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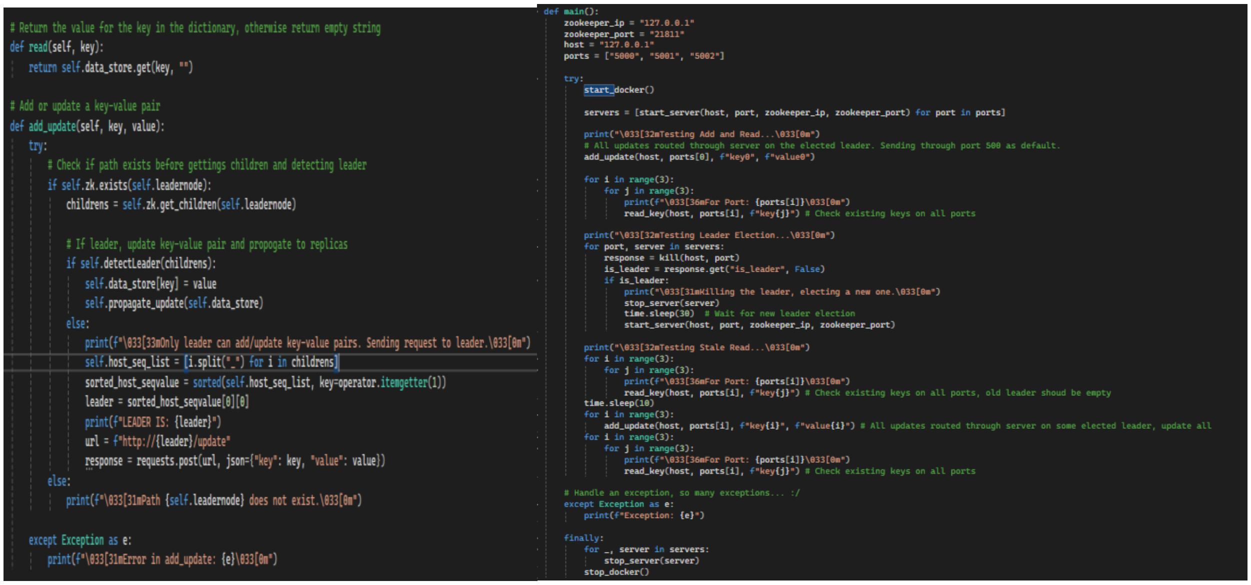
CS2510

Assignment 2: Zookeeper

Project Description: This project is based on the project code provide in class. The zk_election_another.py program and docker-compose.yml file were extended to meet the assignment requirements. A replicated key-value data store maintained by N servers was implemented and each server maintains a copy of the data store. Zookeeper was used in order to implement leader election. All requests are routed through the leader and propagated to the replicas.

Project Implementation:

(Left) Zookeeper.py with read and add_update methods implemented and (Right) the main method for server.py that handles all test cases.



