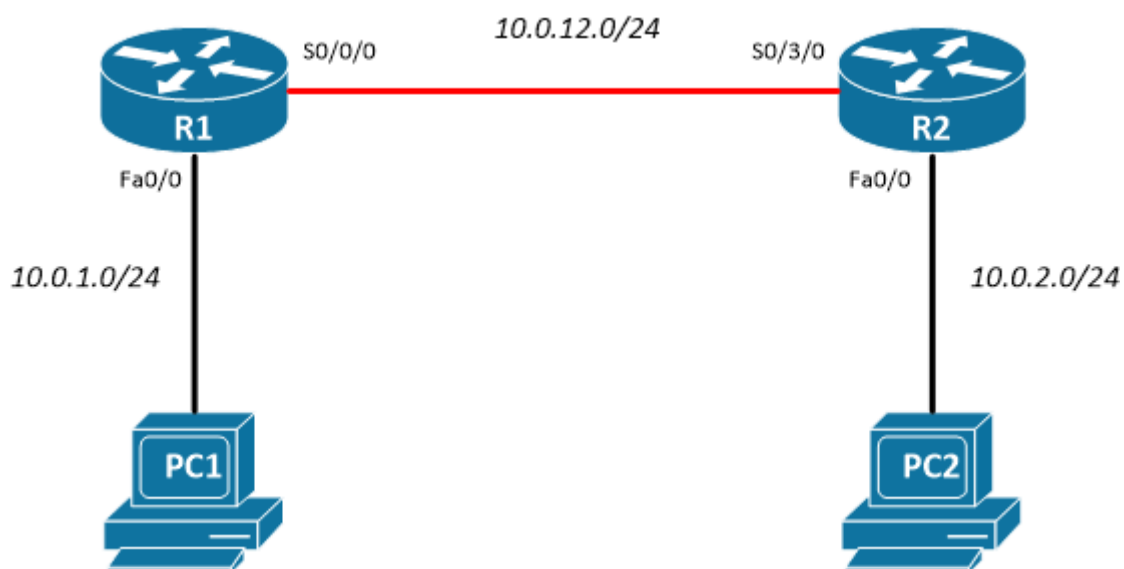


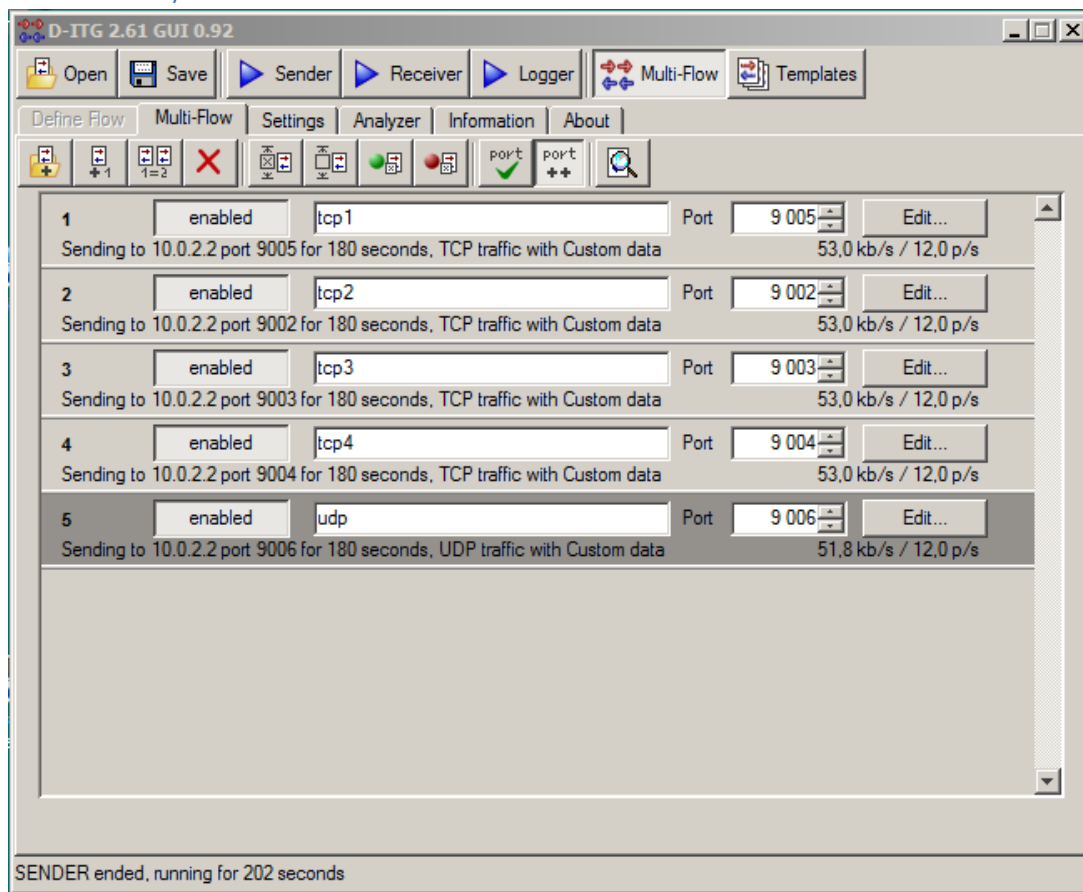
Experimenty s QoS mechanizmom WRED

Vypracovali: Dočár Miroslav, Drozdík Martin

Topológia

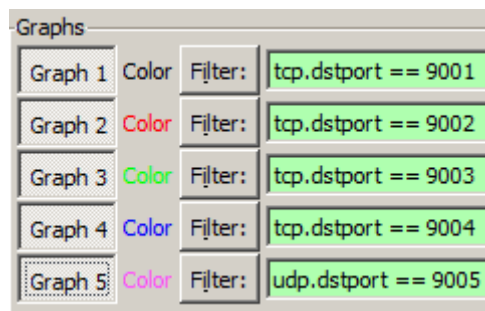


Generované toky



Generované toky s malým prekročením 128 kb linky					
Tok	port	značkovanie	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Čierny	9001 (TCP)	AF11	12	512	50 000
Červený	9002 (TCP)	AF12	12	512	50 000
Modrý	9003 (TCP)	AF31	12	512	50 000
Zelený	9004 (TCP)	AF33	12	512	50 000
Fialový	9005 (UDP)	AF21	12	512	50 000

Generované toky s väčším prekročením 128 kb linky					
Tok	port	značkovanie	Počet paketov	Veľkosť paketov [B/s]	Intenzita toku [b/s]
Čierny	9001 (TCP)	AF11	20	512	82 000
Červený	9002 (TCP)	AF12	20	512	82 000
Modrý	9003 (TCP)	AF31	20	512	82 000
Zelený	9004 (TCP)	AF33	20	512	82 000
Fialový	9005 (UDP)	AF21	20	512	82 000



