

Replicated log task

Дмитренко Данііл, Рябко Дмитро, Мартиненко Денис ФБ-42мп

Iteration 0.

Choose a desirable language for implementation and try to implement (or find the implementation) a simple *Echo Client-Server* application.

Server:

```
PS C:\Users\dmytr\Desktop\5_2\dsd\project> python .\iteration0\echo_server.py
2025-06-04 16:46:55,358 - SERVER - INFO - Echo server listening on 0.0.0.0:65432
2025-06-04 16:46:57,753 - SERVER - INFO - Connected by ('127.0.0.1', 62419)
2025-06-04 16:46:57,753 - SERVER - INFO - Received from ('127.0.0.1', 62419): Test Message 1 from client
2025-06-04 16:46:57,753 - SERVER - INFO - Echoed to ('127.0.0.1', 62419): Test Message 1 from client
2025-06-04 16:46:57,753 - SERVER - INFO - Connection closed by ('127.0.0.1', 62419)
2025-06-04 16:46:58,753 - SERVER - INFO - Connected by ('127.0.0.1', 62420)
2025-06-04 16:46:58,753 - SERVER - INFO - Received from ('127.0.0.1', 62420): Another Message from client
2025-06-04 16:46:58,753 - SERVER - INFO - Echoed to ('127.0.0.1', 62420): Another Message from client
2025-06-04 16:46:58,753 - SERVER - INFO - Connection closed by ('127.0.0.1', 62420)
```

Client:

```
PS C:\Users\dmytr\Desktop\5_2\dsd\project> python .\iteration0\echo_client.py
2025-06-04 16:46:57,752 - CLIENT - INFO - Sending: 'Test Message 1 from client'
2025-06-04 16:46:57,753 - CLIENT - INFO - Received echo: 'Test Message 1 from client'
2025-06-04 16:46:58,753 - CLIENT - INFO - Sending: 'Another Message from client'
2025-06-04 16:46:58,753 - CLIENT - INFO - Received echo: 'Another Message from client'
PS C:\Users\dmytr\Desktop\5_2\dsd\project>
```

Iteration 1.

Task

The Replicated Log should have the following deployment architecture: one **Master** and any number of **Secondaries**.

Master should expose a simple HTTP server (or alternative service with a similar API) with:

- *POST method* - appends a message into the in-memory list
- *GET method* - returns all messages from the in-memory list

Secondary should expose a simple HTTP server(or alternative service with a similar API) with:

- *GET method* - returns all replicated messages from the in-memory list

Properties and assumptions:

- after each POST request, the message should be replicated on every *Secondary* server
- *Master* should ensure that *Secondaries* have received a message via *ACK*
- *Master's POST request* should be finished only after receiving *ACKs* from all *Secondaries* (blocking replication approach)
- to test that the replication is blocking, introduce the delay/sleep on the *Secondary*
- at this stage assume that the communication channel is a perfect link (no failures and messages lost)
- any RPC framework can be used for *Master-Secondary* communication (Sockets, language-specific RPC, HTTP, Rest, gRPC, ...)
- your implementation should support logging
- *Master* and *Secondaries* should run in Docker

Demonstration:

Запустимо наші ноди:

<input type="checkbox"/>	iteration1	Running (3/3)	0%	10 seconds ago	
<input type="checkbox"/>	master_11_fastapi 0be4de04b487	iteration1-master	Running	0% 5000:5000	6 minutes ago
<input type="checkbox"/>	secondary2_11_fastapi 8e115de2a2dc	iteration1-secondary2	Running	0% 5002:5002	10 seconds ago
<input type="checkbox"/>	secondary1_11_fastapi 3f90c331daa9	iteration1-secondary1	Running	0% 5001:5001	10 seconds ago

Додамо перше повідомлення:

Postman interface showing a POST request to `http://localhost:8001/message` with a body of `{ "message": "Hello FastAPI Replicated World!" }`. The response is a 201 Created status with a body of `{ "status": "message appended and replicated", "message_id": "15e4bab8-9c6c-48a9-ab0d-c28a46733906" }`.

Виведемо список усіх повідомлень:

Postman interface showing a GET request to `http://localhost:8001/messages`. The response is a 200 OK status with a body of `{ "id": "15e4bab8-9c6c-48a9-ab0d-c28a46733906", "message": "Hello FastAPI Replicated World!" }`.

