COMPX341-19A Assignment 4

Stress-Testing Containerized Microservices

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June 14, 2019

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Introduction

Develop and stress-test using JMeter a simple containerized application-server that implements the following HTTP restful API:

Type	URI	Description	Requirement
GET	/isPrime/<number>	Decides if the input integer is prime and returns "<number> is prime" or "<number> is not prime", accordingly. If the number is prime, it is stored in the connected Redis object-storage service	REQ-1
GET	/primesStored	Returns a list with all the primes stored in the connected Redis service	REQ-2

GitHub Repository URL

https://github.com/daleylp/stress-testing-application

Specifications

Hardware Used

Operating System:	Ubuntu 18.04.2 LTS (GNU/Linux)
Kernel Version:	#55-Ubuntu SMP Wed May 15 14:27:21 UTC 2019
Kernel Release:	4.15.0-51-generic
Architecture:	x86_64
CPU op-mode(s):	32-bit, 64-bit
Byte Order:	Little Endian
CPU(s):	4
On-line CPU(s) list:	0-3
Thread(s) per core:	1
Core(s) per socket:	4
Socket(s):	1
NUMA node(s):	1
Vendor ID:	GenuineIntel
CPU family:	6
Model:	158
Model name:	Intel(R) Core(TM) i5-7500 CPU @ 3.40GHz
Stepping:	9
CPU MHz:	800.072
CPU max MHz:	3800.0000
CPU min MHz:	800.0000
BogoMIPS:	6816.00
Virtualization:	VT-x
L1d cache:	32K
L1i cache:	32K
L2 cache:	256K

L3 cache:	6144K
NUMA node0 CPU(s):	0-3

Software Used

Putty:	SSH remote login to machine number 25 in the ‘R’ block laboratory number ‘1’ at the University of Waikato Computer Science (cms-r1-25) and develop/test the application from the command line terminal.
WINSCP:	Secure file transfer between a windows local machine and a linux remote machine (cms-r1-25).
Docker:	Build and run the application in a container.
Flask:	Unit testing support.
Redis:	Store numbers in a hash-map using the Python API of Redis
Python:	High-level programming language used.
Apache JMeter:	Load testing tool to analyse and measure the performance of the application during stress testing.
Xming:	Tunnelling Apache JMeter GUI from remote machine to local machine.

Unit Testing

White-Box/Black-Box Coverage Test Cases

Test case ID#	UTC001
Requirement ID#	REQ-2
Test Level	Unit
Test Priority	Medium
Testing Objective	Black-box
Summary	Ensure the redis cache does not contain any stored values
Prerequisites	The code is implemented to the software requirements specification ready for testing.
Software Testing Tools	N/A
Procedure	Build and run the docker container Call the following URI: /primesStored
Data Used	N/A
Expected Result	[ ]
Actual Result	[ ]
Status	Pass
Comments	N/A
Author	Liam Daley
Date	12/06/2019
Time	11.13PM

Test case ID#	UTC002
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Ensure a single digit negative integer does not return a prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC001 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/-1
Data Used	-1
Expected Result	-1 is not prime
Actual Result	-1 is not prime
Status	Pass
Comments	N/A
Author	Liam Daley
Date	12/06/2019
Time	11.20PM

Test case ID#	UTC003
Requirement ID#	REQ-2
Test Level	Unit
Test Priority	Medium
Testing Objective	White-box
Summary	Ensure a non-prime integer is not stored in the list of prime numbers
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC002 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /primesStored
Data Used	N/A
Expected Result	[ ]
Actual Result	[ ]
Status	
Comments	N/A
Author	Liam Daley
Date	12/06/2019
Time	11.28PM

Test case ID#	UTC004
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	Low
Testing Objective	Black-box
Summary	Multiple digit negative integer does not return a prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC003 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/-2147483647
Data Used	-2147483647
Expected Result	-2147483647 is not prime
Actual Result	-2147483647 is not prime
Status	Pass
Comments	N/A
Author	Liam Daley
Date	12/06/2019
Time	11.32PM