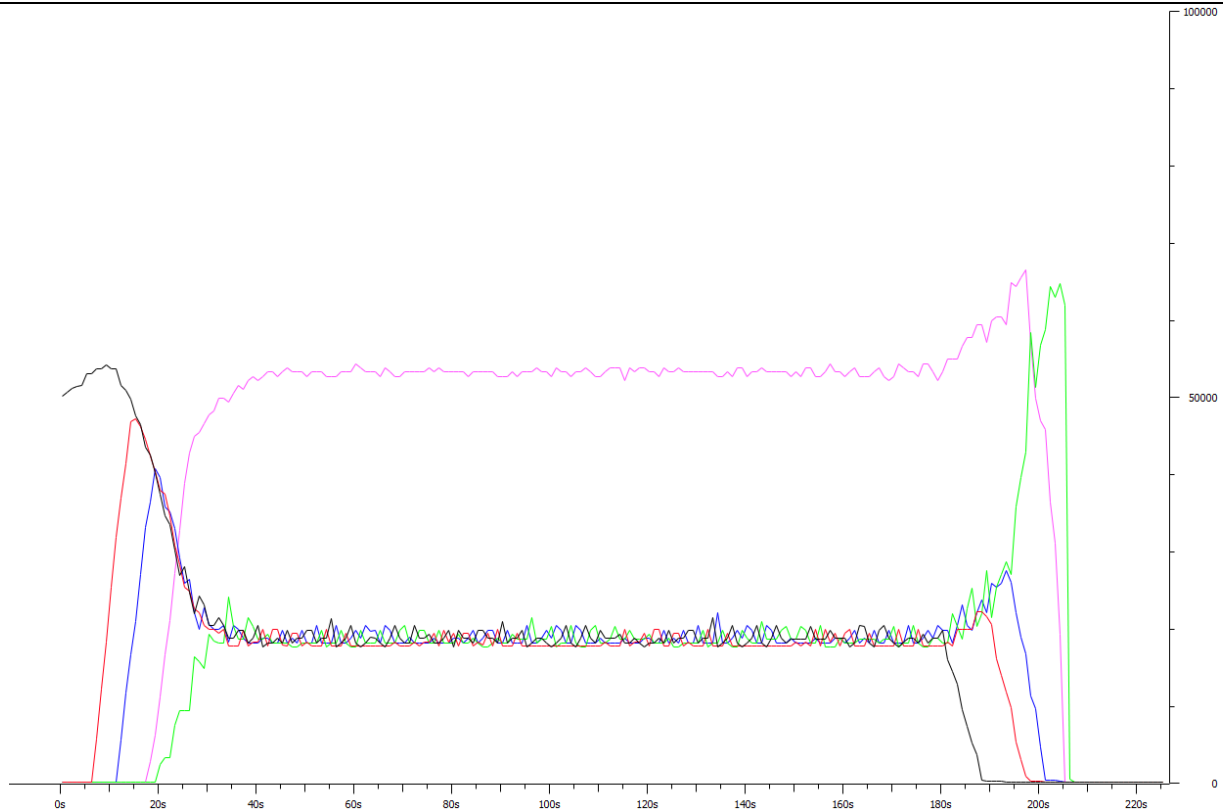
1. scenár – FIFO

```

R1#sh interfaces 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 99/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:06, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 1259
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
    7077 packets input, 323476 bytes, 0 no buffer
    Received 338 broadcasts (0 IP multicasts)
    0 runs, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort

```

21133 packets output, 13745508 bytes, 0 underruns
 0 output errors, 0 collisions, 5 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



Flow number: 1
From 10.0.1.2:1050
To 10.0.2.2:9001

 Total time = 183.705000 s
 Total packets = 946
 Minimum delay = -104.423000 s
 Maximum delay = -99.399000 s
 Average delay = -101.502411 s
 Average jitter = 0.113935 s
 Delay standard deviation = 1.579001 s
 Bytes received = 484352
 Average bitrate = 21.092600 Kbit/s
 Average packet rate = 5.149560 pkt/s
 Packets dropped = 0 (0.00 %)
 Average loss-burst size = 0.000000 pkt

Flow number: 2
From 10.0.1.2:1051
To 10.0.2.2:9002

 Total time = 182.986000 s
 Total packets = 845
 Minimum delay = -104.477000 s
 Maximum delay = -99.484000 s
 Average delay = -101.100917 s
 Average jitter = 0.284748 s
 Delay standard deviation = 1.275746 s
 Bytes received = 432640
 Average bitrate = 18.914671 Kbit/s
 Average packet rate = 4.617840 pkt/s
 Packets dropped = 0 (0.00 %)
 Average loss-burst size = 0.000000 pkt

Flow number: 3
From 10.0.1.2:1053
To 10.0.2.2:9003

 Total time = 178.328000 s
 Total packets = 834

Flow number: 4
From 10.0.1.2:1052
To 10.0.2.2:9004

 Total time = 181.209000 s
 Total packets = 841

Minimum delay = -105.186000 s	Minimum delay = -104.966000 s
Maximum delay = -99.488000 s	Maximum delay = -100.007000 s
Average delay = -102.112598 s	Average delay = -101.499828 s
Average jitter = 0.153421 s	Average jitter = 0.125598 s
Delay standard deviation = 0.962333 s	Delay standard deviation = 0.883328 s
Bytes received = 427008	Bytes received = 430592
Average bitrate = 19.156072 Kbit/s	Average bitrate = 19.009740 Kbit/s
Average packet rate = 4.676775 pkt/s	Average packet rate = 4.641050 pkt/s
Packets dropped = 0 (0.00 %)	Packets dropped = 0 (0.00 %)
Average loss-burst size = 0.000000 pkt	Average loss-burst size = 0.000000 pkt
Flow number: 5 From 10.0.1.2:50546 To 10.0.2.2:9005 <hr/>	
Total time = 179.571000 s Total packets = 2160 Minimum delay = -103.475000 s Maximum delay = -100.470000 s Average delay = -100.792588 s Average jitter = 0.057960 s Delay standard deviation = 0.521682 s Bytes received = 1105920 Average bitrate = 49.269425 Kbit/s Average packet rate = 12.028668 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	

Pri tomto scenári vidíme, že UDP úplne zahltilo linku, keďže bolo nastavené FIFO. Žiadne straty neboli zaznamenané, ale vidíme, že za približne 3 minúty prešlo 2160 paketov, zatiaľ čo TCP paketov v priemere 850.

2. scenár – CBWFQ

Konfigurácia

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

class-map match-all vystupAF31
  match dscp af31
class-map match-all vystupAF12
  match dscp af12
class-map match-all vystupAF21
  match dscp af21
class-map match-all vystupAF11
  match dscp af11
class-map match-all vystupAF33
  match dscp af33
class-map match-all znackuj2
  match access-group 101
class-map match-all znackuj3
  match access-group 102
class-map match-all znackuj4
  match access-group 103
class-map match-all znackuj5
  match access-group 104
class-map match-all znackuj
  match access-group 100

policy-map shape
class vystupAF11
  bandwidth percent 25
class vystupAF12
  bandwidth percent 25
class vystupAF21
  bandwidth percent 25
class class-default
  fair-queue
  bandwidth percent 25
policy-map znackujP
class znackuj
  set dscp af11
class znackuj2
  set dscp af12
class znackuj5
  set dscp af21
class znackuj3
  set dscp af31
class znackuj4
  set dscp af33
class class-default
policy-map WFQ
class class-default
```

fair-queue

```
access-list 100 permit tcp any any eq 9001
access-list 101 permit tcp any any eq 9002
access-list 102 permit tcp any any eq 9003
access-list 103 permit tcp any any eq 9004
access-list 104 permit udp any any eq 9005
```

```
interface FastEthernet0/0
ip address 10.0.1.1 255.255.255.0
duplex auto
speed auto
service-policy input znackujP
```

```
interface Serial0/0/0
bandwidth 128
ip address 10.0.12.1 255.255.255.0
service-policy output shape
```

