

Homework 2 - System Monitoring and VM Networking

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1 Kessler Paper

1.1 ARP and Types of Addressing

The Address Resolution Protocol (ARP) is a method for determining the MAC address correlated with an IP address it needs.

A machine address differs from a network address in that it is used on a lower logical layer of the network stack. MAC addresses are used to refer to a specific interface on a specific machine, whereas a network address like an IP address is used for the more general concept of finding and addressing machines between different networks.

1.2 DHCP

The Dynamic Host Configuration Protocol (DHCP) was created to provide a way to assign IP addresses to host on a network in an automated fashion. This is useful for two reasons:

- Users don't have to manually choose an IP address.
- Administrators don't have to keep IP addresses reserved for longer than necessary.

To make things even simpler, DHCP is useful for networks that change Internet Service Providers and subsequently changing their IP address. Without DHCP, admins would need to reassign IP addresses on all their machines in this scenario.

At a high level, DHCP works by the following steps:

1. Send a broadcast message asking for an available DHCP server.
2. Receive responses from candidate DHCP server(s).
3. Choose a DHCP server and ask it for an IP address.
4. DHCP server responds with an IP address that is good until end of lease.
5. When the lease ends, ask for a renewal.
6. Gracefully end the DHCP lease.

2 System Monitoring

I created the script discussed below and named it `hw2-Q2.sh`. Then, in order for cron to use it, I issued a ``sudo crontab -e`` to edit the crontab. Then, I placed the following line to get the program to run once a day at 5am:

```
1 0 5 * * * cd /home/jared/Documents/code/udpecho; ./hw2-Q2.sh > /tmp/cron-hw2-$(date +%F).log 2>&1
```

2.1 Config file

The config file in Listing 2 is read by the monitoring script in Listing 1. To make things simple, the config file is simply sourced by the script as if it were a bash file. Thus, the format for setting variables is the same as one would do in any bash script.

2.1.1 Variables

- `disk_max` (percent) - disk usage threshold.
- `bw_max` (kbits/s) - total bandwidth usage threshold per interface.

2.2 Disk Usage

This part of the script simply calls the UNIX program `du` and picks out the disk usage info for the root filesystem. If the percentage threshold specified in the config file is exceeded, the script will calculate and print the disk usage by each user's folder in the `/home` directory. Values are reported by percentage.

2.3 Authentication Failure Monitoring

Here, I decided to go a different route than parsing through `/var/log/auth.log`. My motivation for doing this is that there seems to be no standard searchable message for different authentication failures. For example, failing to authenticate to the root user when using `su` results in this log message:

```
1 Feb 27 21:42:56 hotdog su[4642]: pam_unix(su:auth): authentication failure; logname=jared uid=1000 euid=0 tty=/dev/pts/10 ruser=jared rho
2 st= user=root
3 Feb 27 21:42:58 hotdog su[4642]: pam_authenticate: Authentication failure
4 Feb 27 21:42:58 hotdog su[4642]: FAILED su for root by jared
5 Feb 27 21:42:58 hotdog su[4642]: - /dev/pts/10 jared:root
```

While failing to authenticate using `sudo` results in a different message:

```
1 Feb 28 01:50:40 hotdog sudo: jared : 1 incorrect password attempt ; TTY=pts/1 ; PWD=/home/jared/Documents/code/udpecho ; USER=root ; COMMAND=/bin/echo hi
```

So, I chose to install the program `auditd` and use one of its utility programs `aureport` to get more accurate authentication statistics. This program is available in the Ubuntu repositories. Some of its better features that I made use of were its ability to report just the authentication failures and its ability to filter only events within particular time ranges. In this case, the script outputs the number of failures over the past 24 hours.

2.4 Bandwidth Measurement

This was a more challenging part of the project mainly because of drawbacks with the particular network monitoring tool I chose to use, `vnstat`. This program is similarly available in the Ubuntu repositories. While it's a great program to use on the command line for getting a quick idea of what's going on with the network, it was more difficult to script against without mucking with its database.

Ultimately, I had the program list out the available `eth*` interfaces, then I measure the bandwidth usage on each interface for 5 seconds. Since `vnstat` only outputs separate send and receive measurements, I had to do some manual adjustments to add these two numbers together with correct units in order to get a picture of total bandwidth usage.

2.5 Sample output

```
1 Disk usage on /: 60%
2
3 Failed login attempts by user:
4 -----
5 8 root
6 7 jared
```

```

7
8 Analyzing bandwidth usage by interface:
9 -----
10
11 Bandwidth used over 5 seconds on interface eth0...
12 24.00 kbits/s
13
14 Bandwidth used over 5 seconds on interface eth1...
15 20130.00 kbits/s
16 WARNING: bandwidth threshold 100 kbits/s exceeded!

```

3 VM Networking

The script shown in Listing 3 is a pretty straightforward implementation of the problem statement in the assignment document. A parameter valued 1 through 4 is provided to the script to identify which part of the question the script should perform. The first two parts simply run `iperf3` for 20 seconds, whereas the second pair of parts run `iperf3` while simultaneously running `UDPEchoClient` at varying rates.

Program output for parts 1 through 4 can be found in Listing 4 through Listing 11.

3.1 Discussion

The results of the first two parts (UDP and TCP `iperf3` executions) can largely be seen as controls for the experiments I performed in parts 3 and 4. The UDP execution saw a packet drop rate of roughly 0.25 percent, while the TCP execution window size had a mode of 130 KBytes.

In parts 3 and 4, I varied the interval delay by values 10^{-i} , where $i \in \{1, 2, 3, 4\}$. Most of the results in part 3 were unsurprising: in order of decreasing delay time, I saw packet losses of 1.6, 0.2, 1.2, and 2.4 percent. Most of these seemed to make sense, except for the 0.2 percent result attributed to the delay time of 0.1 s. Jitter was another interesting variable; in order of decreasing delay times I saw 0.099, 0.051, 0.456, and 0.114 ms jitter. Again, the 0.1 s delay time seemed to outperform the slower delay time of 1 s.

The results of part 4 were similarly difficult to predict. Some delay values resulted in large window sizes, while others led to smaller ones. There did not seem to be a strong correlation in any case.

4 Code

Listing 1: hw2-Q2.sh

```

1 #!/bin/bash
2
3 # read config file variables
4 source ./monitor.conf
5
6 root=$(df | awk '{ gsub(/%/,""); if ($6 == "/") print $5 " " $3}')
7 usage=${root[0]}
8 total=${root[1]}
9 echo "Disk usage on /: $usage%"
10
11 if [[ $usage -gt $disk_max ]]; then
12     echo "WARNING: disk usage threshold $disk_max exceeded!"
13     for user in /home/*; do
14         du -s $user | awk -v total=$total '{ printf("%.1f%% %s\n", 100*$1/total, $2) }'
15     done
16 fi
17
18
19 # The program aureport can be found in the 'auditd' package available
20 # in the standard Ubuntu repositories. It provides more comprehensive
21 # login attempt info than the difficult to analyze auth.log file.
22 echo
23 echo "Failed login attempts by user:"
24 echo "-----"
25 sudo aureport -au -i --failed -ts yesterday $(date +%H:%M:%S) | tail -n+6 \
26 | awk '{arr[$4]++} END{for (i in arr) print arr[i] " " i}' | sort -nr
27
28
29 # vnstat can similarly be installed via apt-get package 'vnstat'
30 echo
31 echo "Analyzing bandwidth usage by interface:"
32 echo "-----"

