Assignment Two: Analysis

## UDP Datagram Contents

All packets contain a few pieces of data. As a UDP datagram it contains the typical header containing a source port, a destination port, a length and a check sum. They also contain the IP address of where they started and where they are going. The first piece of a payload from the client is a sequence number, **1 byte in length**. Then, a reserved byte is placed at offset 1 for extensibility. At **offset 2**, the length of the file stream data is written. Finally, **offset 3** and beyond will contain at most 124 sequential bytes of file data. A termination datagram, or end of transmission datagram, is simply a datagram with a sequence number of negative one and is used to shut down the server. The server will shut down when receiving a sequence with -1 after sending an ACK to the client with a sequence of -1 as well. On the server side acknowledgement datagrams only contain the sequence number of what the datagram is acknowledging in their payloads.

## Timing Analysis

**Accelerator** is a 300KB file and **homura** is a 1,500KB (1.5MB) file so they are both considered large files. On these two files, *Stop and Wait* (window size = 1) was consistently slower than *“Go Back N”*. On the accelerator image with and no loss, *Stop and Wait* was 10 times slower than *“Go Back N”* with a window size of 10. With no packet loss on the large files doubling the window size approximately halves the time taken, similarly multiplying the window by 4 divides time taken by approximately 4 and the pattern continues at size 10.

Increasing packet loss greatly increases the time required to send a large file but also diminishes the amount of time saved by increasing the window size. When not losing any packets, a window size of 80 sends the 300KB image in **2.2 seconds** and a window size of 40 sends it in **3.8 seconds**. Losing one in 5 packets causes the image to take 68-71 seconds to transmit for all three of the *“Go Back N*’s” with a timeout of 100ms. With *“Go Back N”* if we lose a packet every window increasing the window size has exponentially diminishing returns.

When different timeout values are used with different window sizes and a loss rate of zero for either file it has almost no effect on transmission time. Tripling the timeout value increases the time by about 0.03 times. With a loss rate of 1/5, based on the **accelerator** image, and stop and wait protocol, tripling the timeout multiplies transmission time by about 1.6 and multiplying timeout by 5 multiplies it by about 2.2. With a window size of 10, all else equal, tripling timeout increases transmission time by 2.8 times and multiplying timeout by 5 multiplies transmission time by 4.8 times. For a window size of 80 the multipliers are slightly larger. **Homura** has larger multipliers then **accelerator** which implies increasing the file size increases the multipliers.

For small files such as test border stop and wait is slower than any of the *“Go Back N”*’s with the same variables. The window size of “**test border**” has very little effect since it is a small file. With “**test short**” multiplying the window size by 10 divides time taken by about 5.5. This implies that with very short files increasing the window size has less of an effect than with large files. Loss rates have less of an effect with a timeout of 100. The time taken increases from 0.17s to 0.27s when 1 in 100 are lost 0.47s for a window size of 80 and a loss of 1/5.

In general long timeouts mixed with high loss rates greatly slows down the transfer regardless of file size. Timeouts are relatively unimportant when loss rates are low. With low loss rates window size greatly improves performance but does very little with high loss rates. A single packet in error can cause “*Go Back N*” to transmit many packets unnecessarily, the earlier in a window it occurs the more packets are wasted and while this has little to no effect on our system produces a significant amount of unnecessary congestion on the network. To keep congestion low, balancing the timeout and window size is important.