```
R1(config-if)#do 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 53/255, rxload 1/255
Encapsulation HDLC, loopback not set
Keepalive set (10 sec)
Last input 00:00:06, output 00:00:01, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 1259
```

Queueing strategy: Class-based queueing

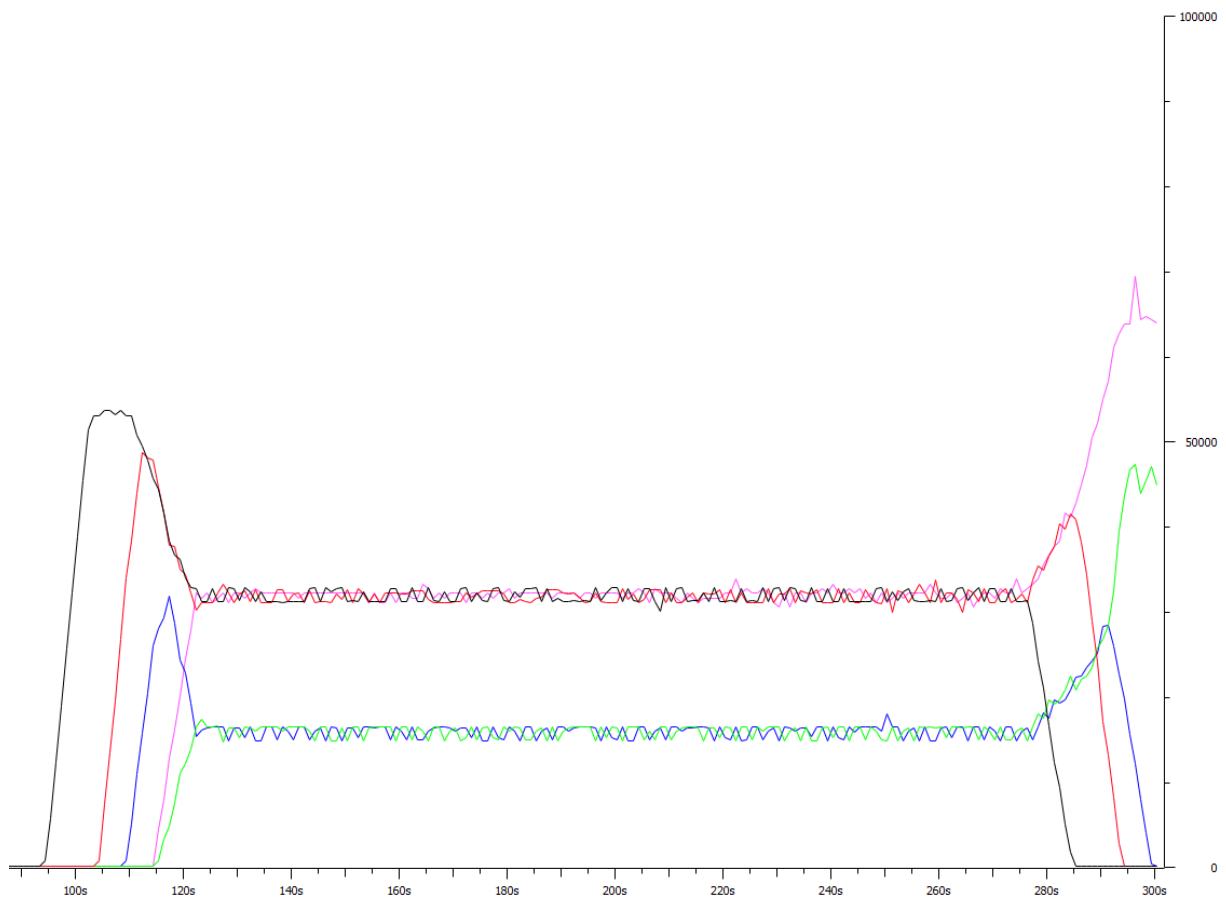
```
Output queue: 0/1000/0 (size/max total/drops)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
 7090 packets input, 324456 bytes, 0 no buffer
Received 351 broadcasts (0 IP multicasts)
 0 runs, 0 giants, 0 throttles
 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
21146 packets output, 13746488 bytes, 0 underruns
 0 output errors, 0 collisions, 6 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
```

```
R1#show policy-map interface s0/0/0
Serial0/0/0
```

Service-policy output: WFQ

Class-map: class-default (match-any)
4875 packets, 3625473 bytes
5 minute offered rate 34000 bps, drop rate 0000 bps
Match: any
Queueing
queue limit 64 packets
(queue depth/total drops/no-buffer drops/flowdrops) 0/1053/0/1053
(pkts output/bytes output) 3822/3052641
Fair-queue: per-flow queue limit 16 packets

R1#show policy-map WFQ
Policy Map WFQ
Class class-default
fair-queue



Flow number: 1
From 10.0.1.2:1254
To 10.0.2.2:9001

Total time = 181.146000 s
Total packets = 1399
Minimum delay = -85.142000 s
Maximum delay = -82.423000 s
Average delay = -83.238352 s

Flow number: 2
From 10.0.1.2:1255
To 10.0.2.2:9002

Total time = 180.391000 s
Total packets = 1370
Minimum delay = -89.605000 s
Maximum delay = -86.861000 s
Average delay = -87.605891 s

Average jitter = 0.176466 s Delay standard deviation = 0.762513 s Bytes received = 716288 Average bitrate = 31.633621 Kbit/s Average packet rate = 7.723052 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Average jitter = 0.139861 s Delay standard deviation = 0.545364 s Bytes received = 701440 Average bitrate = 31.107539 Kbit/s Average packet rate = 7.594614 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 3 From 10.0.1.2:1257 To 10.0.2.2:9003 ----- Total time = 180.367000 s Total packets = 735 Minimum delay = -94.402000 s Maximum delay = -89.279000 s Average delay = -90.820618 s Average jitter = 0.349366 s Delay standard deviation = 1.139829 s Bytes received = 376320 Average bitrate = 16.691302 Kbit/s Average packet rate = 4.075025 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Flow number: 4 From 10.0.1.2:1256 To 10.0.2.2:9004 ----- Total time = 180.191000 s Total packets = 703 Minimum delay = -92.105000 s Maximum delay = -86.489000 s Average delay = -87.945831 s Average jitter = 0.361627 s Delay standard deviation = 1.024042 s Bytes received = 359936 Average bitrate = 15.980199 Kbit/s Average packet rate = 3.901416 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 5 From 10.0.1.2:51044 To 10.0.2.2:9005 ----- Total time = 180.107000 s Total packets = 1387 Minimum delay = -94.970000 s Maximum delay = -85.754000 s Average delay = -87.094509 s Average jitter = 0.129624 s Delay standard deviation = 2.009275 s Bytes received = 710144 Average bitrate = 31.543205 Kbit/s Average packet rate = 7.700978 pkt/s Packets dropped = 736 (34.67 %) Average loss-burst size = 1.559322 pkt	