Логи:

```
master_11_fastapi 2025-06-04 17:09:18 secondary1_11_fastapi INFO: Will watch for changes in these directories: ['/app']
Iteration1-master 2025-06-04 17:09:18 secondary1_11_fastapi INFO: Uvicorn running on http://0.0.0.0:5001 (Press CTRL+C to quit)
Running 5000-5000 2025-06-04 17:09:19 secondary1_11_fastapi INFO: Started server process [7] using Watchfiles
2025-06-04 17:09:19 secondary1_11_fastapi INFO: Started server process [9]
secondary1_11_fastapi 2025-06-04 17:09:19 secondary1_11_fastapi INFO: Waiting for application startup.
Iteration1-secondary 2025-06-04 17:10:32 secondary1_11_fastapi INFO: Application startup complete.
Running 5001-5001 2025-06-04 14:10:32,665 - SECONDARY (secondary1) - INFO - Received replication request for message: ID 15e4bab8-9cdc-48a9-abbd-c28a6733906, Message: 'Hello FastAPI Replicated World!'
2025-06-04 17:10:32 secondary1_11_fastapi 2025-06-04 14:10:32,665 - SECONDARY (secondary1) - INFO - Artificial delay of 2.0 seconds started...
2025-06-04 17:10:34 secondary1_11_fastapi 2025-06-04 14:10:34,664 - SECONDARY (secondary1) - INFO - Artificial delay finished.
2025-06-04 17:10:34 secondary1_11_fastapi 2025-06-04 14:10:34,665 - SECONDARY (secondary1) - INFO - Message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 appended to secondary log.
2025-06-04 17:10:34 secondary1_11_fastapi INFO: 172.24.0.2:55778 - "POST /replicate HTTP/1.1" 200 OK
secondary1_11_fastapi 2025-06-04 17:09:18 secondary2_11_fastapi INFO: Will watch for changes in these directories: ['/app']
Iteration1-secondary 2025-06-04 17:09:18 secondary2_11_fastapi INFO: Uvicorn running on http://0.0.0.0:5002 (Press CTRL+C to quit)
Running 5001-5001 2025-06-04 17:09:19 secondary2_11_fastapi INFO: Started server process [7] using Watchfiles
2025-06-04 17:09:19 secondary2_11_fastapi INFO: Started server process [9]
2025-06-04 17:09:19 secondary2_11_fastapi INFO: Waiting for application startup.
2025-06-04 17:09:19 secondary2_11_fastapi INFO: Application startup complete.
2025-06-04 17:10:32 secondary2_11_fastapi 2025-06-04 14:10:32,665 - SECONDARY (secondary2) - INFO - Received replication request for message: ID 15e4bab8-9cdc-48a9-abbd-c28a6733906, Message: 'Hello FastAPI Replicated World!'
2025-06-04 17:10:32 secondary2_11_fastapi 2025-06-04 14:10:32,665 - SECONDARY (secondary2) - INFO - Artificial delay of 5.0 seconds started...
2025-06-04 17:10:37 secondary2_11_fastapi 2025-06-04 14:10:37,666 - SECONDARY (secondary2) - INFO - Artificial delay finished.
2025-06-04 17:10:37 secondary2_11_fastapi 2025-06-04 14:10:37,666 - SECONDARY (secondary2) - INFO - Message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 appended to secondary log.
2025-06-04 17:10:37 secondary2_11_fastapi INFO: 172.24.0.2:46054 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:03:11 master_11_fastapi INFO: Will watch for changes in these directories: ['/app']
2025-06-04 17:03:11 master_11_fastapi INFO: Uvicorn running on http://0.0.0.0:5000 (Press CTRL+C to quit)
2025-06-04 17:03:11 master_11_fastapi INFO: Started server process [1] using Watchfiles
2025-06-04 17:03:12 master_11_fastapi INFO: Started server process [3]
2025-06-04 17:03:12 master_11_fastapi INFO: Master initialized. Secondary URLs: ['http://secondary1:5001', 'http://secondary2:5002']
2025-06-04 17:03:12 master_11_fastapi INFO: Waiting for application startup.
2025-06-04 17:03:12 master_11_fastapi INFO: Application startup complete.
2025-06-04 17:10:06 master_11_fastapi INFO: 172.24.0.1:51262 - "GET /message HTTP/1.1" 404 Not Found
2025-06-04 17:10:18 master_11_fastapi INFO: 172.24.0.1:38228 - "GET /messages HTTP/1.1" 200 OK
2025-06-04 17:10:32 master_11_fastapi 2025-06-04 14:10:32,660 - MASTER - INFO - Appended message to master log: {'id': '15e4bab8-9cdc-48a9-abbd-c28a6733906', 'message': 'Hello FastAPI Replicated World!' }
2025-06-04 17:10:32 master_11_fastapi 2025-06-04 14:10:32,660 - MASTER - INFO - Replicating message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 to http://secondary1:5001...
2025-06-04 17:10:32 master_11_fastapi 2025-06-04 14:10:32,660 - MASTER - INFO - Replicating message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 to http://secondary2:5002...
2025-06-04 17:10:32 master_11_fastapi 2025-06-04 14:10:32,661 - MASTER - INFO - Waiting for ACKs from 2 secondaries for message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906...
2025-06-04 17:10:34 master_11_fastapi 2025-06-04 14:10:34,666 - MASTER - INFO - Successfully replicated message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 to http://secondary1:5001. ACK received (HTTP 200).
2025-06-04 17:10:34 master_11_fastapi 2025-06-04 14:10:34,666 - MASTER - INFO - Received ACK confirmation for message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 (event 1/2 processed).
2025-06-04 17:10:37 master_11_fastapi 2025-06-04 14:10:37,667 - MASTER - INFO - Successfully replicated message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 to http://secondary2:5002. ACK received (HTTP 200).
2025-06-04 17:10:37 master_11_fastapi 2025-06-04 14:10:37,667 - MASTER - INFO - Received ACK confirmation for message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906 (event 2/2 processed).
2025-06-04 17:10:37 master_11_fastapi 2025-06-04 14:10:37,667 - MASTER - INFO - All ACKs received for message ID 15e4bab8-9cdc-48a9-abbd-c28a6733906. Responding to client.
2025-06-04 17:10:37 master_11_fastapi INFO: 172.24.0.1:50194 - "POST /messages HTTP/1.1" 201 Created
2025-06-04 17:12:24 master_11_fastapi INFO: 172.24.0.1:49268 - "GET /messages HTTP/1.1" 200 OK
```

Iteration 2.

Task

In the previous iteration, the replication was blocking for all secondaries, i.e. to return a response to the client we should receive acknowledgements (ACK) from all secondaries.

Current iteration should provide tunable semi-synchronicity for replication, by defining *write concern* parameters.

- client POST request in addition to the message should also contain *write concern* parameter $w=1,2,3,...,n$
- w value specifies how many ACKs the master should receive from secondaries before responding to the client

$w = 1$ - only from master

$w = 2$ - from master and one secondary

$w = 3$ - from master and two secondaries

Please emulate the replica's inconsistency (and eventual consistency) with the master by introducing the artificial delay on the secondary node. In this case, the master and secondary should temporarily return different lists of messages.

Add logic for messages deduplication and to guarantee the total ordering of messages.

Demonstration:

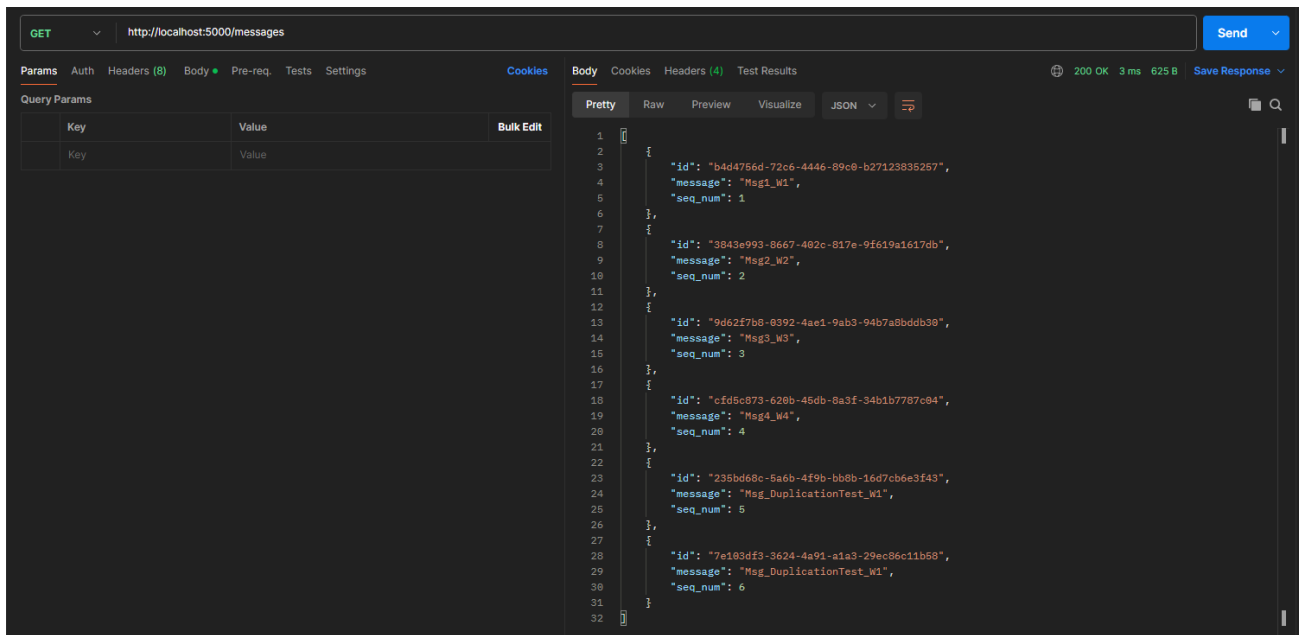
The screenshot shows a Kubernetes dashboard with a deployment named 'Iteration2' in a 'Running' state with 4/4 pods. The pods are: 'master_t2_fastapi' (fa0eebb6ae26), 'secondary1_t2_fastapi' (a91ce693142d), 'secondary2_t2_fastapi' (7bb20e012c72), and 'secondary3_t2_fastapi' (4f1a7171ef0). Below the dashboard is a terminal log showing the application startup sequence. The log indicates that the master node starts first, followed by the secondary nodes. Each node logs information about watching directories, running Uvicorn, starting a reloader process, and waiting for application startup. The master node also logs the initialization of secondary URLs: 'http://secondary1:5001', 'http://secondary2:5002', and 'http://secondary3:5003'.

