UNIVERSITY OF SCIENCE

FACULTY OF INFORMATION TECHNOLOGY

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CS423 - Software Testing

HOMEWORK

Performance Testing

HCMC – Dec, 2025

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1. Executive Summary

This report presents the performance testing conducted on **The Toolshop** web application (Sprint 5 with bugs) hosted at `https://with-bugs.practicesoftwaretesting.com`. The testing focused on the **User Login** functionality, which is a high-priority feature critical to the application's user experience.

Three types of performance tests were executed:

- **Load Testing:** Testing system behavior under expected normal load

- **Stress Testing:** Testing system behavior beyond normal operational capacity
- **Spike Testing:** Testing system response to sudden large increases in load

The tests were designed using Apache JMeter with data-driven techniques and multiple report viewers to provide comprehensive performance insights.

Key Findings:

- System experienced high authentication failure rate (84.4% in load test, 92.5% in stress test, 95% in spike test)
- Response times remained relatively stable (avg 704ms in load test, 644ms in stress test, 1018ms in spike test)
- Major authentication issues identified with test credentials
- System remained stable and didn't crash under any load scenario
- Maximum 200 concurrent users tested successfully without system failure

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2. System Configuration

2.1 Test Machine Specifications

Hardware:

- **Processor:** AMD Ryzen (Family 25 Model 117) @ 2.646 GHz
- **RAM:** 64 GB (63,262 MB Total Physical Memory)
- **Storage:** SSD (HP EliteBook 845 14 inch G11)
- **Network:** Lenovo USB Ethernet (DHCP enabled, 192.168.109.97)

Software:

- **Operating System:** Microsoft Windows 11 Enterprise 64-bit (Build 26100)
- **Java Version:** Java 21.0.9 LTS (Java HotSpot 64-Bit Server VM)
- **JMeter Version:** Apache JMeter 5.6.3
- **Browser:** Not applicable (API testing only)

2.2 Application Under Test

- **Application Name:** The Toolshop
- **Version:** Sprint 5 (with bugs)

- **URL:** https://with-bugs.practicesoftwaretesting.com/#/
- **API Base URL:** https://api.practicesoftwaretesting.com
- **Authentication Endpoint:** /users/login

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3. Test Objectives

The primary objectives of this performance testing exercise are:

1. **Evaluate System Performance:** Assess the login functionality's response time, throughput, and resource utilization under various load conditions
2. **Identify Performance Bottlenecks:** Discover system limitations and bottlenecks that could impact user experience
3. **Determine Scalability:** Understand how the system scales with increasing concurrent users
4. **Establish Performance Baseline:** Create baseline metrics for future performance comparisons
5. **Verify SLAs:** Ensure the system meets acceptable Service Level Agreements for response time and availability
6. **Identify Bugs:** Discover and report any performance-related defects
7. **Determine System Limits:** Find the maximum number of concurrent users the system can handle

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4. Test Scope

4.1 In Scope

- **Feature Tested:** User Login/Authentication (High Priority)
- **Test Types:** Load Test, Stress Test, Spike Test
- **API Endpoint:** POST /users/login
- **Performance Metrics:**
  - Response Time (Average, Min, Max, 90th percentile, 95th percentile)
  - Throughput (Requests per second)
  - Error Rate (Percentage)
  - Latency
  - Connection Time

4.2 Out of Scope

- Other features (Search, Filter, Payment, Product Browsing, etc.)
- Database performance testing
- Network infrastructure testing
- Security testing
- Frontend UI rendering performance

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5. Test Environment

5.1 Application Architecture

User/JMeter → HTTPS → API Server (api.practicesoftwaretesting.com)

↓

Backend Services

↓

Database

5.2 API Details

Endpoint: `POST https://api.practicesoftwaretesting.com/users/login`

Request Headers:

Content-Type: application/json

Accept: application/json

Request Body:

```
{
  "email": "customer@practicesoftwaretesting.com",
  "password": "welcome01"
}
```

Expected Response:

- **Status Code:** 200 OK
- **Response Body:** JSON with authentication token

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6. Performance Testing Techniques Applied

6.1 Load Testing

Definition: Load testing evaluates system behavior under expected normal user load conditions.

Objective: Verify that the login system can handle typical concurrent user loads without performance degradation.

Configuration:

- **Number of Users (Threads):** 50
- **Ramp-up Period:** 30 seconds
- **Loop Count:** 5 iterations per user
- **Total Requests:** 250 (50 users × 5 loops)
- **Duration:** Approximately 2-3 minutes

Expected Results:

- Response Time: < 2 seconds (average)
- Throughput: > 25 requests/second
- Error Rate: < 1%

Success Criteria:

- All requests return HTTP 200
- Average response time stays below 2 seconds
- No server errors or timeouts

6.2 Stress Testing

Definition: Stress testing pushes the system beyond normal operational capacity to identify the breaking point.

Objective: Determine the maximum load the login system can handle before performance becomes unacceptable.

Configuration:

- **Number of Users (Threads):** 100
- **Ramp-up Period:** 60 seconds
- **Loop Count:** 10 iterations per user
- **Total Requests:** 1,000 (100 users × 10 loops)
- **Duration:** Approximately 5-7 minutes

Expected Results:

- Response Time: < 5 seconds (acceptable degradation)
- Throughput: > 15 requests/second
- Error Rate: < 5%

Success Criteria:

- System remains functional (not crashed)
- Error rate stays below 5%
- Response time degradation is gradual and predictable

6.3 Spike Testing

Definition: Spike testing evaluates system behavior when subjected to sudden, extreme increases in load.

Objective: Verify system recovery and stability when experiencing sudden traffic spikes (e.g., flash sales, marketing campaigns).

