Practica SDN

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Practica 1:

Practica 1A:

Antes de arrancar la aplicación con el controlador Pox o ¿Hay conectividad entre hosts? ¿Por qué ocurre esto?

No hay conectividad entre los hosts porque las reglas del switch no han sido inicializadas por el controlador.

```
mininet> h1 ping -c2 h2
ping: unknown host -c2
mininet> h1 ping -c2 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
From 10.0.0.1 icmp_seq=1 Destination Host Unreachable
From 10.0.0.1 icmp_seq=2 Destination Host Unreachable
--- 10.0.0.2 ping statistics ---
2 packets transmitted, 0 received, +2 errors, 100% packet loss, time 999ms
pipe 2
```

No.	Time	Source	Destination	Protocol	Length Info
	1 0.000000000	127.0.0.1	127.0.0.1	TCP	76 47000-6633 [SYN] Seq=0 Win=43690 Len=0 MSS=65495 SACK_PERM=1 TSval=9413750 TSecr=0 WS=512
	2 0.000015000	127.0.0.1	127.0.0.1	TCP	56 6633→47000 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
	3 1.000145000	127.0.0.1	127.0.0.1	TCP	76 47001→6633 [SYN] Seq=0 Win=43690 Len=0 MSS=65495 SACK_PERM=1 TSval=9414000 TSecr=0 WS=512
	4 1.000175000	127.0.0.1	127.0.0.1	TCP	56 6633-47001 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
	5 1.335281000	127.0.0.1	127.0.0.1	TCP	311 41906→20129 [PSH, ACK] Seq=1 Ack=1 Win=86 Len=243 TSval=9414084 TSecr=9413546
	6 1.335992000	127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=1 Ack=244 Win=2050 Len=12 TSval=9414084 TSecr=9414084
	7 1.336064000	127.0.0.1	127.0.0.1	TCP	68 41906→20129 [ACK] Seq=244 Ack=13 Win=86 Len=0 TSval=9414084 TSecr=9414084
	8 1.999942000	127.0.0.1	127.0.0.1	TCP	76 47002-6633 [SYN] Seq=0 Win=43690 Len=0 MSS=65495 SACK_PERM=1 TSval=9414250 TSecr=0 WS=512
	9 1.999980000	127.0.0.1	127.0.0.1	TCP	56 6633-47002 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
	10 2.999397000	127.0.0.1	127.0.0.1	TCP	76 47003-6633 [SYN] Seq=0 Win=43690 Len=0 MSS=65495 SACK_PERM=1 TSval=9414500 TSecr=0 WS=512
	11 2.999427000	127.0.0.1	127.0.0.1	TCP	56 6633-47003 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
	12 3.465375000	127.0.0.1	127.0.0.1	TCP	311 41906→20129 [PSH, ACK] Seq=244 Ack=13 Win=86 Len=243 TSval=9414616 TSecr=9414084
	13 3.465897000	127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=13 Ack=487 Win=2050 Len=12 TSval=9414616 TSecr=9414616
	14 3.465939000	127.0.0.1	127.0.0.1	TCP	68 41906-20129 [ACK] Seq=487 Ack=25 Win=86 Len=0 TSval=9414616 TSecr=9414616

Ejecutar la aplicación forwarding.tutorial_l2_hub o ¿Qué nuevos mensajes aparecen en la red? o Ejecutar un ping entre 2 hosts e indicar que nuevo intercambio de mensajes ocurre en la red y entre que entidades se produce dicho intercambio.

Vemos la aparición de mensajes OpenFlow (ECHO_REQUEST/REPLY) entre el switch y el controlador.

١o.	Time	Source	Destination	Protocol Le	ength Info
	1 0.000000000	127.0.0.1	127.0.0.1	TCP	311 41906→20129 [PSH, ACK] Seq=1 Ack=1 Win=86 Len=243 TSval=9456727 TSecr=9456216
	2 0.000208000	127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=1 Ack=244 Win=2050 Len=12 TSval=9456727 TSecr=9456727
	3 0.000225000	127.0.0.1	127.0.0.1	TCP	68 41906→20129 [ACK] Seq=244 Ack=13 Win=86 Len=0 TSval=9456727 TSecr=9456727
	4 0.091409000	127.0.0.1	127.0.0.1	OpenFlow	76 Type: 0FPT_ECHO_REQUEST
	5 0.091444000	127.0.0.1	127.0.0.1	TCP	68 6633-47167 [ACK] Seq=1 Ack=9 Win=88 Len=0 TSval=9456750 TSecr=9456750
	6 0.137210000	127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT ECHO REPLY
	7 0.174607000	127.0.0.1	127.0.0.1	TCP	68 47167→6633 [ACK] Seq=9 Ack=9 Win=86 Len=0 TSval=9456771 TSecr=9456761
	8 2.163646000	127.0.0.1	127.0.0.1	TCP	311 41906→20129 [PSH, ACK] Seq=244 Ack=13 Win=86 Len=243 TSval=9457268 TSecr=9456727
	9 2.164033000	127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=13 Ack=487 Win=2050 Len=12 TSval=9457268 TSecr=9457268
	10 2.164067000	127.0.0.1	127.0.0.1	TCP	68 41906→20129 [ACK] Seq=487 Ack=25 Win=86 Len=0 TSval=9457268 TSecr=9457268
	11 4.325388000	127.0.0.1	127.0.0.1	TCP	311 41906→20129 [PSH, ACK] Seq=487 Ack=25 Win=86 Len=243 TSval=9457808 TSecr=9457268
	12 4.325659000	127.0.0.1	127.0.0.1	TCP	80 20129→41906 [PSH, ACK] Seq=25 Ack=730 Win=2050 Len=12 TSval=9457808 TSecr=9457808
	13 4.325787000	127.0.0.1	127.0.0.1	TCP	68 41906→20129 [ACK] Seq=730 Ack=37 Win=86 Len=0 TSval=9457808 TSecr=9457808
	14 5.091211000	127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT ECHO REQUEST

