

Project: Network Traffic Management Lab (iperf3 + Linux tc)

Lab Topology (both networks)

LAN Client VM → generates traffic

LAN Server VM → receives traffic

Same subnet, test port: 5201

Network 1 — Baseline + Traffic Shaping (TBF rate limiting)

Goal

Measure baseline throughput, then **apply bandwidth shaping** (simulate congestion), re-test, and rollback.

Step N1.1 — Confirm IP config (Client)

Run on: Ubuntu Client

```
ip a
ip route
```

 Evidence:

```
yasmin@lan-client-1:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host noprefixroute
        valid_lft forever preferred_lft forever
2: enp0s1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether f2:1d:67:fa:b1:53 brd ff:ff:ff:ff:ff:ff
    inet 192.168.64.2/24 metric 100 brd 192.168.64.255 scope global dynamic enp0s1
        valid_lft 2742sec preferred_lft 2742sec
    inet6 fdcd:c6d0:8e22:b904:f01d:67ff:fe:fa:b153/64 scope global dynamic mngtmpaddr noprefixroute
        valid_lft 2591964sec preferred_lft 604764sec
    inet6 fe80::f01d:67ff:fe:fa:b153/64 scope link
        valid_lft forever preferred_lft forever
yasmin@lan-client-1:~$ ip route
default via 192.168.64.1 dev enp0s1 proto dhcp src 192.168.64.2 metric 100
192.168.64.0/24 dev enp0s1 proto kernel scope link src 192.168.64.2 metric 100
192.168.64.1 dev enp0s1 proto dhcp scope link src 192.168.64.2 metric 100
yasmin@lan-client-1:~$
```

- Evidences/Network 1/Evaluate stage/ip a + route_client1.png

Step N1.2 — SSH + Port 22 checks (Server)

Run on: Ubuntu Server

```
sudo systemctl status ssh
sudo ss -lntp | grep :22 || echo "Port 22 not listening"
```

 Evidence:

```
yasmin@lan-client-1:~$ systemctl is-enabled ssh
enabled
yasmin@lan-client-1:~$ systemctl status ssh --no-pager
● ssh.service - OpenBSD Secure Shell server
  Loaded: loaded (/usr/lib/systemd/system/ssh.service; enabled; preset: enabled)
  Active: active (running) since Wed 2026-02-11 01:09:37 UTC; 13min ago
  TriggeredBy: ● ssh.socket
    Docs: man:sshd(8)
           man:sshd_config(5)
  Process: 12184 ExecStartPre=/usr/sbin/sshd -t (code=exited, status=0/SUCCESS)
  Main PID: 12187 (sshd)
    Tasks: 2 (limit: 4549)
   Memory: 2.9M (peak: 2.6M)
      CPU: 9ms
     CGroup: /system.slice/ssh.service
             └─11678 "sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups"
                  ├─12187 "sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups"

Feb 11 01:09:37 lan-client-1 systemd[1]: Starting ssh.service - OpenBSD Secure Shell server...
Feb 11 01:09:37 lan-client-1 systemd[1]: ssh.service: Found left-over process 11678 (sshd) in control group while starting unit. Ignoring.
Feb 11 01:09:37 lan-client-1 systemd[1]: ssh.service: This usually indicates unclean termination of a previous run, or service implementation deficiencies.
Feb 11 01:09:37 lan-client-1 sshd[12187]: Server listening on 0.0.0.0 port 22.
Feb 11 01:09:37 lan-client-1 sshd[12187]: Server listening on :: port 22.
Feb 11 01:09:37 lan-client-1 systemd[1]: Started ssh.service - OpenBSD Secure Shell server.
yasmin@lan-client-1:~$ _
```

```
yasmin@lan-client-1:~$ sudo ss -lntp | grep ':22'
[sudo] password for yasmin:
LISTEN 0      4096          0.0.0.0:22          0.0.0.0:*      users:(("sshd",pid=11678,fd=3))
LISTEN 0      4096          [::]:22            [::]:*       users:(("sshd",pid=11678,fd=4))
yasmin@lan-client-1:~$ _
```

```
yasmin@lan-client-1:~$ sudo ss -lntp | grep :22
[sudo] password for yasmin:
Sorry, try again.
[sudo] password for yasmin:
LISTEN 0      4096          0.0.0.0:22          0.0.0.0:*      users:(("sshd",pid=12187,fd=3),("sshd",pid=11678,fd=3),("systemd",pid=1,fd=195))
LISTEN 0      4096          [::]:22            [::]:*       users:(("sshd",pid=12187,fd=4),("sshd",pid=11678,fd=4),("systemd",pid=1,fd=196))
yasmin@lan-client-1:~$ _
```

```
yasmim@lan-client-1:~$ sudo systemctl stop ssh || true .
yasmim@lan-client-1:~$ sudo systemctl stop ssh || true
yasmim@lan-client-1:~$ sudo systemctl stop ssh.socket || true
yasmim@lan-client-1:~$ sudo pkill sshd || true
yasmim@lan-client-1:~$ sudo systemctl disable ssh.socket
Removed "/etc/systemd/system/sockets.target.wants/ssh.socket".
Removed "/etc/systemd/system/ssh.service.requires/ssh.socket".
yasmim@lan-client-1:~$ sudo systemctl mask ssh.socket
Created symlink /etc/systemd/system/ssh.socket → /dev/null.
yasmim@lan-client-1:~$ sudo systemctl enabled ssh
Unknown command verb 'enabled', did you mean 'enable'?
yasmim@lan-client-1:~$ sudo systemctl enable ssh
Synchronizing state of ssh.service with SysV service script with /usr/lib/lib/systemd/systemv-install.
Executing: /usr/lib/lib/systemd/systemv-install enable ssh
yasmim@lan-client-1:~$ sudo systemctl start ssh
yasmim@lan-client-1:~$ systemctl is-enabled ssh
enabled
yasmim@lan-client-1:~$ systemctl status ssh --no-pager
● ssh.service - OpenBSD Secure Shell server
  Loaded: loaded (/usr/lib/lib/systemd/system/ssh.service; enabled; preset: enabled)
  Active: active (running) since Wed 2026-02-11 03:38:10 UTC; 4min 15s ago
    Docs: man:sshd(8)
          man:sshd_config(5)
  Process: 13113 ExecStartPre=/usr/sbin/sshd -t (code=exited, status=0/SUCCESS)
 Main PID: 13114 (sshd)
    Tasks: 1 (limit: 4549)
   Memory: 1.1M (peak: 1.4M)
      CPU: 11ms
     CGroup: /system.slice/ssh.service
             └─13114 "sshd: /usr/sbin/sshd -D [listener] 0 of 10-100 startups"

Feb 11 03:38:10 lan-client-1 systemd[1]: Starting ssh.service - OpenBSD Secure Shell server...
Feb 11 03:38:10 lan-client-1 sshd[13114]: Server listening on 0.0.0.0 port 22.
Feb 11 03:38:10 lan-client-1 sshd[13114]: Server listening on :: port 22.
Feb 11 03:38:10 lan-client-1 systemd[1]: Started ssh.service - OpenBSD Secure Shell server.
yasmim@lan-client-1:~$ sudo ss -lntp | grep ':22'
LISTEN 0      128      0.0.0.0:22          0.0.0.0:*      users:(("sshd",pid=13114,fd=3))
LISTEN 0      128      [::]:22            [::]:*      users:(("sshd",pid=13114,fd=4))
yasmim@lan-client-1:~$
```

