

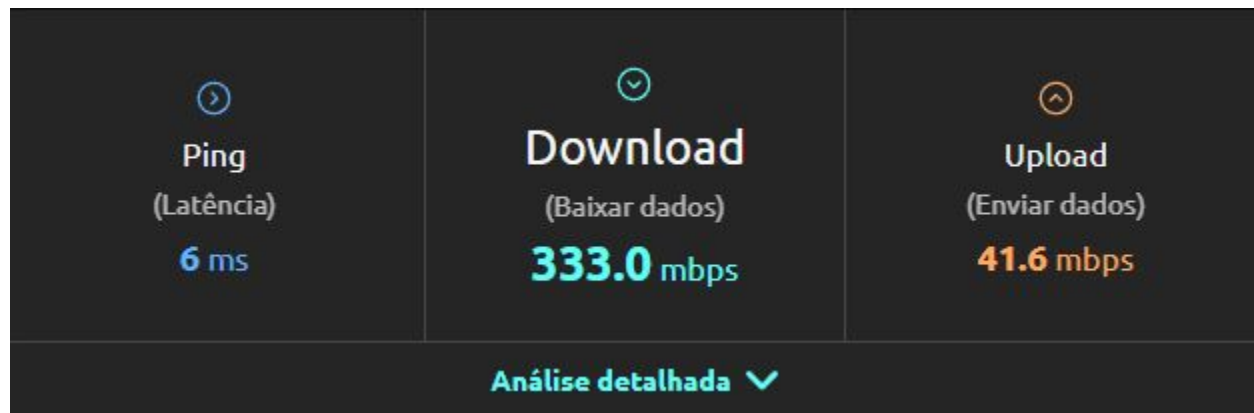
**Estudo aumentando gradativamente a carga
UDP. Qual o impacto no TCP?
Ocorre starvation?**

Ferramentas utilizadas

- Iperf3 para monitoramento de rede
- Python para extrair os dados mais importantes

Observações

- Para o cenário 1 e cenário 2 os computadores estão na mesma rede
- Foram fechado processos que consumiam banda
- Ambos continham o sistemas operacionais Windows 10



Observações

TCP

- Executando servidor e cliente na mesma máquina

```
-----
Server listening on 5201
-----
Accepted connection from 192.168.0.136, port 36888
[ 5] local 192.168.0.129 port 5201 connected to 192.168.0.136 port 36900
[ ID] Interval          Transfer      Bandwidth
[ 5] 0.00-1.00 sec      265 MBytes   2.22 Gbits/sec
[ 5] 1.00-2.00 sec      249 MBytes   2.09 Gbits/sec
[ 5] 2.00-3.00 sec      282 MBytes   2.36 Gbits/sec
[ 5] 3.00-4.00 sec      282 MBytes   2.37 Gbits/sec
[ 5] 4.00-5.00 sec      290 MBytes   2.43 Gbits/sec
[ 5] 5.00-6.00 sec      280 MBytes   2.35 Gbits/sec
[ 5] 6.00-7.00 sec      285 MBytes   2.39 Gbits/sec
[ 5] 7.00-8.00 sec      275 MBytes   2.31 Gbits/sec
[ 5] 8.00-9.00 sec      258 MBytes   2.17 Gbits/sec
[ 5] 9.00-10.00 sec     264 MBytes   2.21 Gbits/sec
[ 5] 10.00-10.04 sec    11.0 MBytes   2.37 Gbits/sec
-----
[ ID] Interval          Transfer      Bandwidth
[ 5] 0.00-10.04 sec     0.00 Bytes    0.00 bits/sec
[ 5] 0.00-10.04 sec     2.68 GBytes   2.29 Gbits/sec
                                     sender
                                     receiver
```

Observações

UDP

- Executando servidor e cliente na mesma máquina

```
Server listening on 5201
-----
Accepted connection from 192.168.0.136, port 36134
[ 5] local 192.168.0.129 port 5201 connected to 192.168.0.136 port 52902
[ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
[ 5]  0.00-1.00    sec  40.1 MBytes  337 Mbits/sec  0.018 ms    22221/51040 (44%)
[ 5]  1.00-2.00    sec  41.5 MBytes  348 Mbits/sec  0.024 ms    22775/52604 (43%)
[ 5]  2.00-3.00    sec  42.0 MBytes  353 Mbits/sec  0.025 ms    26602/56795 (47%)
[ 5]  3.00-4.00    sec  42.1 MBytes  353 Mbits/sec  0.026 ms    28487/58689 (49%)
[ 5]  4.00-5.00    sec  42.2 MBytes  354 Mbits/sec  0.018 ms    27728/58036 (48%)
[ 5]  5.00-6.00    sec  41.4 MBytes  347 Mbits/sec  0.018 ms    27703/57430 (48%)
[ 5]  6.00-7.00    sec  42.3 MBytes  355 Mbits/sec  0.024 ms    27665/58077 (48%)
[ 5]  7.00-8.00    sec  42.0 MBytes  352 Mbits/sec  0.020 ms    41587/71747 (58%)
[ 5]  8.00-9.00    sec  40.7 MBytes  341 Mbits/sec  0.006 ms    87275/116500 (75%)
[ 5]  9.00-10.00   sec  40.2 MBytes  337 Mbits/sec  0.011 ms    80285/109161 (74%)
[ 5] 10.00-10.04   sec   1.41 MBytes  317 Mbits/sec  0.016 ms     2913/3924 (74%)
-----
[ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
[ 5]  0.00-10.04   sec    0.00 Bytes    0.00 bits/sec  0.016 ms   395241/694003 (57%)
-----
```

Observações

TCP

- Executando servidor (Ethernet) e cliente (Wireless) em máquinas separadas mas na mesma rede

```
-----
Server listening on 5201
-----
Accepted connection from 192.168.0.129 port 5201 connected to 192.168.0.162 port 53418
[ 5] local 192.168.0.129 port 5201 connected to 192.168.0.162 port 53418
[ ID] Interval          Transfer      Bandwidth
[ 5] 0.00-1.00 sec      28.1 MBytes  236 Mbits/sec
[ 5] 1.00-2.00 sec      30.7 MBytes  258 Mbits/sec
[ 5] 2.00-3.00 sec      29.9 MBytes  251 Mbits/sec
[ 5] 3.00-4.00 sec      22.9 MBytes  192 Mbits/sec
[ 5] 4.00-5.00 sec      19.2 MBytes  161 Mbits/sec
[ 5] 5.00-6.00 sec      18.7 MBytes  157 Mbits/sec
[ 5] 6.00-7.00 sec      24.1 MBytes  202 Mbits/sec
[ 5] 7.00-8.00 sec      28.6 MBytes  240 Mbits/sec
[ 5] 8.00-9.00 sec      27.9 MBytes  234 Mbits/sec
[ 5] 9.00-10.00 sec     27.5 MBytes  230 Mbits/sec
[ 5] 10.00-10.04 sec    1.26 MBytes  255 Mbits/sec
-----
[ ID] Interval          Transfer      Bandwidth
[ 5] 0.00-10.04 sec      0.00 Bytes   0.00 bits/sec
[ 5] 0.00-10.04 sec      259 MBytes  216 Mbits/sec
                                     sender
                                     receiver
```

Observações

UDP

- Executando servidor (Ethernet) e cliente (Wireless) em máquinas separadas mas na mesma rede

```
Server listening on 5201
-----
Accepted connection from 177.34.71.239, port 63815
[ 5] local 192.168.0.129 port 5201 connected to 177.34.71.239 port 58868
[ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
[ 5]  0.00-1.00    sec  38.4 MBytes  322 Mbits/sec  0.250 ms    0/4909 (0%)
[ 5]  1.00-2.00    sec  41.1 MBytes  345 Mbits/sec  0.197 ms    0/5264 (0%)
[ 5]  2.00-3.00    sec  40.6 MBytes  341 Mbits/sec  0.363 ms    0/5198 (0%)
[ 5]  3.00-4.00    sec  40.5 MBytes  340 Mbits/sec  0.277 ms    0/5181 (0%)
[ 5]  4.00-5.00    sec  40.8 MBytes  342 Mbits/sec  0.295 ms   22/5248 (0.42%)
[ 5]  5.00-6.00    sec  40.6 MBytes  341 Mbits/sec  0.288 ms    8/5201 (0.15%)
[ 5]  6.00-7.00    sec  40.7 MBytes  342 Mbits/sec  0.205 ms    0/5213 (0%)
[ 5]  7.00-8.00    sec  41.0 MBytes  344 Mbits/sec  0.203 ms    0/5252 (0%)
[ 5]  8.00-9.00    sec  40.3 MBytes  338 Mbits/sec  0.268 ms    0/5160 (0%)
[ 5]  9.00-10.00   sec  40.8 MBytes  343 Mbits/sec  0.251 ms   35/5263 (0.67%)
[ 5] 10.00-10.05   sec   2.18 MBytes  341 Mbits/sec  0.215 ms    0/279 (0%)
-----
[ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
[ 5]  0.00-10.05   sec   0.00 Bytes   0.00 bits/sec  0.215 ms   65/52168 (0.12%)
-----
```


Observações

TCP

- Executando servidor (Ethernet) e cliente (Wireless) em máquinas e redes separadas

```
-----
Server listening on 5201
-----
Accepted connection from 177.181.61.21, port 30851
[ 5] local 192.168.0.129 port 5201 connected to 177.181.61.21 port 31158
[ ID] Interval          Transfer      Bandwidth
[ 5]  0.00-1.00    sec   65.0 KBytes    531 Kbits/sec
[ 5]  1.00-2.00    sec   1.35 KBytes   11.1 Kbits/sec
[ 5]  2.00-3.00    sec    138 KBytes   1.13 Mbits/sec
[ 5]  3.00-4.00    sec   73.1 KBytes    599 Kbits/sec
[ 5]  4.00-5.00    sec   74.4 KBytes    611 Kbits/sec
[ 5]  5.00-6.00    sec   74.1 KBytes    607 Kbits/sec
[ 5]  6.00-7.00    sec   73.1 KBytes    599 Kbits/sec
[ 5]  7.00-8.00    sec   74.4 KBytes    609 Kbits/sec
[ 5]  8.00-9.00    sec   73.1 KBytes    598 Kbits/sec
[ 5]  9.00-10.00   sec   73.1 KBytes    600 Kbits/sec
[ 5] 10.00-10.13   sec   10.8 KBytes    685 Kbits/sec
-----
[ ID] Interval          Transfer      Bandwidth
[ 5]  0.00-10.13   sec    0.00 Bytes    0.00 bits/sec
[ 5]  0.00-10.13   sec   731 KBytes    591 Kbits/sec
                                     sender
                                     receiver
```


