

project1_executive_summary_weiqing_gao

Assignment Overview

From my perspective, this assignment has two main objectives. First, we have learned the theory of how to communicate between a server and a client, this assignment requires us to implement such communication process using programming, focusing on the use of communication protocols. This involves setting up a server and a client, assigning ports, binding sockets to interfaces, using buffer to hold the incoming message, processing client requests, and sending responses. This process helps us understand fundamental networking concepts and learn how to implement reliable data transmission in practical applications. Second, by implementing both UDP and TCP protocols, this assignment allows us to compare their differences in terms of implementation, data transmission mechanisms, error handling, and reliability. UDP, being a connectionless protocol, emphasizes low latency and efficient transmission, whereas TCP, as a connection-oriented protocol, ensures data reliability and integrity. Of course, it also involves some points like the timeout mechanism, which can be used to deal with the blocking method `receive()` of `DatagramSocket` used by UDP protocol. Through this assignment, we not only became familiar with fundamental network programming techniques but also gained a deeper understanding of the suitability of different protocols in various application scenarios.

Technical Impression

During this assignment, I gained a deeper understanding of the complexity of network programming, particularly in implementing client-server communication. Regardless of whether I used UDP or TCP, setting up the basic framework was complex but not overly difficult. The key, for me, was to have a clear understanding of the entire communication process; otherwise, it was easy to get lost in implementation details. For example, where should request handling be implemented? At the first place, I placed it as a method of the server. But finally I find that it is a protocol parsing operating, thus I moved it to the `Protocol` class. And once the server binds to a port and receives a request, how should it extract the received data? How should a `byte[]` be converted into a `Request` (a custom data structure), extract key-value information, and then re-encode it into a `byte[]` for efficient transmission? These questions involved protocol design, data encoding/decoding, and efficient data processing.

During the implementation, I spent a significant amount of time on details like error handling, logging, and timestamp formatting, to ensure that both the server and client logs contained clear, timestamped information that facilitated debugging. Additionally, while comparing UDP and TCP, I observed that TCP provides more reliable data transmission but requires more complex connection management and flow control, whereas UDP offers higher efficiency but lacks reliability. This experience highlighted the importance of choosing the appropriate protocol based on the application's needs.

If I try to implement a chat application, I will use TCP to ensure reliable delivery of messages, maintaining a persistent connection between users to prevent message loss, while I will use UDP for real-time notifications or status updates where speed is more critical than guaranteed delivery.

