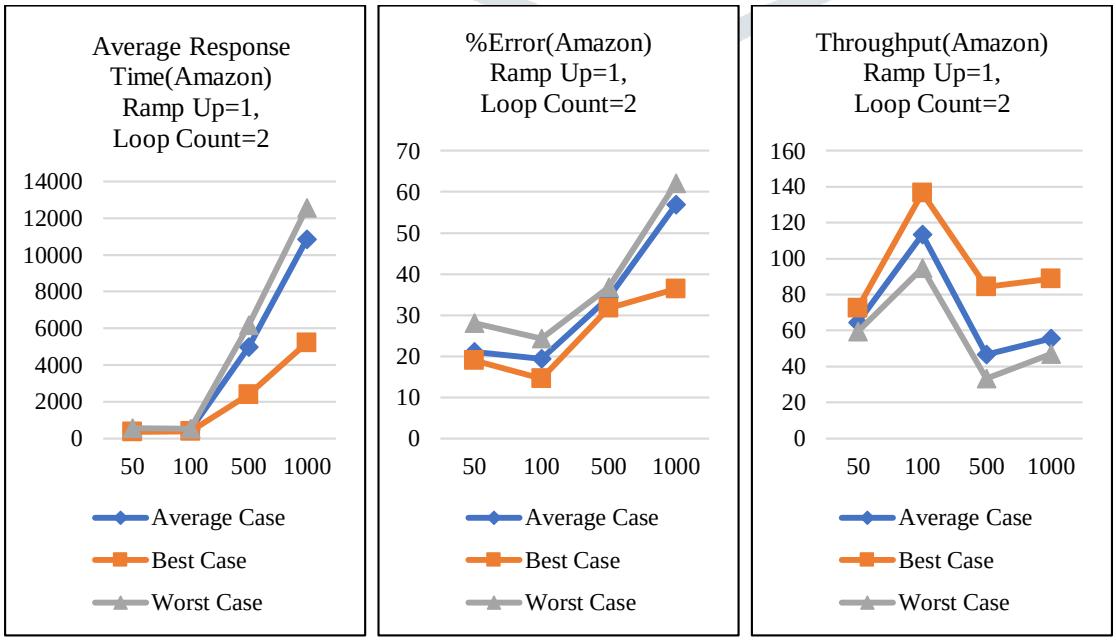

Figure 21: Performance testing results for Amazon.in with Ramp-Up Period as 1 second and Loop Count as 2.

Figure 21 shows that with loop count as 2 and ramp-up period as 1 the average response time obtained for 1000 number of users is less as compared to the Average Response Time obtained when the loop count was 1 and the %Error observed reduced while the throughput raised for 1000 threads as seen is figure 18.

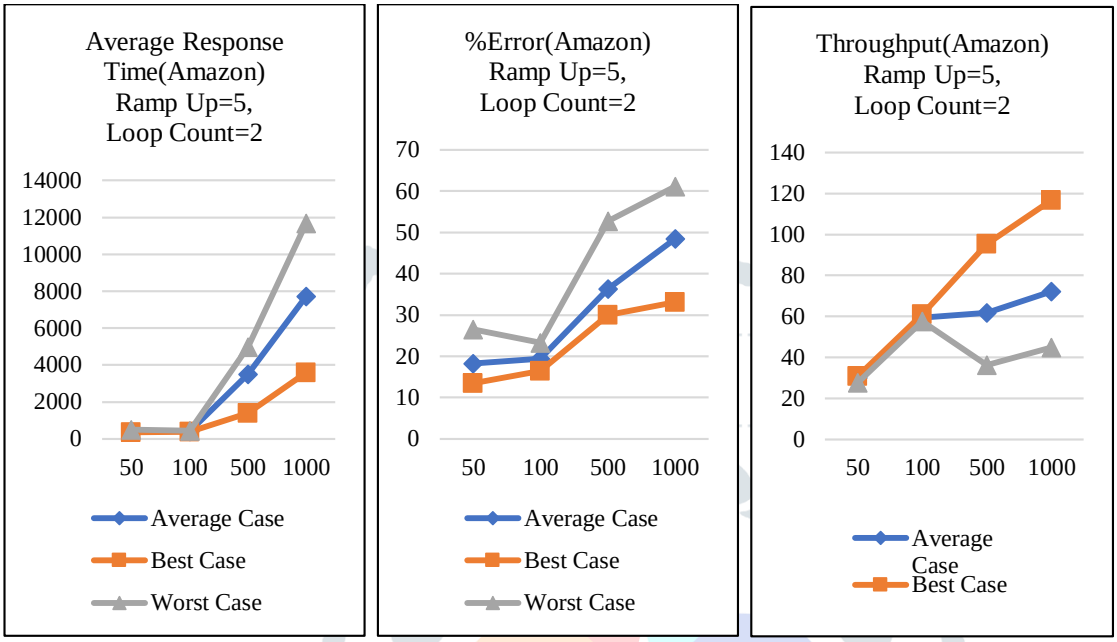

Figure 22: Performance testing results for Amazon.in with Ramp-Up Period as 5 seconds and Loop Count as 2.