Зальємо повідомлення з різними W, при створенні секондарі нод у них були різні таймаути.

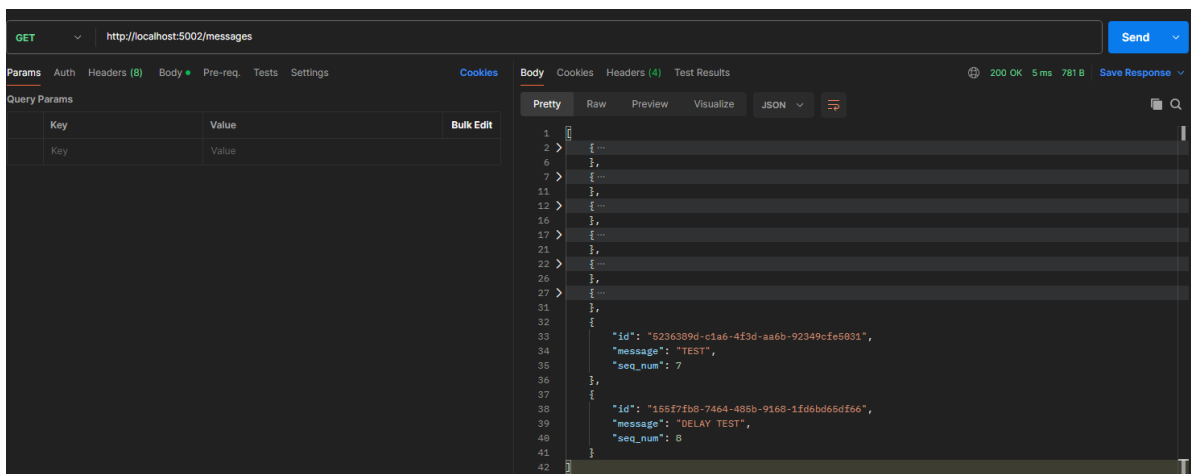
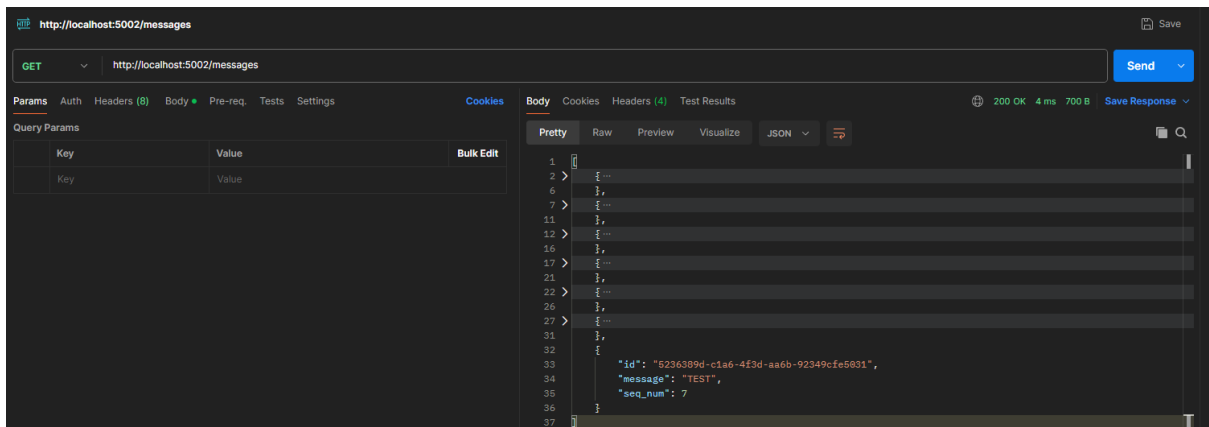
The four screenshots show a sequence of POST requests to 'http://localhost:5000/messages' and the corresponding JSON responses. Each request contains a 'message' and a 'w' value. The responses show the status of the message (appended or replicated) and a unique 'message_id' and 'sequence_number'.

- Request 1:** {"message": "Msg1_W1", "w": 1}. **Response:** {"status": "message appended to master", "message_id": "b4d47E6d-72c6-4446-89c8-b27123835257", "sequence_number": 1}.
- Request 2:** {"message": "Msg2_W2", "w": 2}. **Response:** {"status": "message appended and replicated with w=2", "message_id": "3843e993-8667-482c-817e-9f619a1617db", "sequence_number": 2}.
- Request 3:** {"message": "Msg3_W3", "w": 3}. **Response:** {"status": "message appended and replicated with w=3", "message_id": "9d62f7b8-8392-4ae1-9ab3-94b7a8bddd39", "sequence_number": 3}.
- Request 4:** {"message": "Msg4_W4", "w": 4}. **Response:** {"status": "message appended and replicated with w=4", "message_id": "cfd5c873-620b-45db-8a3f-34b1b7787c84", "sequence_number": 4}.

Нижче бачимо результат, успішна дедуплікація.



Спробуємо отримати ситуацію коли у secondary через delay не відображаються всі messages. Спочатку додам повідомлення, а після одразу ж зроблю запит на секундарі з затримкою а потім через деякий час знову зроблю запит:



Як бачимо спрацювало, подивимося лог:

```

2025-06-04 17:32:10 master_12_fastapi | 2025-06-04 14:32:19,693 - MASTER - INFO - Appended to master log: ID 155f7fb8-7464-485b-9168-1fd6bd65df66, Seq 8, Msg 'DELAY TEST', w=1
2025-06-04 17:32:10 master_12_fastapi | 2025-06-04 14:32:19,693 - MASTER - INFO - w=1, responding to client for msg_id 155f7fb8-7464-485b-9168-1fd6bd65df66 immediately.
2025-06-04 17:32:10 master_12_fastapi | INFO: 172.25.0.1:47689 - "POST /message HTTP/1.1" 201 Created
2025-06-04 17:32:10 master_12_fastapi | 2025-06-04 14:32:19,712 - MASTER - INFO - Replicating message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 (Seq 8) to http://secondary1:5001...
2025-06-04 17:32:10 master_12_fastapi | 2025-06-04 14:32:19,733 - MASTER - INFO - Replicating message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 (Seq 8) to http://secondary2:5002...
2025-06-04 17:32:10 master_12_fastapi | 2025-06-04 14:32:19,750 - MASTER - INFO - Replicating message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 (Seq 8) to http://secondary3:5003...
2025-06-04 17:32:10 secondary2_12_fastapi | 2025-06-04 14:32:19,754 - SECONDARY (secondary2) - INFO - Received replication request: ID 155f7fb8-7464-485b-9168-1fd6bd65df66, Seq 8, Msg 'DELAY TEST'
2025-06-04 17:32:10 secondary2_12_fastapi | 2025-06-04 14:32:19,754 - SECONDARY (secondary2) - INFO - Artificial delay of 3.0 seconds started...
2025-06-04 17:32:10 secondary1_12_fastapi | 2025-06-04 14:32:19,755 - SECONDARY (secondary1) - INFO - Received replication request: ID 155f7fb8-7464-485b-9168-1fd6bd65df66, Seq 8, Msg 'DELAY TEST'
2025-06-04 17:32:10 secondary1_12_fastapi | 2025-06-04 14:32:19,755 - SECONDARY (secondary1) - INFO - Artificial delay of 1.0 seconds started...
2025-06-04 17:32:10 secondary3_12_fastapi | 2025-06-04 14:32:19,755 - SECONDARY (secondary3) - INFO - Received replication request: ID 155f7fb8-7464-485b-9168-1fd6bd65df66, Seq 8, Msg 'DELAY TEST'
2025-06-04 17:32:10 secondary3_12_fastapi | 2025-06-04 14:32:19,755 - SECONDARY (secondary3) - INFO - Message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 (Seq 8) appended to secondary log. Log size: 8
2025-06-04 17:32:10 secondary3_12_fastapi | INFO: 172.25.0.2:60068 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:32:10 master_12_fastapi | 2025-06-04 14:32:19,756 - MASTER - INFO - HTTP Request: POST http://secondary3:5003/replicate "HTTP/1.1 200 OK"
2025-06-04 17:32:10 master_12_fastapi | 2025-06-04 14:32:19,756 - MASTER - INFO - Successfully replicated message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 to http://secondary3:5003. ACK received.
2025-06-04 17:32:20 secondary1_12_fastapi | 2025-06-04 14:32:20,755 - SECONDARY (secondary1) - INFO - Artificial delay finished.
2025-06-04 17:32:20 secondary1_12_fastapi | 2025-06-04 14:32:20,755 - SECONDARY (secondary1) - INFO - Message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 (Seq 8) appended to secondary log. Log size: 8
2025-06-04 17:32:20 secondary1_12_fastapi | INFO: 172.25.0.2:43794 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:32:20 master_12_fastapi | 2025-06-04 14:32:20,756 - MASTER - INFO - HTTP Request: POST http://secondary2:5002/replicate "HTTP/1.1 200 OK"
2025-06-04 17:32:20 master_12_fastapi | 2025-06-04 14:32:20,757 - MASTER - INFO - Successfully replicated message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 to http://secondary2:5002. ACK received.
2025-06-04 17:32:21 secondary2_12_fastapi | 2025-06-04 14:32:20,757 - MASTER - INFO - GET /message HTTP/1.1" 200 OK
2025-06-04 17:32:21 secondary2_12_fastapi | INFO: 172.25.0.1:43394 - "GET /message HTTP/1.1" 200 OK
2025-06-04 17:32:22 secondary2_12_fastapi | 2025-06-04 14:32:22,754 - SECONDARY (secondary2) - INFO - Artificial delay finished.
2025-06-04 17:32:22 secondary2_12_fastapi | 2025-06-04 14:32:22,754 - SECONDARY (secondary2) - INFO - Message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 (Seq 8) appended to secondary log. Log size: 8
2025-06-04 17:32:22 secondary2_12_fastapi | INFO: 172.25.0.2:40066 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:32:22 master_12_fastapi | 2025-06-04 14:32:22,755 - MASTER - INFO - HTTP Request: POST http://secondary2:5002/replicate "HTTP/1.1 200 OK"
2025-06-04 17:32:22 master_12_fastapi | 2025-06-04 14:32:22,755 - MASTER - INFO - Successfully replicated message ID 155f7fb8-7464-485b-9168-1fd6bd65df66 to http://secondary2:5002. ACK received.
2025-06-04 17:34:11 secondary2_12_fastapi | INFO: 172.25.0.1:51408 - "GET /message HTTP/1.1" 200 OK

```

Тут бачимо що спочатку користувач запросив список повідомлень, а вже після відбулася реплікація.