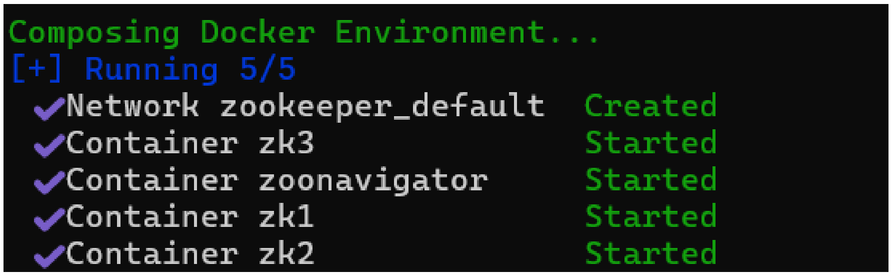
```
# Return the value for the key in the dictionary, otherwise return empty string
def read(self, key):
    return self.data_store.get(key, "")

# Add or update a key-value pair
def add_update(self, key, value):
    try:
        # Check if path exists before gettings children and detecting leader
        if self.zk.exists(self.leadernode):
            childrens = self.zk.get_children(self.leadernode)

            # If leader, update key-value pair and propogate to replicas
            if self.detectLeader(childrens):
                self.data_store[key] = value
                self.propagate_update(self.data_store)
            else:
                print(f"\033[33mOnly leader can add/update key-value pairs. Sending request to leader.\033[0m")
                self.host_seq_list = [i.split("_") for i in childrens]
                sorted_host_seqvalue = sorted(self.host_seq_list, key=operator.itemgetter(1))
                leader = sorted_host_seqvalue[0][0]
                print(f"LEADER IS: {leader}")
                url = f"http://{leader}/update"
                response = requests.post(url, json={"key": key, "value": value})
        else:
            print(f"\033[31mPath {self.leadernode} does not exist.\033[0m")

    except Exception as e:
        print(f"\033[31mError in add_update: {e}\033[0m")
```

```
def main():
    zookeeper_ip = "127.0.0.1"
    zookeeper_port = "21811"
    host = "127.0.0.1"
    ports = ["5000", "5001", "5002"]

    try:
        start_docker()

        servers = [start_server(host, port, zookeeper_ip, zookeeper_port) for port in ports]

        print("\033[32mTesting Add and Read...\033[0m")
        # All updates routed through server on the elected leader. Sending through port 500 as default.
        add_update(host, ports[0], f"key0", f"value0")

        for i in range(3):
            for j in range(3):
                print(f"\033[36mFor Port: {ports[i]}\033[0m")
                read_key(host, ports[i], f"key{j}") # Check existing keys on all ports

        print("\033[32mTesting Leader Election...\033[0m")
        for port, server in servers:
            response = kill(host, port)
            is_leader = response.get("is_leader", False)
            if is_leader:
                print("\033[31mKilling the leader, electing a new one.\033[0m")
                stop_server(server)
                time.sleep(30)  # Wait for new leader election
                start_server(host, port, zookeeper_ip, zookeeper_port)

        print("\033[32mTesting Stale Read...\033[0m")
        for i in range(3):
            for j in range(3):
                print(f"\033[36mFor Port: {ports[i]}\033[0m")
                read_key(host, ports[i], f"key{j}") # Check existing keys on all ports, old leader shoud be empty
        time.sleep(10)
        for i in range(3):
            add_update(host, ports[i], f"key{i}", f"value{i}") # All updates routed through server on some elected leader, update all
        for i in range(3):
            for j in range(3):
                print(f"\033[36mFor Port: {ports[i]}\033[0m")
                read_key(host, ports[i], f"key{j}") # Check existing keys on all ports

    # Handle an exception, so many exceptions... :/
    except Exception as e:
        print(f"Exception: {e}")

    finally:
        for _, server in servers:
            stop_server(server)
        stop_docker()
```

Project Testing:

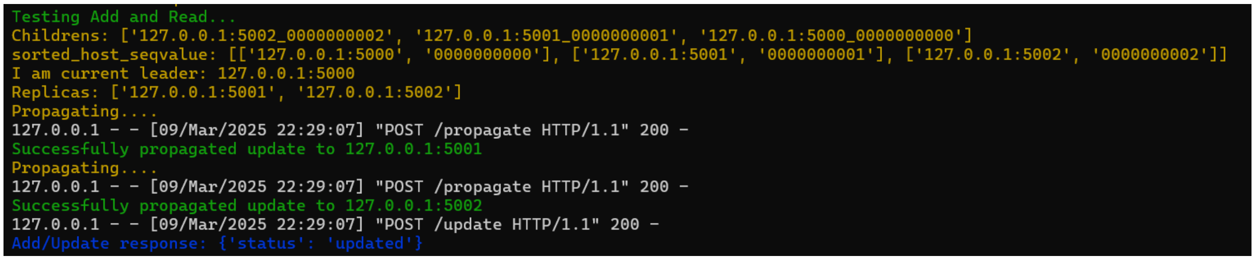
Test 1:

(a.) Three servers started in docker containers.



