# NetEm – Emulación de Red

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## Características emuladas

Consideramos las siguientes características de red a emular:

* Limitación del ancho de banda (velocidad máxima de transferencia sostenida en el tiempo).
* Latencia (demora momentánea o permanente en la entrega de paquetes).
* Pérdida de paquetes (paquetes que salen, pero no llegan a destino).
* Errores en red (corrupción de paquetes en tránsito).

## Características no emuladas

Las siguientes características producen efectos menores, y no las consideramos en estas pruebas:

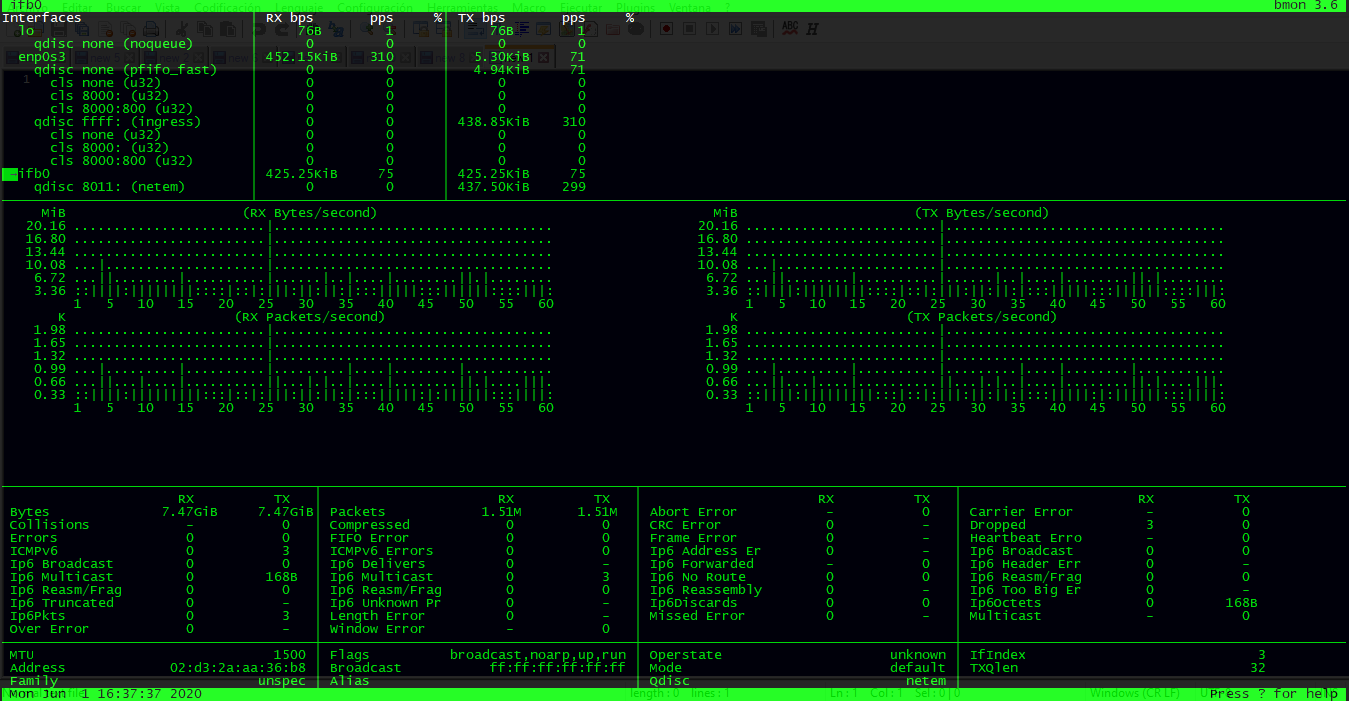
* Paquetes desordenados en destino (recepción de números de secuencia desordenados).
* Duplicación de paquetes (recepción más de una vez del mismo número de secuencia).

## Control de tráfico en Linux

Para controlar las características de red en Linux, usamos el programa “tc” (“Traffic Control”).

Para monitorear todos los parámetros de red, usamos “bmon”:





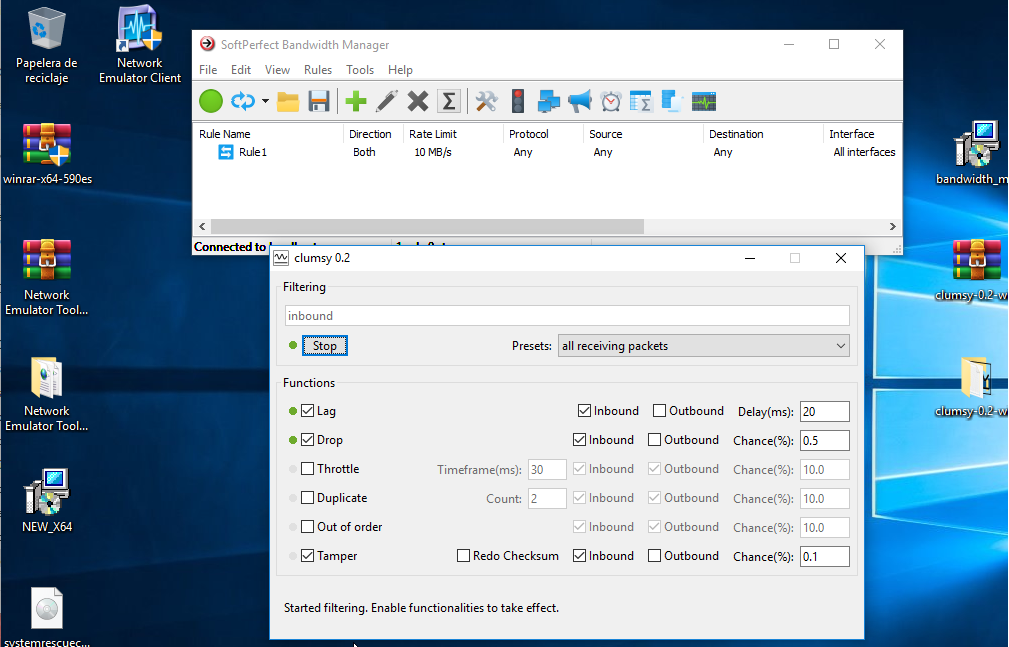
Para monitorear desde el lado del cliente (el que envía el tráfico), simplemente usamos “ping”.

## Control de tráfico en Windows

Todas las características de red pueden establecerse en servidores Windows.

