

(a)

N/A

(b)

TCP server and client

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(hw4-py3.12) duong hw4 → (master) 22:05 python TCP-server.py 6000
TCP server listening on port 6000
Connected by ('127.0.0.1', 52583)
Connected by ('127.0.0.1', 52584)
Connected by ('127.0.0.1', 52585)
Connected by ('127.0.0.1', 52586)
[]

(hw4-py3.12) duong hw4 → (master) 22:05 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:05:52.962+00:00Z
Local time: 2024-10-04T03:05:52.963+00:00Z
Time difference (ms): 1.072

(hw4-py3.12) duong hw4 → (master) 22:05 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:05:53.506+00:00Z
Local time: 2024-10-04T03:05:53.506+00:00Z
Time difference (ms): 0.475

(hw4-py3.12) duong hw4 → (master) 22:05 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:05:53.964+00:00Z
Local time: 2024-10-04T03:05:53.964+00:00Z
Time difference (ms): 0.373

(hw4-py3.12) duong hw4 → (master) 22:05 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:05:54.820+00:00Z
Local time: 2024-10-04T03:05:54.820+00:00Z
Time difference (ms): 0.636

```

UDP server and client

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(hw4-py3.12) duong hw4 → (master) 22:07 python UDP-server.py 6000
UDP server listening on port 6000
Received request from ('127.0.0.1', 60698)
Received request from ('127.0.0.1', 60699)
Received request from ('127.0.0.1', 60700)
Received request from ('127.0.0.1', 60701)
[]

(hw4-py3.12) duong hw4 → (master) 22:07 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:07:08.201+00:00Z
Local time: 2024-10-04T03:07:08.201+00:00Z
Time difference (ms): 0.195

(hw4-py3.12) duong hw4 → (master) 22:07 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:07:08.977+00:00Z
Local time: 2024-10-04T03:07:08.977+00:00Z
Time difference (ms): 0.721

(hw4-py3.12) duong hw4 → (master) 22:07 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:07:09.906+00:00Z
Local time: 2024-10-04T03:07:09.906+00:00Z
Time difference (ms): 0.41800000000000004

(hw4-py3.12) duong hw4 → (master) 22:07 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:07:10.757+00:00Z
Local time: 2024-10-04T03:07:10.757+00:00Z
Time difference (ms): 0.656

```

(c)

UDP is typically faster on average than TCP. This agrees with the knowledge that UDP is a simpler protocol with smaller header and less handshakes than TCP.

(d)

TCP server and client (modified w/ RTT)

```
(hw4-py3.12) duong hw4 → (master) ♡ 22:24 python TCP-server.py 6000
TCP server listening on port 6000
Connected by ('127.0.0.1', 52814)
Connected by ('127.0.0.1', 52815)
Connected by ('127.0.0.1', 52816)
Connected by ('127.0.0.1', 52817)
█

(hw4-py3.12) duong hw4 → (master) ♡ 22:25 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:25:01.643+00:00Z
Local time: 2024-10-04T03:25:01.643+00:00Z
Time difference (ms): 0.258
RTT (ms): 0.0

(hw4-py3.12) duong hw4 → (master) ♡ 22:25 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:25:02.488+00:00Z
Local time: 2024-10-04T03:25:02.488+00:00Z
Time difference (ms): 0.801
RTT (ms): 0.0

(hw4-py3.12) duong hw4 → (master) ♡ 22:25 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:25:03.329+00:00Z
Local time: 2024-10-04T03:25:03.329+00:00Z
Time difference (ms): 0.786
RTT (ms): 0.5166530609130859

(hw4-py3.12) duong hw4 → (master) ♡ 22:25 python TCP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:25:04.335+00:00Z
Local time: 2024-10-04T03:25:04.335+00:00Z
Time difference (ms): 0.844
RTT (ms): 0.5049705505371094
```

## UDP server and client (modified w/ RTT)

```

(hw4-py3.12) duong hw4 → (master) 22:26 python UDP-server.py 6000
UDP server listening on port 6000
Received request from ('127.0.0.1', 50324)
Received request from ('127.0.0.1', 50325)
Received request from ('127.0.0.1', 50326)
Received request from ('127.0.0.1', 50327)
[]

(hw4-py3.12) duong hw4 → (master) 22:26 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:26:06.728+00:00Z
Local time: 2024-10-04T03:26:06.728+00:00Z
Time difference (ms): 0.697
RTT (ms): 0.0

(hw4-py3.12) duong hw4 → (master) 22:26 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:26:07.561+00:00Z
Local time: 2024-10-04T03:26:07.561+00:00Z
Time difference (ms): 0.795
RTT (ms): 0.4878044128417969

(hw4-py3.12) duong hw4 → (master) 22:26 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:26:08.438+00:00Z
Local time: 2024-10-04T03:26:08.438+00:00Z
Time difference (ms): 0.479
RTT (ms): 0.0

(hw4-py3.12) duong hw4 → (master) 22:26 python UDP-client.py 127.0.0.1 6000
Server timestamp: 2024-10-04T03:26:09.117+00:00Z
Local time: 2024-10-04T03:26:09.117+00:00Z
Time difference (ms): 0.53
RTT (ms): 0.4932880401611328

```

Due to running the client and server on the same machine the RTT is very small. Without also modifying the server it is hard to determine the client-to-server and server-to-client delay respectively, since we can only know the overall RTT time.

But in general we should not expect these delays to be the same, since depending on how long it takes the server to respond, the original path could have gotten more or less congested. IE. packets may have taken different paths to get to the server than the path used to send back, either increasing or decreasing the server-to-client delay slightly.

We shouldn't expect the variance to extraordinarily large, unless there is something causing huge network assymetry (ie. more packets sent by server than client or vice/versa, or unequal network up/down speeds).

## (e)

When I run the udp/tcp servers on physically distant machines there is generally a small observable increase in delay. I notice a relative greater delay when using the machines during congested times of day (ie. during business hours or noon), has a greater impact on delay than when running at say midnight (relative is only 2-5 ms more than physical distance delay).

The obvious explanation for physically distant machines is obviously that there may be a longer network path the packets have to take (but it's not necessarily true that physically distant servers correlate directly with longer network path, maybe some physically distant networks have high-speed connections between them).

The explanation for packets taking longer during more or less congested times of day is due to network availability/ network sharing. As many users access the same network, the most optimal path may already be

utilized by another user, so a less than ideal path may have to be utilized to send packets. That or the packets simply have to wait in the network.