

## Assignment Overview

The project is to replicate key-value stored across 5 distinct servers. The client should be able to contact any of the five key-value replica servers and get consistent data back from any of the replicas.

Ensuring PUT and DELETE operations are consistent. To do this, implement a two-phase protocol for updates.

Use client to pre-populate the key-value store. Also adding multi-threaded server capabilities using Remote Procedure Call.

## Technical Impression

The client randomly select one of the 5 servers for each operation, ensuring that operations are distributed across all replicas. In the server class, the `connectToOtherServers()` method connects the server to the other 4 servers, creating a network of 5 servers total. The `put` method and the `delete` method use a 2PC protocol to ensure consistency across all servers.

### Two-Phase Commit (2PC) for consistency:

Prepare phase: The `prepareAllServers()` method implements the prepare phase of 2PC, ensuring all servers are ready for a change.

Commit phase: the `commitAllServers()` method implements the commit phase of 2PC, applying the change to all servers.

Abort mechanism: the `abortAllServers()` method aborts the operation if the prepare phase fails.

When a PUT or DELETE operation is received, the server initiates the prepare phase with all other servers.

If all servers respond with "YES" (ACK), the commit phase is initiated.

If any server fails to respond or responds with "NO", the operation is aborted on all servers.

The commit phase ensures that all servers apply the change.

The implementation includes a timeout of 5 seconds in the prepare phase, addressing the requirement for defensive coding with timeouts.

Aggregating data from all servers: the `getAll()` method aggregates data from all servers, ensuring clients can get consistent data from any server.

Server startup coordination: the `coordinateStartup()` method ensures all servers are ready before the system becomes fully operational.

I encounter server connection refuse issue when try to connect the current server 8001 to

other servers, because they are not yet running. I fix the error by Implement a startup coordination. Instead of having each server try to connect to all others immediately, implement a "master" server that coordinates the startup of other servers. This is done by isMaster(), coordinateStartup(), waitForMasterSignal() methods. I Open five separate terminal windows and start each server individually:

```
java Server 8001 8002 8003 8004 8005 true  
java Server 8002 8001 8003 8004 8005 false  
java Server 8003 8001 8002 8004 8005 false  
java Server 8004 8001 8002 8003 8005 false  
java Server 8005 8001 8002 8003 8004 false
```

The last parameter (true or false) indicates whether the server is the master coordinator.

### How to Run

1. cd to the current working path, then comply all java files: javac \*.java
2. run 5 instances of servers: java Server 8001 8002 8003 8004 8005 true
  - java Server 8002 8001 8003 8004 8005 false
  - java Server 8003 8001 8002 8004 8005 false
  - java Server 8004 8001 8002 8003 8005 false
  - java Server 8005 8001 8002 8003 8004 false
3. run the client: testing with one server
  - java Client localhost 8001 localhost 8001 localhost 8001 localhost 8001 localhost 8001
4. enter command when client is running: GET key, PUT key value, DELETE key, GETALL, QUIT

The followings are examples of all 5 servers running and client testing on one server to perform 5 GET, 5 PUT, 5 DELETE, GETALL and Quit commands.

A screenshot of a terminal window within a development environment. The terminal tab is active, showing the output of a Java application named Server1. The log output is as follows:

```
mac@Emmas-Laptop src % java Server1 8001 8002 8003 8004 8005 true
...
Jul 20, 2024 5:25:12 PM Server1 main
INFO: Server bound to registry on port 8001
Jul 20, 2024 5:25:12 PM Server1 coordinateStartup
INFO: Master server coordinating startup
Jul 20, 2024 5:25:12 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:17 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:22 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:27 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:32 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:37 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:42 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:47 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:52 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:25:57 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8002
Jul 20, 2024 5:26:02 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8003
Jul 20, 2024 5:26:07 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8003
Jul 20, 2024 5:26:12 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8003
Jul 20, 2024 5:26:17 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8003
Jul 20, 2024 5:26:22 PM Server1 coordinateStartup
```

The terminal also shows navigation icons for back, forward, and search, and a status bar at the bottom indicating the current directory is 'src' and there is an 'Execution Summary' available.