Para eso usamos dos herramientas de software:

* SoftPerfect Bandwidth Manager  
  <https://www.softperfect.com/products/bandwidth/>   
  Permite limitar el ancho de banda.
* Clumsy  
  <https://jagt.github.io/clumsy/download.html>   
  Permite cambiar todos los otros parámetros (latencia, pérdida de paquetes, errores en red, etc.)



## Pruebas iniciales

Estas pruebas consisten en introducir cambios, inicialmente de un parámetro a la vez.

Luego de ejecutar cada cambio, lanzamos un ping de 100 paquetes, con intervalo de 100ms, y en algunos casos donde es interesante, copiamos un archivo de 1GB al servidor objetivo.

### Condiciones normales

Primero verificamos el comportamiento sin introducir ningún cambio. El servidor destino es 192.168.1.47.

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=0.795 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=0.365 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=0.697 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=0.602 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=0.461 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=0.888 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=1.345 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=0.657 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=0.677 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=0.333 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=0.246 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=0.296 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=0.329 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=0.361 ms

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=0.644 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=0.637 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=0.367 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=0.783 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=0.521 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=0.544 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=0.375 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=0.276 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=0.569 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=0.395 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=0.389 ms

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=0.695 ms

64 bytes from 192.168.1.47: icmp\_seq=26 ttl=64 time=0.672 ms

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=0.510 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=0.447 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=0.736 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=0.634 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=0.365 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=0.469 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=0.432 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=0.407 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=0.528 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=0.548 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=0.458 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=0.652 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=0.873 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=0.418 ms

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=0.566 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=0.562 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=0.447 ms

64 bytes from 192.168.1.47: icmp\_seq=44 ttl=64 time=0.421 ms

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=0.284 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=0.352 ms

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=0.356 ms

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=0.560 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=0.497 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=0.422 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=0.575 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=0.382 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=0.553 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=0.388 ms

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=0.333 ms

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=0.350 ms

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=0.503 ms

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=0.541 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=0.376 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=0.434 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=0.333 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=0.477 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=0.546 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=0.368 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=0.551 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=0.592 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=0.576 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=0.455 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=0.401 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=0.614 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=0.460 ms

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=0.428 ms

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=0.438 ms

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=0.364 ms

64 bytes from 192.168.1.47: icmp\_seq=75 ttl=64 time=0.415 ms

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=0.575 ms

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=0.462 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=0.298 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=0.367 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=0.561 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=0.563 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=0.469 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=0.510 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=0.336 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=0.475 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=0.341 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=0.568 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=1.009 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=0.545 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=0.402 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=0.574 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=0.501 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=0.514 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=0.500 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=0.394 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=0.615 ms

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=0.512 ms

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=0.464 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=0.405 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 100 packets received, 0.0% packet loss**

**round-trip min/avg/max/stddev = 0.246/0.503/1.345/0.162 ms**

$ scp file\_1gb root@192.168.1.47:/disco2

file\_1gb **100% 1000MB 80.9MB/s 00:12**

### Activación del filtrado de tráfico entrante

Antes de poder ejecutar las pruebas, necesitamos activar el modo que nos permite interactuar con el tráfico entrante. Para esto, en Linux, procedemos como sigue:

[root@zabbix ~]# modprobe ifb

[root@zabbix ~]# ip link set dev ifb0 up

[root@zabbix ~]# tc qdisc add dev enp0s3 ingress

[root@zabbix ~]# tc filter add dev enp0s3 parent ffff: protocol ip u32 match u32 0 0 flowid 1:1 action mirred egress redirect dev ifb0

### Desactivación del modo de filtrado de tráfico entrante

Para desactivar el modo de filtrado de tráfico entrante, y volver al servidor Linux normal, se ejecuta lo siguiente:

[root@zabbix ~]# tc qdisc del dev ifb0 root

[root@zabbix ~]# tc qdisc del dev enp0s3 handle ffff: ingress

[root@zabbix ~]# modprobe -r ifb

### Introducción de latencia fija 100ms

Llegamos a una latencia promedio de 100,704ms, con una desviación estándar muy baja, de 0,297ms. El valor indicado de latencia (100ms) es un objetivo estadístico.

[root@zabbix ~]# tc qdisc add dev ifb0 root netem delay 100ms

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=100.579 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=101.904 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=100.759 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=100.496 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=100.915 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=100.879 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=100.723 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=101.148 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=100.854 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=100.683 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=101.174 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=101.240 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=100.574 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=100.633 ms

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=100.656 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=100.448 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=100.535 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=100.424 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=100.465 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=100.641 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=100.515 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=100.823 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=100.828 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=100.717 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=100.790 ms

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=100.548 ms

64 bytes from 192.168.1.47: icmp\_seq=26 ttl=64 time=100.631 ms

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=101.117 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=100.920 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=100.504 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=100.652 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=100.482 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=101.084 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=100.480 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=100.890 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=100.624 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=101.089 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=100.647 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=100.321 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=100.618 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=101.452 ms

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=100.478 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=100.334 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=100.654 ms

64 bytes from 192.168.1.47: icmp\_seq=44 ttl=64 time=100.535 ms

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=100.465 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=100.501 ms

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=100.480 ms

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=100.721 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=101.004 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=100.546 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=100.871 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=100.472 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=101.050 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=101.056 ms

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=101.560 ms

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=100.454 ms

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=100.428 ms

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=100.383 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=100.431 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=100.441 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=100.482 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=100.608 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=101.112 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=100.620 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=100.807 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=100.467 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=100.534 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=100.537 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=100.707 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=100.768 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=100.496 ms

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=100.619 ms

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=100.897 ms

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=100.486 ms

64 bytes from 192.168.1.47: icmp\_seq=75 ttl=64 time=100.471 ms

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=100.472 ms

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=100.497 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=100.617 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=100.591 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=100.802 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=101.080 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=101.382 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=101.061 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=100.357 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=100.919 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=100.533 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=100.456 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=100.408 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=100.341 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=100.718 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=100.464 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=100.738 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=100.511 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=100.514 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=100.506 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=101.527 ms

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=100.453 ms

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=100.614 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=100.893 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 100 packets received, 0.0% packet loss**

**round-trip min/avg/max/stddev = 100.321/100.704/101.904/0.297 ms**

### Introducción de latencia uniforme 100ms ± 10ms

Llegamos a un mínimo de 90,548ms y un máximo de 110,479ms, ya que el intervalo solicitado (90ms – 110ms) es un objetivo estadístico.