Observações

UDP

- Executando servidor (Ethernet) e cliente (Wireless) em máquinas e redes separadas

```
-----
Server listening on 5201
-----
Accepted connection from 177.181.59.60, port 20614
[ 5] local 192.168.0.129 port 5201 connected to 177.181.59.60 port 20754
[ ID] Interval          Transfer      Bandwidth      Jitter    Lost/Total Datagrams
[ 5] 0.00-1.00 sec      48.0 KBytes   393 Kbits/sec  2888.144 ms  0/6 (0%)
[ 5] 1.00-2.00 sec       0.00 Bytes    0.00 bits/sec  2888.144 ms  0/0 (0%)
[ 5] 2.00-3.00 sec      16.0 KBytes   131 Kbits/sec  2569.189 ms  537/539 (1e+02%)
[ 5] 3.00-4.00 sec      40.0 KBytes   328 Kbits/sec  1907.839 ms  576/581 (99%)
[ 5] 4.00-5.00 sec      24.0 KBytes   196 Kbits/sec  1607.851 ms  326/329 (99%)
[ 5] 5.00-6.00 sec       0.00 Bytes    0.00 bits/sec  1607.851 ms  0/0 (0%)
[ 5] 6.00-7.00 sec      32.0 KBytes   262 Kbits/sec  1259.409 ms  1217/1221 (1e+02%)
[ 5] 7.00-8.00 sec       0.00 Bytes    0.00 bits/sec  1259.409 ms  0/0 (0%)
[ 5] 8.00-9.00 sec      32.0 KBytes   262 Kbits/sec  1007.069 ms  1221/1225 (1e+02%)
[ 5] 9.00-10.00 sec     8.00 KBytes   65.5 Kbits/sec  946.131 ms  181/182 (99%)
[ 5] 10.00-10.62 sec     0.00 Bytes    0.00 bits/sec  946.131 ms  0/0 (0%)
-----
[ ID] Interval          Transfer      Bandwidth      Jitter    Lost/Total Datagrams
[ 5] 0.00-10.62 sec     0.00 Bytes    0.00 bits/sec  946.131 ms  4058/4083 (99%)
-----
```

Base do cenário de teste

- Cenário 1 (Cliente e Servidor em máquinas diferentes mas na mesma rede)
 - 1 processo TCP (máximo)
 - 2 processo TCP (máximo)
 - 1 processo TCP (máximo) + 1 processo UDP (20%)
 - 1 processo TCP (máximo) + 1 processo UDP (40%)
 - 1 processo TCP (máximo) + 1 processo UDP (80%)
 - 1 processo TCP (máximo) + 1 processo UDP (100%)
- Cenário 2 (Cliente e Servidor em máquinas diferentes mas na mesma rede)
 - 1 processo TCP (máximo) + 2 processo UDP (0%)
 - 1 processo TCP (máximo) + 2 processo UDP (20%)
 - 1 processo TCP (máximo) + 2 processo UDP (40%)
 - 1 processo TCP (máximo) + 2 processo UDP (80%)
 - 1 processo TCP (máximo) + 2 processo UDP (100%)
- Cenário extra:
 - 1 processo TCP (máximo) + 1 processo UDP (100%)

Comandos

Servidor:

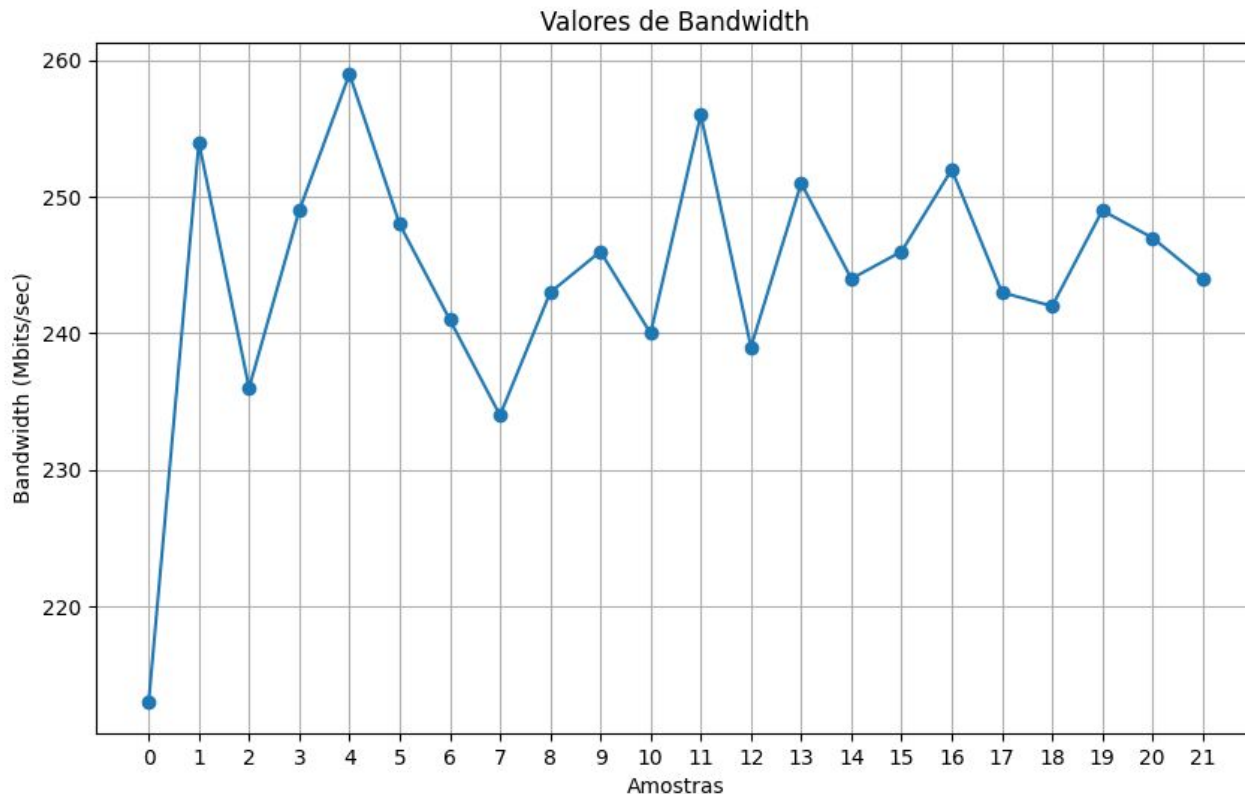
- Iniciar servidor TCP: `iperf3 -s -p 5201 --logfile ./output.txt`
- Iniciar servidor UDP: `iperf3 -s -p 5202`

Cliente:

- Iniciar cliente tcp: `iperf3 -c ip_servidor -p porta_servidor_N -b 1G -t 0 -P 1 -R`
- Iniciar cliente udp: `iperf3 -c ip_servidor -p 5201 -u -t 10 -b 0 -R`

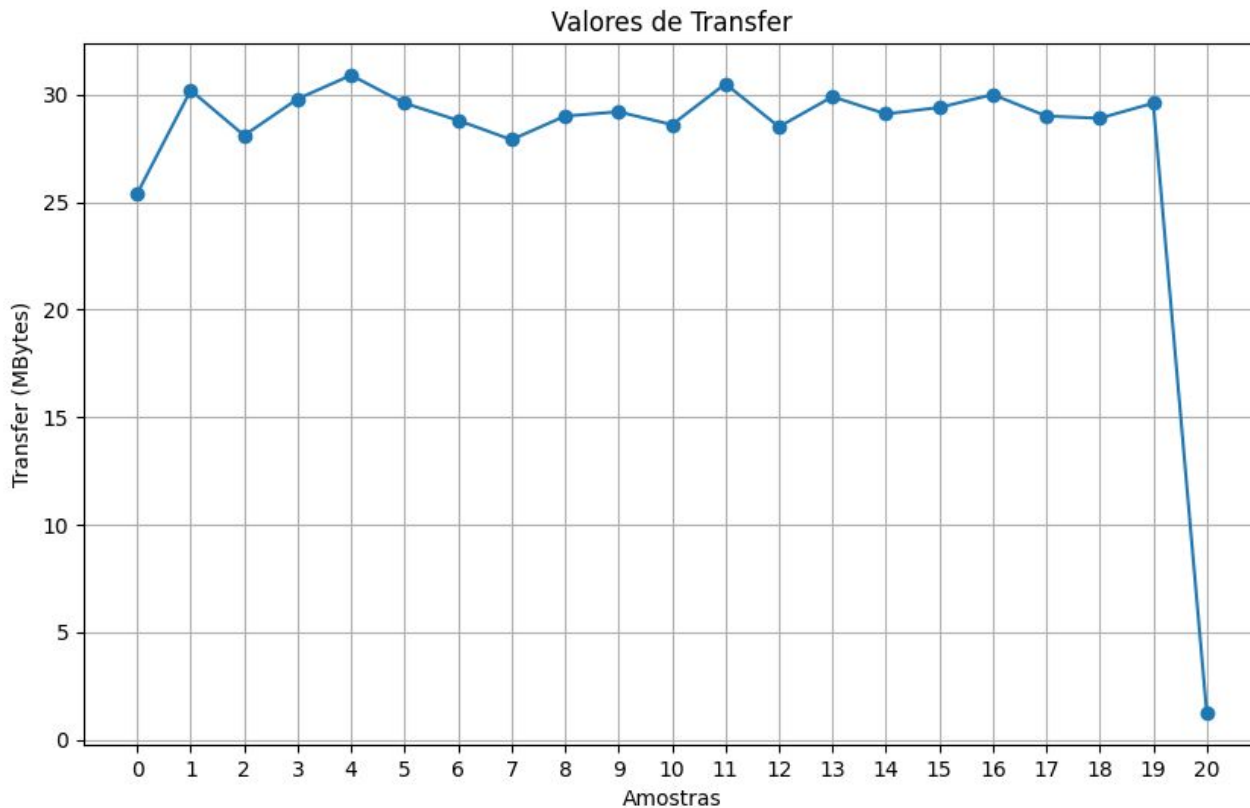
Cenário de teste 1: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)



