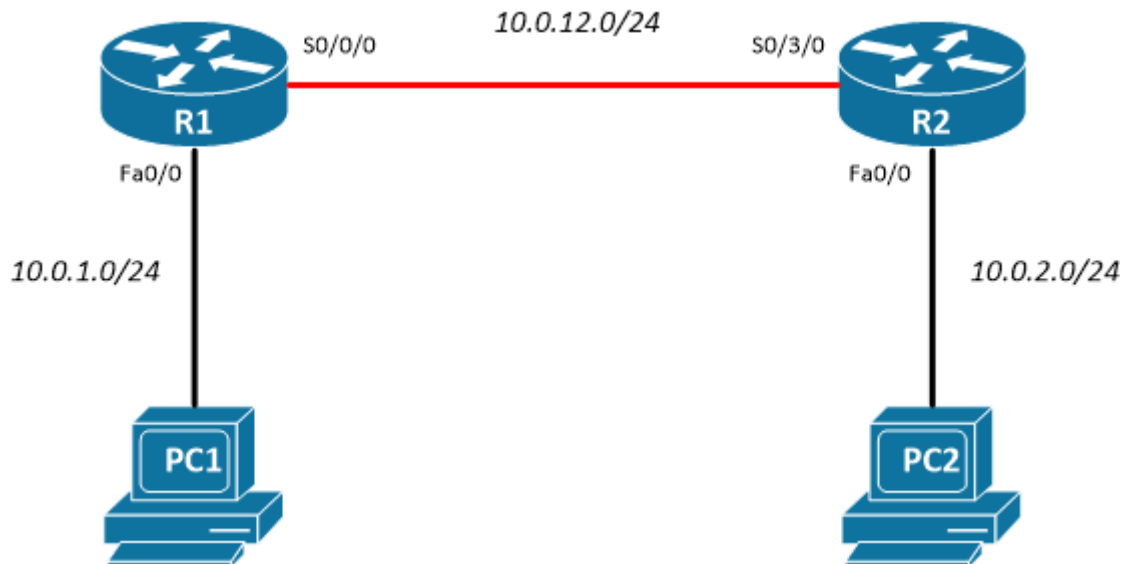


Porovnanie QoS mechanizmov

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Topológia



1. Preskúmajte hardvérový front smerovača

Hardvérový front smerovača sa nastavil podľa kapacity sériovej linky na 128. Vo výpise príkazu `show controllers s0/0/0` vidíme defaultne nastavené `tx_limited = 0(128)`.

Zmeniť to vieme nasledovne:

```
int s0/0/0
tx-ring-limit 2
show controllers s0/0/0
tx_limited = 0(2)
```

2. Preskúmajte defaultné nastavenia WFQ

V prvom rade sme si museli nakonfigurovať danú politiku. Konfigurovanie prebieha pomocou `policy-map` a nie priamo na rozhraní smerovača. Preto aj vo výpise vidíme *Queueing strategy: Class-based queueing*

```
policy-map WFQ
class class-default
fair-queue

show int s0/0/0
Serial0/0/0 is up, line protocol is up
```

```
Hardware is GT96K Serial
Internet address is 10.0.12.1/24
MTU 1500 bytes, BW 128 Kbit/sec, DLY 20000 usec,
  reliability 255/255, txload 1/255, rxload 1/255
Encapsulation HDLC, loopback not set
Keepalive set (10 sec)
Last input 00:00:05, output 00:00:06, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: Class-based queueing
Output queue: 0/1000/0 (size/max total/drops)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
 581 packets input, 44850 bytes, 0 no buffer
Received 544 broadcasts (0 IP multicasts)
 0 runs, 0 giants, 0 throttles
 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
570 packets output, 43835 bytes, 0 underruns
 0 output errors, 0 collisions, 8 interface resets
 0 unknown protocol drops
 0 output buffer failures, 0 output buffers swapped out
 2 carrier transitions
 DCD=up DSR=up DTR=up RTS=up CTS=up
```

Dodatočné nastavenia pri politike fair-queue:

```
R1(config-pmap-c)#fair-queue ?
<16-4096> Number Dynamic Conversation Queues <cr>
```

3. Experimenty s FIFO, PQ, CQ a WFQ

Kapacita našej linky medzi smerovačmi R1 a R2:

128 000 b/s

Maximálny počet paketov pri veľkosti jedného 512 B:

$128\,000 : (512 * 8) = \mathbf{31,25 \text{ paketov}}$

FIFO

Ako prvú sme porovnávali defaultnú politiku FIFO. Vo výpise *show interfaces s0/0/0* vidíme *Queueing strategy: fifo*