[root@zabbix ~]# tc qdisc change dev ifb0 root netem delay 100ms 10ms

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

Request timeout for icmp\_seq 0

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=109.949 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=93.361 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=100.985 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=102.668 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=94.541 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=91.990 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=105.306 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=95.481 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=110.388 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=95.591 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=107.050 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=98.256 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=105.762 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=103.958 ms

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=96.482 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=104.726 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=95.838 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=96.382 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=93.479 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=104.527 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=107.574 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=96.081 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=99.674 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=102.037 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=97.428 ms

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=105.376 ms

64 bytes from 192.168.1.47: icmp\_seq=26 ttl=64 time=107.077 ms

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=101.096 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=91.433 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=107.838 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=98.291 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=101.581 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=90.848 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=97.158 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=101.301 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=93.523 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=110.479 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=107.434 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=99.825 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=102.579 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=90.548 ms

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=92.764 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=101.809 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=100.142 ms

64 bytes from 192.168.1.47: icmp\_seq=44 ttl=64 time=98.146 ms

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=93.237 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=100.192 ms

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=99.340 ms

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=104.648 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=103.123 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=110.097 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=96.010 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=92.368 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=99.039 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=104.516 ms

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=100.815 ms

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=110.058 ms

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=99.673 ms

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=97.217 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=97.702 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=99.734 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=108.656 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=95.250 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=94.633 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=93.020 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=102.334 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=95.600 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=106.728 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=96.571 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=91.693 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=101.104 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=98.603 ms

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=97.679 ms

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=99.863 ms

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=104.527 ms

64 bytes from 192.168.1.47: icmp\_seq=75 ttl=64 time=94.147 ms

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=108.701 ms

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=94.076 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=96.990 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=102.010 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=100.530 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=110.346 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=97.921 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=101.864 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=104.153 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=93.587 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=104.140 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=95.196 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=98.222 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=92.874 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=110.423 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=106.424 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=108.329 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=98.131 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=94.087 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=99.377 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=100.686 ms

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=109.111 ms

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=96.436 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=109.109 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 100 packets received, 0.0% packet loss**

**round-trip min/avg/max/stddev = 90.548/100.297/110.479/5.486 ms**

### Introducción de latencia uniforme 100ms ± 10ms, correlación 25%

En este caso, se producen “rachas” de respuestas > 100ms, y “rachas” de respuestas < 100ms.

[root@zabbix ~]# tc qdisc change dev ifb0 root netem delay 100ms 10ms 25%

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

Request timeout for icmp\_seq 0

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=101.326 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=108.851 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=105.191 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=103.364 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=101.067 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=107.014 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=97.349 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=110.338 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=100.259 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=101.807 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=109.951 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=101.315 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=98.515 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=106.880 ms

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=92.247 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=99.972 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=104.959 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=105.582 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=110.007 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=97.891 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=104.999 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=100.957 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=100.783 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=105.940 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=109.015 ms

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=95.185 ms

64 bytes from 192.168.1.47: icmp\_seq=26 ttl=64 time=102.679 ms

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=109.003 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=90.609 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=103.466 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=95.712 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=91.900 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=107.084 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=110.435 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=97.763 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=100.297 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=102.626 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=90.799 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=97.807 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=99.571 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=110.167 ms

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=105.201 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=102.972 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=98.952 ms

64 bytes from 192.168.1.47: icmp\_seq=44 ttl=64 time=108.727 ms

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=95.766 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=103.690 ms

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=96.813 ms

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=100.146 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=92.657 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=95.237 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=100.194 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=100.402 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=95.204 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=95.262 ms

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=108.453 ms

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=102.071 ms

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=109.124 ms

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=97.154 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=109.780 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=105.153 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=102.953 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=99.740 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=93.547 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=92.466 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=94.876 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=96.368 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=102.410 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=92.978 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=95.039 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=110.480 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=92.794 ms

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=91.137 ms

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=109.738 ms

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=97.305 ms

64 bytes from 192.168.1.47: icmp\_seq=75 ttl=64 time=104.501 ms

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=105.990 ms

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=101.625 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=107.121 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=98.427 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=103.924 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=106.691 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=107.036 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=104.947 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=109.711 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=93.001 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=93.596 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=94.330 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=103.230 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=97.529 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=102.166 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=91.503 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=97.231 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=101.343 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=100.740 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=106.225 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=108.865 ms

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=109.428 ms

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=108.059 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=99.583 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 100 packets received, 0.0% packet loss**

**round-trip min/avg/max/stddev = 90.609/101.423/110.480/5.683 ms**

### Introducción de latencia normal, media 100ms, desviación estándar 20ms

Llegamos a valores de 98,337% de media y 21,27 de desviación estándar, ya que los valores indicados son objetivos estadísticos.

[root@zabbix ~]# tc qdisc change dev ifb0 root netem delay 100ms 20ms distribution normal

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

Request timeout for icmp\_seq 0

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=124.111 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=90.324 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=140.020 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=133.716 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=90.132 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=98.075 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=134.069 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=88.345 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=107.483 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=112.838 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=92.509 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=65.383 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=90.205 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=103.854 ms

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=73.209 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=49.984 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=131.904 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=77.935 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=43.434 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=119.542 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=117.618 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=82.878 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=120.423 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=94.340 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=112.603 ms

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=133.399 ms

64 bytes from 192.168.1.47: icmp\_seq=26 ttl=64 time=78.805 ms

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=100.334 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=97.683 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=118.054 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=69.982 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=79.054 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=81.207 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=108.105 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=79.275 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=114.308 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=77.638 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=81.544 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=65.288 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=107.419 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=107.339 ms

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=109.188 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=75.161 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=81.952 ms

64 bytes from 192.168.1.47: icmp\_seq=44 ttl=64 time=72.532 ms

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=138.893 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=96.551 ms

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=113.249 ms

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=86.270 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=115.145 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=101.541 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=105.831 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=111.959 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=74.251 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=59.230 ms

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=138.436 ms

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=103.447 ms

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=69.443 ms

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=97.948 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=104.267 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=109.326 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=133.594 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=91.056 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=97.903 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=111.140 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=115.631 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=107.496 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=78.544 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=96.390 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=118.611 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=101.476 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=87.661 ms

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=111.932 ms

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=110.012 ms

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=80.491 ms

64 bytes from 192.168.1.47: icmp\_seq=75 ttl=64 time=113.559 ms

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=89.427 ms

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=81.894 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=113.926 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=83.203 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=113.951 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=99.378 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=87.865 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=95.483 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=54.971 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=134.067 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=114.204 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=113.442 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=117.020 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=106.550 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=116.950 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=55.704 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=90.484 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=88.518 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=118.055 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=62.991 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=107.571 ms

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=84.943 ms

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=117.854 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=70.777 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 100 packets received, 0.0% packet loss**

**round-trip min/avg/max/stddev = 43.434/98.337/140.020/21.270 ms**

### Introducción de pérdida de paquetes aleatoria al 10%

Llegamos a un 12% en la práctica, ya que el 10% indicado es un objetivo estadístico.