Screenshots

Screenshots - UDP Client

```
[2025-02-01 22:34:15.606] Enter command (PUT/GET/DELETE) or 'exit': PUT
[2025-02-01 22:34:27.376] Enter key: lexus
[2025-02-01 22:34:30.779] Enter value: gs350
[2025-02-01 22:34:39.560] INFO: Sent PUT request to 127.0.0.1:3000 for key: lexus
[2025-02-01 22:34:39.580] INFO: Response in 22 ms
[2025-02-01 22:34:39.581] Response: OK
[2025-02-01 22:34:39.581] Enter command (PUT/GET/DELETE) or 'exit': PUT
[2025-02-01 22:34:43.334] Enter key: lincoln
[2025-02-01 22:34:54.030] Enter value: continental
[2025-02-01 22:35:01.768] INFO: Sent PUT request to 127.0.0.1:3000 for key: lincoln
[2025-02-01 22:35:01.769] INFO: Response in 1 ms
[2025-02-01 22:35:01.769] Response: OK
[2025-02-01 22:35:01.770] Enter command (PUT/GET/DELETE) or 'exit': put
[2025-02-01 22:35:03.299] Enter key: genesis
[2025-02-01 22:35:05.743] Enter value: g80
[2025-02-01 22:35:07.934] INFO: Sent PUT request to 127.0.0.1:3000 for key: genesis
[2025-02-01 22:35:07.935] INFO: Response in 1 ms
[2025-02-01 22:35:07.936] Response: OK
[2025-02-01 22:35:07.936] Enter command (PUT/GET/DELETE) or 'exit': put
[2025-02-01 22:35:09.255] Enter key: cadillac
[2025-02-01 22:35:14.923] Enter value: ct6
[2025-02-01 22:35:17.265] INFO: Sent PUT request to 127.0.0.1:3000 for key: cadillac
[2025-02-01 22:35:17.267] INFO: Response in 2 ms
[2025-02-01 22:35:17.267] Response: OK
[2025-02-01 22:35:17.268] Enter command (PUT/GET/DELETE) or 'exit': Put
[2025-02-01 22:35:21.417] Enter key: volvo
[2025-02-01 22:35:26.503] Enter value: s90
[2025-02-01 22:35:31.110] INFO: Sent PUT request to 127.0.0.1:3000 for key: volvo
[2025-02-01 22:35:31.111] INFO: Response in 1 ms
[2025-02-01 22:35:31.111] Response: OK
[2025-02-01 22:35:31.111] Enter command (PUT/GET/DELETE) or 'exit': GET
[2025-02-01 22:35:35.443] Enter key: genesis
[2025-02-01 22:35:40.741] INFO: Sent GET request to 127.0.0.1:3000 for key: genesis
[2025-02-01 22:35:40.742] INFO: Response in 1 ms
[2025-02-01 22:35:40.742] Response: g80
[2025-02-01 22:35:40.743] Enter command (PUT/GET/DELETE) or 'exit': Get
[2025-02-01 22:35:50.611] Enter key: cadillac
[2025-02-01 22:35:57.515] INFO: Sent GET request to 127.0.0.1:3000 for key: cadillac
[2025-02-01 22:35:57.517] INFO: Response in 2 ms
[2025-02-01 22:35:57.517] Response: ct6
[2025-02-01 22:35:57.517] Enter command (PUT/GET/DELETE) or 'exit': get
[2025-02-01 22:35:58.964] Enter key: lincoln
```

```
[2025-02-01 22:36:02.578] INFO: Sent GET request to 127.0.0.1:3000 for key: lincoln
[2025-02-01 22:36:02.579] INFO: Response in 1 ms
[2025-02-01 22:36:02.579] Response: continental
[2025-02-01 22:36:02.579] Enter command (PUT/GET/DELETE) or 'exit': get
[2025-02-01 22:36:03.929] Enter key: lexus
[2025-02-01 22:36:08.458] INFO: Sent GET request to 127.0.0.1:3000 for key: lexus
[2025-02-01 22:36:08.460] INFO: Response in 2 ms
[2025-02-01 22:36:08.461] Response: gs350
```

```
[2025-02-01 22:36:08.458] INFO: Sent GET request to 127.0.0.1:3000 for key: lexus
[2025-02-01 22:36:08.460] INFO: Response in 2 ms