The screenshot shows a Java IDE interface with a terminal window open. The terminal tab is selected, and the output shows the log of a Server1 application starting up. The log includes messages indicating the server is waiting for other servers to start and then connecting to them on port 8002.

```
Jul 20, 2024 5:26:22 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8003
...
Jul 20, 2024 5:26:27 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8004
Jul 20, 2024 5:26:32 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8004
Jul 20, 2024 5:26:37 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8004
Jul 20, 2024 5:26:42 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8004
Jul 20, 2024 5:26:47 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8005
Jul 20, 2024 5:26:52 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8005
Jul 20, 2024 5:26:57 PM Server1 coordinateStartup
WARNING: Waiting for server on port 8005
Jul 20, 2024 5:27:02 PM Server1 coordinateStartup
INFO: All servers are ready
Jul 20, 2024 5:27:02 PM Server1 connectToOtherServers
INFO: Successfully connected to server at localhost:8002
Jul 20, 2024 5:27:02 PM Server1 connectToOtherServers
INFO: Successfully connected to server at localhost:8003
Jul 20, 2024 5:27:02 PM Server1 connectToOtherServers
INFO: Successfully connected to server at localhost:8004
Jul 20, 2024 5:27:02 PM Server1 connectToOtherServers
INFO: Successfully connected to server at localhost:8005
Jul 20, 2024 5:27:02 PM Server1 main
INFO: Server fully started and connected on port 8001
```

The screenshot shows a terminal window within a development environment. The title bar includes 'src' and 'Version control'. The tabs at the top are 'Project', 'Client.java', 'KeyValueRPC.java', 'Server1.java', and 'Execution Summary'. The active tab is 'Terminal'. The log output is as follows:

```
mac@Emmas-Laptop src % java Server1 8002 8001 8003 8004 8005 false
...
Jul 20, 2024 5:26:01 PM Server1 main
INFO: Server bound to registry on port 8002
Jul 20, 2024 5:26:02 PM Server1 signalReady
INFO: Received ready signal from master
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
```

```
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Prepare request received: DELETE key1
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Preparing to commit operation: DELETE on key: key1
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Prepare request received: PUT key6 value6
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key6
```

The screenshot shows a terminal window with the following details:

- Project:** src
- Version control:** Version control
- Terminal:** Local (4) is selected.
- Log Output:**

```
mac@Emmas-Laptop src % java Server1 8003 8001 8002 8004 8005 false
...
Jul 20, 2024 5:26:23 PM Server1 main
INFO: Server bound to registry on port 8003
Jul 20, 2024 5:26:27 PM Server1 signalReady
INFO: Received ready signal from master
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
```

**Sidebar:** The sidebar on the left contains icons for Project, Terminal, Local (4), Local (5), Local (6), Local (7), and Execution Summary.

The screenshot shows a Java IDE interface with a terminal window displaying log output from a distributed system simulation. The terminal tab bar includes tabs for Project, Client.java, KeyValueRPC.java, Server1.java, and Execution Summary. The execution summary tab is currently selected.

```
INFO: Preparing to commit operation: PUT on key: key2
...
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Prepare request received: DELETE key1
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Preparing to commit operation: DELETE on key: key1
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Prepare request received: PUT key6 value6
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key6
```

The screenshot shows a terminal window with the following details:

- Project:** src
- Version control:** Version control
- Terminal:** Local (5) (highlighted)
- Log Output:**

```
mac@Emmas-Laptop src % java Server1 8004 8001 8002 8003 8005 false
...
Jul 20, 2024 5:26:45 PM Server1 main
INFO: Server bound to registry on port 8004
Jul 20, 2024 5:26:47 PM Server1 signalReady
INFO: Received ready signal from master
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
```

Bottom navigation:  
src > Execution Summary

```
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:19 PM Server1 prepare
...
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Prepare request received: DELETE key1
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Preparing to commit operation: DELETE on key: key1
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Prepare request received: PUT key6 value6
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key6
```

src > Execution Summary

The screenshot shows a terminal window with the following details:

- Project:** src
- Version control:** Version control
- Terminal:** Local (6) (selected)
- Other tabs:** Local, Local (2), Local (3), Local (4), Local (5), Local (7)

The terminal output is as follows:

```
mac@Emmas-Laptop src % java Server1 8005 8001 8002 8003 8004 false
...
Jul 20, 2024 5:27:01 PM Server1 main
INFO: Server bound to registry on port 8005
Jul 20, 2024 5:27:02 PM Server1 signalReady
INFO: Received ready signal from master
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
```

Bottom navigation:  
src > Execution Summary

The screenshot shows a Java IDE interface with a terminal window displaying log output. The terminal tab is selected, showing a sequence of INFO-level log messages from a server process named 'Server1'. The log output details multiple 'PUT' and 'DELETE' operations on various keys, with timestamps indicating the sequence of events over a 5-minute period.

```
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:19 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key1 value1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key1
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key2 value2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key2
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key3 value3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key3
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key4 value4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key4
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Prepare request received: PUT key5 value5
Jul 20, 2024 5:30:55 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key5
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Prepare request received: DELETE key1
Jul 20, 2024 5:31:18 PM Server1 prepare
INFO: Preparing to commit operation: DELETE on key: key1
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Prepare request received: PUT key6 value6
Jul 20, 2024 5:31:33 PM Server1 prepare
INFO: Preparing to commit operation: PUT on key: key6
```