[root@zabbix ~]# tc qdisc change dev ifb0 root netem loss random 10%

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=0.547 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=0.492 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=0.369 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=0.696 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=0.681 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=1.218 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=0.661 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=0.458 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=0.814 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=0.738 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=0.354 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=0.355 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=0.351 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=0.400 ms

Request timeout for icmp\_seq 14

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=0.405 ms

Request timeout for icmp\_seq 16

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=0.524 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=0.604 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=0.368 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=0.307 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=0.319 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=0.339 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=0.413 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=0.462 ms

Request timeout for icmp\_seq 25

Request timeout for icmp\_seq 26

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=0.946 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=0.356 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=0.414 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=0.550 ms

Request timeout for icmp\_seq 31

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=0.430 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=0.387 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=0.565 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=0.426 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=0.463 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=0.427 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=0.809 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=0.325 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=0.340 ms

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=0.309 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=0.365 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=0.522 ms

Request timeout for icmp\_seq 44

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=0.490 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=0.357 ms

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=0.419 ms

Request timeout for icmp\_seq 48

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=0.559 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=0.539 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=0.327 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=0.565 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=0.585 ms

Request timeout for icmp\_seq 54

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=0.404 ms

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=0.671 ms

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=0.426 ms

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=0.482 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=0.773 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=0.478 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=0.431 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=0.349 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=0.471 ms

Request timeout for icmp\_seq 64

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=0.474 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=0.334 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=0.564 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=0.605 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=0.542 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=0.385 ms

Request timeout for icmp\_seq 71

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=0.400 ms

Request timeout for icmp\_seq 73

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=0.483 ms

64 bytes from 192.168.1.47: icmp\_seq=75 ttl=64 time=0.368 ms

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=0.588 ms

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=0.343 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=0.763 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=0.390 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=0.392 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=0.375 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=0.519 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=0.372 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=0.411 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=0.565 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=0.536 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=0.598 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=0.323 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=0.550 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=0.459 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=0.484 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=0.579 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=0.521 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=0.388 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=0.318 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=0.630 ms

Request timeout for icmp\_seq 97

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=0.616 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=0.663 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 88 packets received, 12.0% packet loss**

**round-trip min/avg/max/stddev = 0.307/0.493/1.218/0.155 ms**

### Introducción de pérdida de paquetes aleatoria al 30%, correlación 10%

En este caso, tenemos “rachas” de paquetes perdidos.

[root@zabbix ~]# tc qdisc change dev ifb0 root netem loss random 30% 10%

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=0.308 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=0.315 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=0.468 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=0.397 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=0.321 ms

Request timeout for icmp\_seq 5

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=1.076 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=0.454 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=0.513 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=0.369 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=0.435 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=0.389 ms

Request timeout for icmp\_seq 12

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=0.564 ms

Request timeout for icmp\_seq 14

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=0.447 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=0.448 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=0.397 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=0.352 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=0.419 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=0.369 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=0.835 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=0.597 ms

Request timeout for icmp\_seq 23

Request timeout for icmp\_seq 24

Request timeout for icmp\_seq 25

Request timeout for icmp\_seq 26

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=0.438 ms

Request timeout for icmp\_seq 28

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=0.323 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=0.376 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=0.574 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=0.555 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=0.391 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=0.305 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=0.341 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=0.552 ms

Request timeout for icmp\_seq 37

Request timeout for icmp\_seq 38

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=0.682 ms

Request timeout for icmp\_seq 40

Request timeout for icmp\_seq 41

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=0.608 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=0.654 ms

Request timeout for icmp\_seq 44

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=0.331 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=0.342 ms

Request timeout for icmp\_seq 47

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=0.528 ms

Request timeout for icmp\_seq 49

Request timeout for icmp\_seq 50

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=0.353 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=0.457 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=0.459 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=0.672 ms

Request timeout for icmp\_seq 55

Request timeout for icmp\_seq 56

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=0.501 ms

Request timeout for icmp\_seq 58

Request timeout for icmp\_seq 59

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=0.472 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=0.615 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=0.501 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=0.651 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=0.551 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=0.547 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=0.422 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=0.547 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=0.427 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=0.401 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=0.339 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=0.588 ms

Request timeout for icmp\_seq 72

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=0.340 ms

Request timeout for icmp\_seq 74

Request timeout for icmp\_seq 75

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=0.407 ms

Request timeout for icmp\_seq 77

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=0.467 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=0.364 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=0.539 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=0.563 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=0.383 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=0.307 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=0.607 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=0.387 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=0.387 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=0.544 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=0.493 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=0.372 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=0.562 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=0.461 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=0.571 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=0.529 ms

Request timeout for icmp\_seq 94

Request timeout for icmp\_seq 95

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=0.680 ms

Request timeout for icmp\_seq 97

Request timeout for icmp\_seq 98

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=0.427 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 72 packets received, 28.0% packet loss**

**round-trip min/avg/max/stddev = 0.305/0.477/1.076/0.132 ms**

### Introducción de errores en transmisión, probabilidad 5%

Los errores se reflejan como paquetes perdidos en el ping.