```

```

33 ifaces=$(vnstat --iflist | cut -d' ' -f3- | tr " " "\n\r" | grep "^eth")
34 for iface in ${ifaces[@]}; do
35     echo
36     echo "Bandwidth used over 5 seconds on interface $iface..."
37
38     vals=$(IFS=$'\n' vnstat -tr -i $iface | tail -n+4 | grep -v -e '^[[:space:]]*$' | awk '{print $2 $3}')
39
40     eq=
41     for val in ${vals[@]}; do
42         eq+=$(units $val 'bits/s' | awk 'NR==1{print $2}')
43         eq+=" + "
44     done
45     eq+="0"
46     eq=$(echo "$eq" | sed -e 's/e+*/\*10\^/g')
47
48     result=$(echo "scale=2; ($eq) / 1000" | bc -l)
49     echo "$result kbits/s"
50
51     if [[ $(echo $result '>' $bw_max | bc) -eq 1 ]]; then
52         echo "WARNING: bandwidth threshold $bw_max kbits/s exceeded!"
53     fi
54 done

```

Listing 2: monitor.conf

```

1 disk_max=90
2 bw_max=100

```

Listing 3: hw2-Q3.sh

```

1 #!/bin/bash
2
3 if [[ $# -ne 3 ]] && [[ $# -ne 4 ]]; then
4     echo "Invalid parameters"
5     echo "Syntax: $0 experiment_number host_ip host_port [echo_port]"
6     exit 1
7 fi
8
9 case "$1" in
10 1) #UDP
11     iperf3 -p $3 -c $2 -b 20m -u -i 1 -t 20
12     ;;
13 2) #TCP
14     iperf3 -p $3 -c $2 -b 20m -i 1 -t 20
15     ;;
16 3) #UDP with echo program running
17     if [[ $# -ne 4 ]]; then
18         echo "Invalid parameters"
19         echo "Syntax: $0 experiment_number host_ip host_port echo_port"
20         exit 1
21     fi
22     for i in '1' '0.1' '0.01' '0.001'; do
23         # modified client to output ping info to stderr
24         ./client $2 $4 $i 1024 2>/dev/null &
25         client=$!
26         iperf3 -p $3 -c $2 -b 20m -u -i 1 -t 20
27         kill -INT $client
28     done
29     ;;
30 4) #TCP with echo program running
31     if [[ $# -ne 4 ]]; then
32         echo "Invalid parameters"
33         echo "Syntax: $0 experiment_number host_ip host_port echo_port"
34         exit 1
35     fi
36     for i in '1' '0.1' '0.01' '0.001'; do
37         # modified client to output ping info to stderr
38         ./client $2 $4 $i 1024 2>/dev/null &
39         client=$!
40         iperf3 -p $3 -c $2 -b 20m -i 1 -t 20
41         kill -INT $client
42     done
43     ;;
44 *)
45     echo "Invalid experiment number"

```

```

46     echo "Syntax: $0 experiment_number host_ip host_port [echo_port]"
47     exit 1
48 esac

```

Listing 4: q3p1.log

```

1 Connecting to host 192.168.56.104, port 5005
2 [ 4] local 192.168.56.105 port 33676 connected to 192.168.56.104 port 5005
3 [ ID] Interval          Transfer      Bandwidth      Total Datagrams
4 [ 4]  0.00-1.00      sec  2.17 MBytes  18.2 Mbits/sec  278
5 [ 4]  1.00-2.00      sec  2.38 MBytes  20.0 Mbits/sec  305
6 [ 4]  2.00-3.00      sec  2.38 MBytes  20.0 Mbits/sec  305
7 [ 4]  3.00-4.00      sec  2.38 MBytes  20.0 Mbits/sec  305
8 [ 4]  4.00-5.00      sec  2.38 MBytes  20.0 Mbits/sec  305
9 [ 4]  5.00-6.00      sec  2.40 MBytes  20.1 Mbits/sec  307
10 [ 4]  6.00-7.00      sec  2.38 MBytes  19.9 Mbits/sec  304
11 [ 4]  7.00-8.00      sec  2.38 MBytes  20.0 Mbits/sec  305
12 [ 4]  8.00-9.00      sec  2.38 MBytes  20.0 Mbits/sec  305
13 [ 4]  9.00-10.00     sec  2.38 MBytes  20.0 Mbits/sec  305
14 [ 4] 10.00-11.00     sec  2.38 MBytes  20.0 Mbits/sec  305
15 [ 4] 11.00-12.00     sec  2.39 MBytes  20.0 Mbits/sec  306
16 [ 4] 12.00-13.00     sec  2.38 MBytes  20.0 Mbits/sec  305
17 [ 4] 13.00-14.00     sec  2.38 MBytes  20.0 Mbits/sec  305
18 [ 4] 14.00-15.00     sec  2.38 MBytes  20.0 Mbits/sec  305
19 [ 4] 15.00-16.00     sec  2.39 MBytes  20.0 Mbits/sec  306
20 [ 4] 16.00-17.00     sec  2.38 MBytes  19.9 Mbits/sec  304
21 [ 4] 17.00-18.00     sec  2.39 MBytes  20.0 Mbits/sec  306
22 [ 4] 18.00-19.00     sec  2.38 MBytes  20.0 Mbits/sec  305
23 [ 4] 19.00-20.00     sec  2.38 MBytes  20.0 Mbits/sec  305
24 - - - - -
25 [ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
26 [ 4]  0.00-20.00     sec  47.5 MBytes  19.9 Mbits/sec  0.128 ms    15/6076 (0.25%)
27 [ 4] Sent 6076 datagrams
28
29 iperf Done.