Test case ID#	UTC005
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Zero does not return a prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC004 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/0
Data Used	0
Expected Result	0 is not prime
Actual Result	0 is not prime
Status	Pass
Comments	N/A
Author	Liam Daley
Date	12/06/2019
Time	11.33PM

Test case ID#	UTC006
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Single digit non-prime positive integer does not return prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC005 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/1
Data Used	1
Expected Result	1 is not prime
Actual Result	1 is not prime
Status	Pass
Comments	N/A
Author	Liam Daley
Date	12/06/2019
Time	11.34PM

Test case ID#	UTC007
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	Low
Testing Objective	Black-box
Summary	Multiple digit non-prime positive integer does not return prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC006 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/2147483646
Data Used	2147483646
Expected Result	2147483646 is not prime
Actual Result	2147483646 is not prime
Status	Pass
Comments	N/A
Author	Liam Daley
Date	12/06/2019
Time	11.37PM

Test case ID#	UTC008
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Single digit prime positive integer returns prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC007 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/2
Data Used	2
Expected Result	2 is prime
Actual Result	2 is not prime
Status	Fail
Comments	Code is not checking for 2 and 3 as prime numbers
Author	Liam Daley
Date	12/06/2019
Time	11.40PM

Test case ID#	UTC008_001
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Integers 2 and 3 return prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC008 Fail
Software Testing Tools	N/A
Procedure	Call the following URIs: a. /isPrime/2 b. /isPrime/3
Data Used	2 3
Expected Result	a. 2 is prime b. 3 is prime
Actual Result	2 is prime
Status	Pass
Comments	Modified code to include integers 2 and 3
Author	Liam Daley
Date	13/06/2019
Time	12.00AM

Test case ID#	UTC009
Requirement ID#	REQ-2
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Integers 2 and 3 are stored in the cache
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC008_001 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /primesStored
Data Used	N/A
Expected Result	[2, 3]
Actual Result	[2, 3]
Status	Pass
Comments	N/A
Author	Liam Daley
Date	13/06/2019
Time	12.06AM

Test case ID#	UTC010
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	Medium
Testing Objective	Black-box
Summary	Multiple digit prime positive integer returns prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC009 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/2147483647
Data Used	2147483647
Expected Result	2147483647 is prime
Actual Result	2147483647 is prime
Status	Pass
Comments	N/A
Author	Liam Daley
Date	13/06/2019
Time	12.09AM

Test case ID#	UTC011
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	Black-box
Summary	No argument returns a 404 error message
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC010 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/
Data Used	N/A
Expected Result	Response: “is not prime”
Actual Result	404
Status	Pass
Comments	N/A
Author	Liam Daley
Date	13/06/2019
Time	12.11AM

Test case ID#	UTC012
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	Black-box
Summary	Single character string returns not prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC011 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/a
Data Used	a
Expected Result	a is not prime
Actual Result	500 error message: ValueError: invalid literal for int() with base 10: 'a'
Status	Fail
Comments	Value error is not considered, causing the application to crash.
Author	Liam Daley
Date	13/06/2019
Time	12.13AM

Test case ID#	UTC012_001
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Single character string returns not prime
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC012 Fail
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/a
Data Used	a
Expected Result	a is not prime
Actual Result	a is not prime
Status	Pass
Comments	Modified code to handle strings with ‘ValueError’ exception
Author	Liam Daley
Date	13/06/2019
Time	12.22AM

Test case ID#	UTC013
Requirement ID#	REQ-1
Test Level	Unit
Test Priority	Low
Testing Objective	Black-box
Summary	Multiple character string containing python code referencing a system integer value
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC012_001 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /isPrime/sys_maxint
Data Used	sys_maxint
Expected Result	sys_maxint is not prime
Actual Result	sys_maxint is not prime
Status	Pass
Comments	N/A
Author	Liam Daley
Date	13/06/2019
Time	12.26AM

Test case ID#	UTC014
Requirement ID#	REQ-2
Test Level	Unit
Test Priority	High
Testing Objective	White-box
Summary	Integers 2, 3 and 2147483647 are stored in the cache
Prerequisites	The code is implemented to the software requirements specification ready for testing. UTC013 Pass
Software Testing Tools	N/A
Procedure	Call the following URI: /primesStored
Data Used	N/A
Expected Result	[2, 3, 2147483647]
Actual Result	[2, 3, 2147483647]
Status	Pass
Comments	N/A
Author	Liam Daley
Date	13/06/2019
Time	12.29AM

Stress Testing

The Apache JMeter GUI is installed and correctly 'tunnelling' to the local machine with the use of an x11 server (Xming).

