Name	Prakriti Sharma
Subject	CS550 Advance Operating Systems
CWID	A20575259
Topic	PA1

INDEX

Requirement:

The assignment is a Publisher Subscriber System in JAVA language.

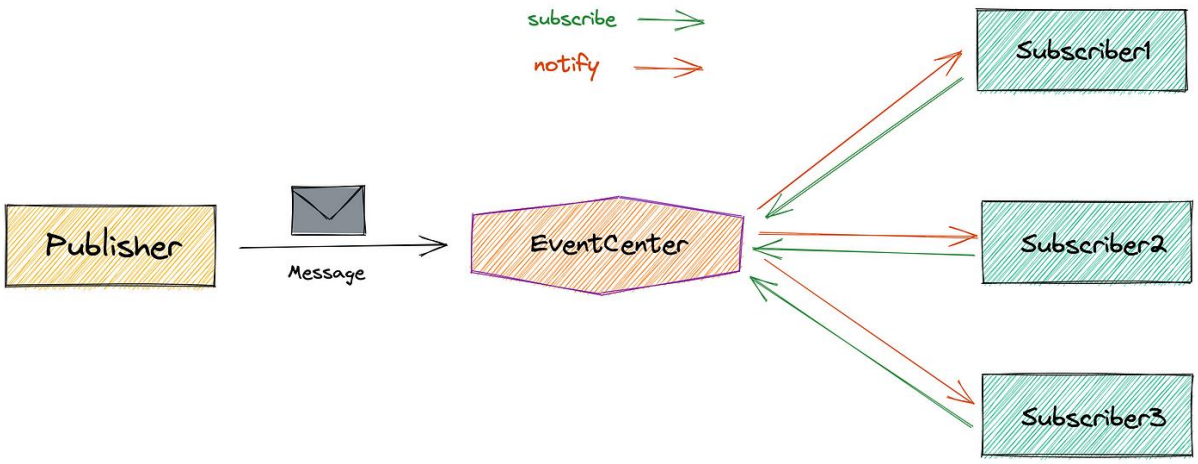
Tools Used:

Maven, Gradle, XChart, JavaFX, SpringBoot

What exactly is a Publisher Subscriber System?

A publisher-subscriber system is a messaging pattern where publishers send messages to a topic without knowing who subscribes to it. Subscribers express interest in specific topics and receive messages published to those topics. This decouples the sender and receiver, allowing for scalable and flexible communication. It's commonly used in event-driven architectures, messaging systems, and real-time applications.

DIAGRAM



Structure of the code:

The requirement according to the PA1 document states that we can divide the structure of the code into three different parts:

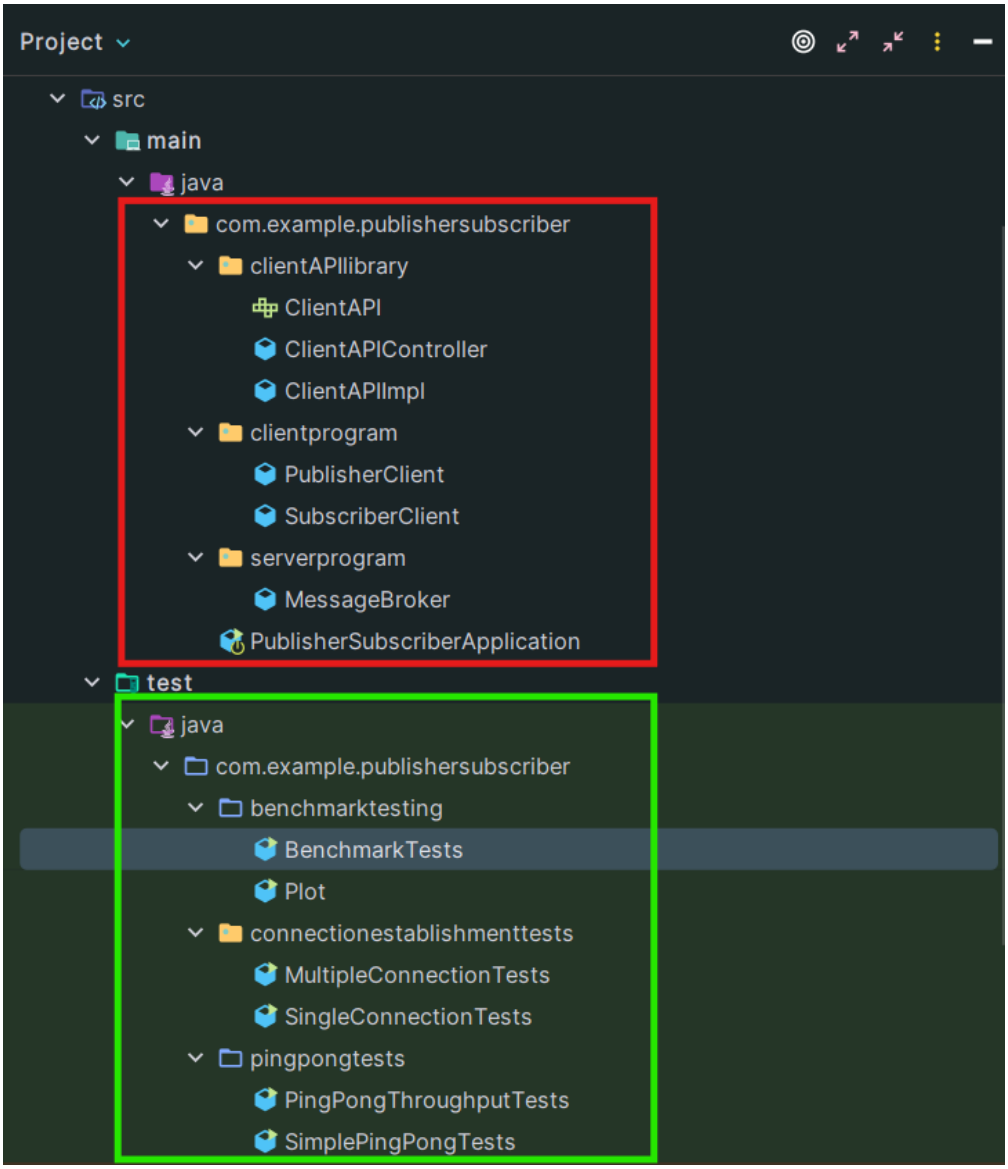
1. **ClientAPILibrary**
   Client API Library has three files in total, one which declares an interface for the publisher and its functionalities, the client API implementation implements that interface and the client API controller renders that implementation into https REST APIs.
2. **ClientProgram**
   The client program pulls the functions together for publisher and the subscriber individually, verifying its very basic functionality that is:
   - Registering a publisher on the server. It has been assigned a specific format that is **PUB-#num**. Each time someone hits that endpoint, a new publisher with a counter++ equals to the #num is created.
   - It later pulls the function to **register a topic under the publisher**.
   - The publisher can **push a message to the pool of messages** using the push message to pool functionality.

- Registering the subscriber on the server. It has been assigned a specific format that is **SUB-#num**. Each time someone hits that endpoint, a new subscriber with a counter++ equals to the #num is created.
- The subscriber then is able to **subscribe to a topic**.
- A **subscriber can pull the messages from the pool**, by providing its subscriber Id and the topic it wants to pull the freshly pushed messages from.
- **Basically, if a message is read by SUB-1 and not read by SUB-2, it will always stay in the memory. We use flagging concept to log if the message is read by all the subscriber or not, or what subscriber Ids have already read the message.**
- Once, a set of pushed messages are read by all the publishers, it is referred to as junk and then the junk is **dumped from the buffer memory**.

3. **ServerProgram**
   The server program **maintains the anonymity of the communication**. It hides the details of message transportation from the users that is the client programs do not have to take care of the connection establishments. The **message broker** file initialises a server like communication platform **to hide the publishing details from the subscriber and vice versa**. It also maintains the buffer for different topic and handles request from the clients.

This covers the Overview section requirements.

The structure of the project files are as follows:



The Process Description:

The functionality concludes by deploying the APIs in the below order:

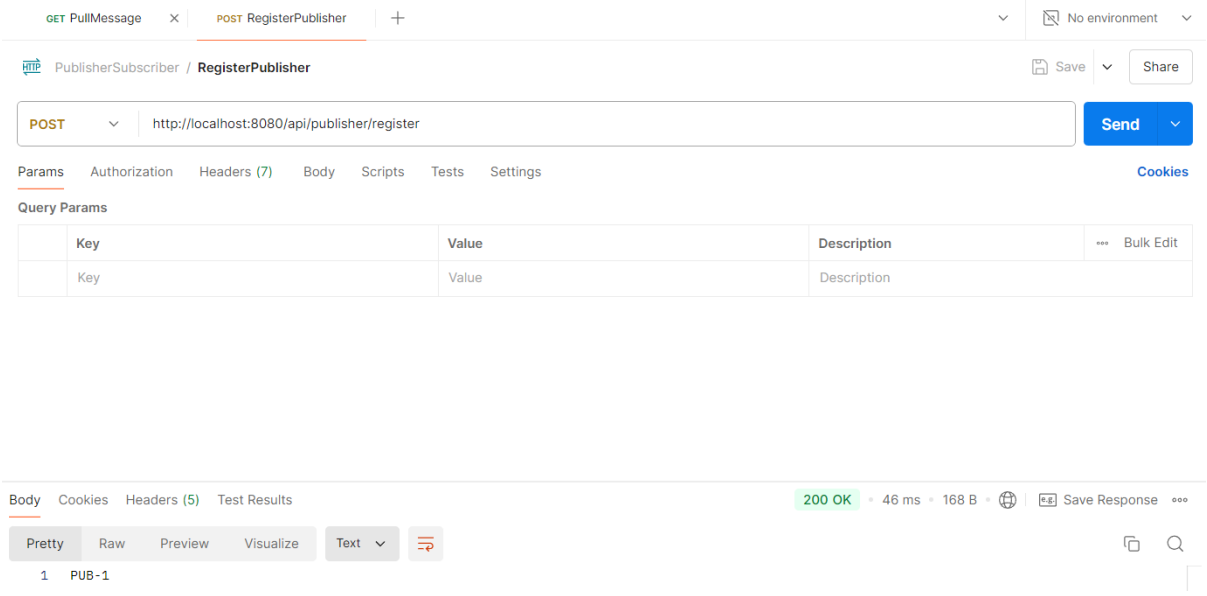
1. *registerPublisher()*
2. *createTopic(PID, String topic)*
3. *deleteTopic(Pid, String topic, String message)*
4. *send(PID, String topic, String message)*
5. *registerSubscriber()*
6. *subscribeTopic(SID, String topic)*
7. *List<String> pullMessages(SID, String topic)*

Below is the screenshot of the working APIs and the fulfilment of basic functionalities of the assignment:
This covers the Client API implementation requirements.

Register Publisher API

cURL : curl --location --request POST 'http://localhost:8080/api/publisher/register'

The register API return a unique ID which allows the client to act as a publisher or subscriber.

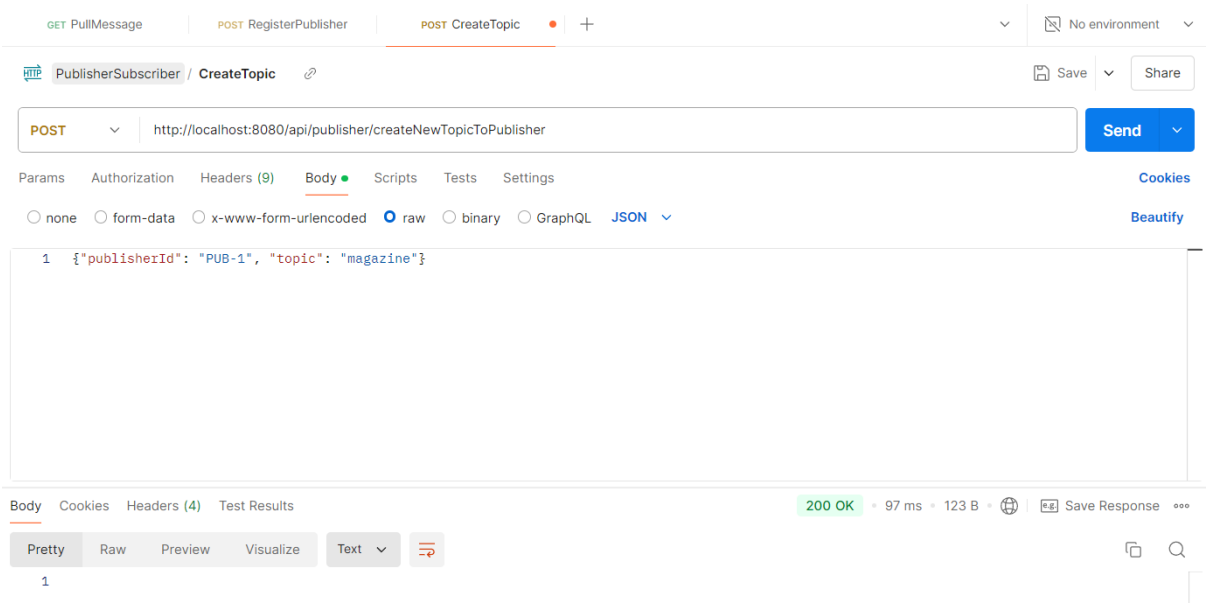


Create Topic API :

cURL: curl --location 'http://localhost:8080/api/publisher/createNewTopicToPublisher' \

--header 'Content-Type: application/json' \

--data '{"publisherId": "PUB-1", "topic": "magazine"}'