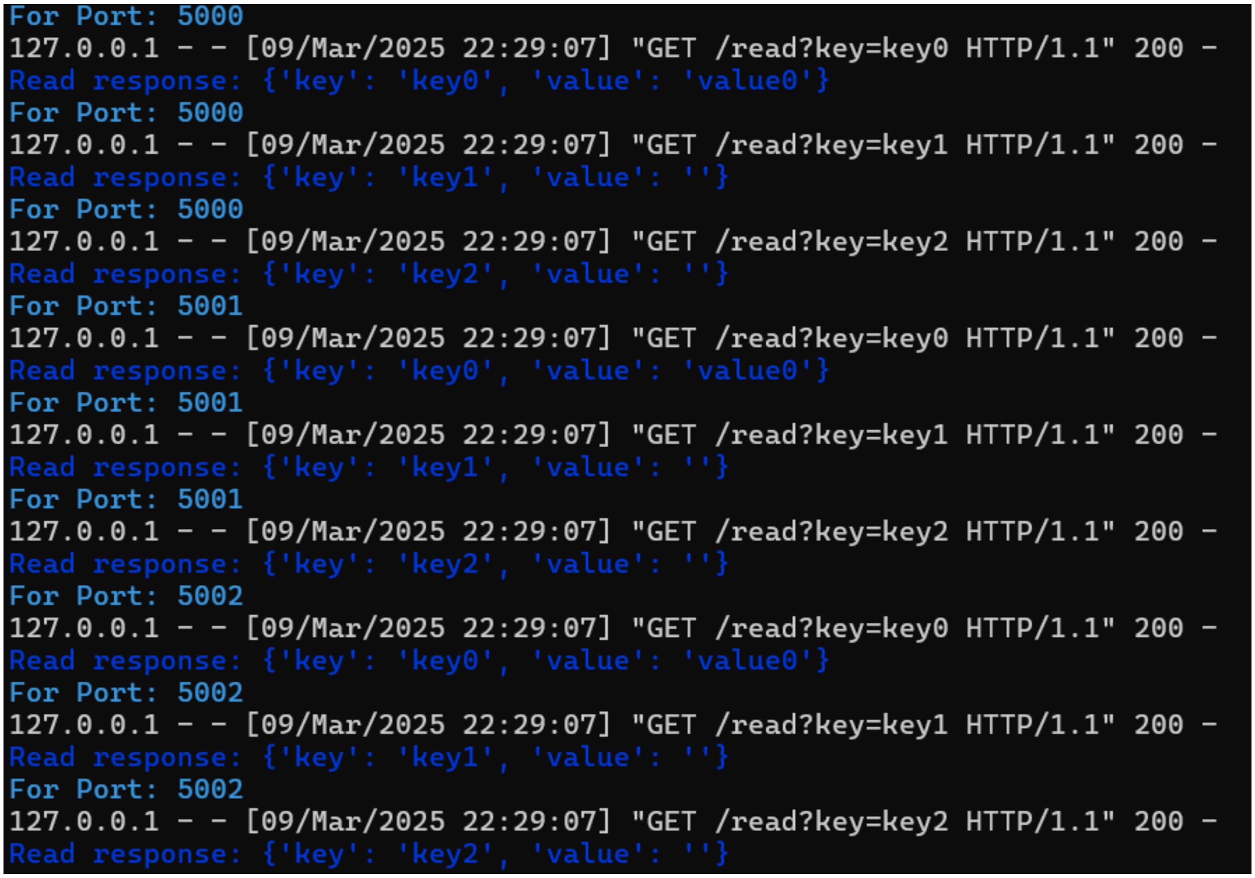
```
Composing Docker Environment...
[+] Running 5/5
 ✔Network zookeeper_default   Created
 ✔Container zk3               Started
 ✔Container zoonavigator      Started
 ✔Container zk1               Started
 ✔Container zk2               Started
```