Pri scenári, kde sme využili CBWFQ vidíme, že straty na UDP toku sú približne 35%.

Na nasledujúcich dvoch obrázkoch vidíme, že značkovanie nám fungovalo (vidieť značky AF11 a AF31).

3136	208.433946	10.0.2.2	10.0.1.2	TCP	54	9003-1257	[ACK]	Seq=1 Ack=168373 win=65536 Len=0
3137	208.440044	10.0.1.2	10.0.2.2	TCP	130	1254-9001	[PSH, ACK]	Seq=452533 Ack=1 win=65536 Len=76
3138	208.535819	10.0.1.2	10.0.2.2	TCP	1514	1254-9001	[ACK]	Seq=452609 Ack=1 win=65536 Len=1460
3139	208.535863	10.0.2.2	10.0.1.2	TCP	54	9001-1254	[ACK]	Seq=1 Ack=454069 win=65536 Len=0
3140	208.537363	10.0.2.2	10.0.1.2	TCP	54	9002-1255	[ACK]	Seq=1 Ack=393141 win=65536 Len=0
3141	208.543460	10.0.1.2	10.0.2.2	TCP	130	1256-9004	[PSH, ACK]	Seq=189365 Ack=1 win=64240 Len=76
3142	208.611763	10.0.1.2	10.0.2.2	TCP	1078	1256-9004	[PSH, ACK]	Seq=189441 Ack=1 win=64240 Len=1024
3143	208.611805	10.0.2.2	10.0.1.2	TCP	54	9004-1256	[ACK]	Seq=1 Ack=190465 win=63140 Len=0
3144	208.619356	10.0.1.2	10.0.2.2	TCP	130	1255-9002	[PSH, ACK]	Seq=393141 Ack=1 win=65536 Len=76
3145	208.715182	10.0.1.2	10.0.2.2	TCP	1514	1255-9002	[ACK]	Seq=393217 Ack=1 win=65536 Len=1460
3146	208.715213	10.0.2.2	10.0.1.2	TCP	54	9002-1255	[ACK]	Seq=1 Ack=394677 win=65536 Len=0
3147	208.749761	10.0.1.2	10.0.2.2	UDP	554	Source port: 51044	Destination port: 9005	
3148	208.784474	10.0.1.2	10.0.2.2	UDP	554	Source port: 51044	Destination port: 9005	
3149	208.819186	10.0.1.2	10.0.2.2	UDP	554	Source port: 51044	Destination port: 9005	
3150	208.826882	10.0.1.2	10.0.2.2	TCP	130	1254-9001	[PSH, ACK]	Seq=454069 Ack=1 win=65536 Len=76
3151	208.922656	10.0.1.2	10.0.2.2	TCP	1514	1254-9001	[ACK]	Seq=454145 Ack=1 win=65536 Len=1460
3152	208.922677	10.0.2.2	10.0.1.2	TCP	54	9001-1254	[ACK]	Seq=1 Ack=455605 win=65536 Len=0
3153	208.930312	10.0.1.2	10.0.2.2	TCP	130	1257-9003	[PSH, ACK]	Seq=168373 Ack=1 win=65536 Len=76
3154	209.026240	10.0.1.2	10.0.2.2	TCP	1514	1257-9003	[ACK]	Seq=168449 Ack=1 win=65536 Len=1460

Frame 3151: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface 0

Ethernet II, Src: Cisco_10:74:d0 (00:64:40:10:74:d0), Dst: 7a:b3:01:02:01:04 (7a:b3:01:02:01:04)

Internet Protocol Version 4, Src: 10.0.1.2 (10.0.1.2), Dst: 10.0.2.2 (10.0.2.2)

Version: 4

Header Length: 20 bytes

Differentiated Services Field: 0x28 (DSCP 0x0a: Assured Forwarding 11; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))

3153	208.930312	10.0.1.2	10.0.2.2	TCP	130	1257-9003	[PSH, ACK]	Seq=168373 Ack=1 win=65536 Len=76
3154	209.026240	10.0.1.2	10.0.2.2	TCP	1514	1257-9003	[ACK]	Seq=168449 Ack=1 win=65536 Len=1460

Frame 3153: 130 bytes on wire (1040 bits), 130 bytes captured (1040 bits) on interface 0

Ethernet II, Src: Cisco_10:74:d0 (00:64:40:10:74:d0), Dst: 7a:b3:01:02:01:04 (7a:b3:01:02:01:04)

Internet Protocol Version 4, Src: 10.0.1.2 (10.0.1.2), Dst: 10.0.2.2 (10.0.2.2)

Version: 4

Header Length: 20 bytes

Differentiated Services Field: 0x68 (DSCP 0x1a: Assured Forwarding 31; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))

3. scenár – CBWFQ+WRED

Konfigurácia