Figure 22 shows trst results for Ramp-Up Period of 5 seconds and Loop Count as 2. The average response time is observed to decrement as compared to the case when the Loop Count is 1 for Ramp-Up Period of 5 seconds. The %Error on reduced while the Throughput augmented for 1000 number of users.

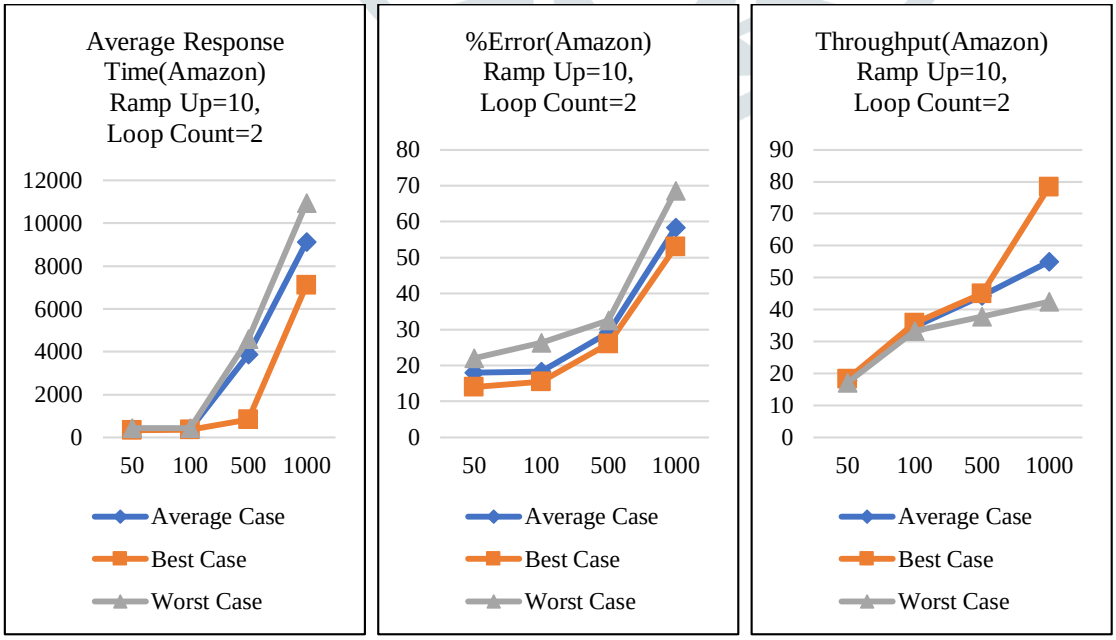

Figure 23: Performance testing results for Amazon.in with Ramp-Up Period= 10 and Loop Count=2

In case of ramp-up period of 10 seconds and loop count of 2 the average response time and %error for 1000 users drops as compared to the same parameter observed in figure 20. On the other hand, Throughput value increased.

4.1.2 Performance Testing Results for Flipkart.com

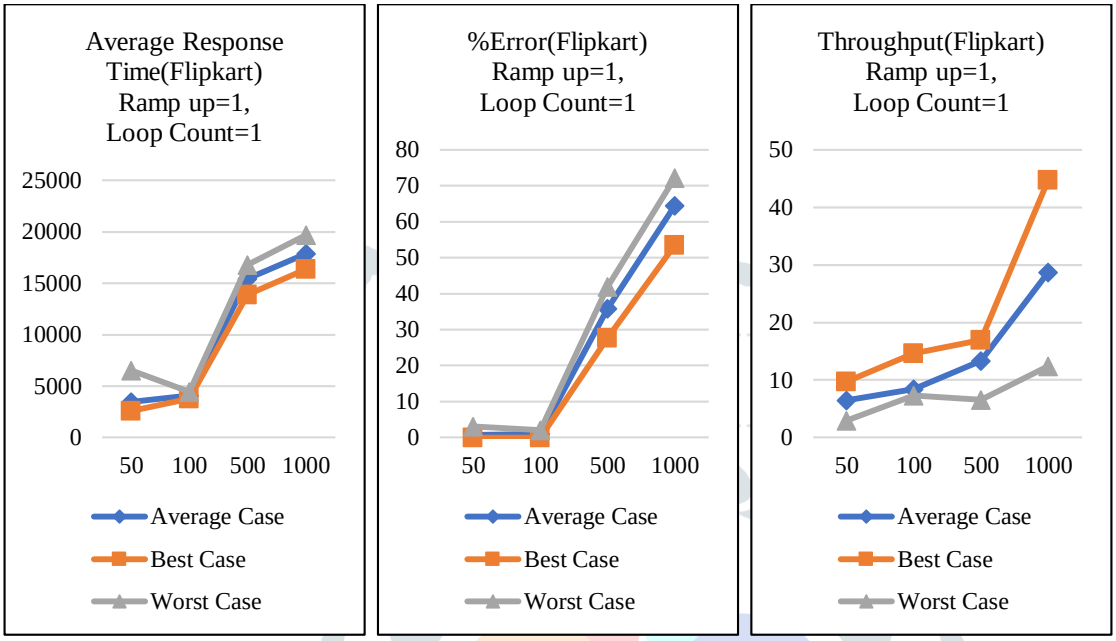

Figure 24: Performance testing results for Flipkart.com with Ramp-Up Period and Loop Count as 1

For Flipkart.com the performance tests conducted with loop count and ramp-up period as 1 showed that the throughput value is highest for 1000 threads. %Error is least for 50 threads and response time is fastest for 50 users.