Thread Group Initial Setup

Number of Threads (users):	50
Ramp-Up Period (in seconds):	1
Loop Count:	Forever
Scheduler:	On
Duration (seconds):	60

Scenarios

1. Repeatedly decides if the number 2147483647 is prime by invoking the app's isPrime URI.
2. First invokes the isPrime API for all numbers between 1 and 100; then, it repeatedly invokes the primesStored URI of the app.

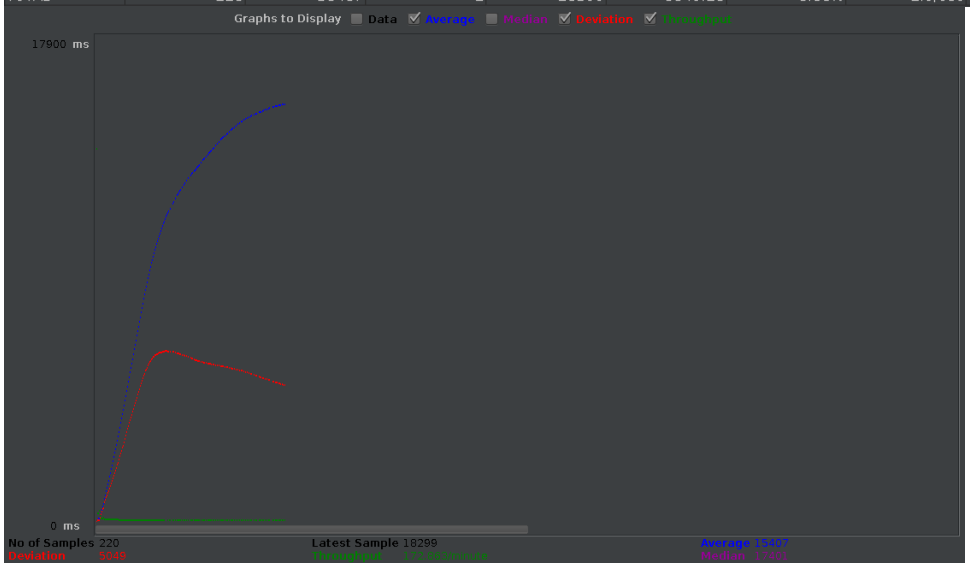
Experiments

1. Try at least three different CPU limits for the web service
    a. 0.01 CPU limit
    b. 0.5 CPU limit
    c. 4.0 CPU limit
2. Try at least three different timer delays in JMeter
    a. 0ms delay
    b. 300ms delay
    c. 3000ms second delay