[2025-02-01 22:36:08.461] Response: gs350
[2025-02-01 22:36:08.461] Enter command (PUT/GET/DELETE) or 'exit': GET
[2025-02-01 22:36:12.883] Enter key: volvo
[2025-02-01 22:36:23.025] INFO: Sent GET request to 127.0.0.1:3000 for key: volvo
[2025-02-01 22:36:23.028] INFO: Response in 3 ms
[2025-02-01 22:36:23.028] Response: s90
[2025-02-01 22:36:23.028] Enter command (PUT/GET/DELETE) or 'exit': put
[2025-02-01 22:36:34.140] Enter key: lexus
[2025-02-01 22:36:36.722] Enter value: ls460
[2025-02-01 22:36:39.629] INFO: Sent PUT request to 127.0.0.1:3000 for key: lexus
[2025-02-01 22:36:39.630] INFO: Response in 1 ms
[2025-02-01 22:36:39.630] Response: The key lexus has been already existed
[2025-02-01 22:36:39.630] Enter command (PUT/GET/DELETE) or 'exit': get
[2025-02-01 22:36:45.525] Enter key: Mazda
[2025-02-01 22:36:55.964] INFO: Sent GET request to 127.0.0.1:3000 for key: Mazda
[2025-02-01 22:36:55.969] INFO: Response in 5 ms
[2025-02-01 22:36:55.970] Response: NOT_FOUND
[2025-02-01 22:36:55.970] Enter command (PUT/GET/DELETE) or 'exit': DELETE
[2025-02-01 22:37:04.905] Enter key: lexus
[2025-02-01 22:37:08.099] INFO: Sent DELETE request to 127.0.0.1:3000 for key: lexus
[2025-02-01 22:37:08.102] INFO: Response in 3 ms
[2025-02-01 22:37:08.102] Response: OK
[2025-02-01 22:37:08.102] Enter command (PUT/GET/DELETE) or 'exit': delete
[2025-02-01 22:37:11.985] Enter key: genesis
[2025-02-01 22:37:18.299] INFO: Sent DELETE request to 127.0.0.1:3000 for key: genesis
[2025-02-01 22:37:18.300] INFO: Response in 1 ms
[2025-02-01 22:37:18.300] Response: OK
[2025-02-01 22:37:18.301] Enter command (PUT/GET/DELETE) or 'exit': delete
[2025-02-01 22:37:20.939] Enter key: volvo
[2025-02-01 22:37:26.190] INFO: Sent DELETE request to 127.0.0.1:3000 for key: volvo
[2025-02-01 22:37:26.193] INFO: Response in 3 ms
[2025-02-01 22:37:26.193] Response: OK
[2025-02-01 22:37:26.193] Enter command (PUT/GET/DELETE) or 'exit': delete
[2025-02-01 22:37:28.111] Enter key: cadillac
[2025-02-01 22:37:32.551] INFO: Sent DELETE request to 127.0.0.1:3000 for key: cadillac
[2025-02-01 22:37:32.552] INFO: Response in 2 ms
[2025-02-01 22:37:32.552] Response: OK
[2025-02-01 22:37:32.553] Enter command (PUT/GET/DELETE) or 'exit': delete
[2025-02-01 22:37:34.199] Enter key: lincoln
[2025-02-01 22:37:36.074] INFO: Sent DELETE request to 127.0.0.1:3000 for key: lincoln
[2025-02-01 22:37:36.075] INFO: Response in 1 ms
[2025-02-01 22:37:36.075] Response: OK
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```
[2025-02-01 22:37:36.075] Enter command (PUT/GET/DELETE) or 'exit': delete
[2025-02-01 22:37:41.355] Enter key: lincoln
[2025-02-01 22:37:44.459] INFO: Sent DELETE request to 127.0.0.1:3000 for key: lincoln
[2025-02-01 22:37:44.462] INFO: Response in 3 ms
[2025-02-01 22:37:44.462] Response: The key lincoln is not found
[2025-02-01 22:37:44.462] Enter command (PUT/GET/DELETE) or 'exit': exit
[2025-02-01 22:37:52.455] Exiting client...
weiqinggao@Weiqings-MBP src %
```