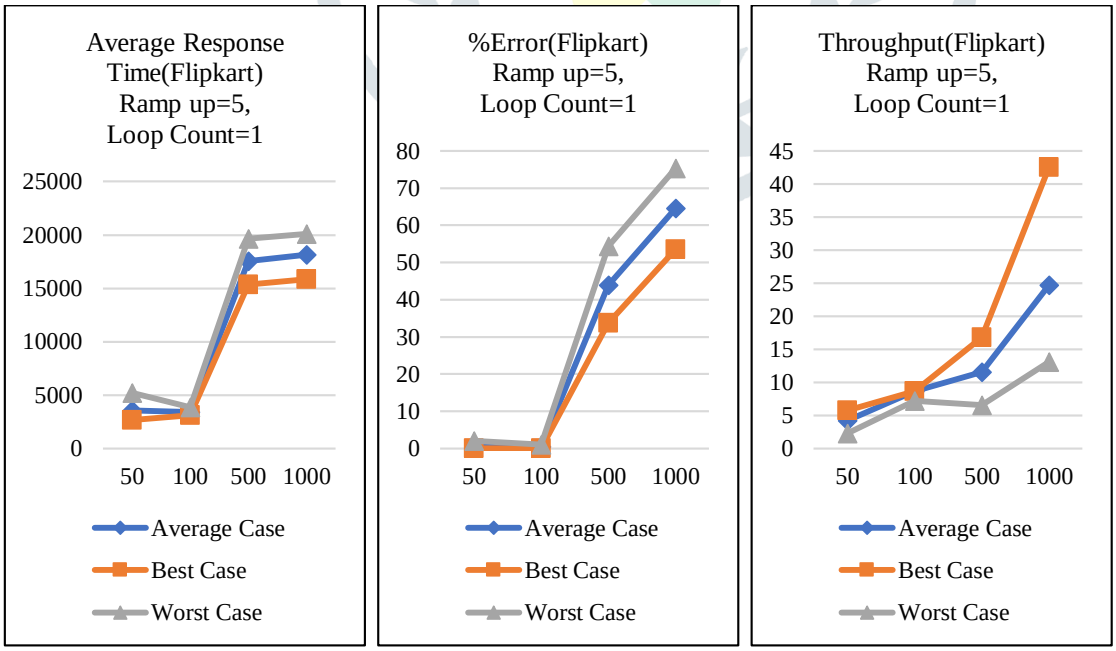

Figure 25: Performance testing results for Amazon.in with Ramp-Up Period= 5 and Loop Count= 1

In figure 25 it can be detected that growing the ramp-up period to 5 seconds and keeping the loop count as 1, very slight decrement in the value of throughput is observed with 1000 number of users.

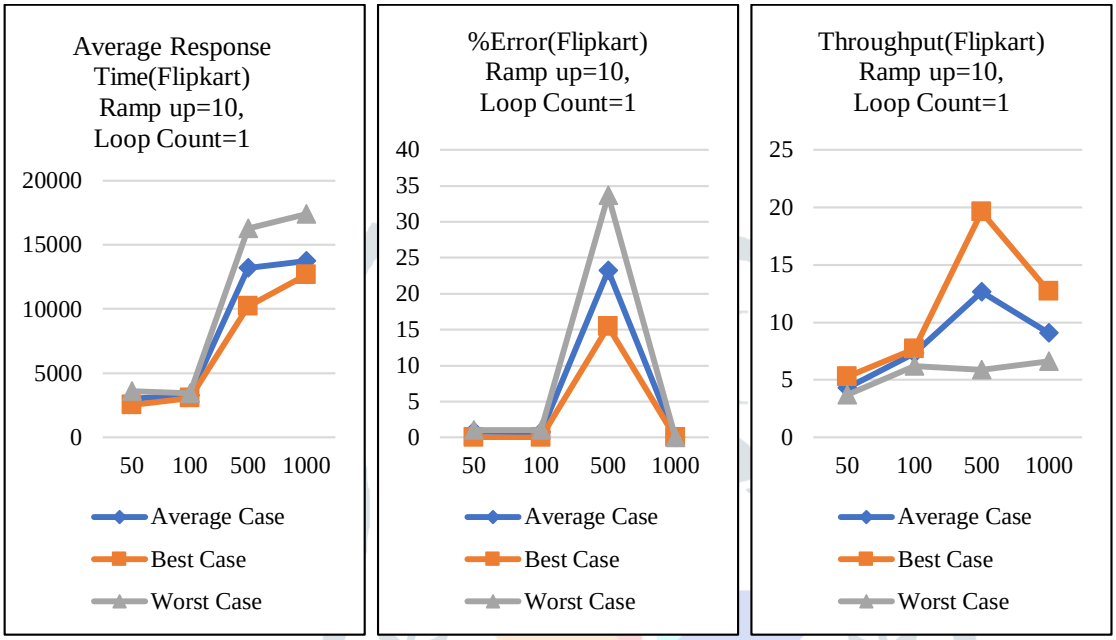

Figure 26: Performance testing results for Amazon.in with Ramp-Up Period= 10 and Loop Count= 1

Figure 26 shows that with ramp-up time of 10 seconds and loop count of 1 the %error becomes almost negligible for 1000 threads while the throughput value is less as compared to the throughput obtained with ramp-up period of 5 seconds. Responses are obtained faster when the ram-up is increased to 10 seconds.

