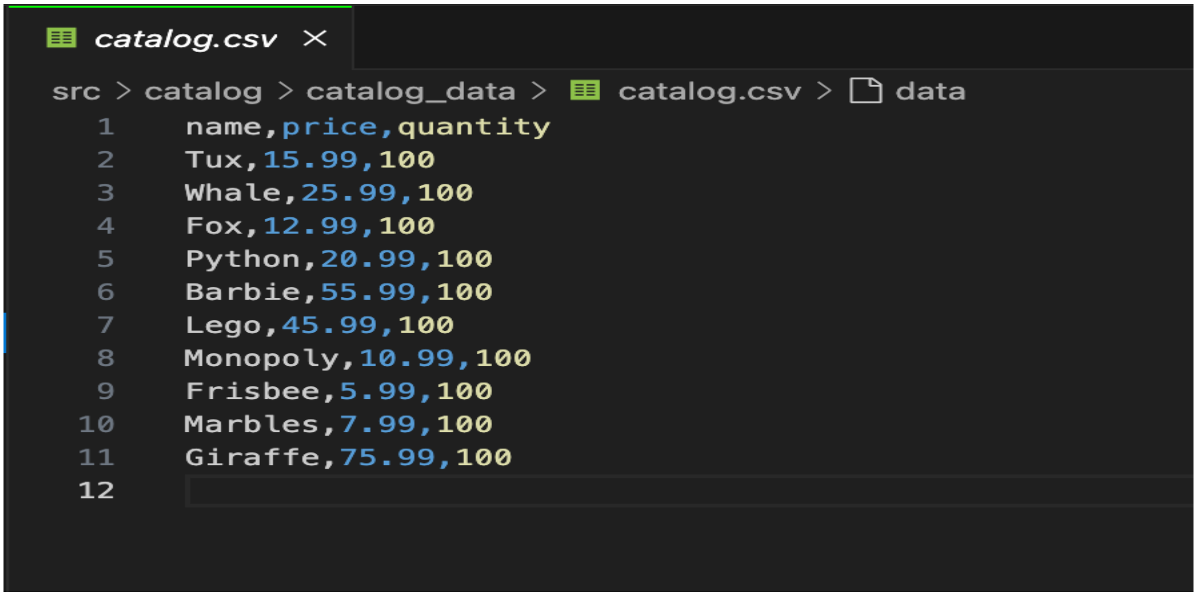
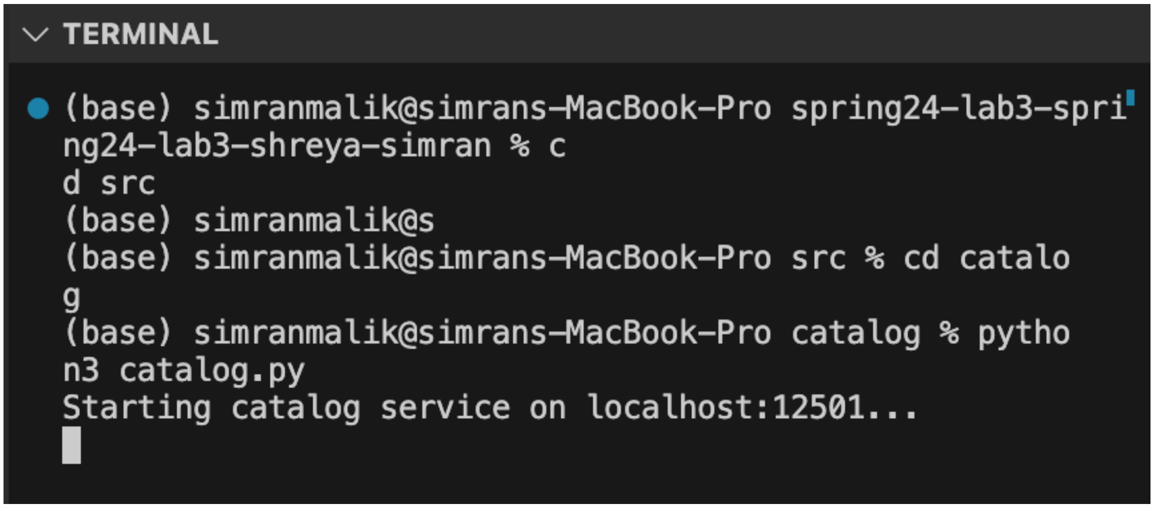
Crash Failure Evaluation and Testing Document
Lab 3
Shreya Birthare
Simran Malik

Initial catalog data

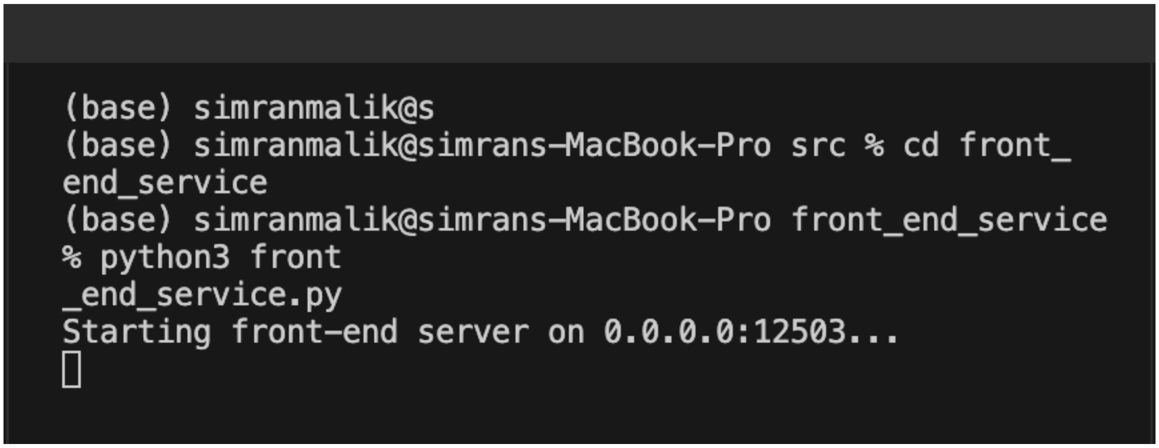


```
name,price,quantity
Tux,15.99,100
Whale,25.99,100
Fox,12.99,100
Python,20.99,100
Barbie,55.99,100
Lego,45.99,100
Monopoly,10.99,100
Frisbee,5.99,100
Marbles,7.99,100
Giraffe,75.99,100

```

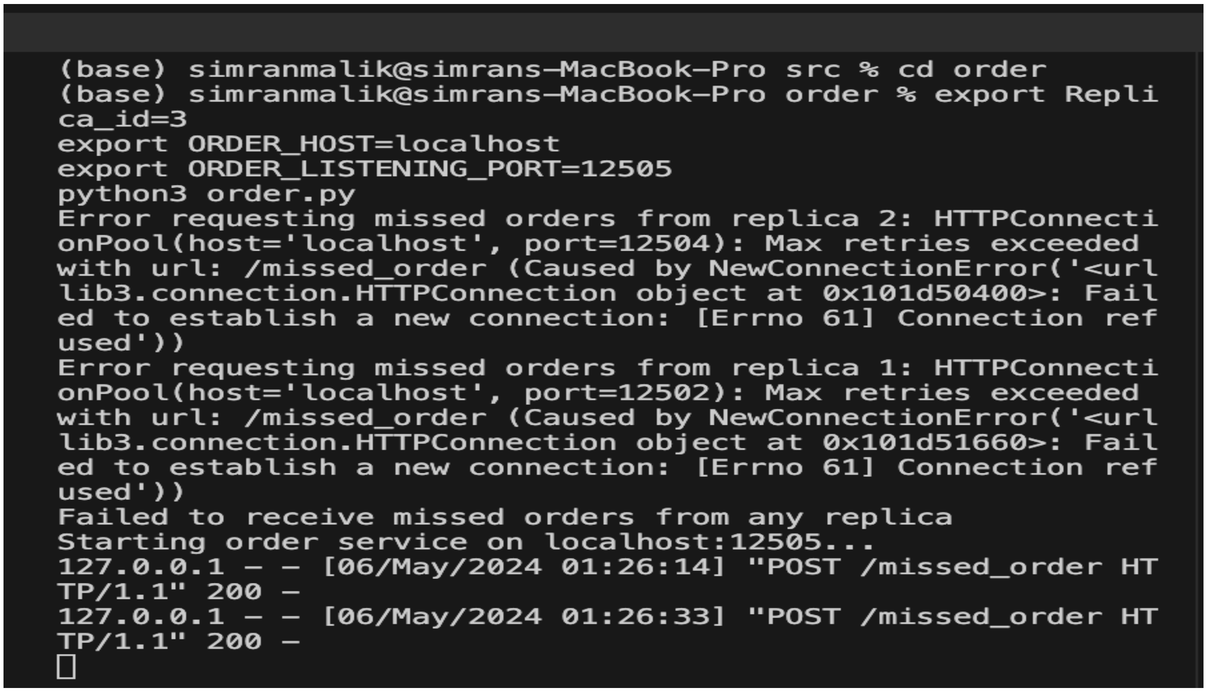
Running microservices on local terminal



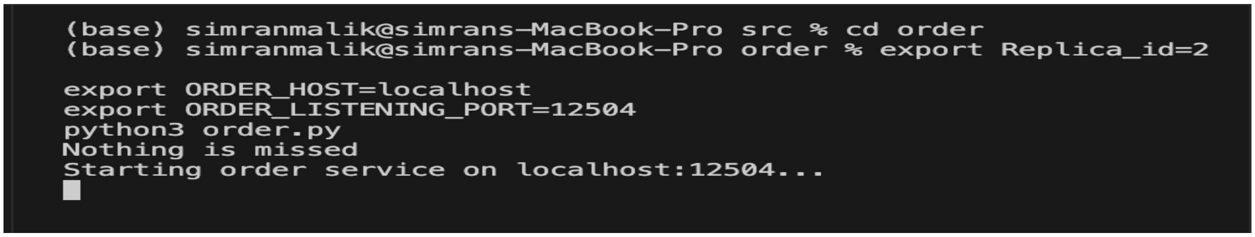
```
(base) simranmalik@simrans-MacBook-Pro spring24-lab3-spri
ng24-lab3-shreya-simran % c
d src
(base) simranmalik@s
(base) simranmalik@simrans-MacBook-Pro src % cd catalo
g
(base) simranmalik@simrans-MacBook-Pro catalog % pytho
n3 catalog.py
Starting catalog service on localhost:12501...
```



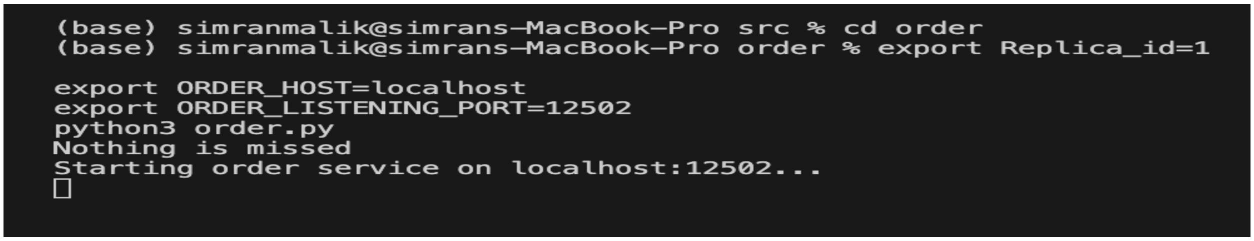
```
(base) simranmalik@s
(base) simranmalik@simrans-MacBook-Pro src % cd front_
end_service
(base) simranmalik@simrans-MacBook-Pro front_end_service
% python3 front
_end_service.py
Starting front-end server on 0.0.0.0:12503...
```



```
(base) simranmalik@simrans-MacBook-Pro src % cd order
(base) simranmalik@simrans-MacBook-Pro order % export Repli
ca_id=3
export ORDER_HOST=localhost
export ORDER_LISTENING_PORT=12505
python3 order.py
Error requesting missed orders from replica 2: HTTPConnecti
onPool(host='localhost', port=12504): Max retries exceeded
with url: /missed_order (Caused by NewConnectionError('<url
lib3.connection.HTTPConnection object at 0x101d50400>: Fail
ed to establish a new connection: [Errno 61] Connection ref
used'))
Error requesting missed orders from replica 1: HTTPConnecti
onPool(host='localhost', port=12502): Max retries exceeded
with url: /missed_order (Caused by NewConnectionError('<url
lib3.connection.HTTPConnection object at 0x101d51660>: Fail
ed to establish a new connection: [Errno 61] Connection ref
used'))
Failed to receive missed orders from any replica
Starting order service on localhost:12505...
127.0.0.1 - - [06/May/2024 01:26:14] "POST /missed_order HT
TP/1.1" 200 -
127.0.0.1 - - [06/May/2024 01:26:33] "POST /missed_order HT
TP/1.1" 200 -
```



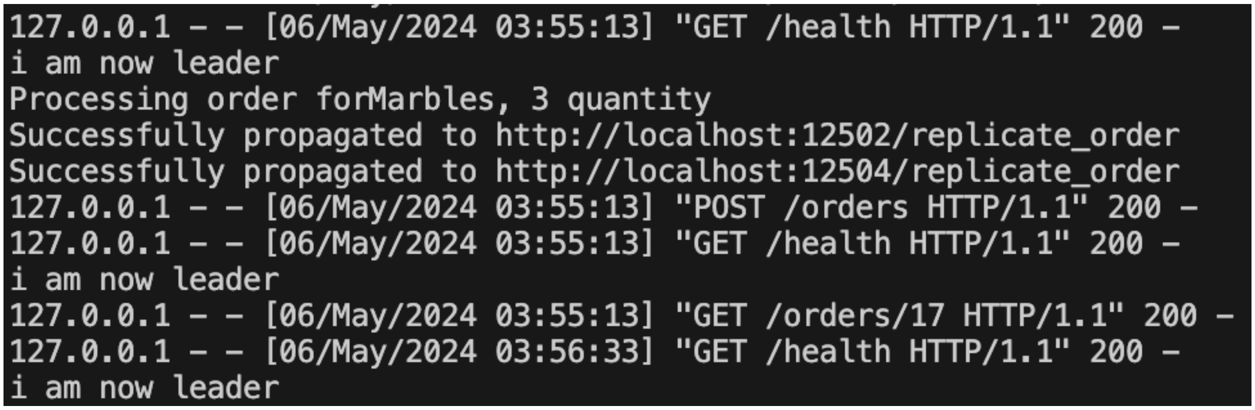
```
(base) simranmalik@simrans-MacBook-Pro src % cd order
(base) simranmalik@simrans-MacBook-Pro order % export Replica_id=2

export ORDER_HOST=localhost
export ORDER_LISTENING_PORT=12504
python3 order.py
Nothing is missed
Starting order service on localhost:12504...
```



```
(base) simranmalik@simrans-MacBook-Pro src % cd order
(base) simranmalik@simrans-MacBook-Pro order % export Replica_id=1

export ORDER_HOST=localhost
export ORDER_LISTENING_PORT=12502
python3 order.py
Nothing is missed
Starting order service on localhost:12502...
```