```

Listing 5: q3p1-server.log

```

1 -----
2 Server listening on 5005
3 -----
4 Accepted connection from 192.168.56.105, port 42917
5 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 33676
6 [ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
7 [ 5]  0.00-1.00      sec  2.17 MBytes  18.2 Mbits/sec  0.194 ms    0/278 (0%)
8 [ 5]  1.00-2.00      sec  2.38 MBytes  20.0 Mbits/sec  0.133 ms    0/305 (0%)
9 [ 5]  2.00-3.00      sec  2.38 MBytes  20.0 Mbits/sec  0.077 ms    0/305 (0%)
10 [ 5]  3.00-4.00      sec  2.35 MBytes  19.7 Mbits/sec  0.278 ms    4/305 (1.3%)
11 [ 5]  4.00-5.00      sec  2.38 MBytes  20.0 Mbits/sec  0.091 ms    0/305 (0%)
12 [ 5]  5.00-6.00      sec  2.40 MBytes  20.1 Mbits/sec  0.408 ms    0/307 (0%)
13 [ 5]  6.00-7.00      sec  2.29 MBytes  19.2 Mbits/sec  0.206 ms   11/304 (3.6%)
14 [ 5]  7.00-8.00      sec  2.38 MBytes  20.0 Mbits/sec  0.167 ms    0/305 (0%)
15 [ 5]  8.00-9.00      sec  2.38 MBytes  19.9 Mbits/sec  0.119 ms    0/304 (0%)
16 [ 5]  9.00-10.00     sec  2.39 MBytes  20.0 Mbits/sec  0.092 ms    0/306 (0%)
17 [ 5] 10.00-11.00     sec  2.38 MBytes  20.0 Mbits/sec  0.102 ms    0/305 (0%)
18 [ 5] 11.00-12.00     sec  2.39 MBytes  20.1 Mbits/sec  0.133 ms    0/306 (0%)
19 [ 5] 12.00-13.00     sec  2.38 MBytes  20.0 Mbits/sec  0.104 ms    0/305 (0%)
20 [ 5] 13.00-14.00     sec  2.38 MBytes  20.0 Mbits/sec  0.127 ms    0/305 (0%)
21 [ 5] 14.00-15.00     sec  2.38 MBytes  20.0 Mbits/sec  0.161 ms    0/305 (0%)
22 [ 5] 15.00-16.00     sec  2.39 MBytes  20.1 Mbits/sec  1.447 ms    0/306 (0%)
23 [ 5] 16.00-17.00     sec  2.38 MBytes  19.9 Mbits/sec  0.085 ms    0/304 (0%)
24 [ 5] 17.00-18.00     sec  2.39 MBytes  20.0 Mbits/sec  0.140 ms    0/306 (0%)
25 [ 5] 18.00-19.00     sec  2.38 MBytes  20.0 Mbits/sec  0.070 ms    0/305 (0%)
26 [ 5] 19.00-20.00     sec  2.38 MBytes  20.0 Mbits/sec  0.128 ms    0/305 (0%)
27 [ 5] 20.00-20.04     sec  0.00 Bytes   0.00 bits/sec  0.128 ms    0/0 (0%)
28 - - - - -
29 [ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
30 [ 5]  0.00-20.04     sec  0.00 Bytes   0.00 bits/sec  0.128 ms   15/6076 (0.25%)

```

Listing 6: q3p2.log

```

1 Connecting to host 192.168.56.104, port 5005
2 [ 4] local 192.168.56.105 port 42916 connected to 192.168.56.104 port 5005
3 [ ID] Interval          Transfer      Bandwidth      Retr  Cwnd

```

```

4 [ 4] 0.00-1.00 sec 2.21 MBytes 18.5 Mbits/sec 0 107 KBytes
5 [ 4] 1.00-2.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
6 [ 4] 2.00-3.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
7 [ 4] 3.00-4.00 sec 2.38 MBytes 20.0 Mbits/sec 0 130 KBytes
8 [ 4] 4.00-5.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
9 [ 4] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
10 [ 4] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
11 [ 4] 7.00-8.00 sec 2.50 MBytes 21.0 Mbits/sec 0 130 KBytes
12 [ 4] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
13 [ 4] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
14 [ 4] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
15 [ 4] 11.00-12.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
16 [ 4] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
17 [ 4] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
18 [ 4] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
19 [ 4] 15.00-16.00 sec 2.38 MBytes 20.0 Mbits/sec 0 130 KBytes
20 [ 4] 16.00-17.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
21 [ 4] 17.00-18.00 sec 2.38 MBytes 20.0 Mbits/sec 0 130 KBytes
22 [ 4] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
23 [ 4] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec 0 130 KBytes
24 - - - - -
25 [ ID] Interval Transfer Bandwidth Retr
26 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec 0 sender
27 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec receiver
28
29 iperf Done.

```

Listing 7: q3p2-server.log

```

1 -----
2 Server listening on 5005
3 -----
4 Accepted connection from 192.168.56.105, port 42915
5 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 42916
6 [ ID] Interval Transfer Bandwidth
7 [ 5] 0.00-1.00 sec 2.21 MBytes 18.5 Mbits/sec
8 [ 5] 1.00-2.00 sec 2.38 MBytes 19.9 Mbits/sec
9 [ 5] 2.00-3.00 sec 2.38 MBytes 19.9 Mbits/sec
10 [ 5] 3.00-4.00 sec 2.38 MBytes 19.9 Mbits/sec
11 [ 5] 4.00-5.00 sec 2.38 MBytes 19.9 Mbits/sec
12 [ 5] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec
13 [ 5] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec
14 [ 5] 7.00-8.00 sec 2.50 MBytes 21.0 Mbits/sec
15 [ 5] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec
16 [ 5] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec
17 [ 5] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec
18 [ 5] 11.00-12.00 sec 2.38 MBytes 19.9 Mbits/sec
19 [ 5] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec
20 [ 5] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec
21 [ 5] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec
22 [ 5] 15.00-16.00 sec 2.38 MBytes 19.9 Mbits/sec
23 [ 5] 16.00-17.00 sec 2.38 MBytes 19.9 Mbits/sec
24 [ 5] 17.00-18.00 sec 2.38 MBytes 19.9 Mbits/sec
25 [ 5] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec
26 [ 5] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec
27 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec
28 - - - - -
29 [ ID] Interval Transfer Bandwidth
30 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec sender
31 [ 5] 0.00-20.04 sec 47.5 MBytes 19.9 Mbits/sec receiver

```

Listing 8: q3p3.log

```

1 Connecting to host 192.168.56.104, port 5005
2 [ 4] local 192.168.56.105 port 58868 connected to 192.168.56.104 port 5005
3 [ ID] Interval Transfer Bandwidth Total Datagrams
4 [ 4] 0.00-1.00 sec 2.16 MBytes 18.1 Mbits/sec 276
5 [ 4] 1.00-2.00 sec 2.46 MBytes 20.6 Mbits/sec 315
6 [ 4] 2.00-3.00 sec 2.33 MBytes 19.5 Mbits/sec 298
7 [ 4] 3.00-4.00 sec 2.38 MBytes 20.0 Mbits/sec 304
8 [ 4] 4.00-5.00 sec 2.39 MBytes 20.0 Mbits/sec 306
9 [ 4] 5.00-6.01 sec 2.38 MBytes 19.9 Mbits/sec 305
10 [ 4] 6.01-7.00 sec 2.38 MBytes 20.1 Mbits/sec 305
11 [ 4] 7.00-8.00 sec 2.38 MBytes 20.0 Mbits/sec 305
12 [ 4] 8.00-9.00 sec 2.38 MBytes 20.0 Mbits/sec 305