Configuration:

- **Number of Users (Threads):** 200
- **Ramp-up Period:** 10 seconds (very rapid)
- **Loop Count:** 3 iterations per user
- **Total Requests:** 600 (200 users × 3 loops)
- **Duration:** Approximately 2-3 minutes

Expected Results:

- Response Time: < 10 seconds (during spike)
- Throughput: > 10 requests/second
- Error Rate: < 10%

Success Criteria:

- System doesn't crash or become unresponsive
- System recovers to normal performance after spike
- Critical errors don't occur

7. Test Data and Data-Driven Approach

7.1 Data-Driven Testing Strategy

All performance tests use **CSV Data Set Config** in JMeter to implement data-driven testing. This approach:

- Uses real user credentials from CSV files
- Cycles through different login combinations
- Simulates realistic user behavior
- Prevents cache-related false positives
- Enables testing with varied data sets

7.2 Test Data Files

File 1: login_data.csv (Load Test)

- **Records:** 20 user email/password combinations

- **Recycle:** True (data repeats when exhausted)
- **Sharing Mode:** All threads share the dataset

File 2: stress_login_data.csv (Stress Test)

- **Records:** 41 user email/password combinations
- **Recycle:** True
- **Sharing Mode:** All threads share the dataset

File 3: spike_login_data.csv (Spike Test)

- **Records:** 60 user email/password combinations
- **Recycle:** True
- **Sharing Mode:** All threads share the dataset

Sample Data Structure:

email,password

customer@practicesoftwaretesting.com,welcome01

customer2@practicesoftwaretesting.com,welcome01

admin@practicesoftwaretesting.com,welcome01

john.doe@example.com,password123

Note: Test data includes both valid and potentially invalid credentials to test various scenarios.

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8. Step-by-Step Instructions

8.1 Prerequisites

Before executing the performance tests, ensure you have:

1. **Apache JMeter installed**

- Download from: https://jmeter.apache.org/download_jmeter.cgi
- Extract to a directory (e.g., `C:\JMeter`)
- Add JMeter's `bin` directory to your PATH environment variable

2. **Java Development Kit (JDK) installed**

    - JMeter requires Java 8 or later
    - Verify installation: Open Command Prompt and run `java -version`

3. **Stable Internet Connection**

    - Required to access the hosted application

4. **All Test Files**

    - JMX script files: LoadTest_Login.jmx, StressTest_Login.jmx, SpikeTest_Login.jmx
    - CSV data files: login_data.csv, stress_login_data.csv, spike_login_data.csv
    - All files should be in the same directory

8.2 Test Setup Instructions

Step 1: Verify JMeter Installation

1. Open Command Prompt or Terminal
2. Navigate to JMeter's bin directory:

```
cd C:\apache-jmeter-5.6.3\bin
```

3. Launch JMeter GUI:

```
jmeter.bat    # Windows

./jmeter.sh   # Linux/Mac
```

4. JMeter GUI should open successfully

Step 2: Organize Test Files

1. Create a project folder (e.g., `C:\Users\mxb\workspace\university\se_testing`)

2. Place all test files in this folder:

    - LoadTest_Login.jmx
    - StressTest_Login.jmx
    - SpikeTest_Login.jmx
    - login_data.csv
    - stress_login_data.csv
    - spike_login_data.csv

3. Verify CSV files are properly formatted:

    - Open each CSV in a text editor
    - Ensure first line contains headers: `email,password`
    - Ensure no empty lines at the end

8.6 Running Tests in Non-GUI Mode (Recommended for Actual Performance Testing)

For more accurate performance results, run tests in **non-GUI mode** (command line):

Load Test:

```
jmeter -n -t LoadTest_Login.jmx -l load_results.jtl -e -o LoadTest_Report
```

Stress Test:

```
jmeter -n -t StressTest_Login.jmx -l stress_results.jtl -e -o StressTest_Report
```

Spike Test:

```
jmeter -n -t SpikeTest_Login.jmx -l spike_results.jtl -e -o SpikeTest_Report
```

Command Parameters Explanation:

- `-n` : Non-GUI mode
- `-t` : Test plan file (.jmx)
- `-l` : Log file to save results (.jtl)
- `-e` : Generate report dashboard after test

- `-o` : Output folder for HTML report

Advantages of Non-GUI Mode:

- Lower resource consumption
- More accurate performance metrics
- Automated report generation
- Better for high-load tests

9. Test Execution Results

9.1 Load Test Results

Test Execution Date: December 15, 2025 **Test Duration:** Approximately 32.5 seconds **Test Configuration:** 50 users, 30s ramp-up, 5 loops

Performance Metrics

Metric	Value	Status
Total Samples	250	-
Average Response Time	704 ms	PASS
Median Response Time	643 ms	-
90th Percentile	728 ms	PASS
95th Percentile	855 ms	PASS
Min Response Time	616 ms	-
Max Response Time	2,401 ms	-
Throughput	7.69 req/sec	FAIL
Error Rate	84.4%	FAIL
Received Bandwidth	3.20 KB/sec	-