Інші логи:

```

2025-06-04 17:26:01 secondary3_12_fastapi | 2025-06-04 14:26:01,820 - SECONDARY (secondary3) - INFO - Received replication request: ID b4d4756d-72c6-4446-89c0-b27123835257, Seq 1, Msg 'Msg1_W1'
2025-06-04 17:26:01 secondary3_12_fastapi | 2025-06-04 14:26:01,820 - SECONDARY (secondary3) - INFO - Message ID b4d4756d-72c6-4446-89c0-b27123835257 (Seq 1) appended to secondary log. Log size: 1
2025-06-04 17:26:01 secondary3_12_fastapi | INFO: 172.25.0.2:51766 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:26:26 secondary3_12_fastapi | 2025-06-04 14:26:26,167 - SECONDARY (secondary3) - INFO - Received replication request: ID 3843e993-8667-402c-817e-9f619a1617db, Seq 2, Msg 'Msg2_W2'
2025-06-04 17:26:26 secondary3_12_fastapi | 2025-06-04 14:26:26,167 - SECONDARY (secondary3) - INFO - Message ID 3843e993-8667-402c-817e-9f619a1617db (Seq 2) appended to secondary log. Log size: 2
2025-06-04 17:26:26 secondary3_12_fastapi | INFO: 172.25.0.2:49656 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:26:36 secondary3_12_fastapi | 2025-06-04 14:26:36,301 - SECONDARY (secondary3) - INFO - Received replication request: ID 9d62f7b8-0392-4ae1-9ab3-94b7a8b8db30, Seq 3, Msg 'Msg3_W3'
2025-06-04 17:26:36 secondary3_12_fastapi | 2025-06-04 14:26:36,302 - SECONDARY (secondary3) - INFO - Message ID 9d62f7b8-0392-4ae1-9ab3-94b7a8b8db30 (Seq 3) appended to secondary log. Log size: 3
2025-06-04 17:26:36 secondary3_12_fastapi | INFO: 172.25.0.2:58374 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:26:54 secondary3_12_fastapi | 2025-06-04 14:26:54,888 - SECONDARY (secondary3) - INFO - Received replication request: ID cfd5c873-620b-45db-8a3f-34b1b7787c04, Seq 4, Msg 'Msg4_W4'
2025-06-04 17:26:54 secondary3_12_fastapi | 2025-06-04 14:26:54,888 - SECONDARY (secondary3) - INFO - Message ID cfd5c873-620b-45db-8a3f-34b1b7787c04 (Seq 4) appended to secondary log. Log size: 4
2025-06-04 17:26:54 secondary3_12_fastapi | INFO: 172.25.0.2:57210 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:28:27 secondary3_12_fastapi | 2025-06-04 14:28:27,664 - SECONDARY (secondary3) - INFO - Received replication request: ID 235bd68c-5a6b-4f9b-bb8b-16d7cb6e3f43, Seq 5, Msg 'Msg_DuplicationTest_W1'
2025-06-04 17:28:27 secondary3_12_fastapi | 2025-06-04 14:28:27,664 - SECONDARY (secondary3) - INFO - Message ID 235bd68c-5a6b-4f9b-bb8b-16d7cb6e3f43 (Seq 5) appended to secondary log. Log size: 5
2025-06-04 17:28:27 secondary3_12_fastapi | INFO: 172.25.0.2:59354 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:28:28 secondary3_12_fastapi | 2025-06-04 14:28:28,268 - SECONDARY (secondary3) - INFO - Received replication request: ID 7e103df3-3624-4a91-a1a3-29ec86c11b58, Seq 6, Msg 'Msg_DuplicationTest_W1'
2025-06-04 17:28:28 secondary3_12_fastapi | 2025-06-04 14:28:28,268 - SECONDARY (secondary3) - INFO - Message ID 7e103df3-3624-4a91-a1a3-29ec86c11b58 (Seq 6) appended to secondary log. Log size: 6
2025-06-04 17:28:28 secondary3_12_fastapi | INFO: 172.25.0.2:58228 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:18:43 secondary1_12_fastapi | INFO: Will watch for changes in these directories: ['/app']
2025-06-04 17:18:43 secondary2_12_fastapi | INFO: Will watch for changes in these directories: ['/app']
2025-06-04 17:18:43 secondary1_12_fastapi | INFO: Uvicorn running on http://0.0.0.0:5001 (Press CTRL+C to quit)
2025-06-04 17:18:43 secondary1_12_fastapi | INFO: Started reload process [7] using WatchFiles
2025-06-04 17:18:44 secondary1_12_fastapi | INFO: Started server process [9]
2025-06-04 17:18:44 secondary1_12_fastapi | INFO: Waiting for application startup.
2025-06-04 17:18:44 secondary1_12_fastapi | INFO: Application startup complete.
2025-06-04 17:26:01 secondary1_12_fastapi | 2025-06-04 14:26:01,820 - SECONDARY (secondary1) - INFO - Received replication request: ID b4d4756d-72c6-4446-89c0-b27123835257, Seq 1, Msg 'Msg1_W1'
2025-06-04 17:18:43 secondary2_12_fastapi | INFO: Uvicorn running on http://0.0.0.0:5002 (Press CTRL+C to quit)
2025-06-04 17:18:43 secondary2_12_fastapi | INFO: Started reload process [7] using WatchFiles
2025-06-04 17:18:44 secondary2_12_fastapi | INFO: Started server process [9]
2025-06-04 17:18:44 secondary2_12_fastapi | INFO: Waiting for application startup.
2025-06-04 17:18:44 secondary2_12_fastapi | INFO: Application startup complete.
2025-06-04 17:26:01 secondary2_12_fastapi | 2025-06-04 14:26:01,820 - SECONDARY (secondary2) - INFO - Received replication request: ID b4d4756d-72c6-4446-89c0-b27123835257, Seq 1, Msg 'Msg1_W1'
2025-06-04 17:26:01 secondary2_12_fastapi | 2025-06-04 14:26:01,820 - SECONDARY (secondary2) - INFO - Artificial delay of 3.0 seconds started...
2025-06-04 17:26:04 secondary2_12_fastapi | 2025-06-04 14:26:04,820 - SECONDARY (secondary2) - INFO - Artificial delay finished.
2025-06-04 17:26:04 secondary2_12_fastapi | 2025-06-04 14:26:04,821 - SECONDARY (secondary2) - INFO - Message ID b4d4756d-72c6-4446-89c0-b27123835257 (Seq 1) appended to secondary log. Log size: 1
2025-06-04 17:26:04 secondary2_12_fastapi | INFO: 172.25.0.2:38930 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 17:26:26 secondary2_12_fastapi | 2025-06-04 14:26:26,167 - SECONDARY (secondary2) - INFO - Received replication request: ID 3843e993-8667-402c-817e-9f619a1617db, Seq 2, Msg 'Msg2_W2'
2025-06-04 17:26:26 secondary2_12_fastapi | 2025-06-04 14:26:26,167 - SECONDARY (secondary2) - INFO - Artificial delay of 3.0 seconds started...
2025-06-04 17:18:42 master_12_fastapi | INFO: Will watch for changes in these directories: ['/app']
2025-06-04 17:18:42 master_12_fastapi | INFO: Uvicorn running on http://0.0.0.0:5000 (Press CTRL+C to quit)
2025-06-04 17:18:42 master_12_fastapi | INFO: Started reload process [1] using WatchFiles
2025-06-04 17:18:43 master_12_fastapi | 2025-06-04 14:18:43,747 - MASTER - INFO - Master initialized. Secondary URLs: ['http://secondary1:5001', 'http://secondary2:5002', 'http://secondary3:5003']
2025-06-04 17:18:43 master_12_fastapi | INFO: Started server process [8]
2025-06-04 17:18:43 master_12_fastapi | INFO: Waiting for application startup.
2025-06-04 17:18:43 master_12_fastapi | INFO: Application startup complete.
2025-06-04 17:26:01 secondary1_12_fastapi | 2025-06-04 14:26:01,820 - SECONDARY (secondary1) - INFO - Artificial delay of 1.0 seconds started...

```


 t_w

 t_w

 t_w

 t_w

10

Iteration 3.

Task

The current iteration should provide tunable semi-synchronicity for replication with a *retry* mechanism that should deliver all messages *exactly-once* in total order.

Main features:

- If message delivery fails (due to connection, or internal server error, or secondary is unavailable) the delivery attempts should be repeated - *retry*
 - If one of the secondaries is down and $w=3$, the client should be blocked until the node becomes available. Clients running in parallel shouldn't be blocked by the blocked one.
 - If $w>1$ the client should be blocked until the message will be delivered to all secondaries required by the write concern level. Clients running in parallel shouldn't be blocked by the blocked one.
 - All messages that secondaries have missed due to unavailability should be replicated after (re)joining the master
 - Retries can be implemented with an unlimited number of attempts but, possibly, with some "smart" delays logic
 - You can specify a *timeout* for the master in case if there is no response from the secondary
- All messages should be present exactly once in the secondary log - *deduplication*
 - To test deduplication you can generate some random internal server error response from the secondary after the message has been added to the log
- The order of messages should be the same in all nodes - *total order*
 - If secondary has received messages *[msg1, msg2, msg4]*, it shouldn't display the message '*msg4*' until the '*msg3*' will be received
 - To test the total order, you can generate some random internal server error response from the secondaries