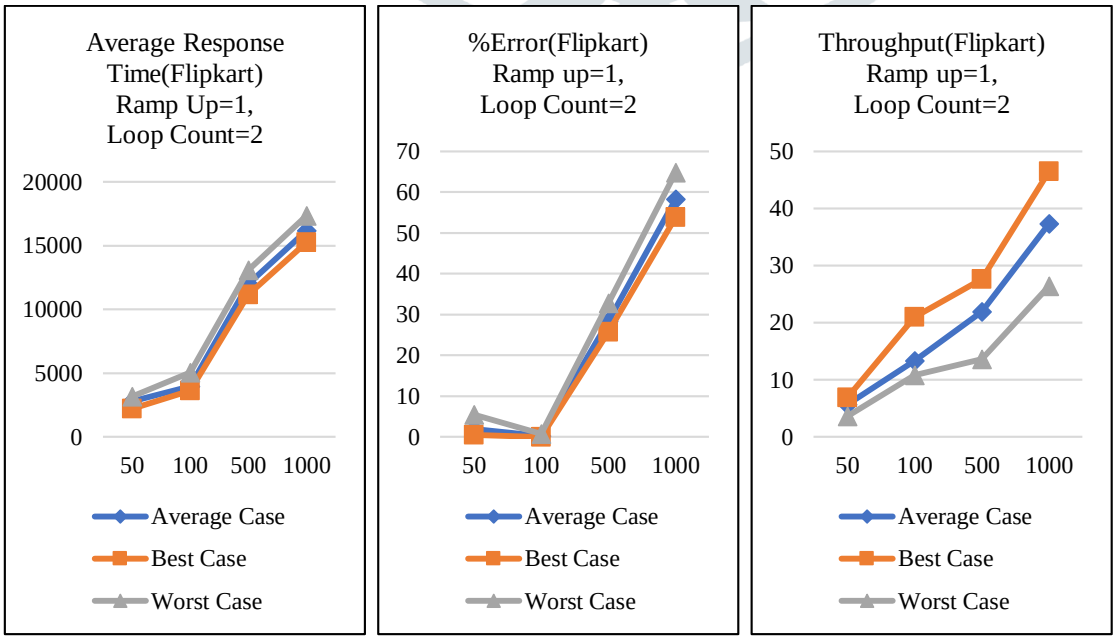

Figure 27: Performance testing results for Flipkart.com with Ramp-Up Period= 1 and Loop Count=2

For the test case scenario where loop count is 2 and ramp-up period is 1 second, the throughput value rises as it can be understood from figure 31 in contrast to the test scenario when the loop count is 1 for same ramp-up time. Other parameters like %error and average response time have also reduced as in figure 27.

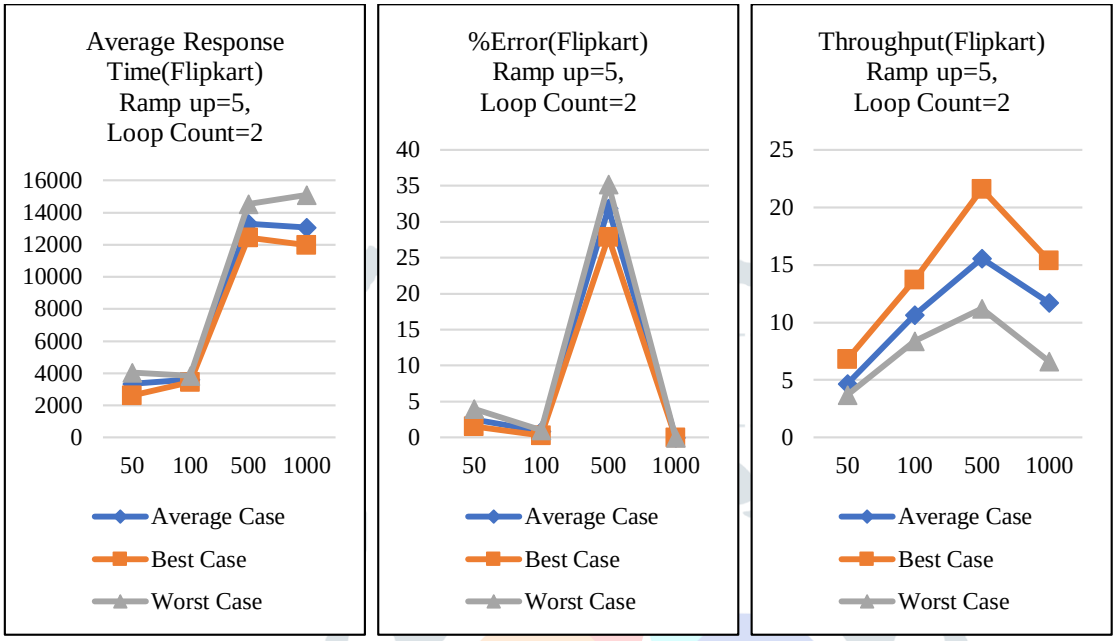

Figure 28: Performance testing results for Flipkart.com with Ramp-Up Period= 5 and Loop Count=2

It is observable from figure 32 that as ramp-up time of 5 seconds at loop count of 2 diminished the error at maximum number of threads. When the number of threads is 500 the throughput value recorded is largest as compared to other values of threads while for 1000 users the throughput value The responses to the requests on the other hand become fast as the average response time is observed to decrease for 1000 use decremented as compared to the test scenario in figure 25.

