

Client Description

This program is for CS6650 assignment 1. It utilizes HttpClient to build a multi-thread client to make POST requests to a specified URL, and test the performance of the server.

The repository url: <https://github.com/tjuqxb/6650-assignment-1>

Server url: might change due to restart instance

How it works

The program entry point Class is ClientService. The typical way of running the program (both part 1 and part 2) is specifying the parameters in parameters.xml file (another way is using command line). The user needs to specify:

- arg0: maximum number of threads to run (numThreads - max 1024)
- arg1: number of skier to generate lift rides for (numSkiers - max 100000), This is effectively the skier's ID (skierID)
- arg2: number of ski lifts (numLifts - range 5-60, default 40)
- arg3: mean numbers of ski lifts each skier rides each day (numRuns - default 10, max 20)
- arg4: IP address and port number of the server

Part 1 client would only produce output window results. Part 2 client would produce output window results, a CSV file and a time graph. Users can use class ImageCreator to create other graphs based on output window results.

Main classes

ClientService: This is the entry point Class for the program. It would accept user specified parameters, generate multiple SingleClientThread threads, and use a thread pool and multiple CountDownLatch to control the whole process of the 3 phases. After execution of all the generated threads, it would gather information(the thread results are returned using Future) and generate the final results.

SingleClientThread: This is the class of a single thread client using HttpClient to make multiple requests to specified URL (or generated URLs). It contains one instance of URLBuilder, which is responsible for generating dynamic POST URLs, and one instance of RandInfoCreator, which is responsible for generate random information for a POST. It would record the number of successful and failed requests, the latency of each record, the maximum latency and the minimum latencies and the start and end time (implemented in part 2).

URLBuilder: This class can build URL string based on input parameters.

RandInfoCreator: This class can generate random information and create a SkierPost object based on the information.

ImageCreator: This is a utility class using JFreeChart to produce images.

Utils: This class contains static common utility functions.

Parameters: The wrapper class for mapping XML parameters.

ThreadInfo: The wrapper class for storing thread returned information, including the number of successful and failed requests, the latency of each record, the maximum latency and the minimum latencies and the start and end time (implemented in part 2).

SkierPost: This class can be mapped to a standard POST JSON object specified by the skier API.

Packages

domain: This package is used to store classes which can be mapped to standard POST JSON objects specified by the API. It currently contains one class: SkierPost.

Calculation of Throughput

Using single thread to test, the average latency is about 28 ms and the throughput is about $(1000/28 = 35.7/s)$. Also, according to Jmeter test, the maximum throughput of the naive server is about 2500/s to 3000/s.

Assuming the number of max threads is N. The total number of requests is M.

There are total 3 phases, phase 1 would use $0.25N$ threads to send $2/9 M$ requests, phase 2 would use $0.6N$ threads to send $2/3 M$ requests and phase 3 would use $0.1N$ threads to send $1/9 M$ requests.

According to test, when 20% of total number of threads of one phase have finished, more than 95% of the total number of the requests of that phase also have been sent. (It is reasonable as all the threads of one phase would have the same priorities and at any point they would almost have sent the same number of requests). So, it is reasonable to calculate the wall time of the 3 phases and add them up for prediction.

There are total 180000 requests. Use average latency = 28 ms to estimate.

Using Little's law, we can get a function: $N = \text{Throughput} * W$ ($\text{NumberOfThreads} = \text{Throughput} * \text{Latency}$).

$\text{Throughput} = \text{NumberOfThreads} / \text{Latency}$

For 32 threads:

$\text{phase1-throughput} = 32 * 0.25 * 1000 / 28 = 285$

$\text{phase2-throughput} = 32 * 1000 / 28 = 1143$

$\text{phase3-throughput} = 32 * 0.1 * 1000 / 28 = 114$

$\text{walltime} = 40000 / 285 + 120000 / 1143 + 20000 / 114 = 420.8\text{s}$

$\text{throughput} = 180000/420.8 = 428$

For 64 threads:

$\text{phase1-throughput} = 64 * 0.25 * 1000 / 28 = 570$

$\text{phase2-throughput} = 64 * 1000 / 28 = 2286$

$\text{phase3-throughput} = 64 * 0.1 * 1000 / 28 = 228$

$\text{walltime} = 40000 / 570 + 120000 / 2286 + 20000 / 228 = 210.4\text{s}$

$\text{throughput} = 180000/210.4 = 856$

For 128 threads:

phase1-throughput = $128 * 0.25 * 1000 / 28 = 1140$

phase2-throughput = $\min\{128 * 1000 / 28, 2500\} = \min\{4572, 2500\} = 2500$

phase3-throughput = $128 * 0.1 * 1000 / 28 = 456$

walltime = $40000 / 1140 + 120000 / 2500 + 20000 / 456 = 126.9s$

throughput = $180000 / 126.9 = 1418$

For 256 threads:

phase1-throughput = $256 * 0.25 * 1000 / 28 = 2280$

phase2-throughput = $\min\{256 * 1000 / 28, 2500\} = \min\{9144, 2500\} = 2500$

phase3-throughput = $256 * 0.1 * 1000 / 28 = 912$

walltime = $40000 / 2280 + 120000 / 2500 + 20000 / 912 = 87.5s$

throughput = $180000 / 87.5 = 2057$

Output and Charts

Part1:

The screenshot shows the IntelliJ IDEA interface with the project 'assignment_1' open. The code editor displays `ClientService.java` which contains Java code for managing three phases of requests using CountDownLatch and ExecutorService. The run output window shows the execution results for 32 threads, indicating 180000 successful requests, 0 failed requests, a wall time of 431425 ms, and a throughput of 417 requests per second. The Maven tool window on the right shows dependencies like Java, Lifecycle, Plugins, and various Apache libraries.

```
ClientService.java
submitThreads(numThreads1, countDownLatch1,
    executor1, res1, startTime: 1, endTime: 90, (int)(numRuns * 0.2));
countDownLatch1.await();
// Phase 2
System.out.println("Phase 2 start!");
int numThreads2 = numThreads;
CountDownLatch countDownLatch2 = new CountDownLatch(numThreads2/5);
ExecutorService executor2 = Executors.newFixedThreadPool(numThreads2);
List<Future<ThreadInfo>> res2 = new ArrayList<>();
submitThreads(numThreads2, countDownLatch2,
    executor2, res2, startTime: 91, endTime: 360, (int)(numRuns * 0.6));
countDownLatch2.await();
// Phase 3
System.out.println("Phase 3 start!");
int numThreads3 = numThreads/10;
CountDownLatch countDownLatch3 = new CountDownLatch(numThreads3);
ExecutorService executor3 = Executors.newFixedThreadPool(numThreads3);
List<Future<ThreadInfo>> res3 = new ArrayList<>();
submitThreads(numThreads3, countDownLatch3,
```

Run: ClientService
"D:\Program Files\Java\jdk-11.0.14\bin\java.exe" ...
number of threads: 32
Phase 1 start!
Phase 2 start!
Phase 3 start!
number of success requests: 180000
number of failed requests: 0
wall time: 431425
throughput: 417
Process finished with exit code 0

32 Threads

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help assignment1_part1 - parameters.xml

Project assignment_1 D:\courses\CS6650\assignment\assignment_1

src main java

- main
 - java
 - domain
 - ClientService
 - ImageCreator
 - Parameters
 - parameters.xml
 - RandInfoCreator
 - SingleClientThread
 - ThreadInfo
 - URLBuilder
 - Utils

resources

target

Run: ClientService

```
"D:\Program Files\Java\jdk-11.0.14\bin\java.exe" ...
number of threads: 64
Phase 1 starts!
Phase 2 starts!
Phase 3 starts!
number of success requests: 180000
number of failed requests: 0
wall time: 223575
throughput: 805

Process finished with exit code 0
```

Build completed successfully in 846 ms (20 minutes ago)

8:14 CRLF UTF-8 4 spaces Event Log

64 Threads

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help assignment1_part1 - parameters.xml

Project assignment_1 D:\courses\CS6650\assignment\assignment_1

src main java

- main
 - java
 - domain
 - SkierPost
 - ClientService
 - Parameters
 - parameters.xml
 - RandInfoCreator
 - SingleClientThread
 - ThreadInfo
 - URLBuilder
 - Utils

resources

target

assignment_1.iml pom.xml

parameters : numThreads

Run: ClientService

```
"D:\Program Files\Java\jdk-11.0.14\bin\java.exe" ...
number of threads: 128
Phase 1 start!
Phase 2 start!
Phase 3 start!
number of success requests: 180000
number of failed requests: 0
wall time: 124637
throughput: 1444

Process finished with exit code 0
```

Build completed successfully in 959 ms (2 minutes ago)

3:20 CRLF UTF-8 4 spaces Event Log

128 Threads

Screenshot of IntelliJ IDEA showing the code editor, project structure, and run output for a Java application named "ClientService".