Self-check acceptance test:

1. Start M + S1
2. send (Msg1, W=1) - Ok

- ### Demonstration:

- | Iteration2 | | | | Running (2/3) | 0.54% | 2 minutes ago | | | |
|------------|---|---------------------------------------|---------------------------------------|---------------|---------------------------------|---------------|-------|--|--|
| |  | master_i3_fastapi
e8c03bc77590 | iteration3-master | Running | 0.18% 5000.5000 | 2 minutes ago | | | |
| |  | secondary2_i3_fastapi
c2f703a66ffe | iteration3-secondary2 | Exited (137) | 0.17% 5002.5002 | 2 minutes ago | | | |
| |  | secondary1_i3_fastapi
5195f956a0e5 | iteration3-secondary1 | Running | 0.19% 5001.5001 | 2 minutes ago | Start | | |

- ```
POST http://localhost:5000/messages

Params Auth Headers (8) Body Pre-req. Tests Settings Cookies Body Cookies Headers (4) Test Results 202 Accepted 3 ms 204 B Save Response

raw JSON Beautify Pretty Raw Preview Visualize JSON

1 {"message": "Msg1",
2 "w": 1
3
4 }

1 {
2 "message_id": "36ef7965-cd17-43de-9178-bba8a294015",
3 "sequence_number": 1
4 }
```

```
2025-06-04 18:15:21 master_13_fastapi | INFO: 172.28.0.1:38196 - "GET /messages HTTP/1.1" 200 OK
2025-06-04 18:15:24 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - INFO - Appended to master log ID 36ef7965-cd17-43de-9178-bba8a294015 Seq 1. Msg 'Msg1', w=1
2025-06-04 18:15:24 master_13_fastapi | INFO: 172.28.0.1:38196 - "POST /messages HTTP/1.1" 202 Accepted
2025-06-04 18:15:24 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - WARNING - No condition found for message_id 36ef7965-cd17-43de-9178-bba8a294015. Request may have timed out. Task for http://s
econdary1:5001 will continue silently.
2025-06-04 18:15:24 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - INFO - Attempting to replicate message ID 36ef7965-cd17-43de-9178-bba8a294015 to http://secondary1:5001...
2025-06-04 18:15:24 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - WARNING - No condition found for message_id 36ef7965-cd17-43de-9178-bba8a294015. Request may have timed out. Task for http://s
econdary2:5002 will continue silently.
2025-06-04 18:15:25 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - INFO - Attempting to replicate message ID 36ef7965-cd17-43de-9178-bba8a294015 to http://secondary2:5002...
2025-06-04 18:15:25 secondary1_13_fastapi | INFO: 172.28.0.1:38196 - SECONDARY (secondary1) - INFO - Received replication request: ID 36ef7965-cd17-43de-9178-bba8a294015 Seq 1
2025-06-04 18:15:25 secondary1_13_fastapi | INFO: 172.28.0.1:38196 - SECONDARY (secondary1) - INFO - Received expected message Seq 1, Appending to log.
2025-06-04 18:15:25 secondary1_13_fastapi | INFO: 172.28.0.1:38196 - SECONDARY (secondary1) - INFO - Log size: 1. Next expected Seq: 2
2025-06-04 18:15:25 secondary1_13_fastapi | INFO: 172.28.0.1:38196 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 18:15:26 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - INFO - HTTP Request: POST http://secondary1:5001/replicate "HTTP/1.1 200 OK"
2025-06-04 18:15:26 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - INFO - Successfully replicated message ID 36ef7965-cd17-43de-9178-bba8a294015 to http://secondary1:5001. ACK received.
2025-06-04 18:15:31 master_13_fastapi | ERROR: 172.28.0.1:38196 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 36ef7965-cd17-43de-9178-bba8a294015. Retrying...
2025-06-04 18:15:31 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - INFO - Attempting to replicate message ID 36ef7965-cd17-43de-9178-bba8a294015 to http://secondary2:5002...
2025-06-04 18:15:36 master_13_fastapi | ERROR: 172.28.0.1:38196 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 36ef7965-cd17-43de-9178-bba8a294015. Retrying...
2025-06-04 18:15:38 master_13_fastapi | INFO: 172.28.0.1:38196 - MASTER - INFO - Attempting to replicate message ID 36ef7965-cd17-43de-9178-bba8a294015 to http://secondary2:5002...
```

- The screenshot shows the Postman interface with a POST request to http://localhost:5000/messages. The response is a 202 Accepted status with a 1047 ms response time. The response body is shown in JSON format: {"message\_id": "464bbf86-cf31-478f-b1dc-499f7996ddfc", "sequence\_number": 2}. The interface includes tabs for Params, Auth, Headers, Body, Pre-request, Tests, and Settings. The Body tab is active, showing the raw JSON response.

```

2025-06-04 18:15:52 master_13_fastapi | 2025-06-04 15:15:52,067 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 36ef7965-cd17-43de-9178-bba88a294015: . Retrying...
2025-06-04 18:15:59 master_13_fastapi | 2025-06-04 15:15:59,463 - MASTER - INFO - Appended to master log: ID 464bbf86-cf31-470f-b1dc-499f7996ddf, Seq 2, Msg 'Msg2', w=2
2025-06-04 18:15:59 master_13_fastapi | 2025-06-04 15:15:59,480 - MASTER - INFO - Attempting to replicate message ID 464bbf86-cf31-470f-b1dc-499f7996ddf to http://secondary1:5001...
2025-06-04 18:15:59 master_13_fastapi | 2025-06-04 15:15:59,498 - MASTER - INFO - Attempting to replicate message ID 464bbf86-cf31-470f-b1dc-499f7996ddf to http://secondary2:5002...
2025-06-04 18:15:59 secondary_13_fastapi | 2025-06-04 15:15:59,581 - SECONDARY (secondary1) - INFO - Received replication request: ID 464bbf86-cf31-470f-b1dc-499f7996ddf, Seq 2
2025-06-04 18:16:00 master_13_fastapi | 2025-06-04 15:16:00,088 - MASTER - INFO - Attempting to replicate message ID 36ef7965-cd17-43de-9178-bba88a294015 to http://secondary2:5002...
2025-06-04 18:16:00 secondary_13_fastapi | 2025-06-04 15:16:00,502 - SECONDARY (secondary1) - INFO - Received expected message Seq 2. Appending to log.
2025-06-04 18:16:00 secondary_13_fastapi | 2025-06-04 15:16:00,502 - SECONDARY (secondary1) - INFO - Log size: 2. Next expected Seq: 3
2025-06-04 18:16:00 secondary_13_fastapi | INFO: 172.28.0.2:44898 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 18:16:00 master_13_fastapi | 2025-06-04 15:16:00,503 - MASTER - INFO - HTTP Request: POST http://secondary1:5001/replicate "HTTP/1.1 200 OK"
2025-06-04 18:16:00 master_13_fastapi | 2025-06-04 15:16:00,504 - MASTER - INFO - Successfully replicated message ID 464bbf86-cf31-470f-b1dc-499f7996ddf to http://secondary1:5001. ACK received.
2025-06-04 18:16:00 master_13_fastapi | 2025-06-04 15:16:00,504 - MASTER - INFO - Met write concern w=2 for message 464bbf86-cf31-470f-b1dc-499f7996ddf with 2 ACKs.
2025-06-04 18:16:00 master_13_fastapi | INFO: 172.28.0.1:42688 - "POST /messages HTTP/1.1" 202 Accepted
2025-06-04 18:16:04 master_13_fastapi | 2025-06-04 15:16:04,500 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 464bbf86-cf31-470f-b1dc-499f7996ddf: . Retrying...
2025-06-04 18:16:05 master_13_fastapi | 2025-06-04 15:16:05,090 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 36ef7965-cd17-43de-9178-bba88a294015: . Retrying...
2025-06-04 18:16:05 master_13_fastapi | 2025-06-04 15:16:05,521 - MASTER - INFO - Attempting to replicate message ID 464bbf86-cf31-470f-b1dc-499f7996ddf to http://secondary2:5002...
2025-06-04 18:16:10 master_13_fastapi | 2025-06-04 15:16:10,523 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 464bbf86-cf31-470f-b1dc-499f7996ddf: . Retrying...
2025-06-04 18:16:12 master_13_fastapi | 2025-06-04 15:16:12,541 - MASTER - INFO - Attempting to replicate message ID 464bbf86-cf31-470f-b1dc-499f7996ddf to http://secondary2:5002...
2025-06-04 18:16:17 master_13_fastapi | 2025-06-04 15:16:17,543 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 464bbf86-cf31-470f-b1dc-499f7996ddf: . Retrying...
2025-06-04 18:16:21 master_13_fastapi | 2025-06-04 15:16:21,110 - MASTER - INFO - Attempting to replicate message ID 36ef7965-cd17-43de-9178-bba88a294015 to http://secondary2:5002...
2025-06-04 18:16:21 master_13_fastapi | 2025-06-04 15:16:21,560 - MASTER - INFO - Attempting to replicate message ID 464bbf86-cf31-470f-b1dc-499f7996ddf to http://secondary2:5002...