[root@zabbix ~]# tc qdisc change dev ifb0 root netem corrupt 5%

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=0.458 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=0.607 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=0.604 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=0.500 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=0.492 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=0.603 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=0.553 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=0.991 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=0.342 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=0.310 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=0.337 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=0.360 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=0.610 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=0.480 ms

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=0.374 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=0.324 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=0.352 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=0.388 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=0.479 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=0.585 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=0.561 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=0.402 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=0.428 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=0.617 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=0.407 ms

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=0.369 ms

64 bytes from 192.168.1.47: icmp\_seq=26 ttl=64 time=0.545 ms

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=0.380 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=0.645 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=0.470 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=0.494 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=0.384 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=0.646 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=0.403 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=0.411 ms

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=0.608 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=0.507 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=0.363 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=0.463 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=0.414 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=0.561 ms

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=0.545 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=0.574 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=0.407 ms

Request timeout for icmp\_seq 44

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=0.545 ms

64 bytes from 192.168.1.47: icmp\_seq=46 ttl=64 time=0.390 ms

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=0.259 ms

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=0.336 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=0.430 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=0.458 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=0.566 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=0.389 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=0.370 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=0.340 ms

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=0.410 ms

Request timeout for icmp\_seq 56

Request timeout for icmp\_seq 57

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=0.575 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=0.509 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=0.650 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=0.476 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=0.462 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=0.525 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=1.135 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=0.567 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=0.331 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=0.556 ms

Request timeout for icmp\_seq 68

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=0.443 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=0.379 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=0.566 ms

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=0.580 ms

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=0.528 ms

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=0.397 ms

64 bytes from 192.168.1.47: icmp\_seq=75 ttl=64 time=0.548 ms

Request timeout for icmp\_seq 76

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=0.453 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=0.405 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=0.265 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=0.556 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=0.549 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=0.379 ms

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=0.489 ms

Request timeout for icmp\_seq 84

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=0.356 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=0.436 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=0.533 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=0.461 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=0.388 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=0.417 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=0.544 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=0.532 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=0.351 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=0.403 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=0.569 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=0.538 ms

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=0.511 ms

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=0.418 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=0.690 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 94 packets received, 6.0% packet loss**

**round-trip min/avg/max/stddev = 0.259/0.482/1.135/0.129 ms**

### Introducción de errores en transmisión, probabilidad 10%, correlación 25%

Se producen “rachas” de paquetes con errores.

[root@zabbix ~]# tc qdisc change dev ifb0 root netem corrupt 10% 25%

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=0.574 ms

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=0.391 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=0.426 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=0.525 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=0.586 ms

64 bytes from 192.168.1.47: icmp\_seq=5 ttl=64 time=0.584 ms

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=0.373 ms

64 bytes from 192.168.1.47: icmp\_seq=7 ttl=64 time=0.333 ms

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=0.519 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=0.443 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=0.602 ms

64 bytes from 192.168.1.47: icmp\_seq=11 ttl=64 time=0.373 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=0.378 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=0.293 ms

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=0.405 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=0.381 ms

64 bytes from 192.168.1.47: icmp\_seq=16 ttl=64 time=0.465 ms

64 bytes from 192.168.1.47: icmp\_seq=17 ttl=64 time=0.346 ms

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=0.540 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=0.562 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=0.584 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=0.336 ms

64 bytes from 192.168.1.47: icmp\_seq=22 ttl=64 time=0.428 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=0.345 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=0.582 ms

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=0.415 ms

64 bytes from 192.168.1.47: icmp\_seq=26 ttl=64 time=0.586 ms

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=0.502 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=0.604 ms

64 bytes from 192.168.1.47: icmp\_seq=29 ttl=64 time=0.797 ms

64 bytes from 192.168.1.47: icmp\_seq=30 ttl=64 time=0.481 ms

64 bytes from 192.168.1.47: icmp\_seq=31 ttl=64 time=0.304 ms

64 bytes from 192.168.1.47: icmp\_seq=32 ttl=64 time=0.341 ms

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=0.621 ms

64 bytes from 192.168.1.47: icmp\_seq=34 ttl=64 time=0.558 ms

Request timeout for icmp\_seq 35

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=0.614 ms

Request timeout for icmp\_seq 37

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=0.601 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=0.820 ms

Request timeout for icmp\_seq 40

64 bytes from 192.168.1.47: icmp\_seq=41 ttl=64 time=0.432 ms

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=0.926 ms

64 bytes from 192.168.1.47: icmp\_seq=43 ttl=64 time=0.388 ms

Request timeout for icmp\_seq 44

Request timeout for icmp\_seq 45

Request timeout for icmp\_seq 46

64 bytes from 192.168.1.47: icmp\_seq=47 ttl=64 time=0.358 ms

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=0.603 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=0.327 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=0.804 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=0.528 ms

64 bytes from 192.168.1.47: icmp\_seq=52 ttl=64 time=0.390 ms

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=0.540 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=0.557 ms

64 bytes from 192.168.1.47: icmp\_seq=55 ttl=64 time=0.564 ms

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=0.555 ms

Request timeout for icmp\_seq 57

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=0.470 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=0.614 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=0.311 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=0.272 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=0.703 ms

64 bytes from 192.168.1.47: icmp\_seq=63 ttl=64 time=0.754 ms

64 bytes from 192.168.1.47: icmp\_seq=64 ttl=64 time=0.558 ms

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=0.381 ms

64 bytes from 192.168.1.47: icmp\_seq=66 ttl=64 time=0.490 ms

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=0.358 ms

64 bytes from 192.168.1.47: icmp\_seq=68 ttl=64 time=0.466 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=0.488 ms

64 bytes from 192.168.1.47: icmp\_seq=70 ttl=64 time=0.386 ms

64 bytes from 192.168.1.47: icmp\_seq=71 ttl=64 time=0.340 ms

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=0.596 ms

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=0.548 ms

Request timeout for icmp\_seq 74

Request timeout for icmp\_seq 75

64 bytes from 192.168.1.47: icmp\_seq=76 ttl=64 time=0.606 ms

64 bytes from 192.168.1.47: icmp\_seq=77 ttl=64 time=0.574 ms

64 bytes from 192.168.1.47: icmp\_seq=78 ttl=64 time=0.506 ms

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=0.291 ms

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=0.265 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=0.330 ms

Request timeout for icmp\_seq 82

64 bytes from 192.168.1.47: icmp\_seq=83 ttl=64 time=0.418 ms

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=0.688 ms

64 bytes from 192.168.1.47: icmp\_seq=85 ttl=64 time=0.369 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=0.562 ms

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=0.542 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=0.455 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=0.319 ms

64 bytes from 192.168.1.47: icmp\_seq=90 ttl=64 time=0.354 ms

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=0.489 ms

64 bytes from 192.168.1.47: icmp\_seq=92 ttl=64 time=0.546 ms

64 bytes from 192.168.1.47: icmp\_seq=93 ttl=64 time=0.554 ms

64 bytes from 192.168.1.47: icmp\_seq=94 ttl=64 time=0.566 ms

64 bytes from 192.168.1.47: icmp\_seq=95 ttl=64 time=0.561 ms

64 bytes from 192.168.1.47: icmp\_seq=96 ttl=64 time=0.357 ms

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=0.369 ms

64 bytes from 192.168.1.47: icmp\_seq=98 ttl=64 time=0.469 ms

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=0.428 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 90 packets received, 10.0% packet loss**

**round-trip min/avg/max/stddev = 0.265/0.488/0.926/0.133 ms**

### Combinación de latencia, pérdidas y errores

Con 30% de pérdida introducida (10% correlación), más 20% de errores introducidos (25% correlación), se terminó perdiendo un 37% de los paquetes. Los paquetes entregados tienen 100ms de latencia media (distribución normal, 20ms desviación estándar).