(b.) The servers elect a leader and all requests are routed to the leader.



```
Testing Add and Read...
Childrens: ['127.0.0.1:5002_0000000002', '127.0.0.1:5001_0000000001', '127.0.0.1:5000_0000000000']
sorted_host_seqvalue: [['127.0.0.1:5000', '0000000000'], ['127.0.0.1:5001', '0000000001'], ['127.0.0.1:5002', '0000000002']]
I am current leader: 127.0.0.1:5000
Replicas: ['127.0.0.1:5001', '127.0.0.1:5002']
Propagating....
127.0.0.1 - - [09/Mar/2025 22:29:07] "POST /propagate HTTP/1.1" 200 -
Successfully propagated update to 127.0.0.1:5001
Propagating....
127.0.0.1 - - [09/Mar/2025 22:29:07] "POST /propagate HTTP/1.1" 200 -
Successfully propagated update to 127.0.0.1:5002
127.0.0.1 - - [09/Mar/2025 22:29:07] "POST /update HTTP/1.1" 200 -
Add/Update response: {'status': 'updated'}
```

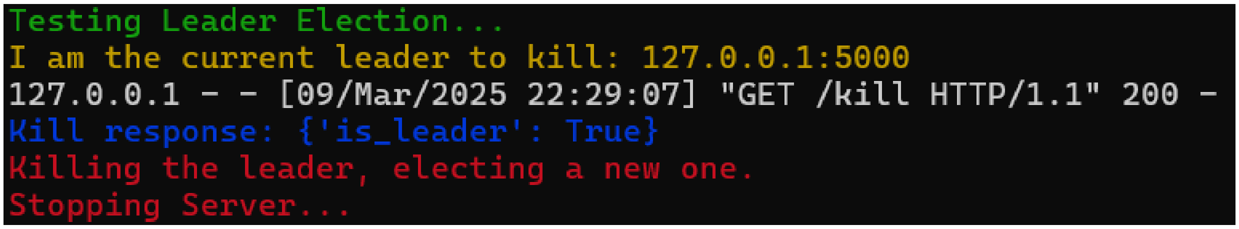
(c.) Subsequent requests of the key can be fetched from any server.



```
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
```

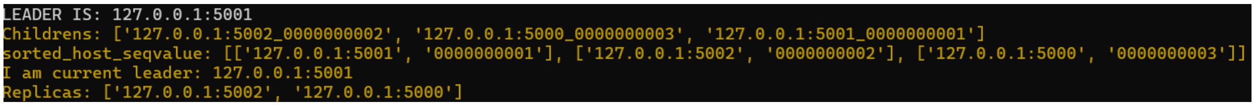
Test 2:

(a.) Kill the leader.