Data Tables

All tests were conducted against a **DigitalOcean** server located in New York City. Ping statistics are given below:

Ping statistics for 104.236.62.77:

Packets: Sent = 100, Received = 100, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 49ms, Maximum = 148ms, Average = 62ms

# File Size Mapping Table

|  |  |
| --- | --- |
| File Name | File Size (Bytes) |
| Homura.png | 1,481,396 |
| Accelerator.jpg | 312,835 |
| Test\_short.txt | 767 |
| Test\_medium | 76,024 |
| Test\_long.txt | 129,180 |
| Test\_border.txt | 6 |

# Test Run Timings

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| File Name | Reliability Number | Window Size | Timeout Value (in millseconds) | Time (in seconds) |
| accelerator.jpg | 0 | 1 | 100 | 131.3442 |
| accelerator.jpg | 5 | 1 | 100 | 198.0722 |
| accelerator.jpg | 100 | 1 | 100 | 138.8452 |
| accelerator.jpg | 0 | 10 | 100 | 13.9876 |
| accelerator.jpg | 5 | 10 | 100 | 70.30409 |
| accelerator.jpg | 100 | 10 | 100 | 16.26743 |
| accelerator.jpg | 0 | 40 | 100 | 3.862785 |
| accelerator.jpg | 5 | 40 | 100 | 69.42953 |
| accelerator.jpg | 100 | 40 | 100 | 5.392754 |
| accelerator.jpg | 0 | 80 | 100 | 2.280841 |
| accelerator.jpg | 5 | 80 | 100 | 68.08334 |
| accelerator.jpg | 100 | 80 | 100 | 3.41488 |
| accelerator.jpg | 0 | 1 | 300 | 133.2539 |
| accelerator.jpg | 5 | 1 | 300 | 328.0112 |
| accelerator.jpg | 100 | 1 | 300 | 148.1826 |
| accelerator.jpg | 0 | 10 | 300 | 13.67713 |
| accelerator.jpg | 5 | 10 | 300 | 199.4791 |
| accelerator.jpg | 100 | 10 | 300 | 21.33811 |
| accelerator.jpg | 0 | 40 | 300 | 3.923289 |
| accelerator.jpg | 5 | 40 | 300 | 211.3862 |
| accelerator.jpg | 100 | 40 | 300 | 13.22427 |
| accelerator.jpg | 0 | 80 | 300 | 2.140684 |
| accelerator.jpg | 5 | 80 | 300 | 190.2243 |
| accelerator.jpg | 100 | 80 | 300 | 7.20571 |
| accelerator.jpg | 0 | 1 | 500 | 131.4196 |
| accelerator.jpg | 5 | 1 | 500 | 445.6884 |
| accelerator.jpg | 100 | 1 | 500 | 145.3268 |
| accelerator.jpg | 0 | 10 | 500 | 14.44885 |
| accelerator.jpg | 5 | 10 | 500 | 337.726 |
| accelerator.jpg | 100 | 10 | 500 | 24.97293 |
| accelerator.jpg | 0 | 40 | 500 | 4.34945 |
| accelerator.jpg | 5 | 40 | 500 | 331.5759 |
| accelerator.jpg | 100 | 40 | 500 | 15.41676 |
| accelerator.jpg | 0 | 80 | 500 | 2.174893 |
| accelerator.jpg | 5 | 80 | 500 | 329.9176 |
| accelerator.jpg | 100 | 80 | 500 | 15.55935 |
| homura.png | 0 | 1 | 100 | 604.6048 |
| homura.png | 5 | 1 | 100 | 910.8798 |
| homura.png | 100 | 1 | 100 | 630.693 |
| homura.png | 0 | 10 | 100 | 63.88887 |
| homura.png | 5 | 10 | 100 | 320.1506 |
| homura.png | 100 | 10 | 100 | 74.4638 |