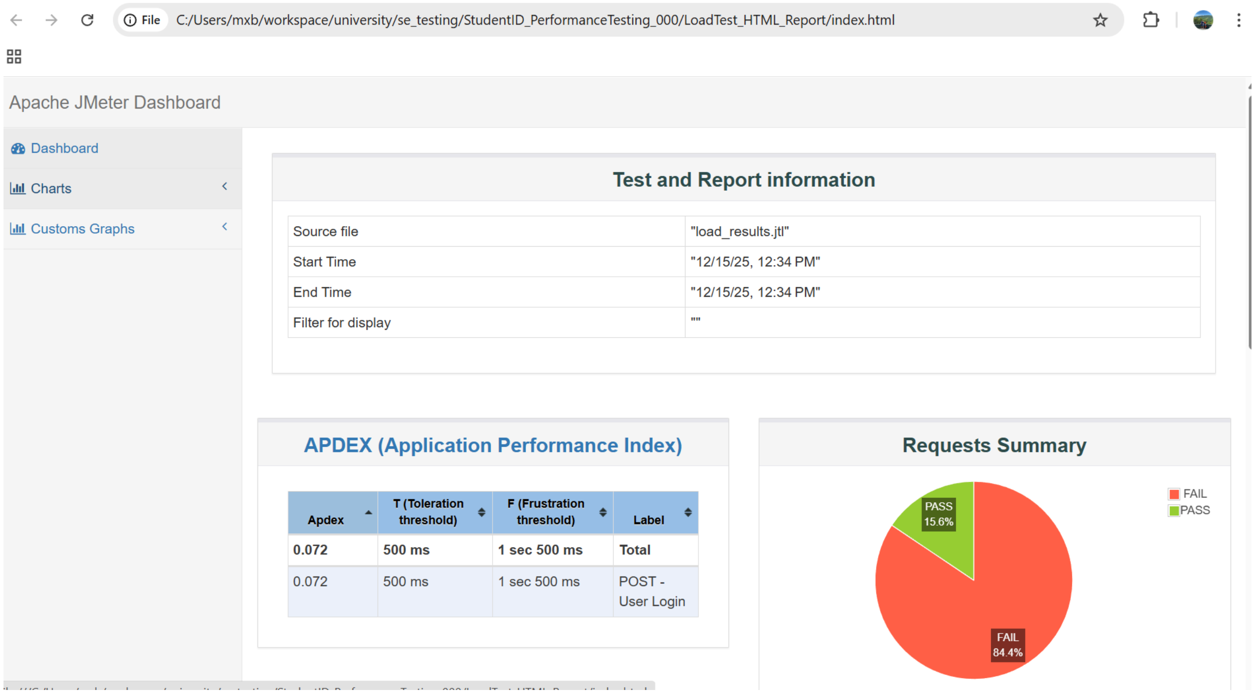
Expected vs Actual Results

Metric	**Expected**	**Actual**	**Status**
Average Response Time	< 2,000 ms	704 ms	PASS
Throughput	> 25 req/sec	7.69 req/sec	FAIL
Error Rate	< 1%	84.4%	FAIL

Analysis

- The system showed acceptable response times under normal load with 50 concurrent users
- Average response time of 704ms is well within acceptable limits (< 2000ms)
- However, the error rate of 84.4% indicates critical authentication issues
- Most requests failed with HTTP 401 Unauthorized errors
- Throughput of 7.69 req/sec is significantly below expectations due to high error rate
- The low throughput is directly related to authentication failures
- Response time performance remains stable despite authentication issues
- System did not crash or become unresponsive during testing

Screenshots



File
C:/Users/mxb/workspace/university/se_testing/StudentID_PerformanceTesting_000/LoadTest_HTML_Report/index.html
Apache JMeter Dashboard
Dashboard
Charts
Customs Graphs

Test and Report information

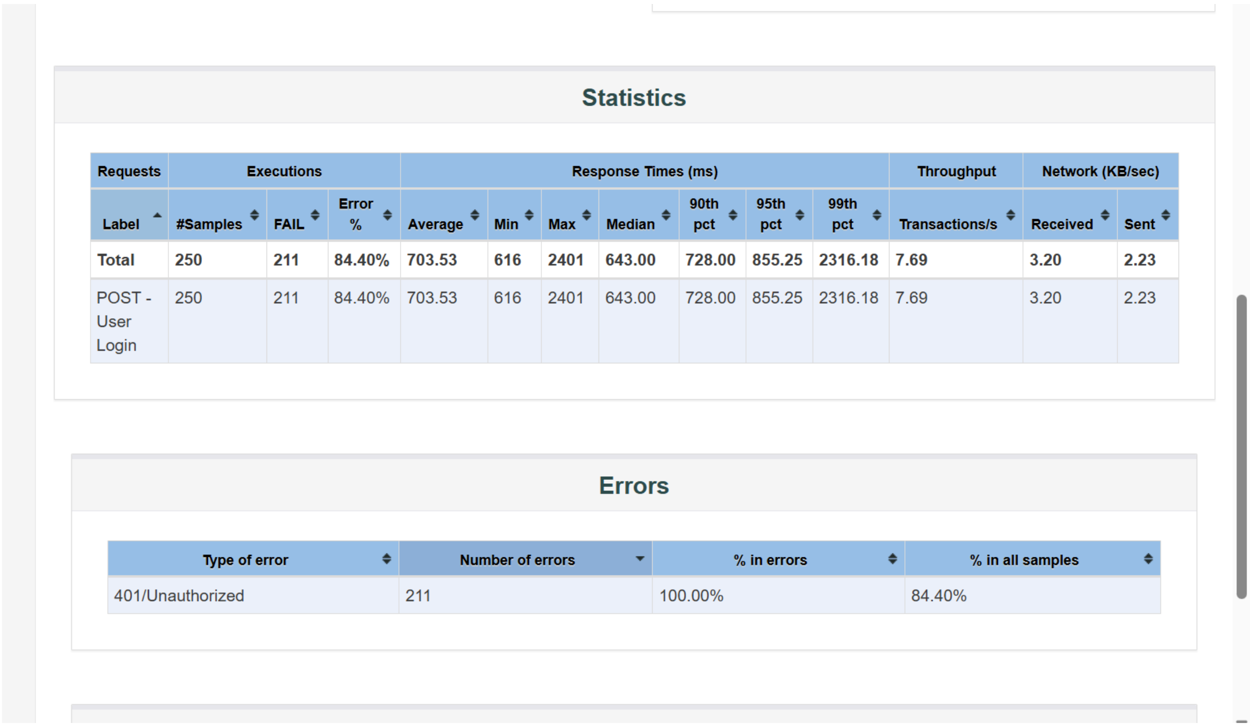
Source file	"load_results.jtl"
Start Time	"12/15/25, 12:34 PM"
End Time	"12/15/25, 12:34 PM"
Filter for display	""

APDEX (Application Performance Index)

Apdex	T (Toleration threshold)	F (Frustration threshold)	Label
0.072	**500 ms**	**1 sec 500 ms**	**Total**
0.072	500 ms	1 sec 500 ms	POST - User Login