Code Editor:

```
<?xml version="1.0" encoding="UTF-8"?>
<parameters>
    <numThreads>256</numThreads>
    <numSkiers>20000</numSkiers>
    <numLifts>40</numLifts>
    <numRuns>10</numRuns>
    <InetAddrAndPort>http://34.216.68.235/LAB2_2_war</InetAddrAndPort>
</parameters>
```

Project Structure:

- assignment_1
 - src
 - main
 - java
 - domain
 - SkierPost
 - ClientService
 - Parameters
 - parameters.xml
 - RandInfoCreator
 - SingleClientThread
 - ThreadInfo
 - URLBuilder
 - Utils
 - resources
 - target

Run Output:

```
number of threads: 256
Phase 1 start!
Phase 2 start!
Phase 3 start!
number of success requests: 180000
number of failed requests: 0
wall time: 86116
throughput: 2090

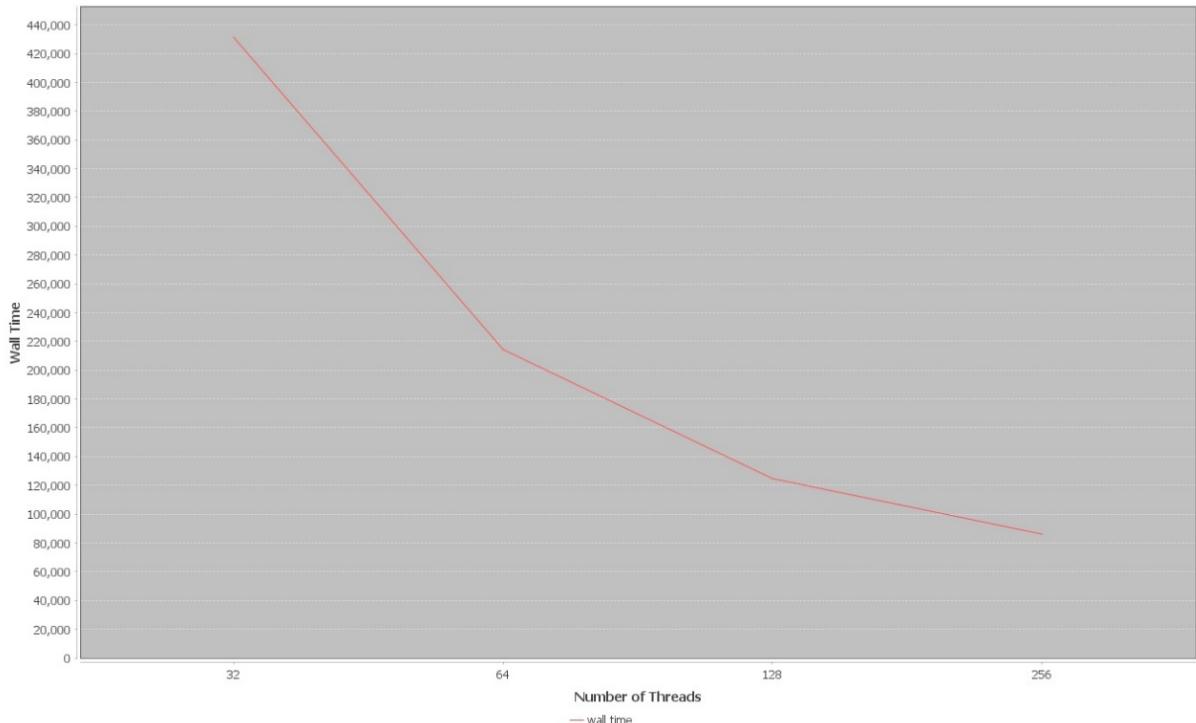
Process finished with exit code 0
```

Event Log:

Build completed successfully in 901 ms (2 minutes ago)