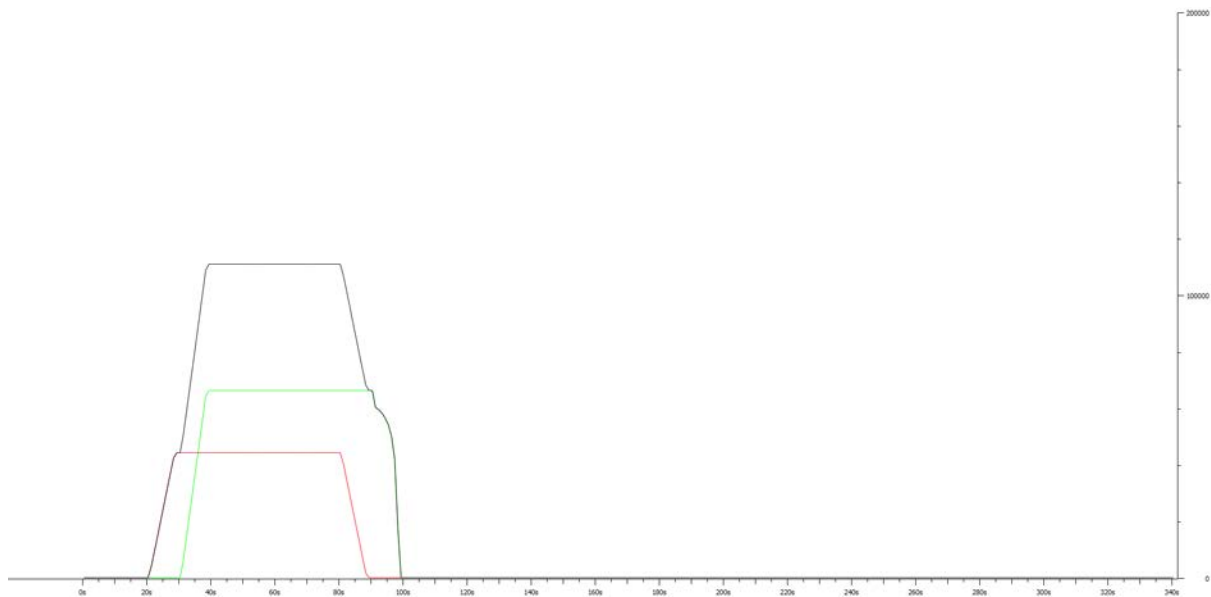
Najskôr sme generovali dva UDP toky ktoré v súčte nezahltia linku:

```
R1#sh int s0/0/0
Serial0/0/0 is up, line protocol is up
Hardware is GT96K Serial
Internet address is 10.0.12.1/24
MTU 1500 bytes, BW 128 Kbit/sec, DLY 20000 usec,
  reliability 255/255, txload 21/255, rxload 1/255
Encapsulation HDLC, loopback not set
Keepalive set (10 sec)
Last input 00:00:05, output 00:00:05, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
  701 packets input, 53746 bytes, 0 no buffer
  Received 651 broadcasts (0 IP multicasts)
  0 runs, 0 giants, 0 throttles
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
  2190 packets output, 868457 bytes, 0 underruns
  0 output errors, 0 collisions, 9 interface resets
  0 unknown protocol drops
  0 output buffer failures, 0 output buffers swapped out
  2 carrier transitions
  DCD=up DSR=up DTR=up RTS=up CTS=up
```

Intenzity generovaných tokov, ktorých súčet je menší ako kapacita linky:

Tok	UDP port	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Červený	9001	10	512	40 960
Zelený	9002	15	512	61 440
Celkový		25	512	102 400

Podľa tabuľky výpočtu vidíme, že celkový tok je 102 kb/s čo je menej ako kapacita našej linky (128 kb/s).



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Compile-time options:

Flow number: 1

From 10.0.1.2:54776

To 10.0.2.2:9001

Total time = 59.897000 s
Total packets = 600
Minimum delay = -112.997000 s
Maximum delay = -112.989000 s
Average delay = -112.993918 s
Average jitter = 0.004045 s
Delay standard deviation = 0.002438 s
Bytes received = 307200
Average bitrate = 41.030436 Kbit/s
Average packet rate = 10.017196 pkt/s
Packets dropped = 0 (0.00 %)
Average loss-burst size = 0.000000 pkt

Flow number: 2

From 10.0.1.2:54777

To 10.0.2.2:9002

Total time = 59.934000 s
Total packets = 900
Minimum delay = -112.992000 s
Maximum delay = -112.959000 s
Average delay = -112.982074 s
Average jitter = 0.017601 s
Delay standard deviation = 0.013619 s
Bytes received = 460800
Average bitrate = 61.507658 Kbit/s

```
Average packet rate = 15.016518 pkt/s
Packets dropped      = 0 (0.00 %)
Average loss-burst size = 0.000000 pkt
-----
```

***** TOTAL RESULTS *****

```
Number of flows      = 2
Total time           = 69.901000 s
Total packets        = 1500
Minimum delay        = -112.997000 s
Maximum delay        = -112.959000 s
Average delay        = -112.986812 s
Average jitter       = 0.012185 s
Delay standard deviation = 0.012138 s
Bytes received       = 768000
Average bitrate      = 87.895738 Kbit/s
Average packet rate  = 21.458920 pkt/s
Packets dropped      = 0 (0.00 %)
Average loss-burst size = 0 pkt
Error lines          = 0
-----
```