[root@zabbix ~]# tc qdisc change dev ifb0 root netem delay 100ms 20ms distribution normal loss random 30% 10% corrupt 20% 25%

$ ping -i .1 -A -c 100 192.168.1.47

PING 192.168.1.47 (192.168.1.47): 56 data bytes

64 bytes from 192.168.1.47: icmp\_seq=0 ttl=64 time=82.222 ms

Request timeout for icmp\_seq 1

64 bytes from 192.168.1.47: icmp\_seq=1 ttl=64 time=109.044 ms

64 bytes from 192.168.1.47: icmp\_seq=2 ttl=64 time=108.012 ms

64 bytes from 192.168.1.47: icmp\_seq=3 ttl=64 time=106.434 ms

64 bytes from 192.168.1.47: icmp\_seq=4 ttl=64 time=83.711 ms

Request timeout for icmp\_seq 6

64 bytes from 192.168.1.47: icmp\_seq=6 ttl=64 time=105.665 ms

Request timeout for icmp\_seq 8

64 bytes from 192.168.1.47: icmp\_seq=8 ttl=64 time=130.401 ms

64 bytes from 192.168.1.47: icmp\_seq=9 ttl=64 time=135.245 ms

64 bytes from 192.168.1.47: icmp\_seq=10 ttl=64 time=112.580 ms

64 bytes from 192.168.1.47: icmp\_seq=12 ttl=64 time=66.105 ms

64 bytes from 192.168.1.47: icmp\_seq=13 ttl=64 time=82.516 ms

Request timeout for icmp\_seq 14

64 bytes from 192.168.1.47: icmp\_seq=14 ttl=64 time=117.610 ms

64 bytes from 192.168.1.47: icmp\_seq=15 ttl=64 time=130.954 ms

Request timeout for icmp\_seq 17

Request timeout for icmp\_seq 18

64 bytes from 192.168.1.47: icmp\_seq=18 ttl=64 time=107.069 ms

64 bytes from 192.168.1.47: icmp\_seq=19 ttl=64 time=89.186 ms

64 bytes from 192.168.1.47: icmp\_seq=20 ttl=64 time=92.442 ms

64 bytes from 192.168.1.47: icmp\_seq=21 ttl=64 time=149.902 ms

64 bytes from 192.168.1.47: icmp\_seq=23 ttl=64 time=78.292 ms

64 bytes from 192.168.1.47: icmp\_seq=24 ttl=64 time=101.171 ms

Request timeout for icmp\_seq 25

64 bytes from 192.168.1.47: icmp\_seq=25 ttl=64 time=122.246 ms

Request timeout for icmp\_seq 27

64 bytes from 192.168.1.47: icmp\_seq=27 ttl=64 time=116.880 ms

64 bytes from 192.168.1.47: icmp\_seq=28 ttl=64 time=77.022 ms

Request timeout for icmp\_seq 30

Request timeout for icmp\_seq 31

Request timeout for icmp\_seq 32

64 bytes from 192.168.1.47: icmp\_seq=33 ttl=64 time=85.231 ms

Request timeout for icmp\_seq 34

Request timeout for icmp\_seq 35

64 bytes from 192.168.1.47: icmp\_seq=35 ttl=64 time=123.700 ms

64 bytes from 192.168.1.47: icmp\_seq=36 ttl=64 time=108.246 ms

64 bytes from 192.168.1.47: icmp\_seq=37 ttl=64 time=74.626 ms

64 bytes from 192.168.1.47: icmp\_seq=38 ttl=64 time=86.979 ms

64 bytes from 192.168.1.47: icmp\_seq=39 ttl=64 time=89.608 ms

64 bytes from 192.168.1.47: icmp\_seq=40 ttl=64 time=81.535 ms

Request timeout for icmp\_seq 42

64 bytes from 192.168.1.47: icmp\_seq=42 ttl=64 time=141.541 ms

64 bytes from 192.168.1.47: icmp\_seq=44 ttl=64 time=80.718 ms

64 bytes from 192.168.1.47: icmp\_seq=45 ttl=64 time=62.963 ms

Request timeout for icmp\_seq 46

Request timeout for icmp\_seq 47

Request timeout for icmp\_seq 48

64 bytes from 192.168.1.47: icmp\_seq=48 ttl=64 time=124.468 ms

64 bytes from 192.168.1.47: icmp\_seq=49 ttl=64 time=87.986 ms

64 bytes from 192.168.1.47: icmp\_seq=50 ttl=64 time=87.670 ms

64 bytes from 192.168.1.47: icmp\_seq=51 ttl=64 time=85.173 ms

Request timeout for icmp\_seq 53

64 bytes from 192.168.1.47: icmp\_seq=53 ttl=64 time=104.467 ms

64 bytes from 192.168.1.47: icmp\_seq=54 ttl=64 time=102.597 ms

Request timeout for icmp\_seq 56

64 bytes from 192.168.1.47: icmp\_seq=56 ttl=64 time=111.427 ms

64 bytes from 192.168.1.47: icmp\_seq=57 ttl=64 time=95.524 ms

64 bytes from 192.168.1.47: icmp\_seq=58 ttl=64 time=74.981 ms

64 bytes from 192.168.1.47: icmp\_seq=59 ttl=64 time=89.101 ms

64 bytes from 192.168.1.47: icmp\_seq=60 ttl=64 time=93.250 ms

64 bytes from 192.168.1.47: icmp\_seq=61 ttl=64 time=135.995 ms

64 bytes from 192.168.1.47: icmp\_seq=62 ttl=64 time=97.744 ms

Request timeout for icmp\_seq 64

Request timeout for icmp\_seq 65

64 bytes from 192.168.1.47: icmp\_seq=65 ttl=64 time=107.204 ms

Request timeout for icmp\_seq 67

64 bytes from 192.168.1.47: icmp\_seq=67 ttl=64 time=109.372 ms

64 bytes from 192.168.1.47: icmp\_seq=69 ttl=64 time=99.890 ms

Request timeout for icmp\_seq 70

Request timeout for icmp\_seq 71

64 bytes from 192.168.1.47: icmp\_seq=72 ttl=64 time=85.434 ms

Request timeout for icmp\_seq 73

64 bytes from 192.168.1.47: icmp\_seq=73 ttl=64 time=106.173 ms

64 bytes from 192.168.1.47: icmp\_seq=74 ttl=64 time=144.298 ms

Request timeout for icmp\_seq 76

Request timeout for icmp\_seq 77

Request timeout for icmp\_seq 78