● ● ● 🖥 yas — yasmim@lan-client-1: ~ — ssh yasmim@192.168.64.2 — 80x34

```
[yasmim@192.168.64.2's password: ]  
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.8.0-100-generic aarch64)
```

```
* Documentation: https://help.ubuntu.com  
* Management: https://landscape.canonical.com  
* Support: https://ubuntu.com/pro
```

```
System information as of Wed Feb 11 03:45:17 AM UTC 2026
```

```
System load: 0.0  
Usage of /: 21.7% of 29.82GB  
Memory usage: 6%  
Swap usage: 0%  
Processes: 107  
Users logged in: 1  
IPv4 address for enp0s1: 192.168.64.2  
IPv6 address for enp0s1: fdcd:c6d0:e822:b904:f01d:67ff:fefab153
```

```
* Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s just raised the bar for easy, resilient and secure K8s cluster deployment.
```

```
https://ubuntu.com/engage/secure-kubernetes-at-the-edge
```

```
Expanded Security Maintenance for Applications is not enabled.
```

```
0 updates can be applied immediately.
```

```
Enable ESM Apps to receive additional future security updates.  
See https://ubuntu.com/esm or run: sudo pro status
```

```
Last login: Wed Feb 11 00:42:49 2026 from 192.168.64.1
```

```
yasmim@lan-client-1:~$ █
```

- Evidences/Network 1/Traffic control/Enabled+verified status.png
- Evidences/Network 1/Traffic control/Port 22 listener check.png
- Evidences/Network 1/Traffic control/Port listening.png
- Evidences/Network 1/Evaluate stage/fix SSH.png (if you used it)
- Evidences/Network 1/Evaluate stage/Terminal_Login_Ubuntu.png

Step N1.3 — Start iperf3 server (Server)

Run on: Ubuntu Server

iperf3 -s

 Evidence:

```
yasmim@lan-client-1:~$ iperf3 -s
-----
Server listening on 5201 (test #1)
-----
yasmim@lan-server-1:~$ iperf3 -s
-----
Server listening on 5201 (test #1)
-----
```

- Evidences/Network 1/Traffic control/Client server listening on 5201....png
 - Evidences/Network 1/Evaluate stage/Server listening on 5201.png
-

Step N1.4 — Run baseline throughput test (Client)

Run on: Ubuntu Client

iperf3 -c 192.168.64.3 -t 10

Evidence:

Ubuntu-LAN-Client

```
* Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s just raised the bar for easy, resilient and secure K8s cluster deployment.

https://ubuntu.com/engage/secure-kubernetes-at-the-edge

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

2 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.com/esm

yasmim@lan-client-1:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
        inet 127.0.0.1/8 scope host lo
            valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host noprefixroute
            valid_lft forever preferred_lft forever
2: enp0s1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether f2:1d:67:fa:b1:53 brd ff:ff:ff:ff:ff:ff
        inet 192.168.64.2/24 metric 100 brd 192.168.64.255 scope global dynamic enp0s1
            valid_lft 3562sec preferred_lft 3562sec
        inet6 fdcd:c6d0:e822:b904:f01d:67ff:fe:fa:b153/64 scope global dynamic mngtmpaddr noprefixroute
            valid_lft 2591965sec preferred_lft 604765sec
        inet6 fe80::f01d:67ff:fe:fa:b153/64 scope link
            valid_lft forever preferred_lft forever
yasmim@lan-client-1:~$ iperf3 -c 192.168.64.3
Connecting to host 192.168.64.3, port 5201
[ 5] local 192.168.64.2 port 44618 connected to 192.168.64.3 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 5]  0.00-1.00   sec   418 MBytes  3.50 Gbits/sec    0  1.90 MBytes
[ 5]  1.00-2.00   sec   410 MBytes  3.43 Gbits/sec    0  2.10 MBytes
[ 5]  2.00-3.00   sec   404 MBytes  3.39 Gbits/sec    0  2.22 MBytes
[ 5]  3.00-4.00   sec   414 MBytes  3.47 Gbits/sec    0  2.35 MBytes
[ 5]  4.00-5.00   sec   406 MBytes  3.41 Gbits/sec    0  2.35 MBytes
[ 5]  5.00-6.00   sec   412 MBytes  3.46 Gbits/sec    0  2.35 MBytes
[ 5]  6.00-7.00   sec   408 MBytes  3.43 Gbits/sec    0  2.35 MBytes
[ 5]  7.00-8.00   sec   414 MBytes  3.48 Gbits/sec    0  2.63 MBytes
[ 5]  8.00-9.00   sec   416 MBytes  3.49 Gbits/sec    0  2.63 MBytes
[ 5]  9.00-10.00  sec   410 MBytes  3.43 Gbits/sec    0  2.63 MBytes
[ 5]  0.00-10.00  sec  4.02 GBytes  3.45 Gbits/sec    0
[ 5]  0.00-10.02  sec  4.02 GBytes  3.44 Gbits/sec
iperf Done.
yasmim@lan-client-1:~$ -----
Server listening on 5201 (test #2)
-----
```

```
Last login: Wed Jan 12 00:42:47 2020 from 172.168.64.1
[yasmim@lan-client-1:~$ iperf3 --version
iperf 3.16 (cJSON 1.7.15)
Linux lan-client-1 6.8.0-100-generic #100-Ubuntu SMP PREEMPT_DYNAMIC Tue Jan 13
16:39:21 UTC 2026 aarch64
Optional features available: CPU affinity setting, IPv6 flow label, SCTP, TCP co
ngestion algorithm setting, sendfile / zero-copy, socket pacing, authentication,
bind to device, support IPv4 don't fragment, POSIX threads
yasmim@lan-client-1:~$ iperf3 -c 192.168.64.2
Connecting to host 192.168.64.2, port 5201
[ 5] local 192.168.64.2 port 58428 connected to 192.168.64.2 port 5201
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 5]  0.00-1.00   sec  13.0 GBytes   112 Gbits/sec    0  1.56 MBytes
[ 5]  1.00-2.00   sec  12.0 GBytes   103 Gbits/sec    2  2.06 MBytes
[ 5]  2.00-3.00   sec  13.1 GBytes   113 Gbits/sec    0  2.12 MBytes
[ 5]  3.00-4.00   sec  12.8 GBytes   110 Gbits/sec    1  2.75 MBytes
[ 5]  4.00-5.00   sec  12.8 GBytes   110 Gbits/sec    0  2.75 MBytes
[ 5]  5.00-6.00   sec  13.2 GBytes   113 Gbits/sec    0  2.75 MBytes
[ 5]  6.00-7.00   sec  12.9 GBytes   110 Gbits/sec    0  2.75 MBytes
[ 5]  7.00-8.00   sec  12.4 GBytes   107 Gbits/sec    1  2.75 MBytes
[ 5]  8.00-9.00   sec  13.1 GBytes   113 Gbits/sec    0  2.87 MBytes
[ 5]  9.00-10.00  sec  11.9 GBytes   102 Gbits/sec    0  3.18 MBytes
- - - - -
[ ID] Interval          Transfer     Bitrate      Retr
[ 5]  0.00-10.00  sec  127 GBytes   109 Gbits/sec    4
[ 5]  0.00-10.00  sec  127 GBytes   109 Gbits/sec
sender
receiver

iperf Done.
yasmim@lan-client-1:~$
```

```
perf Done.
yasmim@lan-client-1:~$ ip a
:: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host noprefixroute
        valid_lft forever preferred_lft forever
:: enp0s1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether f2:1d:67:fa:b1:53 brd ff:ff:ff:ff:ff:ff
    inet 192.168.64.2/24 metric 100 brd 192.168.64.255 scope global dynamic enp0s1
        valid_lft 3561sec preferred_lft 3561sec
    inet6 fdcdc:c6d0:e822:b904:f01d:67ff:fe:fa:b153/64 scope global dynamic mngtmpaddr noprefixroute
        valid_lft 2591949sec preferred_lft 604749sec
    inet6 fe80::f01d:67ff:fe:fa:b153/64 scope link
        valid_lft forever preferred_lft forever
yasmim@lan-client-1:~$
```