Después de ejecutar forwarding.tutorial_I2_hub.py, aparecen los mensajes PACKET IN/OUT entre el switch y el controlador.

```
26 4.227577000 10.0.0.1
                                            10.0.0.2
                                                                                     100 Echo (ping) request id=0x2b0f, seg=2/512, ttl=64 (no response found!)
27 4.227591000 10.0.0.1
                                                                                      100 Echo (ping) request id=0x2b0f, seq=2/512, ttl=64 (reply in 28
                                                                                     100 Echo (ping) reply
184 Type: OFPT_PACKET_IN
28 4.227635000 10.0.0.2
                                            10.0.0.1
                                                                       TCMP
                                                                                                                  id=0x2b0f, seq=2/512, ttl=64 (request in 27)
29 4.228440000 10.0.0.2
                                            10.0.0.1
                                                                       OpenFlow
30 4.230292000 127.0.0.1
                                                                      OpenFlow
ICMP
                                                                                      92 Type: OFPT_PACKET_OUT
                                            127.0.0.1
31 4.230568000 10.0.0.2
                                                                                     100 Echo (ping) reply
100 Echo (ping) reply
                                                                                                                  id=0x2b0f, seg=2/512, ttl=64
                                            10.0.0.1
32 4.230578000 10.0.0.2
                                                                       ICMP
                                                                                                                  id=0x2b0f, seq=2/512, ttl=64
33 4.267338000 127.0.0.1
                                            127.0.0.1
                                                                       TCP
                                                                                      68 47202-6633 [ACK] Seq=473 Ack=105 Win=86 Len=0 TSval=9760817 TSecr=9760807
34 5.221849000 10.0.0.1
                                                                       ICMP
                                                                                      100 Echo (ping) request id=0x2b0f, seq=3/768, ttl=64 (no response found!)
                                            10.0.0.2
                                                                      OpenFlow
                                                                                     184 Type: OFPT PACKET IN
68 6633-47202 [ACK] Seq=105 Ack=589 Win=88 Len=0 TSval=9761065 TSecr=9761055
35 5.222610000 10.0.0.1
                                            10.0.0.2
36 5.259411000 127.0.0.1
                                            127.0.0.1
                                                                       TCP
37 5.272035000 127.0.0.1
                                                                       OpenFlow
                                                                                       92 Type: OFPT_PACKET_OUT
                                                                                     88 47202-6633 [ACK] Seq=589 Ack=129 Win=86 Len=0 TSval=9761068 TSecr=9761068 100 Echo (ping) request id=0x2b0f, seq=3/768, ttl=64 (no response found!) 100 Echo (ping) request id=0x2b0f, seq=3/768, ttl=64 (reply in 41) 100 Echo (ping) reply id=0x2b0f, seq=3/768, ttl=64 (request in 40)
38 5.272205000 127.0.0.1
                                            127.0.0.1
                                                                       TCP
39 5.272546000 10.0.0.1
40 5.272558000 10.0.0.1
                                                                      TCMP
                                            10.0.0.2
                                                                      ICMP
41 5.272599000 10.0.0.2
                                            10.0.0.1
                                                                       OpenFlow
                                                                                     184 Type: OFPT_PACKET_IN
42 5.273370000 10.0.0.2
                                            10.0.0.1
                                                                                      68 6633-47202 [ACK] Seg=129 Ack=705 Win=88 Len=0 TSval=9761068 TSecr=9761068
43 5.273412000 127.0.0.1
                                            127.0.0.1
                                                                      OpenFlow
44 5.275859000 127.0.0.1
                                            127.0.0.1
                                                                                      92 Type: OFPT_PACKET_OUT
```

Ejecutar la aplicación forwarding.l2_learning o Ejecutar un ping entre 2 hosts, ¿cuál es la principal diferencia que existe entre esta aplicación y la anteriormente ejecutada? Explicar esta diferencia basándose en los mensajes intercambiados actualmente en la red.