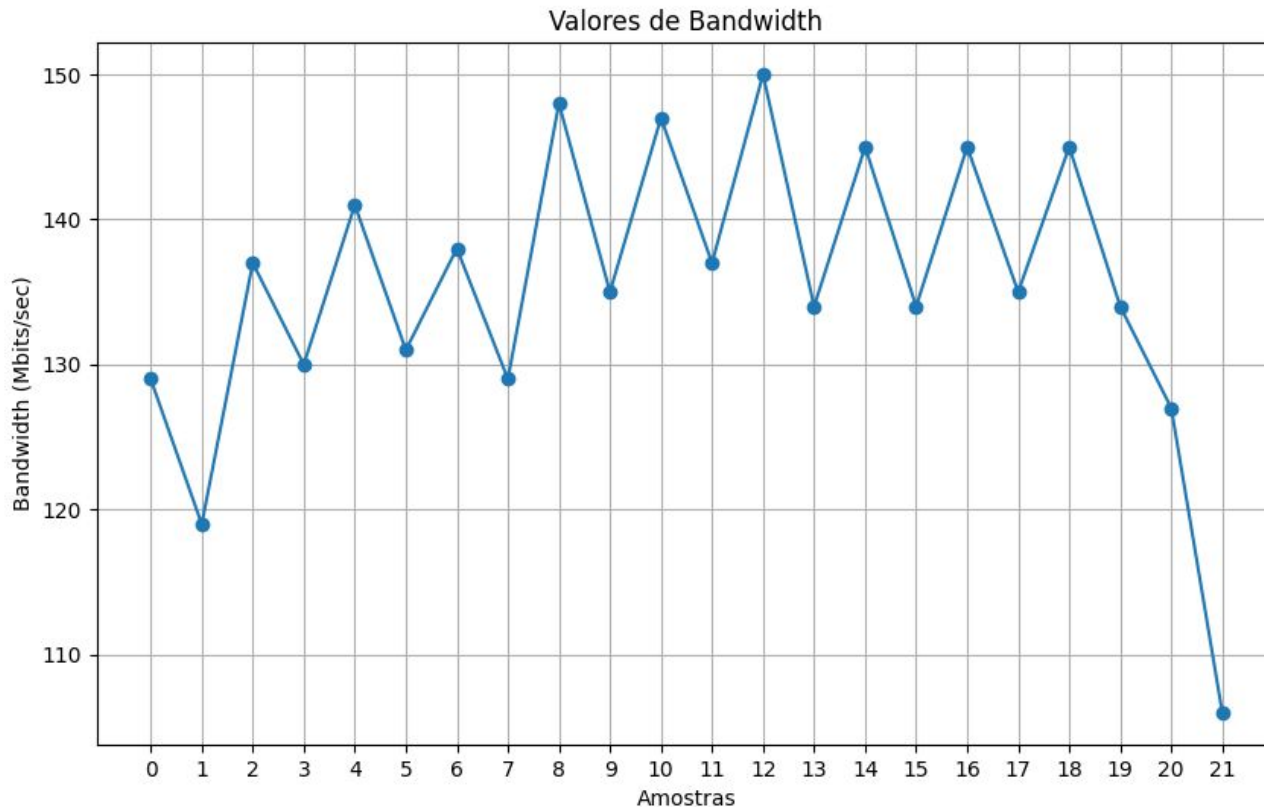
Cenário de teste 1: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)



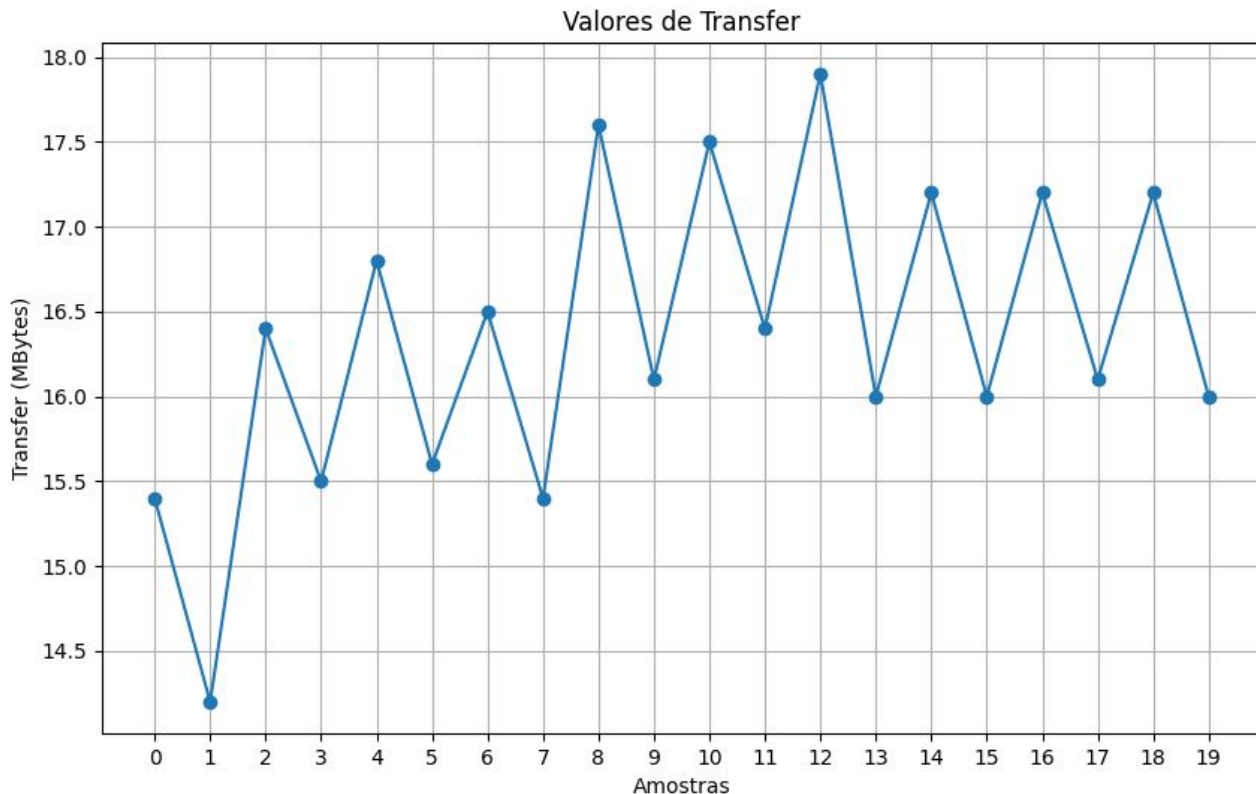
Cenário de teste 1: Largura de Banda

- 2 processos TCP (banda máxima 250Mbits/sec)



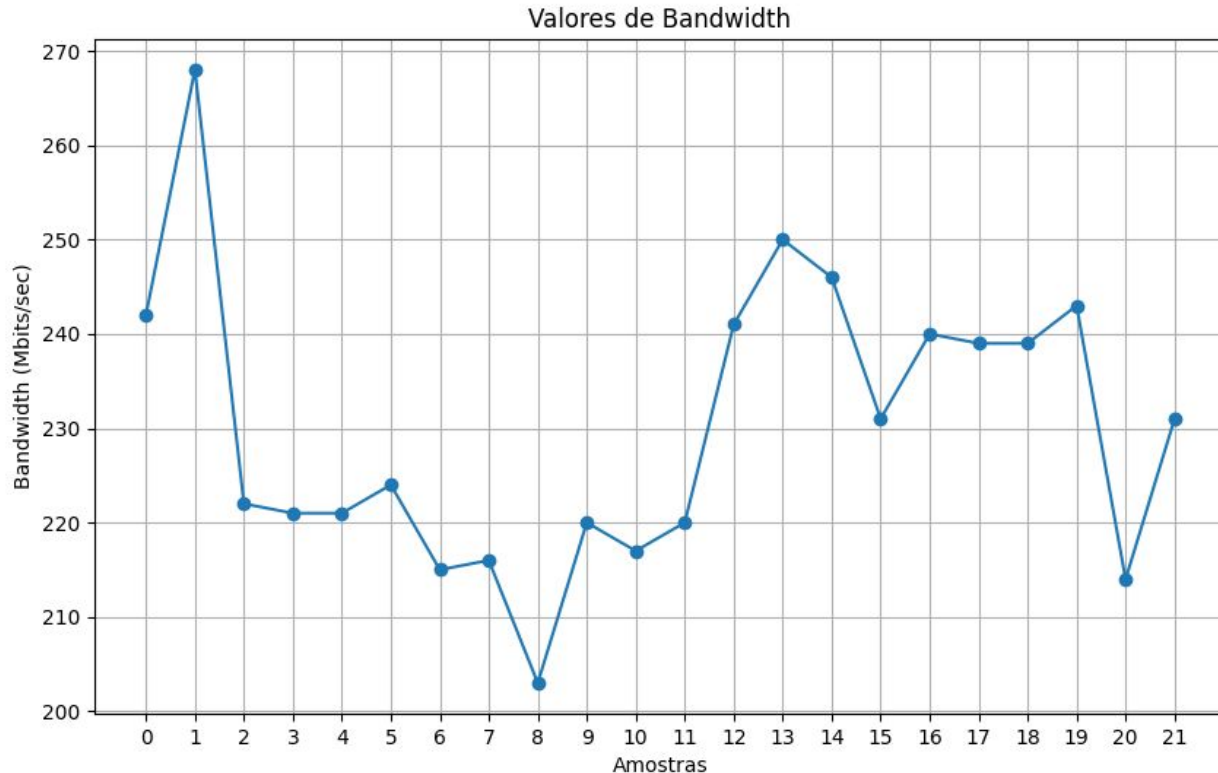
Cenário de teste 1: Taxa de Transferência