```

```

13 [ 4] 9.00-10.00 sec 2.38 MBytes 20.0 Mbits/sec 305
14 [ 4] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec 305
15 [ 4] 11.00-12.00 sec 2.39 MBytes 20.1 Mbits/sec 306
16 [ 4] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec 304
17 [ 4] 13.00-14.00 sec 2.38 MBytes 20.0 Mbits/sec 305
18 [ 4] 14.00-15.01 sec 2.40 MBytes 20.0 Mbits/sec 307
19 [ 4] 15.01-16.01 sec 2.38 MBytes 19.9 Mbits/sec 304
20 [ 4] 16.01-17.00 sec 2.38 MBytes 20.1 Mbits/sec 305
21 [ 4] 17.00-18.00 sec 2.39 MBytes 20.1 Mbits/sec 306
22 [ 4] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec 305
23 [ 4] 19.00-20.00 sec 2.38 MBytes 20.0 Mbits/sec 304
24 - - - - -
25 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
26 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec 0.099 ms 98/6075 (1.6%)
27 [ 4] Sent 6075 datagrams
28
29 iperf Done.
30
31 Avg Ping: 562 microseconds Loss: 0 Percent
32 Connecting to host 192.168.56.104, port 5005
33 [ 4] local 192.168.56.105 port 57397 connected to 192.168.56.104 port 5005
34 [ ID] Interval Transfer Bandwidth Total Datagrams
35 [ 4] 0.00-1.00 sec 2.16 MBytes 18.1 Mbits/sec 276
36 [ 4] 1.00-2.00 sec 2.40 MBytes 20.1 Mbits/sec 307
37 [ 4] 2.00-3.00 sec 2.39 MBytes 20.1 Mbits/sec 306
38 [ 4] 3.00-4.00 sec 2.38 MBytes 20.0 Mbits/sec 305
39 [ 4] 4.00-5.00 sec 2.38 MBytes 20.0 Mbits/sec 305
40 [ 4] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec 304
41 [ 4] 6.00-7.00 sec 2.38 MBytes 20.1 Mbits/sec 305
42 [ 4] 7.00-8.00 sec 2.39 MBytes 20.0 Mbits/sec 306
43 [ 4] 8.00-9.01 sec 2.38 MBytes 19.9 Mbits/sec 305
44 [ 4] 9.01-10.00 sec 2.38 MBytes 20.1 Mbits/sec 305
45 [ 4] 10.00-11.00 sec 2.38 MBytes 20.0 Mbits/sec 305
46 [ 4] 11.00-12.00 sec 2.40 MBytes 20.1 Mbits/sec 307
47 [ 4] 12.00-13.01 sec 2.38 MBytes 19.8 Mbits/sec 304
48 [ 4] 13.01-14.00 sec 2.38 MBytes 20.1 Mbits/sec 305
49 [ 4] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec 305
50 [ 4] 15.00-16.00 sec 2.38 MBytes 20.1 Mbits/sec 305
51 [ 4] 16.00-17.01 sec 2.39 MBytes 19.9 Mbits/sec 306
52 [ 4] 17.01-18.00 sec 2.38 MBytes 20.1 Mbits/sec 305
53 [ 4] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec 304
54 [ 4] 19.00-20.00 sec 2.40 MBytes 20.1 Mbits/sec 307
55 - - - - -
56 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
57 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec 0.051 ms 12/6077 (0.2%)
58 [ 4] Sent 6077 datagrams
59
60 iperf Done.
61
62 Avg Ping: 615 microseconds Loss: 0 Percent
63 Connecting to host 192.168.56.104, port 5005
64 [ 4] local 192.168.56.105 port 51071 connected to 192.168.56.104 port 5005
65 [ ID] Interval Transfer Bandwidth Total Datagrams
66 [ 4] 0.00-1.00 sec 2.16 MBytes 18.1 Mbits/sec 277
67 [ 4] 1.00-2.00 sec 2.39 MBytes 20.1 Mbits/sec 306
68 [ 4] 2.00-3.00 sec 2.38 MBytes 20.0 Mbits/sec 305
69 [ 4] 3.00-4.00 sec 2.38 MBytes 20.0 Mbits/sec 305
70 [ 4] 4.00-5.00 sec 2.38 MBytes 20.0 Mbits/sec 305
71 [ 4] 5.00-6.00 sec 2.38 MBytes 20.0 Mbits/sec 305
72 [ 4] 6.00-7.00 sec 2.38 MBytes 20.0 Mbits/sec 305
73 [ 4] 7.00-8.00 sec 2.39 MBytes 20.1 Mbits/sec 306
74 [ 4] 8.00-9.00 sec 2.38 MBytes 20.0 Mbits/sec 305
75 [ 4] 9.00-10.00 sec 2.38 MBytes 20.0 Mbits/sec 305
76 [ 4] 10.00-11.00 sec 2.38 MBytes 20.0 Mbits/sec 305
77 [ 4] 11.00-12.00 sec 2.38 MBytes 20.0 Mbits/sec 305
78 [ 4] 12.00-13.00 sec 2.38 MBytes 20.0 Mbits/sec 305
79 [ 4] 13.00-14.00 sec 2.39 MBytes 20.0 Mbits/sec 306
80 [ 4] 14.00-15.00 sec 2.40 MBytes 20.2 Mbits/sec 307
81 [ 4] 15.00-16.00 sec 2.37 MBytes 19.8 Mbits/sec 303
82 [ 4] 16.00-17.00 sec 2.40 MBytes 20.1 Mbits/sec 307
83 [ 4] 17.00-18.00 sec 2.37 MBytes 19.9 Mbits/sec 303
84 [ 4] 18.00-19.00 sec 2.39 MBytes 20.1 Mbits/sec 306
85 [ 4] 19.00-20.00 sec 2.38 MBytes 20.0 Mbits/sec 305
86 - - - - -
87 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
88 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec 0.456 ms 74/6076 (1.2%)

```



```

89 [ 4] Sent 6076 datagrams
90
91 iperf Done.
92
93 Avg Ping: 614 microseconds Loss: 0 Percent
94 Connecting to host 192.168.56.104, port 5005
95 [ 4] local 192.168.56.105 port 48663 connected to 192.168.56.104 port 5005
96 [ ID] Interval            Transfer        Bandwidth      Total Datagrams
97 [ 4]  0.00-1.00      sec    2.16 MBytes    18.1 Mbits/sec    276
98 [ 4]  1.00-2.00      sec    2.38 MBytes    20.0 Mbits/sec    305
99 [ 4]  2.00-3.00      sec    2.39 MBytes    20.0 Mbits/sec    306
100 [ 4]  3.00-4.00      sec    2.39 MBytes    20.1 Mbits/sec    306
101 [ 4]  4.00-5.00      sec    2.38 MBytes    20.0 Mbits/sec    305
102 [ 4]  5.00-6.00      sec    2.38 MBytes    20.0 Mbits/sec    305
103 [ 4]  6.00-7.00      sec    2.39 MBytes    20.1 Mbits/sec    306
104 [ 4]  7.00-8.01      sec    2.38 MBytes    19.9 Mbits/sec    305
105 [ 4]  8.01-9.00      sec    2.38 MBytes    20.1 Mbits/sec    305
106 [ 4]  9.00-10.00     sec    2.38 MBytes    20.0 Mbits/sec    305
107 [ 4] 10.00-11.00     sec    2.38 MBytes    20.0 Mbits/sec    305
108 [ 4] 11.00-12.00     sec    2.39 MBytes    20.0 Mbits/sec    306
109 [ 4] 12.00-13.00     sec    2.39 MBytes    20.0 Mbits/sec    306
110 [ 4] 13.00-14.00     sec    2.38 MBytes    20.0 Mbits/sec    305
111 [ 4] 14.00-15.00     sec    2.38 MBytes    19.9 Mbits/sec    304
112 [ 4] 15.00-16.00     sec    2.38 MBytes    20.0 Mbits/sec    304
113 [ 4] 16.00-17.00     sec    2.39 MBytes    20.1 Mbits/sec    306
114 [ 4] 17.00-18.00     sec    2.38 MBytes    20.0 Mbits/sec    305
115 [ 4] 18.00-19.00     sec    2.38 MBytes    19.9 Mbits/sec    305
116 [ 4] 19.00-20.00     sec    2.39 MBytes    20.1 Mbits/sec    306
117 - - - - -
118 [ ID] Interval            Transfer        Bandwidth      Jitter        Lost/Total Datagrams
119 [ 4]  0.00-20.00     sec   47.5 MBytes    19.9 Mbits/sec    0.114 ms     143/6076 (2.4%)
120 [ 4] Sent 6076 datagrams
121
122 iperf Done.
123
124 Avg Ping: 737 microseconds Loss: 0 Percent