Screenshots - UDP Server

```
weiqinggao@Weiqings-MBP src % java -cp out server.KeyValueStoreUDPServer 3000
[2025-02-01 22:34:09.152] INFO: UDP Key-Value Store Server started on port 3000
[2025-02-01 22:34:39.560] INFO: Received request of length 19 from 127.0.0.1:52589
[2025-02-01 22:34:39.562] INFO: PUT: lexus = gs350
[2025-02-01 22:34:39.563] INFO: Response sent to 127.0.0.1:52589
[2025-02-01 22:35:01.768] INFO: Received request of length 27 from 127.0.0.1:60729
[2025-02-01 22:35:01.769] INFO: PUT: lincoln = continental
[2025-02-01 22:35:01.769] INFO: Response sent to 127.0.0.1:60729
[2025-02-01 22:35:07.934] INFO: Received request of length 19 from 127.0.0.1:56752
[2025-02-01 22:35:07.935] INFO: PUT: genesis = g80
[2025-02-01 22:35:07.935] INFO: Response sent to 127.0.0.1:56752
[2025-02-01 22:35:17.266] INFO: Received request of length 20 from 127.0.0.1:54231
[2025-02-01 22:35:17.267] INFO: PUT: cadillac = ct6
[2025-02-01 22:35:17.267] INFO: Response sent to 127.0.0.1:54231
[2025-02-01 22:35:31.110] INFO: Received request of length 17 from 127.0.0.1:51513
[2025-02-01 22:35:31.110] INFO: PUT: volvo = s90
[2025-02-01 22:35:31.111] INFO: Response sent to 127.0.0.1:51513
[2025-02-01 22:35:40.741] INFO: Received request of length 16 from 127.0.0.1:58408
[2025-02-01 22:35:40.742] INFO: GET: genesis -> g80
[2025-02-01 22:35:40.742] INFO: Response sent to 127.0.0.1:58408
[2025-02-01 22:35:57.515] INFO: Received request of length 17 from 127.0.0.1:62957
[2025-02-01 22:35:57.516] INFO: GET: cadillac -> ct6
[2025-02-01 22:35:57.517] INFO: Response sent to 127.0.0.1:62957
[2025-02-01 22:36:02.578] INFO: Received request of length 16 from 127.0.0.1:54653
[2025-02-01 22:36:02.579] INFO: GET: lincoln -> continental
[2025-02-01 22:36:02.579] INFO: Response sent to 127.0.0.1:54653
[2025-02-01 22:36:08.459] INFO: Received request of length 14 from 127.0.0.1:50786
[2025-02-01 22:36:08.460] INFO: GET: lexus -> gs350
[2025-02-01 22:36:08.460] INFO: Response sent to 127.0.0.1:50786
[2025-02-01 22:36:23.026] INFO: Received request of length 14 from 127.0.0.1:59074
[2025-02-01 22:36:23.027] INFO: GET: volvo -> s90
[2025-02-01 22:36:23.027] INFO: Response sent to 127.0.0.1:59074
[2025-02-01 22:36:39.629] INFO: Received request of length 19 from 127.0.0.1:49758
[2025-02-01 22:36:39.630] INFO: PUT failed: The key lexus has been already existed
[2025-02-01 22:36:39.630] INFO: Response sent to 127.0.0.1:49758
[2025-02-01 22:36:55.964] INFO: Received request of length 14 from 127.0.0.1:61217
[2025-02-01 22:36:55.966] INFO: GET: Mazda -> NOT_FOUND
[2025-02-01 22:36:55.968] INFO: Response sent to 127.0.0.1:61217
[2025-02-01 22:37:08.100] INFO: Received request of length 14 from 127.0.0.1:50920
[2025-02-01 22:37:08.101] INFO: DELETE: lexus
[2025-02-01 22:37:08.101] INFO: Response sent to 127.0.0.1:50920
[2025-02-01 22:37:18.299] INFO: Received request of length 16 from 127.0.0.1:61087
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[2025-02-01 22:37:18.277] INFO: Received request of length 18 from 127.0.0.1:61087
[2025-02-01 22:37:18.300] INFO: DELETE: genesis
[2025-02-01 22:37:18.300] INFO: Response sent to 127.0.0.1:61087
[2025-02-01 22:37:26.192] INFO: Received request of length 14 from 127.0.0.1:58149
[2025-02-01 22:37:26.192] INFO: DELETE: volvo
[2025-02-01 22:37:26.193] INFO: Response sent to 127.0.0.1:58149
[2025-02-01 22:37:32.551] INFO: Received request of length 17 from 127.0.0.1:57210
[2025-02-01 22:37:32.551] INFO: DELETE: cadillac
[2025-02-01 22:37:32.552] INFO: Response sent to 127.0.0.1:57210
[2025-02-01 22:37:36.074] INFO: Received request of length 16 from 127.0.0.1:63517
[2025-02-01 22:37:36.074] INFO: DELETE: lincoln
```

```
[2025-02-01 22:37:36.074] INFO: DELETE: lincoln
[2025-02-01 22:37:36.074] INFO: Response sent to 127.0.0.1:63517
[2025-02-01 22:37:44.460] INFO: Received request of length 16 from 127.0.0.1:64361
[2025-02-01 22:37:44.461] INFO: DELETE failed: The key lincoln is not found
[2025-02-01 22:37:44.462] INFO: Response sent to 127.0.0.1:64361
```