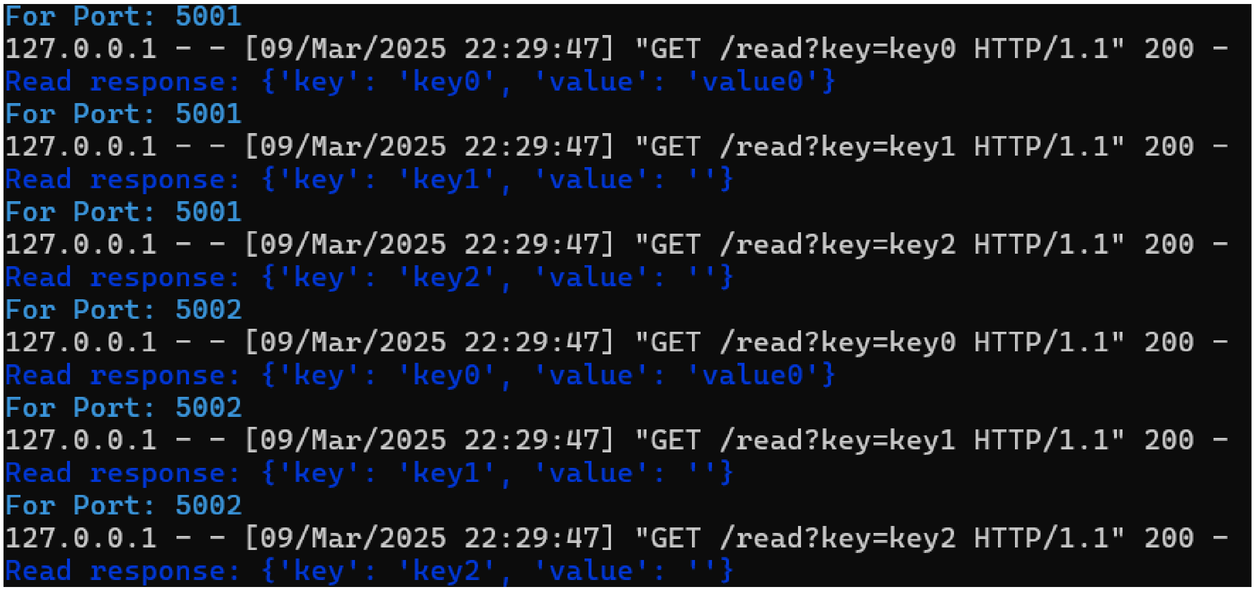
```
Testing Leader Election...
I am the current leader to kill: 127.0.0.1:5000
127.0.0.1 - - [09/Mar/2025 22:29:07] "GET /kill HTTP/1.1" 200 -
Kill response: {'is_leader': True}
Killing the leader, electing a new one.
Stopping Server...
```

(b.) A new leader is elected.



```
LEADER IS: 127.0.0.1:5001
Childrens: ['127.0.0.1:5002_0000000002', '127.0.0.1:5000_0000000003', '127.0.0.1:5001_0000000001']
sorted_host_seqvalue: [['127.0.0.1:5001', '0000000001'], ['127.0.0.1:5002', '0000000002'], ['127.0.0.1:5000', '0000000003']]
I am current leader: 127.0.0.1:5001
Replicas: ['127.0.0.1:5002', '127.0.0.1:5000']
```

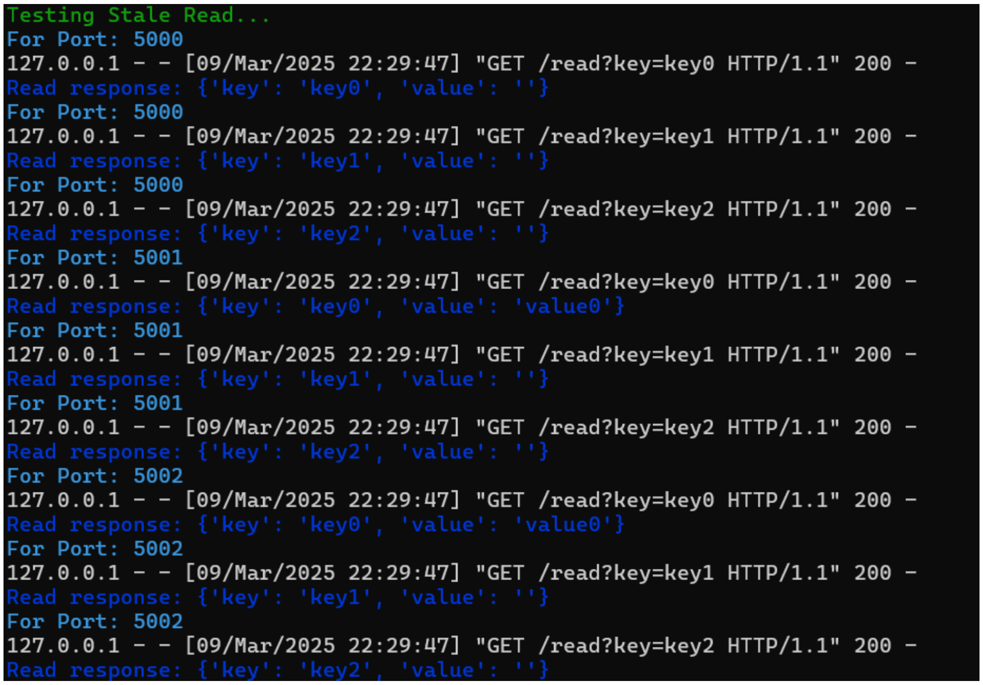
(c.) *Subsequent requests are routed through the new leader.*



```
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
```