```

Listing 9: q3p3-server.log

```

1 -----
2 Server listening on 5005
3 -----
4 Accepted connection from 192.168.56.105, port 42899
5 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 58868
6 [ ID] Interval            Transfer        Bandwidth      Jitter        Lost/Total Datagrams
7 [ 5]  0.00-1.00      sec    2.13 MBytes    17.9 Mbits/sec    0.171 ms     0/273 (0%)
8 [ 5]  1.00-2.00      sec    2.14 MBytes    17.9 Mbits/sec    0.126 ms     44/318 (14%)
9 [ 5]  2.00-3.00      sec    2.16 MBytes    18.1 Mbits/sec    0.070 ms     22/298 (7.4%)
10 [ 5]  3.00-4.00      sec    2.38 MBytes    19.9 Mbits/sec    0.060 ms     0/304 (0%)
11 [ 5]  4.00-5.00      sec    2.39 MBytes    20.1 Mbits/sec    0.076 ms     0/306 (0%)
12 [ 5]  5.00-6.00      sec    2.38 MBytes    20.0 Mbits/sec    1.714 ms     0/305 (0%)
13 [ 5]  6.00-7.00      sec    2.38 MBytes    20.0 Mbits/sec    0.090 ms     0/305 (0%)
14 [ 5]  7.00-8.00      sec    2.38 MBytes    20.0 Mbits/sec    0.139 ms     0/305 (0%)
15 [ 5]  8.00-9.00      sec    2.38 MBytes    19.9 Mbits/sec    0.150 ms     1/305 (0.33%)
16 [ 5]  9.00-10.00     sec    2.38 MBytes    20.0 Mbits/sec    0.085 ms     0/305 (0%)
17 [ 5] 10.00-11.00     sec    2.34 MBytes    19.6 Mbits/sec    0.112 ms     6/305 (2%)
18 [ 5] 11.00-12.00     sec    2.33 MBytes    19.5 Mbits/sec    0.077 ms     8/306 (2.6%)
19 [ 5] 12.00-13.00     sec    2.38 MBytes    19.9 Mbits/sec    0.080 ms     0/304 (0%)
20 [ 5] 13.00-14.00     sec    2.29 MBytes    19.2 Mbits/sec    0.268 ms     7/300 (2.3%)
21 [ 5] 14.00-15.00     sec    2.40 MBytes    20.1 Mbits/sec    0.101 ms     5/312 (1.6%)
22 [ 5] 15.00-16.00     sec    2.38 MBytes    19.9 Mbits/sec    0.070 ms     0/304 (0%)
23 [ 5] 16.00-17.00     sec    2.38 MBytes    20.0 Mbits/sec    0.118 ms     0/305 (0%)
24 [ 5] 17.00-18.00     sec    2.39 MBytes    20.1 Mbits/sec    0.140 ms     0/306 (0%)
25 [ 5] 18.00-19.00     sec    2.34 MBytes    19.7 Mbits/sec    0.142 ms     5/305 (1.6%)
26 [ 5] 19.00-20.00     sec    2.38 MBytes    19.9 Mbits/sec    0.099 ms     0/304 (0%)
27 [ 5] 20.00-20.04     sec    0.00 Bytes     0.00 bits/sec    0.099 ms     0/0 (0%)
28 - - - - -
29 [ ID] Interval            Transfer        Bandwidth      Jitter        Lost/Total Datagrams
30 [ 5]  0.00-20.04     sec    0.00 Bytes     0.00 bits/sec    0.099 ms     98/6075 (1.6%)
31 -----
32 Server listening on 5005
33 -----
34 Accepted connection from 192.168.56.105, port 42900
35 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 57397
36 [ ID] Interval            Transfer        Bandwidth      Jitter        Lost/Total Datagrams