256 Threads

Wall Time Vs Number of Threads



Walltime VS Number of Threads

Part2:

The screenshot shows the IntelliJ IDEA interface with the project 'assignment1_part2' open. The code editor displays the 'ClientService.java' file, which contains logic for processing records and writing files. The run output window shows the following results for 32 threads:

```
number of threads: 32
Phase 1 starts!
Phase 2 starts!
Phase 3 starts!
number of success requests: 180000
number of failed requests: 0
wall time: 417226
throughput: 431
mean response time: 28.8 milliseconds
median response time: 26.0 milliseconds
P99 response time: 98 milliseconds
min response time: 10 milliseconds
max response time: 3501 milliseconds

Process finished with exit code 0
```

The bottom status bar indicates the build completed successfully in 2 seconds.

32 Threads

The screenshot shows the IntelliJ IDEA interface with the project 'assignment1_part2' open. The code editor displays the 'ClientService.java' file. The run output window shows the following results for 64 threads:

```
number of threads: 64
Phase 1 starts!
Phase 2 starts!
Phase 3 starts!
number of success requests: 180000
number of failed requests: 0
wall time: 227867
throughput: 789
mean response time: 32.2 milliseconds
median response time: 28.0 milliseconds
P99 response time: 82 milliseconds
min response time: 11 milliseconds
max response time: 4981 milliseconds

Process finished with exit code 0
```

The bottom status bar indicates all files are up-to-date (43 minutes ago).

64 Threads

```

private static void createTimeGraphFromMap(HashMap<Long, List<long[]> timeRecords) throws IOException {
    int[] sumRecords = new int[(int)(endTime - startTime)/1000 + 1];
    int[] cntRecords = new int[(int)(endTime - startTime)/1000 + 1];
    for (Long k : timeRecords.keySet()) {
        List<long[]> list = timeRecords.get(k);
        long sum = 0;
        for (int i = 0; i < list.size(); i++) {
            sum += list.get(i)[0];
        }
        sumRecords[(int)((k - startTime)/1000)] += sum;
        cntRecords[(int)((k - startTime)/1000)] += list.size();
    }
}

```

Run: ClientService
 "D:\Program Files\Java\jdk-11.0.14\bin\java.exe" ...
 number of threads: 128
 Phase 1 starts!
 Phase 2 starts!
 Phase 3 starts!
 number of success requests: 180000
 number of failed requests: 0
 wall time: 124055
 throughput: 1450
 mean response time: 39.2 milliseconds
 median response time: 32.0 milliseconds
 P99 response time: 94 milliseconds
 min response time: 10 milliseconds
 max response time: 5919 milliseconds
 Process finished with exit code 0

128 Threads

```

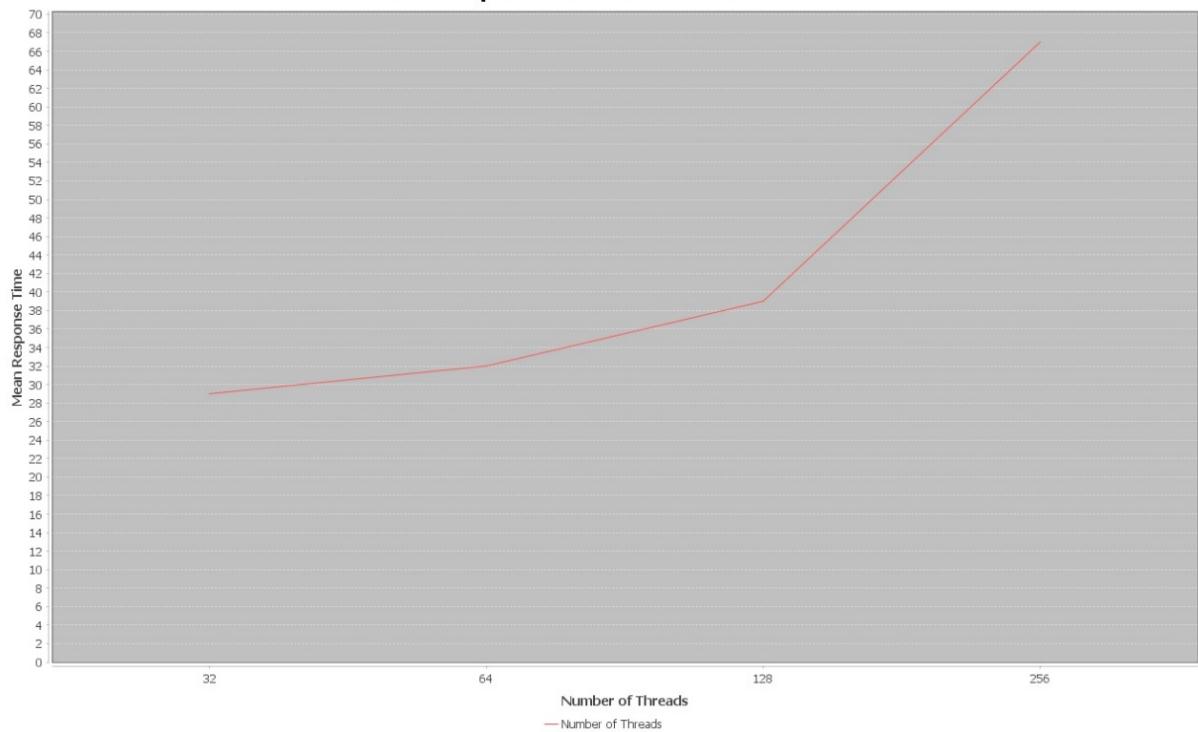
for (int i = 0; i < sumRecords.length; i++) {
    if (cntRecords[i] != 0) {
        sumRecords[i] = sumRecords[i] / cntRecords[i];
    }
}
ImageCreator.createTimeGraph(sumRecords, idName: String.valueOf(numThreads) + " Threads");