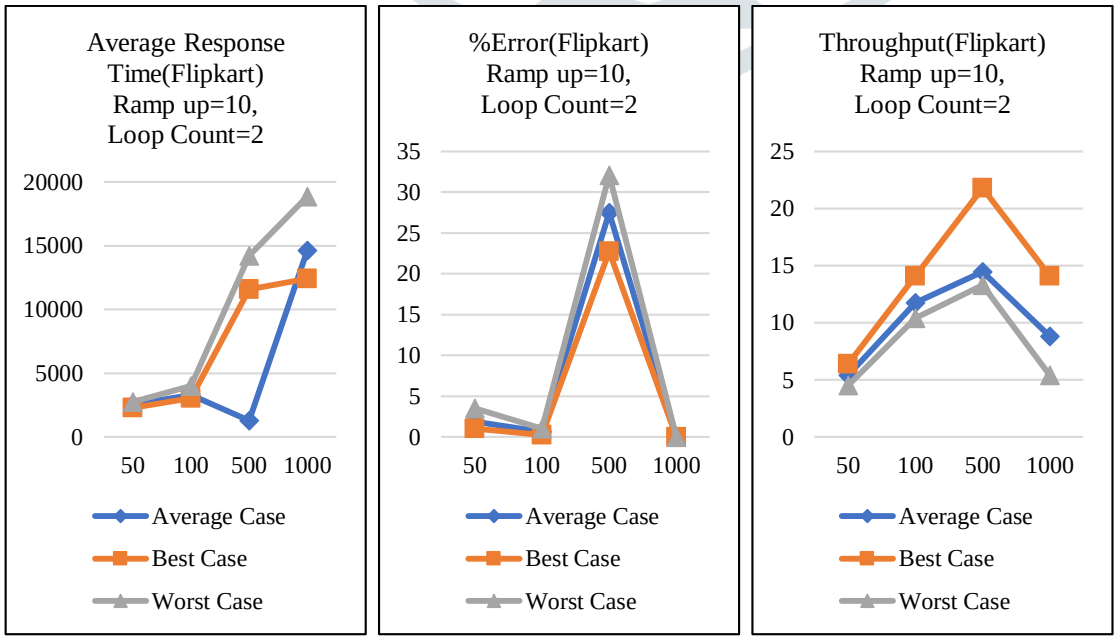

Figure 29: Performance testing results for Flipkart.com with Ramp-Up Period= 10 and Loop Count=2

The %error remains negligible for 1000 threads at loop count 2 and ramp-up period of 10 seconds while it is high for 500 threads as it can be seen in figure 33. For 1000 threads the throughput for loop count as 2 drops as compared to the throughput in figure 32 for loop ramp-up time of 5 seconds. The response time on the other hand does not show significant change.

6.1.3 Performance Testing Results for Ajio.com

For Ajio.com the performance test results can be seen in Figure 34 to 39.

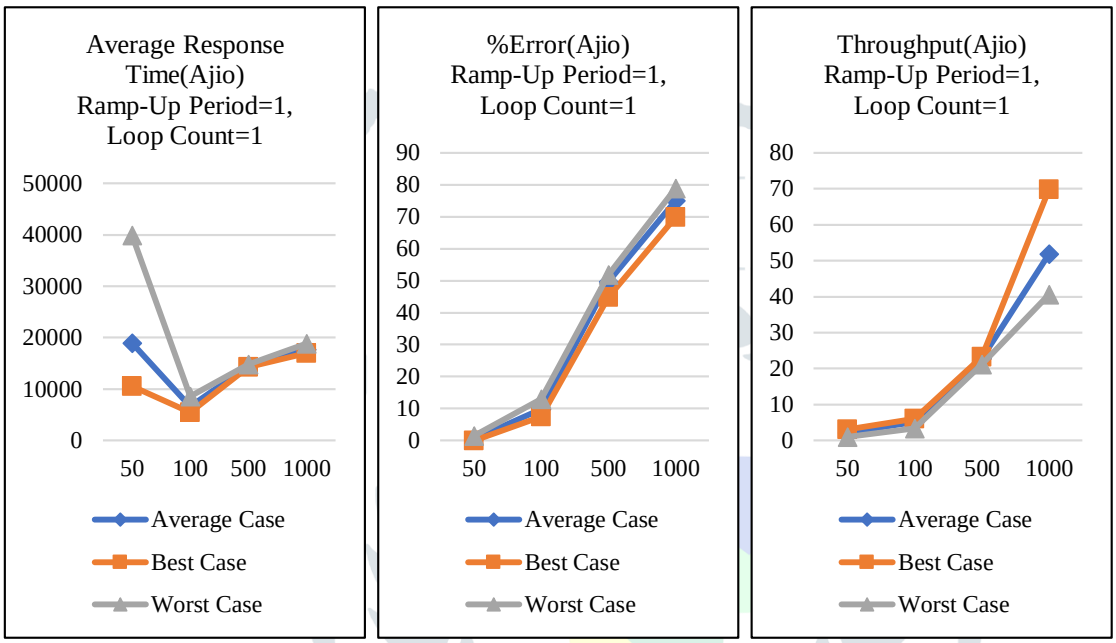

Figure 30: Performance Testing Results for Ajio.com with Ramp-Up Period and Loop Count as 1.