```
class class-default
  fair-queue
  bandwidth percent 25
  random-detect
```

```
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 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:05, 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: 3048
Queueing strategy: Class-based queueing
  Output queue: 0/1000/736 (size/max total/drops)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    11194 packets input, 519167 bytes, 0 no buffer
    Received 750 broadcasts (0 IP multicasts)
    0 runs, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
    29440 packets output, 13999378 bytes, 0 underruns
    0 output errors, 0 collisions, 7 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
```

```
R1#sh policy-map int fa0/0
FastEthernet0/0

Service-policy input: znackujP

Class-map: znackuj (match-all)
  914 packets, 769252 bytes
  5 minute offered rate 0000 bps, drop rate 0000 bps
  Match: access-group 100
  QoS Set
    dscp af11
    Packets marked 914

Class-map: znackuj2 (match-all)
  838 packets, 751836 bytes
  5 minute offered rate 0000 bps, drop rate 0000 bps
  Match: access-group 101
```

QoS Set
dscp af12
Packets marked 838

Class-map: znackuj5 (match-all)
2160 packets, 1196640 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: access-group 104
QoS Set
dscp af21
Packets marked 2160

Class-map: znackuj3 (match-all)
471 packets, 403320 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: access-group 102
QoS Set
dscp af31
Packets marked 471

Class-map: znackuj4 (match-all)
453 packets, 393128 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: access-group 103
QoS Set
dscp af33
Packets marked 453

Class-map: class-default (match-any)
25 packets, 1623 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: any

R1#sh policy-map int s0/0/0
Serial0/0/0

Service-policy output: shape

Class-map: vystupAF11 (match-all)
914 packets, 760100 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: dscp af11 (10)
Queueing
queue limit 64 packets
(queue depth/total drops/no-buffer drops) 0/0/0
(pkts output/bytes output) 914/760100
bandwidth 25% (32 kbps)

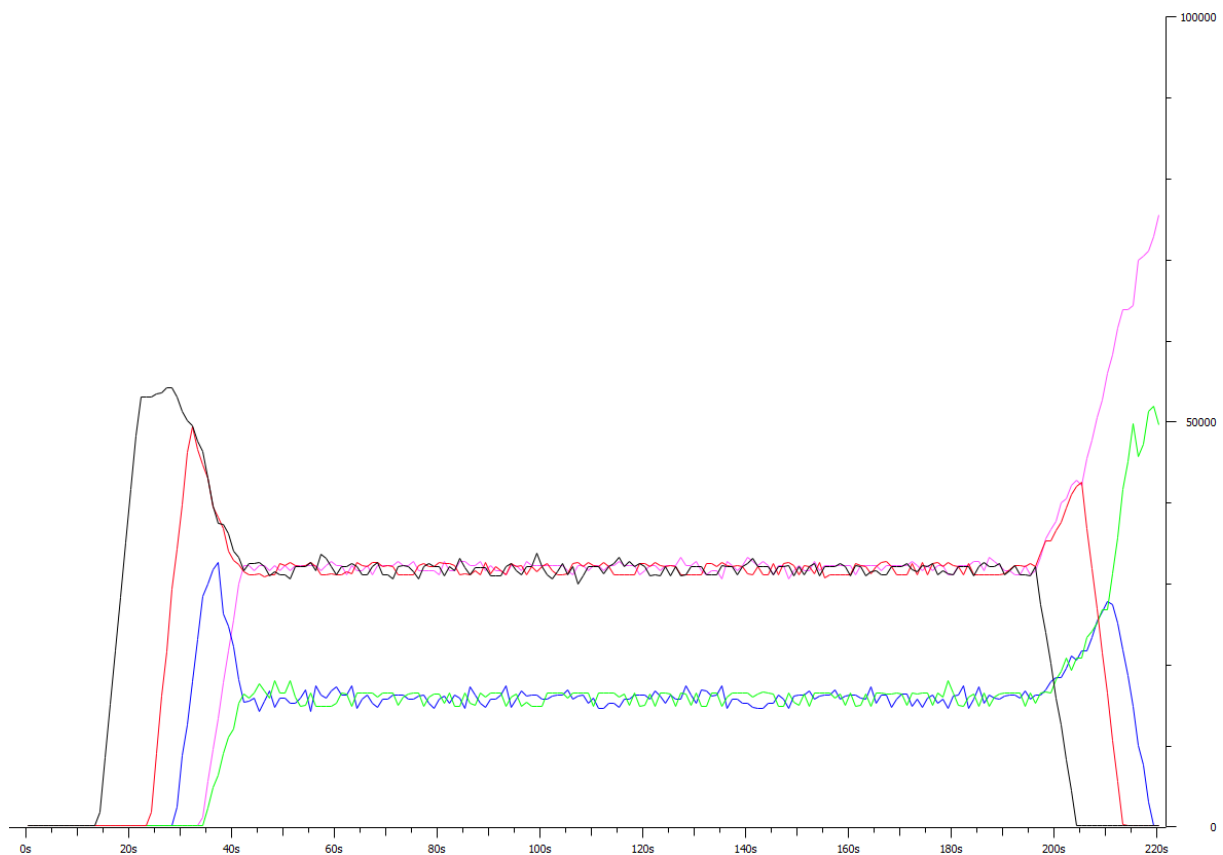
Class-map: vystupAF12 (match-all)
838 packets, 743444 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps

Match: dscp af12 (12)
Queueing
queue limit 64 packets
(queue depth/total drops/no-buffer drops) 0/0/0
(pkts output/bytes output) 838/743444
bandwidth 25% (32 kbps)

Class-map: vystupAF21 (match-all)
2160 packets, 1175040 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: dscp af21 (18)
Queueing
queue limit 64 packets
(queue depth/total drops/no-buffer drops) 0/736/0
(pkts output/bytes output) 1424/774656
bandwidth 25% (32 kbps)

Class-map: class-default (match-any)
1021 packets, 793863 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: any
Queueing
queue limit 64 packets
(queue depth/total drops/no-buffer drops/flowdrops) 0/0/0/0
(pkts output/bytes output) 1021/793863
Fair-queue: per-flow queue limit 16 packets
bandwidth 25% (32 kbps)

Menšie toky

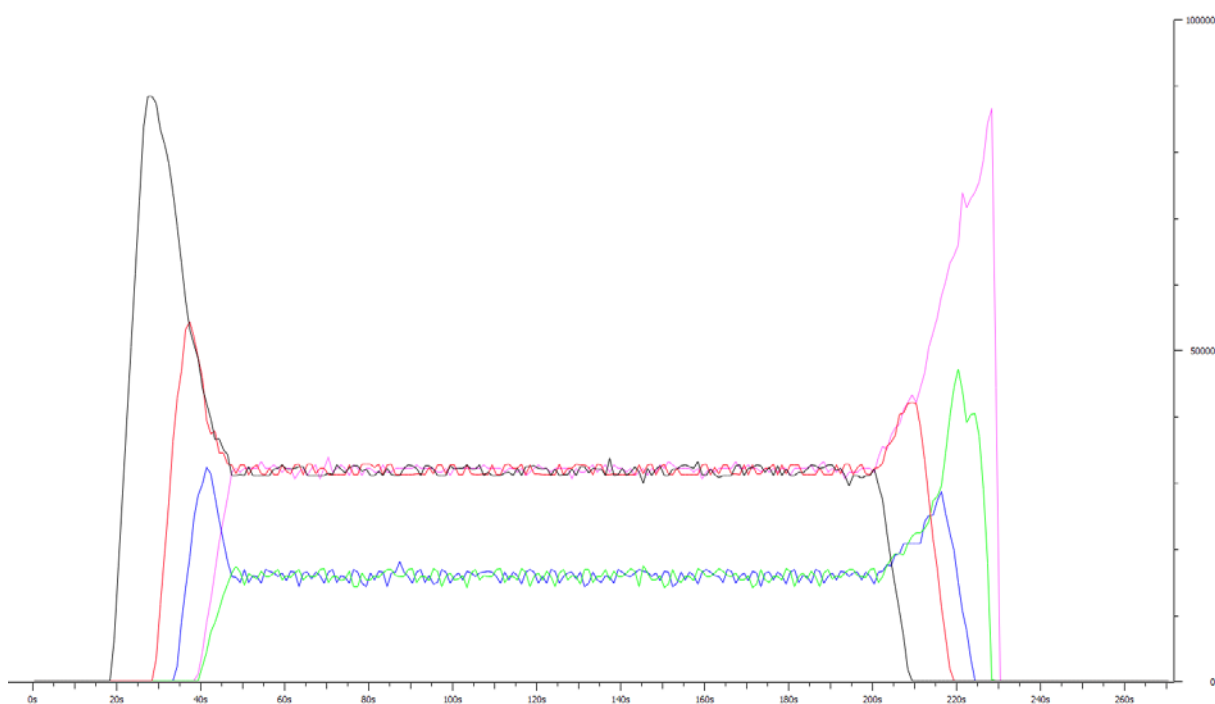


Flow number: 1 From 10.0.1.2:1259 To 10.0.2.2:9001 <hr/> Total time = 180.863000 s Total packets = 1405 Minimum delay = -105.221000 s Maximum delay = -102.488000 s Average delay = -103.394392 s Average jitter = 0.089968 s Delay standard deviation = 0.729533 s Bytes received = 719360 Average bitrate = 31.819001 Kbit/s Average packet rate = 7.768311 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Flow number: 2 From 10.0.1.2:1260 To 10.0.2.2:9002 <hr/> Total time = 180.295000 s Total packets = 1368 Minimum delay = -105.244000 s Maximum delay = -102.545000 s Average delay = -103.244040 s Average jitter = 0.129892 s Delay standard deviation = 0.522559 s Bytes received = 700416 Average bitrate = 31.078666 Kbit/s Average packet rate = 7.587565 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 3 From 10.0.1.2:1262 To 10.0.2.2:9003 <hr/> Total time = 180.078000 s Total packets = 735 Minimum delay = -104.550000 s Maximum delay = -99.626000 s	Flow number: 4 From 10.0.1.2:1261 To 10.0.2.2:9004 <hr/> Total time = 180.142000 s Total packets = 710 Minimum delay = -105.221000 s Maximum delay = -99.734000 s