| homura.png | 0 | 40 | 100 | 16.08515 |
| homura.png | 5 | 40 | 100 | 313.5878 |
| homura.png | 100 | 40 | 100 | 28.09522 |
| homura.png | 0 | 80 | 100 | 8.77639 |
| homura.png | 5 | 80 | 100 | 304.7992 |
| homura.png | 100 | 80 | 100 | 20.30085 |
| homura.png | 0 | 1 | 300 | 610.3656 |
| homura.png | 5 | 1 | 300 | 1517.982 |
| homura.png | 100 | 1 | 300 | 659.5585 |
| homura.png | 0 | 10 | 300 | 64.12733 |
| homura.png | 5 | 10 | 300 | 922.7717 |
| homura.png | 100 | 10 | 300 | 102.0611 |
| homura.png | 0 | 40 | 300 | 16.95166 |
| homura.png | 5 | 40 | 300 | 875.9216 |
| homura.png | 100 | 40 | 300 | 51.68552 |
| homura.png | 0 | 80 | 300 | 9.010271 |
| homura.png | 5 | 80 | 300 | 900.0537 |
| homura.png | 100 | 80 | 300 | 38.7888 |
| homura.png | 0 | 1 | 500 | 607.6181 |
| homura.png | 5 | 1 | 500 | 2144.851 |
| homura.png | 100 | 1 | 500 | 687.2477 |
| homura.png | 0 | 10 | 500 | 64.06942 |
| homura.png | 5 | 10 | 500 | 1584.435 |
| homura.png | 100 | 10 | 500 | 125.5415 |
| homura.png | 0 | 40 | 500 | 16.87746 |
| homura.png | 5 | 40 | 500 | 1533.123 |
| homura.png | 100 | 40 | 500 | 72.26439 |
| homura.png | 0 | 80 | 500 | 8.767542 |
| homura.png | 5 | 80 | 500 | 1578.698 |
| homura.png | 100 | 80 | 500 | 75.24278 |
| test\_border.txt | 0 | 1 | 100 | 0.4148 |
| test\_border.txt | 5 | 1 | 100 | 0.623781 |
| test\_border.txt | 100 | 1 | 100 | 0.520651 |
| test\_border.txt | 0 | 10 | 100 | 0.172758 |
| test\_border.txt | 5 | 10 | 100 | 0.680945 |
| test\_border.txt | 100 | 10 | 100 | 0.1602 |
| test\_border.txt | 0 | 40 | 100 | 0.163978 |
| test\_border.txt | 5 | 40 | 100 | 0.474593 |
| test\_border.txt | 100 | 40 | 100 | 0.163541 |
| test\_border.txt | 0 | 80 | 100 | 0.182228 |
| test\_border.txt | 5 | 80 | 100 | 0.472585 |
| test\_border.txt | 100 | 80 | 100 | 0.173217 |
| test\_border.txt | 0 | 1 | 300 | 0.716748 |
| test\_border.txt | 5 | 1 | 300 | 1.638449 |
| test\_border.txt | 100 | 1 | 300 | 0.425784 |
| test\_border.txt | 0 | 10 | 300 | 0.171498 |
| test\_border.txt | 5 | 10 | 300 | 0.46358 |
| test\_border.txt | 100 | 10 | 300 | 0.17431 |
| test\_border.txt | 0 | 40 | 300 | 0.171769 |
| test\_border.txt | 5 | 40 | 300 | 0.764958 |
| test\_border.txt | 100 | 40 | 300 | 0.170708 |
| test\_border.txt | 0 | 80 | 300 | 0.1612 |
| test\_border.txt | 5 | 80 | 300 | 1.067337 |
| test\_border.txt | 100 | 80 | 300 | 0.164205 |
| test\_border.txt | 0 | 1 | 500 | 0.428874 |
| test\_border.txt | 5 | 1 | 500 | 0.91815 |
| test\_border.txt | 100 | 1 | 500 | 0.419526 |
| test\_border.txt | 0 | 10 | 500 | 0.169211 |
| test\_border.txt | 5 | 10 | 500 | 0.173481 |
| test\_border.txt | 100 | 10 | 500 | 0.168193 |