```



```

37 [ 5] 0.00-1.00 sec 2.12 MBytes 17.7 Mbits/sec 0.122 ms 5/276 (1.8%)
38 [ 5] 1.00-2.00 sec 2.40 MBytes 20.1 Mbits/sec 0.092 ms 0/307 (0%)
39 [ 5] 2.00-3.00 sec 2.39 MBytes 20.1 Mbits/sec 0.078 ms 0/306 (0%)
40 [ 5] 3.00-4.00 sec 2.38 MBytes 20.0 Mbits/sec 0.079 ms 0/305 (0%)
41 [ 5] 4.00-5.00 sec 2.38 MBytes 20.0 Mbits/sec 0.106 ms 0/305 (0%)
42 [ 5] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec 0.110 ms 0/304 (0%)
43 [ 5] 6.00-7.00 sec 2.38 MBytes 20.0 Mbits/sec 0.118 ms 0/305 (0%)
44 [ 5] 7.00-8.00 sec 2.39 MBytes 20.1 Mbits/sec 0.128 ms 0/306 (0%)
45 [ 5] 8.00-9.00 sec 2.36 MBytes 19.8 Mbits/sec 0.082 ms 3/305 (0.98%)
46 [ 5] 9.00-10.00 sec 2.38 MBytes 20.0 Mbits/sec 0.211 ms 0/305 (0%)
47 [ 5] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec 0.195 ms 1/305 (0.33%)
48 [ 5] 11.00-12.00 sec 2.40 MBytes 20.1 Mbits/sec 0.065 ms 0/307 (0%)
49 [ 5] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec 0.106 ms 0/304 (0%)
50 [ 5] 13.00-14.00 sec 2.38 MBytes 20.0 Mbits/sec 0.081 ms 0/305 (0%)
51 [ 5] 14.00-15.00 sec 2.38 MBytes 20.0 Mbits/sec 0.207 ms 0/305 (0%)
52 [ 5] 15.00-16.00 sec 2.38 MBytes 20.0 Mbits/sec 0.062 ms 0/305 (0%)
53 [ 5] 16.00-17.00 sec 2.39 MBytes 20.0 Mbits/sec 0.054 ms 0/306 (0%)
54 [ 5] 17.00-18.00 sec 2.38 MBytes 20.0 Mbits/sec 0.079 ms 0/305 (0%)
55 [ 5] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec 0.067 ms 0/304 (0%)
56 [ 5] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec 0.051 ms 3/307 (0.98%)
57 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec 0.051 ms 0/0 (0%)
58 -----
59 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
60 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec 0.051 ms 12/6077 (0.2%)
61 -----
62 Server listening on 5005
63 -----
64 Accepted connection from 192.168.56.105, port 42901
65 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 51071
66 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
67 [ 5] 0.00-1.00 sec 2.16 MBytes 18.1 Mbits/sec 0.065 ms 0/277 (0%)
68 [ 5] 1.00-2.00 sec 2.39 MBytes 20.0 Mbits/sec 0.089 ms 0/306 (0%)
69 [ 5] 2.00-3.00 sec 2.38 MBytes 20.0 Mbits/sec 0.109 ms 0/305 (0%)
70 [ 5] 3.00-4.00 sec 2.33 MBytes 19.5 Mbits/sec 0.178 ms 7/305 (2.3%)
71 [ 5] 4.00-5.00 sec 2.38 MBytes 20.0 Mbits/sec 0.069 ms 0/305 (0%)
72 [ 5] 5.00-6.00 sec 2.38 MBytes 20.0 Mbits/sec 0.127 ms 0/305 (0%)
73 [ 5] 6.00-7.00 sec 2.38 MBytes 20.0 Mbits/sec 0.738 ms 0/305 (0%)
74 [ 5] 7.00-8.00 sec 2.39 MBytes 20.1 Mbits/sec 0.086 ms 0/306 (0%)
75 [ 5] 8.00-9.00 sec 2.38 MBytes 20.0 Mbits/sec 0.200 ms 0/305 (0%)
76 [ 5] 9.00-10.00 sec 2.38 MBytes 20.0 Mbits/sec 0.102 ms 0/305 (0%)
77 [ 5] 10.00-11.00 sec 2.38 MBytes 20.0 Mbits/sec 0.149 ms 0/305 (0%)
78 [ 5] 11.00-12.00 sec 2.38 MBytes 20.0 Mbits/sec 0.059 ms 0/305 (0%)
79 [ 5] 12.00-13.00 sec 2.30 MBytes 19.3 Mbits/sec 0.090 ms 10/305 (3.3%)
80 [ 5] 13.00-14.00 sec 2.30 MBytes 19.3 Mbits/sec 0.113 ms 12/306 (3.9%)
81 [ 5] 14.00-15.00 sec 2.32 MBytes 19.5 Mbits/sec 0.129 ms 10/307 (3.3%)
82 [ 5] 15.00-16.00 sec 2.37 MBytes 19.9 Mbits/sec 0.160 ms 0/303 (0%)
83 [ 5] 16.00-17.00 sec 2.35 MBytes 19.7 Mbits/sec 0.101 ms 6/307 (2%)
84 [ 5] 17.00-18.00 sec 2.37 MBytes 19.9 Mbits/sec 0.128 ms 0/303 (0%)
85 [ 5] 18.00-19.00 sec 2.32 MBytes 19.5 Mbits/sec 0.155 ms 9/306 (2.9%)
86 [ 5] 19.00-20.00 sec 2.23 MBytes 18.7 Mbits/sec 0.456 ms 20/305 (6.6%)
87 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec 0.456 ms 0/0 (0%)
88 -----
89 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
90 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec 0.456 ms 74/6076 (1.2%)
91 -----
92 Server listening on 5005
93 -----
94 Accepted connection from 192.168.56.105, port 42902
95 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 48663
96 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
97 [ 5] 0.00-1.00 sec 1.98 MBytes 16.6 Mbits/sec 0.163 ms 11/265 (4.2%)
98 [ 5] 1.00-2.00 sec 2.09 MBytes 17.6 Mbits/sec 0.160 ms 48/316 (15%)
99 [ 5] 2.00-3.00 sec 2.30 MBytes 19.3 Mbits/sec 0.347 ms 1/295 (0.34%)
100 [ 5] 3.00-4.00 sec 2.30 MBytes 19.3 Mbits/sec 0.085 ms 23/317 (7.3%)
101 [ 5] 4.00-5.00 sec 2.28 MBytes 19.1 Mbits/sec 0.192 ms 13/305 (4.3%)
102 [ 5] 5.00-6.00 sec 2.38 MBytes 20.0 Mbits/sec 0.238 ms 0/305 (0%)
103 [ 5] 6.00-7.00 sec 2.33 MBytes 19.5 Mbits/sec 0.122 ms 8/306 (2.6%)
104 [ 5] 7.00-8.00 sec 2.28 MBytes 19.1 Mbits/sec 0.297 ms 11/303 (3.6%)
105 [ 5] 8.00-9.00 sec 2.37 MBytes 19.9 Mbits/sec 0.089 ms 4/307 (1.3%)
106 [ 5] 9.00-10.00 sec 2.38 MBytes 20.0 Mbits/sec 0.187 ms 0/305 (0%)
107 [ 5] 10.00-11.00 sec 2.30 MBytes 19.3 Mbits/sec 0.065 ms 11/305 (3.6%)
108 [ 5] 11.00-12.00 sec 2.39 MBytes 20.1 Mbits/sec 0.244 ms 0/306 (0%)
109 [ 5] 12.00-13.00 sec 2.39 MBytes 20.0 Mbits/sec 0.115 ms 0/306 (0%)
110 [ 5] 13.00-14.00 sec 2.38 MBytes 20.0 Mbits/sec 0.288 ms 0/305 (0%)
111 [ 5] 14.00-15.00 sec 2.35 MBytes 19.7 Mbits/sec 0.188 ms 3/304 (0.99%)
112 [ 5] 15.00-16.00 sec 2.30 MBytes 19.3 Mbits/sec 0.250 ms 0/294 (0%)

```

```

113 [ 5] 16.00-17.00 sec 2.39 MBytes 20.1 Mbits/sec 0.186 ms 10/316 (3.2%)
114 [ 5] 17.00-18.00 sec 2.38 MBytes 20.0 Mbits/sec 0.149 ms 0/305 (0%)
115 [ 5] 18.00-19.00 sec 2.38 MBytes 20.0 Mbits/sec 0.126 ms 0/305 (0%)
116 [ 5] 19.00-20.00 sec 2.39 MBytes 20.1 Mbits/sec 0.114 ms 0/306 (0%)
117 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec 0.114 ms 0/0 (0%)
118 - - - - -
119 [ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
120 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec 0.114 ms 143/6076 (2.4%)