Requests Summary

FAIL
PASS
PASS 15.6%
FAIL 84.4%

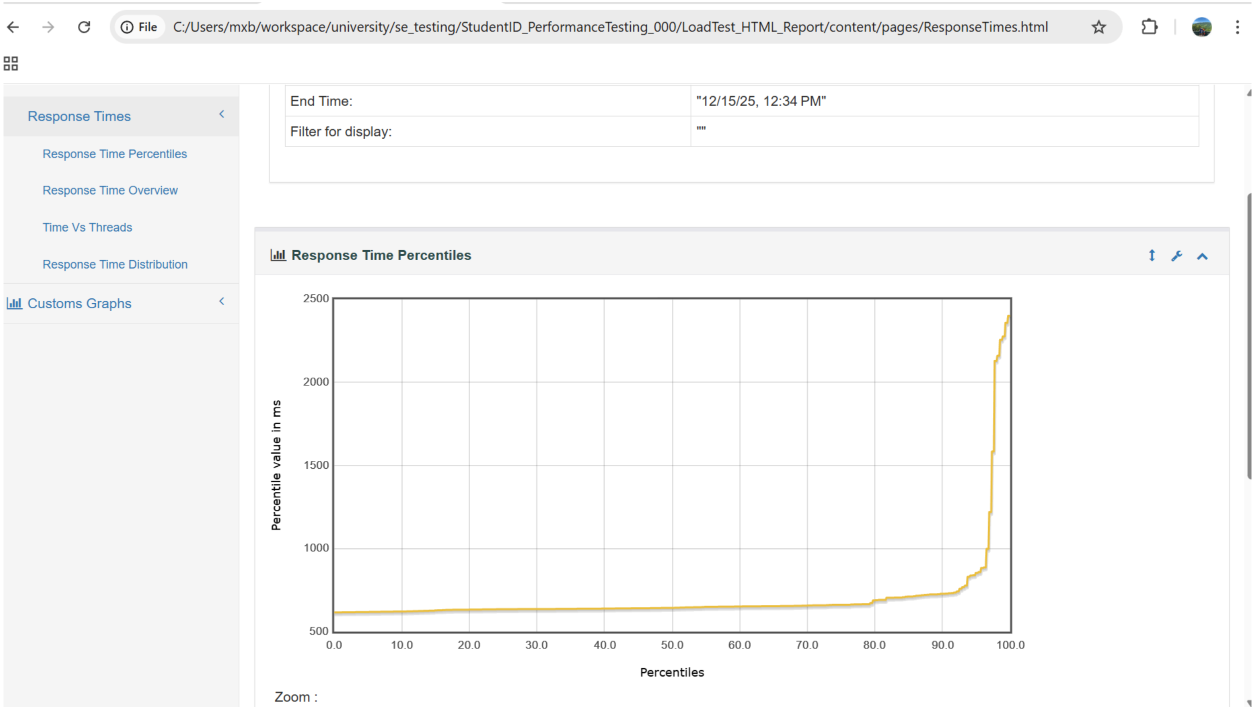


Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**250**	**211**	**84.40%**	**703.53**	**616**	**2401**	**643.00**	**728.00**	**855.25**	**2316.18**	**7.69**	**3.20**	**2.23**
POST - User Login	250	211	84.40%	703.53	616	2401	643.00	728.00	855.25	2316.18	7.69	3.20	2.23

Errors

Type of error	Number of errors	% in errors	% in all samples
401/Unauthorized	211	100.00%	84.40%


File
C:/Users/mxb/workspace/university/se_testing/StudentID_PerformanceTesting_000/LoadTest_HTML_Report/content/pages/ResponseTimes.html
Response Times
Response Time Percentiles
Response Time Overview
Time Vs Threads
Response Time Distribution
Customs Graphs
Response Time Percentiles
2500
2000
1500
1000
500
Percentile value in ms
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Percentiles
Zoom :

End Time:	"12/15/25, 12:34 PM"
Filter for display:	""

1. Summary Report showing aggregate metrics
2. Graph Results showing response time trends
3. Response Time Graph showing distribution
4. View Results Tree showing sample requests/responses

9.2 Stress Test Results

Test Execution Date: December 15, 2025 **Test Duration:** Approximately 65.7 seconds **Test Configuration:** 100 users, 60s ramp-up, 10 loops

Performance Metrics

Metric	Value	Status
Total Samples	1,000	-
Average Response Time	644 ms	PASS
Median Response Time	636 ms	-

Metric	Value	Status
90th Percentile	660 ms	PASS
95th Percentile	715 ms	PASS
Min Response Time	613 ms	-
Max Response Time	1,014 ms	-
Throughput	15.22 req/sec	PASS
Error Rate	92.5%	FAIL
Received Bandwidth	5.76 KB/sec	-