| test\_border.txt | 0 | 40 | 500 | 0.17422 |
| test\_border.txt | 5 | 40 | 500 | 2.667954 |
| test\_border.txt | 100 | 40 | 500 | 0.166208 |
| test\_border.txt | 0 | 80 | 500 | 0.17722 |
| test\_border.txt | 5 | 80 | 500 | 0.166207 |
| test\_border.txt | 100 | 80 | 500 | 0.165207 |
| test\_long.txt | 0 | 1 | 100 | 57.56053 |
| test\_long.txt | 5 | 1 | 100 | 87.09577 |
| test\_long.txt | 100 | 1 | 100 | 59.52004 |
| test\_long.txt | 0 | 10 | 100 | 6.186211 |
| test\_long.txt | 5 | 10 | 100 | 29.09815 |
| test\_long.txt | 100 | 10 | 100 | 6.85561 |
| test\_long.txt | 0 | 40 | 100 | 1.630564 |
| test\_long.txt | 5 | 40 | 100 | 30.12347 |
| test\_long.txt | 100 | 40 | 100 | 2.812276 |
| test\_long.txt | 0 | 80 | 100 | 1.151097 |
| test\_long.txt | 5 | 80 | 100 | 31.40481 |
| test\_long.txt | 100 | 80 | 100 | 1.85032 |
| test\_long.txt | 0 | 1 | 300 | 57.61417 |
| test\_long.txt | 5 | 1 | 300 | 150.1978 |
| test\_long.txt | 100 | 1 | 300 | 64.13299 |
| test\_long.txt | 0 | 10 | 300 | 6.025547 |
| test\_long.txt | 5 | 10 | 300 | 90.55995 |
| test\_long.txt | 100 | 10 | 300 | 10.76575 |
| test\_long.txt | 0 | 40 | 300 | 1.710143 |
| test\_long.txt | 5 | 40 | 300 | 76.9148 |
| test\_long.txt | 100 | 40 | 300 | 5.055358 |
| test\_long.txt | 0 | 80 | 300 | 1.058327 |
| test\_long.txt | 5 | 80 | 300 | 79.55254 |
| test\_long.txt | 100 | 80 | 300 | 5.882368 |
| test\_long.txt | 0 | 1 | 500 | 58.38539 |
| test\_long.txt | 5 | 1 | 500 | 206.5459 |
| test\_long.txt | 100 | 1 | 500 | 66.21308 |
| test\_long.txt | 0 | 10 | 500 | 6.175734 |
| test\_long.txt | 5 | 10 | 500 | 158.4217 |
| test\_long.txt | 100 | 10 | 500 | 7.672611 |
| test\_long.txt | 0 | 40 | 500 | 1.797088 |
| test\_long.txt | 5 | 40 | 500 | 137.3231 |
| test\_long.txt | 100 | 40 | 500 | 9.461852 |
| test\_long.txt | 0 | 80 | 500 | 1.466836 |
| test\_long.txt | 5 | 80 | 500 | 143.4689 |
| test\_long.txt | 100 | 80 | 500 | 9.313397 |
| test\_medium.txt | 0 | 1 | 100 | 31.16704 |
| test\_medium.txt | 5 | 1 | 100 | 49.29846 |
| test\_medium.txt | 100 | 1 | 100 | 33.35478 |
| test\_medium.txt | 0 | 10 | 100 | 3.431301 |
| test\_medium.txt | 5 | 10 | 100 | 16.10233 |
| test\_medium.txt | 100 | 10 | 100 | 3.712639 |
| test\_medium.txt | 0 | 40 | 100 | 1.037745 |
| test\_medium.txt | 5 | 40 | 100 | 15.42429 |
| test\_medium.txt | 100 | 40 | 100 | 1.327703 |
| test\_medium.txt | 0 | 80 | 100 | 0.725909 |
| test\_medium.txt | 5 | 80 | 100 | 16.47064 |
| test\_medium.txt | 100 | 80 | 100 | 1.170541 |
| test\_medium.txt | 0 | 1 | 300 | 31.73075 |
| test\_medium.txt | 5 | 1 | 300 | 77.08442 |
| test\_medium.txt | 100 | 1 | 300 | 34.87978 |