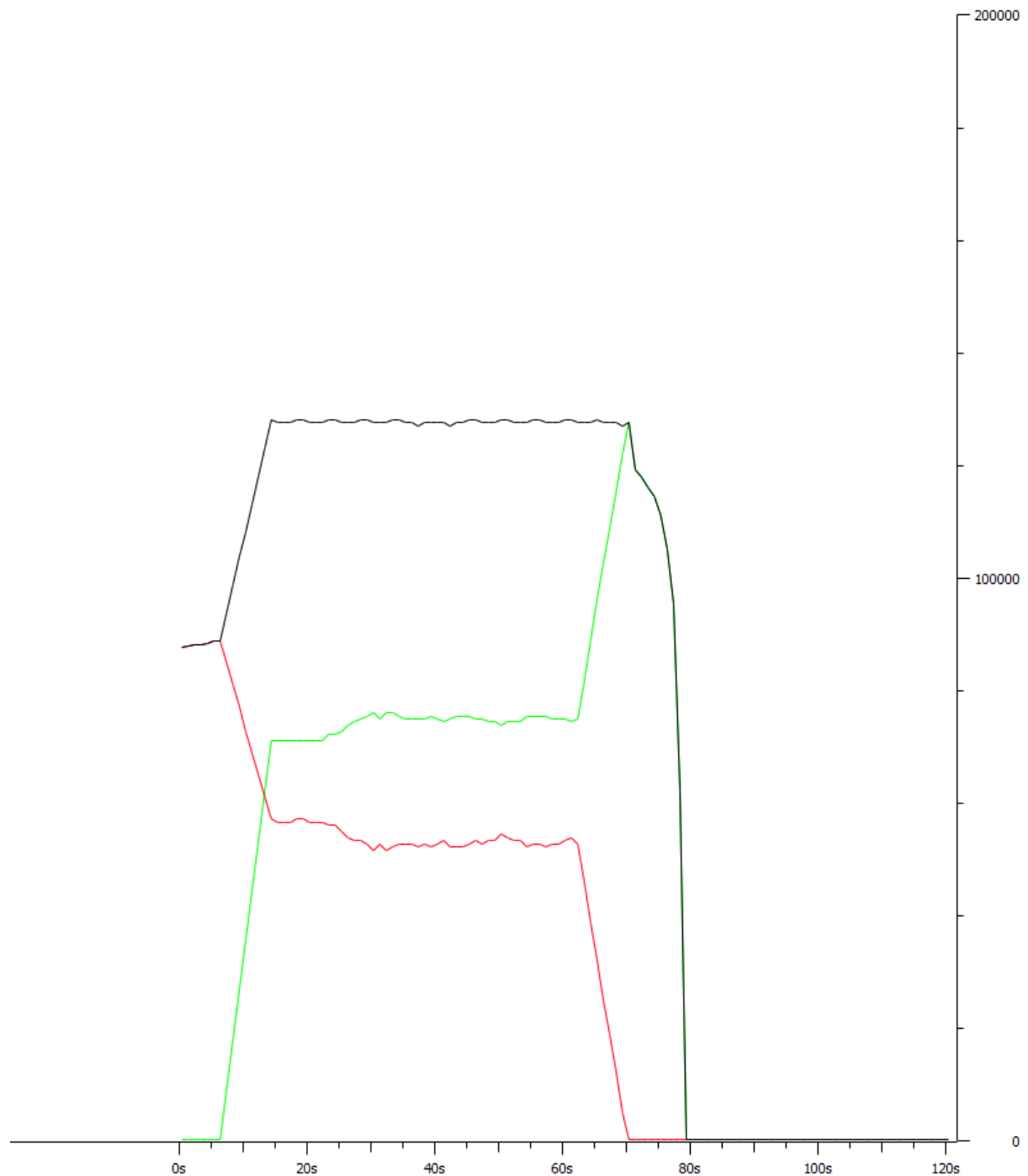
Ako druhý pokus sme si zvolili dva toky ktoré v súčte prelezú kapacitu linky:

```
R1#sh int s0/0/0
Serial0/0/0 is up, line protocol is up
Hardware is GT96K Serial
Internet address is 10.0.12.1/24
MTU 1500 bytes, BW 128 Kbit/sec, DLY 20000 usec,
  reliability 255/255, txload 59/255, rxload 1/255
Encapsulation HDLC, loopback not set
Keepalive set (10 sec)
Last input 00:00:03, output 00:00:04, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 645
Queueing strategy: fifo
Output queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 30000 bits/sec, 13 packets/sec
  777 packets input, 59062 bytes, 0 no buffer
  Received 708 broadcasts (0 IP multicasts)
  0 runs, 0 giants, 0 throttles
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
  4321 packets output, 1991419 bytes, 0 underruns
  0 output errors, 0 collisions, 9 interface resets
  0 unknown protocol drops
  0 output buffer failures, 0 output buffers swapped out
  2 carrier transitions
DCD=up DSR=up DTR=up RTS=up CTS=up
```

Intenzity generovaných tokov, ktorých súčet je väčší ako kapacita linky:

Tok	UDP port	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Červený	9001	20	512	81 920
Zelený	9002	25	512	102 400
Celkový		45	512	184 320

Celkový súčet tokov je väčší ako kapacita linky, preto nastávajú straty paketov ako je vidieť nižšie z výpisov štatistík D-ITG.