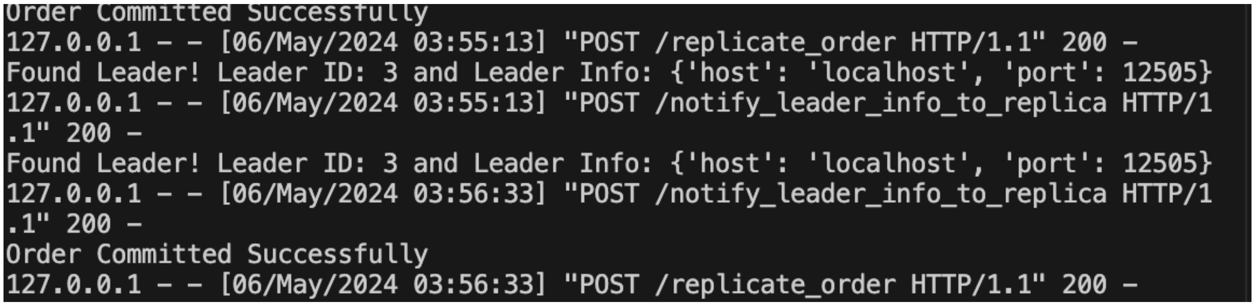
As it is visible in the screenshot, whenever an order service starts, it checks with the highest order replica id(other than itself-possible leader) if it has missed any order logs.

Normal operation of order replica 3, Responds to health checks and shows when it is selected as leader, whenever any order request comes in. Processes both order query and purchase requests. Generates order number, updates its order log and replicates order log update to followers after successful buy operation.

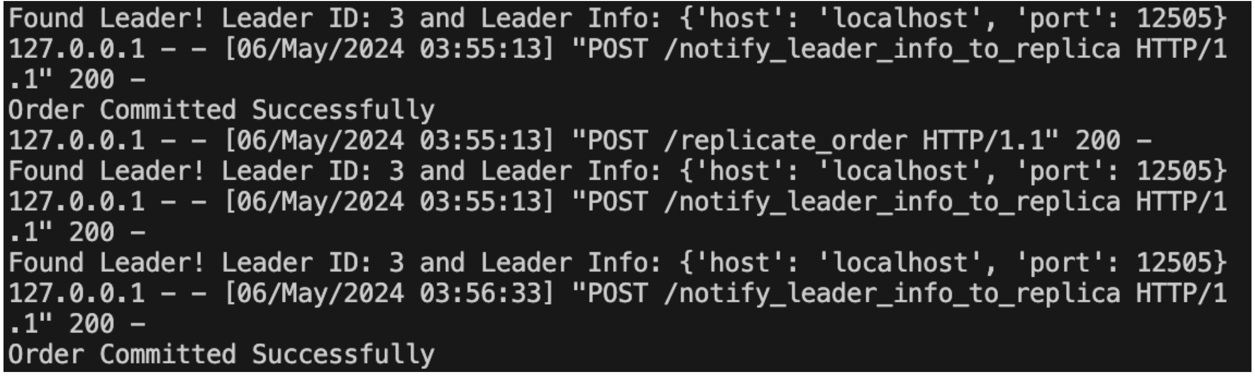


```
127.0.0.1 - - [06/May/2024 03:55:13] "GET /health HTTP/1.1" 200 -
i am now leader
Processing order forMarbles, 3 quantity
Successfully propagated to http://localhost:12502/replicate_order
Successfully propagated to http://localhost:12504/replicate_order
127.0.0.1 - - [06/May/2024 03:55:13] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:55:13] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:55:13] "GET /orders/17 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:56:33] "GET /health HTTP/1.1" 200 -
i am now leader
```

Normal operation of replica 1,2 : Successfully receive notification about leader from front end service and processes order log replication requests from leader replica 3

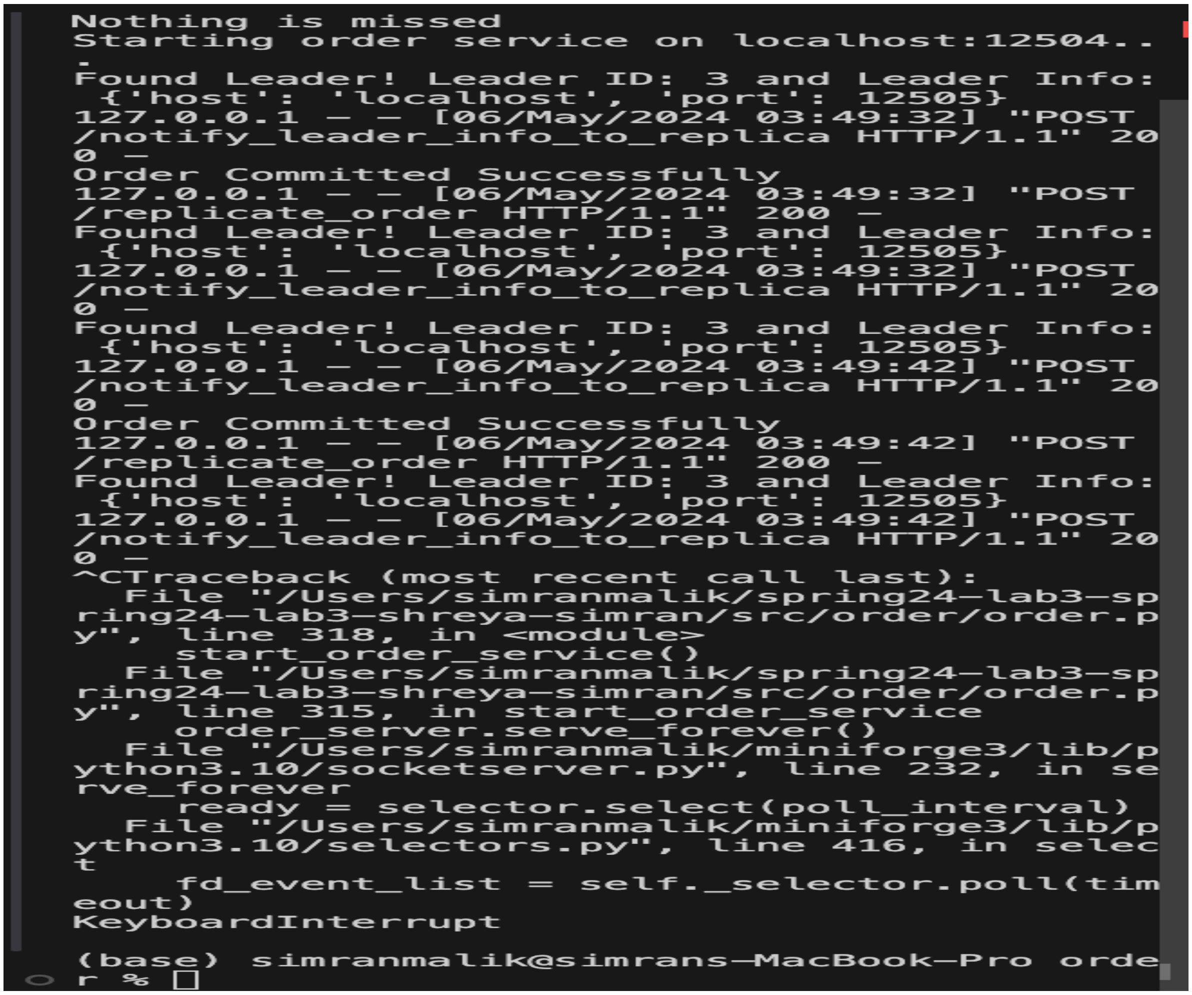


```
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:55:13] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:55:13] "POST /notify_leader_info_to_replica HTTP/1
.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:56:33] "POST /notify_leader_info_to_replica HTTP/1
.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:56:33] "POST /replicate_order HTTP/1.1" 200 -
```



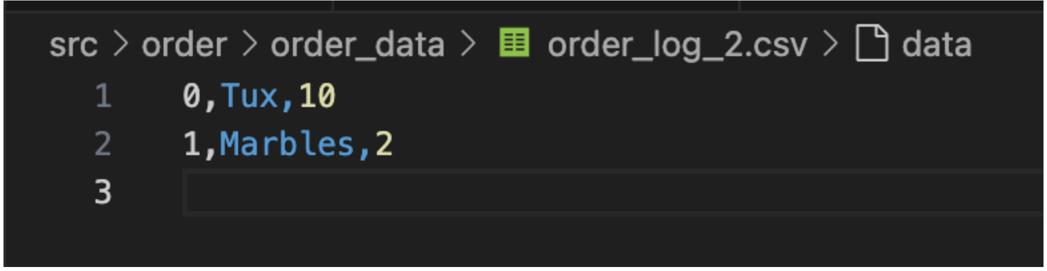
```
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:55:13] "POST /notify_leader_info_to_replica HTTP/1
.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:55:13] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:55:13] "POST /notify_leader_info_to_replica HTTP/1
.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:56:33] "POST /notify_leader_info_to_replica HTTP/1
.1" 200 -
Order Committed Successfully
```

Killed order replica 2:



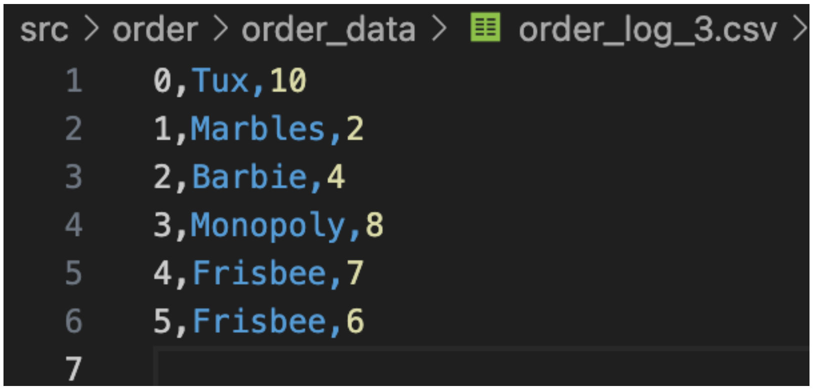
```
Nothing is missed
Starting order service on localhost:12504..
.
Found Leader! Leader ID: 3 and Leader Info:
 {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:49:32] "POST
/notify_leader_info_to_replica HTTP/1.1" 20
0 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:49:32] "POST
/replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info:
 {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:49:32] "POST
/notify_leader_info_to_replica HTTP/1.1" 20
0 -
Found Leader! Leader ID: 3 and Leader Info:
 {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:49:42] "POST
/notify_leader_info_to_replica HTTP/1.1" 20
0 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:49:42] "POST
/replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info:
 {'host': 'localhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:49:42] "POST
/notify_leader_info_to_replica HTTP/1.1" 20
0 -
^CTraceback (most recent call last):
  File "/Users/simranmalik/spring24-lab3-sp
ring24-lab3-shreya-simran/src/order/order.p
y", line 318, in <module>
    start_order_service()
  File "/Users/simranmalik/spring24-lab3-sp
ring24-lab3-shreya-simran/src/order/order.p
y", line 315, in start_order_service
    order_server.serve_forever()
  File "/Users/simranmalik/miniforge3/lib/p
ython3.10/socketserver.py", line 232, in se
rve_forever
    ready = selector.select(poll_interval)
  File "/Users/simranmalik/miniforge3/lib/p
ython3.10/selectors.py", line 416, in selec
t
    fd_event_list = self._selector.poll(tim
eout)
KeyboardInterrupt

(base) simranmalik@simrans-MacBook-Pro orde
r % 
```

As we can see, order log of replica 2 is stopped at order number 1, order log of leader replica 3 and other replica has gone ahead.