| test\_medium.txt | 0 | 10 | 300 | 3.45633 |
| test\_medium.txt | 5 | 10 | 300 | 51.50713 |
| test\_medium.txt | 100 | 10 | 300 | 4.308419 |
| test\_medium.txt | 0 | 40 | 300 | 1.022261 |
| test\_medium.txt | 5 | 40 | 300 | 42.82764 |
| test\_medium.txt | 100 | 40 | 300 | 3.294126 |
| test\_medium.txt | 0 | 80 | 300 | 0.681887 |
| test\_medium.txt | 5 | 80 | 300 | 53.75897 |
| test\_medium.txt | 100 | 80 | 300 | 1.499763 |
| test\_medium.txt | 0 | 1 | 500 | 31.91492 |
| test\_medium.txt | 5 | 1 | 500 | 103.8462 |
| test\_medium.txt | 100 | 1 | 500 | 35.64307 |
| test\_medium.txt | 0 | 10 | 500 | 3.500386 |
| test\_medium.txt | 5 | 10 | 500 | 82.07072 |
| test\_medium.txt | 100 | 10 | 500 | 6.484463 |
| test\_medium.txt | 0 | 40 | 500 | 1.485861 |
| test\_medium.txt | 5 | 40 | 500 | 76.55199 |
| test\_medium.txt | 100 | 40 | 500 | 3.424541 |
| test\_medium.txt | 0 | 80 | 500 | 0.660828 |
| test\_medium.txt | 5 | 80 | 500 | 81.22677 |
| test\_medium.txt | 100 | 80 | 500 | 3.9718 |
| test\_short.txt | 0 | 1 | 100 | 1.568966 |
| test\_short.txt | 5 | 1 | 100 | 2.191747 |
| test\_short.txt | 100 | 1 | 100 | 1.627038 |
| test\_short.txt | 0 | 10 | 100 | 0.270181 |
| test\_short.txt | 5 | 10 | 100 | 1.181936 |
| test\_short.txt | 100 | 10 | 100 | 0.276345 |
| test\_short.txt | 0 | 40 | 100 | 0.172216 |
| test\_short.txt | 5 | 40 | 100 | 0.695698 |
| test\_short.txt | 100 | 40 | 100 | 0.200515 |
| test\_short.txt | 0 | 80 | 100 | 0.178223 |
| test\_short.txt | 5 | 80 | 100 | 0.47583 |
| test\_short.txt | 100 | 80 | 100 | 0.280351 |
| test\_short.txt | 0 | 1 | 300 | 1.541931 |
| test\_short.txt | 5 | 1 | 300 | 3.95266 |
| test\_short.txt | 100 | 1 | 300 | 1.606005 |
| test\_short.txt | 0 | 10 | 300 | 0.290325 |
| test\_short.txt | 5 | 10 | 300 | 3.179983 |
| test\_short.txt | 100 | 10 | 300 | 0.277858 |
| test\_short.txt | 0 | 40 | 300 | 0.189234 |
| test\_short.txt | 5 | 40 | 300 | 2.902636 |
| test\_short.txt | 100 | 40 | 300 | 0.181227 |
| test\_short.txt | 0 | 80 | 300 | 0.18323 |
| test\_short.txt | 5 | 80 | 300 | 1.375723 |
| test\_short.txt | 100 | 80 | 300 | 0.474893 |
| test\_short.txt | 0 | 1 | 500 | 1.565961 |
| test\_short.txt | 5 | 1 | 500 | 6.10489 |
| test\_short.txt | 100 | 1 | 500 | 2.091524 |
| test\_short.txt | 0 | 10 | 500 | 0.292366 |
| test\_short.txt | 5 | 10 | 500 | 4.728151 |
| test\_short.txt | 100 | 10 | 500 | 0.28722 |
| test\_short.txt | 0 | 40 | 500 | 0.177836 |
| test\_short.txt | 5 | 40 | 500 | 4.187245 |
| test\_short.txt | 100 | 40 | 500 | 0.671243 |
| test\_short.txt | 0 | 80 | 500 | 0.17663 |
| test\_short.txt | 5 | 80 | 500 | 5.185603 |
| test\_short.txt | 100 | 80 | 500 | 0.180126 |