Compile-time options:

Flow number: 1
From 10.0.1.2:50720
To 10.0.2.2:9001

Total time = 65.659000 s
Total packets = 877
Minimum delay = -112.992000 s
Maximum delay = -107.143000 s
Average delay = -109.182327 s
Average jitter = 0.013506 s
Delay standard deviation = 2.514065 s
Bytes received = 449024
Average bitrate = 54.709819 Kbit/s
Average packet rate = 13.356889 pkt/s
Packets dropped = 321 (26.79 %)
Average loss-burst size = 1.377682 pkt

Flow number: 2
From 10.0.1.2:50721
To 10.0.2.2:9002

Total time = 64.418000 s
Total packets = 1178
Minimum delay = -112.970000 s
Maximum delay = -107.142000 s
Average delay = -107.959724 s
Average jitter = 0.013414 s
Delay standard deviation = 1.409890 s
Bytes received = 603136
Average bitrate = 74.902791 Kbit/s
Average packet rate = 18.286814 pkt/s
Packets dropped = 322 (21.47 %)
Average loss-burst size = 1.412281 pkt

***** TOTAL RESULTS *****

Number of flows = 2
Total time = 74.399000 s
Total packets = 2055
Minimum delay = -112.992000 s
Maximum delay = -107.142000 s
Average delay = -108.481487 s
Average jitter = 0.016169 s
Delay standard deviation = 2.050004 s
Bytes received = 1052160
Average bitrate = 113.137005 Kbit/s
Average packet rate = 27.621339 pkt/s
Packets dropped = 643 (23.83 %)
Average loss-burst size = 1.394794 pkt
Error lines = 0

PQ

Na starších iSoch sa táto politika kofigurovala priamo v konfiguračnom režime príkazom *priority-list* a obsahovala 4 levely. V novších iSoch obsahuje už len 2 levely a rieši sa to cez *policy-mapy* nasledovne:

```
access-list 101 permit udp any any eq 9001
access-list 102 permit udp any any eq 9002
```

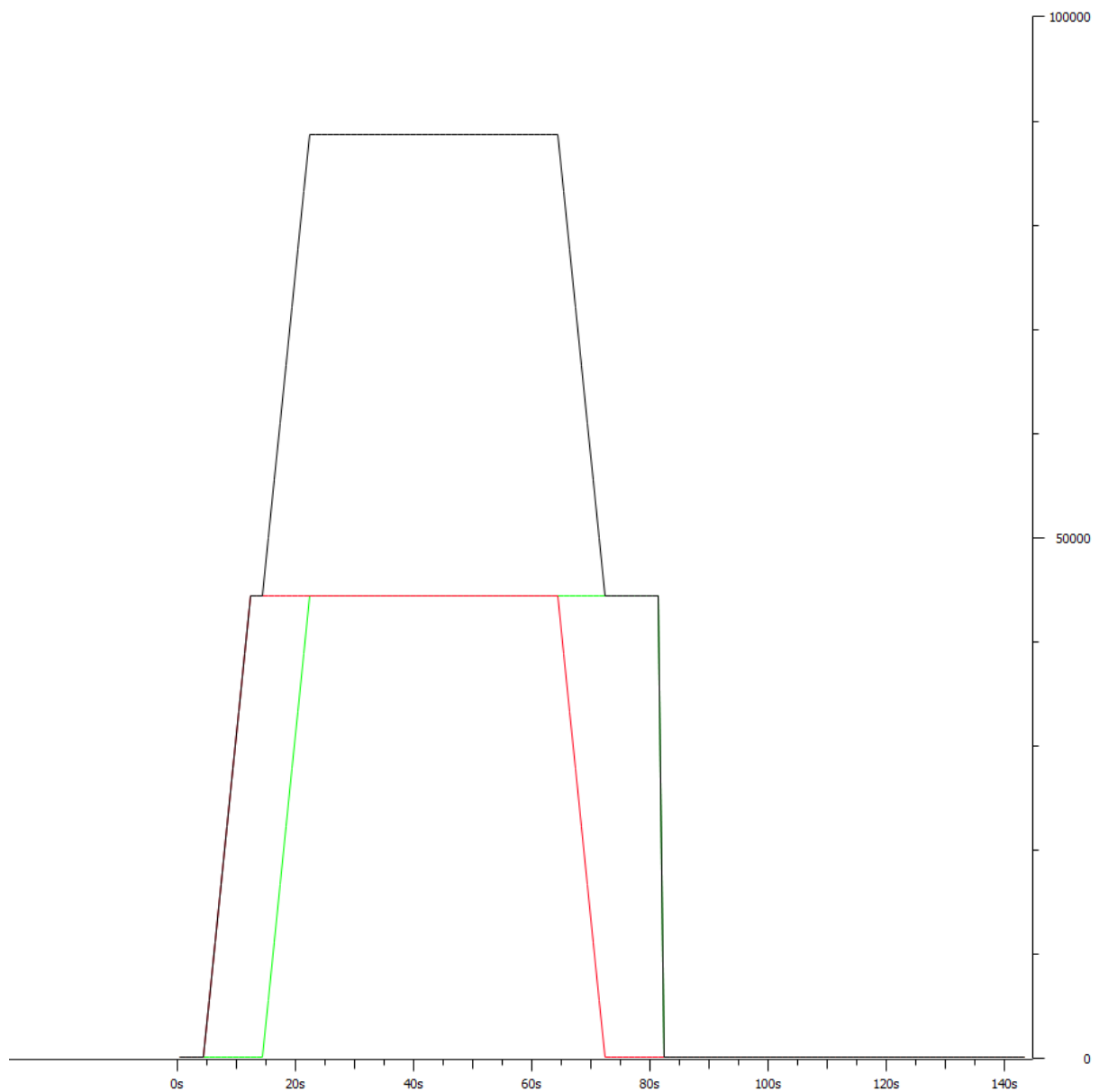
```
class-map match-all Pclass2
  match access-group 102
class-map match-all Pclass
  match access-group 101
```

```
policy-map Ppolicy
  class Pclass
    priority level 1
  class Pclass2
    priority level 2
```

```
interface Serial0/0/0
  service-policy output Ppolicy
```