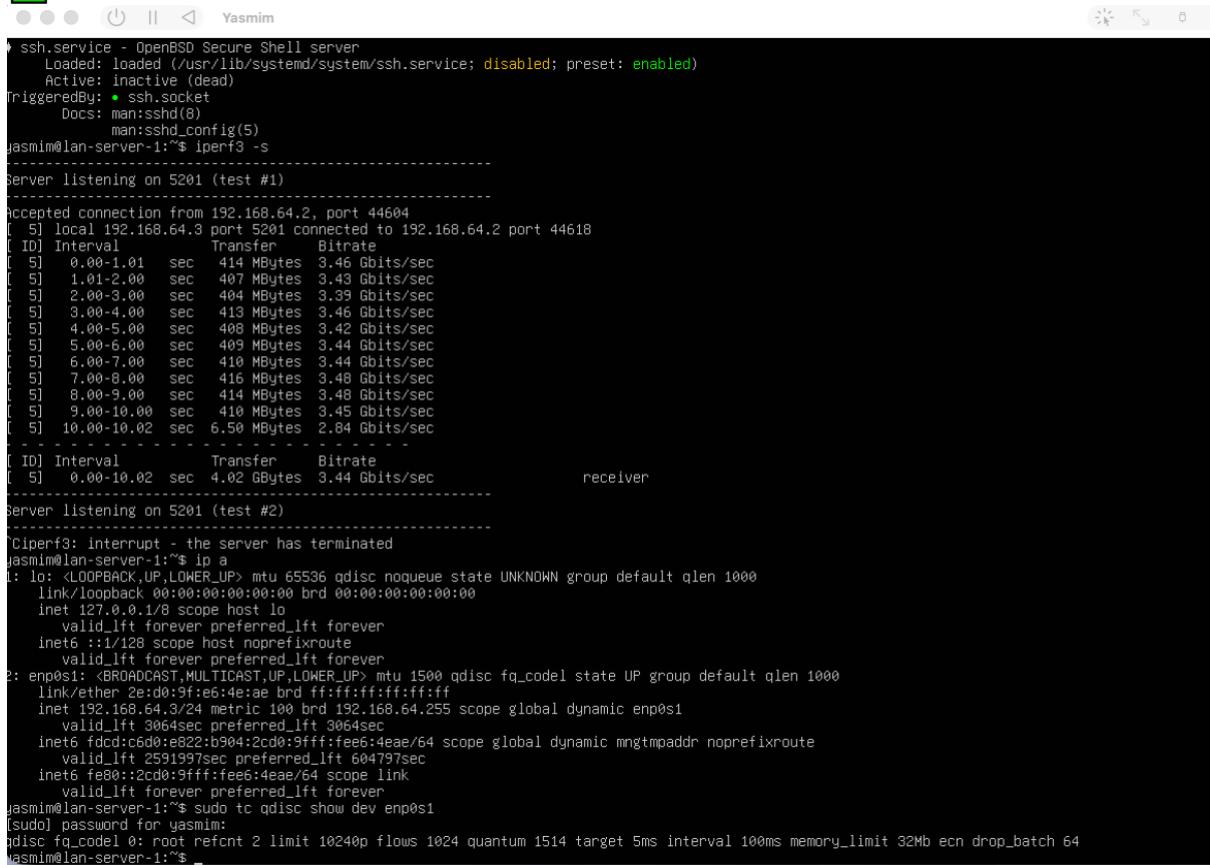
- Evidences/Network 1/Evaluate stage/iperf3 CLIENT to SERVER.png
- Evidences/Network 1/Evaluate stage/iperf3 test result.png
- Evidences/Network 1/Traffic control/Baseline throughput.png

Step N1.5 — Check current qdisc (Server)

Run on: Ubuntu Server

sudo tc qdisc show dev enp0s1

 Evidence:



```

● Evidence:
Yasmin
ssh.service - OpenBSD Secure Shell server
  Loaded: loaded (/usr/lib/systemd/system/ssh.service; disabled; preset: enabled)
  Active: inactive (dead)
TriggeredBy: • ssh.socket
    Docs: man:sshd(8)
           man:sshd_config(5)
yasmim@lan-server-1:~$ iperf3 -s
Server listening on 5201 (test #1)
Accepted connection from 192.168.64.2, port 44604
[ 5] local 192.168.64.3 port 5201 connected to 192.168.64.2 port 44604
[ ID] Interval      Transfer     Bitrate
[ 5]  0.00-1.01   sec   414 MBytes  3.46 Gbits/sec
[ 5]  1.01-2.00   sec   407 MBytes  3.43 Gbits/sec
[ 5]  2.00-3.00   sec   404 MBytes  3.39 Gbits/sec
[ 5]  3.00-4.00   sec   413 MBytes  3.46 Gbits/sec
[ 5]  4.00-5.00   sec   408 MBytes  3.42 Gbits/sec
[ 5]  5.00-6.00   sec   409 MBytes  3.44 Gbits/sec
[ 5]  6.00-7.00   sec   410 MBytes  3.44 Gbits/sec
[ 5]  7.00-8.00   sec   416 MBytes  3.48 Gbits/sec
[ 5]  8.00-9.00   sec   414 MBytes  3.48 Gbits/sec
[ 5]  9.00-10.00  sec   410 MBytes  3.45 Gbits/sec
[ 5] 10.00-10.02  sec   6.50 MBytes  2.84 Gbits/sec
[ ID] Interval      Transfer     Bitrate
[ 5]  0.00-10.02  sec  4.02 GBytes  3.44 Gbits/sec
                                         receiver
Server listening on 5201 (test #2)
Ciperf3: interrupt - the server has terminated
yasmim@lan-server-1:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
  link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
      valid_lft forever preferred_lft forever
  inetc6 ::1/128 scope host noprefixroute
    valid_lft forever preferred_lft forever
2: enp0s1: <NOQUEUE,BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
  link/ether 2e:0:9f:e6:4e:ae brd ff:ff:ff:ff:ff:ff
    inet 192.168.64.3/24 metric 100 brd 192.168.64.255 scope global dynamic enp0s1
      valid_lft 3064sec preferred_lft 3064sec
    inetc6 fd00:e822:b904:2cd0:9ffff:fee6:4eae/64 scope global dynamic mngtmpaddr noprefixroute
      valid_lft 604797sec preferred_lft 604797sec
  inetc6 fe80::2cd0:9ffff:fee6:4eae/64 scope link
    valid_lft forever preferred_lft forever
yasmim@lan-server-1:~$ sudo tc qdisc show dev enp0s1
[sudo] password for yasmim:
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mb ecn drop_batch 64
yasmim@lan-server-1:~$ 

```

- Evidences/Network 1/Traffic control/qdisc.png

Step N1.6 — Apply traffic shaping (TBF) (Server)