Average delay = -101.218245 s Average jitter = 0.350069 s Delay standard deviation = 1.140375 s Bytes received = 376320 Average bitrate = 16.718089 Kbit/s Average packet rate = 4.081565 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Average delay = -101.201472 s Average jitter = 0.132267 s Delay standard deviation = 1.005754 s Bytes received = 363520 Average bitrate = 16.143709 Kbit/s Average packet rate = 3.941335 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 5 From 10.0.1.2:58416 To 10.0.2.2:9005 ----- Total time = 179.974000 s Total packets = 1386 Minimum delay = -105.001000 s Maximum delay = -95.932000 s Average delay = -97.182893 s Average jitter = 0.113465 s Delay standard deviation = 1.986731 s Bytes received = 709632 Average bitrate = 31.543756 Kbit/s Average packet rate = 7.701112 pkt/s Packets dropped = 735 (34.65 %) Average loss-burst size = 1.444008 pkt	

Pri generovaní menších tokov vidíme, že straty pri UDP sú cca. 35% pričom sa zahodilo 735 paketov.

Väčšie toky



Flow number: 1

Flow number: 2

From 10.0.1.2:1264 To 10.0.2.2:9001 <hr/> Total time = 180.958000 s Total packets = 1497 Minimum delay = -104.864000 s Maximum delay = -102.121000 s Average delay = -103.061701 s Average jitter = 0.120378 s Delay standard deviation = 0.773618 s Bytes received = 766464 Average bitrate = 33.884725 Kbit/s Average packet rate = 8.272638 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	From 10.0.1.2:1265 To 10.0.2.2:9002 <hr/> Total time = 180.855000 s Total packets = 1387 Minimum delay = -105.217000 s Maximum delay = -102.535000 s Average delay = -103.157642 s Average jitter = 0.178689 s Delay standard deviation = 0.415105 s Bytes received = 710144 Average bitrate = 31.412745 Kbit/s Average packet rate = 7.669127 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 3 From 10.0.1.2:1267 To 10.0.2.2:9003 <hr/> Total time = 180.315000 s Total packets = 731 Minimum delay = -105.165000 s Maximum delay = -100.204000 s Average delay = -101.559291 s Average jitter = 0.337830 s Delay standard deviation = 1.099517 s Bytes received = 374272 Average bitrate = 16.605252 Kbit/s Average packet rate = 4.054017 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Flow number: 4 From 10.0.1.2:1266 To 10.0.2.2:9004 <hr/> Total time = 180.326000 s Total packets = 712 Minimum delay = -105.405000 s Maximum delay = -100.250000 s Average delay = -101.443178 s Average jitter = 0.350823 s Delay standard deviation = 1.028856 s Bytes received = 364544 Average bitrate = 16.172665 Kbit/s Average packet rate = 3.948405 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 5 From 10.0.1.2:64069 To 10.0.2.2:9005 <hr/> Total time = 179.851000 s Total packets = 1384 Minimum delay = -104.688000 s Maximum delay = -95.844000 s Average delay = -96.854165 s Average jitter = 0.139895 s Delay standard deviation = 1.659209 s Bytes received = 708608 Average bitrate = 31.519780 Kbit/s Average packet rate = 7.695259 pkt/s Packets dropped = 2133 (60.65 %) Average loss-burst size = 2.465896 pkt	

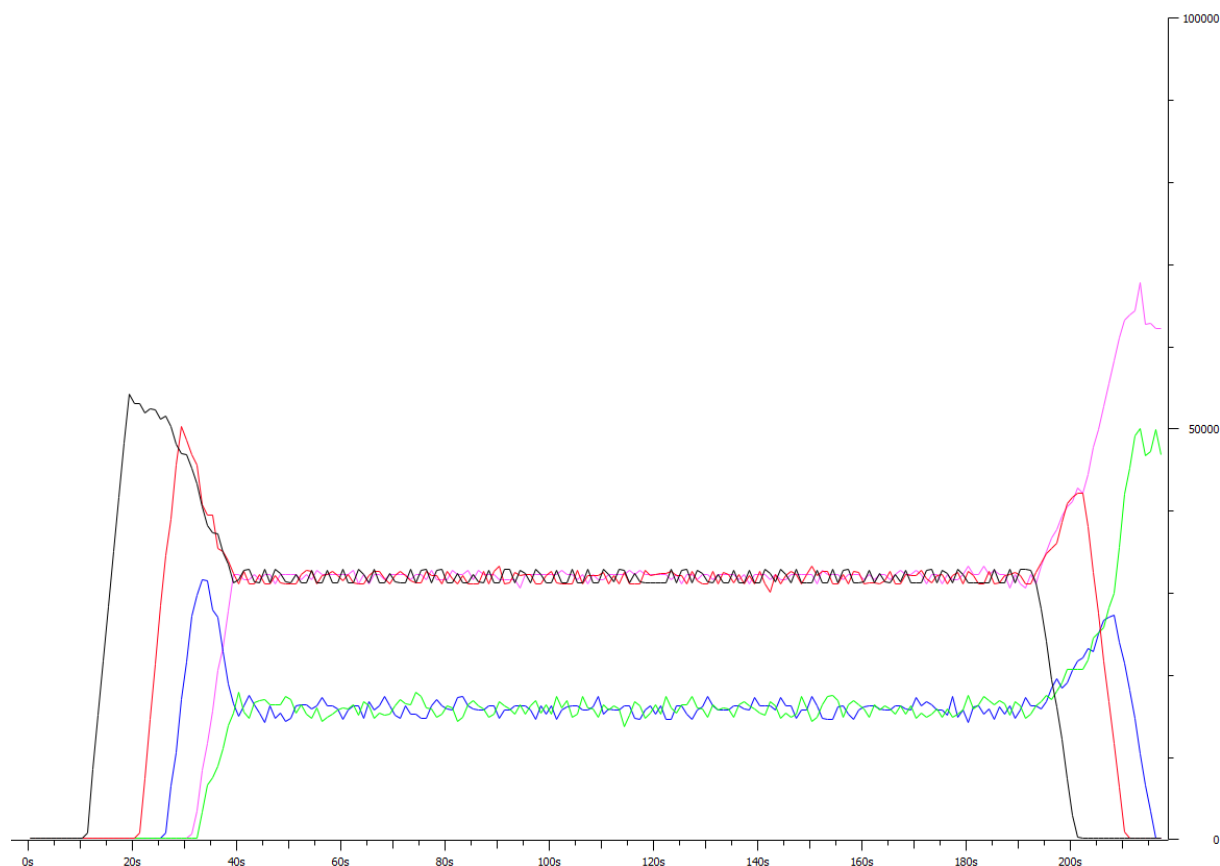
Pri generovaní väčších tokov sa straty pri UDP rapídne zväčšili a to až na 61% približne pričom sa zahodilo 2133 paketov.

4. scenár – CBWFQ+WRED+ECN

Konfigurácia