Intenzity generovaných tokov, ktorých súčet je menší ako kapacita linky:

Tok	UDP port	Priority level	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Červený	9001	1 (high)	10	512	40 960
Zelený	9002	2 (low)	10	512	40 960
Celkový			20	512	81 920



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Compile-time options:

Flow number: 1

From 10.0.1.2:63696

To 10.0.2.2:9001

Total time	=	59.899000 s
Total packets	=	600
Minimum delay	=	-122.881000 s
Maximum delay	=	-122.856000 s
Average delay	=	-122.878062 s
Average jitter	=	0.000987 s
Delay standard deviation	=	0.001300 s
Bytes received	=	307200
Average bitrate	=	41.029066 Kbit/s
Average packet rate	=	10.016862 pkt/s
Packets dropped	=	0 (0.00 %)
Average loss-burst size	=	0.000000 pkt

Flow number: 2
From 10.0.1.2:63697
To 10.0.2.2:9002

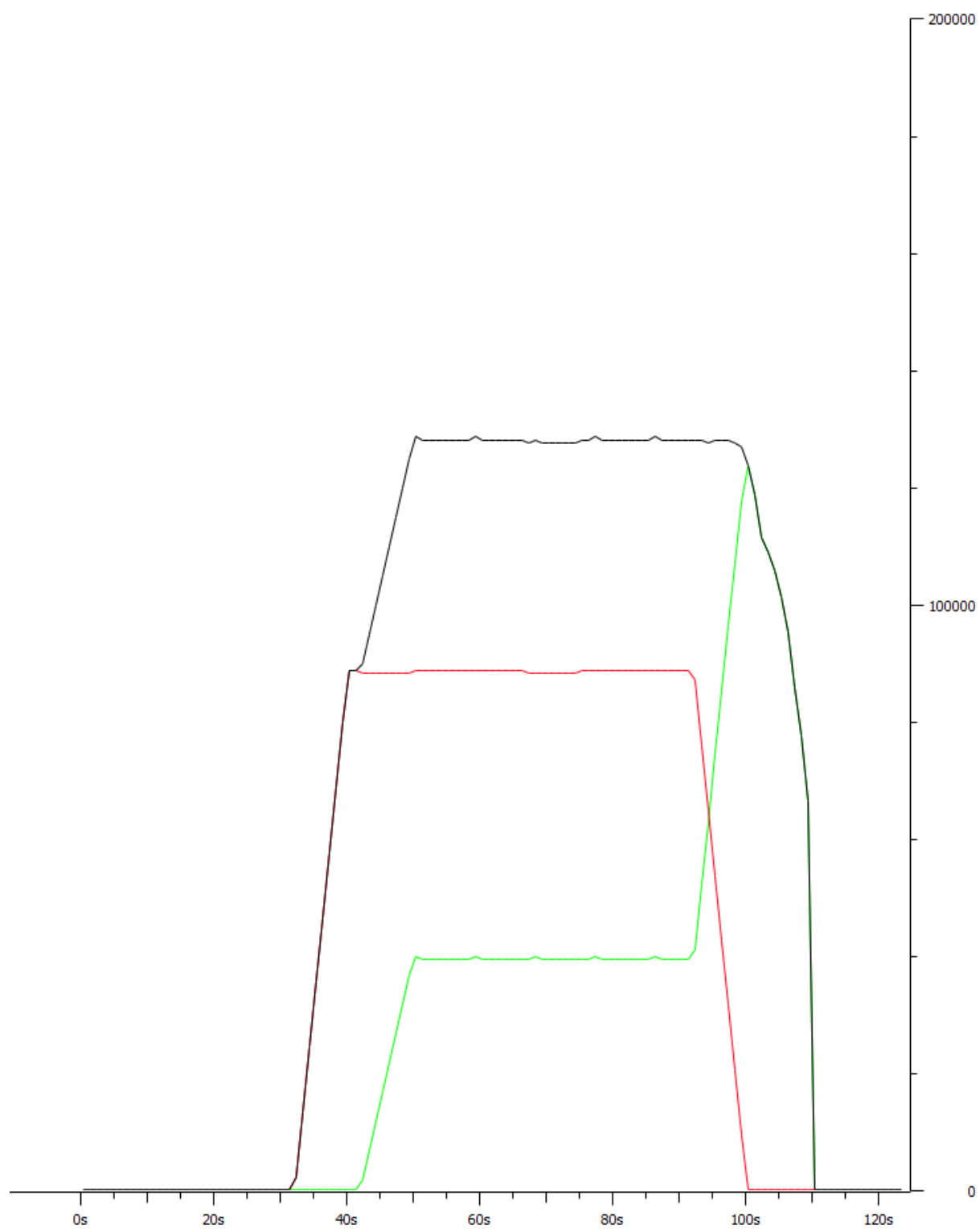
Total time = 59.901000 s
Total packets = 600
Minimum delay = -122.732000 s
Maximum delay = -122.729000 s
Average delay = -122.730512 s
Average jitter = 0.000661 s
Delay standard deviation = 0.000666 s
Bytes received = 307200
Average bitrate = 41.027696 Kbit/s
Average packet rate = 10.016527 pkt/s
Packets dropped = 0 (0.00 %)
Average loss-burst size = 0.000000 pkt