src > order > order_data > order_log_2.csv > data

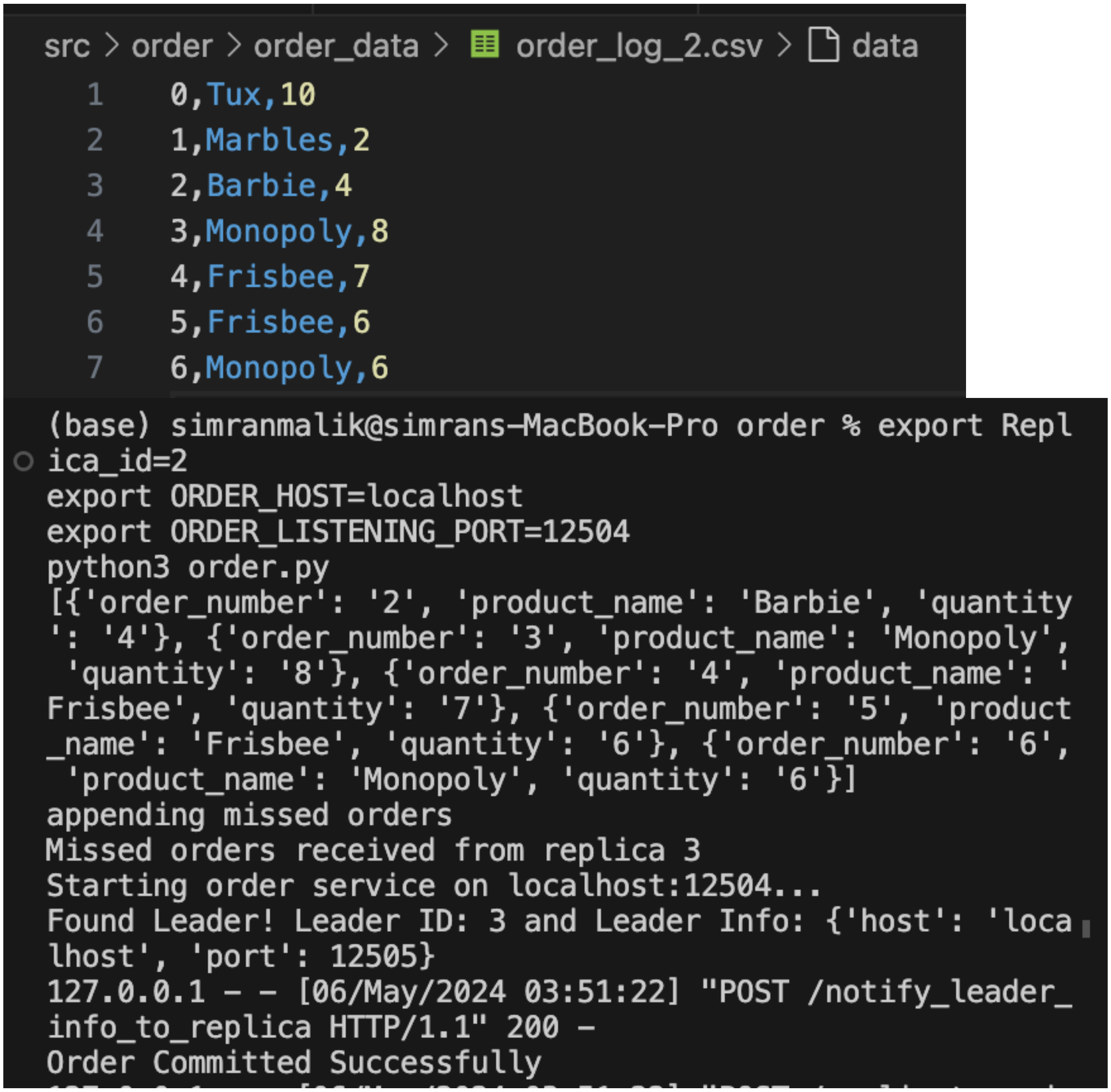
```
0,Tux,10
1,Marbles,2

```



src > order > order_data > order_log_3.csv >

```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
```

Replica 2 brought up- receives missed logs from replica 3- leader

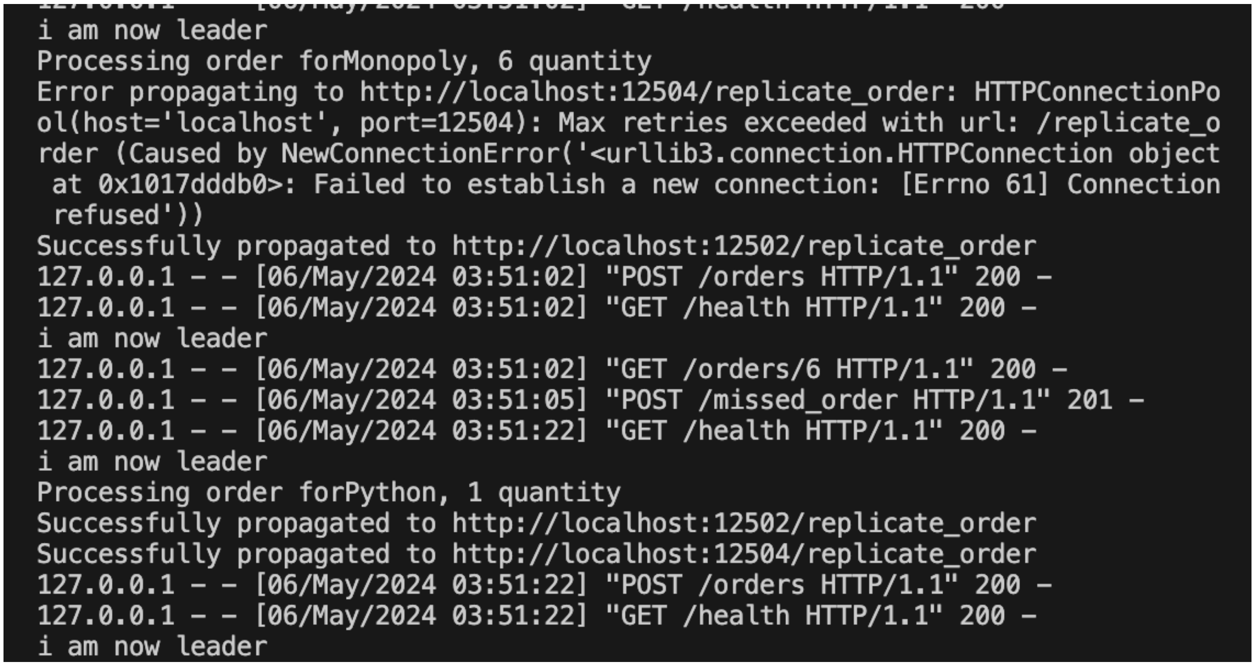


src > order > order_data > order_log_2.csv > data

```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
6,Monopoly,6
```

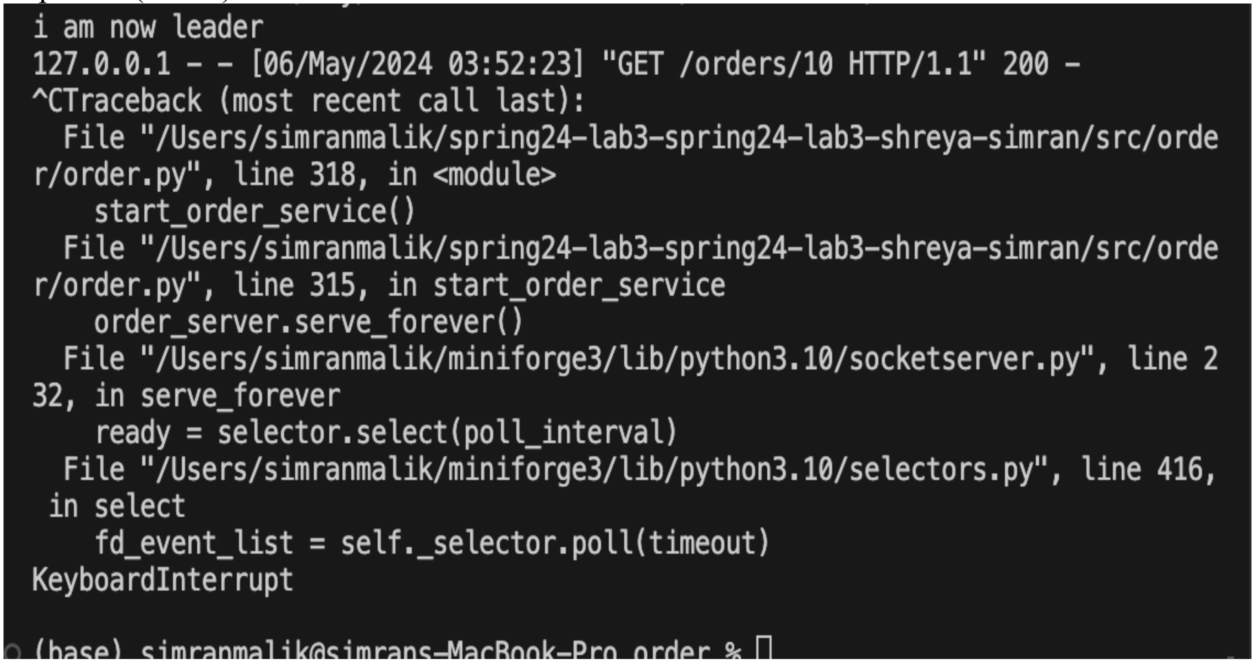
```
(base) simranmalik@simrans-MacBook-Pro order % export Repl
ica_id=2
export ORDER_HOST=localhost
export ORDER_LISTENING_PORT=12504
python3 order.py
[{'order_number': '2', 'product_name': 'Barbie', 'quantity
': '4'}, {'order_number': '3', 'product_name': 'Monopoly',
 'quantity': '8'}, {'order_number': '4', 'product_name': '
Frisbee', 'quantity': '7'}, {'order_number': '5', 'product
_name': 'Frisbee', 'quantity': '6'}, {'order_number': '6',
 'product_name': 'Monopoly', 'quantity': '6'}]
appending missed orders
Missed orders received from replica 3
Starting order service on localhost:12504...
Found Leader! Leader ID: 3 and Leader Info: {'host': 'loca
lhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:51:22] "POST /notify_leader_
info_to_replica HTTP/1.1" 200 -
Order Committed Successfully
```

Replica 3 output: successfully processes missed Post order request with code 201 and sends json doc containing missed orders



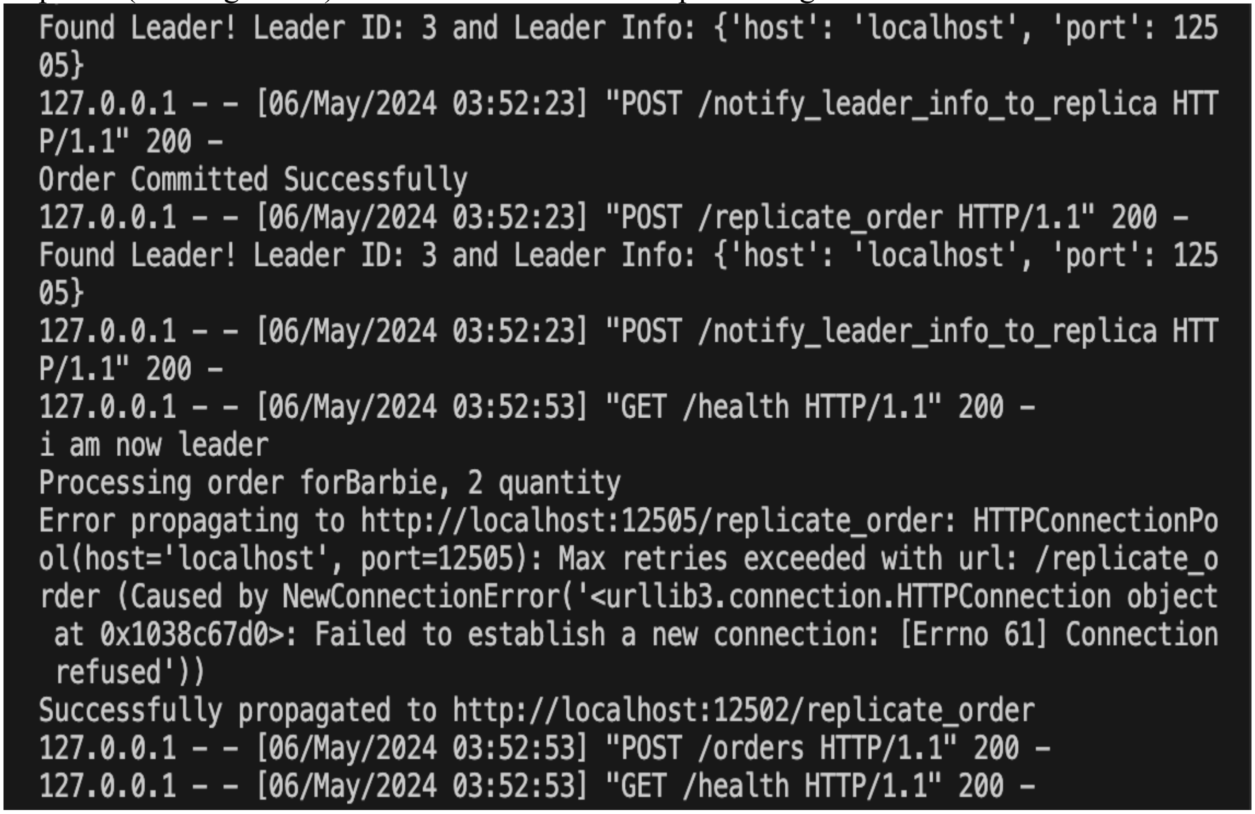
```
127.0.0.1 - - [06/May/2024 03:51:02] "GET /health HTTP/1.1" 200 -
i am now leader
Processing order forMonopoly, 6 quantity
Error propagating to http://localhost:12504/replicate_order: HTTPConnectionPo
ol(host='localhost', port=12504): Max retries exceeded with url: /replicate_o
rder (Caused by NewConnectionError('<urllib3.connection.HTTPConnection object
 at 0x1017dddb0>: Failed to establish a new connection: [Errno 61] Connection
 refused'))
Successfully propagated to http://localhost:12502/replicate_order
127.0.0.1 - - [06/May/2024 03:51:02] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:51:02] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:51:02] "GET /orders/6 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:51:05] "POST /missed_order HTTP/1.1" 201 -
127.0.0.1 - - [06/May/2024 03:51:22] "GET /health HTTP/1.1" 200 -
i am now leader
Processing order forPython, 1 quantity
Successfully propagated to http://localhost:12502/replicate_order
Successfully propagated to http://localhost:12504/replicate_order
127.0.0.1 - - [06/May/2024 03:51:22] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:51:22] "GET /health HTTP/1.1" 200 -
i am now leader
```