```

#### 4. send (Msg3, W=3) – Wait

POST http://localhost:5000/messages

Params Auth Headers (8) Body Pre-req. Tests Settings

Body: {"message": "Msg3", "w": 3}

Response: 202 Accepted 1047 ms 204 B

Body: {"message\_id": "464bbf86-cf31-470f-b1dc-499f7996ddf", "sequence\_number": 2}

#### 5. send (Msg4, W=1) – Ok

POST http://localhost:5000/messages

Params Auth Headers (8) Body Pre-req. Tests Settings

Body: {"message": "Msg4", "w": 1}

Response: 202 Accepted 5 ms 204 B

Body: {"message\_id": "cab2439c-baaa-4870-bf0d-03deab575bd0", "sequence\_number": 4}

```

2025-06-04 18:17:05 master_13_fastapi | 2025-06-04 15:17:05,993 - MASTER - INFO - Appended to master log: ID cab2439c-baaa-4870-bf0d-03deab575bd0, Seq 4, Msg 'Msg4', w=1
2025-06-04 18:17:05 master_13_fastapi | INFO: 172.28.0.1:59686 - "POST /messages HTTP/1.1" 202 Accepted
2025-06-04 18:17:05 master_13_fastapi | 2025-06-04 15:17:05,994 - MASTER - WARNING - No condition found for message_id cab2439c-baaa-4870-bf0d-03deab575bd0. Request may have timed out. Task for http://s
2025-06-04 18:17:06 master_13_fastapi | 2025-06-04 15:17:06,017 - MASTER - INFO - Attempting to replicate message ID cab2439c-baaa-4870-bf0d-03deab575bd0 to http://secondary1:5001...
2025-06-04 18:17:06 master_13_fastapi | 2025-06-04 15:17:06,018 - MASTER - WARNING - No condition found for message_id cab2439c-baaa-4870-bf0d-03deab575bd0. Request may have timed out. Task for http://s
2025-06-04 18:17:06 master_13_fastapi | 2025-06-04 15:17:06,041 - MASTER - INFO - Attempting to replicate message ID cab2439c-baaa-4870-bf0d-03deab575bd0 to http://secondary2:5002...
2025-06-04 18:17:10 master_13_fastapi | 2025-06-04 15:17:10,125 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 7b9a8fcb-23c3-4990-bcce-6e22a865a553: . Retrying...
2025-06-04 18:17:11 master_13_fastapi | 2025-06-04 15:17:11,045 - MASTER - ERROR - Failed to connect to http://secondary1:5001 for msg cab2439c-baaa-4870-bf0d-03deab575bd0: . Retrying...
2025-06-04 18:17:11 master_13_fastapi | 2025-06-04 15:17:11,045 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg cab2439c-baaa-4870-bf0d-03deab575bd0: . Retrying...
2025-06-04 18:17:12 master_13_fastapi | 2025-06-04 15:17:12,064 - MASTER - INFO - Attempting to replicate message ID cab2439c-baaa-4870-bf0d-03deab575bd0 to http://secondary1:5001...
2025-06-04 18:17:12 master_13_fastapi | 2025-06-04 15:17:12,085 - MASTER - INFO - Attempting to replicate message ID cab2439c-baaa-4870-bf0d-03deab575bd0 to http://secondary2:5002...
2025-06-04 18:17:13 master_13_fastapi | 2025-06-04 15:17:13,026 - MASTER - ERROR - Timeout waiting for w=3 ACKs for message 7b9a8fcb-23c3-4990-bcce-6e22a865a553. Have 2 ACKs.
2025-06-04 18:17:13 secondary_13_fastapi | 2025-06-04 15:17:13,130 - SECONDARY (secondary1) - INFO - Received replication request: ID cab2439c-baaa-4870-bf0d-03deab575bd0, Seq 4
2025-06-04 18:17:14 secondary_13_fastapi | 2025-06-04 15:17:14,131 - SECONDARY (secondary1) - INFO - Received expected message Seq 4. Appending to log.
2025-06-04 18:17:14 secondary_13_fastapi | 2025-06-04 15:17:14,131 - SECONDARY (secondary1) - INFO - Log size: 4. Next expected Seq: 5
2025-06-04 18:17:14 master_13_fastapi | INFO: 172.28.0.2:42196 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 18:17:14 master_13_fastapi | 2025-06-04 15:17:14,132 - MASTER - INFO - HTTP Request: POST http://secondary1:5001/replicate "HTTP/1.1 200 OK"
2025-06-04 18:17:14 master_13_fastapi | 2025-06-04 15:17:14,133 - MASTER - INFO - Successfully replicated message ID cab2439c-baaa-4870-bf0d-03deab575bd0 to http://secondary1:5001. ACK received.
2025-06-04 18:17:14 master_13_fastapi | 2025-06-04 15:17:14,133 - MASTER - WARNING - Secondary http://secondary1:5001 is now HEALTHY.
2025-06-04 18:17:17 master_13_fastapi | 2025-06-04 15:17:17,086 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg cab2439c-baaa-4870-bf0d-03deab575bd0: . Retrying...
2025-06-04 18:17:18 master_13_fastapi | 2025-06-04 15:17:18,148 - MASTER - INFO - Attempting to replicate message ID 7b9a8fcb-23c3-4990-bcce-6e22a865a553 to http://secondary2:5002...
2025-06-04 18:17:19 master_13_fastapi | 2025-06-04 15:17:19,107 - MASTER - INFO - Attempting to replicate message ID cab2439c-baaa-4870-bf0d-03deab575bd0 to http://secondary2:5002...
2025-06-04 18:17:23 master_13_fastapi | 2025-06-04 15:17:23,149 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg 7b9a8fcb-23c3-4990-bcce-6e22a865a553: . Retrying...
2025-06-04 18:17:24 master_13_fastapi | 2025-06-04 15:17:24,188 - MASTER - ERROR - Failed to connect to http://secondary2:5002 for msg cab2439c-baaa-4870-bf0d-03deab575bd0: . Retrying...