```
class class-default
  fair-queue
  bandwidth percent 25
  random-detect ecn
```

Menšie toky



Flow number: 1
From 10.0.1.2:1274
To 10.0.2.2:9001

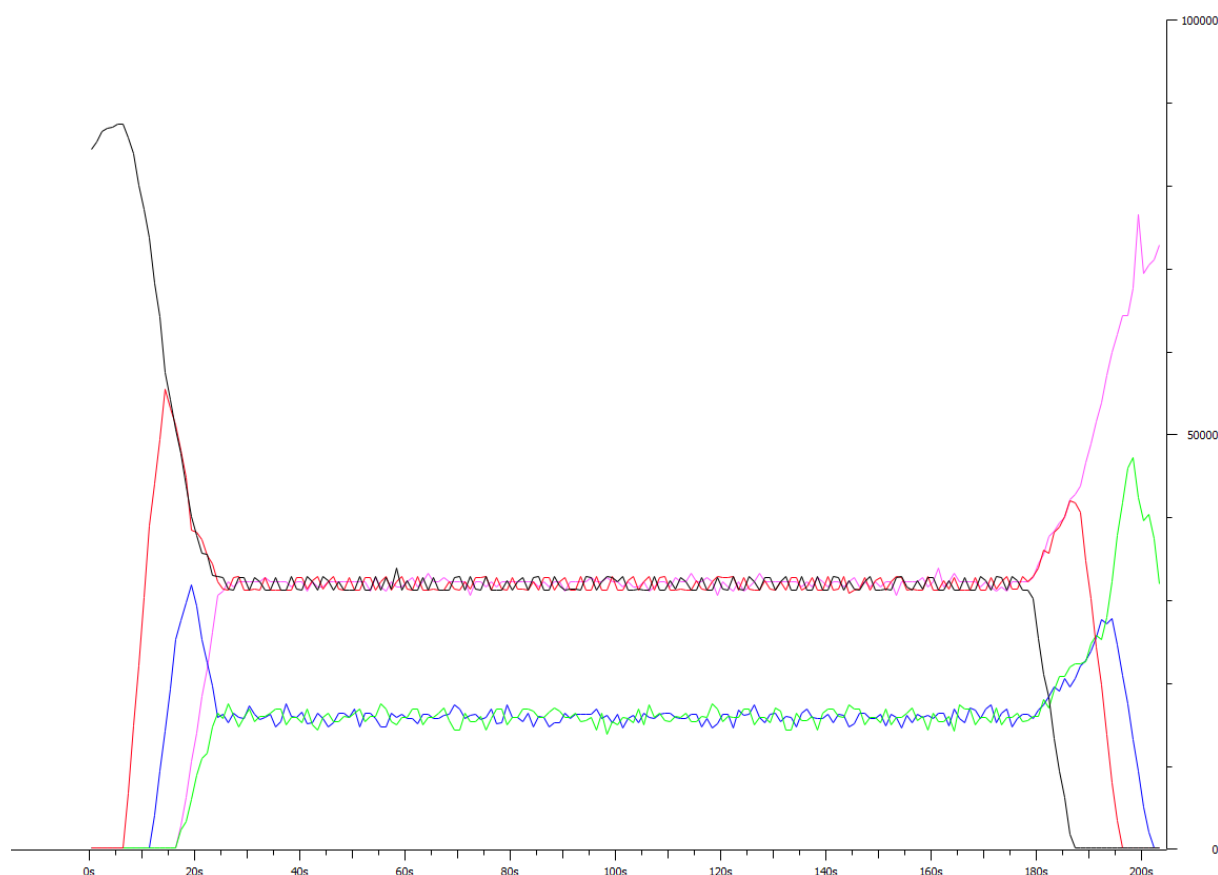
Total time	=	180.851000 s
Total packets	=	1399
Minimum delay	=	-105.039000 s
Maximum delay	=	-102.372000 s
Average delay	=	-103.137558 s
Average jitter	=	0.166698 s
Delay standard deviation	=	0.755919 s
Bytes received	=	716288
Average bitrate	=	31.685222 Kbit/s
Average packet rate	=	7.735650 pkt/s
Packets dropped	=	0 (0.00 %)
Average loss-burst size	=	0.000000 pkt

Flow number: 2
From 10.0.1.2:1275
To 10.0.2.2:9002

Total time	=	181.006000 s
Total packets	=	1378
Minimum delay	=	-105.067000 s
Maximum delay	=	-102.390000 s
Average delay	=	-103.073199 s
Average jitter	=	0.133705 s
Delay standard deviation	=	0.543057 s
Bytes received	=	705536
Average bitrate	=	31.182878 Kbit/s
Average packet rate	=	7.613007 pkt/s
Packets dropped	=	0 (0.00 %)
Average loss-burst size	=	0.000000 pkt

Flow number: 3 From 10.0.1.2:1277 To 10.0.2.2:9003 <hr/> Total time = 179.852000 s Total packets = 736 Minimum delay = -104.568000 s Maximum delay = -99.369000 s Average delay = -101.109427 s Average jitter = 0.233581 s Delay standard deviation = 1.124579 s Bytes received = 376832 Average bitrate = 16.761871 Kbit/s Average packet rate = 4.092254 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Flow number: 4 From 10.0.1.2:1276 To 10.0.2.2:9004 <hr/> Total time = 180.370000 s Total packets = 711 Minimum delay = -105.082000 s Maximum delay = -99.559000 s Average delay = -101.022083 s Average jitter = 0.125423 s Delay standard deviation = 0.955198 s Bytes received = 364032 Average bitrate = 16.146011 Kbit/s Average packet rate = 3.941897 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 5 From 10.0.1.2:64305 To 10.0.2.2:9005 <hr/> Total time = 180.026000 s Total packets = 1385 Minimum delay = -104.769000 s Maximum delay = -95.737000 s Average delay = -96.985278 s Average jitter = 0.122288 s Delay standard deviation = 1.946082 s Bytes received = 709120 Average bitrate = 31.511893 Kbit/s Average packet rate = 7.693333 pkt/s Packets dropped = 737 (34.73 %) Average loss-burst size = 1.468127 pkt	

Väčšie toky



Flow number: 1 From 10.0.1.2:1269 To 10.0.2.2:9001 <hr/> Total time = 180.667000 s Total packets = 1492 Minimum delay = -104.726000 s Maximum delay = -102.095000 s Average delay = -102.887600 s Average jitter = 0.159885 s Delay standard deviation = 0.790914 s Bytes received = 763904 Average bitrate = 33.825945 Kbit/s Average packet rate = 8.258287 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Flow number: 2 From 10.0.1.2:1270 To 10.0.2.2:9002 <hr/> Total time = 180.322000 s Total packets = 1382 Minimum delay = -105.110000 s Maximum delay = -102.496000 s Average delay = -103.048105 s Average jitter = 0.166067 s Delay standard deviation = 0.411904 s Bytes received = 707584 Average bitrate = 31.392021 Kbit/s Average packet rate = 7.664068 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 3 From 10.0.1.2:1272 To 10.0.2.2:9003 <hr/> Total time = 180.633000 s Total packets = 734 Minimum delay = -105.076000 s Maximum delay = -99.690000 s	Flow number: 4 From 10.0.1.2:1271 To 10.0.2.2:9004 <hr/> Total time = 180.146000 s Total packets = 715 Minimum delay = -105.233000 s Maximum delay = -99.861000 s

Average delay = -101.230519 s Average jitter = 0.346080 s Delay standard deviation = 1.131399 s Bytes received = 375808 Average bitrate = 16.644046 Kbit/s Average packet rate = 4.063488 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt	Average delay = -101.364179 s Average jitter = 0.156952 s Delay standard deviation = 0.982693 s Bytes received = 366080 Average bitrate = 16.257036 Kbit/s Average packet rate = 3.969003 pkt/s Packets dropped = 0 (0.00 %) Average loss-burst size = 0.000000 pkt
Flow number: 5 From 10.0.1.2:62081 To 10.0.2.2:9005 ----- Total time = 179.910000 s Total packets = 1384 Minimum delay = -104.859000 s Maximum delay = -95.926000 s Average delay = -96.960317 s Average jitter = 0.141501 s Delay standard deviation = 1.672826 s Bytes received = 708608 Average bitrate = 31.509444 Kbit/s Average packet rate = 7.692735 pkt/s Packets dropped = 2131 (60.63 %) Average loss-burst size = 2.567470 pkt	

Vidíme, že pri značkových paketoch AF21 je ECN nastavené na 00.