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weiqinggao@Weiqings-MBP src %

weiqinggao@Weiqings-MBP src %

Screenshots - TCP Client


```
java -cp out client.KeyValueStoreTCPClient 127.0.0.1 4000
```

```
[2025-02-01 23:03:19.497] Enter command (PUT/GET/DELETE) or 'exit': EWLFGJ
[2025-02-01 23:03:23.321] Invalid command. Use PUT, GET, or DELETE.
[2025-02-01 23:03:23.322] Enter command (PUT/GET/DELETE) or 'exit': PUT
[2025-02-01 23:03:27.819] Enter key: Lexus
[2025-02-01 23:04:13.332] Enter value: LS460
[2025-02-01 23:04:19.858] INFO: Sent PUT request to 127.0.0.1:4000 for key: Lexus
[2025-02-01 23:04:19.878] INFO: Received response in 35 ms: OK
[2025-02-01 23:04:19.881] Response: OK
[2025-02-01 23:04:19.881] Enter command (PUT/GET/DELETE) or 'exit': PUT
[2025-02-01 23:04:23.188] Enter key: Genesis
[2025-02-01 23:04:37.408] Enter value: G90 Ultimate
[2025-02-01 23:04:43.574] INFO: Sent PUT request to 127.0.0.1:4000 for key: Genesis
[2025-02-01 23:04:43.576] INFO: Received response in 3 ms: OK
[2025-02-01 23:04:43.577] Response: OK
[2025-02-01 23:04:43.577] Enter command (PUT/GET/DELETE) or 'exit': PUT
[2025-02-01 23:04:51.328] Enter key: Lincoln
[2025-02-01 23:04:56.577] Enter value: Continental Reserve II
[2025-02-01 23:05:15.132] INFO: Sent PUT request to 127.0.0.1:4000 for key: Lincoln
[2025-02-01 23:05:15.133] INFO: Received response in 2 ms: OK
[2025-02-01 23:05:15.134] Response: OK
[2025-02-01 23:05:15.134] Enter command (PUT/GET/DELETE) or 'exit': PUT
[2025-02-01 23:05:18.625] Enter key: Cadillac
[2025-02-01 23:05:29.844] Enter value: ATS-V
[2025-02-01 23:05:37.241] INFO: Sent PUT request to 127.0.0.1:4000 for key: Cadillac
[2025-02-01 23:05:37.242] INFO: Received response in 2 ms: OK
[2025-02-01 23:05:37.243] Response: OK
[2025-02-01 23:05:37.243] Enter command (PUT/GET/DELETE) or 'exit': Put
[2025-02-01 23:05:48.746] Enter key: Mazda
[2025-02-01 23:05:50.560] Enter value: MX-5
[2025-02-01 23:05:54.480] INFO: Sent PUT request to 127.0.0.1:4000 for key: Mazda
[2025-02-01 23:05:54.482] INFO: Received response in 3 ms: OK
[2025-02-01 23:05:54.482] Response: OK
[2025-02-01 23:05:54.482] Enter command (PUT/GET/DELETE) or 'exit': Put
[2025-02-01 23:05:57.913] Enter key: Mazda
[2025-02-01 23:05:59.935] Enter value: Miata
[2025-02-01 23:06:03.780] INFO: Sent PUT request to 127.0.0.1:4000 for key: Mazda
[2025-02-01 23:06:03.782] INFO: Received response in 3 ms: The key Mazda has been already exist
ed
[2025-02-01 23:06:03.783] Response: The key Mazda has been already existed
[2025-02-01 23:06:03.783] Enter command (PUT/GET/DELETE) or 'exit': GET
[2025-02-01 23:06:07.722] Enter key: Mazda
[2025-02-01 23:06:10.034] INFO: Sent GET request to 127.0.0.1:4000 for key: Mazda
[2025-02-01 23:06:10.035] INFO: Received response in 2 ms: MX-5
[2025-02-01 23:06:10.036] Response: MX-5
[2025-02-01 23:06:10.036] Enter command (PUT/GET/DELETE) or 'exit': GET
[2025-02-01 23:06:13.122] Enter key: Cadillac
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[2025-02-01 23:06:16.122] Enter key: Cadillac  
[2025-02-01 23:06:17.306] INFO: Sent GET request to 127.0.0.1:4000 for key: Cadillac  
[2025-02-01 23:06:17.308] INFO: Received response in 3 ms: ATS-V  
[2025-02-01 23:06:17.308] Response: ATS-V  
[2025-02-01 23:06:17.308] Enter command (PUT/GET/DELETE) or 'exit': GET  
[2025-02-01 23:06:18.777] Enter key: Lincoln  
[2025-02-01 23:06:21.913] INFO: Sent GET request to 127.0.0.1:4000 for key: Lincoln  