- 2 processos TCP (banda máxima 250Mbytes/sec)



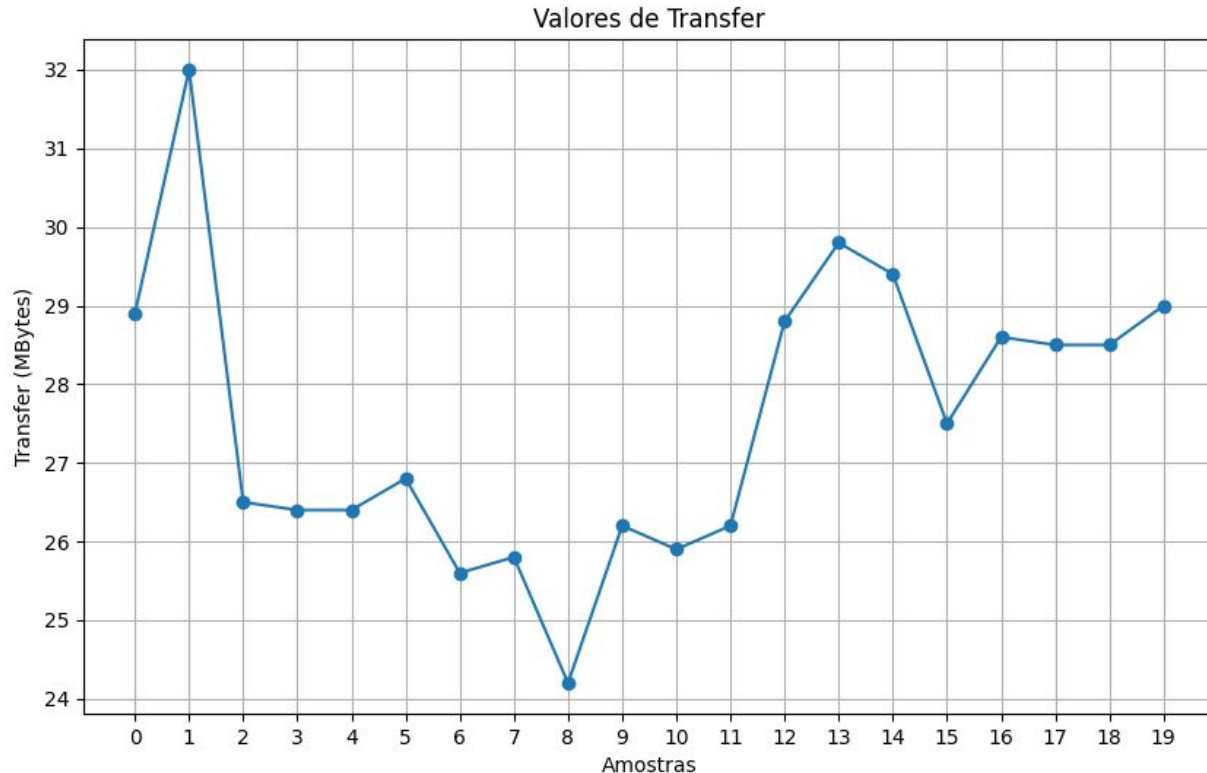
Cenário de teste 1: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)
- 1 Processo UDP 50M (20%)



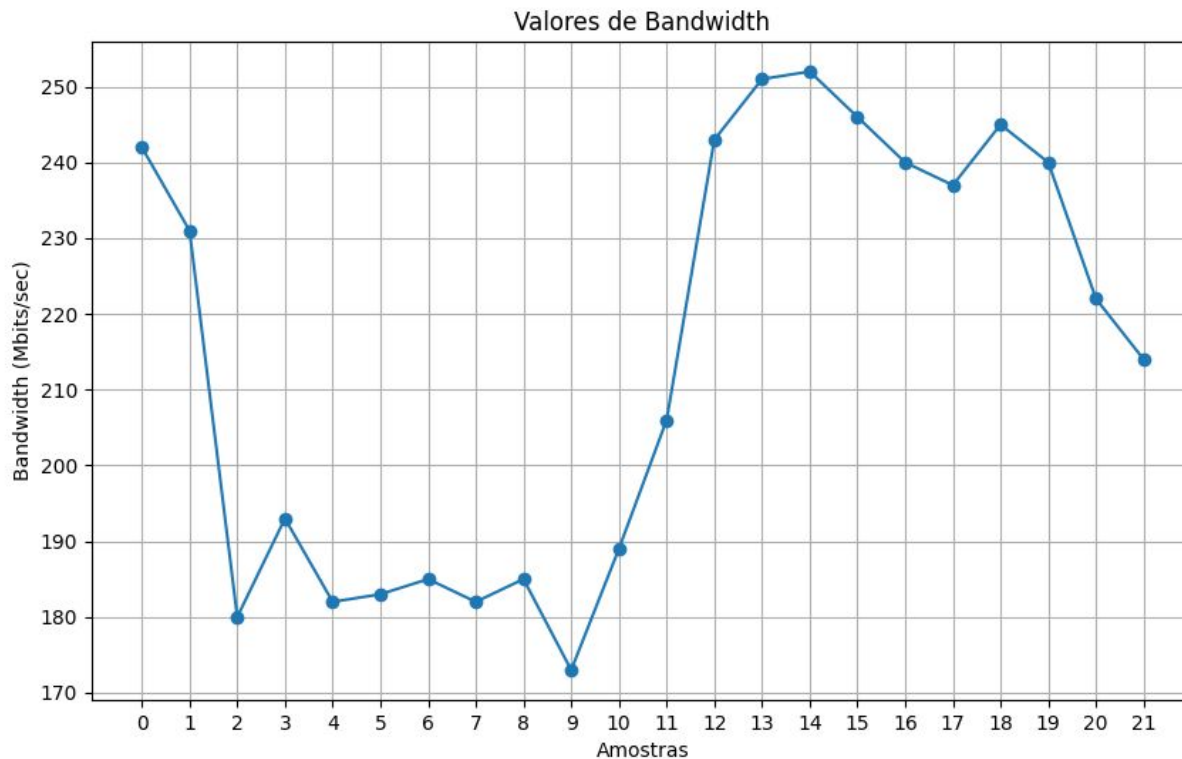
Cenário de teste 1: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 50M (20%)



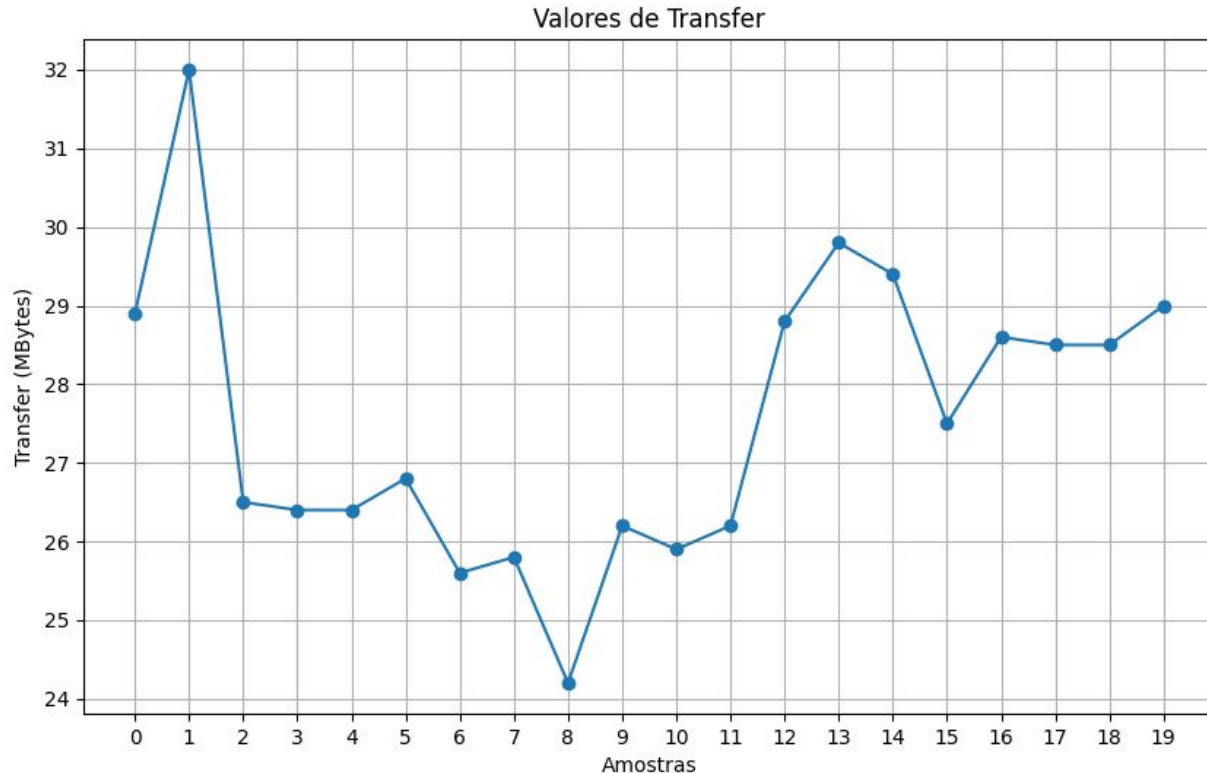
Cenário de teste 1: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)
- 1 Processo UDP 100M (40%)