Replica 3 (leader) killed



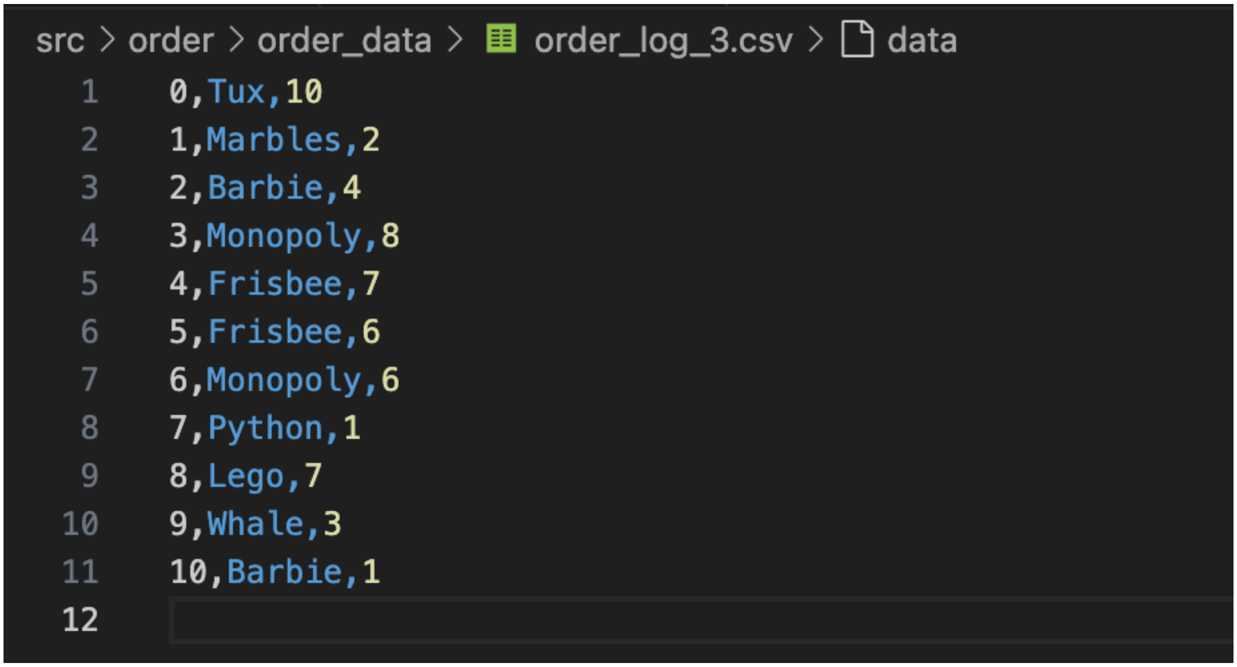
```
i am now leader
127.0.0.1 - - [06/May/2024 03:52:23] "GET /orders/10 HTTP/1.1" 200 -
^CTraceback (most recent call last):
  File "/Users/simranmalik/spring24-lab3-spring24-lab3-shreya-simran/src/orde
r/order.py", line 318, in <module>
    start_order_service()
  File "/Users/simranmalik/spring24-lab3-spring24-lab3-shreya-simran/src/orde
r/order.py", line 315, in start_order_service
    order_server.serve_forever()
  File "/Users/simranmalik/miniforge3/lib/python3.10/socketserver.py", line 2
32, in serve_forever
    ready = selector.select(poll_interval)
  File "/Users/simranmalik/miniforge3/lib/python3.10/selectors.py", line 416,
 in select
    fd_event_list = self._selector.poll(timeout)
KeyboardInterrupt

○ (base) simranmalik@simrans-MacBook-Pro order % 
```

Replica 2(next highest id) becomes leader and starts processing orders



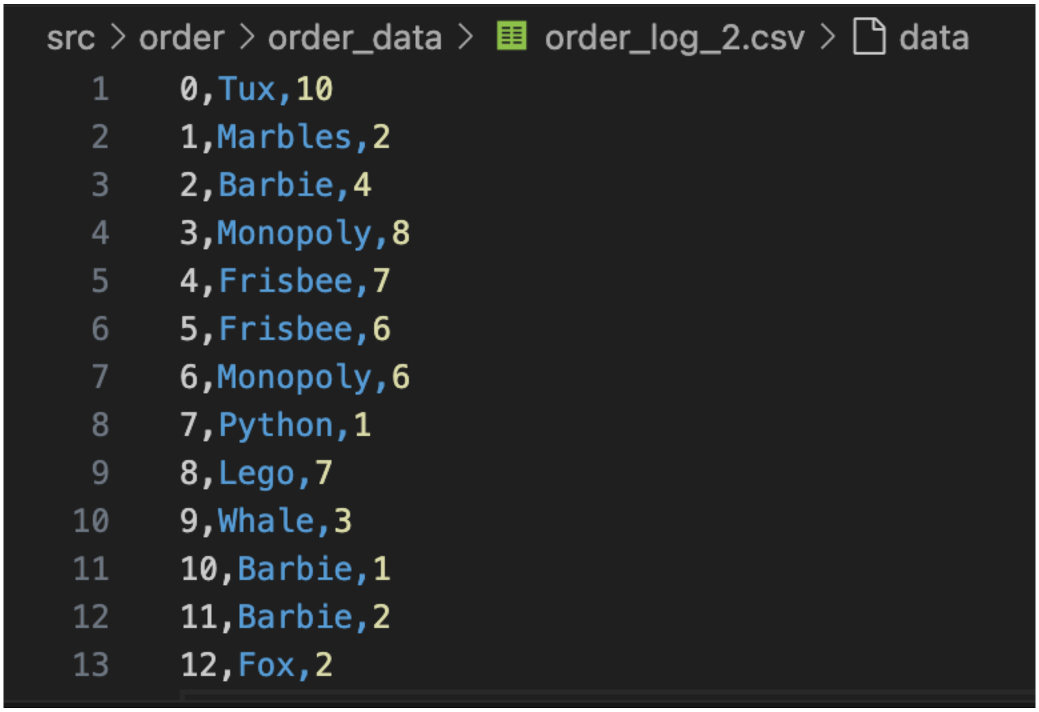
```
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 125
05}
127.0.0.1 - - [06/May/2024 03:52:23] "POST /notify_leader_info_to_replica HTT
P/1.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:52:23] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 125
05}
127.0.0.1 - - [06/May/2024 03:52:23] "POST /notify_leader_info_to_replica HTT
P/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:52:53] "GET /health HTTP/1.1" 200 -
i am now leader
Processing order forBarbie, 2 quantity
Error propagating to http://localhost:12505/replicate_order: HTTPConnectionPo
ol(host='localhost', port=12505): Max retries exceeded with url: /replicate_o
rder (Caused by NewConnectionError('<urllib3.connection.HTTPConnection object
 at 0x1038c67d0>: Failed to establish a new connection: [Errno 61] Connection
 refused'))
Successfully propagated to http://localhost:12502/replicate_order
127.0.0.1 - - [06/May/2024 03:52:53] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:52:53] "GET /health HTTP/1.1" 200 -
```

As we can see, order log of old leader replica 3 is stopped at order number 10, order log of newly elected leader replica 2 and other replica has gone ahead.



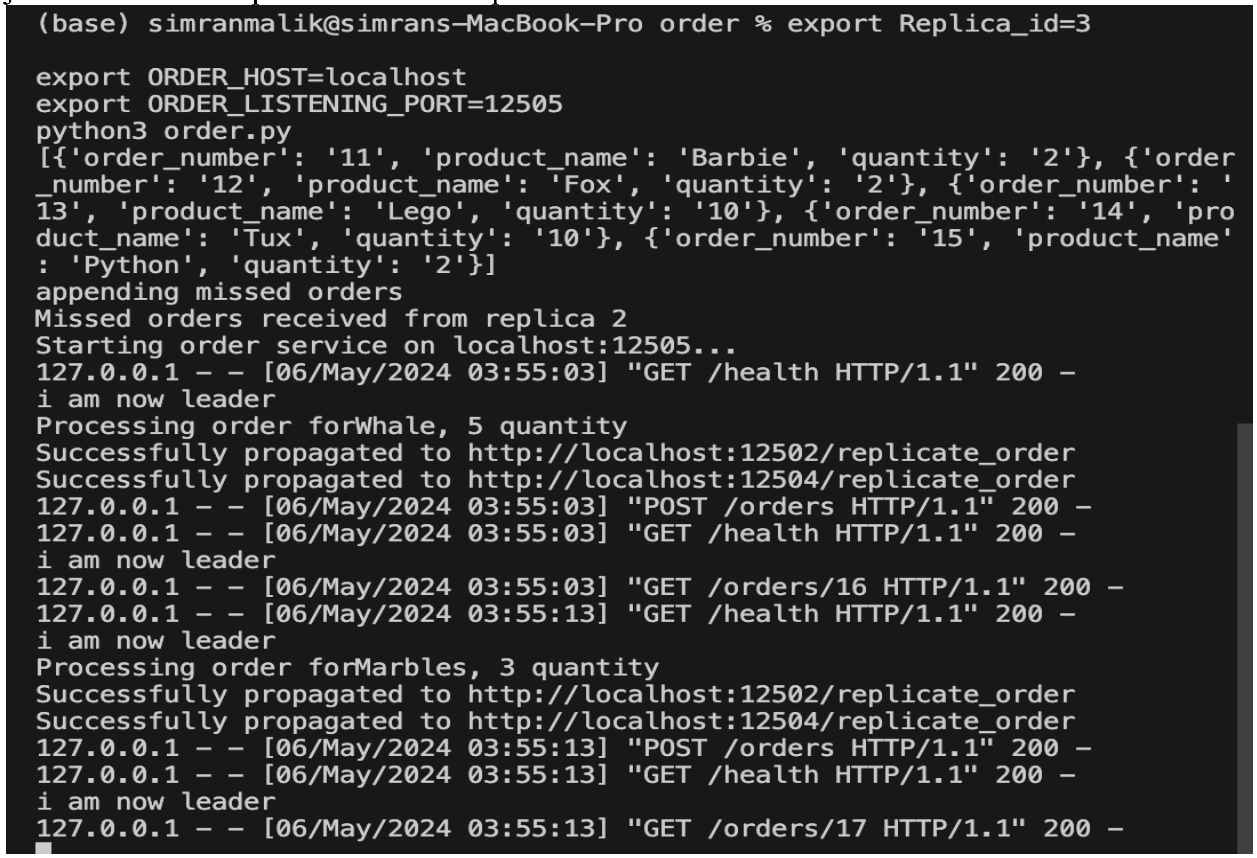
src > order > order_data > order_log_3.csv > data

```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
6,Monopoly,6
7,Python,1
8,Lego,7
9,Whale,3
10,Barbie,1
```



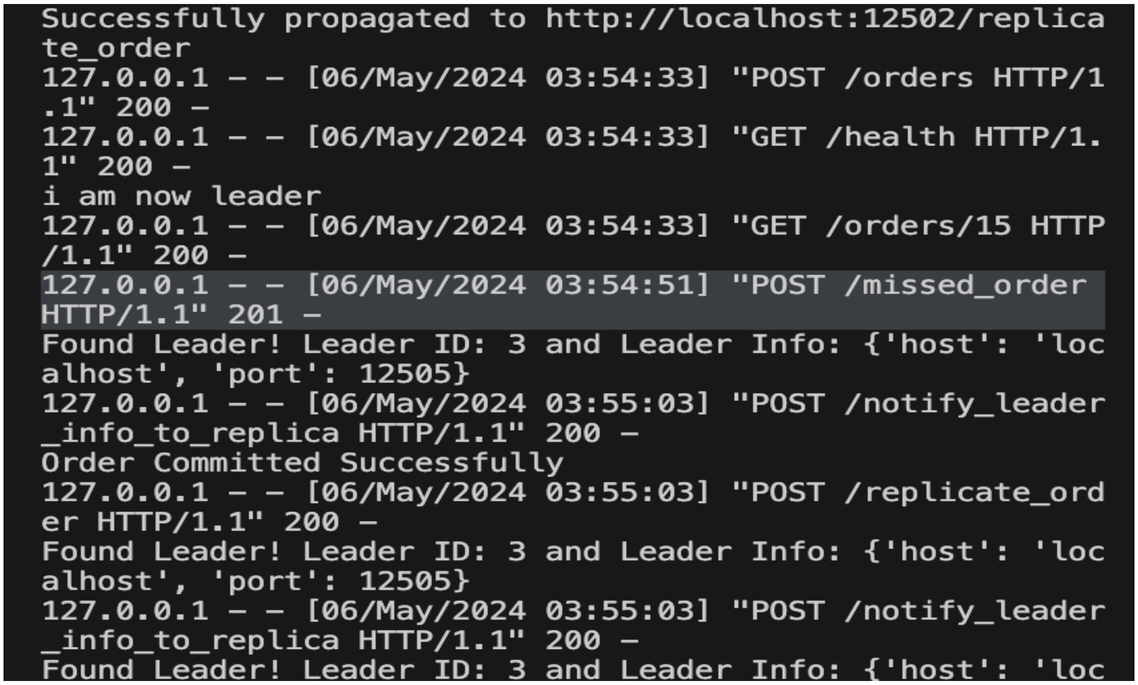
```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
6,Monopoly,6
7,Python,1
8,Lego,7
9,Whale,3
10,Barbie,1
11,Barbie,2
12,Fox,2
```

Replica 3 comes back online, gets missed orders from current leader- replica 2 and resumes its job as a leader and processes order requests

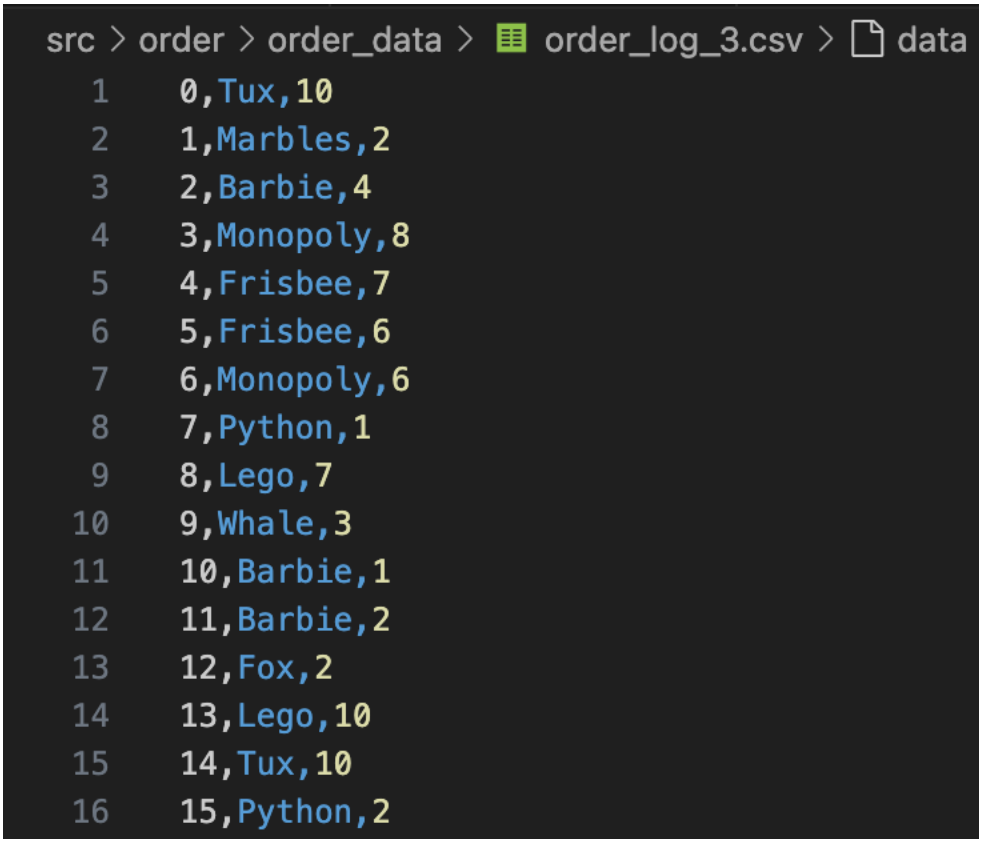


```
(base) simranmalik@simrans-MacBook-Pro order % export Replica_id=3

export ORDER_HOST=localhost
export ORDER_LISTENING_PORT=12505
python3 order.py
[{'order_number': '11', 'product_name': 'Barbie', 'quantity': '2'}, {'order
_number': '12', 'product_name': 'Fox', 'quantity': '2'}, {'order_number': '
13', 'product_name': 'Lego', 'quantity': '10'}, {'order_number': '14', 'pro
duct_name': 'Tux', 'quantity': '10'}, {'order_number': '15', 'product_name'
: 'Python', 'quantity': '2'}]
appending missed orders
Missed orders received from replica 2
Starting order service on localhost:12505...
127.0.0.1 - - [06/May/2024 03:55:03] "GET /health HTTP/1.1" 200 -
i am now leader
Processing order forWhale, 5 quantity
Successfully propagated to http://localhost:12502/replicate_order
Successfully propagated to http://localhost:12504/replicate_order
127.0.0.1 - - [06/May/2024 03:55:03] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:55:03] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:55:03] "GET /orders/16 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:55:13] "GET /health HTTP/1.1" 200 -
i am now leader
Processing order forMarbles, 3 quantity
Successfully propagated to http://localhost:12502/replicate_order
Successfully propagated to http://localhost:12504/replicate_order
127.0.0.1 - - [06/May/2024 03:55:13] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:55:13] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:55:13] "GET /orders/17 HTTP/1.1" 200 -
```

Replica 2 successfully processes missed Post order request with code 201 and sends json doc containing missed orders. Since replica 3 is now back, it resumes its role of follower and starts replication of order logs.