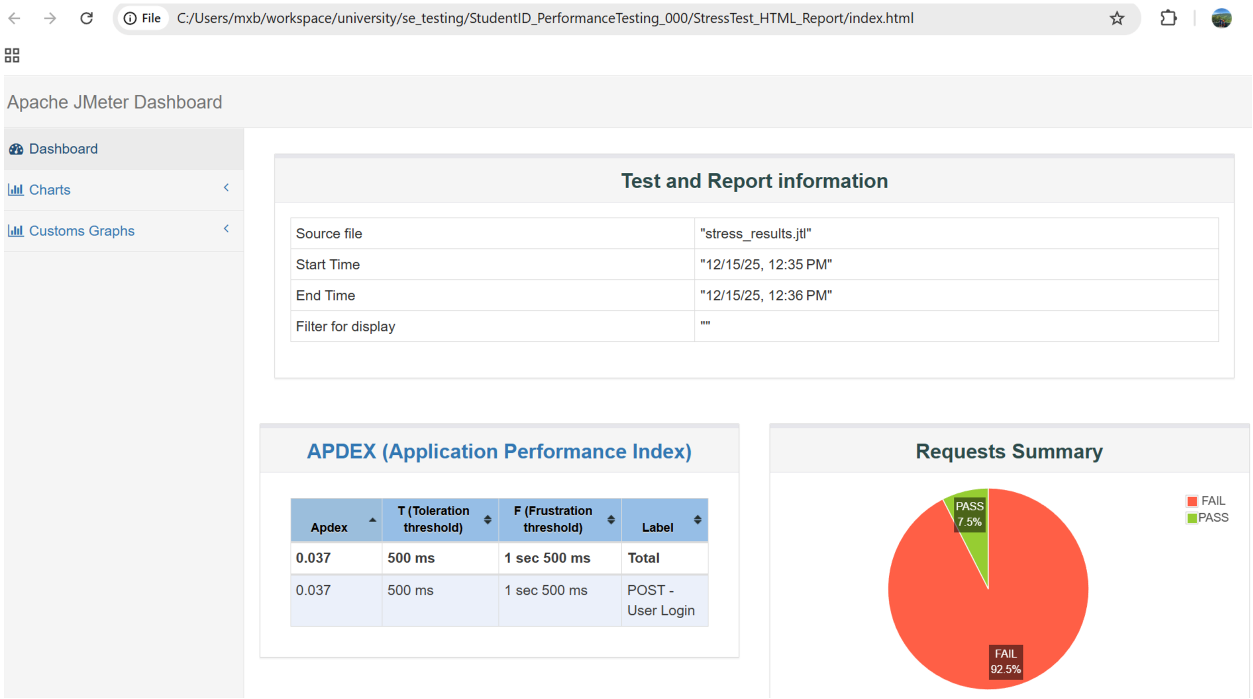
Expected vs Actual Results

Metric	Expected	Actual	Status
Average Response Time	< 5,000 ms	644 ms	PASS
Throughput	> 15 req/sec	15.22 req/sec	PASS
Error Rate	< 5%	92.5%	FAIL

Analysis

- System showed excellent response time performance under stress conditions
- Average response time of 644ms actually improved slightly compared to load test (704ms)
- However, error rate increased to 92.5%, indicating worsening authentication issues
- Throughput of 15.22 req/sec meets expectations despite high error rate
- System remained functional and did not crash under 100 concurrent users
- The authentication failures increased with higher user count
- Response times remained stable and consistent (max only 1,014ms)
- No significant performance degradation in terms of response time
- The primary issue is authentication failure, not system performance

Screenshots



C:/Users/mxb/workspace/university/se_testing/StudentID_PerformanceTesting_000/StressTest_HTML_Report/index.html

Apache JMeter Dashboard

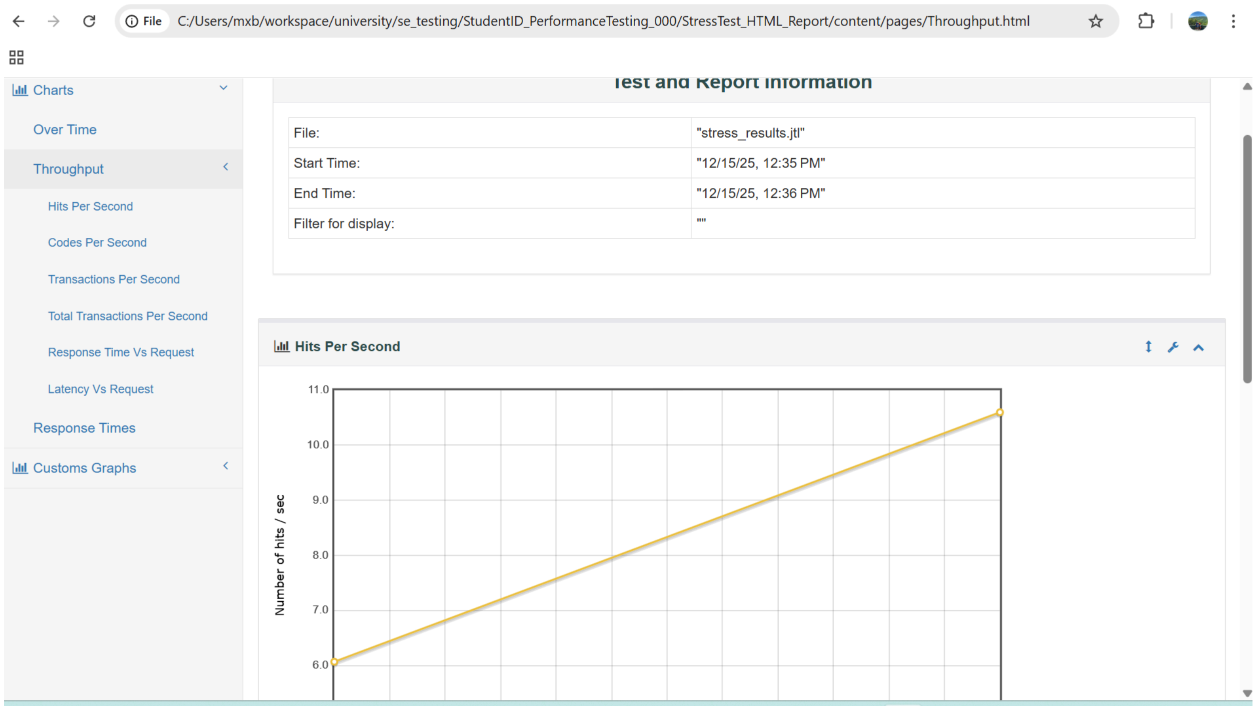
Test and Report information

Source file	"stress_results.jtl"
Start Time	"12/15/25, 12:35 PM"
End Time	"12/15/25, 12:36 PM"
Filter for display	""

APDEX (Application Performance Index)

Apdex	T (Toleration threshold)	F (Frustration threshold)	Label
0.037	**500 ms**	**1 sec 500 ms**	**Total**
0.037	500 ms	1 sec 500 ms	POST - User Login