[2025-02-01 23:06:21.916] INFO: Received response in 3 ms: Continental Reserve II  
[2025-02-01 23:06:21.916] Response: Continental Reserve II
```

```
[2025-02-01 23:06:21.916] INFO: Received response in 3 ms: Continental Reserve II
[2025-02-01 23:06:21.916] Response: Continental Reserve II
[2025-02-01 23:06:21.916] Enter command (PUT/GET/DELETE) or 'exit': GET
[2025-02-01 23:06:24.640] Enter key: Genesis
[2025-02-01 23:06:28.050] INFO: Sent GET request to 127.0.0.1:4000 for key: Genesis
[2025-02-01 23:06:28.052] INFO: Received response in 5 ms: G90 Ultimate
[2025-02-01 23:06:28.053] Response: G90 Ultimate
[2025-02-01 23:06:28.053] Enter command (PUT/GET/DELETE) or 'exit': GET
[2025-02-01 23:06:30.009] Enter key: Lexus
[2025-02-01 23:06:32.394] INFO: Sent GET request to 127.0.0.1:4000 for key: Lexus
[2025-02-01 23:06:32.395] INFO: Received response in 1 ms: LS460
[2025-02-01 23:06:32.396] Response: LS460
[2025-02-01 23:06:32.396] Enter command (PUT/GET/DELETE) or 'exit': GET
[2025-02-01 23:06:34.149] Enter key: Volvo
[2025-02-01 23:06:43.948] INFO: Sent GET request to 127.0.0.1:4000 for key: Volvo
[2025-02-01 23:06:43.949] INFO: Received response in 2 ms: NOT_FOUND
[2025-02-01 23:06:43.949] Response: NOT_FOUND
[2025-02-01 23:06:43.950] Enter command (PUT/GET/DELETE) or 'exit': DELETE
[2025-02-01 23:06:49.826] Enter key: Volvo
[2025-02-01 23:06:56.740] INFO: Sent DELETE request to 127.0.0.1:4000 for key: Volvo
[2025-02-01 23:06:56.742] INFO: Received response in 2 ms: The key Volvo is not found
[2025-02-01 23:06:56.743] Response: The key Volvo is not found
[2025-02-01 23:06:56.743] Enter command (PUT/GET/DELETE) or 'exit': Delete
[2025-02-01 23:07:00.686] Enter key: Lexus
[2025-02-01 23:07:03.359] INFO: Sent DELETE request to 127.0.0.1:4000 for key: Lexus
[2025-02-01 23:07:03.361] INFO: Received response in 2 ms: OK
[2025-02-01 23:07:03.361] Response: OK
[2025-02-01 23:07:03.361] Enter command (PUT/GET/DELETE) or 'exit': delete
[2025-02-01 23:07:05.952] Enter key: Genesis
[2025-02-01 23:07:07.799] INFO: Sent DELETE request to 127.0.0.1:4000 for key: Genesis
[2025-02-01 23:07:07.800] INFO: Received response in 4 ms: OK
[2025-02-01 23:07:07.801] Response: OK
[2025-02-01 23:07:07.801] Enter command (PUT/GET/DELETE) or 'exit': delete
[2025-02-01 23:07:10.001] Enter key: Cadillac
[2025-02-01 23:07:14.352] INFO: Sent DELETE request to 127.0.0.1:4000 for key: Cadillac
[2025-02-01 23:07:14.353] INFO: Received response in 3 ms: OK
[2025-02-01 23:07:14.354] Response: OK
[2025-02-01 23:07:14.354] Enter command (PUT/GET/DELETE) or 'exit': Delete
[2025-02-01 23:07:16.503] Enter key: Lincoln
[2025-02-01 23:07:20.155] INFO: Sent DELETE request to 127.0.0.1:4000 for key: Lincoln
[2025-02-01 23:07:20.156] INFO: Received response in 1 ms: OK
[2025-02-01 23:07:20.156] Response: OK
[2025-02-01 23:07:20.157] Enter command (PUT/GET/DELETE) or 'exit': Delete
[2025-02-01 23:07:23.201] Enter key: Mazda
[2025-02-01 23:07:24.401] INFO: Sent DELETE request to 127.0.0.1:4000 for key: Mazda
```

```
[2025-02-01 23:07:24.402] INFO: Sent DELETE request to 127.0.0.1:4000 for key: h2zad  
[2025-02-01 23:07:24.402] INFO: Received response in 1 ms: OK  
[2025-02-01 23:07:24.403] Response: OK  
[2025-02-01 23:07:24.403] Enter command (PUT/GET/DELETE) or 'exit': exit  
[2025-02-01 23:07:34.422] Exiting client...  
weiqinggao@Weiqings-MBP src %
```