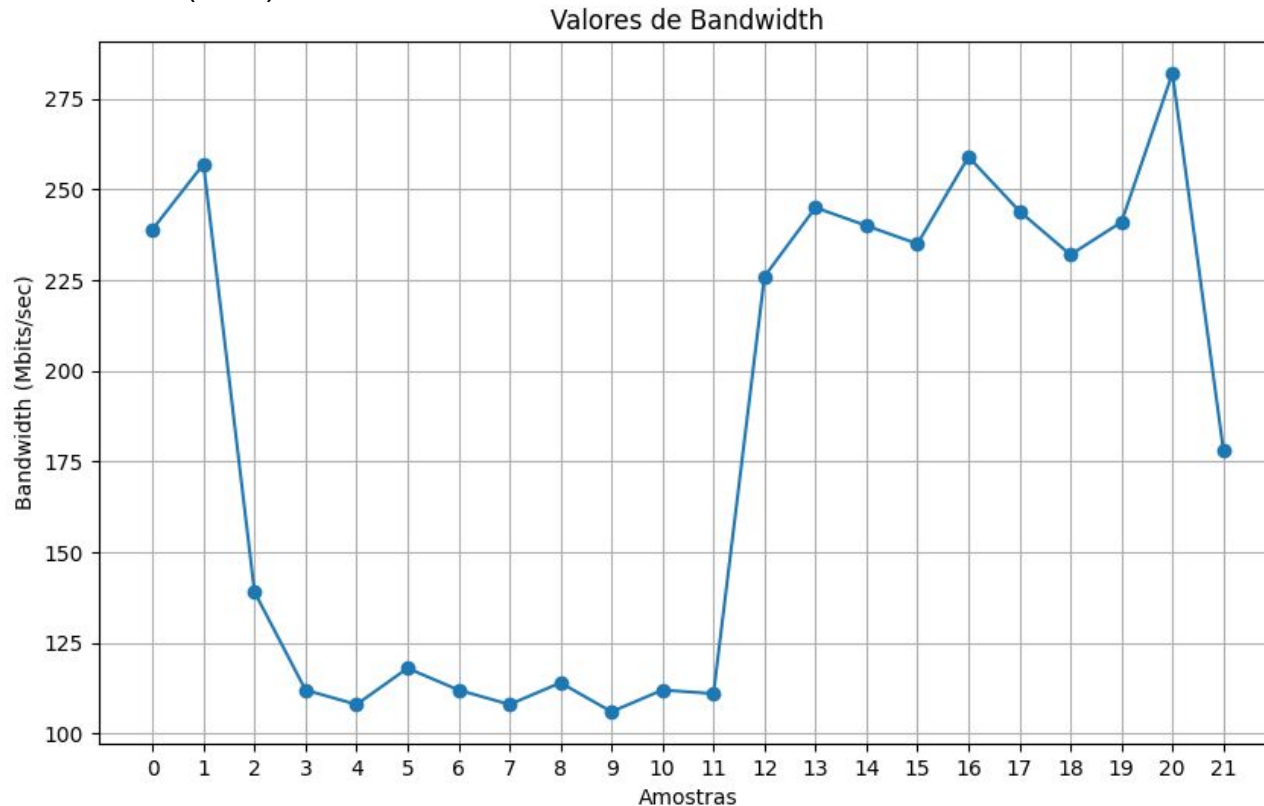
Cenário de teste 1: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 100M (40%)



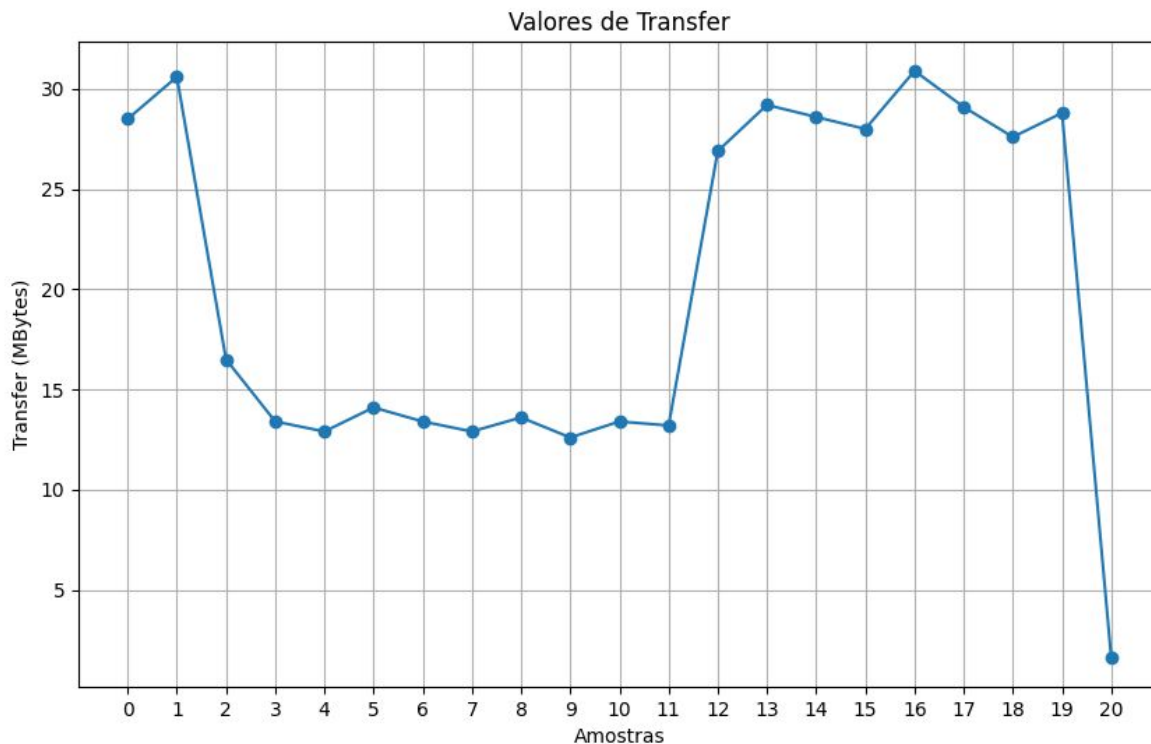
Cenário de teste 1: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)
- 1 Processo UDP 200M (80%)



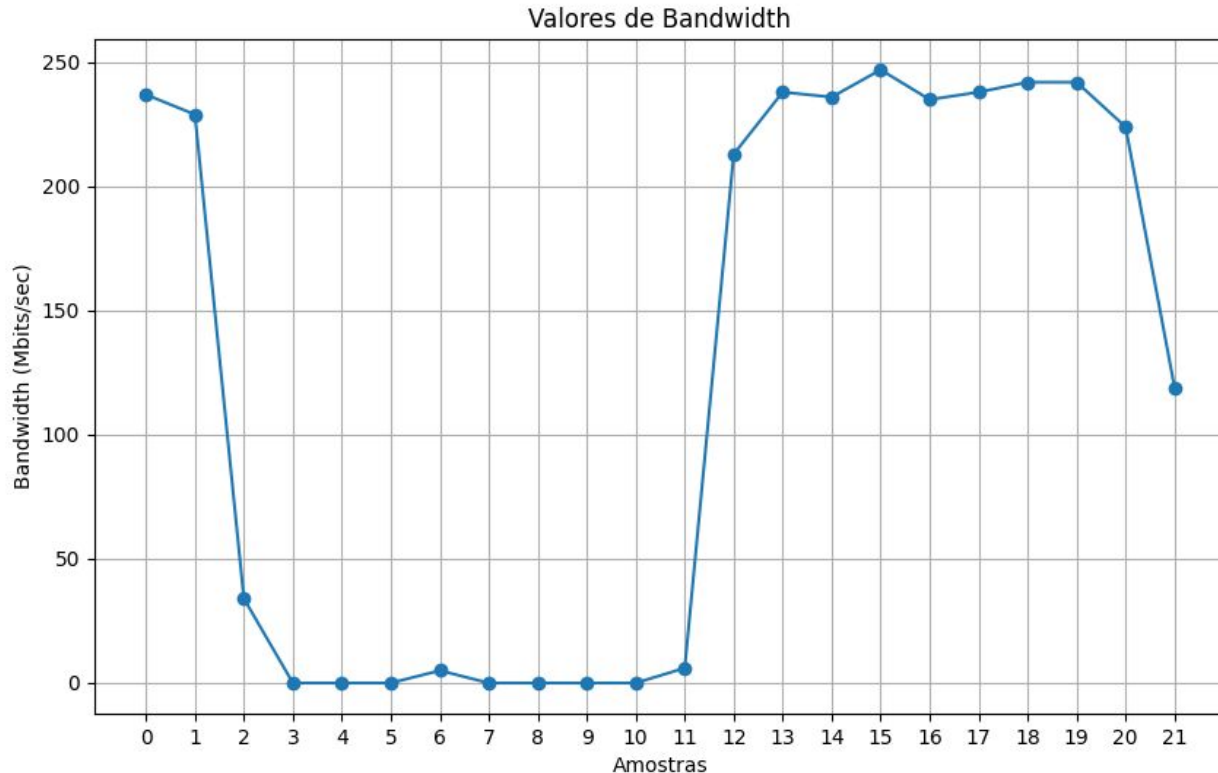
Cenário de teste 1: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 200M (80%)