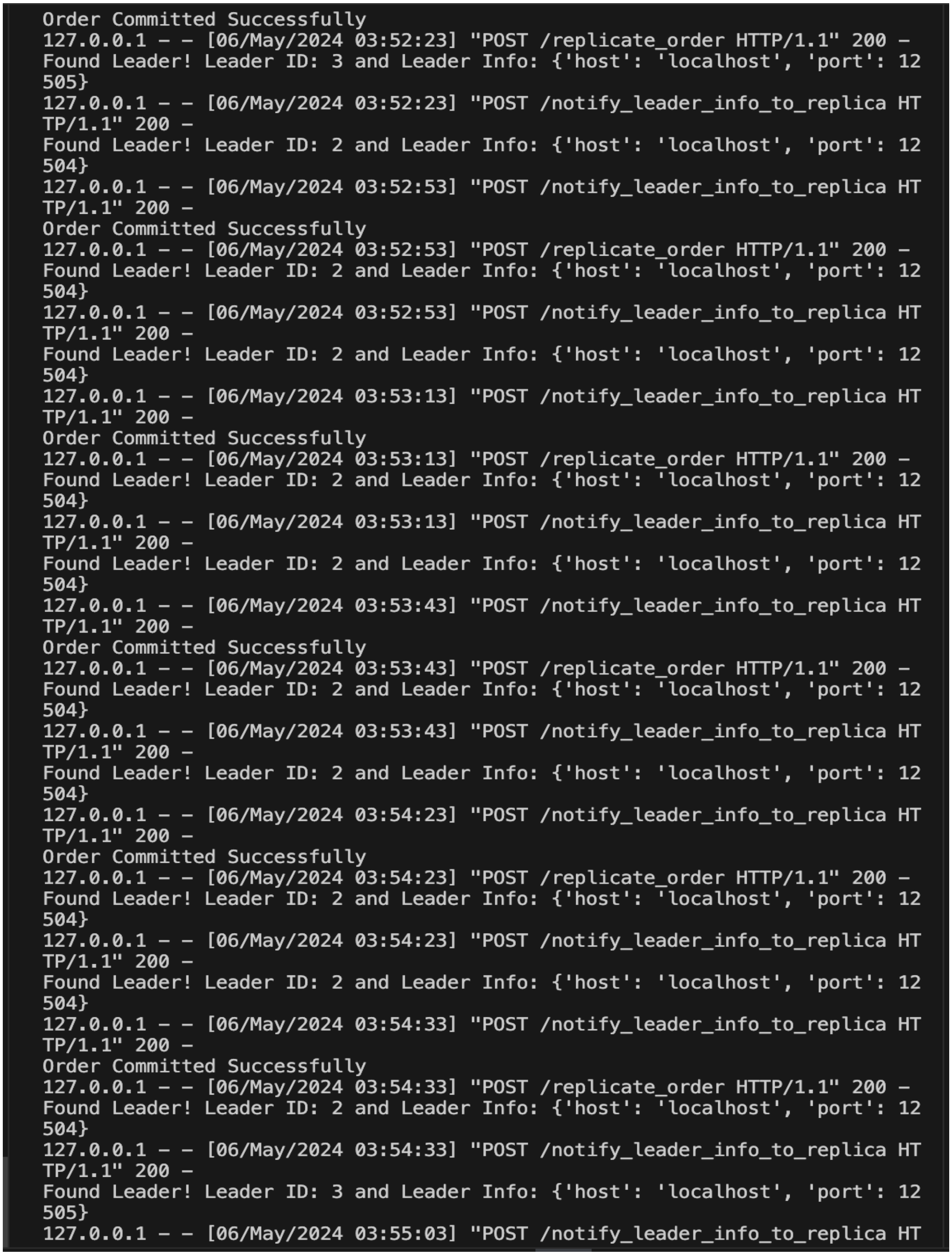
```
Successfully propagated to http://localhost:12502/replica
te_order
127.0.0.1 - - [06/May/2024 03:54:33] "POST /orders HTTP/1
.1" 200 -
127.0.0.1 - - [06/May/2024 03:54:33] "GET /health HTTP/1.
1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:54:33] "GET /orders/15 HTTP
/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:54:51] "POST /missed_order
HTTP/1.1" 201 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'loc
alhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:55:03] "POST /notify_leader
_info_to_replica HTTP/1.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:55:03] "POST /replicate_ord
er HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'loc
alhost', 'port': 12505}
127.0.0.1 - - [06/May/2024 03:55:03] "POST /notify_leader
_info_to_replica HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'loc
```



src > order > order_data > order_log_3.csv > data

```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
6,Monopoly,6
7,Python,1
8,Lego,7
9,Whale,3
10,Barbie,1
11,Barbie,2
12,Fox,2
13,Lego,10
14,Tux,10
15,Python,2
```

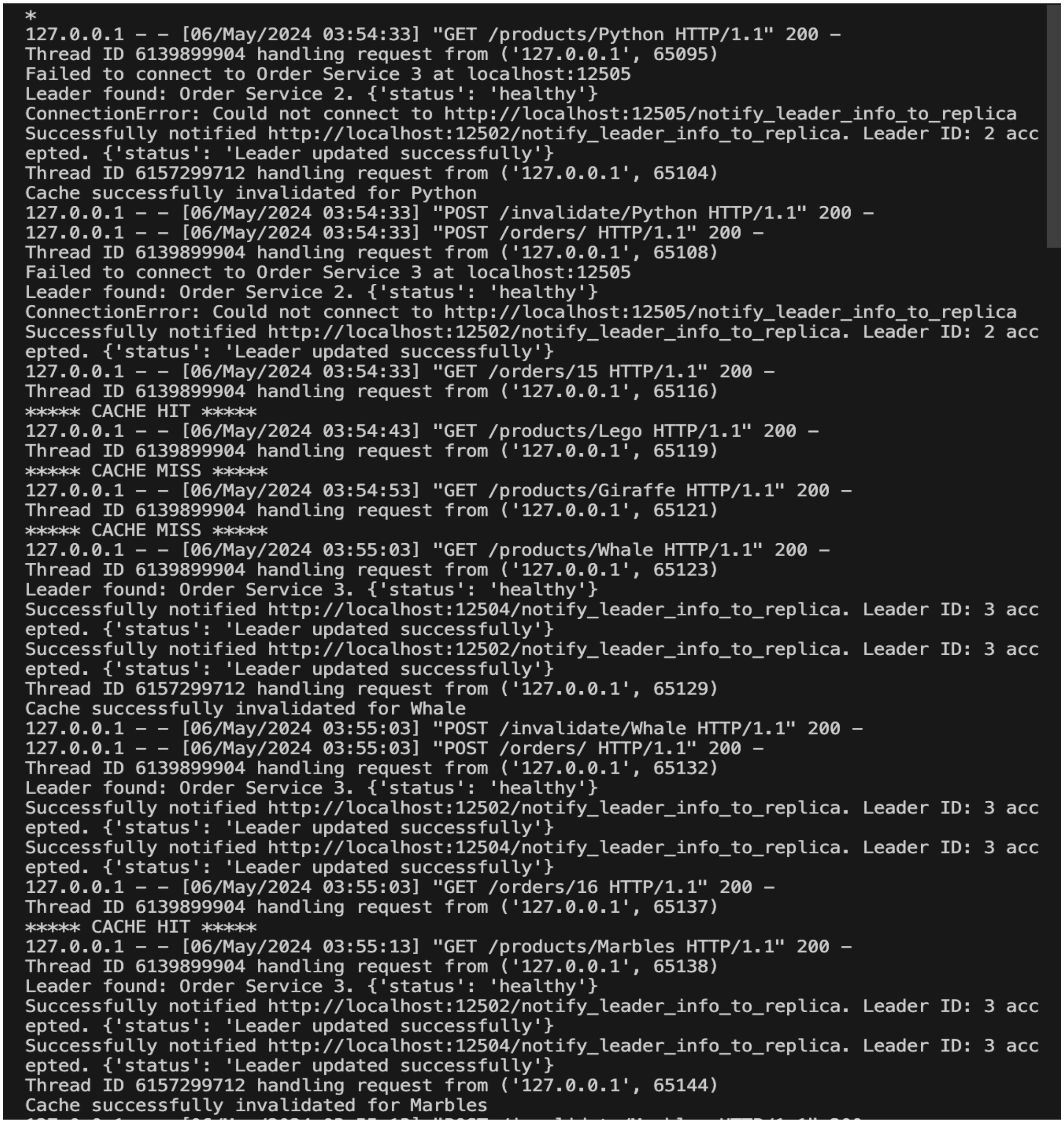
Output for replica 1 that shows leadership if replica 3, then leadership of replica 2 after 3 goes offline, and then re-election of replica 3 as leader when it comes online.



```
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:52:23] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 12
505}
127.0.0.1 - - [06/May/2024 03:52:23] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:52:53] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:52:53] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:52:53] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:53:13] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:53:13] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:53:13] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:53:43] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:53:43] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:53:43] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:54:23] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:54:23] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:54:23] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:54:33] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Order Committed Successfully
127.0.0.1 - - [06/May/2024 03:54:33] "POST /replicate_order HTTP/1.1" 200 -
Found Leader! Leader ID: 2 and Leader Info: {'host': 'localhost', 'port': 12
504}
127.0.0.1 - - [06/May/2024 03:54:33] "POST /notify_leader_info_to_replica HT
TP/1.1" 200 -
Found Leader! Leader ID: 3 and Leader Info: {'host': 'localhost', 'port': 12
505}
127.0.0.1 - - [06/May/2024 03:55:03] "POST /notify_leader_info_to_replica HT
```

front_end_service output:

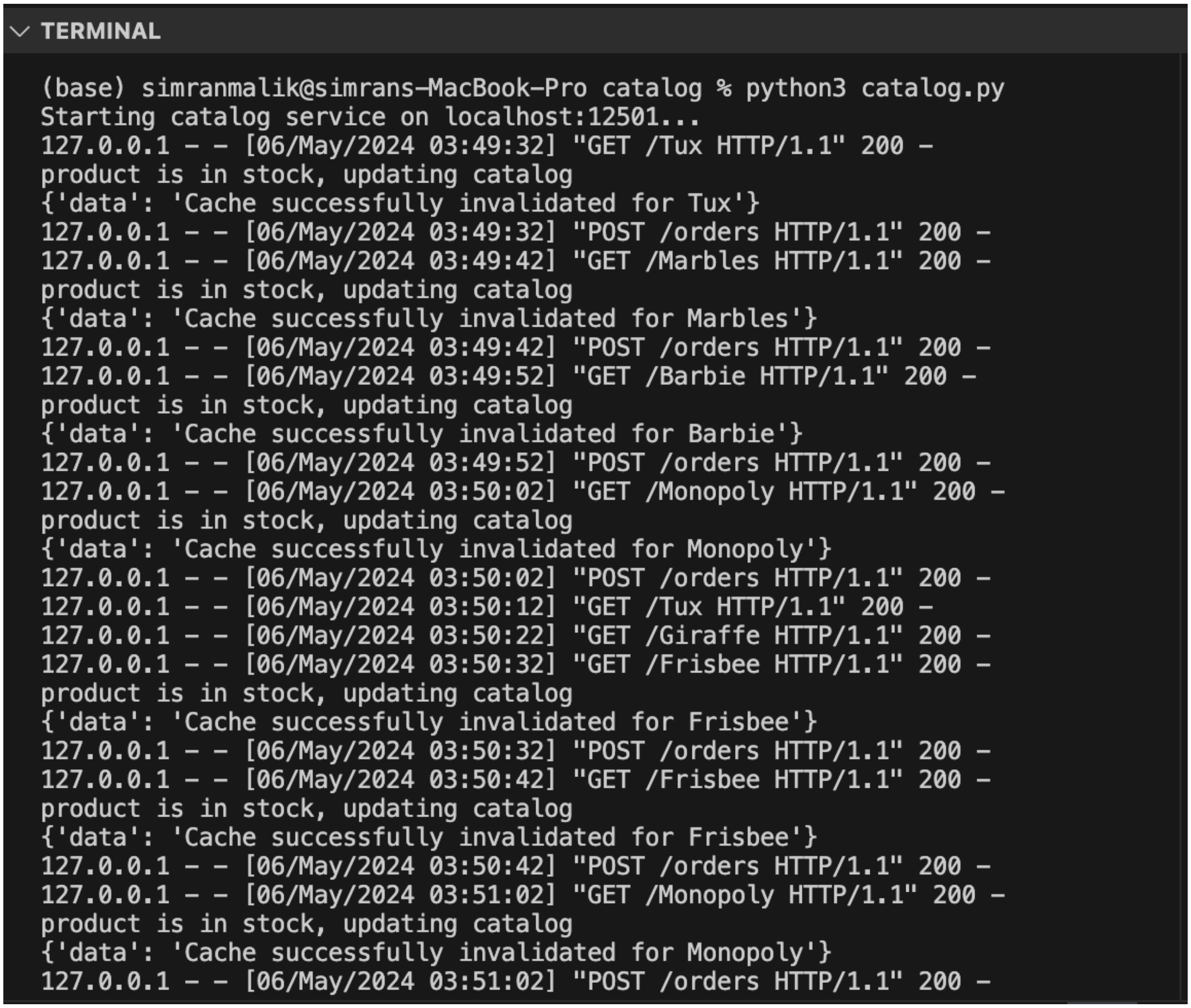
Shows recurrent health checks of order replicas (in reverse order) to elect active leader with highest replica id, and notifies followers about the current leader. Shows passing of leadership from replica 2 to replica 3, when replica 3 is back. Output also shows cache HIT or MISS whenever product query comes in, and invalidates cache for toy when catalog sends cache invalidation request whenever a successful buy operation happens.



```
*
127.0.0.1 - - [06/May/2024 03:54:33] "GET /products/Python HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65095)
Failed to connect to Order Service 3 at localhost:12505
Leader found: Order Service 2. {'status': 'healthy'}
ConnectionError: Could not connect to http://localhost:12505/notify_leader_info_to_replica
Successfully notified http://localhost:12502/notify_leader_info_to_replica. Leader ID: 2 acc
epted. {'status': 'Leader updated successfully'}
Thread ID 6157299712 handling request from ('127.0.0.1', 65104)
Cache successfully invalidated for Python
127.0.0.1 - - [06/May/2024 03:54:33] "POST /invalidate/Python HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:54:33] "POST /orders/ HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65108)
Failed to connect to Order Service 3 at localhost:12505
Leader found: Order Service 2. {'status': 'healthy'}
ConnectionError: Could not connect to http://localhost:12505/notify_leader_info_to_replica
Successfully notified http://localhost:12502/notify_leader_info_to_replica. Leader ID: 2 acc
epted. {'status': 'Leader updated successfully'}
127.0.0.1 - - [06/May/2024 03:54:33] "GET /orders/15 HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65116)
***** CACHE HIT *****
127.0.0.1 - - [06/May/2024 03:54:43] "GET /products/Lego HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65119)
***** CACHE MISS *****
127.0.0.1 - - [06/May/2024 03:54:53] "GET /products/Giraffe HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65121)
***** CACHE MISS *****
127.0.0.1 - - [06/May/2024 03:55:03] "GET /products/Whale HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65123)
Leader found: Order Service 3. {'status': 'healthy'}
Successfully notified http://localhost:12504/notify_leader_info_to_replica. Leader ID: 3 acc
epted. {'status': 'Leader updated successfully'}
Successfully notified http://localhost:12502/notify_leader_info_to_replica. Leader ID: 3 acc
epted. {'status': 'Leader updated successfully'}
Thread ID 6157299712 handling request from ('127.0.0.1', 65129)
Cache successfully invalidated for Whale
127.0.0.1 - - [06/May/2024 03:55:03] "POST /invalidate/Whale HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:55:03] "POST /orders/ HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65132)
Leader found: Order Service 3. {'status': 'healthy'}
Successfully notified http://localhost:12502/notify_leader_info_to_replica. Leader ID: 3 acc
epted. {'status': 'Leader updated successfully'}
Successfully notified http://localhost:12504/notify_leader_info_to_replica. Leader ID: 3 acc
epted. {'status': 'Leader updated successfully'}
127.0.0.1 - - [06/May/2024 03:55:03] "GET /orders/16 HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65137)
***** CACHE HIT *****
127.0.0.1 - - [06/May/2024 03:55:13] "GET /products/Marbles HTTP/1.1" 200 -
Thread ID 6139899904 handling request from ('127.0.0.1', 65138)
Leader found: Order Service 3. {'status': 'healthy'}
Successfully notified http://localhost:12502/notify_leader_info_to_replica. Leader ID: 3 acc
epted. {'status': 'Leader updated successfully'}
Successfully notified http://localhost:12504/notify_leader_info_to_replica. Leader ID: 3 acc
epted. {'status': 'Leader updated successfully'}
Thread ID 6157299712 handling request from ('127.0.0.1', 65144)
Cache successfully invalidated for Marbles
127.0.0.1 - - [06/May/2024 03:55:13] "POST /invalidate/Marbles HTTP/1.1" 200
```

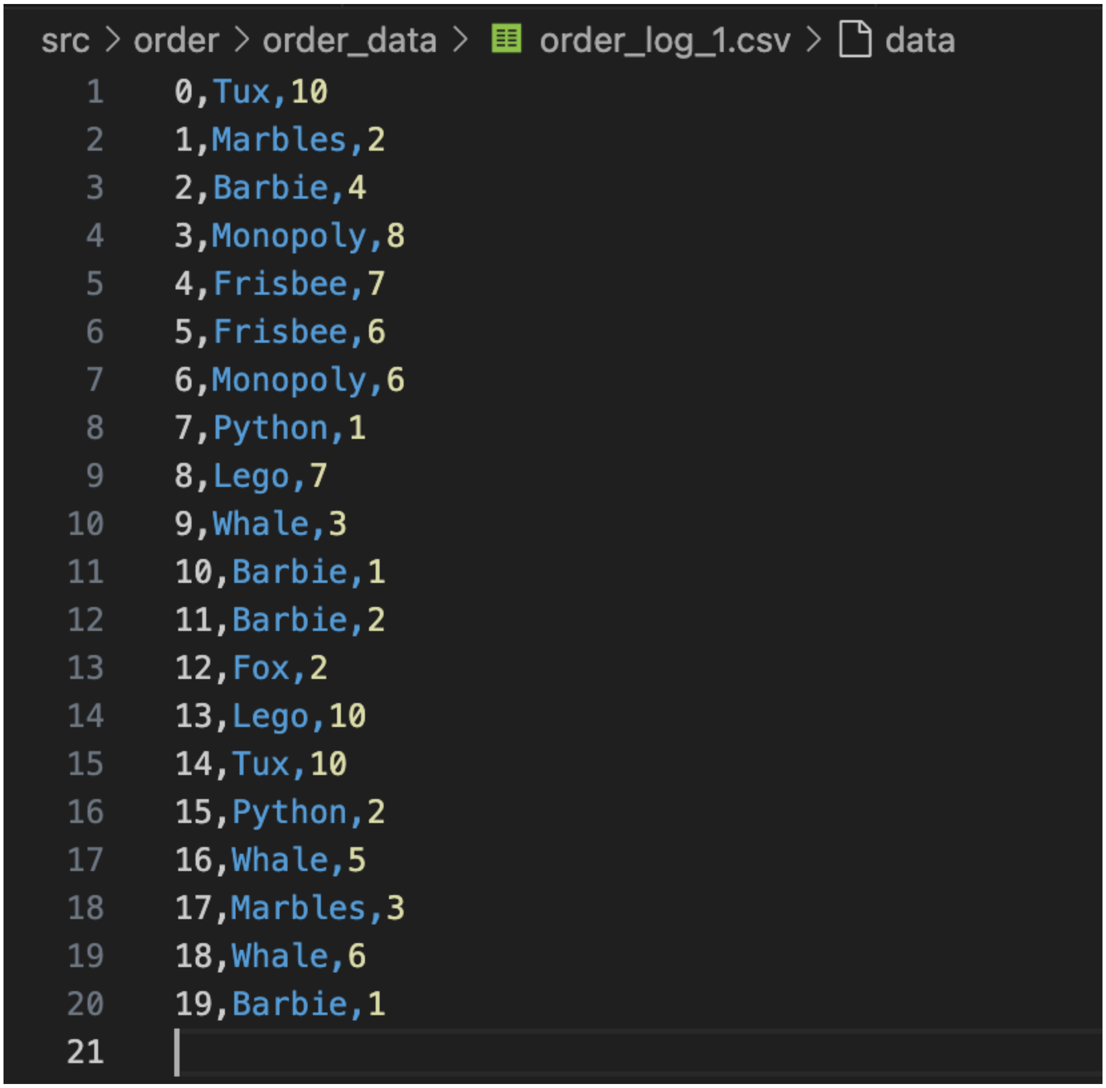
Catalog.py output:

Successfully handles query and buy requests. Also successfully sends cache invalidation requests to front_end_service when buy request is processed.

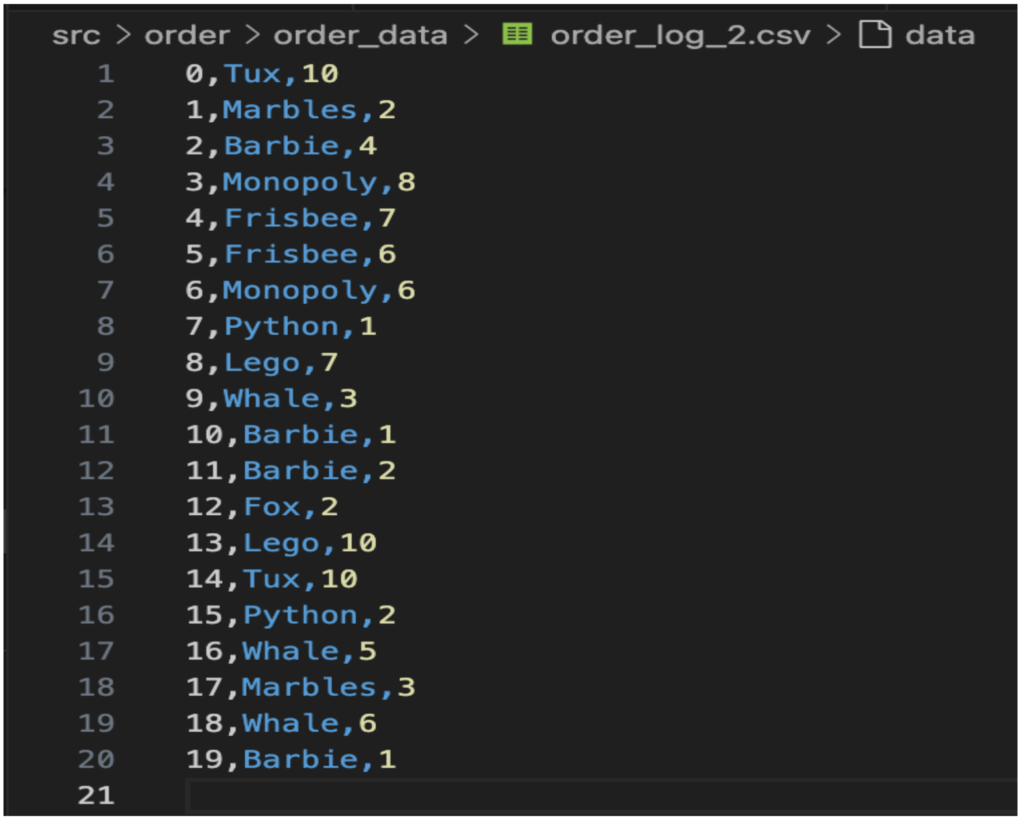


```
(base) simranmalik@simrans-MacBook-Pro catalog % python3 catalog.py
Starting catalog service on localhost:12501...
127.0.0.1 - - [06/May/2024 03:49:32] "GET /Tux HTTP/1.1" 200 -
product is in stock, updating catalog
{'data': 'Cache successfully invalidated for Tux'}
127.0.0.1 - - [06/May/2024 03:49:32] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:49:42] "GET /Marbles HTTP/1.1" 200 -
product is in stock, updating catalog
{'data': 'Cache successfully invalidated for Marbles'}
127.0.0.1 - - [06/May/2024 03:49:42] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:49:52] "GET /Barbie HTTP/1.1" 200 -
product is in stock, updating catalog
{'data': 'Cache successfully invalidated for Barbie'}
127.0.0.1 - - [06/May/2024 03:49:52] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:50:02] "GET /Monopoly HTTP/1.1" 200 -
product is in stock, updating catalog
{'data': 'Cache successfully invalidated for Monopoly'}
127.0.0.1 - - [06/May/2024 03:50:02] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:50:12] "GET /Tux HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:50:22] "GET /Giraffe HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:50:32] "GET /Frisbee HTTP/1.1" 200 -
product is in stock, updating catalog
{'data': 'Cache successfully invalidated for Frisbee'}
127.0.0.1 - - [06/May/2024 03:50:32] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:50:42] "GET /Frisbee HTTP/1.1" 200 -
product is in stock, updating catalog
{'data': 'Cache successfully invalidated for Frisbee'}
127.0.0.1 - - [06/May/2024 03:50:42] "POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:51:02] "GET /Monopoly HTTP/1.1" 200 -
product is in stock, updating catalog
{'data': 'Cache successfully invalidated for Monopoly'}
127.0.0.1 - - [06/May/2024 03:51:02] "POST /orders HTTP/1.1" 200 -
```

Final order logs: same for all replicas despite failures(failure of follower and leader)