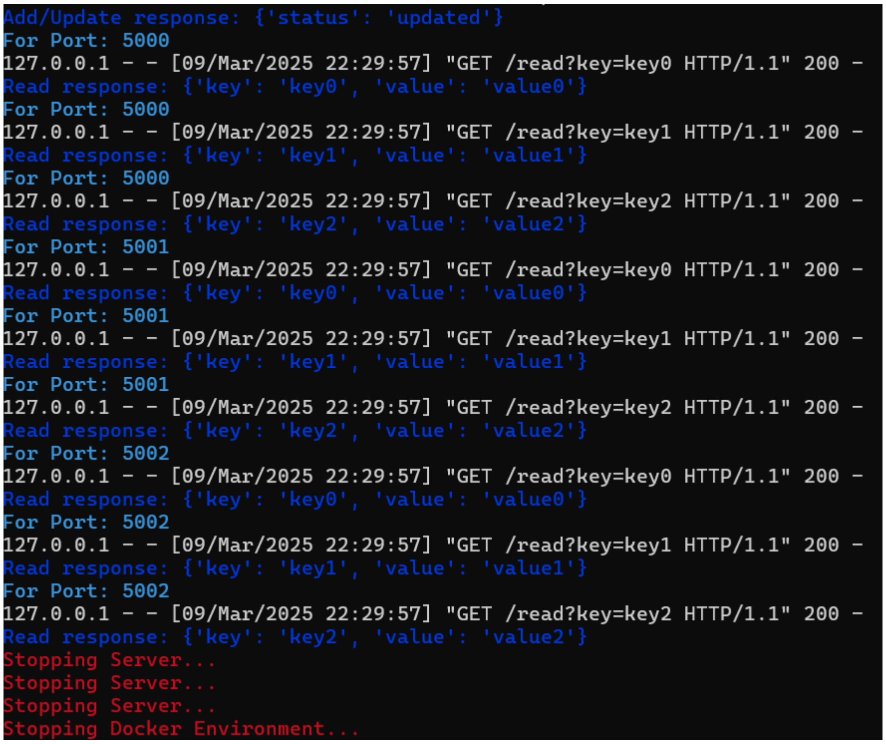
Test 3:

(a.) The killed leader is back online and may have stale data.



```
Testing Stale Read...
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': ''}
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': ''}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:47] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': ''}
```