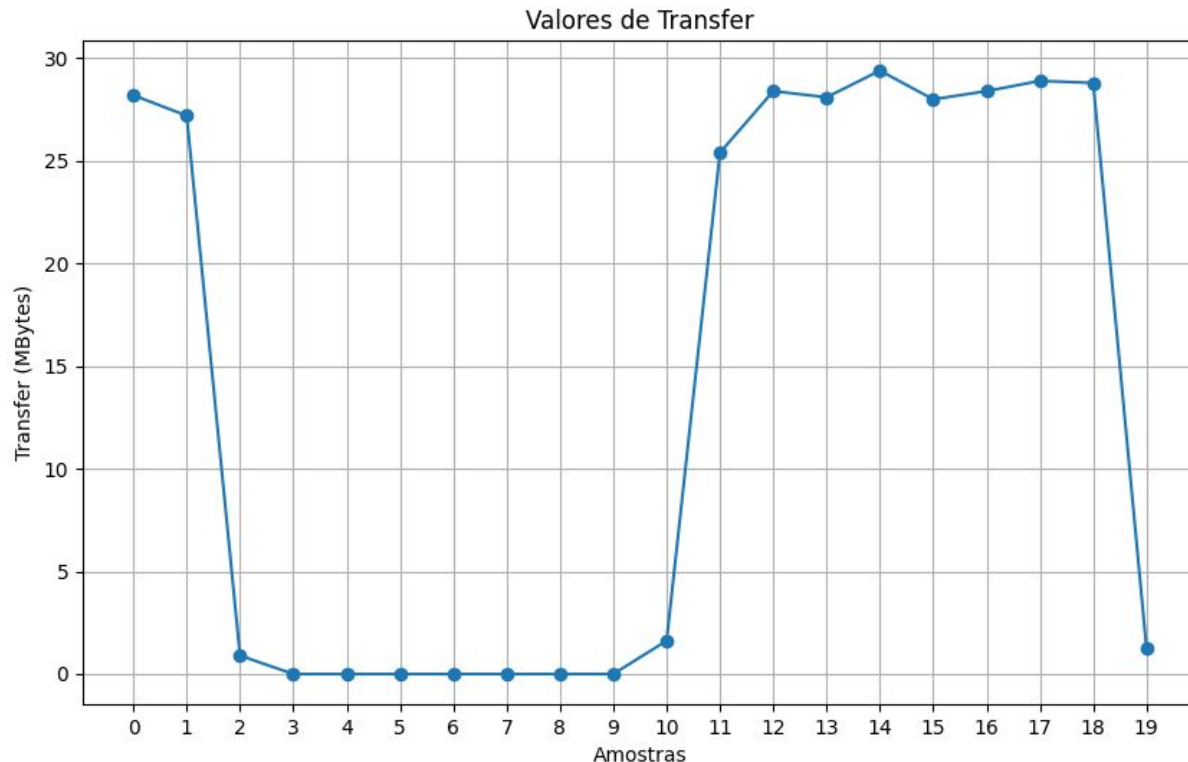
Cenário de teste 1: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)
- 1 Processo UDP 1G (+100%)



Cenário de teste 1: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 1G (+100%)

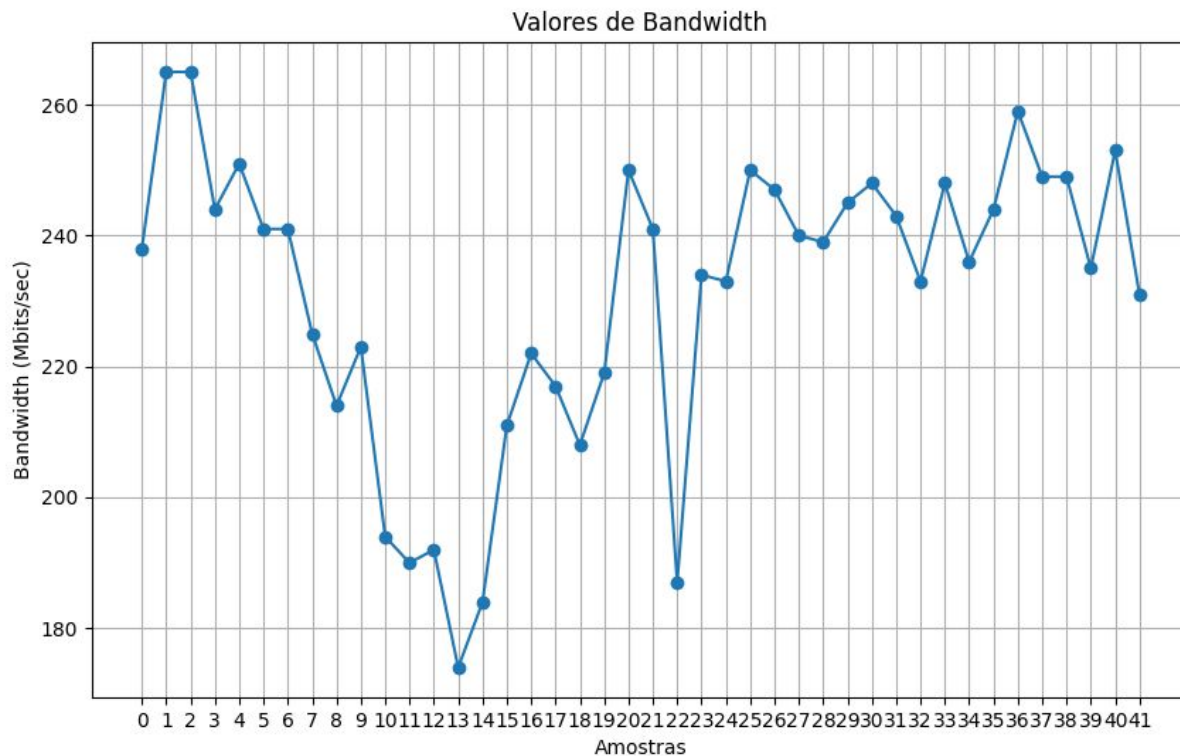


Conclusão Cenário 1

- Com 100% da carga UDP, ocorre o starvation do TCP
- 80% de carga UDP não causa 80% de diminuição da largura de banda TCP
- A largura de banda e a taxa de transferência diminuem de forma proporcional
- A situação crítica é quando ocorre a inanição em 100% do uso do UDP
- Com 2 processos TCP usando 100% da banda, há justiça
- Com 1 processo TCP usando 100% da banda e 1 processo UDP utilizando 100% da banda, ocorre inanição do TCP

Cenário de teste 2: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)
- 2 Processo UDP 50M cada (20%)



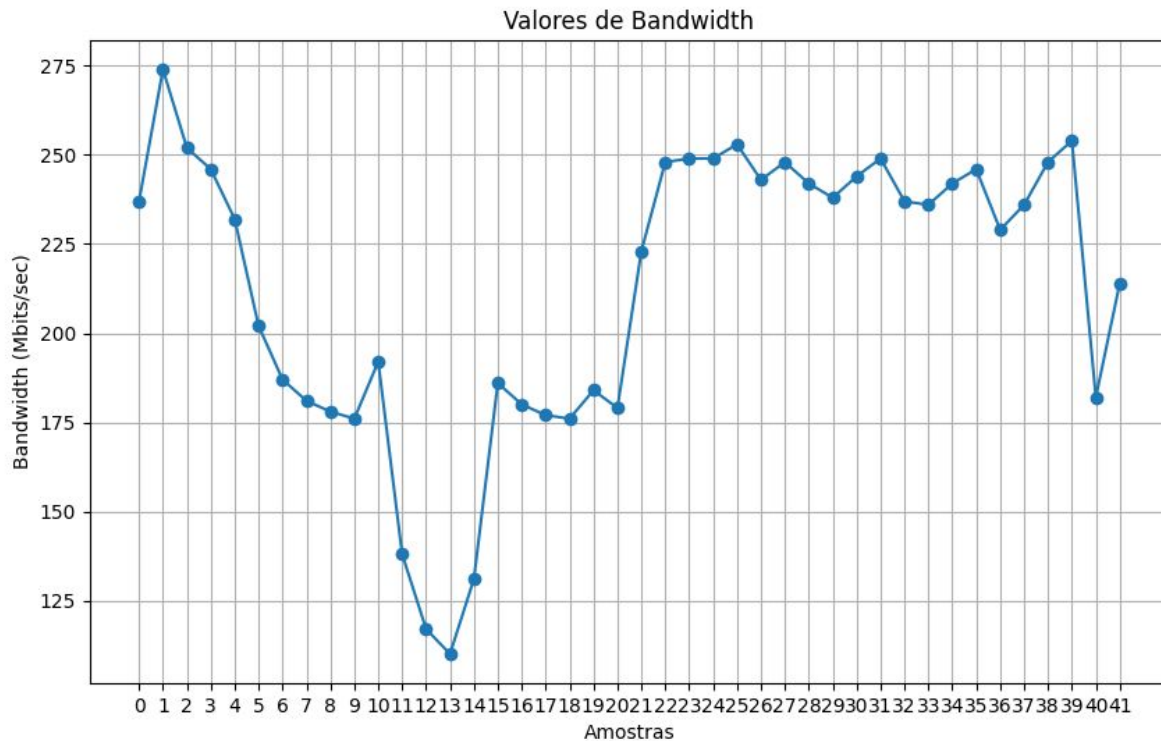
Cenário de teste 2: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 50M cada (20%)



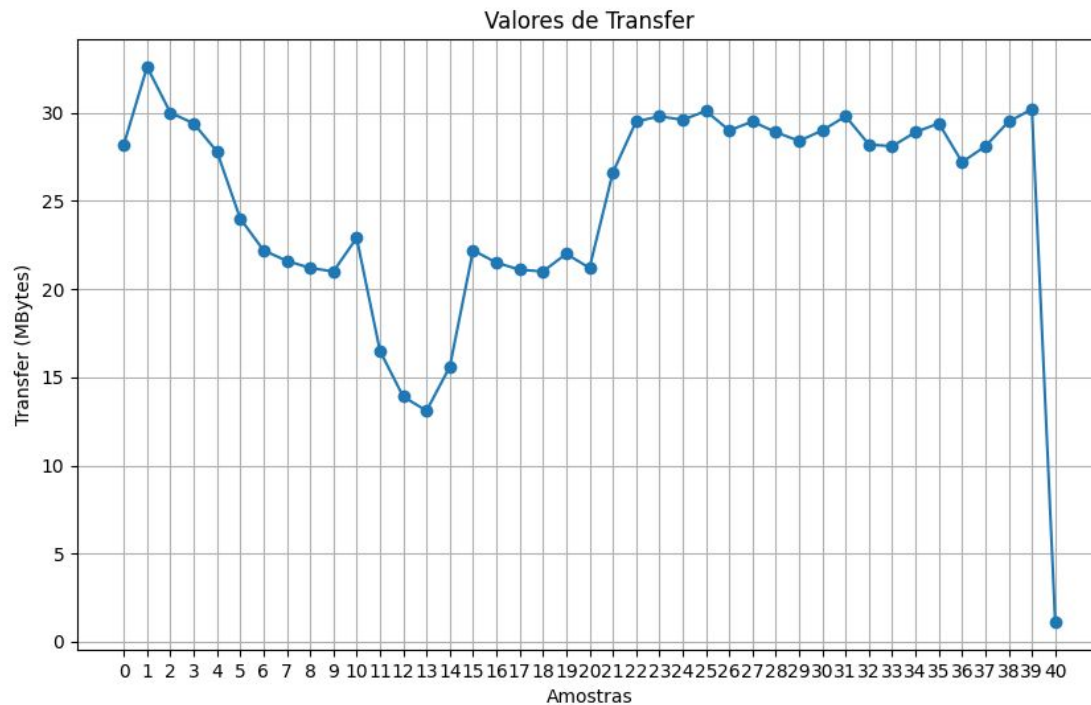
Cenário de teste 2: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)
- 2 Processo UDP 100M cada (40%)