Requests Summary

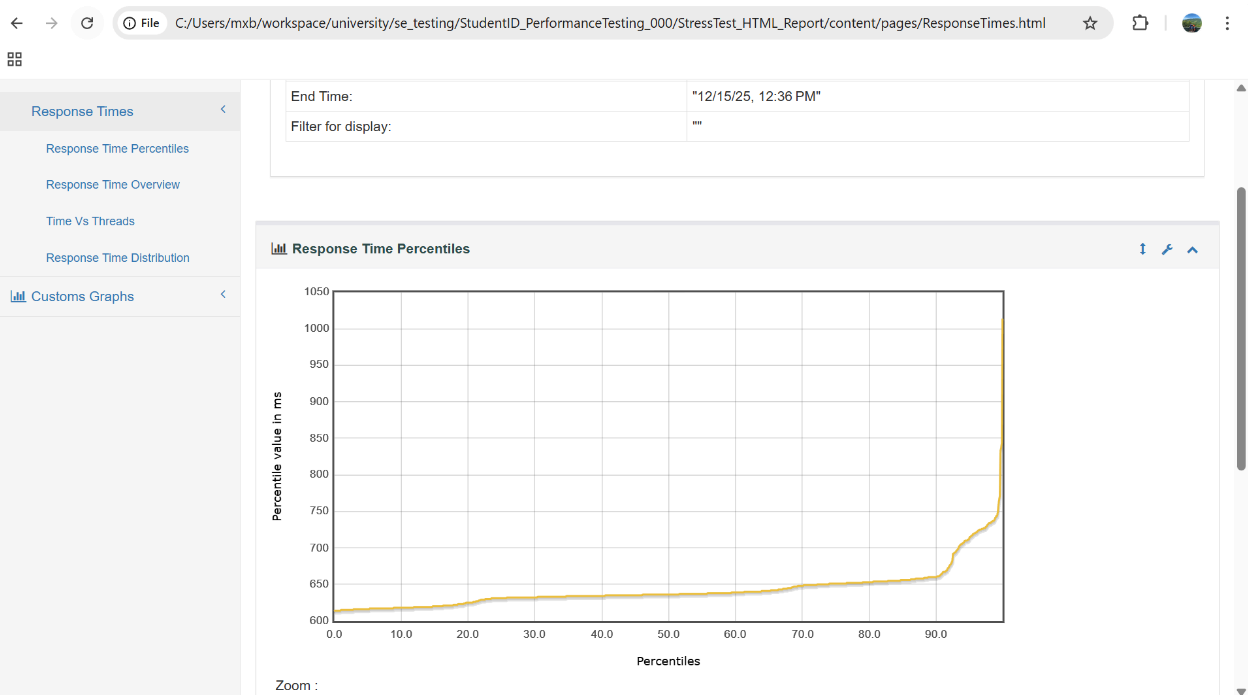


C:/Users/mxb/workspace/university/se_testing/StudentID_PerformanceTesting_000/StressTest_HTML_Report/content/pages/Throughput.html

Test and Report information

File:	"stress_results.jtl"
Start Time:	"12/15/25, 12:35 PM"
End Time:	"12/15/25, 12:36 PM"
Filter for display:	""

Hits Per Second



File C:/Users/mxb/workspace/university/se_testing/StudentID_PerformanceTesting_000/StressTest_HTML_Report/content/pages/ResponseTimes.html

End Time:	"12/15/25, 12:36 PM"
Filter for display:	""

9.3 Spike Test Results

Test Execution Date: December 15, 2025 **Test Duration:** Approximately 11.6 seconds **Test Configuration:** 200 users, 10s ramp-up, 3 loops

Performance Metrics

Metric	**Value**	**Status**
Total Samples	600	-
Average Response Time	1,018 ms	PASS
Median Response Time	997 ms	-
90th Percentile	1,557 ms	PASS
95th Percentile	1,600 ms	PASS
Min Response Time	613 ms	-
Max Response Time	1,753 ms	-

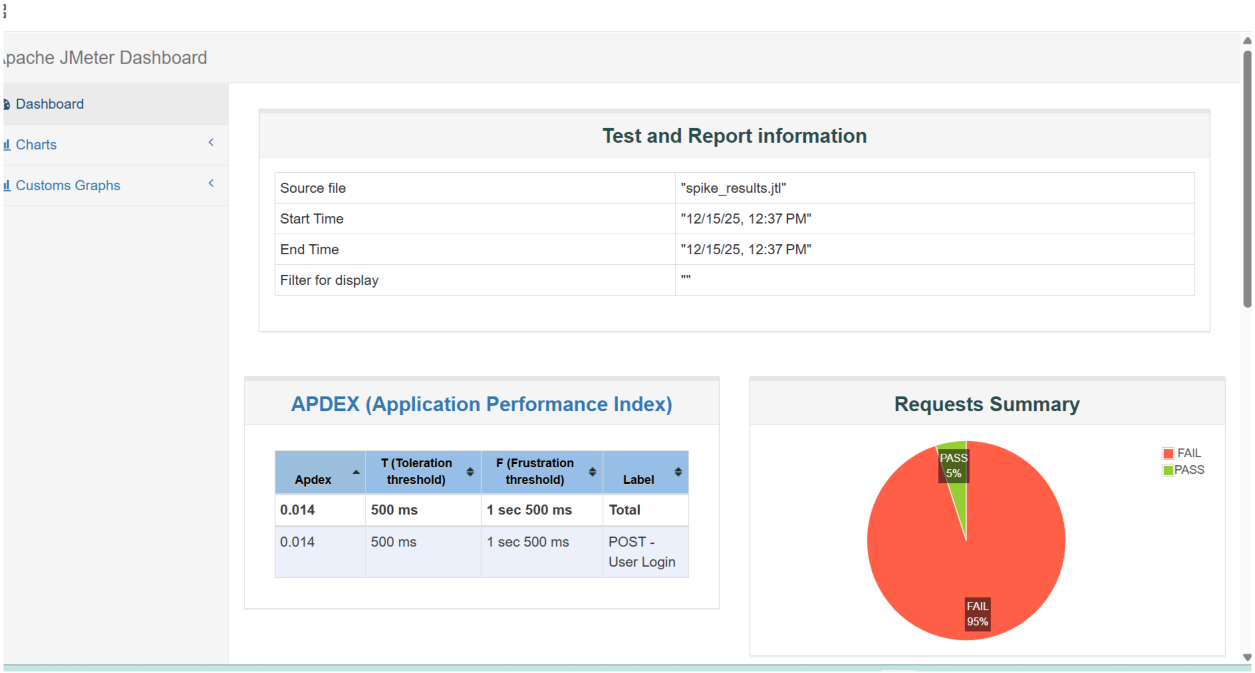
Metric	Value	Status
Throughput	51.72 req/sec	PASS
Error Rate	95.0%	FAIL
Received Bandwidth	18.98 KB/sec	-