***** TOTAL RESULTS *****

Number of flows = 2
Total time = 69.863000 s
Total packets = 1200
Minimum delay = -122.881000 s
Maximum delay = -122.729000 s
Average delay = -122.804287 s
Average jitter = 0.003355 s
Delay standard deviation = 0.073782 s
Bytes received = 614400
Average bitrate = 70.354837 Kbit/s
Average packet rate = 17.176474 pkt/s
Packets dropped = 0 (0.00 %)
Average loss-burst size = 0 pkt
Error lines = 0

Intenzity generovaných tokov, ktorých súčet je väčší ako kapacita linky:

Tok	UDP port	Priority level	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Červený	9001	1 (high)	20	512	81 920
Zelený	9002	2 (low)	20	512	81 920
Celkový			20	512	163 840



ITGDec version 2.8.1 (r1023)

Compile-time options:

Flow number: 1

From 10.0.1.2:54161

To 10.0.2.2:9001

Total time = 60.002000 s

Total packets = 1199

Minimum delay = -120.799000 s
Maximum delay = -120.715000 s
Average delay = -120.742831 s
Average jitter = 0.014327 s
Delay standard deviation = 0.026307 s
Bytes received = 613888
Average bitrate = 81.849005 Kbit/s
Average packet rate = 19.982667 pkt/s
Packets dropped = 1 (0.08 %)
Average loss-burst size = 1.000000 pkt

Flow number: 2
From 10.0.1.2:54162
To 10.0.2.2:9002

Total time = 59.486000 s
Total packets = 700
Minimum delay = -122.737000 s
Maximum delay = -115.370000 s
Average delay = -118.008237 s
Average jitter = 0.031750 s
Delay standard deviation = 2.911983 s
Bytes received = 358400
Average bitrate = 48.199576 Kbit/s
Average packet rate = 11.767475 pkt/s
Packets dropped = 491 (41.23 %)
Average loss-burst size = 1.249364 pkt

***** TOTAL RESULTS *****

Number of flows = 2
Total time = 69.468000 s
Total packets = 1899
Minimum delay = -122.737000 s
Maximum delay = -115.370000 s
Average delay = -119.734818 s
Average jitter = 0.062519 s
Delay standard deviation = 2.206032 s
Bytes received = 972288
Average bitrate = 111.969598 Kbit/s
Average packet rate = 27.336328 pkt/s
Packets dropped = 492 (20.58 %)
Average loss-burst size = 1.248731 pkt
Error lines = 0