```

## 6. Start S2

```
2025-06-04 18:12:42 INFO: Will watch for changes in these directories: ['/app']
2025-06-04 18:12:42 INFO: Uvicorn running on http://0.0.0.0:5002 (Press CTRL+C to quit)
2025-06-04 18:12:42 INFO: Started reloader process [7] using WatchFiles
2025-06-04 18:12:43 INFO: Started server process [9]
2025-06-04 18:12:43 INFO: Waiting for application startup.
2025-06-04 18:12:43 INFO: Application startup complete.
2025-06-04 18:14:34 INFO: Will watch for changes in these directories: ['/app']
2025-06-04 18:14:34 INFO: Uvicorn running on http://0.0.0.0:5002 (Press CTRL+C to quit)
2025-06-04 18:14:34 INFO: Started reloader process [7] using WatchFiles
2025-06-04 18:14:34 INFO: Started server process [9]
2025-06-04 18:14:34 INFO: Waiting for application startup.
2025-06-04 18:14:34 INFO: Application startup complete.
2025-06-04 18:14:34 2025-06-04 15:14:34,880 - SECONDARY (secondary2) - INFO - Received replication request: ID f3897719-fd96-47da-b48f-681f7d47181b, Seq 3
2025-06-04 18:14:34 2025-06-04 15:14:34,880 - SECONDARY (secondary2) - WARNING - Received out-of-order message Seq 3. Expected 1. Buffering.
2025-06-04 18:14:36 2025-06-04 15:14:36,271 - SECONDARY (secondary2) - INFO - Received replication request: ID b86b6723-45b3-4141-a8c1-03502897cb2b, Seq 2
2025-06-04 18:14:36 2025-06-04 15:14:36,271 - SECONDARY (secondary2) - WARNING - Received out-of-order message Seq 2. Expected 1. Buffering.
2025-06-04 18:14:41 2025-06-04 15:14:41,950 - SECONDARY (secondary2) - INFO - Received replication request: ID 9c338a02-946a-46eb-87b3-d3d70e9ea6d4, Seq 1
2025-06-04 18:14:41 2025-06-04 15:14:41,951 - SECONDARY (secondary2) - INFO - Received expected message Seq 1. Appending to log.
2025-06-04 18:14:41 2025-06-04 15:14:41,951 - SECONDARY (secondary2) - INFO - Log size: 1. Next expected Seq: 2
2025-06-04 18:14:41 2025-06-04 15:14:41,951 - SECONDARY (secondary2) - INFO - Processing buffered message Seq 2...
2025-06-04 18:14:41 2025-06-04 15:14:41,951 - SECONDARY (secondary2) - INFO - Log size: 2. Next expected Seq: 3
2025-06-04 18:14:41 2025-06-04 15:14:41,951 - SECONDARY (secondary2) - INFO - Processing buffered message Seq 3...
2025-06-04 18:14:41 2025-06-04 15:14:41,951 - SECONDARY (secondary2) - INFO - Log size: 3. Next expected Seq: 4
2025-06-04 18:17:47 INFO: Will watch for changes in these directories: ['/app']
2025-06-04 18:17:47 INFO: Uvicorn running on http://0.0.0.0:5002 (Press CTRL+C to quit)
2025-06-04 18:17:47 INFO: Started reloader process [7] using WatchFiles
2025-06-04 18:17:47 INFO: Started server process [9]
2025-06-04 18:17:47 INFO: Waiting for application startup.
2025-06-04 18:17:47 INFO: Application startup complete.
2025-06-04 18:14:34 INFO: 172.28.0.2:57742 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 18:14:36 INFO: 172.28.0.2:57746 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 18:14:41 INFO: 172.28.0.2:50468 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 18:18:02 2025-06-04 15:18:02,171 - SECONDARY (secondary2) - INFO - Received replication request: ID cab2439c-baaa-4870-bf0d-03deab575bd8, Seq 4
2025-06-04 18:18:02 2025-06-04 15:18:02,172 - SECONDARY (secondary2) - WARNING - Received out-of-order message Seq 4. Expected 1. Buffering.
2025-06-04 18:18:02 INFO: 172.28.0.2:52188 - "POST /replicate HTTP/1.1" 200 OK
2025-06-04 18:18:03 2025-06-04 15:18:03,152 - SECONDARY (secondary2) - INFO - Received replication request: ID 36ef7965-cd17-43de-9178-bba8a294815, Seq 1
2025-06-04 18:18:03 2025-06-04 15:18:03,152 - SECONDARY (secondary2) - INFO - Received expected message Seq 1. Appending to log.
2025-06-04 18:18:03 2025-06-04 15:18:03,153 - SECONDARY (secondary2) - INFO - Log size: 1. Next expected Seq: 2
2025-06-04 18:18:03 INFO: 172.28.0.2:52196 - "POST /replicate HTTP/1.1" 200 OK
```

## 7. Check messages on S2 - [Msg1, Msg2, Msg3, Msg4]

The screenshot shows a web browser interface with a GET request to `http://localhost:5002/messages`. The response is displayed in JSON format, showing four messages (Msg1, Msg2, Msg3, Msg4) with their respective IDs and sequence numbers.

```
{
 "message": "Msg4",
 "w": 1
}
```

The response body is displayed in JSON format, showing four messages (Msg1, Msg2, Msg3, Msg4) with their respective IDs and sequence numbers.

```
{
 "id": "36ef7965-cd17-43de-9178-bba8a294815",
 "message": "Msg1",
 "seq_num": 1
},
{
 "id": "464bbf06-cf31-470f-b1dc-499f7996ddfc",
 "message": "Msg2",
 "seq_num": 2
},
{
 "id": "7b9a8fcb-23c3-4990-bcce-6e22a865a553",
 "message": "Msg3",
 "seq_num": 3
},
{
 "id": "cab2439c-baaa-4870-bf0d-03deab575bd8",
 "message": "Msg4",
 "seq_num": 4
}
```