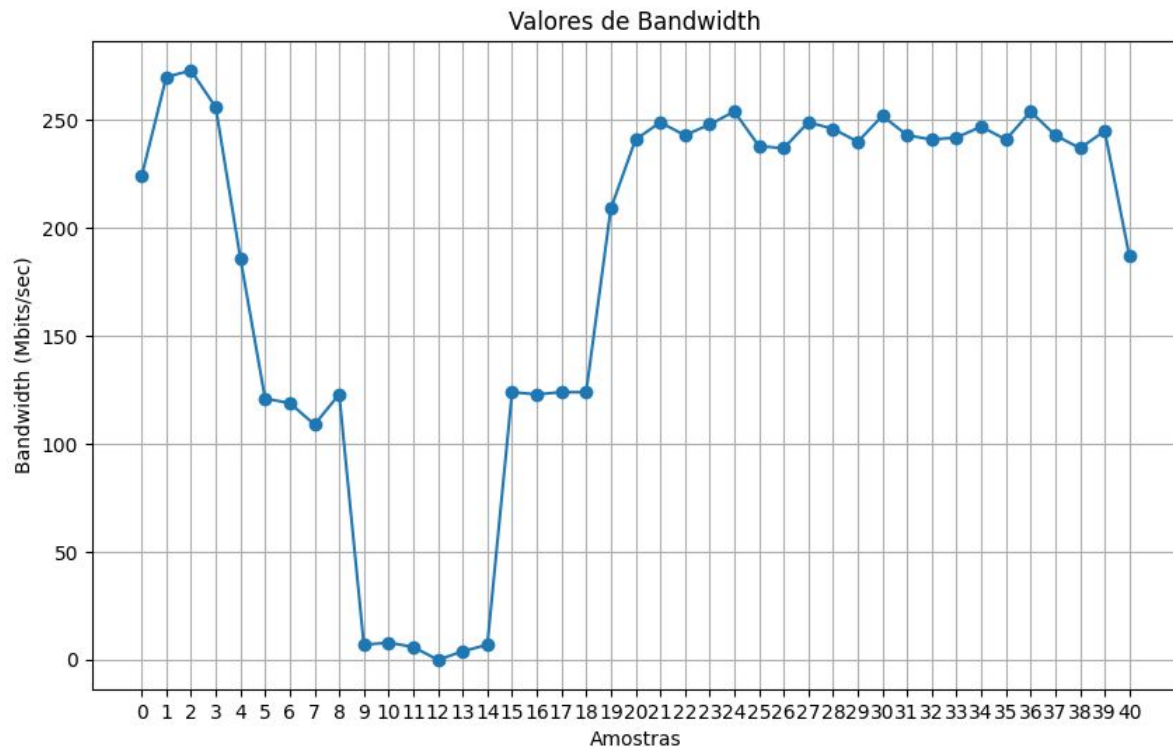
Cenário de teste 2: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 100M cada (40%)



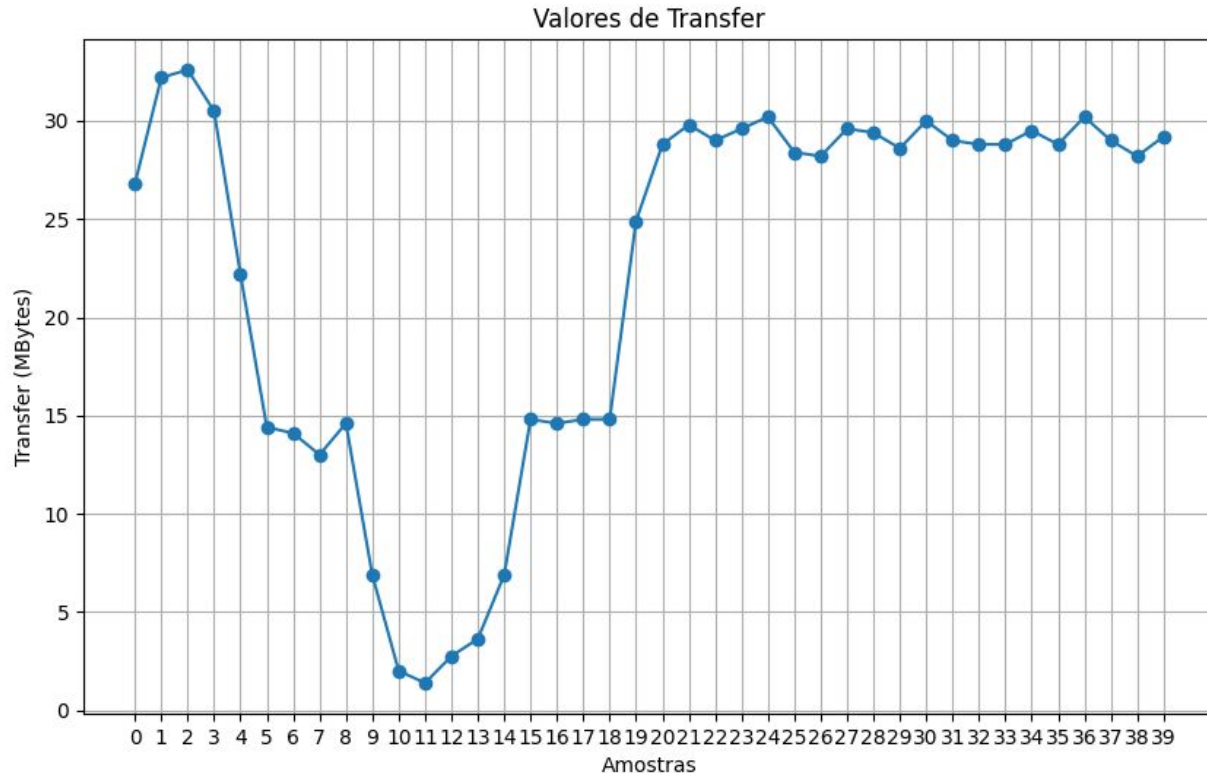
Cenário de teste 2: Largura de Banda

- 1 processo TCP (banda máxima 250Mbps/sec)
- 2 Processo UDP 200M cada (80%)



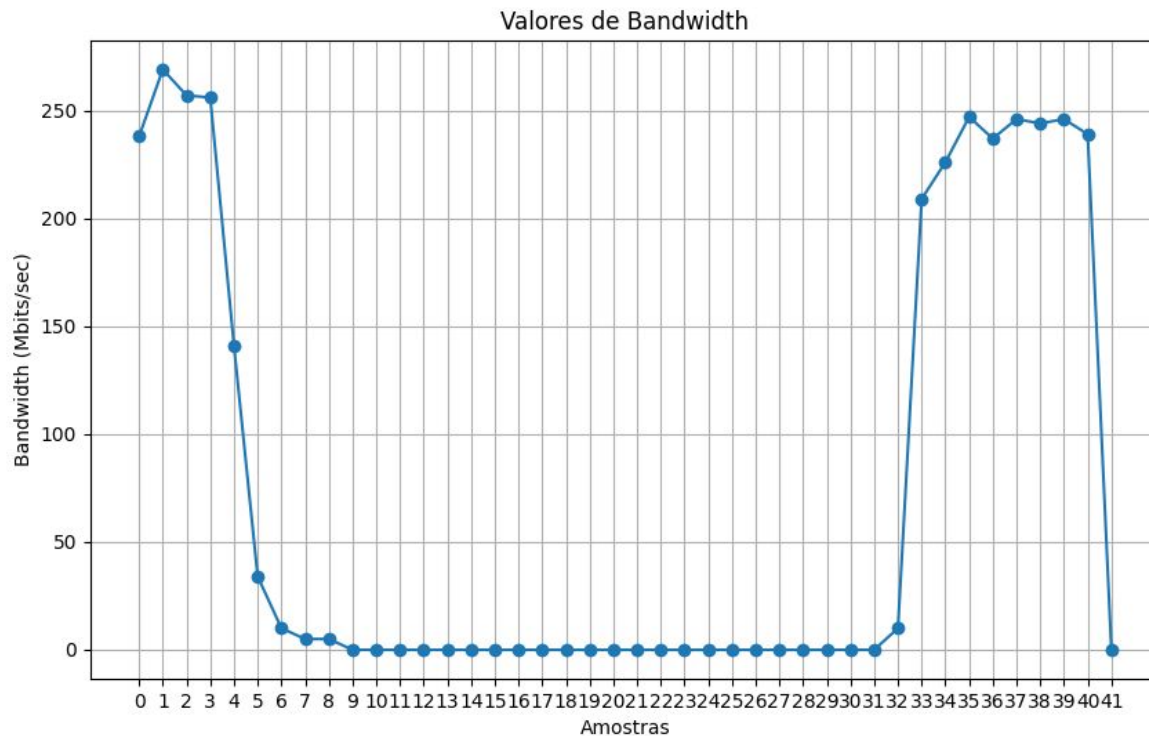
Cenário de teste 2: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 200M cada (80%)