WFQ

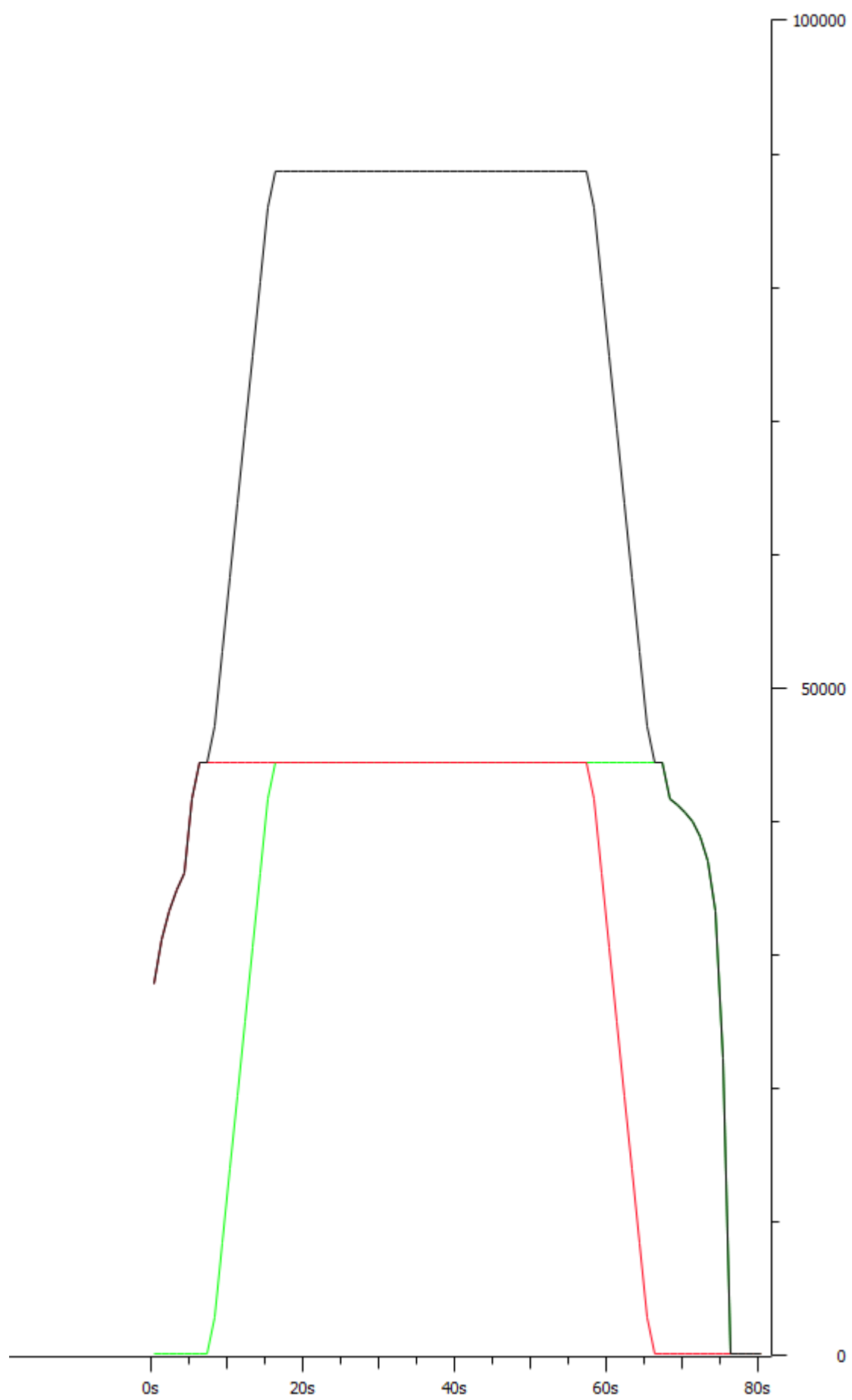
Ako poslednú sme testovali politiku Weighted fair queueing, ktorú sme nakonfigurovali nasledovne:

```
policy-map WFQ
class class-default
  fair-queue

interface Serial0/0/0
  service-policy output WFQ
```

Intenzity generovaných tokov, ktorých súčet je menší ako kapacita linky:

Tok	UDP port	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Červený	9001	10	512	40 960
Zelený	9002	10	512	40 960
Celkový		25	512	81 920



ITGDec version 2.8.1 (r1023)

Compile-time options:

Flow number: 1

From 10.0.1.2:50057

To 10.0.2.2:9001

Total time = 59.898000 s
Total packets = 600
Minimum delay = -115.725000 s
Maximum delay = -115.721000 s
Average delay = -115.723378 s
Average jitter = 0.000631 s
Delay standard deviation = 0.000765 s
Bytes received = 307200
Average bitrate = 41.029751 Kbit/s
Average packet rate = 10.017029 pkt/s
Packets dropped = 0 (0.00 %)
Average loss-burst size = 0.000000 pkt