The screenshot shows a terminal window within a Java development environment. The terminal tab is active, showing the output of a Java application named 'Client'. The application connects to three servers at localhost:8001 and performs key-value operations. The log includes messages for connecting to servers, pre-populating the store with values, verifying data, and interacting with the user via command-line input.

```
mac@Emmas-Laptop src % java Client localhost 8001 localhost 8001 localhost 8001 localhost
...
2024-07-20 18:49:43.700: Connected to server at localhost:8001
2024-07-20 18:49:43.702: Connected to server at localhost:8001
2024-07-20 18:49:43.703: Connected to server at localhost:8001
2024-07-20 18:49:43.703: Connected to server at localhost:8001
2024-07-20 18:49:43.704: Connected to server at localhost:8001
Waiting for servers to set up...
Pre-populating key-value store...
2024-07-20 18:49:44.745: Received from server: SUCCESS
2024-07-20 18:49:44.750: Received from server: SUCCESS
2024-07-20 18:49:44.753: Received from server: SUCCESS
2024-07-20 18:49:44.755: Received from server: SUCCESS
2024-07-20 18:49:44.758: Received from server: SUCCESS
Verifying pre-populated data...
2024-07-20 18:49:44.759: Received from server: value1
2024-07-20 18:49:44.759: Received from server: value2
2024-07-20 18:49:44.759: Received from server: value3
2024-07-20 18:49:44.760: Received from server: value4
2024-07-20 18:49:44.760: Received from server: value5
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
GET key1
2024-07-20 18:50:05.585: Received from server: value1
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
GET key2
2024-07-20 18:50:16.761: Received from server: value2
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
GET key3
2024-07-20 18:50:20.811: Received from server: value3
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
GET key4
2024-07-20 18:50:25.152: Received from server: value4
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
GET key5
2024-07-20 18:50:29.842: Received from server: value5
```

The screenshot shows a terminal window within a development environment. The title bar includes 'src' and 'Version control'. The terminal tab is active, showing a session with the following log output:

```
GET key5
2024-07-20 18:50:29.842: Received from server: value5
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
PUT key6 value6
2024-07-20 18:50:40.401: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
PUT key7 value7
2024-07-20 18:50:51.368: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
PUT key8 value8
2024-07-20 18:50:58.582: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
PUT key9 value9
2024-07-20 18:51:13.858: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
PUT key10 value10
2024-07-20 18:51:20.971: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
DELETE key 6
2024-07-20 18:51:26.843: Invalid DELETE command. Usage: DELETE key
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
DELETE key6
2024-07-20 18:51:38.030: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
DELETE key7
2024-07-20 18:51:43.420: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
DELETE key8
2024-07-20 18:51:47.403: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
DELETE key9
2024-07-20 18:51:51.960: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
DELETE key10
```

The terminal interface includes a 'Project' sidebar on the left with icons for file, folder, terminal, build, and execution summary. The top navigation bar has tabs for 'Terminal', 'Local (1)', 'Local (2)', 'Local (3)', 'Local (4)', 'Local (5)', 'Local (6)', and 'Local (7)'. The bottom navigation bar includes 'src > Execution Summary'.

The screenshot shows a terminal window with a dark theme. At the top, there are three circular icons (red, yellow, green) followed by the text "src" and "Version control". Below the title bar, there is a tab bar with several tabs: "Project", "Client.java", "KeyValueRPC.java", "Server1.java", and "Execution Summary". The "Execution Summary" tab is currently active, indicated by a blue underline.

The main area of the terminal displays the following interaction:

```
DELETE key10
...
2024-07-20 18:51:56.024: Received from server: SUCCESS
Enter a command: PUT key value, GET key, DELETE key, GETALL or 'QUIT' to quit:
GETALL
2024-07-20 18:52:00.737: Received from server: key1 value1
key2 value2
key5 value5
key3 value3
key4 value4
key1 value1
key2 value2
key5 value5
key3 value3
key4 value4
key1 value1
key2 value2
key5 value5
key3 value3
key4 value4
key1 value1
key2 value2
key5 value5
key3 value3
key4 value4
key1 value1
key2 value2
key5 value5
key3 value3
key4 value4
QUIT
Client shutting down...
mac@Emmas-Laptop src %
```

The terminal also features a sidebar on the left with various icons: a folder, a file, a search icon, a refresh icon, a double arrow icon, a minus sign icon, a question mark icon, and a gear icon.