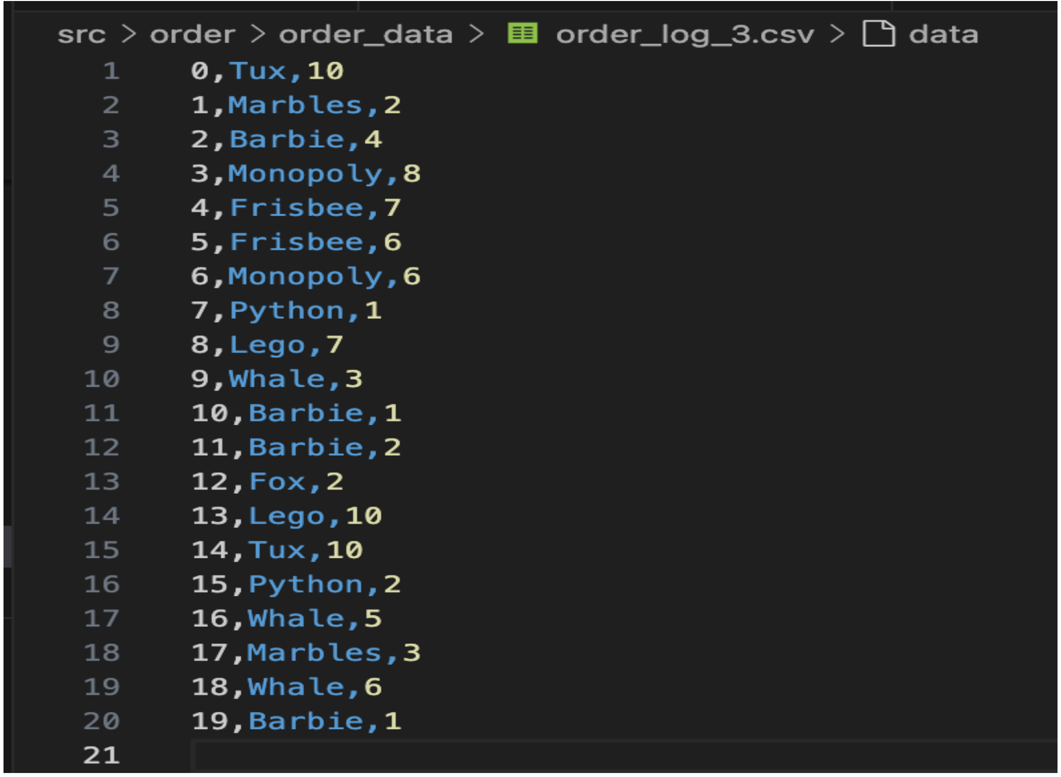


```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
6,Monopoly,6
7,Python,1
8,Lego,7
9,Whale,3
10,Barbie,1
11,Barbie,2
12,Fox,2
13,Lego,10
14,Tux,10
15,Python,2
16,Whale,5
17,Marbles,3
18,Whale,6
19,Barbie,1

```



src > order > order_data > order_log_2.csv > data

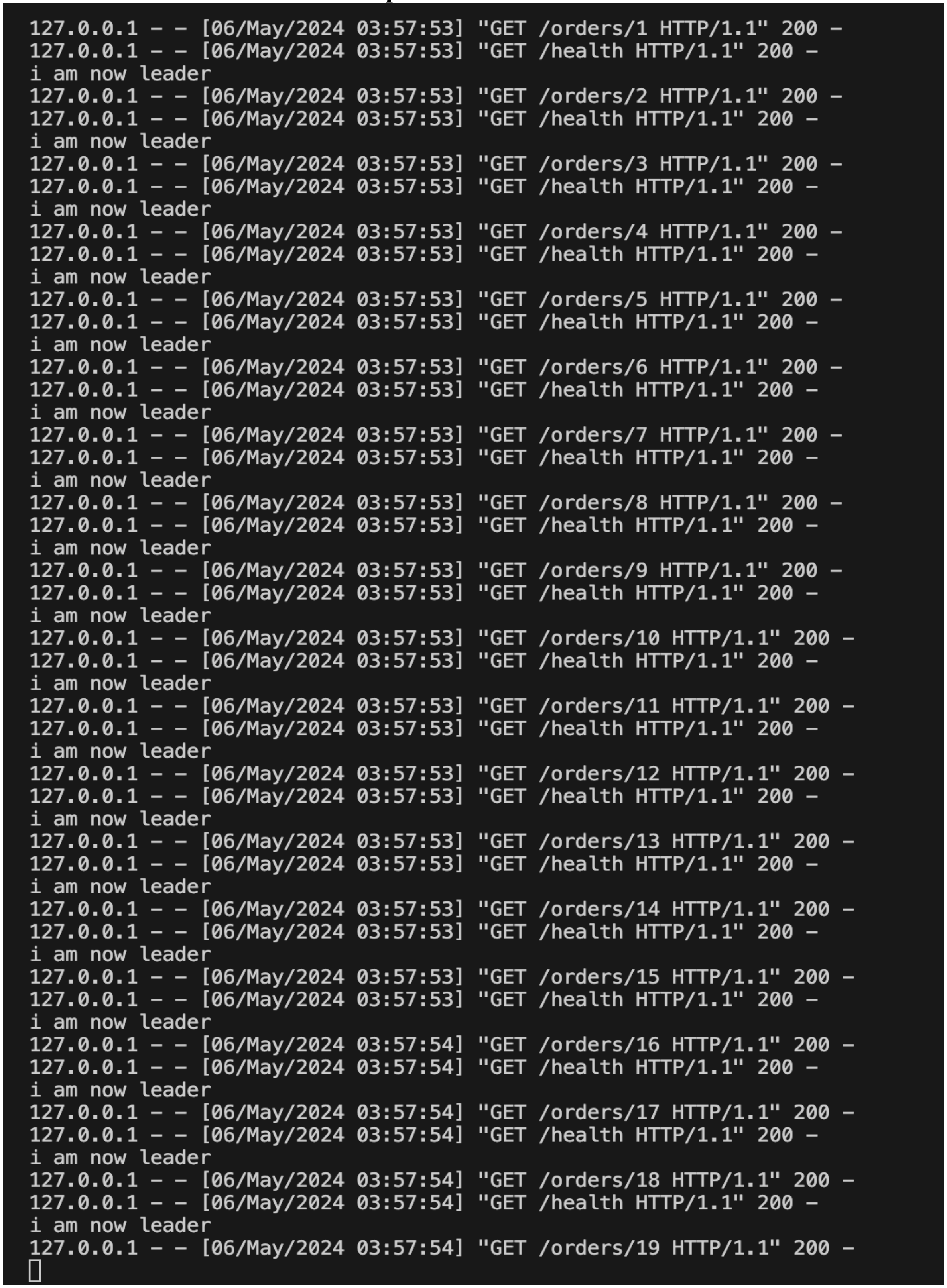
```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
6,Monopoly,6
7,Python,1
8,Lego,7
9,Whale,3
10,Barbie,1
11,Barbie,2
12,Fox,2
13,Lego,10
14,Tux,10
15,Python,2
16,Whale,5
17,Marbles,3
18,Whale,6
19,Barbie,1

```



src > order > order_data > order_log_3.csv > data

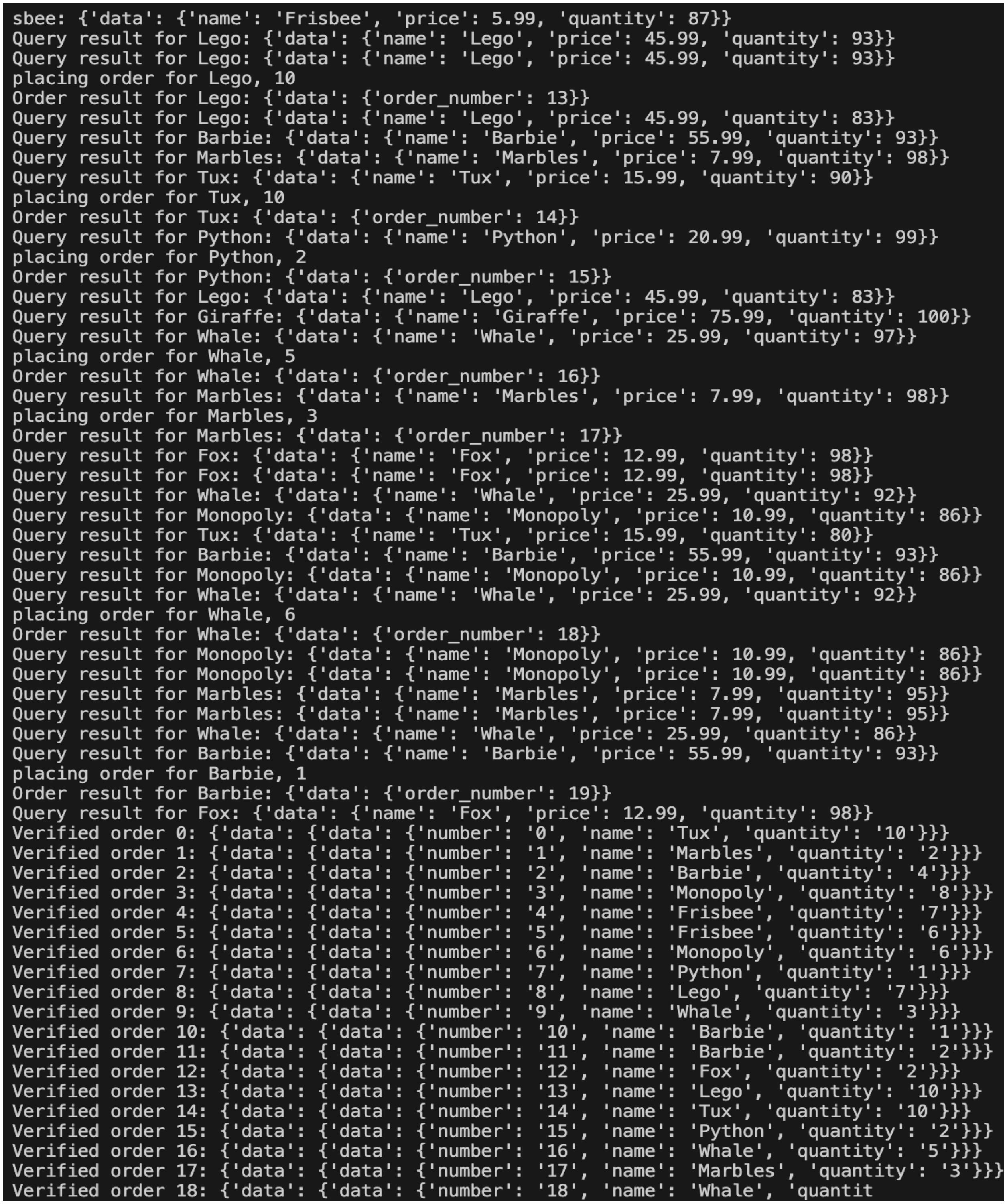
```
0,Tux,10
1,Marbles,2
2,Barbie,4
3,Monopoly,8
4,Frisbee,7
5,Frisbee,6
6,Monopoly,6
7,Python,1
8,Lego,7
9,Whale,3
10,Barbie,1
11,Barbie,2
12,Fox,2
13,Lego,10
14,Tux,10
15,Python,2
16,Whale,5
17,Marbles,3
18,Whale,6
19,Barbie,1

```

Order leader order verification output for client:



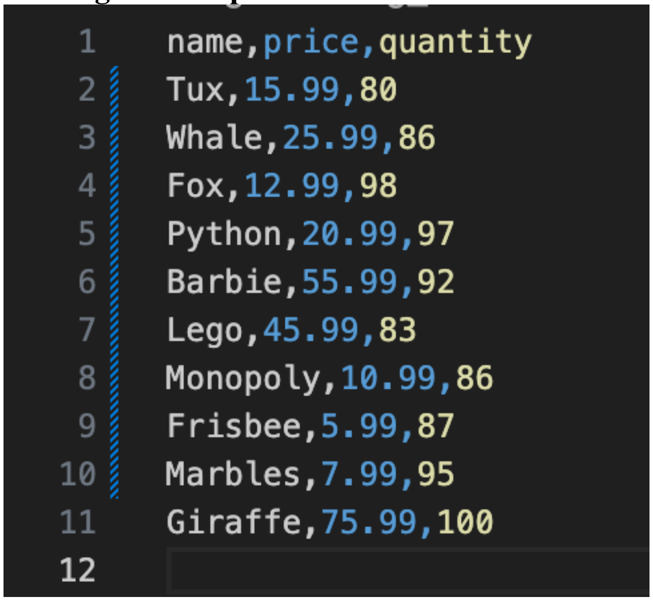
```
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/1 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/2 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/3 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/4 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/5 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/6 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/7 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/8 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/9 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/10 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/11 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/12 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/13 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/14 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:53] "GET /orders/15 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:53] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:54] "GET /orders/16 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:54] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:54] "GET /orders/17 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:54] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:54] "GET /orders/18 HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 03:57:54] "GET /health HTTP/1.1" 200 -
i am now leader
127.0.0.1 - - [06/May/2024 03:57:54] "GET /orders/19 HTTP/1.1" 200 -
```