Screenshots - TCP Server

```
weiqinggao@Weiqings-MBP src % javac -d out server/KeyValueStoreTCPServer.java
```

```
weiqinggao@Weiqings-MBP src % java -cp out server.KeyValueStoreTCPServer 4000
```

```
[2025-02-01 23:02:47.997] INFO: TCP Server started on port 4000
[2025-02-01 23:04:19.858] INFO: Accepted connection from /127.0.0.1:55488
[2025-02-01 23:04:19.860] INFO: Received PUT request from /127.0.0.1:55488 for key: Lexus
[2025-02-01 23:04:19.860] INFO: PUT: Lexus = LS460
[2025-02-01 23:04:19.860] INFO: Response sent in 0 ms to /127.0.0.1:55488
[2025-02-01 23:04:43.574] INFO: Accepted connection from /127.0.0.1:55494
[2025-02-01 23:04:43.575] INFO: Received PUT request from /127.0.0.1:55494 for key: Genesis
[2025-02-01 23:04:43.575] INFO: PUT: Genesis = G90 Ultimate
[2025-02-01 23:04:43.576] INFO: Response sent in 1 ms to /127.0.0.1:55494
[2025-02-01 23:05:15.132] INFO: Accepted connection from /127.0.0.1:55495
[2025-02-01 23:05:15.133] INFO: Received PUT request from /127.0.0.1:55495 for key: Lincoln
[2025-02-01 23:05:15.133] INFO: PUT: Lincoln = Continental Reserve II
[2025-02-01 23:05:15.133] INFO: Response sent in 0 ms to /127.0.0.1:55495
[2025-02-01 23:05:37.241] INFO: Accepted connection from /127.0.0.1:55504
[2025-02-01 23:05:37.241] INFO: Received PUT request from /127.0.0.1:55504 for key: Cadillac
[2025-02-01 23:05:37.241] INFO: PUT: Cadillac = ATS-V
[2025-02-01 23:05:37.242] INFO: Response sent in 1 ms to /127.0.0.1:55504
[2025-02-01 23:05:54.480] INFO: Accepted connection from /127.0.0.1:55507
[2025-02-01 23:05:54.480] INFO: Received PUT request from /127.0.0.1:55507 for key: Mazda
[2025-02-01 23:05:54.481] INFO: PUT: Mazda = MX-5
[2025-02-01 23:05:54.482] INFO: Response sent in 1 ms to /127.0.0.1:55507
[2025-02-01 23:06:03.780] INFO: Accepted connection from /127.0.0.1:55508
[2025-02-01 23:06:03.781] INFO: Received PUT request from /127.0.0.1:55508 for key: Mazda
[2025-02-01 23:06:03.781] INFO: PUT failed: The key Mazda has been already existed
[2025-02-01 23:06:03.782] INFO: Response sent in 1 ms to /127.0.0.1:55508
[2025-02-01 23:06:10.034] INFO: Accepted connection from /127.0.0.1:55511
[2025-02-01 23:06:10.035] INFO: Received GET request from /127.0.0.1:55511 for key: Mazda
[2025-02-01 23:06:10.035] INFO: GET: Mazda -> MX-5
[2025-02-01 23:06:10.035] INFO: Response sent in 0 ms to /127.0.0.1:55511
[2025-02-01 23:06:17.306] INFO: Accepted connection from /127.0.0.1:55512
[2025-02-01 23:06:17.307] INFO: Received GET request from /127.0.0.1:55512 for key: Cadillac
[2025-02-01 23:06:17.307] INFO: GET: Cadillac -> ATS-V
[2025-02-01 23:06:17.308] INFO: Response sent in 1 ms to /127.0.0.1:55512
[2025-02-01 23:06:21.913] INFO: Accepted connection from /127.0.0.1:55513
[2025-02-01 23:06:21.914] INFO: Received GET request from /127.0.0.1:55513 for key: Lincoln
[2025-02-01 23:06:21.914] INFO: GET: Lincoln -> Continental Reserve II
[2025-02-01 23:06:21.915] INFO: Response sent in 1 ms to /127.0.0.1:55513
[2025-02-01 23:06:28.050] INFO: Accepted connection from /127.0.0.1:55514
[2025-02-01 23:06:28.051] INFO: Received GET request from /127.0.0.1:55514 for key: Genesis
[2025-02-01 23:06:28.051] INFO: GET: Genesis -> G90 Ultimate
[2025-02-01 23:06:28.051] INFO: Response sent in 0 ms to /127.0.0.1:55514
[2025-02-01 23:06:32.394] INFO: Accepted connection from /127.0.0.1:55515
[2025-02-01 23:06:32.395] INFO: Received GET request from /127.0.0.1:55515 for key: Lexus
[2025-02-01 23:06:32.395] INFO: GET: Lexus -> LS460
```

```
[2025-02-01 23:06:32.395] INFO: GET: Lexus -> LS460
[2025-02-01 23:06:32.395] INFO: Response sent in 0 ms to /127.0.0.1:55515
[2025-02-01 23:06:43.948] INFO: Accepted connection from /127.0.0.1:55521
[2025-02-01 23:06:43.948] INFO: Received GET request from /127.0.0.1:55521 for key: Volvo
[2025-02-01 23:06:43.949] INFO: GET: Volvo -> NOT_FOUND
[2025-02-01 23:06:43.949] INFO: Response sent in 1 ms to /127.0.0.1:55521
[2025-02-01 23:06:56.741] INFO: Accepted connection from /127.0.0.1:55522
[2025-02-01 23:06:56.742] INFO: Received DELETE request from /127.0.0.1:55522 for key: Volvo
[2025-02-01 23:06:56.742] INFO: DELETE failed: The key Volvo is not found
[2025-02-01 23:06:56.742] INFO: Response sent in 0 ms to /127.0.0.1:55522
[2025-02-01 23:07:03.359] INFO: Accepted connection from /127.0.0.1:55524
```