```

2871 116.679347 10.0.1.2      10.0.2.2      UDP      554 Source port: 64305 Destination port: 9005
2872 116.747424 10.0.1.2      10.0.2.2      TCP      1078 1276-9004 [PSH, ACK] Seq=174593 Ack=1 win=64240 Len=1024
2873 116.782124 10.0.1.2      10.0.2.2      UDP      554 Source port: 64305 Destination port: 9005
2874 116.850218 10.0.1.2      10.0.2.2      TCP      1078 1277-9003 [PSH, ACK] Seq=151553 Ack=1 win=65536 Len=1024
2875 116.884998 10.0.1.2      10.0.2.2      UDP      554 Source port: 64305 Destination port: 9005
2876 116.892688 10.0.1.2      10.0.2.2      TCP      130 1274-9001 [PSH, ACK] Seq=421813 Ack=1 win=64240 Len=76
# Frame 2871: 554 bytes on wire (4432 bits), 554 bytes captured (4432 bits) on interface 0
# Ethernet II, Src: C:\sco-10:74:00 (00:64:40:10:74:00), Dst: 7a:b3:01:02:01:04 (7a:b3:01:02:01:04)
# Internet Protocol Version 4, Src: 10.0.1.2 (10.0.1.2), Dst: 10.0.2.2 (10.0.2.2)
#   Version: 4
#   Header Length: 20 bytes
#   Differentiated Services Field: 0x48 (DSCP 0x12: Assured Forwarding 21; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
#   0100 10.. = Differentiated Services Codepoint: Assured Forwarding 21 (0x12)
#   .... 000 = Explicit Congestion Notification: Not-ECT (Not ECN-Capable Transport) (0x00)

```

Pri značkových paketoch AF31 vidíme že ECN je nastavené na 10.

5541	207.455942	10.0.1.2	10.0.2.2	TCP	1078 1277-9003 [PSH, ACK] Seq=328705 Ack=1 win=65536 Len=1024
5542	207.490568	10.0.1.2	10.0.2.2	UDP	554 Source port: 64305 Destination port: 9005
5543	207.558652	10.0.1.2	10.0.2.2	TCP	1078 1276-9004 [PSH, ACK] Seq=353281 Ack=1 win=64240 Len=1024
Frame 5541: 1078 bytes on wire (8624 bits), 1078 bytes captured (8624 bits) on interface 0					
Ethernet II, Src: Cisco:10:74:d0 (00:64:40:10:74:d0), Dst: 7a:b3:01:02:01:04 (7a:b3:01:02:01:04)					
Internet Protocol Version 4, Src: 10.0.1.2 (10.0.1.2), Dst: 10.0.2.2 (10.0.2.2)					
Version: 4					
Header Length: 20 bytes					
Differentiated Services Field: 0x6a (DSCP 0x1a: Assured Forwarding 31; ECN: 0x02: ECT(0) (ECN-Capable Transport))					
0110 10.. = Differentiated Services Codepoint: Assured Forwarding 31 (0x1a)					
.... ..10 = Explicit Congestion Notification: ECT(0) (ECN-Capable Transport) (0x02)					
Total Length: 1064					
Identification: 0x2a91 (10897)					
Flags: 0x02 (Don't Fragment)					
Fragment offset: 0					
Time to live: 126					
Protocol: TCP (6)					
Header checksum: 0xb6d1 [validation disabled]					
Source: 10.0.1.2 (10.0.1.2)					
Destination: 10.0.2.2 (10.0.2.2)					
[Source GeoIP: Unknown]					
[Destination GeoIP: Unknown]					
Transmission Control Protocol, Src Port: 1277 (1277), Dst Port: 9003 (9003), Seq: 328705, Ack: 1, Len: 1024					
Source Port: 1277 (1277)					
Destination Port: 9003 (9003)					
[Stream index: 4]					
[TCP Segment Len: 1024]					
Sequence number: 328705 (relative sequence number)					
[Next sequence number: 329729 (relative sequence number)]					
Acknowledgment number: 1 (relative ack number)					
Header Length: 20 bytes					
.... 0000 0001 1000 = Flags: 0x018 (PSH, ACK)					
window size value: 256					
[Calculated window size: 65536]					
[window size scaling factor: 256]					

2872	116.747424	10.0.1.2	10.0.2.2	TCP	1078 1276-9004 [PSH, ACK] Seq=174593 Ack=1 win=64240 Len=1024
2873	116.782124	10.0.1.2	10.0.2.2	UDP	554 Source port: 64305 Destination port: 9005
2874	116.850218	10.0.1.2	10.0.2.2	TCP	1078 1277-9003 [PSH, ACK] Seq=151553 Ack=1 win=65536 Len=1024
2875	116.884998	10.0.1.2	10.0.2.2	UDP	554 Source port: 64305 Destination port: 9005
2876	116.892688	10.0.1.2	10.0.2.2	TCP	130 1274-9001 [PSH, ACK] Seq=421813 Ack=1 win=64240 Len=76
Internet Protocol Version 4, Src: 10.0.1.2 (10.0.1.2), Dst: 10.0.2.2 (10.0.2.2)					
Version: 4					
Header Length: 20 bytes					
Differentiated Services Field: 0x7a (DSCP 0x1e: Assured Forwarding 33; ECN: 0x02: ECT(0) (ECN-Capable Transport))					
0111 10.. = Differentiated Services Codepoint: Assured Forwarding 33 (0x1e)					
.... ..10 = Explicit Congestion Notification: ECT(0) (ECN-Capable Transport) (0x02)					
Total Length: 1064					
Identification: 0x2194 (8596)					
Flags: 0x02 (Don't Fragment)					
Fragment offset: 0					
Time to live: 126					
Protocol: TCP (6)					
Header checksum: 0xbfb6 [validation disabled]					
Source: 10.0.1.2 (10.0.1.2)					
Destination: 10.0.2.2 (10.0.2.2)					
[Source GeoIP: Unknown]					
[Destination GeoIP: Unknown]					
Transmission Control Protocol, Src Port: 1276 (1276), Dst Port: 9004 (9004), Seq: 174593, Ack: 1, Len: 1024					
Source Port: 1276 (1276)					
Destination Port: 9004 (9004)					
[Stream index: 3]					
[TCP Segment Len: 1024]					
Sequence number: 174593 (relative sequence number)					
[Next sequence number: 175617 (relative sequence number)]					
Acknowledgment number: 1 (relative ack number)					
Header Length: 20 bytes					
.... 0000 0001 1000 = Flags: 0x018 (PSH, ACK)					
window size value: 64240					
[Calculated window size: 64240]					
[window size scaling factor: -2 (no window scaling used)]					

Zobrazený výpis všetkých paketov, ktoré mali nastavené pole ECN na 1.

Filter: tcp.flags.ecn == 1		Expression...	Clear	Apply	Save	
No.	Time	Source	Destination	Protocol	Length	Info
4	14.6958060	10.0.1.2	10.0.2.2	TCP	66	1273-9000 [SYN, ECN, CWR] Seq=0 win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
7	14.6968500	10.0.2.2	10.0.1.2	TCP	66	9000-1273 [SYN, ACK, ECN] Seq=0 Ack=1 win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
15	14.7306520	10.0.1.2	10.0.2.2	TCP	62	1274-9001 [SYN, ECN, CWR] Seq=0 win=8192 Len=0 MSS=1460 SACK_PERM=1
16	14.7307140	10.0.2.2	10.0.1.2	TCP	62	9001-1274 [SYN, ACK, ECN] Seq=0 Ack=1 win=8192 Len=0 MSS=1460 SACK_PERM=1
174	24.6941920	10.0.1.2	10.0.2.2	TCP	66	1275-9002 [SYN, ECN, CWR] Seq=0 win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
175	24.6942900	10.0.2.2	10.0.1.2	TCP	66	9002-1275 [SYN, ACK, ECN] Seq=0 Ack=1 win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
306	29.6943730	10.0.1.2	10.0.2.2	TCP	62	1276-9004 [SYN, ECN, CWR] Seq=0 win=8192 Len=0 MSS=1460 SACK_PERM=1
307	29.6944450	10.0.2.2	10.0.1.2	TCP	62	9004-1276 [SYN, ACK, ECN] Seq=0 Ack=1 win=8192 Len=0 MSS=1460 SACK_PERM=1
480	35.4333990	10.0.1.2	10.0.2.2	TCP	66	1277-9003 [SYN, ECN, CWR] Seq=0 win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
481	35.4334930	10.0.2.2	10.0.1.2	TCP	66	9003-1277 [SYN, ACK, ECN] Seq=0 Ack=1 win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1

Frame 481: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0

Ethernet II, Src: 7a:b3:01:02:01:04 (7a:b3:01:02:01:04), Dst: Cisco_10:74:d0 (00:64:40:10:74:d0)

Internet Protocol Version 4, Src: 10.0.2.2 (10.0.2.2), Dst: 10.0.1.2 (10.0.1.2)

Transmission Control Protocol, Src Port: 9003 (9003), Dst Port: 1277 (1277), Seq: 0, Ack: 1, Len: 0

Source Port: 9003 (9003)

Destination Port: 1277 (1277)

[Stream index: 4]

[TCP Segment Len: 0]

Sequence number: 0 (relative sequence number)

Acknowledgment number: 1 (relative ack number)

Header Length: 32 bytes

0000 0101 0010 = Flags: 0x052 (SYN, ACK, ECN)

000. = Reserved: Not set

...0 = Nonce: Not set

...0 = Congestion Window Reduced (CWR): Not set

...1. = ECN-Echo: Set

...0. = Urgent: Not set

...1. = Acknowledgment: Set

...0. = Push: Not set

...0. = Reset: Not set

...1. = SYN: Set

...0 = FIN: Not set

window size value: 8192

[calculated window size: 8192]