64 bytes from 192.168.1.47: icmp\_seq=79 ttl=64 time=91.582 ms

Request timeout for icmp\_seq 80

64 bytes from 192.168.1.47: icmp\_seq=80 ttl=64 time=116.047 ms

64 bytes from 192.168.1.47: icmp\_seq=81 ttl=64 time=63.743 ms

64 bytes from 192.168.1.47: icmp\_seq=82 ttl=64 time=74.934 ms

Request timeout for icmp\_seq 84

64 bytes from 192.168.1.47: icmp\_seq=84 ttl=64 time=111.847 ms

64 bytes from 192.168.1.47: icmp\_seq=86 ttl=64 time=76.182 ms

Request timeout for icmp\_seq 87

64 bytes from 192.168.1.47: icmp\_seq=87 ttl=64 time=128.320 ms

64 bytes from 192.168.1.47: icmp\_seq=88 ttl=64 time=82.775 ms

64 bytes from 192.168.1.47: icmp\_seq=89 ttl=64 time=124.952 ms

Request timeout for icmp\_seq 91

64 bytes from 192.168.1.47: icmp\_seq=91 ttl=64 time=107.607 ms

Request timeout for icmp\_seq 93

Request timeout for icmp\_seq 94

Request timeout for icmp\_seq 95

Request timeout for icmp\_seq 96

64 bytes from 192.168.1.47: icmp\_seq=97 ttl=64 time=89.117 ms

Request timeout for icmp\_seq 98

64 bytes from 192.168.1.47: icmp\_seq=99 ttl=64 time=107.716 ms

**--- 192.168.1.47 ping statistics ---**

**100 packets transmitted, 63 packets received, 37.0% packet loss**

**round-trip min/avg/max/stddev = 62.963/100.912/149.902/20.525 ms**

### Cambio de parámetros y aumento del tamaño máximo de cola a 10000 paquetes

Para que no nos limite la cola de procesamiento de paquetes que se arma por software (al tener que introducir “esperas artificiales” en la transmisión), con algunos juegos de parámetros, necesitamos aumentar el tamaño máximo de esa cola, que viene por default en 1000 paquetes.

En este caso, levantamos el límite a 10000 paquetes, para observar el efecto combinado de todos los parámetros.

El comando “tc (…) show (…)” nos permite ver lo parámetros que quedaron efectivos.

En este caso, agregamos la prueba de copiar un archivo de 1GB al servidor objetivo. El tiempo estimado es de 15m12s, a 664.3KB/s promedio.

[root@zabbix disco2]# tc qdisc change dev ifb0 root netem limit 10000 delay 100ms 20ms distribution normal loss random 5% 25% corrupt 2% 25%

[root@zabbix disco2]# tc qdisc show dev ifb0

qdisc netem 8003: parent ffff: limit 10000 delay 100.0ms 20.0ms loss 5% 25% corrupt 2% 25%

C$ scp file\_1gb root@192.168.1.47:/disco2

file\_1gb **1% 19MB 664.3KB/s 25:12 ETA^**

### Limitación del ancho de banda a 10 MBps, latencia máxima permitida 100ms

Para limitar el ancho de banda, hay que especificar (además del tope de velocidad de transferencia), una latencia máxima permitida (a los efectos de manejar la cola interna), y “burst” o tamaño máximo de “pico” en tasa de transferencia, que se puede dar puntualmente, cuando es necesario vaciar rápidamente la cola (por superar la máxima latencia).

En este caso, configuramos valores de manera que no se lleguen a dar picos, y se limite la velocidad de transferencia a 10MB/s.

La copia de un archivo de 1GB demora 1m49s, a 9.1MB/s promedio (por debajo del máximo impuesto, de 10MB/s).

[root@zabbix disco2]# tc qdisc del dev ifb0 root

[root@zabbix disco2]# tc qdisc add dev ifb0 root handle 1:0 tbf rate 10mbps latency 100ms burst 1m

[root@zabbix disco2]# tc qdisc show dev ifb0

qdisc tbf 1: root refcnt 2 rate 80Mbit burst 1024Kb lat 100.0ms

$ scp file\_1gb root@192.168.1.47:/disco2

file\_1gb **100% 1000MB 9.1MB/s 01:49**

### Combinación de ancho de banda limitado, latencia, pérdida y errores

Combinando estos parámetros, obtenemos un resultado mucho peor que solo con la limitación del ancho de banda, de manera que los problemas de red pesan más. Este resultado es comparable con el que no limita el ancho de banda, pero sí introduce los otros parámetros.

[root@zabbix disco2]# tc qdisc add dev ifb0 root handle 1:0 tbf rate 10mbps latency 100ms burst 1m

[root@zabbix disco2]# tc qdisc add dev ifb0 parent 1:0 netem delay limit 10000 100ms 20ms distribution normal loss random 5% 25% corrupt 2% 25%

[root@zabbix disco2]# tc qdisc show dev ifb0

qdisc tbf 1: root refcnt 2 rate 80Mbit burst 1024Kb lat 100.0ms

qdisc netem 8003: parent 1: limit 10000 delay 100.0ms 20.0ms loss 5% 25% corrupt 2% 25%

$ scp file\_1gb root@192.168.1.47:/disco2

file\_1gb **1% 19MB 657.0KB/s 25:29 ETA^**

### Ajuste de parámetros

Luego de varias pruebas, conseguimos una combinación que produce un resultado intermedio entre la limitación del ancho de banda como único factor, y la introducción de todos los componentes.

En este caso, la copia de 1GB se estima en 6m13s, a 2,6MB/s en promedio.