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[2025-02-01 23:06:56.742] INFO: Response sent in 0 ms to /127.0.0.1:55522
[2025-02-01 23:07:03.359] INFO: Accepted connection from /127.0.0.1:55524
[2025-02-01 23:07:03.360] INFO: Received DELETE request from /127.0.0.1:55524 for key: Lexus
[2025-02-01 23:07:03.360] INFO: DELETE: Lexus
[2025-02-01 23:07:03.360] INFO: Response sent in 0 ms to /127.0.0.1:55524
[2025-02-01 23:07:07.799] INFO: Accepted connection from /127.0.0.1:55525
[2025-02-01 23:07:07.800] INFO: Received DELETE request from /127.0.0.1:55525 for key: Genesis
[2025-02-01 23:07:07.800] INFO: DELETE: Genesis
[2025-02-01 23:07:07.800] INFO: Response sent in 0 ms to /127.0.0.1:55525
[2025-02-01 23:07:14.352] INFO: Accepted connection from /127.0.0.1:55526
[2025-02-01 23:07:14.353] INFO: Received DELETE request from /127.0.0.1:55526 for key: Cadillac
[2025-02-01 23:07:14.353] INFO: DELETE: Cadillac
[2025-02-01 23:07:14.353] INFO: Response sent in 0 ms to /127.0.0.1:55526
[2025-02-01 23:07:20.155] INFO: Accepted connection from /127.0.0.1:55528
[2025-02-01 23:07:20.156] INFO: Received DELETE request from /127.0.0.1:55528 for key: Lincoln
[2025-02-01 23:07:20.156] INFO: DELETE: Lincoln
[2025-02-01 23:07:20.156] INFO: Response sent in 0 ms to /127.0.0.1:55528
[2025-02-01 23:07:24.401] INFO: Accepted connection from /127.0.0.1:55529
[2025-02-01 23:07:24.402] INFO: Received DELETE request from /127.0.0.1:55529 for key: Mazda
[2025-02-01 23:07:24.402] INFO: DELETE: Mazda
[2025-02-01 23:07:24.402] INFO: Response sent in 0 ms to /127.0.0.1:55529
```

^C%

weiqinggao@Weiqings-MBP src %

weiqinggao@Weiqings-MBP src %