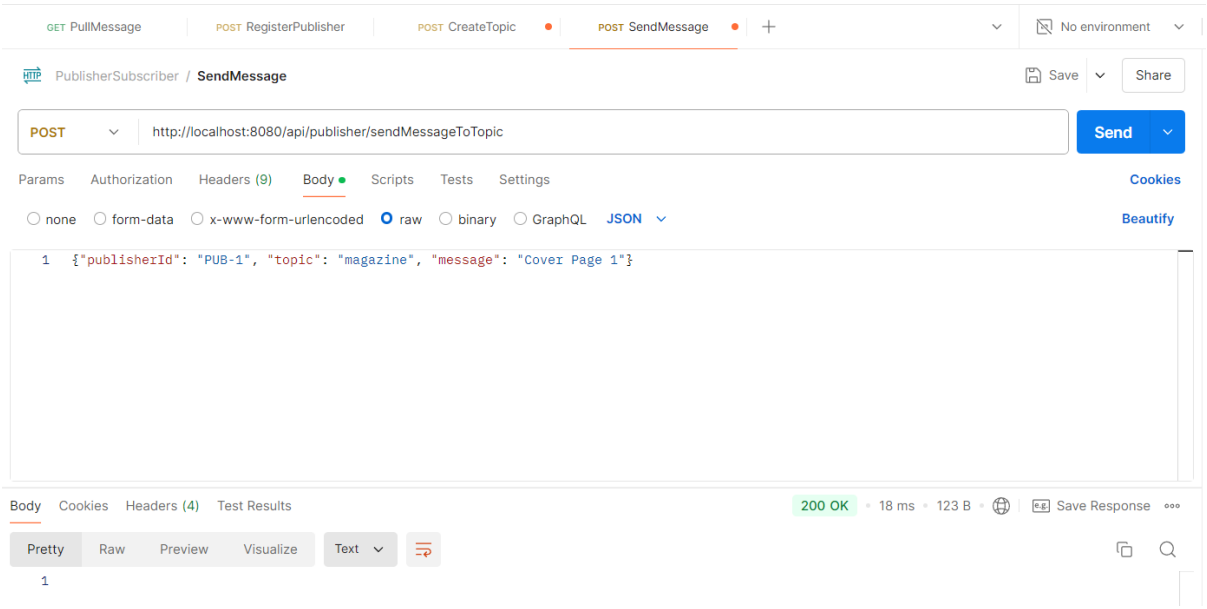


Send Message API :

cURL: curl --location 'http://localhost:8080/api/publisher/sendMessageToTopic' \

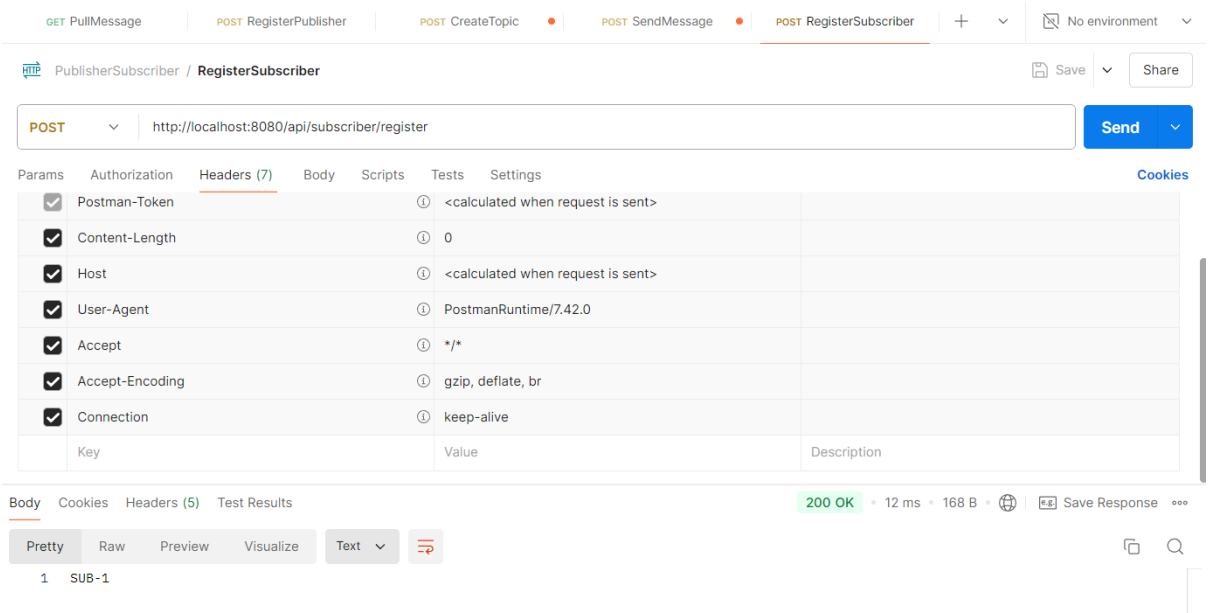
--header 'Content-Type: application/json' \

--data '{"publisherId": "PUB-1", "topic": "magazine", "message": "Cover Page 1"}'



Register Subscriber API :

cURL: curl --location --request POST 'http://localhost:8080/api/subscriber/register'

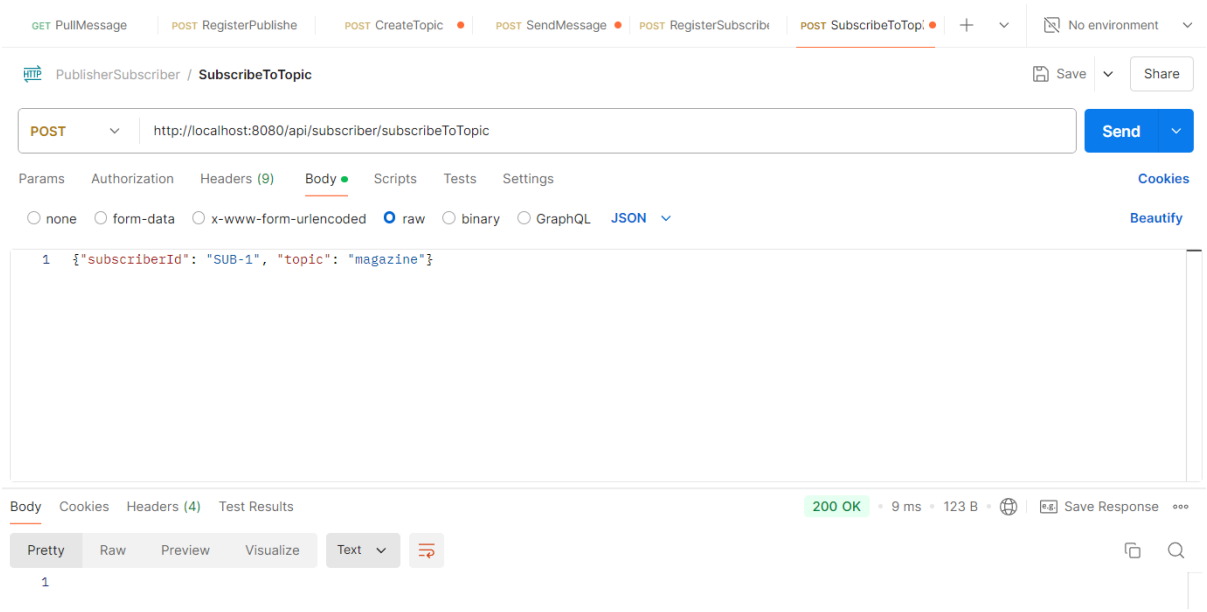


Subscribe to topic API

cURL: curl --location 'http://localhost:8080/api/subscriber/subscribeToTopic' \

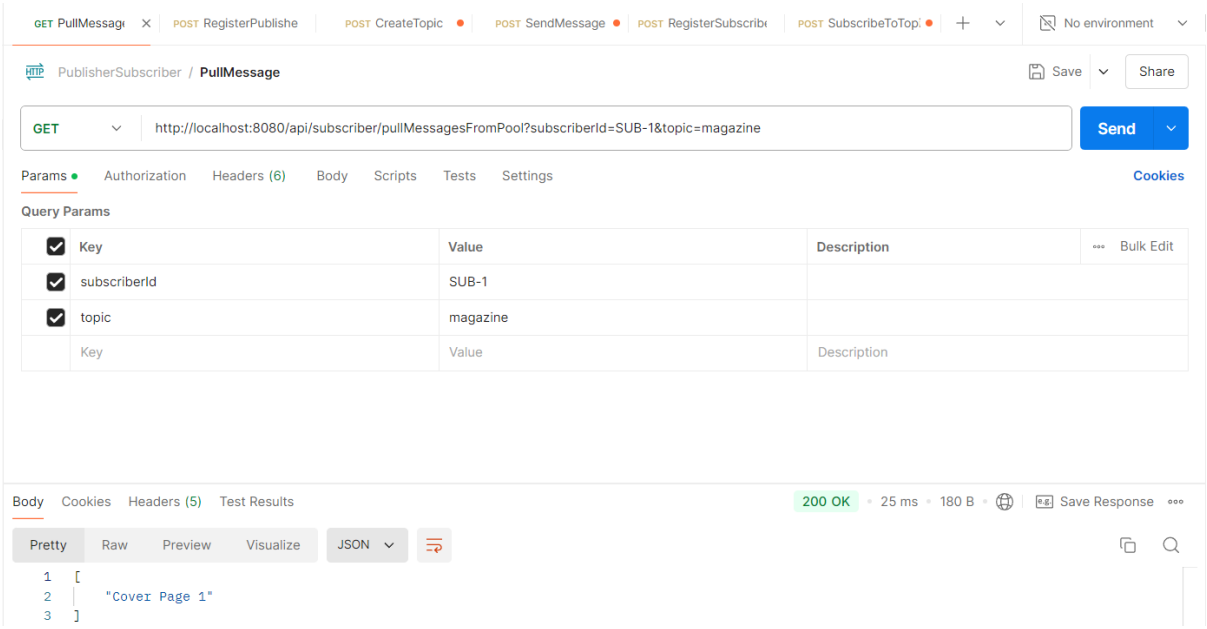
--header 'Content-Type: application/json' \

--data '{"subscriberId": "SUB-1", "topic": "magazine"}'



Pull messages from topic API

cURL: curl --location 'http://localhost:8080/api/subscriber/pullMessagesFromPool?subscriberId=SUB-1&topic=magazine'

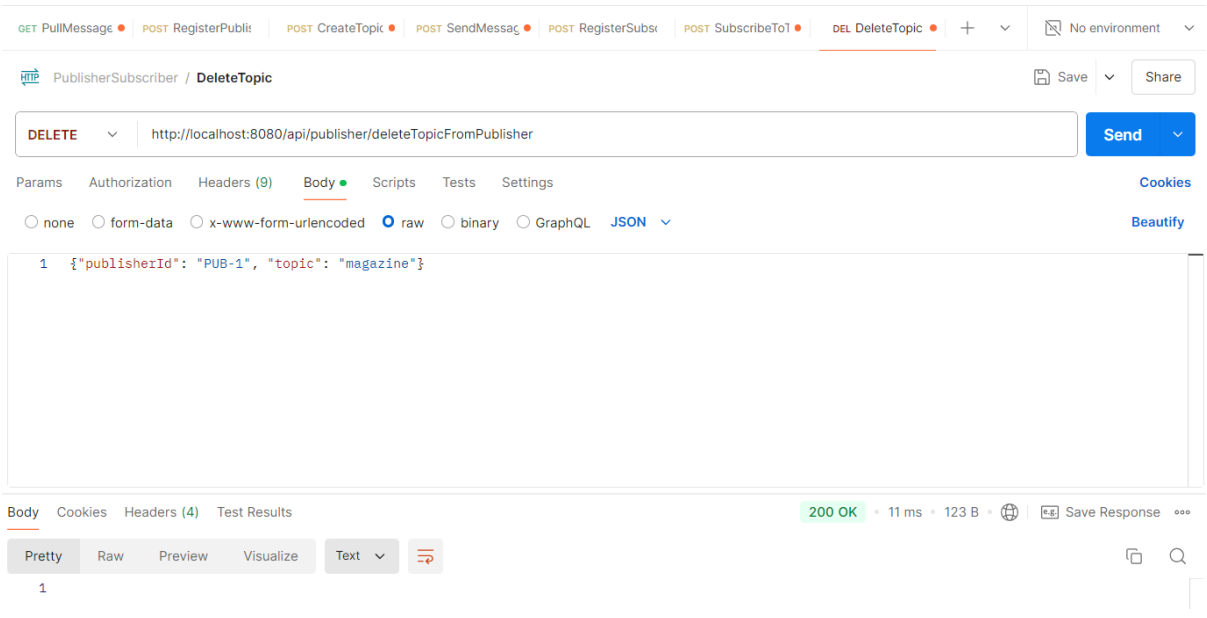


Delete Topic API

cURL: curl --location --request DELETE 'http://localhost:8080/api/publisher/deleteTopicFromPublisher' \

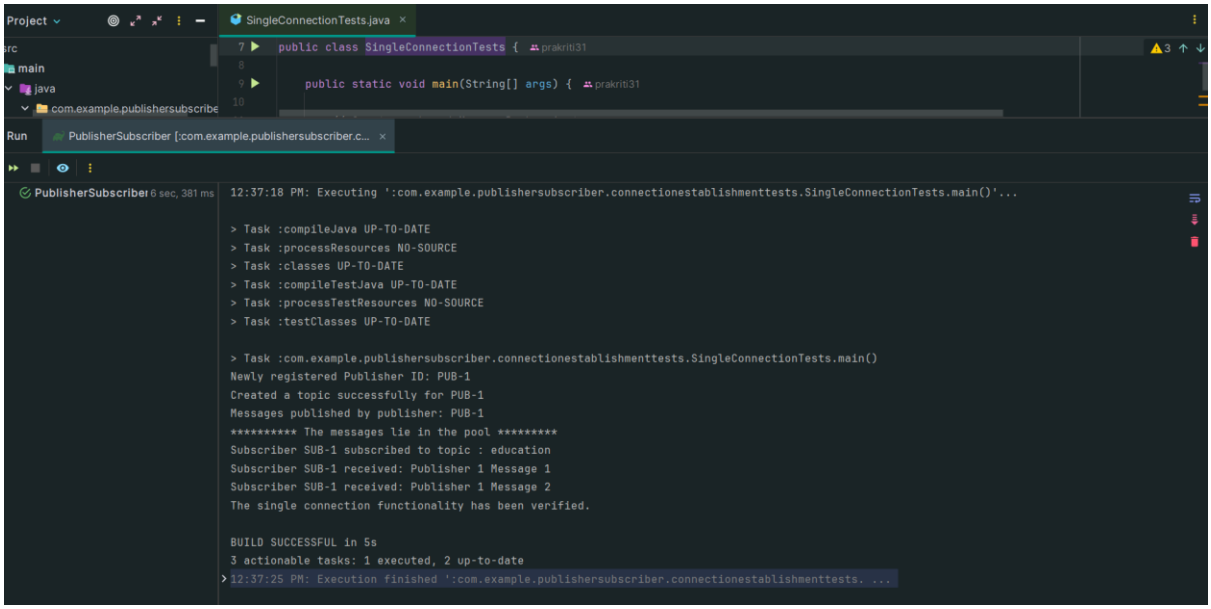
--header 'Content-Type: application/json' \

--data '{"publisherId": "PUB-1", "topic": "magazine"}'



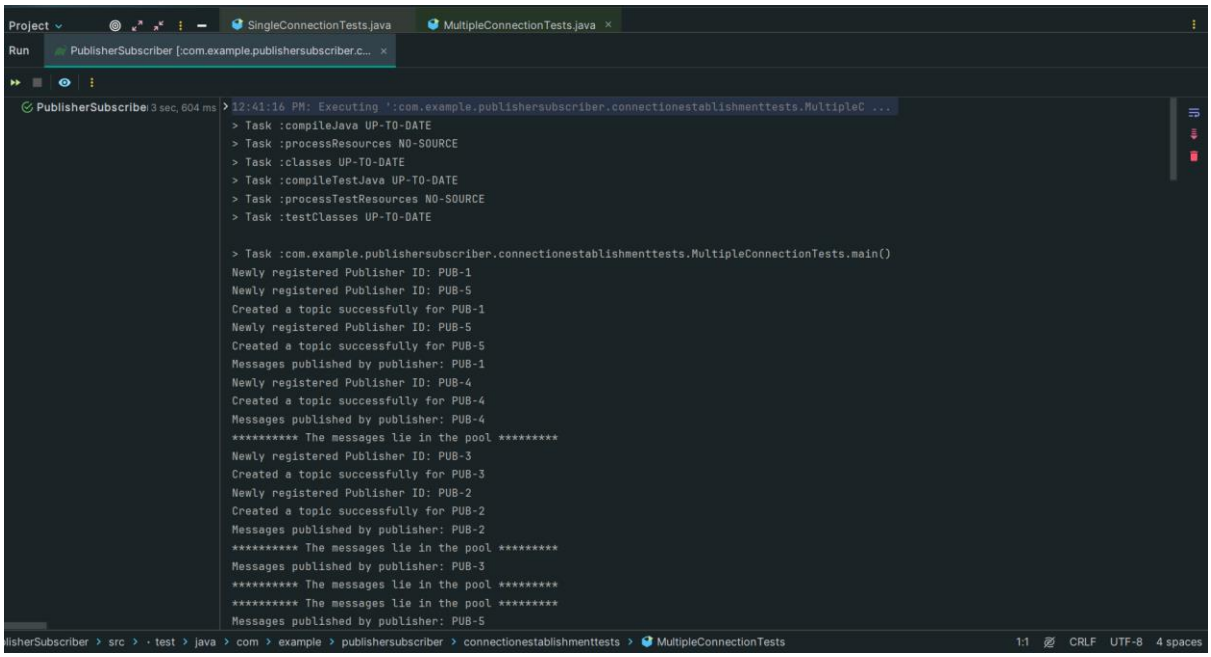
Testing Results:

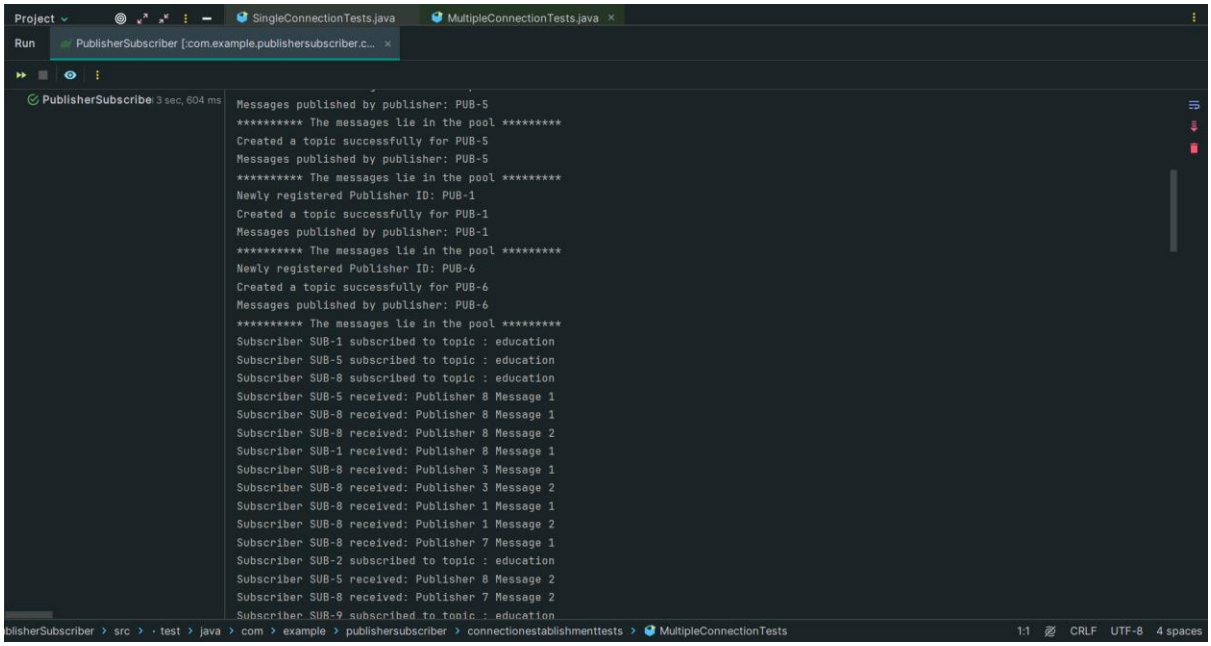
Single Connection Testing

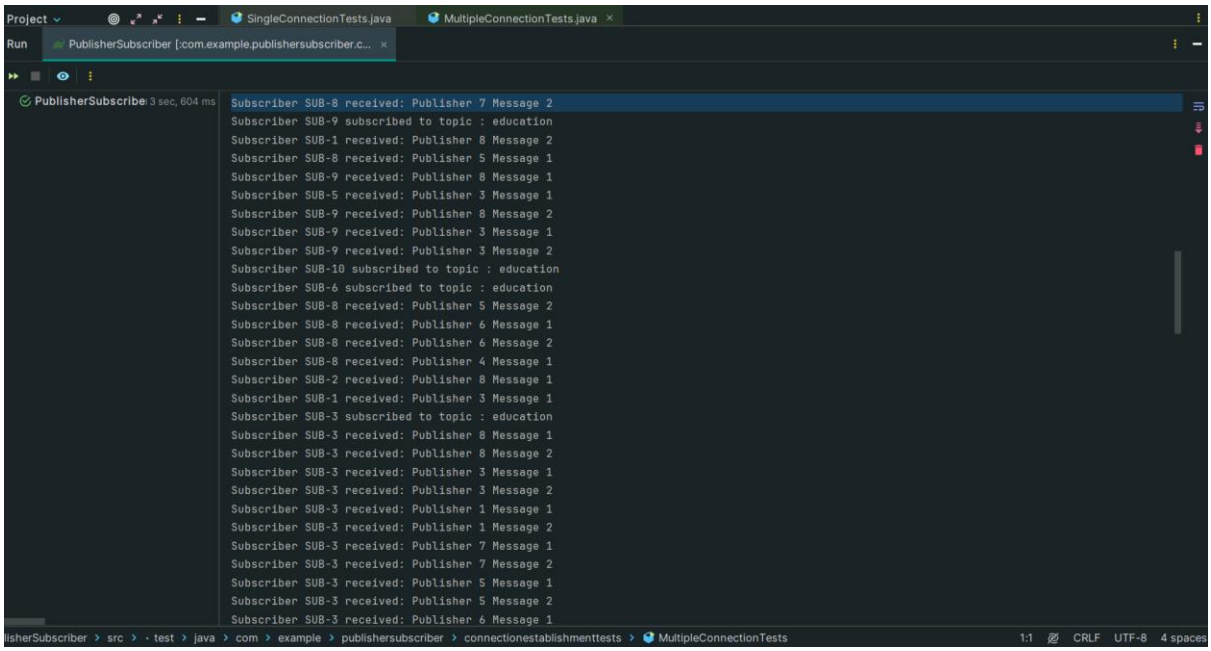


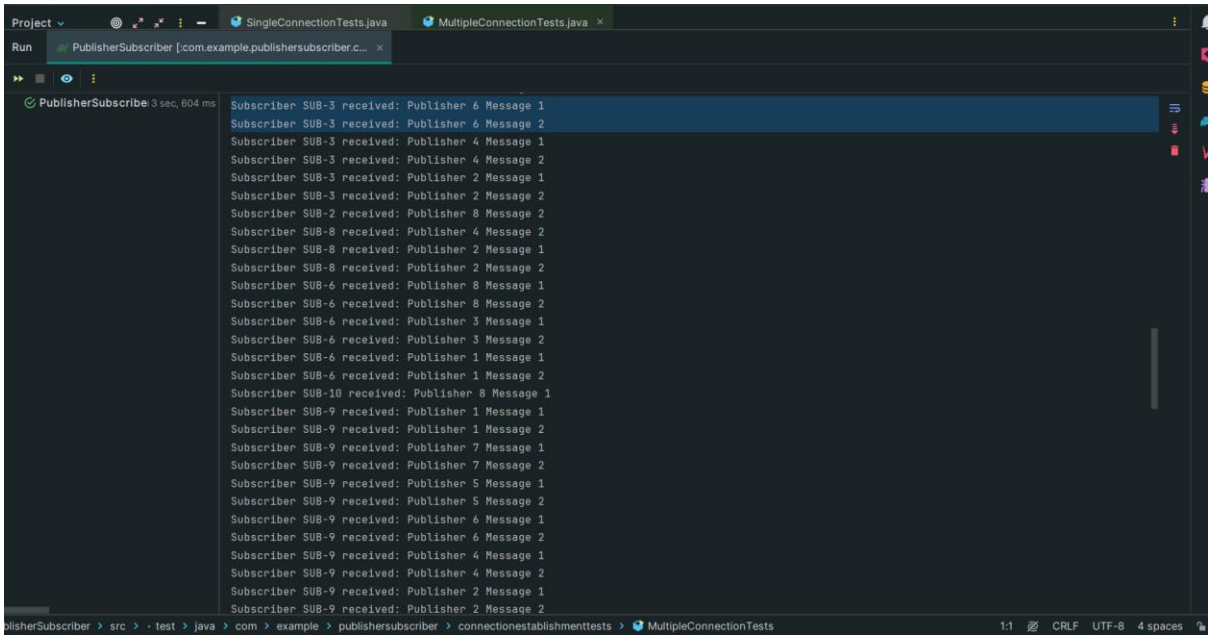
This tests the grounded basic functionality of the code that is one publisher-one subscriber system and just verifies the message receival on the subscriber's end.

Multiple Connection Testing




Project
SingleConnectionTests.java
MultipleConnectionTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.c...
PublisherSubscriber: 3 sec, 604 ms
Messages published by publisher: PUB-5
********** The messages lie in the pool *********
Created a topic successfully for PUB-5
Messages published by publisher: PUB-5
********** The messages lie in the pool *********
Newly registered Publisher ID: PUB-1
Created a topic successfully for PUB-1
Messages published by publisher: PUB-1
********** The messages lie in the pool *********
Newly registered Publisher ID: PUB-6
Created a topic successfully for PUB-6
Messages published by publisher: PUB-6
********** The messages lie in the pool *********
Subscriber SUB-1 subscribed to topic : education
Subscriber SUB-5 subscribed to topic : education
Subscriber SUB-8 subscribed to topic : education
Subscriber SUB-5 received: Publisher 8 Message 1
Subscriber SUB-8 received: Publisher 8 Message 1
Subscriber SUB-8 received: Publisher 8 Message 2
Subscriber SUB-1 received: Publisher 8 Message 1
Subscriber SUB-8 received: Publisher 3 Message 1
Subscriber SUB-8 received: Publisher 3 Message 2
Subscriber SUB-8 received: Publisher 1 Message 1
Subscriber SUB-8 received: Publisher 1 Message 2
Subscriber SUB-8 received: Publisher 7 Message 1
Subscriber SUB-2 subscribed to topic : education
Subscriber SUB-5 received: Publisher 8 Message 2
Subscriber SUB-8 received: Publisher 7 Message 2
Subscriber SUB-9 subscribed to topic : education
blisherSubscriber › src › test › java › com › example › publishersubscriber › connectionestablishmenttests › MultipleConnectionTests
1:1 CRLF UTF-8 4 spaces


Project
SingleConnectionTests.java
MultipleConnectionTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.c...
PublisherSubscriber: 3 sec, 604 ms
Subscriber SUB-8 received: Publisher 7 Message 2
Subscriber SUB-9 subscribed to topic : education
Subscriber SUB-1 received: Publisher 8 Message 2
Subscriber SUB-8 received: Publisher 5 Message 1
Subscriber SUB-9 received: Publisher 8 Message 1
Subscriber SUB-5 received: Publisher 3 Message 1
Subscriber SUB-9 received: Publisher 8 Message 2
Subscriber SUB-9 received: Publisher 3 Message 1
Subscriber SUB-9 received: Publisher 3 Message 2
Subscriber SUB-10 subscribed to topic : education
Subscriber SUB-6 subscribed to topic : education
Subscriber SUB-8 received: Publisher 5 Message 2
Subscriber SUB-8 received: Publisher 6 Message 1
Subscriber SUB-8 received: Publisher 6 Message 2
Subscriber SUB-8 received: Publisher 4 Message 1
Subscriber SUB-2 received: Publisher 8 Message 1
Subscriber SUB-1 received: Publisher 3 Message 1
Subscriber SUB-3 subscribed to topic : education
Subscriber SUB-3 received: Publisher 8 Message 1
Subscriber SUB-3 received: Publisher 8 Message 2
Subscriber SUB-3 received: Publisher 3 Message 1
Subscriber SUB-3 received: Publisher 3 Message 2
Subscriber SUB-3 received: Publisher 1 Message 1
Subscriber SUB-3 received: Publisher 1 Message 2
Subscriber SUB-3 received: Publisher 7 Message 1
Subscriber SUB-3 received: Publisher 7 Message 2
Subscriber SUB-3 received: Publisher 5 Message 1
Subscriber SUB-3 received: Publisher 5 Message 2
Subscriber SUB-3 received: Publisher 6 Message 1
lisherSubscriber › src › test › java › com › example › publishersubscriber › connectionestablishmenttests › MultipleConnectionTests
1:1 CRLF UTF-8 4 spaces