```

Run: ClientService
 "D:\Program Files\Java\jdk-11.0.14\bin\java.exe" ...
 number of threads: 256
 Phase 1 starts!
 Phase 2 starts!
 Phase 3 starts!
 number of success requests: 180000
 number of failed requests: 0
 wall time: 85386
 throughput: 2108
 mean response time: 66.7 milliseconds
 median response time: 47.0 milliseconds
 P99 response time: 145 milliseconds
 min response time: 11 milliseconds
 max response time: 7890 milliseconds
 Process finished with exit code 0

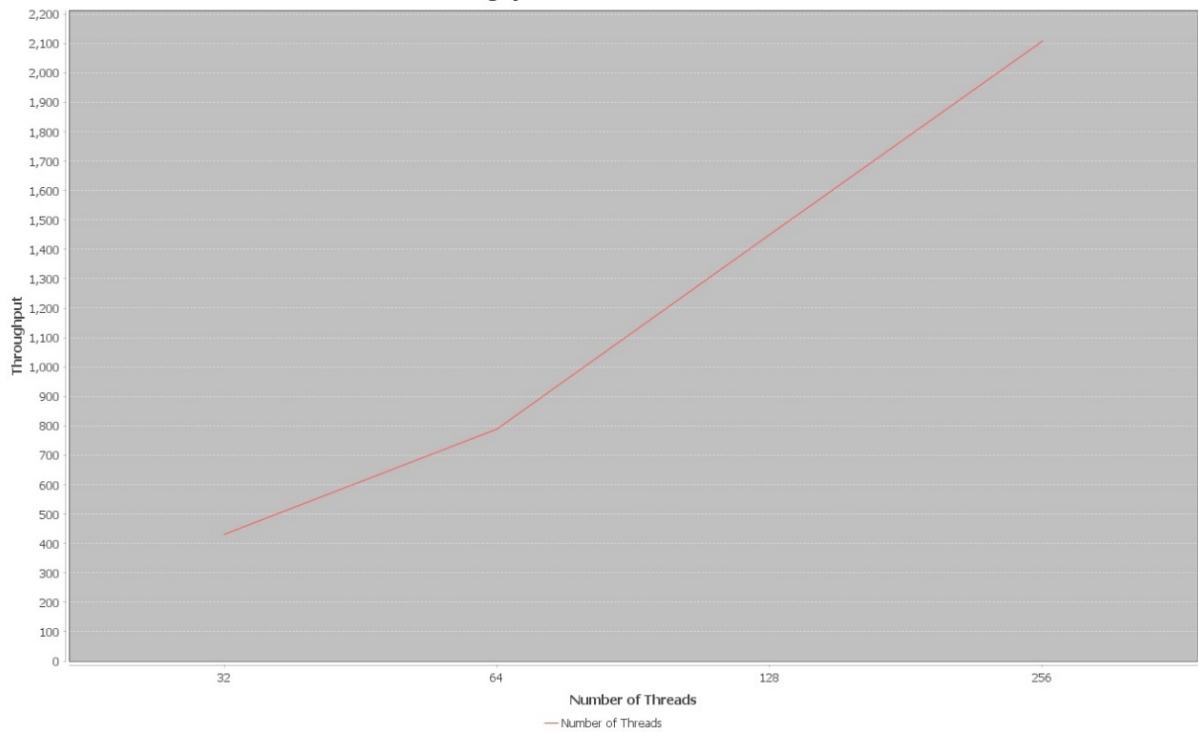
256 Threads

Mean Response Time and Number of Threads



Mean Response Time VS Number of Threads

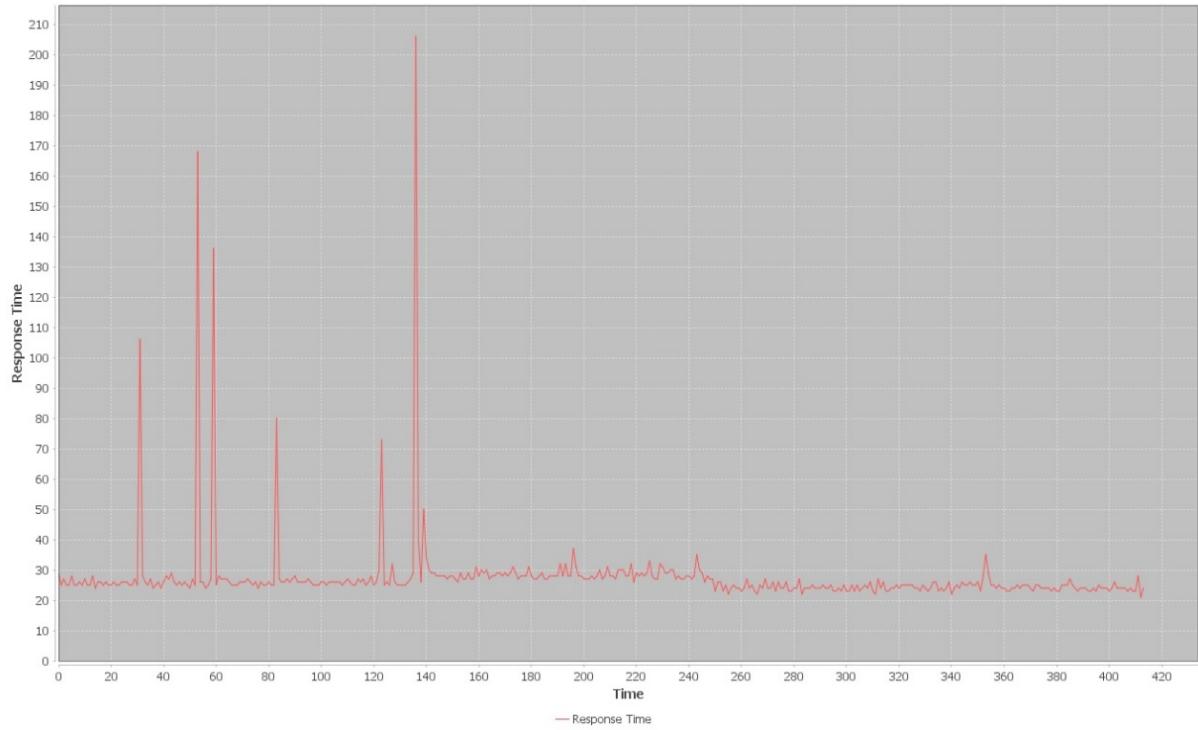
Throughput and Number of Threads



Throughput VS Number of Threads

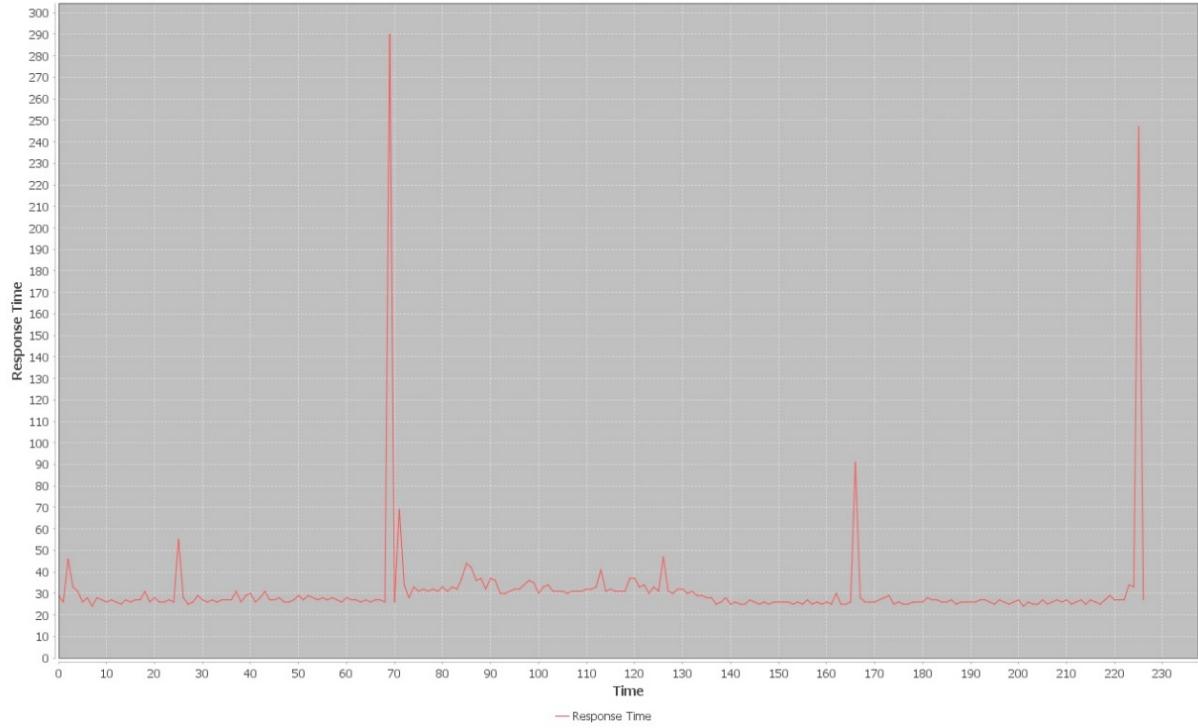
Part 2 Time Charts:

32 Threads Response Time VS Time



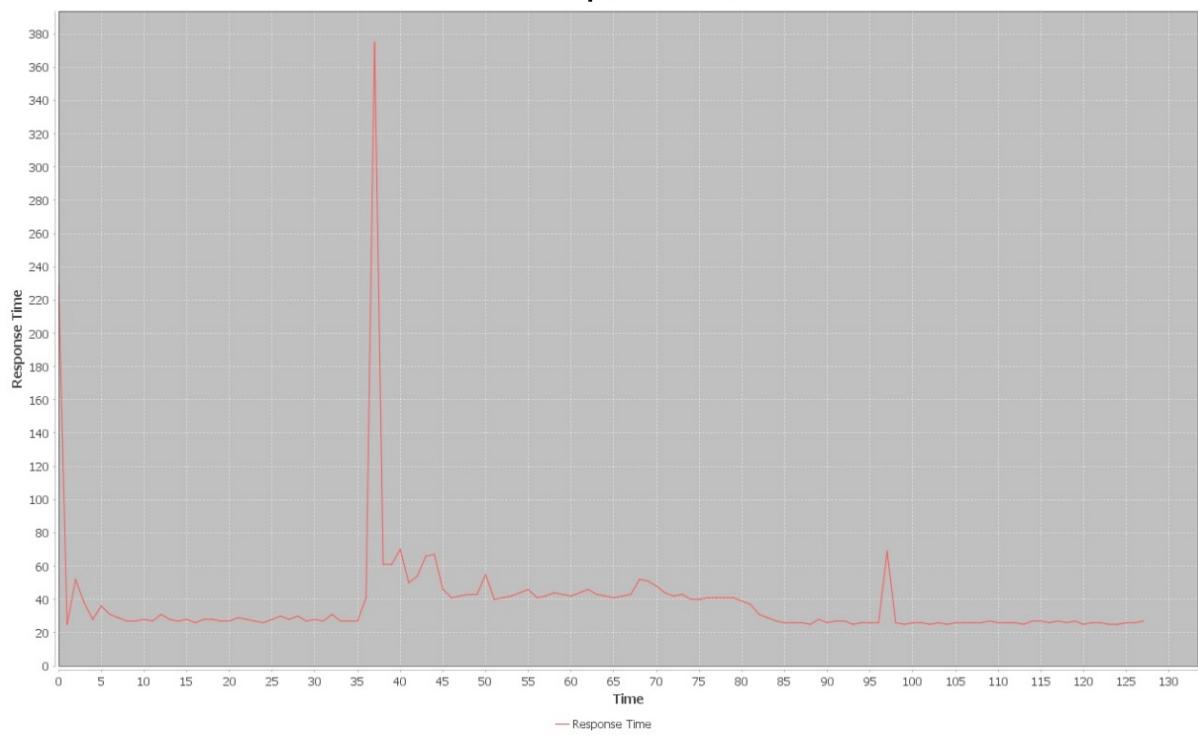
32 Threads

64 Threads Response Time VS Time