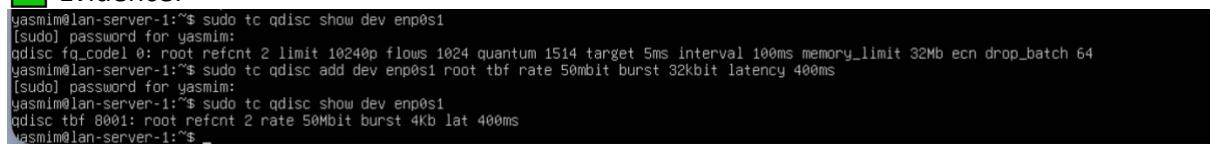
Run on: Ubuntu Server

```

sudo tc qdisc add dev enp0s1 root tbf rate 50mbit burst 32kbit latency 400ms
sudo tc qdisc show dev enp0s1

```

 Evidence:



```

● Evidence:
yasmim@lan-server-1:~$ sudo tc qdisc show dev enp0s1
[sudo] password for yasmim:
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mb ecn drop_batch 64
yasmim@lan-server-1:~$ sudo tc qdisc add dev enp0s1 root tbf rate 50mbit burst 32kbit latency 400ms
[sudo] password for yasmim:
yasmim@lan-server-1:~$ sudo tc qdisc show dev enp0s1
qdisc tbf 8001: root refcnt 2 rate 50Mbit burst 4Kb lat 400ms
yasmim@lan-server-1:~$ 

```

- Evidences/Network 1/Traffic control/TC applied.png

Step N1.7 — Re-test after shaping (Client)

Run on: Ubuntu Client

```

iperf3 -c 192.168.64.3 -t 10

```

Evidence:

```
yasmin@lan-server-1:~$ sudo ss -lntp | grep 5201 || echo "5201 not listening"
[ 5] 0.00-10.00 sec 4.02 GBytes 3.45 Gbits/sec 0 sender
[ 5] 0.00-10.02 sec 4.02 GBytes 3.44 Gbits/sec receiver
5201 not listening
yasmin@lan-server-1:~$ iperf3 -s
-----
Server listening on 5201 (test #1)
-----
Accepted connection from 192.168.64.2, port 34362
[ 5] local 192.168.64.3 port 5201 connected to 192.168.64.2 port 34370
[ 10] Interval Transfer Bitrate
[ 5] 0.00-1.00 sec 414 MBBytes 3.46 Gbits/sec
[ 5] 1.00-2.00 sec 413 MBBytes 3.46 Gbits/sec
[ 5] 2.00-3.00 sec 414 MBBytes 3.47 Gbits/sec
[ 5] 3.00-4.00 sec 410 MBBytes 3.44 Gbits/sec
[ 5] 4.00-5.00 sec 414 MBBytes 3.47 Gbits/sec
[ 5] 5.00-6.00 sec 409 MBBytes 3.44 Gbits/sec
[ 5] 6.00-7.00 sec 412 MBBytes 3.46 Gbits/sec
[ 5] 7.00-8.00 sec 376 MBBytes 3.16 Gbits/sec
[ 5] 8.00-9.00 sec 349 MBBytes 2.93 Gbits/sec
[ 5] 9.00-10.00 sec 384 MBBytes 3.23 Gbits/sec
[ 10] Interval Transfer Bitrate
[ 5] 0.00-10.00 sec 3.90 GBBytes 3.35 Gbits/sec
----- receiver [ 10] Interval Transfer Bitrate Retr Cwnd
[ 5] 0.00-10.00 sec 3.91 GBBytes 3.35 Gbits/sec 0 2.05 MBBytes
[ 5] 0.00-10.00 sec 3.98 GBBytes 3.35 Gbits/sec 0 2.41 MBBytes
iperf Done.
yasmin@lan-client-1:~$ _
```

```
^Ciperf3: interrupt - the server has terminated
yasmin@lan-server-1:~$ sudo tc qdisc del dev enp0s1 root
yasmin@lan-server-1:~$ sudo tc qdisc show dev enp0s1
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mbecn drop_batch 64
yasmin@lan-server-1:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host noprefixroute
        valid_lft forever preferred_lft forever
2: enp0s1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 2e:d0:9f:e6:4e:ae brd ff:ff:ff:ff:ff:ff
    inet 192.168.64.3/24 metric 100 brd 192.168.64.255 scope global dynamic enp0s1
        valid_lft 2210sec preferred_lft 2210sec
    inet6 fd0d:cd00:eb22:b904:2cd0:ffff:feee:4eae/64 scope global dynamic mngtmpaddr noprefixroute
        valid_lft 591983sec preferred_lft 604783sec
    inet6 fe00::c0d0:9fff:feee:4eae/64 scope link
        valid_lft forever preferred_lft forever
yasmin@lan-server-1:~$ sudo tc qdisc show dev enp0s1
[sudo] password for yasmin:
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mbecn drop_batch 64
yasmin@lan-server-1:~$ _
```

- Evidences/Network 1/Traffic control/test after tc_limited speed.png
- Evidences/Network 1/Traffic control/tc shaping.png

Step N1.8 — Rollback (remove shaping) (Server)

Run on: Ubuntu Server

```
sudo tc qdisc del dev enp0s1 root 2>/dev/null
sudo tc qdisc show dev enp0s1
```

Evidence:

```
^Ciperf3: interrupt - the server has terminated
yasmin@lan-server-1:~$ sudo tc qdisc del dev enp0s1 root
yasmin@lan-server-1:~$ sudo tc qdisc show dev enp0s1
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mbecn drop_batch 64
yasmin@lan-server-1:~$ _
```

- Evidences/Network 1/Traffic control/tc removed.png

Network 2 — Baseline + NetEm impairment (delay/jitter/loss)

Goal

Simulate unstable WAN conditions using netem and observe impact.