Project
SingleConnectionTests.java
MultipleConnectionTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.c...
PublisherSubscriber 3 sec, 604 ms
Subscriber SUB-3 received: Publisher 6 Message 1
Subscriber SUB-3 received: Publisher 6 Message 2
Subscriber SUB-3 received: Publisher 4 Message 1
Subscriber SUB-3 received: Publisher 4 Message 2
Subscriber SUB-3 received: Publisher 2 Message 1
Subscriber SUB-3 received: Publisher 2 Message 2
Subscriber SUB-2 received: Publisher 8 Message 2
Subscriber SUB-8 received: Publisher 4 Message 2
Subscriber SUB-8 received: Publisher 2 Message 1
Subscriber SUB-8 received: Publisher 2 Message 2
Subscriber SUB-6 received: Publisher 8 Message 1
Subscriber SUB-6 received: Publisher 8 Message 2
Subscriber SUB-6 received: Publisher 3 Message 1
Subscriber SUB-6 received: Publisher 3 Message 2
Subscriber SUB-6 received: Publisher 1 Message 1
Subscriber SUB-6 received: Publisher 1 Message 2
Subscriber SUB-10 received: Publisher 8 Message 1
Subscriber SUB-9 received: Publisher 1 Message 1
Subscriber SUB-9 received: Publisher 1 Message 2
Subscriber SUB-9 received: Publisher 7 Message 1
Subscriber SUB-9 received: Publisher 7 Message 2
Subscriber SUB-9 received: Publisher 5 Message 1
Subscriber SUB-9 received: Publisher 5 Message 2
Subscriber SUB-9 received: Publisher 6 Message 1
Subscriber SUB-9 received: Publisher 6 Message 2
Subscriber SUB-9 received: Publisher 4 Message 1
Subscriber SUB-9 received: Publisher 4 Message 2
Subscriber SUB-9 received: Publisher 2 Message 1
Subscriber SUB-9 received: Publisher 2 Message 2
blisherSubscriber › src › test › java › com › example › publishersubscriber › connectionestablishmenttests › MultipleConnectionTests
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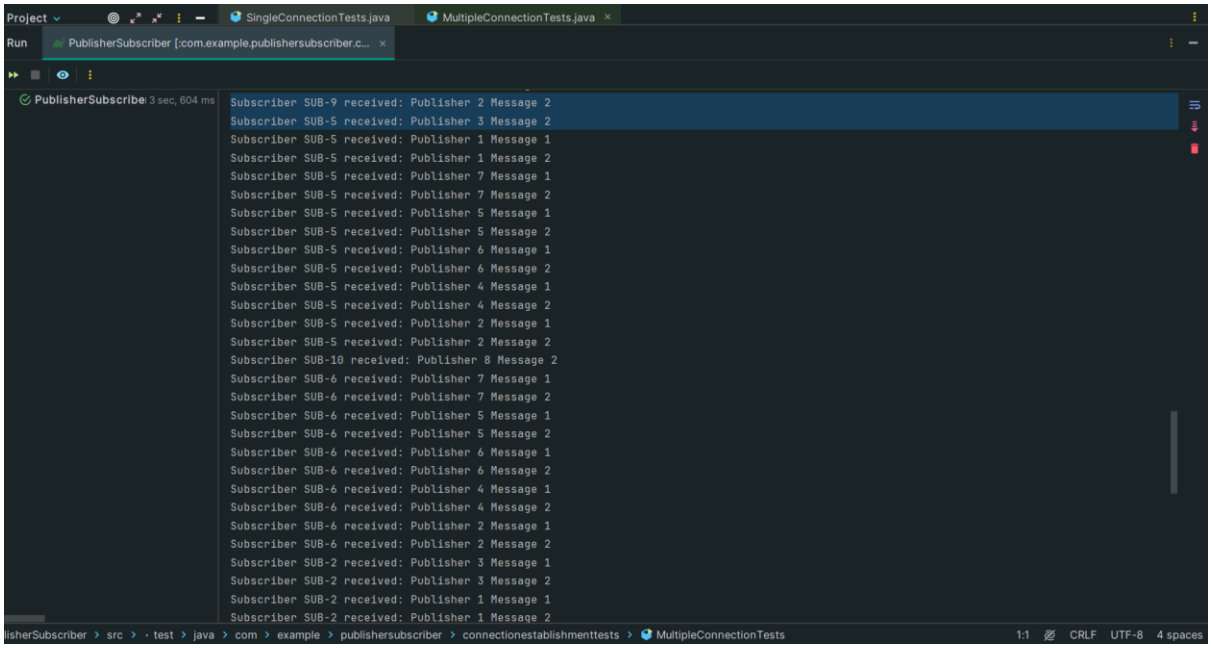
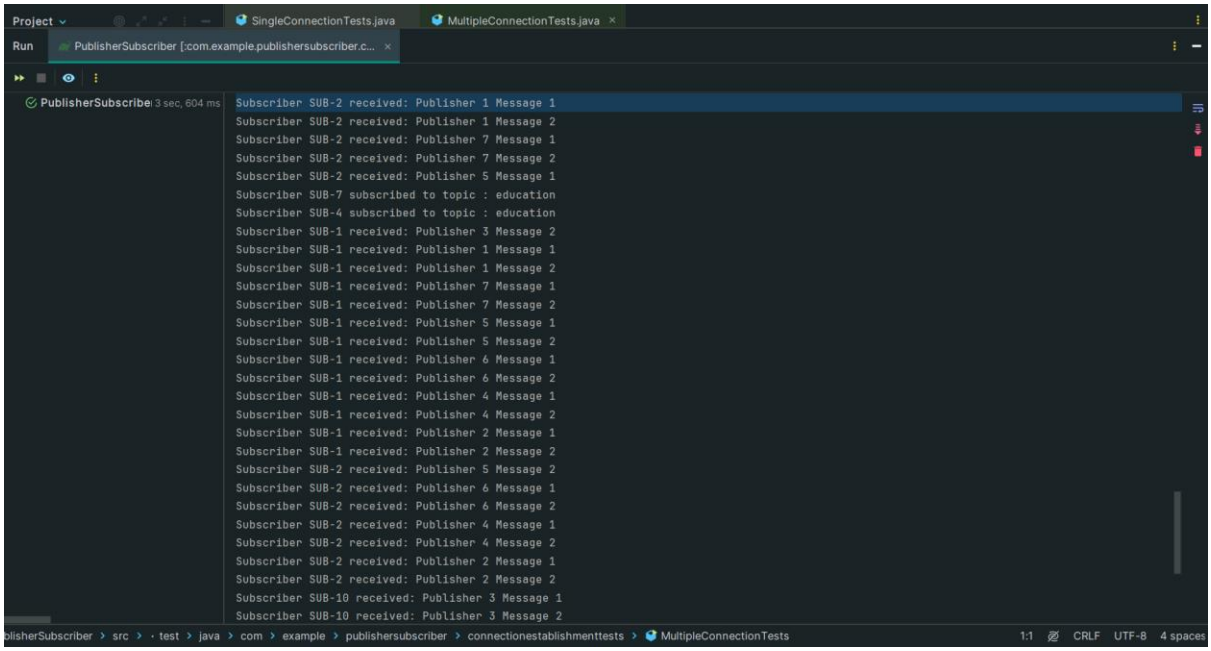

Project
SingleConnectionTests.java
MultipleConnectionTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.c...
PublisherSubscriber 3 sec, 604 ms
Subscriber SUB-9 received: Publisher 2 Message 2
Subscriber SUB-5 received: Publisher 3 Message 2
Subscriber SUB-5 received: Publisher 1 Message 1
Subscriber SUB-5 received: Publisher 1 Message 2
Subscriber SUB-5 received: Publisher 7 Message 1
Subscriber SUB-5 received: Publisher 7 Message 2
Subscriber SUB-5 received: Publisher 5 Message 1
Subscriber SUB-5 received: Publisher 5 Message 2
Subscriber SUB-5 received: Publisher 6 Message 1
Subscriber SUB-5 received: Publisher 6 Message 2
Subscriber SUB-5 received: Publisher 4 Message 1
Subscriber SUB-5 received: Publisher 4 Message 2
Subscriber SUB-5 received: Publisher 2 Message 1
Subscriber SUB-5 received: Publisher 2 Message 2
Subscriber SUB-10 received: Publisher 8 Message 2
Subscriber SUB-6 received: Publisher 7 Message 1
Subscriber SUB-6 received: Publisher 7 Message 2
Subscriber SUB-6 received: Publisher 5 Message 1
Subscriber SUB-6 received: Publisher 5 Message 2
Subscriber SUB-6 received: Publisher 6 Message 1
Subscriber SUB-6 received: Publisher 6 Message 2
Subscriber SUB-6 received: Publisher 4 Message 1
Subscriber SUB-6 received: Publisher 4 Message 2
Subscriber SUB-6 received: Publisher 2 Message 1
Subscriber SUB-6 received: Publisher 2 Message 2
Subscriber SUB-2 received: Publisher 3 Message 1
Subscriber SUB-2 received: Publisher 3 Message 2
Subscriber SUB-2 received: Publisher 1 Message 1
Subscriber SUB-2 received: Publisher 1 Message 2
lisherSubscriber › src › test › java › com › example › publishersubscriber › connectionestablishmenttests › MultipleConnectionTests
1:1 CRLF UTF-8 4 spaces


Project
SingleConnectionTests.java
MultipleConnectionTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.c...
PublisherSubscriber: 3 sec, 604 ms
Subscriber SUB-2 received: Publisher 1 Message 1
Subscriber SUB-2 received: Publisher 1 Message 2
Subscriber SUB-2 received: Publisher 7 Message 1
Subscriber SUB-2 received: Publisher 7 Message 2
Subscriber SUB-2 received: Publisher 5 Message 1
Subscriber SUB-7 subscribed to topic : education
Subscriber SUB-4 subscribed to topic : education
Subscriber SUB-1 received: Publisher 3 Message 2
Subscriber SUB-1 received: Publisher 1 Message 1
Subscriber SUB-1 received: Publisher 1 Message 2
Subscriber SUB-1 received: Publisher 7 Message 1
Subscriber SUB-1 received: Publisher 7 Message 2
Subscriber SUB-1 received: Publisher 5 Message 1
Subscriber SUB-1 received: Publisher 5 Message 2
Subscriber SUB-1 received: Publisher 6 Message 1
Subscriber SUB-1 received: Publisher 6 Message 2
Subscriber SUB-1 received: Publisher 4 Message 1
Subscriber SUB-1 received: Publisher 4 Message 2
Subscriber SUB-1 received: Publisher 2 Message 1
Subscriber SUB-1 received: Publisher 2 Message 2
Subscriber SUB-2 received: Publisher 5 Message 2
Subscriber SUB-2 received: Publisher 6 Message 1
Subscriber SUB-2 received: Publisher 6 Message 2
Subscriber SUB-2 received: Publisher 4 Message 1
Subscriber SUB-2 received: Publisher 4 Message 2
Subscriber SUB-2 received: Publisher 2 Message 1
Subscriber SUB-2 received: Publisher 2 Message 2
Subscriber SUB-10 received: Publisher 3 Message 1
Subscriber SUB-10 received: Publisher 3 Message 2
blisherSubscriber › src › test › java › com › example › publishersubscriber › connectionestablishmenttests › MultipleConnectionTests
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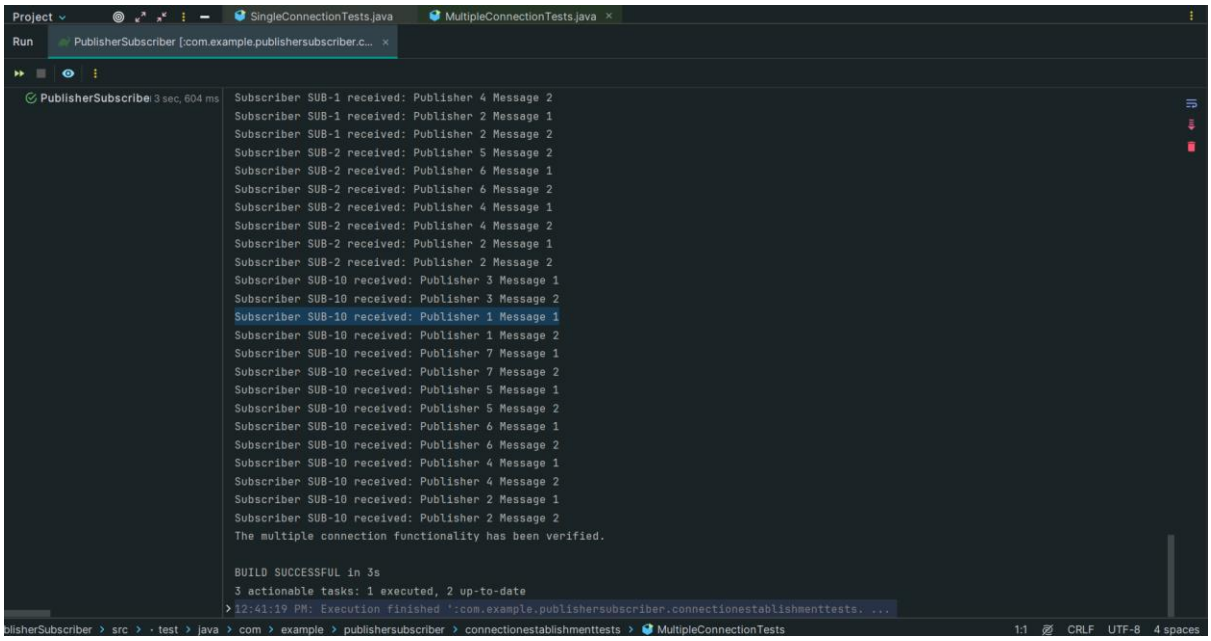
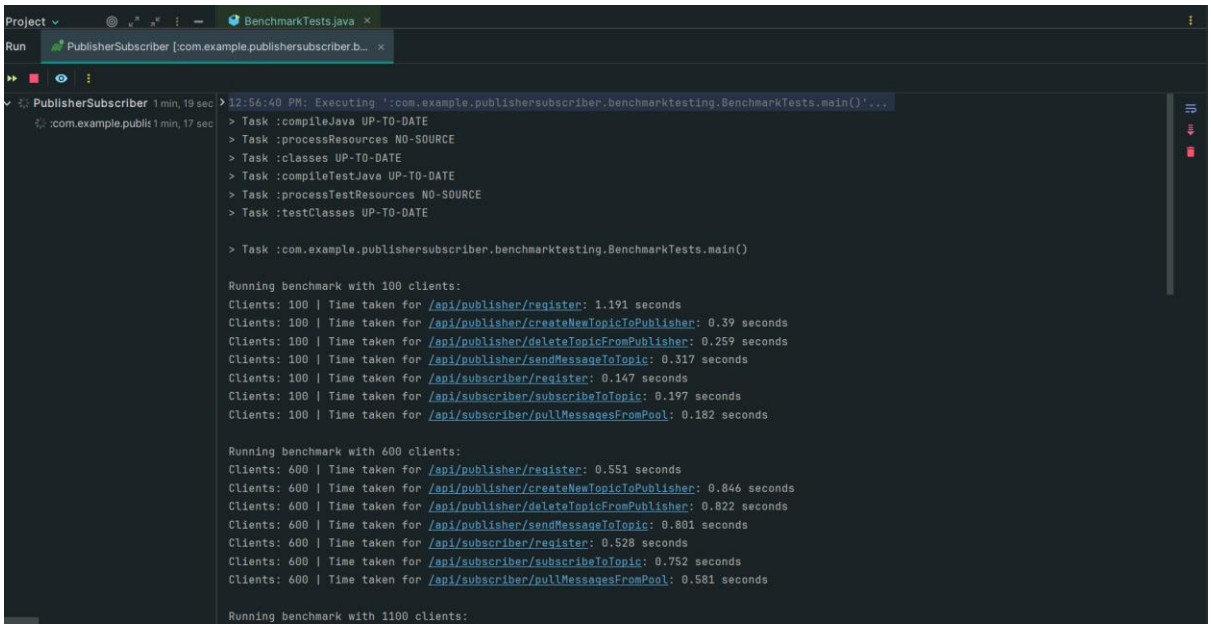
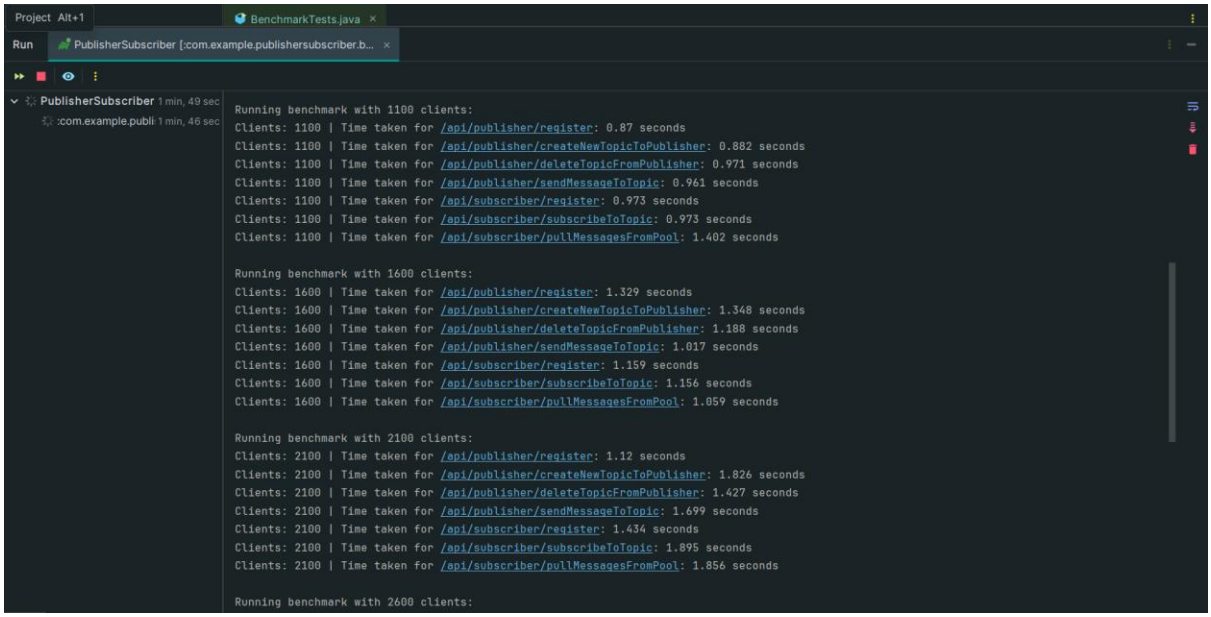
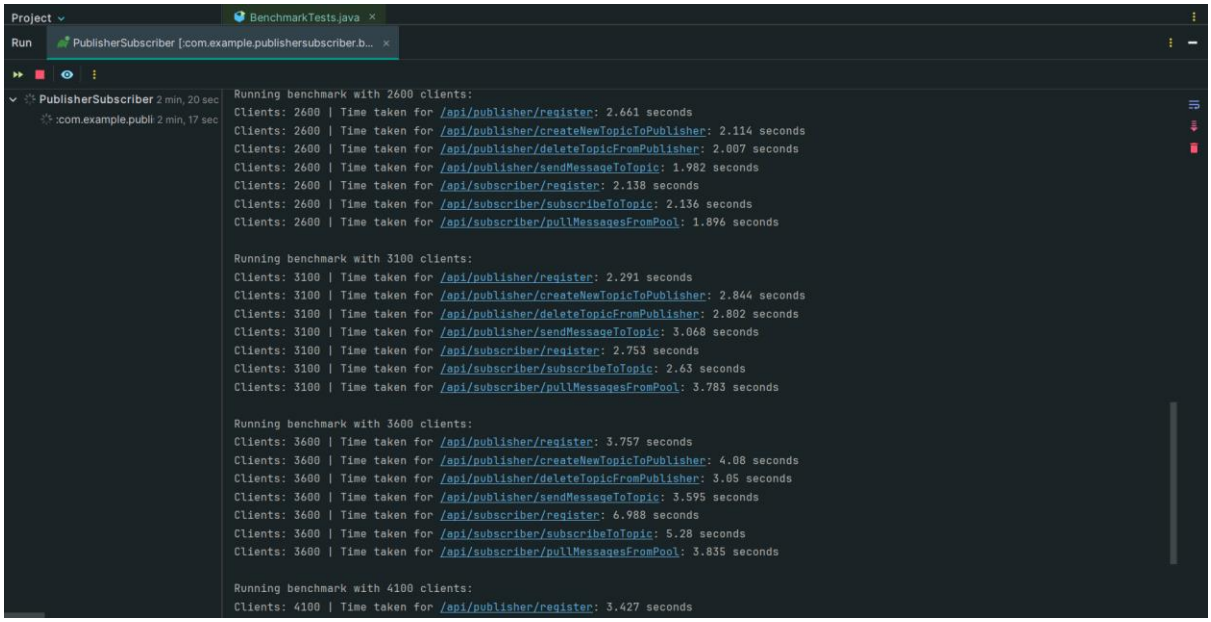
CRLF
UTF-8
4 spaces