It can be seen in Figure 30 when the ramp-up period is set as 1 second and Loop Count as 1 it is observed that the average response time is higher at first and then it decreases after which response time is higher as the users on the web application increase. The Error responses increase sharply as the burden on the website increases on the other hand the throughput grows and it is the highest when the number of users reaches 1000.

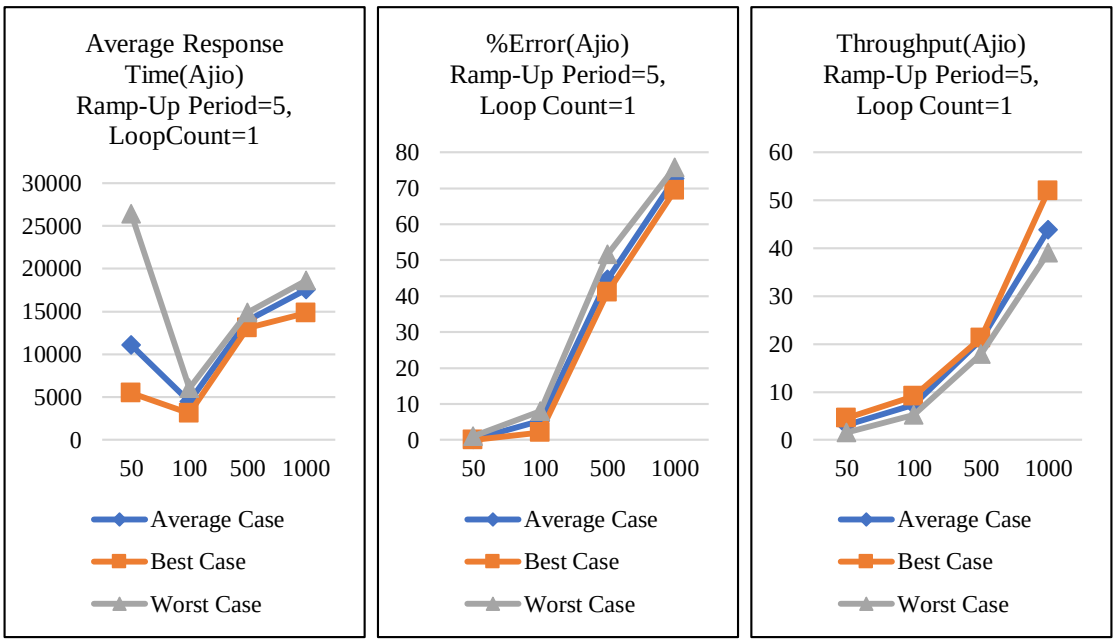

Figure 31: Performance Testing Results for Ajio.com with Ramp-Up Period=5 and Loop Count=1.

Increased ramp-up period of 5 seconds leads to a slight improvement in the number of successful requests as the %error drops somewhat. The throughput value drops in this case when compared to the test scenario in figure 31.