Step N2.1 — Ensure no old tc rule is active (Server)

Run on: Ubuntu Server

SUDO TC QDISC DEL DEV ENP0S1 ROOT 2>/DEV/NULL

SUDO TC QDISC SHOW DEV ENP0S1

Evidence:

```
Ciperf3: interrupt - the server has terminated
yasmim@lan-server-1:~$ sudo tc qdisc del dev enp0s1 root 2>/dev/null
yasmim@lan-server-1:~$ sudo tc qdisc show dev enp0s1
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mb ecn drop_batch 64
yasmim@lan-server-1:~$
```

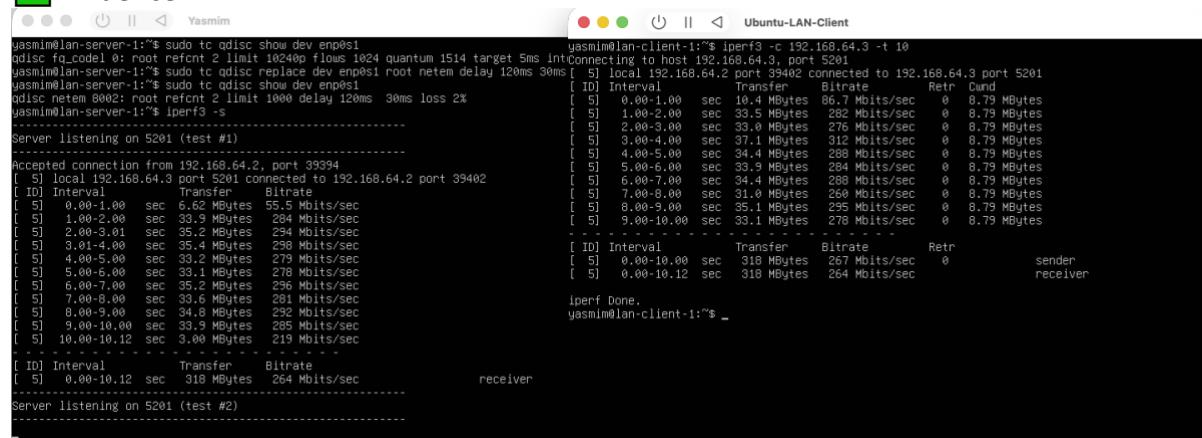
- Evidences/Network 2/N2_tc_removed.png
-

Step N2.2 — Start iperf3 server (Server)

Run on: Ubuntu Server

iperf3 -s

Evidence:



- Evidences/Network 2/N2_Server_listening.png
-

Step N2.3 — Baseline throughput (Client)

Run on: Ubuntu Client

iperf3 -c 192.168.64.3 -t 10

Evidence:

```

yasmim@lan-client-1:~$ iperf3 -c 192.168.64.3 -t 10
Connecting to host 192.168.64.3, port 5201
[ 5] local 192.168.64.2 port 55324 connected to 192.168.64.3 port 5201
[ ID] Interval      Transfer     Bitrate      Retr  Cwnd
[ 5]  0.00-1.00  sec   421 MBytes  3.52 Gbits/sec   0  2.07 MBytes
[ 5]  1.00-2.00  sec   410 MBytes  3.45 Gbits/sec   0  2.19 MBytes
[ 5]  2.00-3.00  sec   413 MBytes  3.46 Gbits/sec   0  2.30 MBytes
[ 5]  3.00-4.00  sec   416 MBytes  3.49 Gbits/sec   0  2.56 MBytes
[ 5]  4.00-5.00  sec   416 MBytes  3.48 Gbits/sec   0  2.56 MBytes
[ 5]  5.00-6.00  sec   412 MBytes  3.46 Gbits/sec   0  2.56 MBytes
[ 5]  6.00-7.00  sec   405 MBytes  3.40 Gbits/sec   0  2.56 MBytes
[ 5]  7.00-8.00  sec   414 MBytes  3.47 Gbits/sec   0  2.56 MBytes
[ 5]  8.00-9.00  sec   414 MBytes  3.47 Gbits/sec   0  2.56 MBytes
[ 5]  9.00-10.01 sec   417 MBytes  3.47 Gbits/sec   0  2.56 MBytes
-
[ ID] Interval      Transfer     Bitrate      Retr
[ 5]  0.00-10.01 sec  4.04 GBytes  3.47 Gbits/sec   0
[ 5]  0.00-10.01 sec  4.04 GBytes  3.47 Gbits/sec

iperf Done.
yasmim@lan-client-1:~$

```

```

gasminelan-server-1:~$ sudo tc qdisc del dev enp0s1 root 2>/dev/null
[sudo] password for yasmim:
gasminelan-server-1:~$ tc qdisc show dev enp0s1
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mb ecn drop_batch 64
gasminelan-server-1:~$ iperf3 -s
-----
Server listening on 5201 (test #1)
-----
Accepted connection from 192.168.64.2, port 55312
[ 5] local 192.168.64.3 port 5201 connected to 192.168.64.2 port 55324
[ ID] Interval      Transfer     Bitrate      Retr
[ 5]  0.00-1.00  sec   417 MBytes  3.49 Gbits/sec
[ 5]  1.00-2.00  sec   411 MBytes  3.45 Gbits/sec
[ 5]  2.00-3.00  sec   413 MBytes  3.47 Gbits/sec
[ 5]  3.00-4.00  sec   417 MBytes  3.49 Gbits/sec
[ 5]  4.00-5.00  sec   416 MBytes  3.48 Gbits/sec
[ 5]  5.00-6.00  sec   410 MBytes  3.44 Gbits/sec
[ 5]  6.00-7.00  sec   405 MBytes  3.39 Gbits/sec
[ 5]  7.00-8.00  sec   414 MBytes  3.48 Gbits/sec
[ 5]  8.00-9.00  sec   413 MBytes  3.47 Gbits/sec
[ 5]  9.00-10.00 sec   418 MBytes  3.50 Gbits/sec
[ 5]  10.00-10.01 sec   3.88 MBytes  2.81 Gbits/sec
-
[ ID] Interval      Transfer     Bitrate      Retr
[ 5]  0.00-10.01 sec  4.04 GBytes  3.47 Gbits/sec

Server listening on 5201 (test #2)
-----