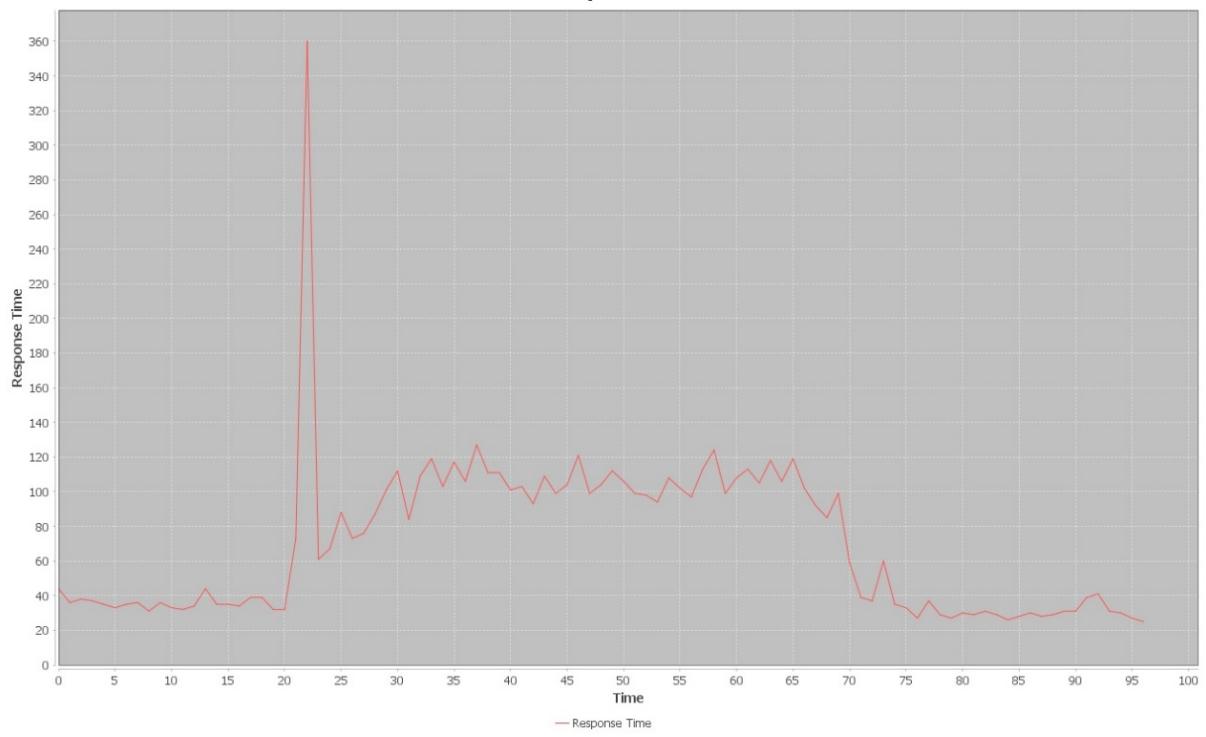
64 Threads

128 Threads Response Time VS Time



128 Threads

256 Threads Response Time VS Time



256 Threads