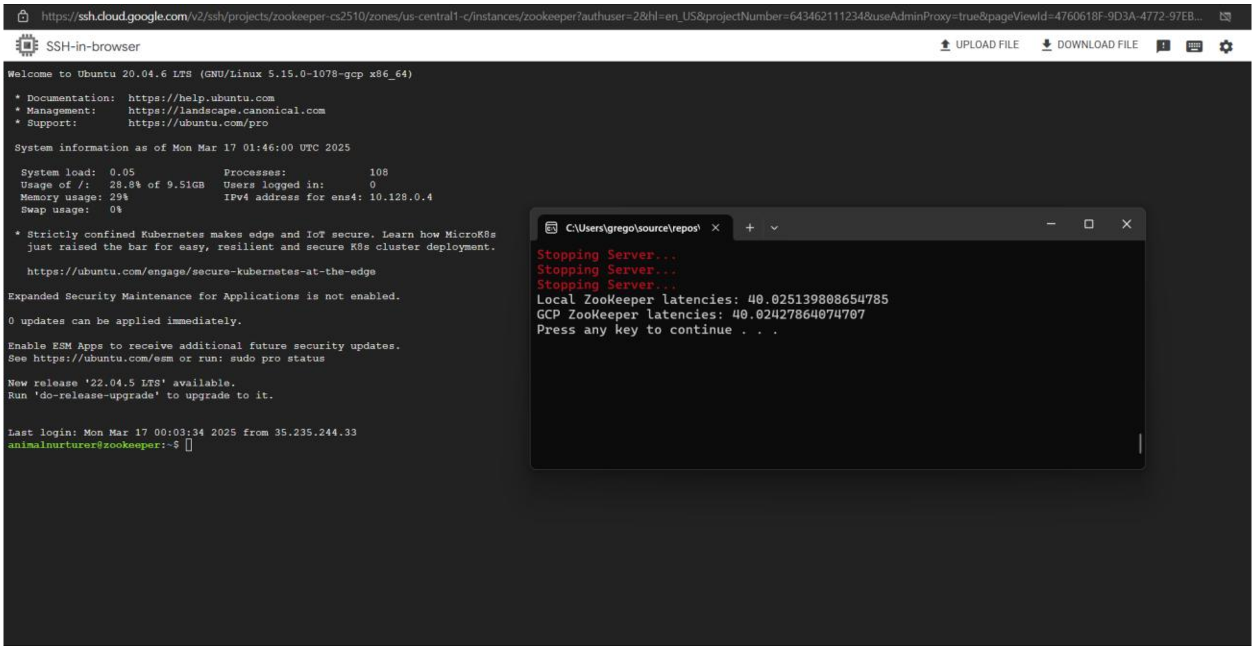
(b.) Once key is updated, output. In this example, I update all key/value pairs.



```
Add/Update response: {'status': 'updated'}
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': 'value1'}
For Port: 5000
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': 'value2'}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': 'value1'}
For Port: 5001
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': 'value2'}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key0 HTTP/1.1" 200 -
Read response: {'key': 'key0', 'value': 'value0'}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key1 HTTP/1.1" 200 -
Read response: {'key': 'key1', 'value': 'value1'}
For Port: 5002
127.0.0.1 - - [09/Mar/2025 22:29:57] "GET /read?key=key2 HTTP/1.1" 200 -
Read response: {'key': 'key2', 'value': 'value2'}
Stopping Server...
Stopping Server...
Stopping Server...
Stopping Docker Environment...
```

Extra Credit:

(a.) Comparing the latency of running zookeeper on a Google’s cloud platform vs locally. The latency is very close.


https://ssh.cloud.google.com/v2/ssh/projects/zookeeper-cs2510/zones/us-central1-c/instances/zookeeper?authuser=2&hl=en_US&projectNumber=643462111234&useAdminProxy=true&pageViewId=4760618F-9D3A-4772-97EB...
SSH-in-browser
UPLOAD FILE
DOWNLOAD FILE
C:\Users\grego\source\repos\

```
Welcome to Ubuntu 20.04.6 LTS (GNU/Linux 5.15.0-1078-gcp x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/pro

 System information as of Mon Mar 17 01:46:00 UTC 2025

  System load:  0.05              Processes:             108
  Usage of /:   28.8% of 9.51GB   Users logged in:       0
  Memory usage: 29%               IPv4 address for ens4: 10.128.0.4
  Swap usage:   0%

 * Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
   just raised the bar for easy, resilient and secure K8s cluster deployment.

   https://ubuntu.com/engage/secure-kubernetes-at-the-edge

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

New release '22.04.5 LTS' available.
Run 'do-release-upgrade' to upgrade to it.


Last login: Mon Mar 17 00:03:34 2025 from 35.235.244.33
animalnurturer@zookeeper:~$ 
```

```
Stopping Server...
Stopping Server...
Stopping Server...
Local ZooKeeper latencies: 40.025139808654785
GCP ZooKeeper latencies: 40.02427864074707
Press any key to continue . . .
```