La aplicación forwarding.l2.learning instala las reglas a nivel del switch, por lo que éste no reenvía sistemáticamente los paquetes al controlador (no hay PACKET_IN/OUT sistemático). Sólo lo hace cuando no tiene una regla definida para un paquete.

```
63 12.96754100€ 10.0.0.1
                                        10.0.0.2
                                                                             100 Echo (ping) request id=0x2af0, seq=3/768, ttl=64 (no response found!)
                                        10.0.0.2
                                                                             100 Echo (ping) request id=0x2af0, seq=3/768, ttl=64 (reply in 65)
100 Echo (ping) reply id=0x2af0, seq=3/768, ttl=64 (request in 64)
64 12.96756900( 10.0.0.1
                                                                ICMP
65 12.96765300€ 10.0.0.2
                                        10.0.0.1
                                                                ICMP
66 12.96766200€ 10.0.0.2
                                                                ICMP
                                                                             100 Echo (ping) reply
                                                                                                        id=0x2af0, seq=3/768, ttl=64
                                                                             100 Echo (ping) request id=0x2af0, seg=4/1024, ttl=64 (no response found!)
67 13.96982700(10.0.0.1
                                        10.0.0.2
                                                                ICMP
68 13.96985800€ 10.0.0.1
                                                                             100 Echo (ping) request id=0x2af0, seq=4/1024, ttl=64 (reply in 69)
                                        10.0.0.1
69 13 969885006 10 0 0 2
                                                                TCMP
                                                                             100 Echo (ping) reply
                                                                                                        id=0x2af0, seq=4/1024, ttl=64 (request in 68)
70 13.96989200(10.0.0.2
                                                                                                        id=0x2af0, seq=4/1024, ttl=64
                                                                ICMP
                                                                             100 Echo (ping) reply
                                        10.0.0.1
71 14.97113700€ 10.0.0.1
                                                                                                        id=0x2af0, seq=5/1280, ttl=64 (no response found!)
                                                                             100 Echo (ping) request
72 14.97116700( 10.0.0.1
                                        10.0.0.2
                                                                ICMP
                                                                             100 Echo (ping) request
                                                                                                        id=0x2af0, seg=5/1280, ttl=64 (reply in 73)
73 14.97119600€ 10.0.0.2
                                                                ICMP
                                                                             100 Echo (ping) reply
                                                                                                        id=0x2af0, seq=5/1280, ttl=64 (request in 72)
                                        10.0.0.1
74 14.97120300( 10.0.0.2
                                                                             100 Echo (ping) reply
                                                                                                        id=0x2af0, seq=5/1280, ttl=64
```

¿Qué ocurre si el ping se ejecuta durante un periodo de tiempo lo suficientemente grande (>30seg)? ¿Está reflejado de alguna forma en la captura de Wireshark?

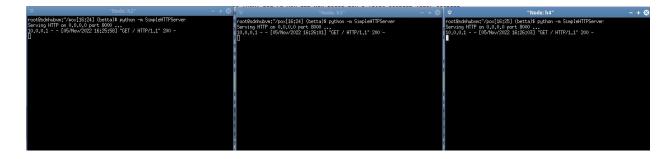
El conmutador reinicia su regla y devuelve un PACKET_IN al controlador.

```
220 34.46644000(10.0.0.1
                                       10.0.0.2
                                                             ICMP
                                                                          100 Echo (ping) request id=0x2b5c, seq=32/8192, ttl=64 (no response found!)
221 34.46647400€ 10.0.0.1
                                                                          100 Echo (ping) request id=0x2b5c, seq=32/8192, ttl=64 (reply in 222)
                                       10.0.0.2
                                                             ICMP
222 34.466508006 10.0.0.2
                                       10.0.0.1
                                                             TCMP
                                                                          100 Echo (ping) reply
                                                                                                  id=0x2b5c, seq=32/8192, ttl=64 (request in 221)
                                                             OpenFlow
                                                                          184 Type: OFPT_PACKET_IN
223 34.46733000€ 10.0.0.2
                                       10.0.0.1
                                                                         148 Type: OFPT_FLOW_MOD
224 34.47557800€ 127.0.0.1
                                                             OpenFlow
                                                                          68 47208-6633 [ACK] Seq=633 Ack=473 Win=86 Len=0 TSval=9809382 TSecr=9809382
225 34.47576200(127.0.0.1
                                       127.0.0.1
                                                             TCP
226 34.47611400€ 10.0.0.2
                                                             ICMP
                                                                                                  id=0x2b5c, seq=32/8192, ttl=64
                                       10.0.0.1
                                                                         100 Echo (ping) reply
                                                                         100 Echo (ping) request id=0x2b5c, seq=33/8448, ttl=64 (no response found!)
227 35.46823900€ 10.0.0.1
                                       10.0.0.2
                                                             ICMP
                                                             OpenFlow
228 35.46879600(10.0.0.1
                                       10.0.0.2
                                                                         184 Type: OFPT PACKET IN
229 35.50436800€ 127.0.0.1
                                                                           68 6633-47208 [ACK] Seq=473 Ack=749 Win=88 Len=0 TSval=9809640 TSecr=9809630
                                                             OpenFlow
230 35.51495500( 127.0.0.1
                                       127.0.0.1
                                                                        148 Type: OFPT_FLOW_MOD
                                                                          68 47208-6633 [ACK] Seq=749 Ack=553 Win=86 Len=0 TSval=9809642 TSecr=9809642
231 35.51502000€ 127.0.0.1
                                      127.0.0.1
```