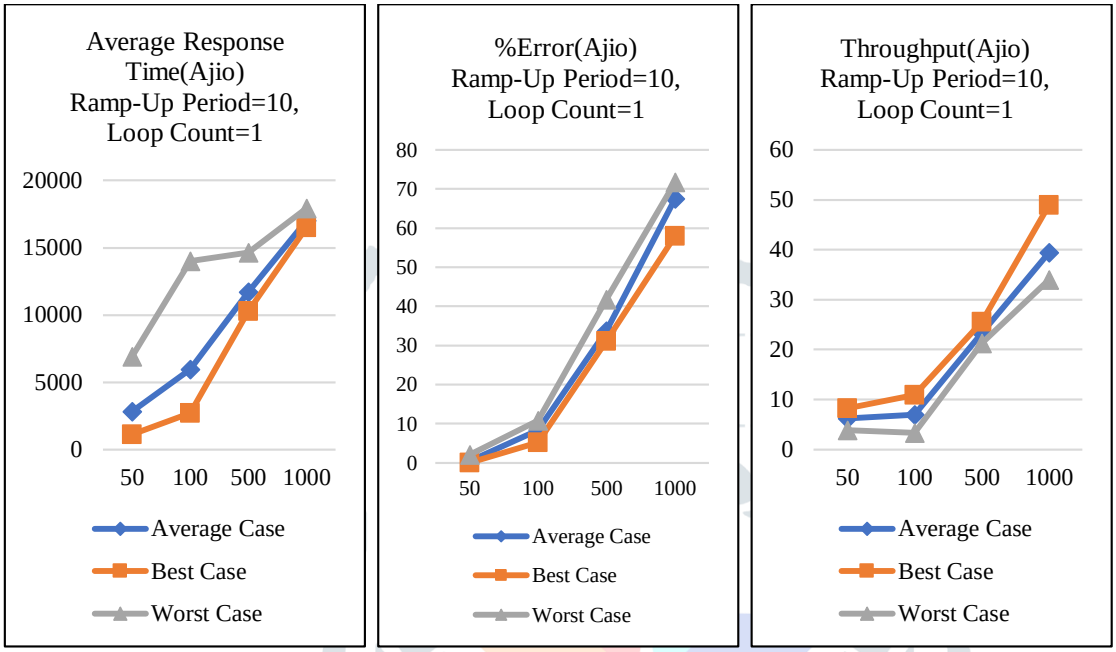

Figure 32: Performance Testing Results for Ajio.com with Ramp-Up Period=10 and Loop Count=1.

As the Loop count is changed and increased to 2 in the Figure 32 it can be seen that the Average Response Time, Error as well as the Throughput rises with respect to number of threads. Throughput value decreased slightly for 1000 users when ramp-up period incremented to 10 seconds from 5 seconds. %error also shows a dip whereas the throughput decreases for 1000 threads.

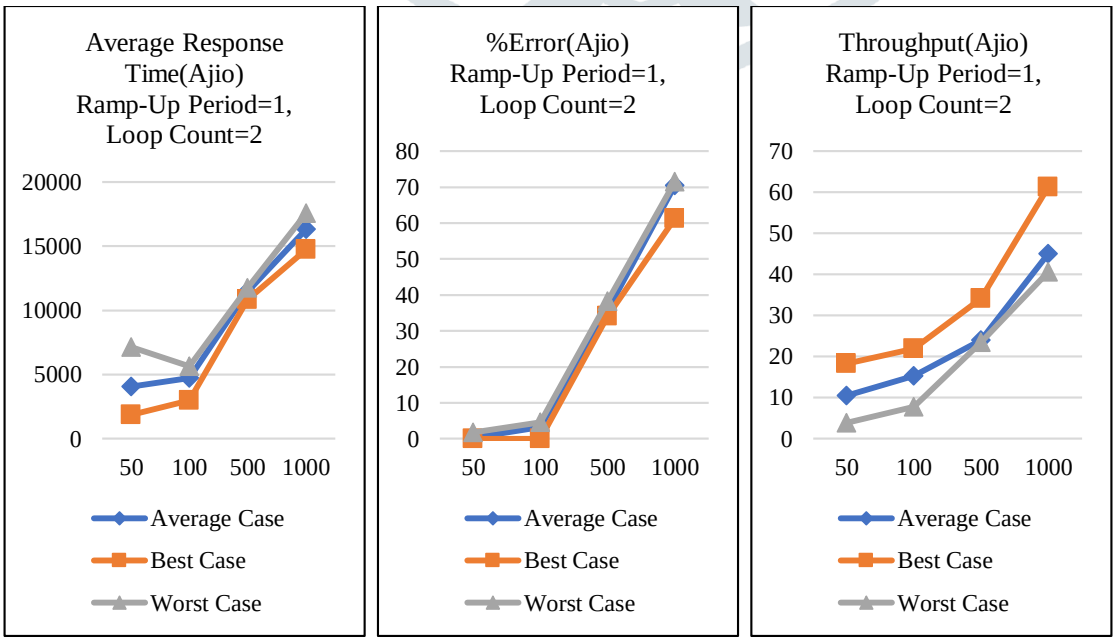

Figure 33: Performance Testing Results for Ajio.com with Ramp-Up Period=1 and Loop Count=2.

With loop count of 2 and ramp-up period of 1 second there is a slight decrease in the average response time when compared to the average response time recorded for loop count of 1 in figure 33.