```

- Evidences/Network 2/Client_N2_baseline_iperf_test.png
- Evidences/Network 2/Server_N2_baseline_iperf_test.png

Step N2.4 — Apply netem impairment (Server)

Run on: Ubuntu Server

sudo tc qdisc replace dev enp0s1 root netem delay 120ms 30ms loss 2%
sudo tc qdisc show dev enp0s1

 Evidence:    ⏻ ⏴ ⏵ Yasmim

```
yasmin@lan-server-1:~$ sudo tc qdisc show dev enp0s1
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mb ecn drop_batch 64
yasmin@lan-server-1:~$ sudo tc qdisc replace dev enp0s1 root netem delay 120ms 30ms loss 2%
qdisc netem 8002: root refcnt 2 limit 1000 delay 120ms 30ms loss 2%
yasmin@lan-server-1:~$ _
```

- Evidences/Network 2/N2_tc_netem_applied.png

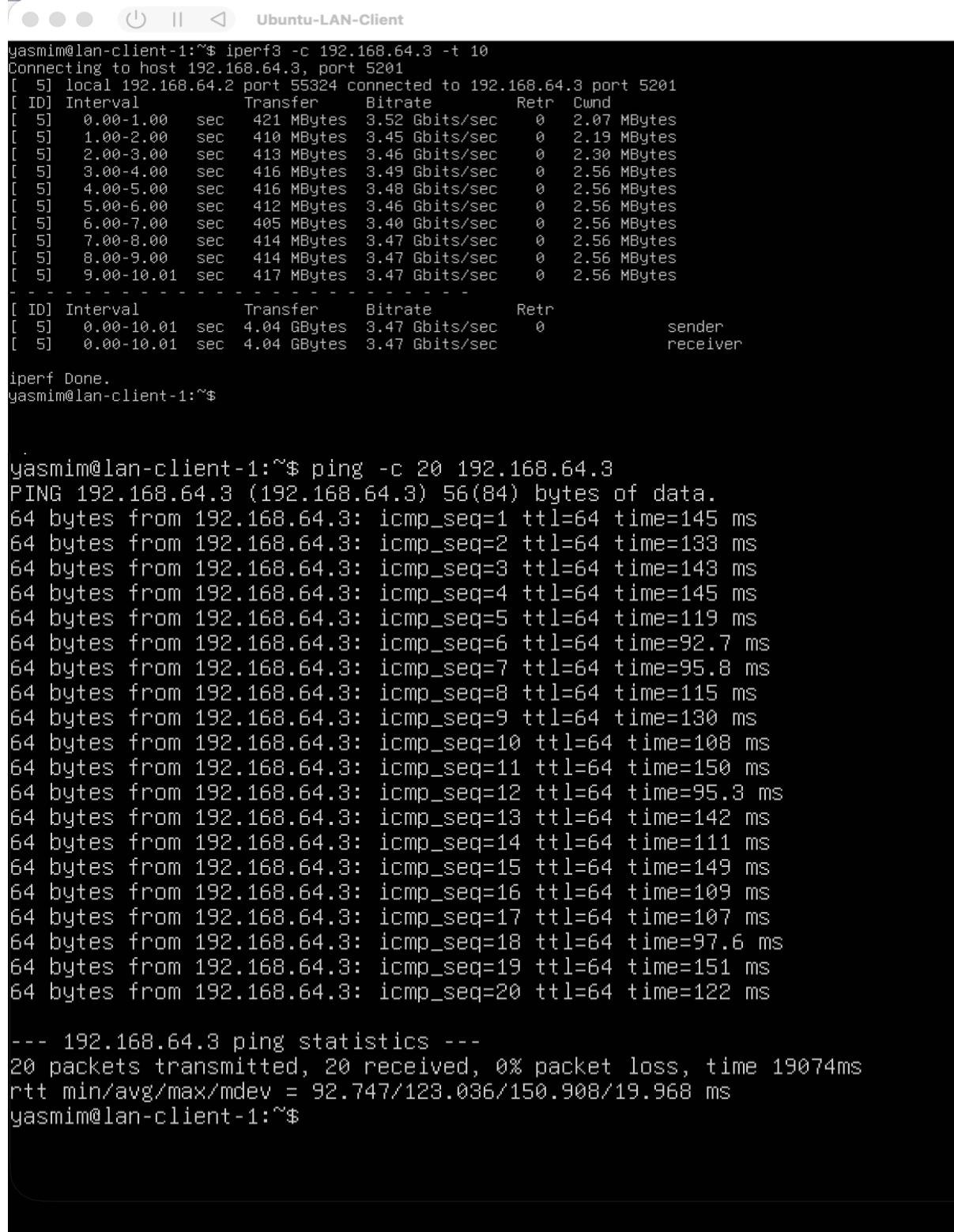
Step N2.5 — Test after impairment (Client)