Results

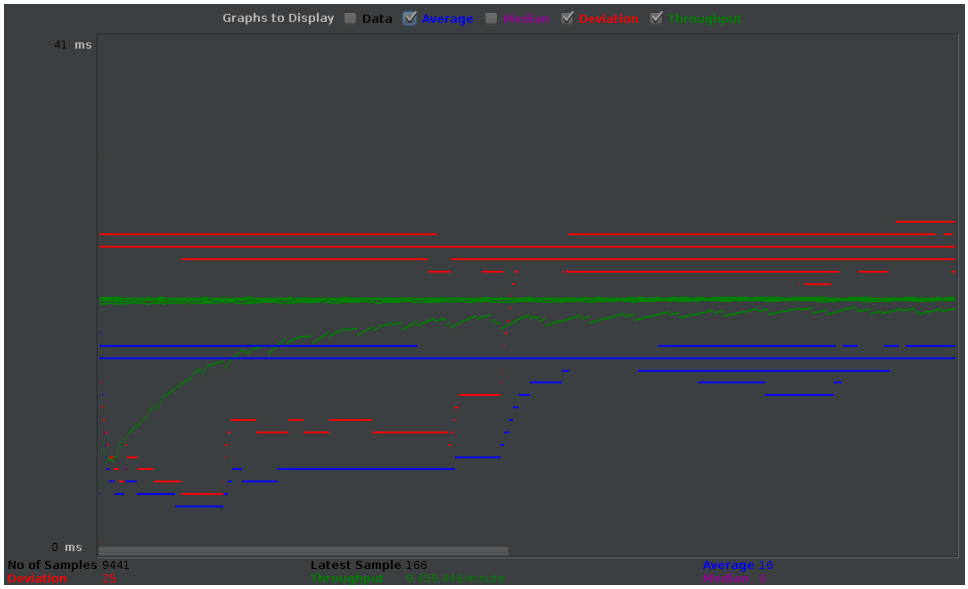
Scenario 1 - 0.01 CPU Limit & 0ms Delay

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/sec	Sent KB/sec	Avg. Bytes
HTTP Request	220	15407	2	20199	5049.25	0.00%	2.9/sec	0.49	0.37	173.0
TOTAL	220	15407	2	20199	5049.25	0.00%	2.9/sec	0.49	0.37	173.0



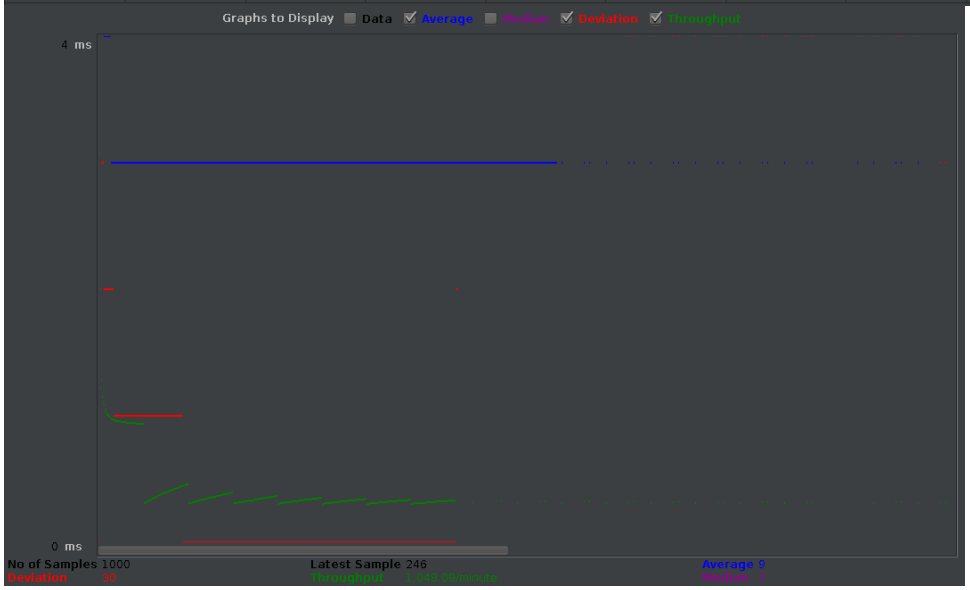
Scenario 1 - 0.5 CPU Limit & 300ms Delay

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/s...	Sent KB/sec	Avg. Bytes
HTTP Request	9441	16	1	213	25.39	0.00%	157.7/sec	26.64	20.48	173.0
TOTAL	9441	16	1	213	25.39	0.00%	157.7/sec	26.64	20.48	173.0



Scenario 1 - 4 CPU Limit & 3000ms Delay

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/s...	Sent KB/sec	Avg. Bytes
HTTP Request	1000	9	1	246	30.46	0.00%	17.5/sec	2.95	2.27	173.0
TOTAL	1000	9	1	246	30.46	0.00%	17.5/sec	2.95	2.27	173.0



References

Python Central. (2017). *How to Test for Prime Numbers in Python*. Retrieved From https://www.pythoncentral.io/how-to-test-for-prime-numbers-in-python/