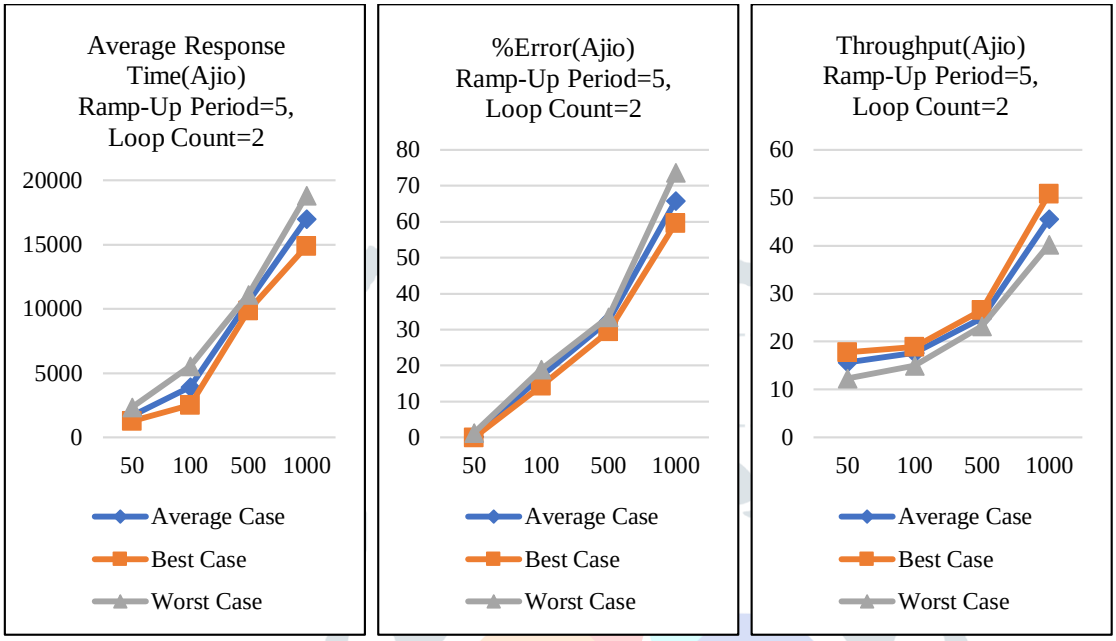

Figure 34: Performance Testing Results for Ajio.com with Ramp-Up Period=5 and Loop Count=2.

Figure 34 depicts that faster responses are obtained by the users when the loop count is incremented to 2. The average response time is greater in case of lower loop count of 1 as seen in figure 31. Also, the number of successful requests is also higher as the %error drops slightly. More number of users can access the web application as the throughput value increased slightly in contrast to the throughput in case of lower ramp-up period for 1000 threads.

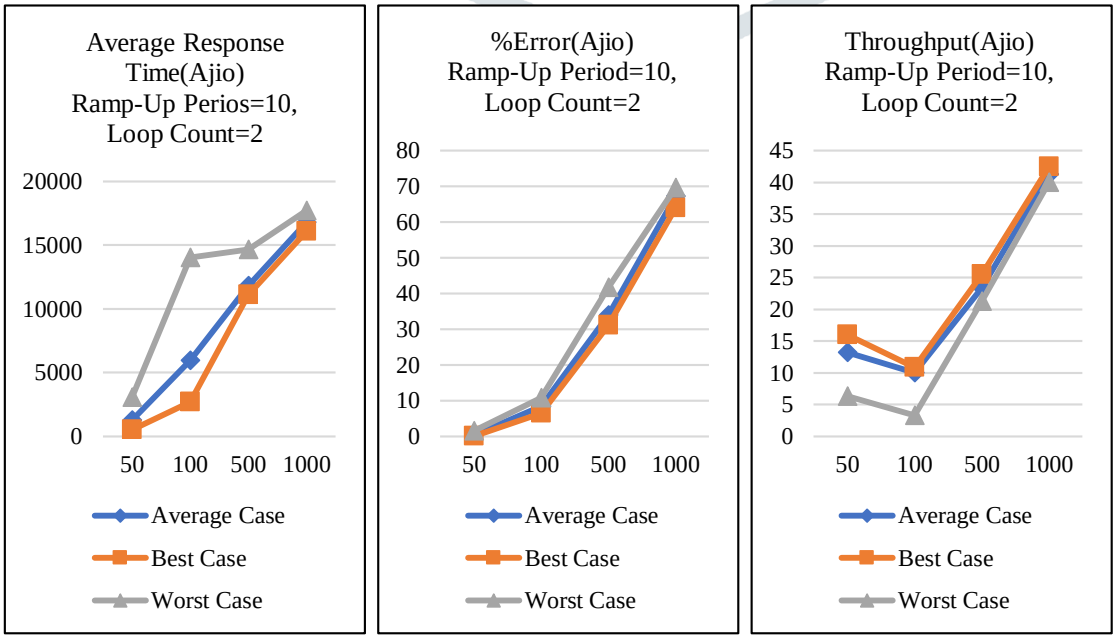

Figure 35: Performance Testing Results for Ajio.com with Ramp-Up Period=10 and Loop Count=2.

Figure 35 portrays the variation of performance parameters obtained for loop count of 2 and ramp-up period of 10 seconds. It can be understood that for 1000 threads the %error, average response time as well as throughput very minute change in the parameter values is recorded with respect to the test scenario in the ramp-up period is 5 seconds and loop count is 2.

IV. CONCLUSIONS

Implementing effective performance testing strategies for web applications can benefit e-commerce businesses in several ways. Firstly, it can help to identify and address system vulnerabilities that could lead to financial losses due to temporary unavailability of the system for customers. Secondly, it can improve the quality of web applications by ensuring that they meet productivity requirements. Thirdly, it can help businesses to scale their software products further by identifying areas that need improvement. Finally, performance testing using open-source tools can significantly reduce costs for small and medium-sized enterprises.
Further, web developers can use existing resting methodologies and tools to help elevate the quality of their web applications to an acceptable level of satisfaction. By implementing a well-studied testing plan, developers can ensure that their web applications are thoroughly tested and free from error or bugs that could negatively impact user experience.
The Meta-Data Analysis for E-Commerce Web-Applications performed in this dissertation gives insights into the scenarios for which a particular web-application would give finest performance. This can help e-commerce businesses to realize the circumstances under which the web-application performs well and also discover the scenarios under which the performance degrades. Also, optimization of the web-application can be done after comprehending whys and wherefores for tainted performance.

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