[root@zabbix disco2]# tc qdisc change dev ifb0 parent 1:0 netem limit 10000 delay 10ms 2ms distribution normal loss random 0.5% 2.5% corrupt 0.2% 2.5%

$ scp file\_1gb root@192.168.1.47:/disco2

file\_1gb **2% 23MB 2.6MB/s 06:13 ETA^**

## Pruebas con scripts de cambio de comportamiento

En base a las pruebas anteriores, generamos un “pack” de scripts que permiten establecer cambios en los parámetros de una manera rápida.

Con estos scripts podemos hacer ajustes de parámetros más rápido, y probar distintas condiciones de red.

Las prueban que siguen consisten en establecer un conjunto de parámetros, copiar un archivo de unos 500MB al servidor objetivo, y ejecutar un ping sin intervalo entre paquetes, dejando que el sistema determine el mínimo intervalo para no saturar la red – se ve con el tag “ipg” (“Inter-packet gap”) en las estadísticas del ping.

Estas pruebas fueron ordenadas de menor a mayor en tiempo de transferencia.

Se incluye la copia, ping e ipg en condiciones normales, como referencia (13s; 0.201ms; 0,281ms).

### Condiciones normales

Se envían 50000 paquetes en 15 segundos y todos se reciben.

**# ./network\_delete\_filters.sh**

qdisc pfifo\_fast 0: root refcnt 2 bands 3 priomap 1 2 2 2 1 2 0 0 1 1 1 1 1 1 1 1

$ scp systemrescuecd-x86-5.2.0.iso root@192.168.1.47:/root

systemrescuecd-x86-5.2.0.iso **100% 543MB 40.8MB/s 00:13**

**--- 192.168.1.48 ping statistics ---**

**50000 packets transmitted, 50000 received, 0% packet loss, time 14072ms**

**rtt min/avg/max/mdev = 0.098/0.201/9.395/0.201 ms, ipg/ewma 0.281/0.183 ms**

### Limitación del ancho de banda

Copia 1m13s, ping 50000 paquetes en 15s.

# ./network\_bwlimit\_only.sh

qdisc tbf 1: root refcnt 2 rate 80000Kbit burst 1048560b lat 20.0ms

$ scp systemrescuecd-x86-5.2.0.iso root@192.168.1.47:/root

systemrescuecd-x86-5.2.0.iso **100% 543MB 8.6MB/s 01:03**

**--- 192.168.1.48 ping statistics ---**

**50000 packets transmitted, 50000 received, 0% packet loss, time 14859ms**

**rtt min/avg/max/mdev = 0.124/0.223/12.670/0.248 ms, pipe 2, ipg/ewma 0.297/0.214 ms**

### Pérdida de paquetes y errores

Copia 3m54s, ping 50000 paquetes en 29s.

# ./network\_noise\_only.sh

qdisc netem 800d: root refcnt 2 limit 10000 loss 10% 25% corrupt 5% 25%

$ scp systemrescuecd-x86-5.2.0.iso root@192.168.1.47:/root

systemrescuecd-x86-5.2.0.iso **100% 543MB 2.3MB/s 03:54**

**--- 192.168.1.48 ping statistics ---**

**50000 packets transmitted, 49055 received, 1% packet loss, time 29170ms**

**rtt min/avg/max/mdev = 0.104/0.210/20.098/0.228 ms, pipe 2, ipg/ewma 0.583/0.171 ms**

### Pérdida de paquetes, errores y limitación del ancho de banda

Copia 4m1s, ping 50000 paquetes en 31s.

# ./network\_noise\_bwlimit.sh

qdisc tbf 1: root refcnt 2 rate 80000Kbit burst 1048560b lat 20.0ms

qdisc netem 10: parent 1: limit 10000 loss 10% 25% corrupt 5% 25%

$ scp systemrescuecd-x86-5.2.0.iso root@192.168.1.47:/root

systemrescuecd-x86-5.2.0.iso **100% 543MB 2.3MB/s 04:01**

**--- 192.168.1.48 ping statistics ---**

**50000 packets transmitted, 49013 received, 1% packet loss, time 31304ms**

**rtt min/avg/max/mdev = 0.124/0.231/9.925/0.223 ms, ipg/ewma 0.626/0.235 ms**

### Solamente latencia

Copia 14m5s, ping 4000 paquetes en 56s.

# ./network\_delay\_only.sh

qdisc netem 8023: root refcnt 2 limit 10000 delay 20.0ms 5.0ms

$ scp systemrescuecd-x86-5.2.0.iso root@192.168.1.47:/root

systemrescuecd-x86-5.2.0.iso **100% 543MB 657.8KB/s 14:05**

**--- 192.168.1.48 ping statistics ---**

**4000 packets transmitted, 4000 received, 0% packet loss, time 56475ms**

**rtt min/avg/max/mdev = 4.543/20.818/41.363/5.086 ms, pipe 4, ipg/ewma 14.122/19.069 ms**

### Pérdida de paquetes, errores y latencia

Copia 16m47s, ping 4000 paquetes en 56s.

# ./network\_noise\_delay.sh

qdisc netem 8025: root refcnt 2 limit 10000 delay 20.0ms 5.0ms loss 10% 25% corrupt 5% 25%

$ scp systemrescuecd-x86-5.2.0.iso root@192.168.1.47:/root

systemrescuecd-x86-5.2.0.iso **100% 543MB 552.3KB/s 16:47**

**--- 192.168.1.48 ping statistics ---**

**4000 packets transmitted, 3920 received, 2% packet loss, time 56630ms**

**rtt min/avg/max/mdev = 3.509/20.841/36.730/5.035 ms, pipe 4, ipg/ewma 14.161/22.234 ms**

### Pérdida de paquetes, errores, latencia y limitación del ancho de banda

Copia 16m51s, ping 4000 paquetes en 56s.

# ./network\_noise\_delay\_bwlimit.sh

qdisc tbf 1: root refcnt 2 rate 80000Kbit burst 1048560b lat 20.0ms

qdisc netem 10: parent 1: limit 10000 delay 20.0ms 5.0ms loss 10% 25% corrupt 5% 25%

$ scp systemrescuecd-x86-5.2.0.iso root@192.168.1.47:/root

systemrescuecd-x86-5.2.0.iso **100% 543MB 550.0KB/s 16:51**

**--- 192.168.1.48 ping statistics ---**

**4000 packets transmitted, 3930 received, 1% packet loss, time 56377ms**

**rtt min/avg/max/mdev = 3.843/20.978/38.569/5.003 ms, pipe 4, ipg/ewma 14.097/24.375 ms**