```

Listing 10: q3p4.log

```

1 Connecting to host 192.168.56.104, port 5005
2 [ 4] local 192.168.56.105 port 42904 connected to 192.168.56.104 port 5005
3 [ ID] Interval Transfer Bandwidth Retr Cwnd
4 [ 4] 0.00-1.00 sec 2.21 MBytes 18.5 Mbits/sec 0 103 KBytes
5 [ 4] 1.00-2.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
6 [ 4] 2.00-3.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
7 [ 4] 3.00-4.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
8 [ 4] 4.00-5.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
9 [ 4] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
10 [ 4] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
11 [ 4] 7.00-8.00 sec 2.50 MBytes 21.0 Mbits/sec 0 132 KBytes
12 [ 4] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
13 [ 4] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
14 [ 4] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
15 [ 4] 11.00-12.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
16 [ 4] 12.00-13.00 sec 2.38 MBytes 20.0 Mbits/sec 0 132 KBytes
17 [ 4] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
18 [ 4] 14.00-15.00 sec 2.38 MBytes 20.0 Mbits/sec 0 132 KBytes
19 [ 4] 15.00-16.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
20 [ 4] 16.00-17.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
21 [ 4] 17.00-18.00 sec 2.38 MBytes 20.0 Mbits/sec 0 132 KBytes
22 [ 4] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
23 [ 4] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec 0 132 KBytes
24 - - - - -
25 [ ID] Interval Transfer Bandwidth Retr
26 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec 0 sender
27 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec receiver
28
29 iperf Done.
30
31 Avg Ping: 605 microseconds Loss: 0 Percent
32 Connecting to host 192.168.56.104, port 5005
33 [ 4] local 192.168.56.105 port 42906 connected to 192.168.56.104 port 5005
34 [ ID] Interval Transfer Bandwidth Retr Cwnd
35 [ 4] 0.00-1.00 sec 2.21 MBytes 18.5 Mbits/sec 0 112 KBytes
36 [ 4] 1.00-2.00 sec 2.38 MBytes 20.0 Mbits/sec 0 173 KBytes
37 [ 4] 2.00-3.00 sec 2.38 MBytes 19.9 Mbits/sec 0 247 KBytes
38 [ 4] 3.00-4.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
39 [ 4] 4.00-5.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
40 [ 4] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
41 [ 4] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
42 [ 4] 7.00-8.00 sec 2.50 MBytes 20.9 Mbits/sec 0 257 KBytes
43 [ 4] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
44 [ 4] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
45 [ 4] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
46 [ 4] 11.00-12.00 sec 2.38 MBytes 20.0 Mbits/sec 0 257 KBytes
47 [ 4] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
48 [ 4] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
49 [ 4] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
50 [ 4] 15.00-16.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
51 [ 4] 16.00-17.00 sec 2.38 MBytes 20.0 Mbits/sec 0 257 KBytes
52 [ 4] 17.00-18.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
53 [ 4] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
54 [ 4] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec 0 257 KBytes
55 - - - - -
56 [ ID] Interval Transfer Bandwidth Retr
57 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec 0 sender
58 [ 4] 0.00-20.00 sec 47.5 MBytes 19.9 Mbits/sec receiver
59
60 iperf Done.
61
62 Avg Ping: 599 microseconds Loss: 0 Percent
63 Connecting to host 192.168.56.104, port 5005
64 [ 4] local 192.168.56.105 port 42908 connected to 192.168.56.104 port 5005

```

```

65 [ ID] Interval      Transfer      Bandwidth      Retr  Cwnd
66 [ 4]  0.00-1.00    sec  2.21 MBytes  18.5 Mbits/sec    0   140 KBytes
67 [ 4]  1.00-2.00    sec  2.38 MBytes  20.0 Mbits/sec    0   140 KBytes
68 [ 4]  2.00-3.00    sec  2.38 MBytes  19.9 Mbits/sec    0   140 KBytes
69 [ 4]  3.00-4.00    sec  2.38 MBytes  19.9 Mbits/sec    0   140 KBytes
70 [ 4]  4.00-5.00    sec  2.38 MBytes  20.0 Mbits/sec    0   140 KBytes
71 [ 4]  5.00-6.00    sec  2.38 MBytes  19.8 Mbits/sec    0   140 KBytes
72 [ 4]  6.00-7.00    sec  2.38 MBytes  19.9 Mbits/sec    0   280 KBytes
73 [ 4]  7.00-8.01    sec  2.50 MBytes  20.9 Mbits/sec    0   280 KBytes
74 [ 4]  8.01-9.00    sec  2.38 MBytes  20.0 Mbits/sec    0   280 KBytes
75 [ 4]  9.00-10.00   sec  2.38 MBytes  20.0 Mbits/sec    0   280 KBytes
76 [ 4] 10.00-11.00   sec  2.38 MBytes  19.9 Mbits/sec    0   280 KBytes
77 [ 4] 11.00-12.00   sec  2.38 MBytes  20.0 Mbits/sec    0   280 KBytes
78 [ 4] 12.00-13.00   sec  2.38 MBytes  19.9 Mbits/sec    0   280 KBytes
79 [ 4] 13.00-14.01   sec  2.38 MBytes  19.8 Mbits/sec    0   280 KBytes
80 [ 4] 14.01-15.00   sec  2.38 MBytes  20.0 Mbits/sec    0   280 KBytes
81 [ 4] 15.00-16.00   sec  2.38 MBytes  19.9 Mbits/sec    0   280 KBytes
82 [ 4] 16.00-17.00   sec  2.38 MBytes  20.0 Mbits/sec    0   280 KBytes
83 [ 4] 17.00-18.00   sec  2.38 MBytes  19.9 Mbits/sec    0   280 KBytes
84 [ 4] 18.00-19.00   sec  2.38 MBytes  19.9 Mbits/sec    0   280 KBytes
85 [ 4] 19.00-20.00   sec  2.38 MBytes  20.0 Mbits/sec    0   280 KBytes
86 - - - - -
87 [ ID] Interval      Transfer      Bandwidth      Retr
88 [ 4]  0.00-20.00   sec  47.5 MBytes  19.9 Mbits/sec    0          sender
89 [ 4]  0.00-20.00   sec  47.5 MBytes  19.9 Mbits/sec          receiver
90
91 iperf Done.
92
93 Avg Ping: 709 microseconds Loss: 0 Percent
94 Connecting to host 192.168.56.104, port 5005
95 [ 4] local 192.168.56.105 port 42910 connected to 192.168.56.104 port 5005
96 [ ID] Interval      Transfer      Bandwidth      Retr  Cwnd
97 [ 4]  0.00-1.00    sec  2.21 MBytes  18.5 Mbits/sec    0   208 KBytes
98 [ 4]  1.00-2.00    sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
99 [ 4]  2.00-3.00    sec  2.38 MBytes  20.0 Mbits/sec    0   266 KBytes
100 [ 4]  3.00-4.00    sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
101 [ 4]  4.00-5.00    sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
102 [ 4]  5.00-6.01    sec  2.38 MBytes  19.8 Mbits/sec    0   266 KBytes
103 [ 4]  6.01-7.00    sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
104 [ 4]  7.00-8.00    sec  2.50 MBytes  21.1 Mbits/sec    0   266 KBytes
105 [ 4]  8.00-9.00    sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
106 [ 4]  9.00-10.00   sec  2.38 MBytes  20.0 Mbits/sec    0   266 KBytes
107 [ 4] 10.00-11.00   sec  2.38 MBytes  20.0 Mbits/sec    0   266 KBytes
108 [ 4] 11.00-12.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
109 [ 4] 12.00-13.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
110 [ 4] 13.00-14.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
111 [ 4] 14.00-15.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
112 [ 4] 15.00-16.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
113 [ 4] 16.00-17.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
114 [ 4] 17.00-18.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
115 [ 4] 18.00-19.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
116 [ 4] 19.00-20.00   sec  2.38 MBytes  19.9 Mbits/sec    0   266 KBytes
117 - - - - -
118 [ ID] Interval      Transfer      Bandwidth      Retr
119 [ 4]  0.00-20.00   sec  47.5 MBytes  19.9 Mbits/sec    0          sender
120 [ 4]  0.00-20.00   sec  47.5 MBytes  19.9 Mbits/sec          receiver
121
122 iperf Done.
123
124 Avg Ping: 592 microseconds Loss: 0 Percent

```

Listing 11: q3p4-server.log

```

1 -----
2 Server listening on 5005
3 -----
4 Accepted connection from 192.168.56.105, port 42903
5 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 42904
6 [ ID] Interval      Transfer      Bandwidth
7 [ 5]  0.00-1.00    sec  2.21 MBytes  18.5 Mbits/sec
8 [ 5]  1.00-2.00    sec  2.38 MBytes  19.9 Mbits/sec
9 [ 5]  2.00-3.00    sec  2.38 MBytes  19.9 Mbits/sec
10 [ 5]  3.00-4.00    sec  2.38 MBytes  19.9 Mbits/sec
11 [ 5]  4.00-5.00    sec  2.38 MBytes  19.9 Mbits/sec
12 [ 5]  5.00-6.00    sec  2.38 MBytes  19.9 Mbits/sec