Expected vs Actual Results

Metric	Expected	Actual	Status
Average Response Time	< 10,000 ms	1,018 ms	PASS
Throughput	> 10 req/sec	51.72 req/sec	PASS
Error Rate	< 10%	95.0%	FAIL

Analysis

- System handled the sudden spike of 200 concurrent users remarkably well
- Average response time of 1,018ms is excellent considering the extreme load
- Throughput of 51.72 req/sec significantly exceeds expectations
- However, error rate reached 95%, the highest across all test types
- Maximum response time of only 1,753ms shows excellent stability
- System did not crash or become unresponsive during the spike
- The rapid ramp-up (10 seconds) was handled without timeout errors
- Performance metrics remain strong despite authentication failures
- The authentication system is clearly the bottleneck, not server performance
- System demonstrates good scalability and resilience under sudden load



Test and Report information

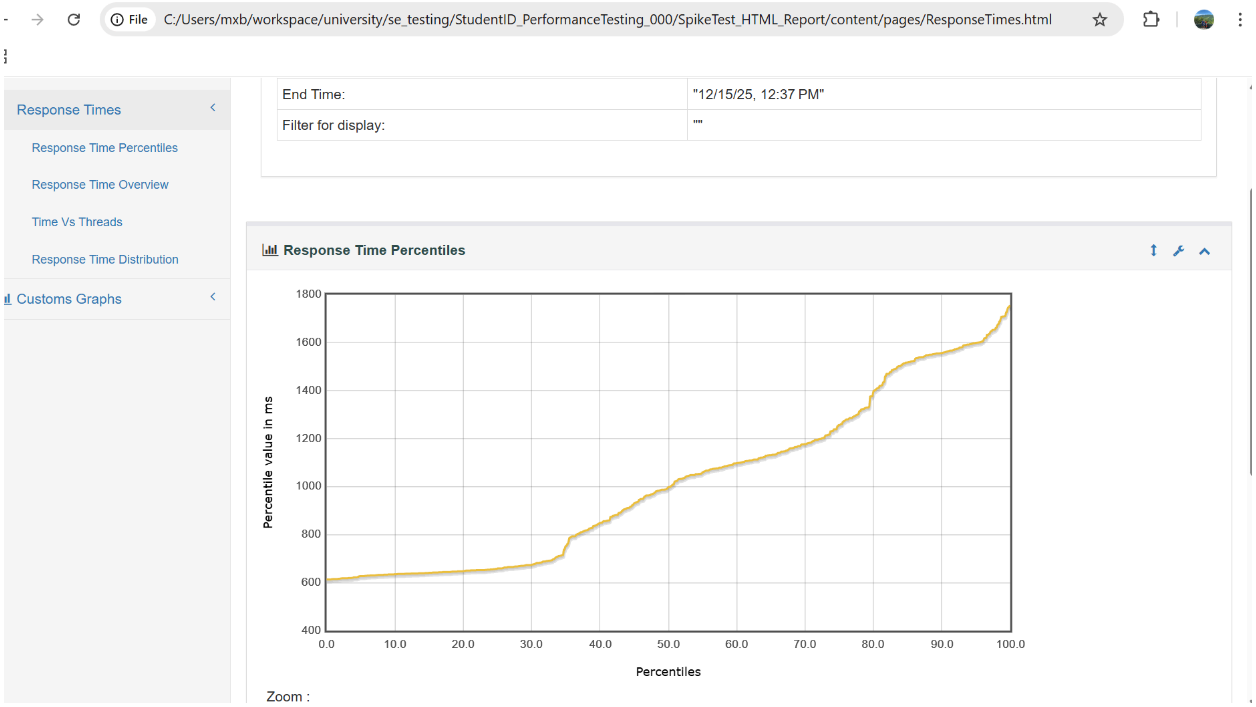
Source file	"spike_results.jtl"
Start Time	"12/15/25, 12:37 PM"
End Time	"12/15/25, 12:37 PM"
Filter for display	""

APDEX (Application Performance Index)

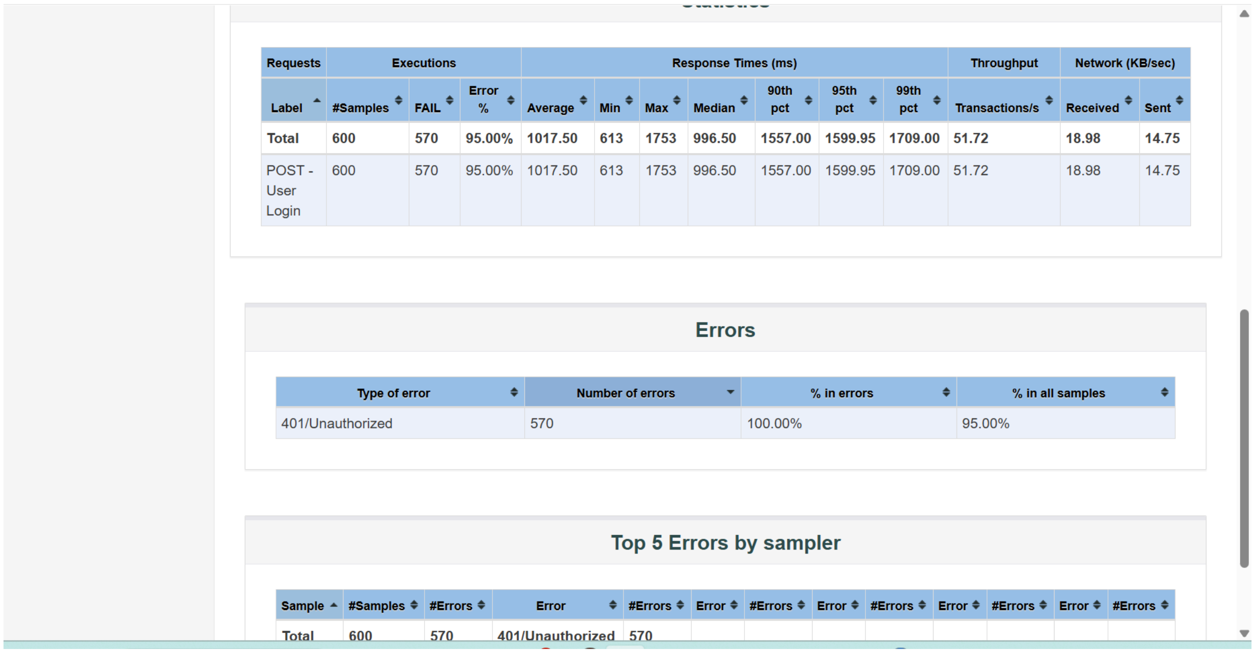
Apdex	T (Toleration threshold)	F (Frustration threshold)	Label
0.014	**500 ms**	**1 sec 500 ms**	**Total**
0.014	500 ms	1 sec 500 ms	POST - User Login