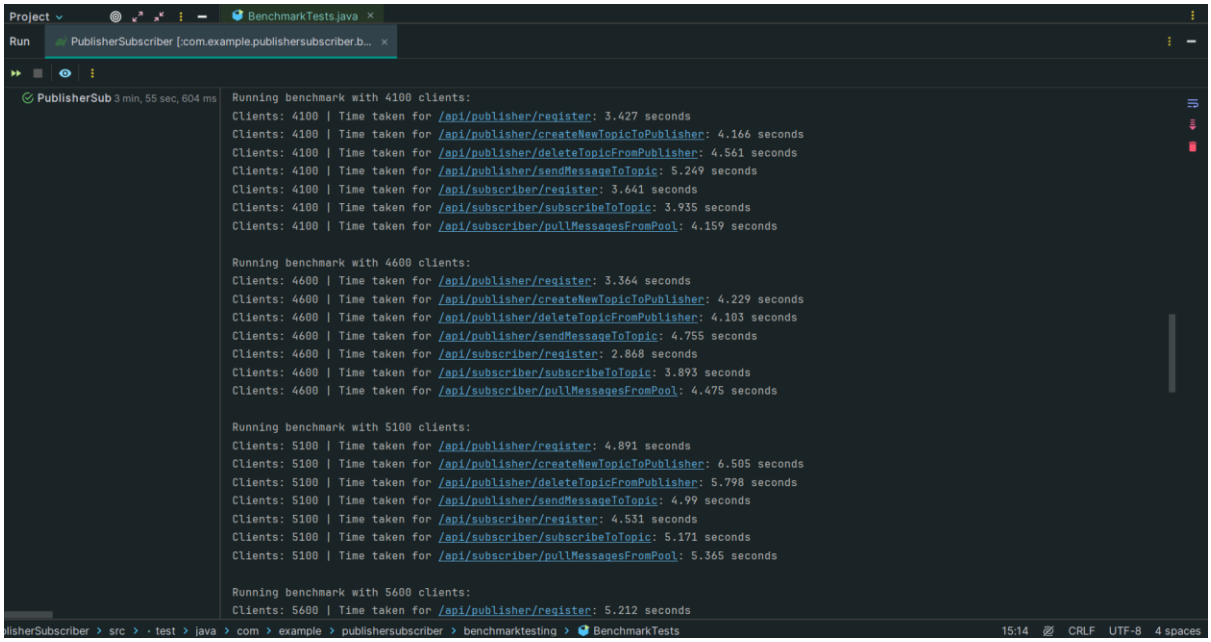

Project
SingleConnectionTests.java
MultipleConnectionTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.c...
PublisherSubscriber: 3 sec, 604 ms
Subscriber SUB-1 received: Publisher 4 Message 2
Subscriber SUB-1 received: Publisher 2 Message 1
Subscriber SUB-1 received: Publisher 2 Message 2
Subscriber SUB-2 received: Publisher 5 Message 2
Subscriber SUB-2 received: Publisher 6 Message 1
Subscriber SUB-2 received: Publisher 6 Message 2
Subscriber SUB-2 received: Publisher 4 Message 1
Subscriber SUB-2 received: Publisher 4 Message 2
Subscriber SUB-2 received: Publisher 2 Message 1
Subscriber SUB-2 received: Publisher 2 Message 2
Subscriber SUB-10 received: Publisher 3 Message 1
Subscriber SUB-10 received: Publisher 3 Message 2
Subscriber SUB-10 received: Publisher 1 Message 1
Subscriber SUB-10 received: Publisher 1 Message 2
Subscriber SUB-10 received: Publisher 7 Message 1
Subscriber SUB-10 received: Publisher 7 Message 2
Subscriber SUB-10 received: Publisher 5 Message 1
Subscriber SUB-10 received: Publisher 5 Message 2
Subscriber SUB-10 received: Publisher 6 Message 1
Subscriber SUB-10 received: Publisher 6 Message 2
Subscriber SUB-10 received: Publisher 4 Message 1
Subscriber SUB-10 received: Publisher 4 Message 2
Subscriber SUB-10 received: Publisher 2 Message 1
Subscriber SUB-10 received: Publisher 2 Message 2
The multiple connection functionality has been verified.
BUILD SUCCESSFUL in 3s
3 actionable tasks: 1 executed, 2 up-to-date
12:41:19 PM: Execution finished ':com.example.publishersubscriber.connectionestablishmenttests. ...
blisherSubscriber › src › test › java › com › example › publishersubscriber › connectionestablishmenttests › MultipleConnectionTests
1:1
CRLF
UTF-8
4 spaces

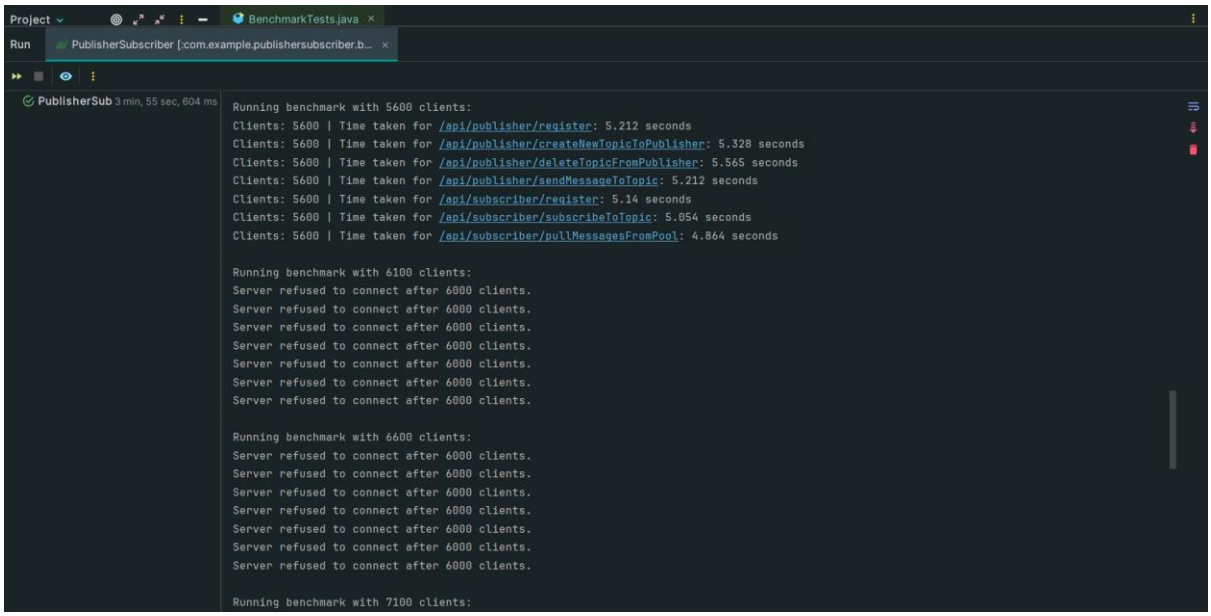
Benchmark Testing Results

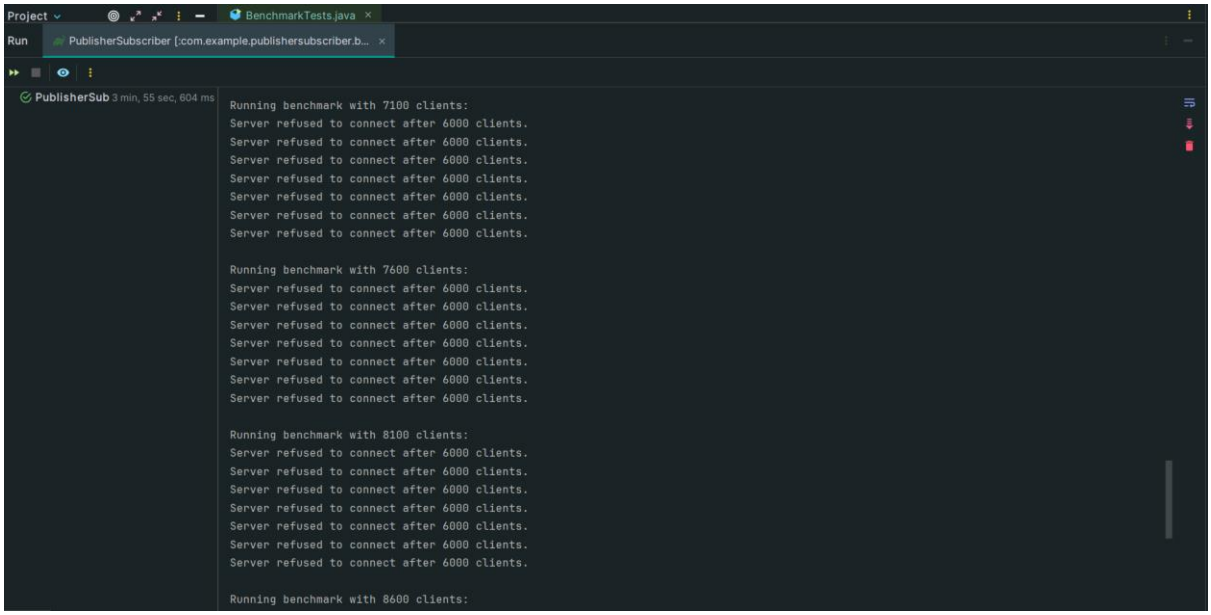


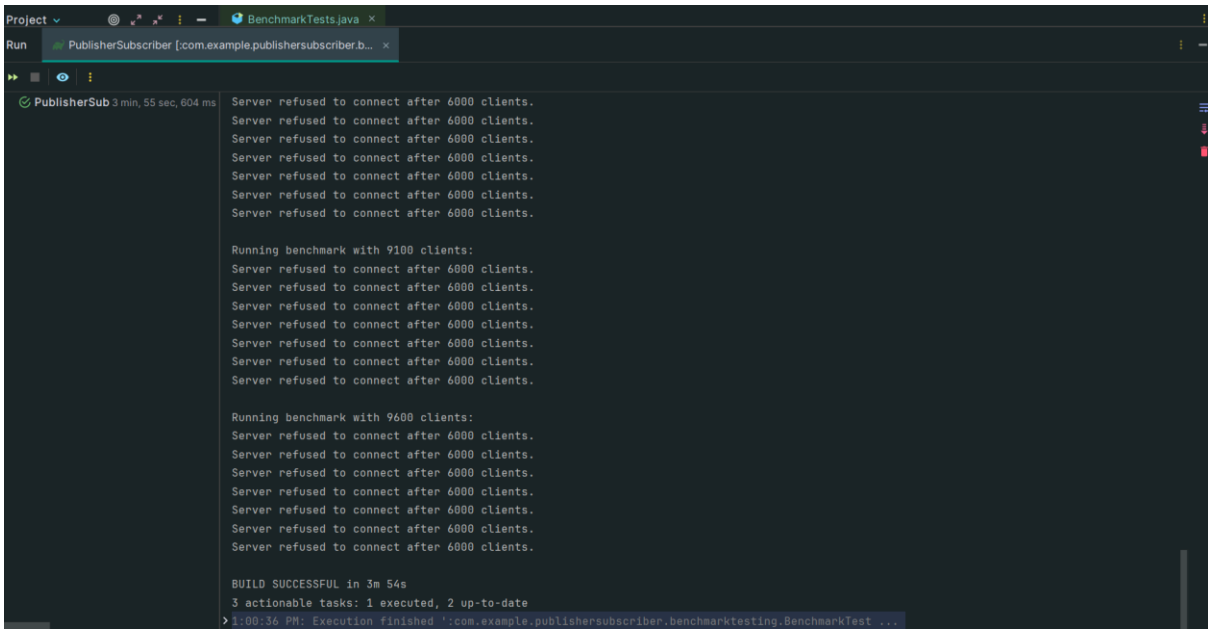

Project Alt+1
BenchmarkTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.b...
PublisherSubscriber 1 min, 49 sec
:com.example.publi 1 min, 46 sec
Running benchmark with 1100 clients:
Clients: 1100 | Time taken for /api/publisher/register: 0.87 seconds
Clients: 1100 | Time taken for /api/publisher/createNewTopicToPublisher: 0.882 seconds
Clients: 1100 | Time taken for /api/publisher/deleteTopicFromPublisher: 0.971 seconds
Clients: 1100 | Time taken for /api/publisher/sendMessageToTopic: 0.961 seconds
Clients: 1100 | Time taken for /api/subscriber/register: 0.973 seconds
Clients: 1100 | Time taken for /api/subscriber/subscribeToTopic: 0.973 seconds
Clients: 1100 | Time taken for /api/subscriber/pullMessagesFromPool: 1.402 seconds
Running benchmark with 1600 clients:
Clients: 1600 | Time taken for /api/publisher/register: 1.329 seconds
Clients: 1600 | Time taken for /api/publisher/createNewTopicToPublisher: 1.348 seconds
Clients: 1600 | Time taken for /api/publisher/deleteTopicFromPublisher: 1.188 seconds
Clients: 1600 | Time taken for /api/publisher/sendMessageToTopic: 1.017 seconds
Clients: 1600 | Time taken for /api/subscriber/register: 1.159 seconds
Clients: 1600 | Time taken for /api/subscriber/subscribeToTopic: 1.156 seconds
Clients: 1600 | Time taken for /api/subscriber/pullMessagesFromPool: 1.059 seconds
Running benchmark with 2100 clients:
Clients: 2100 | Time taken for /api/publisher/register: 1.12 seconds
Clients: 2100 | Time taken for /api/publisher/createNewTopicToPublisher: 1.826 seconds
Clients: 2100 | Time taken for /api/publisher/deleteTopicFromPublisher: 1.427 seconds
Clients: 2100 | Time taken for /api/publisher/sendMessageToTopic: 1.699 seconds
Clients: 2100 | Time taken for /api/subscriber/register: 1.434 seconds
Clients: 2100 | Time taken for /api/subscriber/subscribeToTopic: 1.895 seconds
Clients: 2100 | Time taken for /api/subscriber/pullMessagesFromPool: 1.856 seconds
Running benchmark with 2600 clients:


Project
BenchmarkTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.b...
PublisherSubscriber 2 min, 20 sec
:com.example.publi 2 min, 17 sec
Running benchmark with 2600 clients:
Clients: 2600 | Time taken for /api/publisher/register: 2.661 seconds
Clients: 2600 | Time taken for /api/publisher/createNewTopicToPublisher: 2.114 seconds
Clients: 2600 | Time taken for /api/publisher/deleteTopicFromPublisher: 2.007 seconds
Clients: 2600 | Time taken for /api/publisher/sendMessageToTopic: 1.982 seconds
Clients: 2600 | Time taken for /api/subscriber/register: 2.138 seconds
Clients: 2600 | Time taken for /api/subscriber/subscribeToTopic: 2.136 seconds
Clients: 2600 | Time taken for /api/subscriber/pullMessagesFromPool: 1.896 seconds
Running benchmark with 3100 clients:
Clients: 3100 | Time taken for /api/publisher/register: 2.291 seconds
Clients: 3100 | Time taken for /api/publisher/createNewTopicToPublisher: 2.844 seconds
Clients: 3100 | Time taken for /api/publisher/deleteTopicFromPublisher: 2.802 seconds
Clients: 3100 | Time taken for /api/publisher/sendMessageToTopic: 3.068 seconds
Clients: 3100 | Time taken for /api/subscriber/register: 2.753 seconds
Clients: 3100 | Time taken for /api/subscriber/subscribeToTopic: 2.63 seconds
Clients: 3100 | Time taken for /api/subscriber/pullMessagesFromPool: 3.783 seconds
Running benchmark with 3600 clients:
Clients: 3600 | Time taken for /api/publisher/register: 3.757 seconds
Clients: 3600 | Time taken for /api/publisher/createNewTopicToPublisher: 4.08 seconds
Clients: 3600 | Time taken for /api/publisher/deleteTopicFromPublisher: 3.05 seconds
Clients: 3600 | Time taken for /api/publisher/sendMessageToTopic: 3.595 seconds
Clients: 3600 | Time taken for /api/subscriber/register: 6.988 seconds
Clients: 3600 | Time taken for /api/subscriber/subscribeToTopic: 5.28 seconds
Clients: 3600 | Time taken for /api/subscriber/pullMessagesFromPool: 3.835 seconds
Running benchmark with 4100 clients:
Clients: 4100 | Time taken for /api/publisher/register: 3.427 seconds


Project
BenchmarkTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.b...
PublisherSub 3 min, 55 sec, 604 ms
Running benchmark with 4100 clients:
Clients: 4100 | Time taken for /api/publisher/register: 3.427 seconds
Clients: 4100 | Time taken for /api/publisher/createNewTopicToPublisher: 4.166 seconds
Clients: 4100 | Time taken for /api/publisher/deleteTopicFromPublisher: 4.561 seconds
Clients: 4100 | Time taken for /api/publisher/sendMessageToTopic: 5.249 seconds
Clients: 4100 | Time taken for /api/subscriber/register: 3.641 seconds
Clients: 4100 | Time taken for /api/subscriber/subscribeToTopic: 3.935 seconds
Clients: 4100 | Time taken for /api/subscriber/pullMessagesFromPool: 4.159 seconds
Running benchmark with 4600 clients:
Clients: 4600 | Time taken for /api/publisher/register: 3.364 seconds
Clients: 4600 | Time taken for /api/publisher/createNewTopicToPublisher: 4.229 seconds
Clients: 4600 | Time taken for /api/publisher/deleteTopicFromPublisher: 4.103 seconds
Clients: 4600 | Time taken for /api/publisher/sendMessageToTopic: 4.755 seconds
Clients: 4600 | Time taken for /api/subscriber/register: 2.868 seconds
Clients: 4600 | Time taken for /api/subscriber/subscribeToTopic: 3.893 seconds
Clients: 4600 | Time taken for /api/subscriber/pullMessagesFromPool: 4.475 seconds
Running benchmark with 5100 clients:
Clients: 5100 | Time taken for /api/publisher/register: 4.891 seconds
Clients: 5100 | Time taken for /api/publisher/createNewTopicToPublisher: 6.505 seconds
Clients: 5100 | Time taken for /api/publisher/deleteTopicFromPublisher: 5.798 seconds
Clients: 5100 | Time taken for /api/publisher/sendMessageToTopic: 4.99 seconds
Clients: 5100 | Time taken for /api/subscriber/register: 4.531 seconds
Clients: 5100 | Time taken for /api/subscriber/subscribeToTopic: 5.171 seconds
Clients: 5100 | Time taken for /api/subscriber/pullMessagesFromPool: 5.365 seconds
Running benchmark with 5600 clients:
Clients: 5600 | Time taken for /api/publisher/register: 5.212 seconds
lisherSubscriber › src › test › java › com › example › publishersubscriber › benchmarktesting › BenchmarkTests
15:14 CRLF UTF-8 4 spaces

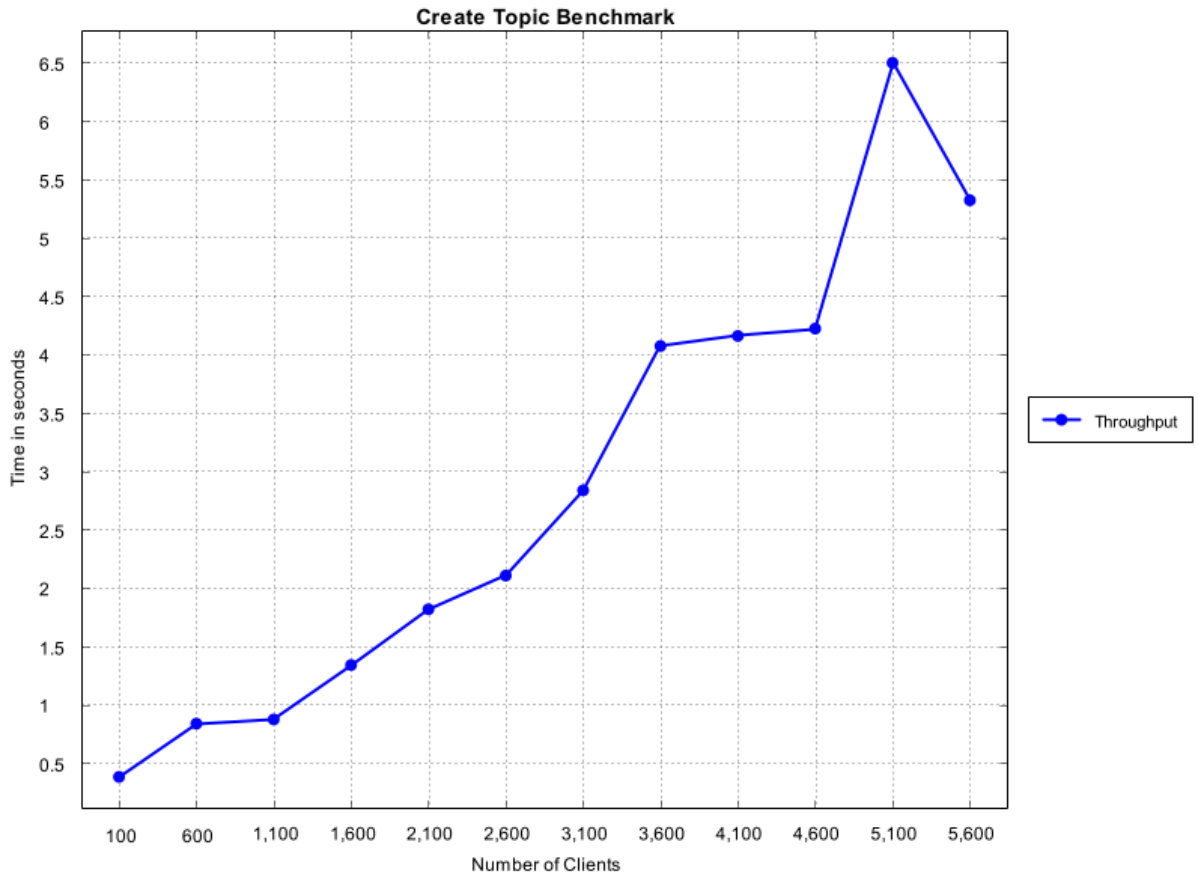

Project
BenchmarkTests.java
Run
PublisherSubscriber [:com.example.publishersubscriber.b...
PublisherSub 3 min, 55 sec, 604 ms
Running benchmark with 5600 clients:
Clients: 5600 | Time taken for /api/publisher/register: 5.212 seconds
Clients: 5600 | Time taken for /api/publisher/createNewTopicToPublisher: 5.328 seconds
Clients: 5600 | Time taken for /api/publisher/deleteTopicFromPublisher: 5.565 seconds
Clients: 5600 | Time taken for /api/publisher/sendMessageToTopic: 5.212 seconds
Clients: 5600 | Time taken for /api/subscriber/register: 5.14 seconds
Clients: 5600 | Time taken for /api/subscriber/subscribeToTopic: 5.054 seconds
Clients: 5600 | Time taken for /api/subscriber/pullMessagesFromPool: 4.864 seconds
Running benchmark with 6100 clients:
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Running benchmark with 6600 clients:
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Server refused to connect after 6000 clients.
Running benchmark with 7100 clients:

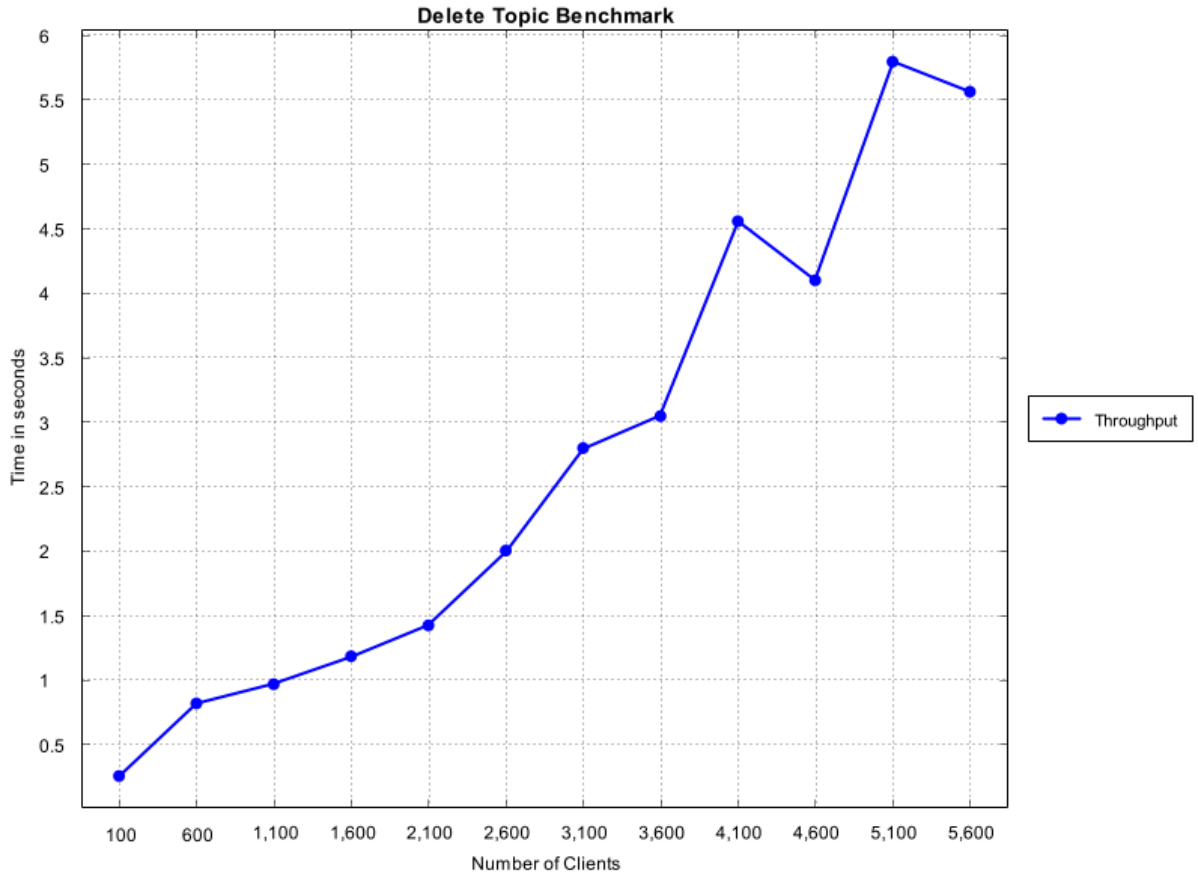


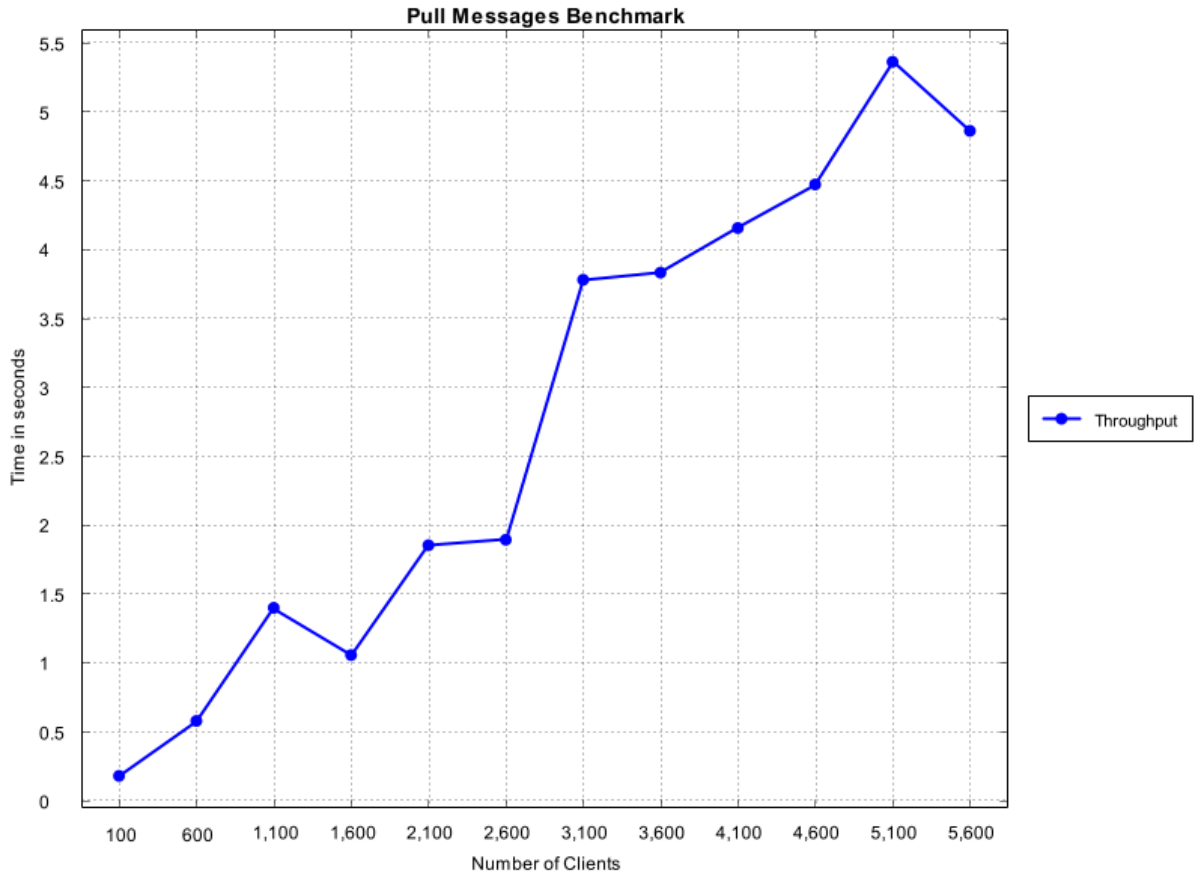


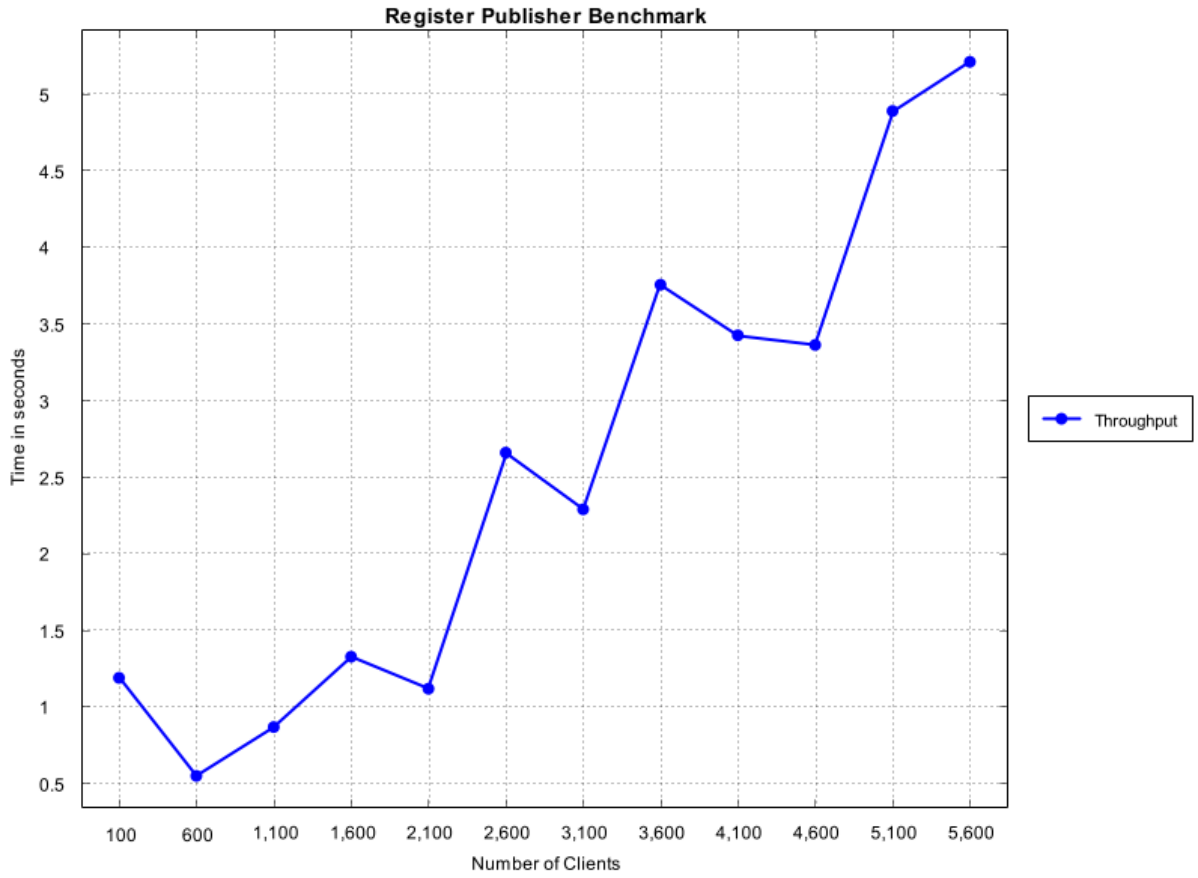
This saves the values to csv files in root folder and the Plot.java file, when run, plots a graph for each API plotting its benchmark results between time in seconds and the number of clients.

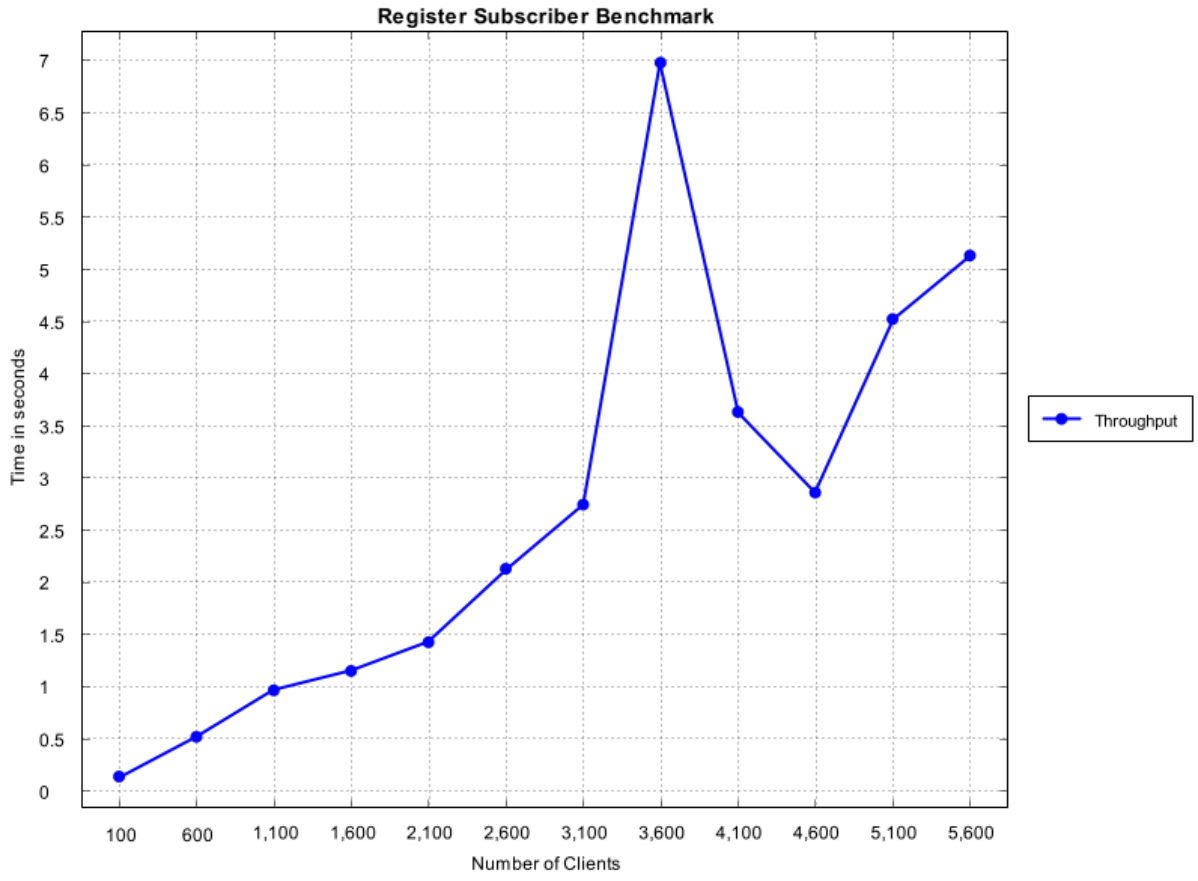
Screenshot of each benchmarked graph is as follows:

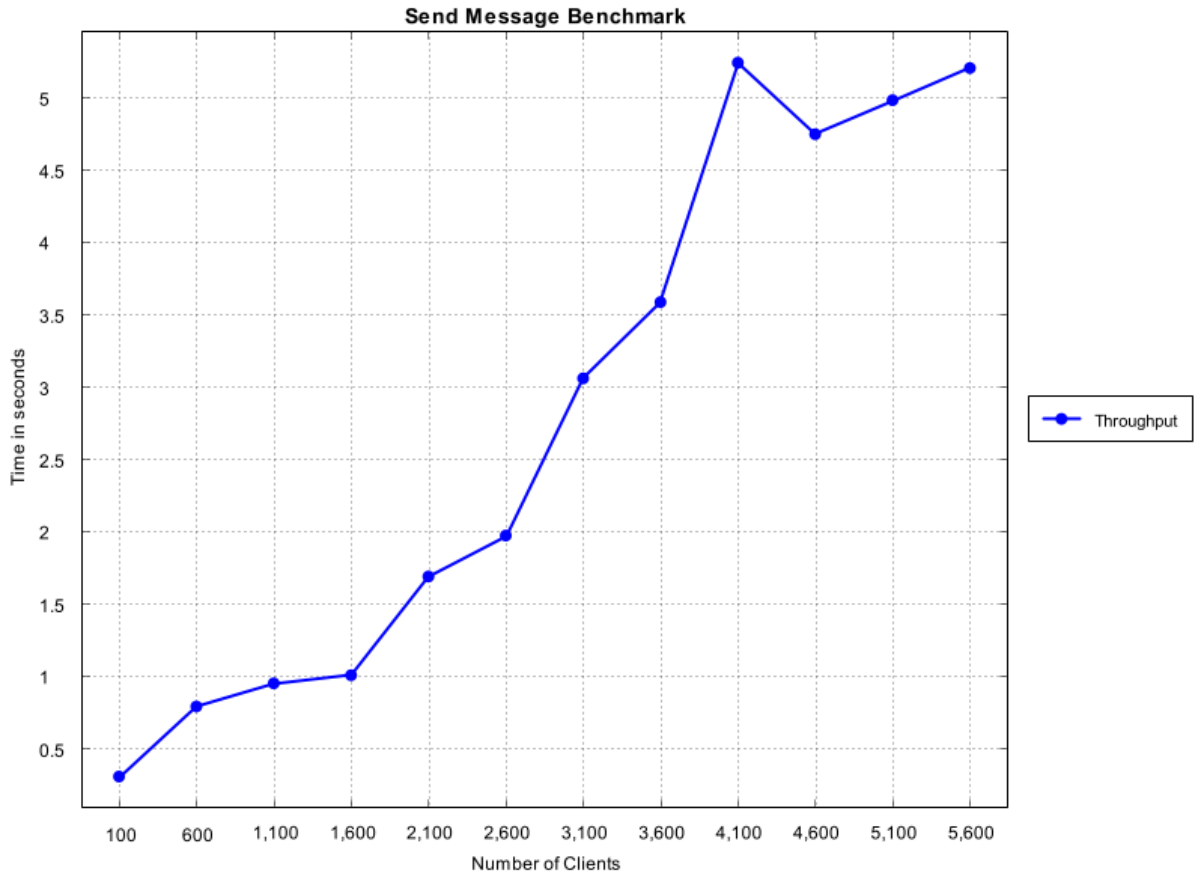


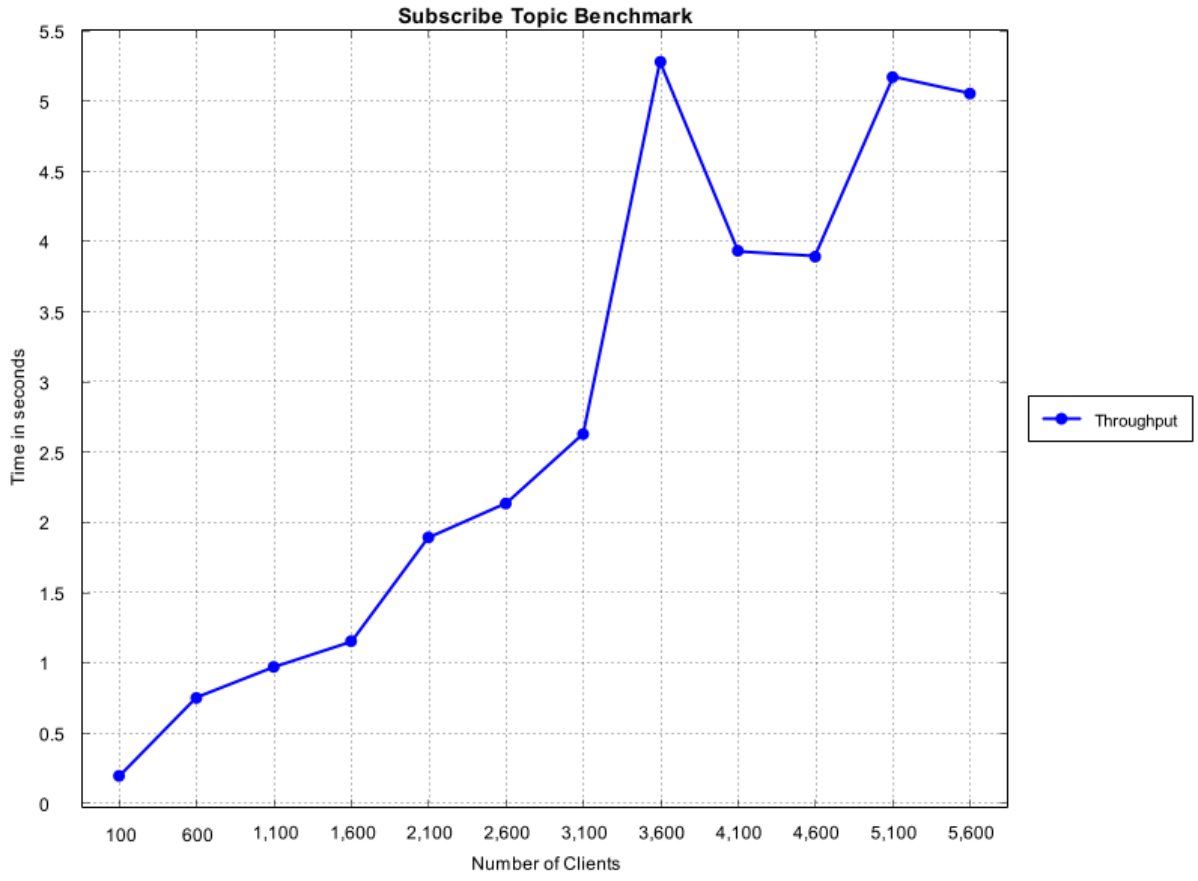

Delete Topic Benchmark
Time in seconds
Number of Clients
Throughput
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
100
600
1,100
1,600
2,100
2,600
3,100
3,600
4,100
4,600
5,100
5,600