Run on: Ubuntu Client

iperf3 -c 192.168.64.3 -t 10

ping -c 20 192.168.64.3

Evidence:



```

yasmim@lan-client-1:~$ iperf3 -c 192.168.64.3 -t 10
Connecting to host 192.168.64.3, port 5201
[ 5] local 192.168.64.2 port 55324 connected to 192.168.64.3 port 5201
[ ID] Interval      Transfer     Bitrate      Retr  Cwnd
[ 5]  0.00-1.00  sec   421 MBytes  3.52 Gbits/sec    0  2.07 MBytes
[ 5]  1.00-2.00  sec   410 MBytes  3.45 Gbits/sec    0  2.19 MBytes
[ 5]  2.00-3.00  sec   413 MBytes  3.46 Gbits/sec    0  2.30 MBytes
[ 5]  3.00-4.00  sec   416 MBytes  3.49 Gbits/sec    0  2.56 MBytes
[ 5]  4.00-5.00  sec   416 MBytes  3.48 Gbits/sec    0  2.56 MBytes
[ 5]  5.00-6.00  sec   412 MBytes  3.46 Gbits/sec    0  2.56 MBytes
[ 5]  6.00-7.00  sec   405 MBytes  3.40 Gbits/sec    0  2.56 MBytes
[ 5]  7.00-8.00  sec   414 MBytes  3.47 Gbits/sec    0  2.56 MBytes
[ 5]  8.00-9.00  sec   414 MBytes  3.47 Gbits/sec    0  2.56 MBytes
[ 5]  9.00-10.01 sec   417 MBytes  3.47 Gbits/sec   0  2.56 MBytes
[ ID] Interval      Transfer     Bitrate      Retr
[ 5]  0.00-10.01 sec  4.04 GBytes  3.47 Gbits/sec    0
[ 5]  0.00-10.01 sec  4.04 GBytes  3.47 Gbits/sec
                                         sender
                                         receiver

iperf Done.
yasmim@lan-client-1:~$


yasmim@lan-client-1:~$ ping -c 20 192.168.64.3
PING 192.168.64.3 (192.168.64.3) 56(84) bytes of data.
64 bytes from 192.168.64.3: icmp_seq=1 ttl=64 time=145 ms
64 bytes from 192.168.64.3: icmp_seq=2 ttl=64 time=133 ms
64 bytes from 192.168.64.3: icmp_seq=3 ttl=64 time=143 ms
64 bytes from 192.168.64.3: icmp_seq=4 ttl=64 time=145 ms
64 bytes from 192.168.64.3: icmp_seq=5 ttl=64 time=119 ms
64 bytes from 192.168.64.3: icmp_seq=6 ttl=64 time=92.7 ms
64 bytes from 192.168.64.3: icmp_seq=7 ttl=64 time=95.8 ms
64 bytes from 192.168.64.3: icmp_seq=8 ttl=64 time=115 ms
64 bytes from 192.168.64.3: icmp_seq=9 ttl=64 time=130 ms
64 bytes from 192.168.64.3: icmp_seq=10 ttl=64 time=108 ms
64 bytes from 192.168.64.3: icmp_seq=11 ttl=64 time=150 ms
64 bytes from 192.168.64.3: icmp_seq=12 ttl=64 time=95.3 ms
64 bytes from 192.168.64.3: icmp_seq=13 ttl=64 time=142 ms
64 bytes from 192.168.64.3: icmp_seq=14 ttl=64 time=111 ms
64 bytes from 192.168.64.3: icmp_seq=15 ttl=64 time=149 ms
64 bytes from 192.168.64.3: icmp_seq=16 ttl=64 time=109 ms
64 bytes from 192.168.64.3: icmp_seq=17 ttl=64 time=107 ms
64 bytes from 192.168.64.3: icmp_seq=18 ttl=64 time=97.6 ms
64 bytes from 192.168.64.3: icmp_seq=19 ttl=64 time=151 ms
64 bytes from 192.168.64.3: icmp_seq=20 ttl=64 time=122 ms

--- 192.168.64.3 ping statistics ---
20 packets transmitted, 20 received, 0% packet loss, time 19074ms
rtt min/avg/max/mdev = 92.747/123.036/150.908/19.968 ms
yasmim@lan-client-1:~$
```

- Evidences/Network 2/ N2_tc_netem_applied.png

Step N2.6 — Rollback (remove netem) (Server)

Run on: Ubuntu Server

```
sudo tc qdisc del dev enp0s1 root 2>/dev/null  
sudo tc qdisc show dev enp0s1
```

Evidence:

```
^Ciperf3: interrupt - the server has terminated  
jasmin@lan-server-1:~$ sudo tc qdisc del dev enp0s1 root 2>/dev/null  
jasmin@lan-server-1:~$ sudo tc qdisc show dev enp0s1  
qdisc fq_codel 0: root refcnt 2 limit 10240p flows 1024 quantum 1514 target 5ms interval 100ms memory_limit 32Mbecn drop_batch 64  
jasmin@lan-server-1:~$
```

- Evidences/Network 2/N2_tc_removed.png
-

Evidence Mapping Summary

Network 1 evidence list

- **IP & route validation:** Evaluate stage/ip a + route_client1.png
- **iperf server ready:** Evaluate stage/Server listening on 5201.png + Traffic control/Client server listening on 5201...png
- **baseline throughput:** Evaluate stage/iperf3 CLIENT to SERVER.png + Traffic control/Baseline throughput.png
- **qdisc baseline:** Traffic control/qdisc.png
- **TBF applied:** Traffic control/TC applied.png
- **throughput reduced after shaping:** Traffic control/test after tc_limited speed.png
- **rollback (tc removed):** Traffic control/tc removed.png
-

Network 2 evidence list

- **tc cleared:** N2_tc_removed.png
 - **iperf server ready:** N2_Server_listening.png
 - **baseline throughput:** Client_N2_baseline_iperf_test.png + Server_N2_baseline_iperf_test.png
 - **netem applied:** N2_tc_netem_applied.png
 - **performance impact after netem:** N2_iperf_after_netem.png
-