Flow number: 2

From 10.0.1.2:50058

To 10.0.2.2:9002

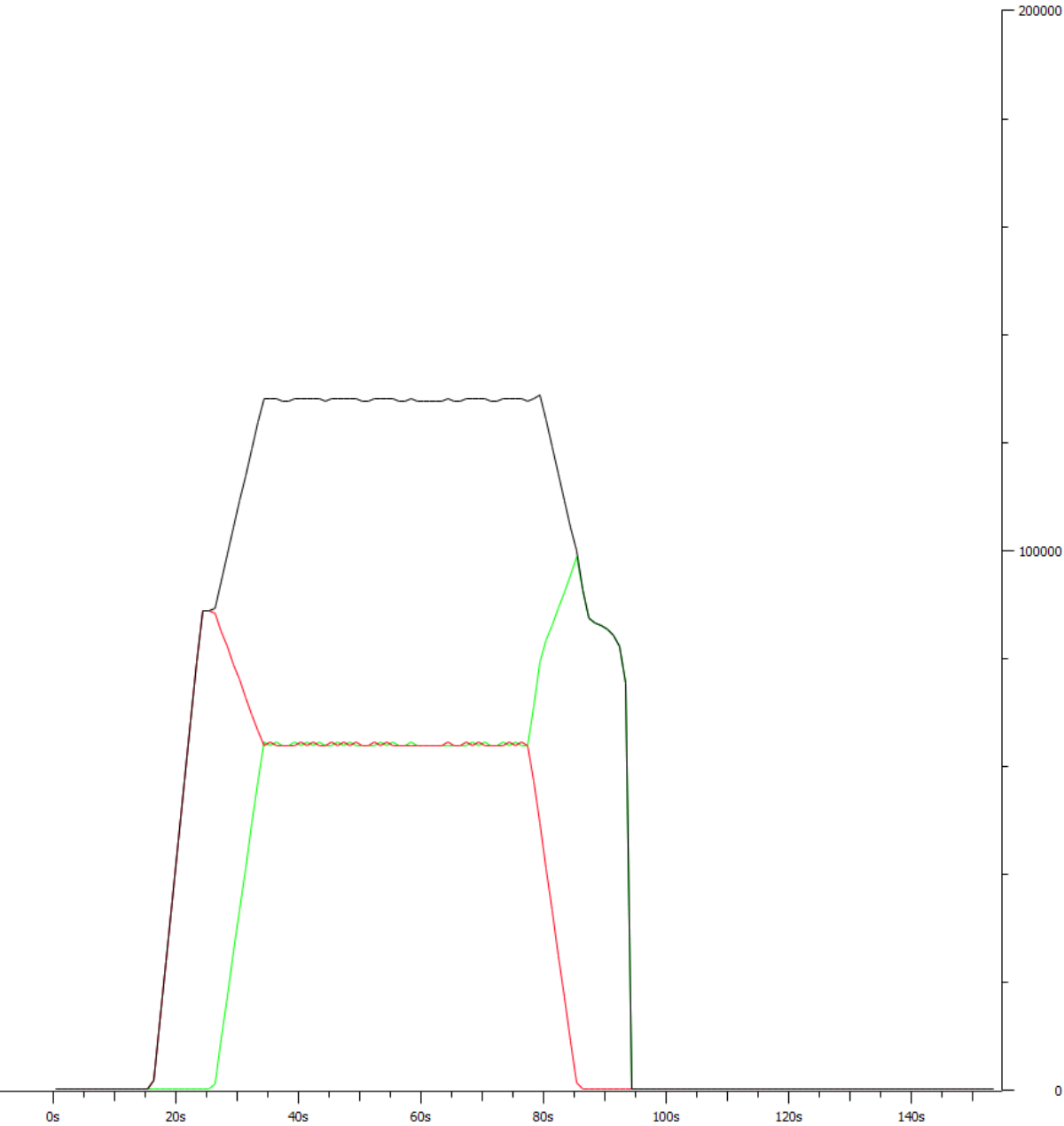
Total time = 59.901000 s
Total packets = 600
Minimum delay = -117.877000 s
Maximum delay = -117.875000 s
Average delay = -117.875615 s
Average jitter = 0.000669 s
Delay standard deviation = 0.000583 s
Bytes received = 307200
Average bitrate = 41.027696 Kbit/s
Average packet rate = 10.016527 pkt/s
Packets dropped = 0 (0.00 %)
Average loss-burst size = 0.000000 pkt

***** TOTAL RESULTS *****

Number of flows = 2
Total time = 69.864000 s
Total packets = 1200
Minimum delay = -117.877000 s
Maximum delay = -115.721000 s
Average delay = -116.799497 s
Average jitter = 0.038329 s
Delay standard deviation = 1.076119 s
Bytes received = 614400
Average bitrate = 70.353830 Kbit/s
Average packet rate = 17.176228 pkt/s
Packets dropped = 0 (0.00 %)
Average loss-burst size = 0 pkt
Error lines = 0

Intenzity generovaných tokov, ktorých súčet je väčší ako kapacita linky:

Tok	UDP port	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Červený	9001	20	512	81 920
Zelený	9002	20	512	81 920
Celkový		25	512	163 840



Flow number: 1
From 10.0.1.2:65030
To 10.0.2.2:9001

Total time = 60.101000 s
Total packets = 923
Minimum delay = -109.924000 s
Maximum delay = -108.637000 s
Average delay = -108.995854 s
Average jitter = 0.018452 s
Delay standard deviation = 0.519337 s
Bytes received = 472576
Average bitrate = 62.904245 Kbit/s
Average packet rate = 15.357482 pkt/s
Packets dropped = 255 (21.65 %)
Average loss-burst size = 1.000000 pkt

Flow number: 2
From 10.0.1.2:65031
To 10.0.2.2:9002

Total time = 59.932000 s
Total packets = 932
Minimum delay = -107.600000 s
Maximum delay = -106.315000 s
Average delay = -106.628499 s
Average jitter = 0.019917 s
Delay standard deviation = 0.472906 s
Bytes received = 477184
Average bitrate = 63.696723 Kbit/s
Average packet rate = 15.550958 pkt/s
Packets dropped = 268 (22.33 %)
Average loss-burst size = 1.000000 pkt

***** TOTAL RESULTS *****

Number of flows = 2
Total time = 69.914000 s
Total packets = 1855
Minimum delay = -109.924000 s
Maximum delay = -106.315000 s
Average delay = -107.806433 s
Average jitter = 0.055843 s
Delay standard deviation = 1.283598 s
Bytes received = 949760
Average bitrate = 108.677518 Kbit/s
Average packet rate = 26.532597 pkt/s
Packets dropped = 523 (21.99 %)
Average loss-burst size = 1.000000 pkt
Error lines = 0