Client output: Client does not get to see any failures as all its requests are processed regardless of failure.



```
sbee: {'data': {'name': 'Frisbee', 'price': 5.99, 'quantity': 87}}
Query result for Lego: {'data': {'name': 'Lego', 'price': 45.99, 'quantity': 93}}
Query result for Lego: {'data': {'name': 'Lego', 'price': 45.99, 'quantity': 93}}
placing order for Lego, 10
Order result for Lego: {'data': {'order_number': 13}}
Query result for Lego: {'data': {'name': 'Lego', 'price': 45.99, 'quantity': 83}}
Query result for Barbie: {'data': {'name': 'Barbie', 'price': 55.99, 'quantity': 93}}
Query result for Marbles: {'data': {'name': 'Marbles', 'price': 7.99, 'quantity': 98}}
Query result for Tux: {'data': {'name': 'Tux', 'price': 15.99, 'quantity': 90}}
placing order for Tux, 10
Order result for Tux: {'data': {'order_number': 14}}
Query result for Python: {'data': {'name': 'Python', 'price': 20.99, 'quantity': 99}}
placing order for Python, 2
Order result for Python: {'data': {'order_number': 15}}
Query result for Lego: {'data': {'name': 'Lego', 'price': 45.99, 'quantity': 83}}
Query result for Giraffe: {'data': {'name': 'Giraffe', 'price': 75.99, 'quantity': 100}}
Query result for Whale: {'data': {'name': 'Whale', 'price': 25.99, 'quantity': 97}}
placing order for Whale, 5
Order result for Whale: {'data': {'order_number': 16}}
Query result for Marbles: {'data': {'name': 'Marbles', 'price': 7.99, 'quantity': 98}}
placing order for Marbles, 3
Order result for Marbles: {'data': {'order_number': 17}}
Query result for Fox: {'data': {'name': 'Fox', 'price': 12.99, 'quantity': 98}}
Query result for Fox: {'data': {'name': 'Fox', 'price': 12.99, 'quantity': 98}}
Query result for Whale: {'data': {'name': 'Whale', 'price': 25.99, 'quantity': 92}}
Query result for Monopoly: {'data': {'name': 'Monopoly', 'price': 10.99, 'quantity': 86}}
Query result for Tux: {'data': {'name': 'Tux', 'price': 15.99, 'quantity': 80}}
Query result for Barbie: {'data': {'name': 'Barbie', 'price': 55.99, 'quantity': 93}}
Query result for Monopoly: {'data': {'name': 'Monopoly', 'price': 10.99, 'quantity': 86}}
Query result for Whale: {'data': {'name': 'Whale', 'price': 25.99, 'quantity': 92}}
placing order for Whale, 6
Order result for Whale: {'data': {'order_number': 18}}
Query result for Monopoly: {'data': {'name': 'Monopoly', 'price': 10.99, 'quantity': 86}}
Query result for Monopoly: {'data': {'name': 'Monopoly', 'price': 10.99, 'quantity': 86}}
Query result for Marbles: {'data': {'name': 'Marbles', 'price': 7.99, 'quantity': 95}}
Query result for Marbles: {'data': {'name': 'Marbles', 'price': 7.99, 'quantity': 95}}
Query result for Whale: {'data': {'name': 'Whale', 'price': 25.99, 'quantity': 86}}
Query result for Barbie: {'data': {'name': 'Barbie', 'price': 55.99, 'quantity': 93}}
placing order for Barbie, 1
Order result for Barbie: {'data': {'order_number': 19}}
Query result for Fox: {'data': {'name': 'Fox', 'price': 12.99, 'quantity': 98}}
Verified order 0: {'data': {'data': {'number': '0', 'name': 'Tux', 'quantity': '10'}}}
Verified order 1: {'data': {'data': {'number': '1', 'name': 'Marbles', 'quantity': '2'}}}
Verified order 2: {'data': {'data': {'number': '2', 'name': 'Barbie', 'quantity': '4'}}}
Verified order 3: {'data': {'data': {'number': '3', 'name': 'Monopoly', 'quantity': '8'}}}
Verified order 4: {'data': {'data': {'number': '4', 'name': 'Frisbee', 'quantity': '7'}}}
Verified order 5: {'data': {'data': {'number': '5', 'name': 'Frisbee', 'quantity': '6'}}}
Verified order 6: {'data': {'data': {'number': '6', 'name': 'Monopoly', 'quantity': '6'}}}
Verified order 7: {'data': {'data': {'number': '7', 'name': 'Python', 'quantity': '1'}}}
Verified order 8: {'data': {'data': {'number': '8', 'name': 'Lego', 'quantity': '7'}}}
Verified order 9: {'data': {'data': {'number': '9', 'name': 'Whale', 'quantity': '3'}}}
Verified order 10: {'data': {'data': {'number': '10', 'name': 'Barbie', 'quantity': '1'}}}
Verified order 11: {'data': {'data': {'number': '11', 'name': 'Barbie', 'quantity': '2'}}}
Verified order 12: {'data': {'data': {'number': '12', 'name': 'Fox', 'quantity': '2'}}}
Verified order 13: {'data': {'data': {'number': '13', 'name': 'Lego', 'quantity': '10'}}}
Verified order 14: {'data': {'data': {'number': '14', 'name': 'Tux', 'quantity': '10'}}}
Verified order 15: {'data': {'data': {'number': '15', 'name': 'Python', 'quantity': '2'}}}
Verified order 16: {'data': {'data': {'number': '16', 'name': 'Whale', 'quantity': '5'}}}
Verified order 17: {'data': {'data': {'number': '17', 'name': 'Marbles', 'quantity': '3'}}}
Verified order 18: {'data': {'data': {'number': '18', 'name': 'Whale', 'quantit
```

Catalog values updated:



```
name,price,quantity
Tux,15.99,80
Whale,25.99,86
Fox,12.99,98
Python,20.99,97
Barbie,55.99,92
Lego,45.99,83
Monopoly,10.99,86
Frisbee,5.99,87
Marbles,7.99,95
Giraffe,75.99,100

```

Part 4 Questions

Can the clients notice the failures (either during order requests or the final order checking phase) or are they transparent to the clients?
Clients cannot notice any failures as all client requests are processed and delivered regardless of failure.

Do all the order service replicas end up with the same database file?
Yes, all order service replicas end with the same file.

Unit test cases:

We have tested our application for 19 test cases- for testing the application as a whole and as individual microservices:
For front end service:

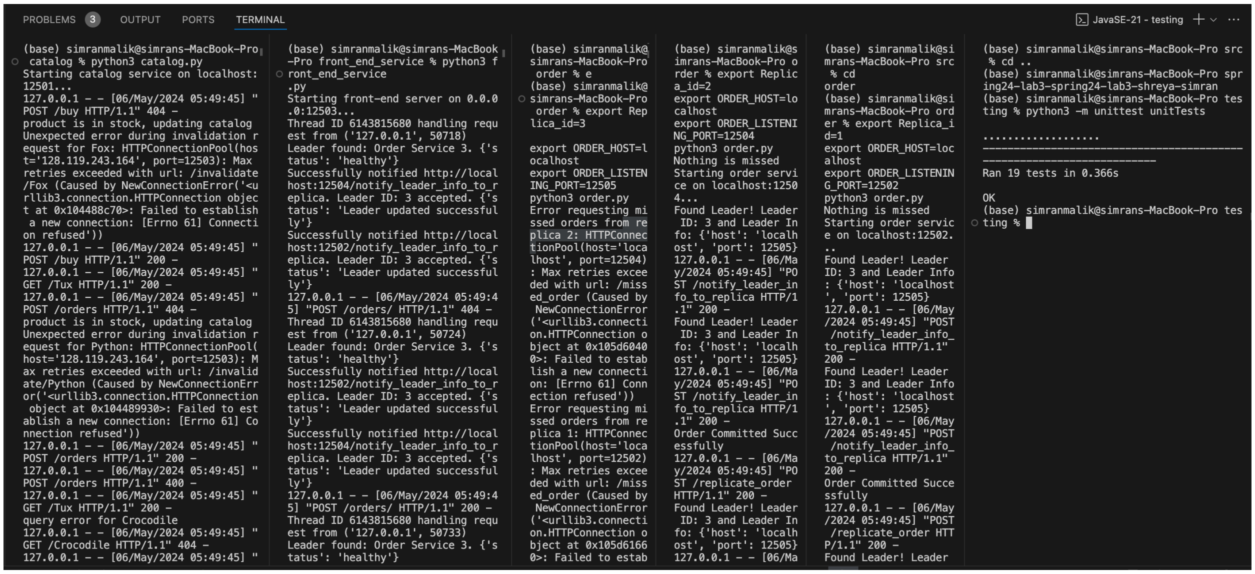
1) test_front_end_query_existing_product
2) test_front_end_query_non_existing_product
3) test_front_end_place_order_successfully
4) test_front_end_quantity_more_than_available
5) test_front_end_place_order_for_non_existing_product
6) test_front_end_query_existing_order_number
7) test_front_end_query_nonexisting_order_number
8) test_health_check
9) test_notify_leader_to_replica
   For Catalog Service:
10) test_retrieve_product_info_directly
11) test_buy_product_successfully

12) test_buy_non_existent_product

For Order Service:

13) test_place_order_successfully
14) test_query_existing_order_number
15) test_query_nonexisting_order_number
16) test_quantity_more_than_available
17) test_place_order_for_non_existing_product
18) test_propagate_order_details_to_follower
19) test_missed_orders

As it is visible in the screenshot, all 19 unit test cases have passed.



```
(base) simranmalik@simrans-MacBook-Pro
 catalog % python3 catalog.py
Starting catalog service on localhost:
12501...
127.0.0.1 - - [06/May/2024 05:49:45] "
POST /buy HTTP/1.1" 404 -
product is in stock, updating catalog
Unexpected error during invalidation r
equest for Fox: HTTPConnectionPool(hos
t='128.119.243.164', port=12503): Max
retries exceeded with url: /invalidate
/Fox (Caused by NewConnectionError('<u
rllib3.connection.HTTPConnection objec
t at 0x104488c70>: Failed to establish
 a new connection: [Errno 61] Connecti
on refused'))
127.0.0.1 - - [06/May/2024 05:49:45] "
POST /buy HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 05:49:45] "
GET /Tux HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 05:49:45] "
POST /orders HTTP/1.1" 404 -
product is in stock, updating catalog
Unexpected error during invalidation r
equest for Python: HTTPConnectionPool(
host='128.119.243.164', port=12503): M
ax retries exceeded with url: /invalid
ate/Python (Caused by NewConnectionErr
or('<urllib3.connection.HTTPConnection
 object at 0x104489930>: Failed to est
ablish a new connection: [Errno 61] Co
nnection refused'))
127.0.0.1 - - [06/May/2024 05:49:45] "
POST /orders HTTP/1.1" 200 -
127.0.0.1 - - [06/May/2024 05:49:45] "
POST /orders HTTP/1.1" 400 -
127.0.0.1 - - [06/May/2024 05:49:45] "
GET /Tux HTTP/1.1" 200 -
query error for Crocodile
127.0.0.1 - - [06/May/2024 05:49:45] "
GET /Crocodile HTTP/1.1" 404 -
127.0.0.1 - - [06/May/2024 05:49:45] "
```

```
(base) simranmalik@simrans-MacBook
-Pro front_end_service % python3 f
ront_end_service
.py
Starting front-end server on 0.0.0
.0:12503...
Thread ID 6143815680 handling requ
est from ('127.0.0.1', 50718)
Leader found: Order Service 3. {'s
tatus': 'healthy'}
Successfully notified http://local
host:12504/notify_leader_info_to_r
eplica. Leader ID: 3 accepted. {'s
tatus': 'Leader updated successful
ly'}
Successfully notified http://local
host:12502/notify_leader_info_to_r
eplica. Leader ID: 3 accepted. {'s
tatus': 'Leader updated successful
ly'}
127.0.0.1 - - [06/May/2024 05:49:4
5] "POST /orders/ HTTP/1.1" 404 -
Thread ID 6143815680 handling requ
est from ('127.0.0.1', 50724)
Leader found: Order Service 3. {'s
tatus': 'healthy'}
Successfully notified http://local
host:12502/notify_leader_info_to_r
eplica. Leader ID: 3 accepted. {'s
tatus': 'Leader updated successful
ly'}
Successfully notified http://local
host:12504/notify_leader_info_to_r
eplica. Leader ID: 3 accepted. {'s
tatus': 'Leader updated successful
ly'}
127.0.0.1 - - [06/May/2024 05:49:4
5] "POST /orders/ HTTP/1.1" 200 -
Thread ID 6143815680 handling requ
est from ('127.0.0.1', 50733)
Leader found: Order Service 3. {'s
tatus': 'healthy'}
```

```
(base) simranmalik@
simrans-MacBook-Pro
 order % e
(base) simranmalik@
simrans-MacBook-Pro
 order % export Rep
lica_id=3

export ORDER_HOST=l
ocalhost
export ORDER_LISTEN
ING_PORT=12505
python3 order.py
Error requesting mi
ssed orders from re
plica 2: HTTPConnec
tionPool(host='loca
lhost', port=12504)
: Max retries excee
ded with url: /miss
ed_order (Caused by
 NewConnectionError
('<urllib3.connecti
on.HTTPConnection o
bject at 0x105d6040
0>: Failed to estab
lish a new connecti
on: [Errno 61] Conn
ection refused'))
Error requesting mi
ssed orders from re
plica 1: HTTPConnec
tionPool(host='loca
lhost', port=12502)
: Max retries excee
ded with url: /miss
ed_order (Caused by
 NewConnectionError
('<urllib3.connecti
on.HTTPConnection o
bject at 0x105d6166
0>: Failed to estab
```

```
(base) simranmalik@s
imrans-MacBook-Pro o
rder % export Replic
a_id=2
export ORDER_HOST=lo
calhost
export ORDER_LISTENI
NG_PORT=12504
python3 order.py
Nothing is missed
Starting order servi
ce on localhost:1250
4...
Found Leader! Leader
 ID: 3 and Leader In
fo: {'host': 'localh
ost', 'port': 12505}
127.0.0.1 - - [06/Ma
y/2024 05:49:45] "PO
ST /notify_leader_in
fo_to_replica HTTP/1
.1" 200 -
Found Leader! Leader
 ID: 3 and Leader In
fo: {'host': 'localh
ost', 'port': 12505}
127.0.0.1 - - [06/Ma
y/2024 05:49:45] "PO
ST /notify_leader_in
fo_to_replica HTTP/1
.1" 200 -
Order Committed Succ
essfully
127.0.0.1 - - [06/Ma
y/2024 05:49:45] "PO
ST /replicate_order
HTTP/1.1" 200 -
Found Leader! Leader
 ID: 3 and Leader In
fo: {'host': 'localh
ost', 'port': 12505}
127.0.0.1 - - [06/Ma
```

```
(base) simranmalik@si
mrans-MacBook-Pro src
 % cd
order
(base) simranmalik@si
mrans-MacBook-Pro ord
er % export Replica_i
d=1
export ORDER_HOST=loc
alhost
export ORDER_LISTENIN
G_PORT=12502
python3 order.py
Nothing is missed
Starting order servic
e on localhost:12502.
..
Found Leader! Leader
ID: 3 and Leader Info
: {'host': 'localhost
', 'port': 12505}
127.0.0.1 - - [06/May
/2024 05:49:45] "POST
 /notify_leader_info_
to_replica HTTP/1.1"
200 -
Found Leader! Leader
ID: 3 and Leader Info
: {'host': 'localhost
', 'port': 12505}
127.0.0.1 - - [06/May
/2024 05:49:45] "POST
 /notify_leader_info_
to_replica HTTP/1.1"
200 -
Order Committed Succe
ssfully
127.0.0.1 - - [06/May
/2024 05:49:45] "POST
 /replicate_order HTT
P/1.1" 200 -
Found Leader! Leader
```

```
(base) simranmalik@simrans-MacBook-Pro src
 % cd ..
(base) simranmalik@simrans-MacBook-Pro spr
ing24-lab3-spring24-lab3-shreya-simran
(base) simranmalik@simrans-MacBook-Pro tes
ting % python3 -m unittest unitTests

...................
------------------------------------------
----------------------------
Ran 19 tests in 0.366s

OK
(base) simranmalik@simrans-MacBook-Pro tes
ting % 
```