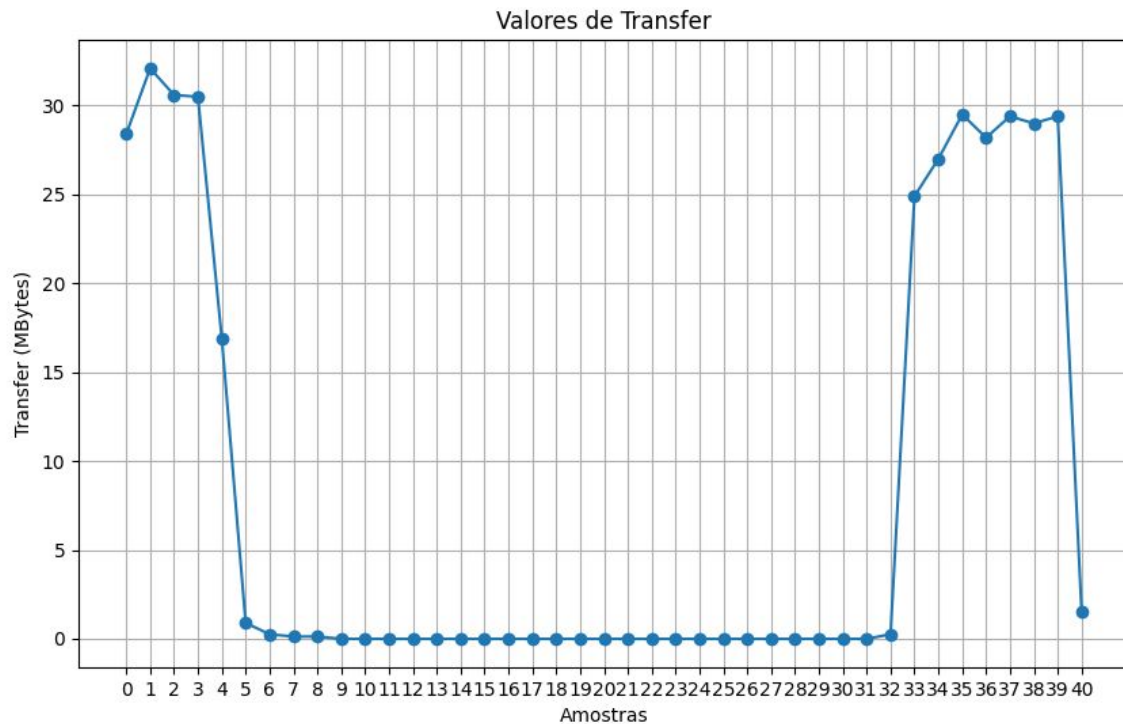
Cenário de teste 2: Largura de Banda

- 1 processo TCP (banda máxima 250Mbits/sec)
- 2 Processo UDP 1G cada (+100%)



Cenário de teste 2: Taxa de Transferência

- 1 processo TCP (banda máxima 250Mbytes/sec)
- 1 Processo UDP 1G cada (+100%)



Conclusão Cenário 2

- Com mais processos TCP, a taxa de banda continua acompanhando proporcionalmente largura de banda
- Quanto mais processos, mais inanição e desigualdade vai existir para o TCP
- Quando 2 processos são colocados com alta carga UDP, os pacotes chegam fora de ordem e quase todos são perdidos

Conclusão Cenário 2

```
C:\Windows\System32\cmd.exe
iperf3: OUT OF ORDER - incoming packet = 29539 and received packet = 89304 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 30281 and received packet = 90787 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 30310 and received packet = 90843 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 31836 and received packet = 93895 AND SP = 4
[ 4] 8.00-9.00 sec 11.7 MBytes 98.3 Mbits/sec 14.059 ms 13215/14705 (90%)
iperf3: OUT OF ORDER - incoming packet = 33674 and received packet = 97543 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 35206 and received packet = 100620 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 35707 and received packet = 101230 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 36578 and received packet = 102103 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 3564 and received packet = 102874 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 37590 and received packet = 103117 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 3875 and received packet = 103495 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 39035 and received packet = 104560 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 40097 and received packet = 105605 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 40837 and received packet = 106367 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 41601 and received packet = 107115 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 42111 and received packet = 107638 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 42872 and received packet = 108369 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 42982 and received packet = 108481 AND SP = 4
iperf3: OUT OF ORDER - incoming packet = 44263 and received packet = 109791 AND SP = 4
[ 4] 9.00-10.00 sec 10.9 MBytes 91.7 Mbits/sec 38.435 ms 13103/14489 (90%)
- - - - -
[ ID] Interval          Transfer      Bandwidth      Jitter    Lost/Total Datagrams
[ 4] 0.00-10.00 sec    861 MBytes    722 Mbits/sec  22.320 ms  96638/110177 (88%)
[ 4] Sent 110177 datagrams
[SUM] 0.0-10.0 sec    77 datagrams received out-of-order

iperf Done.
```

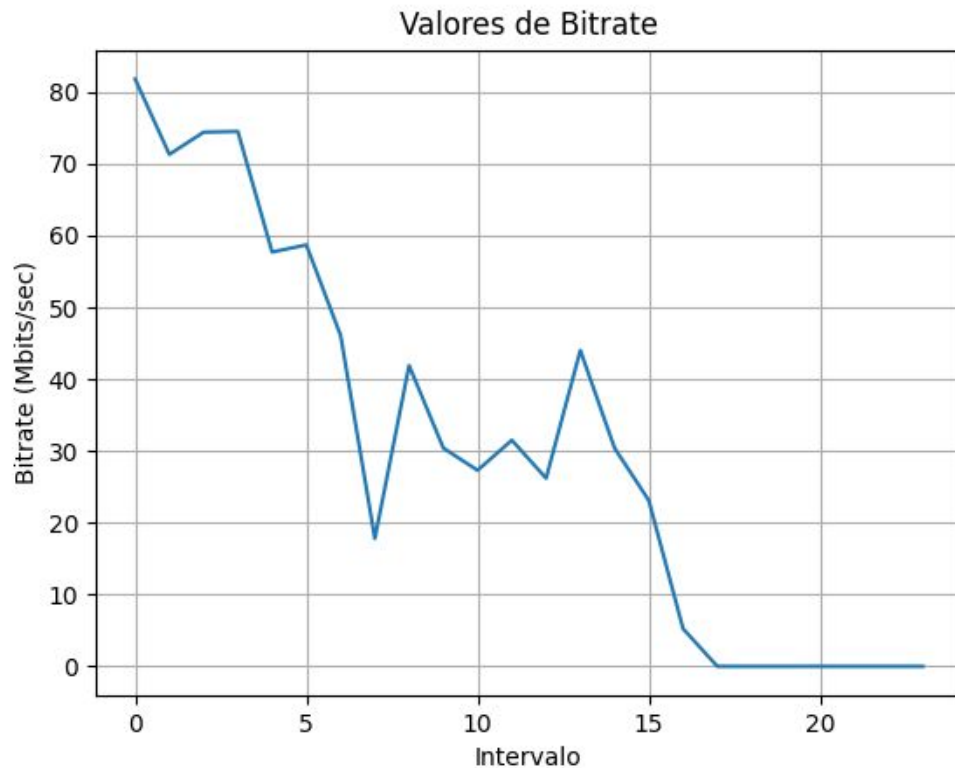
Cenário extra: Inanição AWS EC2

- Teste1: 1 processo TCP 1G + 1 processo UDP 1G



Cenário extra: Inanição AWS EC2

- Teste2: 1 processo TCP 1G + 1 processo UDP 1G



Cenário 3: Inanição AWS EC2

- 1 processo TCP 1G + 1 processo UDP 1G

```
aws  Serviços  Search
ubuntu@ip-172-31-8-63:~$ iperf3 -s -p 5201
-----
Server listening on 5201
-----
Accepted connection from 177.34.71.239, port 52186
[ 5] local 172.31.8.63 port 5201 connected to 177.34.71.239 port 52187
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 5]  0.00-1.00    sec  9.75 MBytes  81.8 Mbits/sec  0    419 KBytes
[ 5]  1.00-2.00    sec  8.50 MBytes  71.3 Mbits/sec  0    419 KBytes
[ 5]  2.00-3.00    sec  8.88 MBytes  74.4 Mbits/sec  0    419 KBytes
[ 5]  3.00-4.00    sec  8.88 MBytes  74.5 Mbits/sec  0    419 KBytes
[ 5]  4.00-5.00    sec  6.88 MBytes  57.7 Mbits/sec  0    419 KBytes
[ 5]  5.00-6.00    sec  7.00 MBytes  58.7 Mbits/sec  0    419 KBytes
[ 5]  6.00-7.00    sec  5.50 MBytes  46.1 Mbits/sec  0    419 KBytes
[ 5]  7.00-8.00    sec  2.12 MBytes  17.8 Mbits/sec  12   292 KBytes
[ 5]  8.00-9.00    sec  5.00 MBytes  41.9 Mbits/sec  0    292 KBytes
[ 5]  9.00-10.00   sec  3.62 MBytes  30.4 Mbits/sec  0    292 KBytes
[ 5] 10.00-11.00   sec  3.25 MBytes  27.3 Mbits/sec  0    292 KBytes
[ 5] 11.00-12.00   sec  3.75 MBytes  31.5 Mbits/sec  0    292 KBytes
[ 5] 12.00-13.00   sec  3.12 MBytes  26.2 Mbits/sec  0    292 KBytes
[ 5] 13.00-14.00   sec  5.25 MBytes  44.0 Mbits/sec  0    292 KBytes
[ 5] 14.00-15.00   sec  3.62 MBytes  30.4 Mbits/sec  0    292 KBytes
[ 5] 15.00-16.00   sec  2.75 MBytes  23.1 Mbits/sec  0    292 KBytes
[ 5] 16.00-17.00   sec    640 KBytes  5.24 Mbits/sec  24   1.43 KBytes
[ 5] 17.00-18.00   sec    0.00 Bytes  0.00 bits/sec  1    1.43 KBytes
[ 5] 18.00-19.00   sec    0.00 Bytes  0.00 bits/sec  1    1.43 KBytes
[ 5] 19.00-20.00   sec    0.00 Bytes  0.00 bits/sec  0    1.43 KBytes
[ 5] 20.00-21.00   sec    0.00 Bytes  0.00 bits/sec  0    1.43 KBytes
```

Conclusão Cenário Extra

- Servidores data centers também sofrem com inanição
- O tamanho da janela cwnd varia de acordo com a taxa de transferência e largura de banda

Créditos

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