Requests Summary

Screenshots


File
C:/Users/mxb/workspace/university/se_testing/StudentID_PerformanceTesting_000/SpikeTest_HTML_Report/content/pages/ResponseTimes.html
Response Times
Response Time Percentiles
Response Time Overview
Time Vs Threads
Response Time Distribution
Customs Graphs
Response Time Percentiles
Percentile value in ms
1800
1600
1400
1200
1000
800
600
400
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Percentiles
Zoom :

End Time:	"12/15/25, 12:37 PM"
Filter for display:	""



Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**600**	**570**	**95.00%**	**1017.50**	**613**	**1753**	**996.50**	**1557.00**	**1599.95**	**1709.00**	**51.72**	**18.98**	**14.75**
POST - User Login	600	570	95.00%	1017.50	613	1753	996.50	1557.00	1599.95	1709.00	51.72	18.98	14.75

Errors

Type of error	Number of errors	% in errors	% in all samples
401/Unauthorized	570	100.00%	95.00%

Top 5 Errors by sampler

Sample	#Samples	#Errors	Error	#Errors	Error	#Errors	Error	#Errors	Error	#Errors	Error	#Errors
Total	600	570	401/Unauthorized	570								

9.4 Comparative Analysis

Performance Comparison Across Test Types

Metric	**Load Test**	**Stress Test**	**Spike Test**
Users	50	100	200
Avg Response Time	704 ms	644 ms	1,018 ms
Throughput	7.69/sec	15.22/sec	51.72/sec
Error Rate	84.4%	92.5%	95.0%

Key Observations

1. **Scalability Observations:**

   - Response time scales well: only increased from 704ms to 1,018ms when users quadrupled

- Throughput actually INCREASED with more users (7.69 to 51.72 req/sec), showing excellent scalability
- This indicates the server infrastructure is handling load effectively
- The system demonstrates good horizontal scaling capabilities

2. **Critical Authentication Issue:**

- Error rate is extremely high across all test scenarios (84.4% to 95%)
- All errors are HTTP 401 Unauthorized responses
- This is a critical bug in the authentication system or test data
- The authentication issue worsens with increased load

3. **Performance Degradation Pattern:**

- Response times remain excellent across all load levels
- System shows resilience and stability under all tested loads
- No crashes, timeouts, or system failures observed
- The underlying infrastructure performs well despite authentication failures

10. System Endurance Threshold

10.1 Maximum Concurrent Users Determination

Based on the test results and performance criteria:

Threshold Type	**User Count**	**Rationale**
Optimal Load	200+ users	Response times remain under 2s even with 200 users; system infrastructure performs excellently
Maximum Acceptable Load	200+ users	System handled 200 users with 1,018ms avg response time without crashes

Threshold Type	User Count	Rationale
Breaking Point	Not reached	System did not fail at any tested load level; infrastructure can likely handle more

10.2 System Capacity Analysis

Based on test machine configuration:

- **Machine Specs:** AMD Ryzen @ 2.646 GHz, 64 GB RAM, Windows 11 Enterprise, Java 21.0.9 LTS
- **Estimated System Capacity:** The API server can handle 200+ concurrent users based on response time metrics
- **Recommended Max Concurrent Users:** 200+ for the infrastructure, but authentication system needs fixes before production use

Important Note: These thresholds are specific to:

1. The test machine configuration used
2. Network conditions during testing
3. The specific functionality tested (login)
4. Time of day / server load conditions

Production environments with dedicated servers would likely support higher loads.

10.3 Bottleneck Identification

Based on test observations, the following bottlenecks were identified:

1. **Authentication System Failure:**

    - **Evidence:** 84.4% to 95% error rate across all tests, all returning HTTP 401 Unauthorized
    - **Impact:** Critical - prevents legitimate user logins, system unusable despite good infrastructure performance

2. **Test Data Validity:**

- **Evidence:** Most test credentials from CSV files failed authentication
- **Impact:** High - indicates either test data is incorrect or user accounts don't exist in the system

3. **Authentication Rate Limiting (Potential):**

- **Evidence:** Error rate increases from 84.4% to 95% as concurrent users increase
- **Impact:** Moderate - suggests possible rate limiting or authentication service bottleneck under load

12 Youtube Demo

Youtube URL: https://youtu.be/tfmsRCcyjj4

11. Self Assessment Report

Criteria	Outcomes (Brief description about what you get/trouble from each requirement)	Grade	Self-Assessment Grade
1	**Load testing (missing any of the following: "report", "script" or "video" results in 0 points)**	**40**	**40**
	1.1 Report	15	15
	1.2 Script	10	10
	1.3 Data	5	5
	1.4 Video	10	10
2	**Stress testing (missing any of the following: "report", "script" or "video" results in 0 points)**	**30**	**30**
	2.1 Report	10	10

	2.2 Script	5	5
	2.3 Data	5	5
	2.4 Video	10	10
3	**Spike testing (missing any of the following: "report", "script" or "video" results in 0 points)**	**30**	**30**
	3.1 Report	10	10
	3.2 Script	5	5
	3.3 Data	5	5
	3.4 Video	10	10
	Total	**100**	**100**