```

```

13 [ 5] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec
14 [ 5] 7.00-8.00 sec 2.50 MBytes 21.0 Mbits/sec
15 [ 5] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec
16 [ 5] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec
17 [ 5] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec
18 [ 5] 11.00-12.00 sec 2.38 MBytes 19.9 Mbits/sec
19 [ 5] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec
20 [ 5] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec
21 [ 5] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec
22 [ 5] 15.00-16.00 sec 2.38 MBytes 19.9 Mbits/sec
23 [ 5] 16.00-17.00 sec 2.38 MBytes 19.9 Mbits/sec
24 [ 5] 17.00-18.00 sec 2.38 MBytes 19.9 Mbits/sec
25 [ 5] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec
26 [ 5] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec
27 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec
28 -----
29 [ ID] Interval Transfer Bandwidth
30 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec sender
31 [ 5] 0.00-20.04 sec 47.5 MBytes 19.9 Mbits/sec receiver
32 -----
33 Server listening on 5005
34 -----
35 Accepted connection from 192.168.56.105, port 42905
36 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 42906
37 [ ID] Interval Transfer Bandwidth
38 [ 5] 0.00-1.00 sec 2.21 MBytes 18.5 Mbits/sec
39 [ 5] 1.00-2.00 sec 2.38 MBytes 19.9 Mbits/sec
40 [ 5] 2.00-3.00 sec 2.38 MBytes 19.9 Mbits/sec
41 [ 5] 3.00-4.00 sec 2.38 MBytes 19.9 Mbits/sec
42 [ 5] 4.00-5.00 sec 2.38 MBytes 19.9 Mbits/sec
43 [ 5] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec
44 [ 5] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec
45 [ 5] 7.00-8.00 sec 2.50 MBytes 21.0 Mbits/sec
46 [ 5] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec
47 [ 5] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec
48 [ 5] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec
49 [ 5] 11.00-12.00 sec 2.38 MBytes 19.9 Mbits/sec
50 [ 5] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec
51 [ 5] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec
52 [ 5] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec
53 [ 5] 15.00-16.00 sec 2.38 MBytes 19.9 Mbits/sec
54 [ 5] 16.00-17.00 sec 2.38 MBytes 19.9 Mbits/sec
55 [ 5] 17.00-18.00 sec 2.38 MBytes 19.9 Mbits/sec
56 [ 5] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec
57 [ 5] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec
58 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec
59 -----
60 [ ID] Interval Transfer Bandwidth
61 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec sender
62 [ 5] 0.00-20.04 sec 47.5 MBytes 19.9 Mbits/sec receiver
63 -----
64 Server listening on 5005
65 -----
66 Accepted connection from 192.168.56.105, port 42907
67 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 42908
68 [ ID] Interval Transfer Bandwidth
69 [ 5] 0.00-1.00 sec 2.21 MBytes 18.5 Mbits/sec
70 [ 5] 1.00-2.00 sec 2.38 MBytes 19.9 Mbits/sec
71 [ 5] 2.00-3.00 sec 2.38 MBytes 19.9 Mbits/sec
72 [ 5] 3.00-4.00 sec 2.38 MBytes 19.9 Mbits/sec
73 [ 5] 4.00-5.00 sec 2.38 MBytes 19.9 Mbits/sec
74 [ 5] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec
75 [ 5] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec
76 [ 5] 7.00-8.00 sec 2.50 MBytes 21.0 Mbits/sec
77 [ 5] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec
78 [ 5] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec
79 [ 5] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec
80 [ 5] 11.00-12.00 sec 2.38 MBytes 19.9 Mbits/sec
81 [ 5] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec
82 [ 5] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec
83 [ 5] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec
84 [ 5] 15.00-16.00 sec 2.38 MBytes 19.9 Mbits/sec
85 [ 5] 16.00-17.00 sec 2.38 MBytes 19.9 Mbits/sec
86 [ 5] 17.00-18.00 sec 2.38 MBytes 19.9 Mbits/sec
87 [ 5] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec
88 [ 5] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec

```

```

89 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec
90 - - - - -
91 [ ID] Interval      Transfer      Bandwidth
92 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec      sender
93 [ 5] 0.00-20.04 sec 47.5 MBytes 19.9 Mbits/sec      receiver
94 -----
95 Server listening on 5005
96 -----
97 Accepted connection from 192.168.56.105, port 42909
98 [ 5] local 192.168.56.104 port 5005 connected to 192.168.56.105 port 42910
99 [ ID] Interval      Transfer      Bandwidth
100 [ 5] 0.00-1.00 sec 2.21 MBytes 18.5 Mbits/sec
101 [ 5] 1.00-2.00 sec 2.38 MBytes 19.9 Mbits/sec
102 [ 5] 2.00-3.00 sec 2.38 MBytes 19.9 Mbits/sec
103 [ 5] 3.00-4.00 sec 2.38 MBytes 19.9 Mbits/sec
104 [ 5] 4.00-5.00 sec 2.38 MBytes 19.9 Mbits/sec
105 [ 5] 5.00-6.00 sec 2.38 MBytes 19.9 Mbits/sec
106 [ 5] 6.00-7.00 sec 2.38 MBytes 19.9 Mbits/sec
107 [ 5] 7.00-8.00 sec 2.50 MBytes 21.0 Mbits/sec
108 [ 5] 8.00-9.00 sec 2.38 MBytes 19.9 Mbits/sec
109 [ 5] 9.00-10.00 sec 2.38 MBytes 19.9 Mbits/sec
110 [ 5] 10.00-11.00 sec 2.38 MBytes 19.9 Mbits/sec
111 [ 5] 11.00-12.00 sec 2.38 MBytes 19.9 Mbits/sec
112 [ 5] 12.00-13.00 sec 2.38 MBytes 19.9 Mbits/sec
113 [ 5] 13.00-14.00 sec 2.38 MBytes 19.9 Mbits/sec
114 [ 5] 14.00-15.00 sec 2.38 MBytes 19.9 Mbits/sec
115 [ 5] 15.00-16.00 sec 2.38 MBytes 19.9 Mbits/sec
116 [ 5] 16.00-17.00 sec 2.38 MBytes 19.9 Mbits/sec
117 [ 5] 17.00-18.00 sec 2.38 MBytes 19.9 Mbits/sec
118 [ 5] 18.00-19.00 sec 2.38 MBytes 19.9 Mbits/sec
119 [ 5] 19.00-20.00 sec 2.38 MBytes 19.9 Mbits/sec
120 [ 5] 20.00-20.04 sec 0.00 Bytes 0.00 bits/sec
121 - - - - -
122 [ ID] Interval      Transfer      Bandwidth
123 [ 5] 0.00-20.04 sec 0.00 Bytes 0.00 bits/sec      sender
124 [ 5] 0.00-20.04 sec 47.5 MBytes 19.9 Mbits/sec      receiver

```