Pull Messages Benchmark
Time in seconds
Number of Clients
Throughput
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
100
600
1,100
1,600
2,100
2,600
3,100
3,600
4,100
4,600
5,100
5,600


Register Publisher Benchmark
Time in seconds
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
100
600
1,100
1,600
2,100
2,600
3,100
3,600
4,100
4,600
5,100
5,600
Number of Clients
Throughput


Register Subscriber Benchmark
Time in seconds
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
100
600
1,100
1,600
2,100
2,600
3,100
3,600
4,100
4,600
5,100
5,600
Number of Clients
Throughput


Send Message Benchmark
Time in seconds
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
100
600
1,100
1,600
2,100
2,600
3,100
3,600
4,100
4,600
5,100
5,600
Number of Clients
Throughput

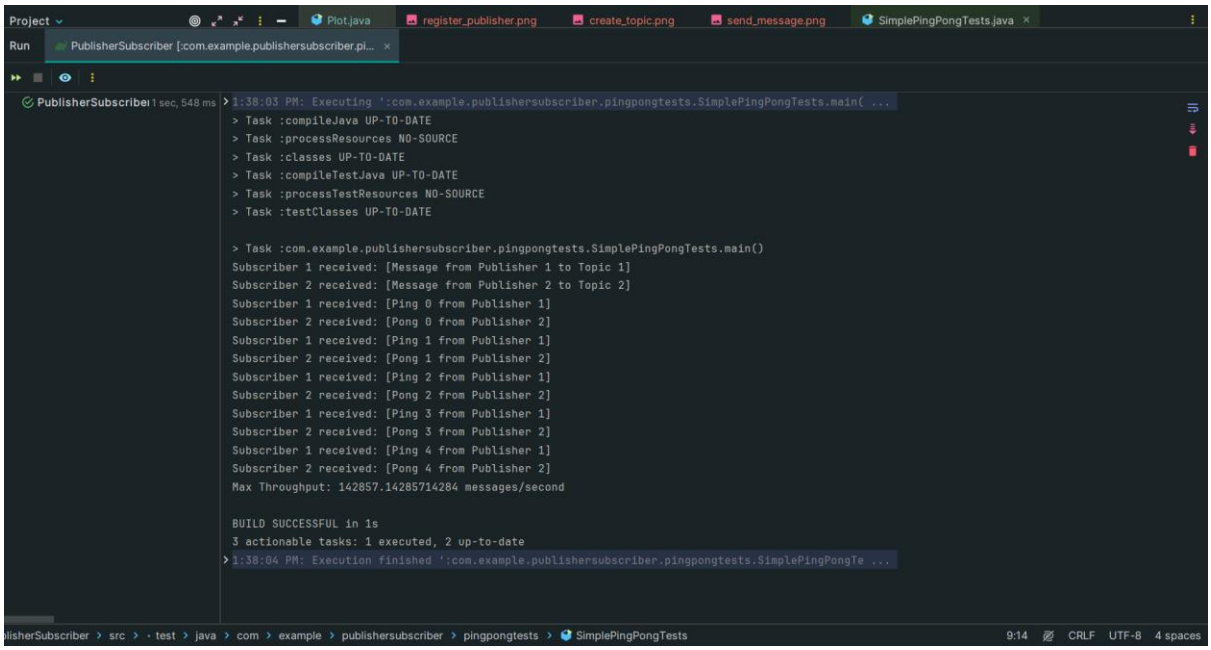

Subscribe Topic Benchmark
Time in seconds
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
100
600
1,100
1,600
2,100
2,600
3,100
3,600
4,100
4,600
5,100
5,600
Number of Clients
Throughput

Ping Pong Testing

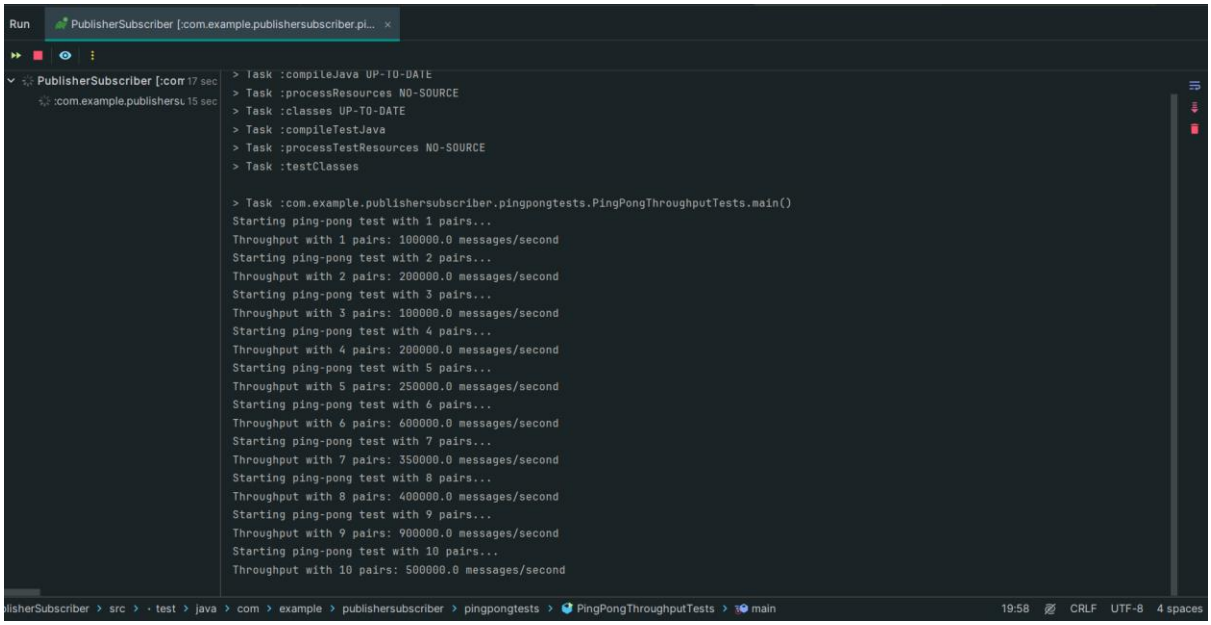
Ping Pong testing in a publisher-subscriber system is used to evaluate the round-trip communication efficiency between the publisher and subscriber. It involves sending a message from the publisher to the subscriber and having the subscriber respond back to the publisher, simulating a ping-pong-like exchange of messages. The purpose of this test is to measure latency, throughput, and the overall performance of the message broker, ensuring that messages are delivered and acknowledged in a timely manner. This helps assess how well the system can handle continuous back-and-forth communication under various loads, ensuring low-latency message exchange, which is critical in real-time applications.

Ping Pong testing in this context is applicable to all 7 APIs of the publisher-subscriber system. It assesses the round-trip communication between the client (either publisher or subscriber) and the server for each API operation, such as registering a publisher, creating or deleting a topic, sending messages, registering a subscriber, subscribing to topics, and pulling messages. The goal is to measure the time taken for a request to travel from the client to the server and back, ensuring that all components, including the message broker and RESTful endpoints, function efficiently under load. This helps determine the overall latency and throughput of the system for different operations.

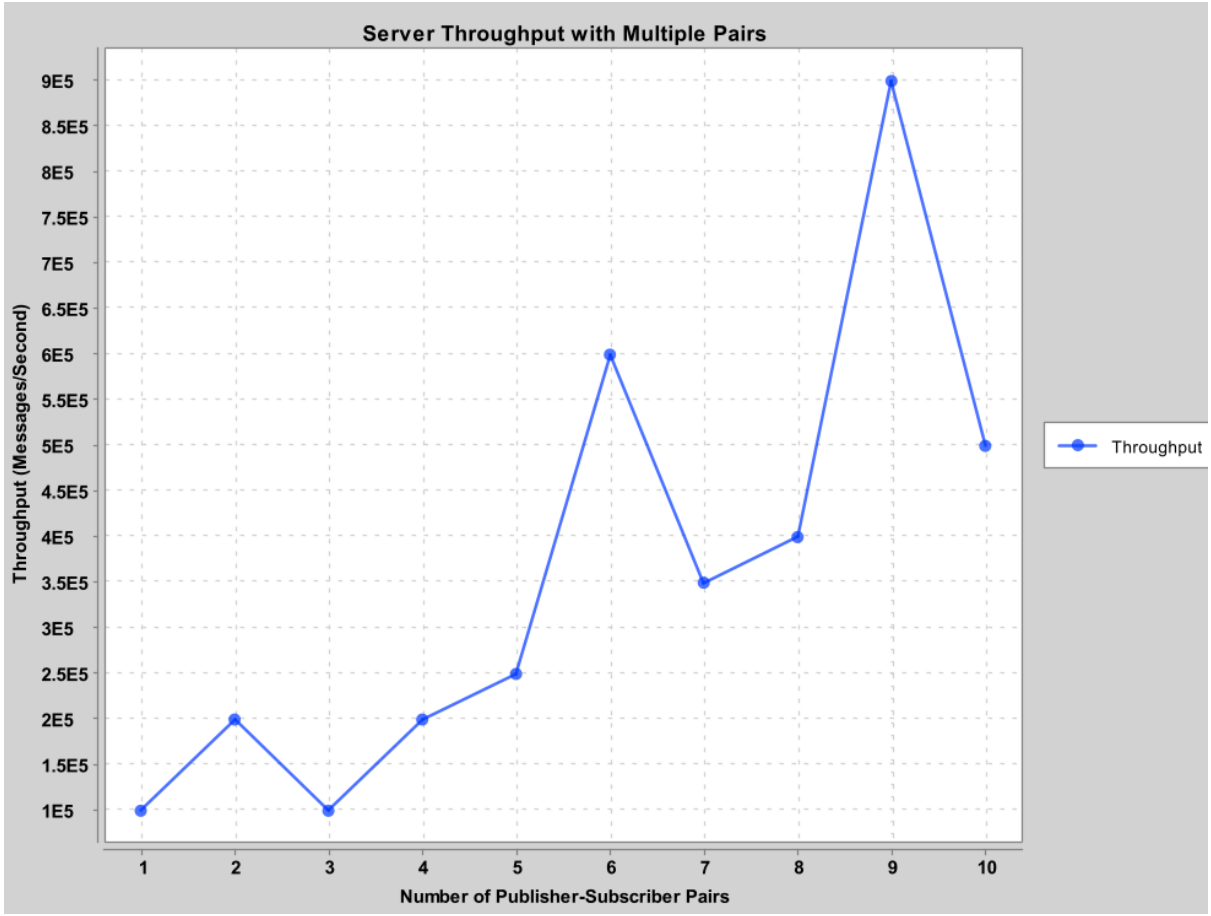
Single Ping Pong Testing:



Multiple Ping Pong Test interaction:



Plotting the observation:



NOTE:

For all the throughput testing, since I have made use of the SpringBoot server, the load it is able to take maxes out even 10000 clients which takes around 15 minutes to run on my system. So, I am just plotting a graph and not choking the connection.

CONCLUSION:

The graph plots for each API in the publisher-subscriber system are likely to show the performance of the system under increasing client load. The key metric being plotted is the time taken (in seconds) on the Y-axis against the number of clients on the X-axis.

Expected Graph Patterns for Each API:

1. ***Register Publisher API:***
    - Graph Title: "Register Publisher Benchmark"
    - Expected Behaviour: Initially, as the number of clients increases, the time taken should increase slightly but stay relatively low since registering a publisher is a lightweight operation. However, as the number of clients grows, the time taken could rise exponentially due to bottlenecks or resource contention.
    - Shape: Slight upward curve, with potential exponential rise after a large number of clients.
2. ***Create Topic API:***
    - Graph Title: "Create Topic Benchmark"
    - Expected Behaviour: Similar to registering publishers, creating a topic is a lightweight task. The time taken should remain low for a smaller number of clients but will increase as concurrency rises.
    - Shape: Gradually increasing curve, with sharper rise at high client counts.
3. ***Delete Topic API:***
    - Graph Title: "Delete Topic Benchmark"
    - Expected Behaviour: Deleting a topic might take slightly longer than creating one, as it may require updating multiple internal structures. The time will increase with the number of clients, especially at higher loads.
    - Shape: Similar to the "Create Topic" graph, but may rise more steeply at higher client counts.
4. ***Send Message API:***
    - Graph Title: "Send Message Benchmark"
    - Expected Behaviour: Sending messages is expected to show a clear upward trend as the number of clients increases. This API requires interacting with the

message broker, which could cause bottlenecks when handling a large number of concurrent messages.

- Shape: Steeper upward curve compared to registration or topic operations, especially at higher loads.

5. **Register Subscriber API:**

- Graph Title: "Register Subscriber Benchmark"
- Expected Behaviour: Similar to the "Register Publisher" benchmark, registering a subscriber is relatively fast but could slow down under heavy client loads.
- Shape: Slightly increasing curve, with a possible steep rise after hitting a client threshold.

6. ***Subscribe Topic API:***

- Graph Title: "Subscribe Topic Benchmark"
- Expected Behaviour: Subscribing to a topic involves updating subscription lists, which can take time as the number of topics and subscribers grows. The graph might show a moderate upward curve, especially as the system handles more clients.
- Shape: Gradual increase, potentially sharper at higher client counts.

7. ***Pull Messages API:***

- Graph Title: "Pull Messages Benchmark"
- Expected Behaviour: Pulling messages may show the most significant increase in time taken, as it depends on the number of messages in the pool, the size of the messages, and the number of clients trying to access the pool. Under high loads, the time taken could spike dramatically.
- Shape: A steeper rise compared to the other APIs, with potential spikes under heavy load.

Overall Expected Behaviour:

- ✓ Initial Phase (lower number of clients): All APIs should exhibit relatively low and stable response times.
- ✓ Mid-Range Phase (medium client load): The curves will begin to show a gradual rise in time taken as more clients interact with the system concurrently.
- ✓ High Load Phase (large number of clients): At some point, the response time will increase exponentially as system bottlenecks or server resource limits are hit.

The send message and pull messages operations are likely to show more dramatic increases compared to registration or topic-related operations.