Practica 1B:

Analizar la salida en los terminales de los hosts (h2, h3 y h4) y estudiar el tráfico con Wireshark para explicar cómo se procesan los paquetes de petición HTTP. Se debe analizar especialmente la secuencia de mensajes Openflow y se deben adjuntar las capturas de pantalla necesarias.

Los paquetes se reparten a partes iguales entre h2, h3 y h4.



Los mensajes interesantes son los que están en gris. En la figura siguiente, se envía un primer paquete al equilibrador de carga (10.0.0.5), que no sabe qué hacer con él y lo envía al controlador. El controlador instala las reglas del

equilibrador de carga (FLOW_MOD). El equilibrador de carga transfiere a h2 (10.0.0.2). h2 realiza la tarea solicitada y luego envía el paquete de vuelta al equilibrador de carga. Finalmente, el equilibrador de carga transfiere la respuesta de h2 a h1. Luego hace lo mismo con h3 para la siguiente solicitud y así sucesivamente.

10 3.756044000 10.0.0.1	10.0.0.5	TCP	76 59075-8000 [SYN] Seg=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9901611 TSecr=0 WS=512
11 3.756253000 10.0.0.1	10.0.0.5	OpenFlow	160 Type: OFPT PACKET IN
12 3.792742000 127.0.0.1	127.0.0.1	OpenFlow	172 Type: 0FPT FLOW MOD
13 3.792809000 127.0.0.1	127.0.0.1	TCP	68 47249-6633 [ACK] Seq=101 Ack=113 Win=86 Len=0 TSval=9901620 TSecr=9901620
14 3.792916000 10.0.0.1	10.0.0.2	TCP	76 59075-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9901611 TSecr=0 WS=512
15 3.792931000 10.0.0.2	10.0.0.1	TCP	76 8000-59075 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=9901620 TSecr
16 3.793109000 10.0.0.2	10.0.0.1	OpenFlow	160 Type: 0FPT_PACKET_IN
17 3.793697000 127.0.0.1	127.0.0.1	0penFlow	172 Type: 0FPT_FLOW_MOD
18 3.830041000 127.0.0.1	127.0.0.1	TCP	68 47249→6633 [ACK] Seq=193 Ack=217 Win=86 Len=0 TSval=9901630 TSecr=9901620
19 4.227222000 127.0.0.1	127.0.0.1	TCP	311 41906-20129 [PSH, ACK] Seq=487 Ack=25 Win=86 Len=243 TSval=9901729 TSecr=9901194
20 4.227729000 127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=25 Ack=730 Win=2050 Len=12 TSval=9901729 TSecr=9901729
21 4.227767000 127.0.0.1	127.0.0.1	TCP	68 41906-20129 [ACK] Seq=730 Ack=37 Win=86 Len=0 TSval=9901729 TSecr=9901729
22 4.754187000 10.0.0.1	10.0.0.5	TCP TCP	76 [TCP Retransmission] 59075-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSVal=990
23 4.754669000 10.0.0.1	10.0.0.2	TCP	76 [TCP Spurious Retransmission] 59075-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1
24 4.754717000 10.0.0.2 25 4.754982000 10.0.0.5	10.0.0.1 10.0.0.1	TCP	76 [TCP Retransmission] 8000-59075 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM= 76 8000-59075 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9901861 TSecr
26 4.755043000 10.0.0.1	10.0.0.5	TCP	68 59075-8000 [ACK] Seq=1 Ack=1 Win=29696 Len=0 TSval=9901861 TSecr=9901861
27 4.755054000 10.0.0.1	10.0.0.2	TCP	68 59075-8000 [ACK] Seq=1 Ack=1 Win=29090 Len=0 TSval=9901861 TSecr=9901861
28 4.755614000 10.0.0.1	10.0.0.5	HTTP	145 GET / HTTP/1.1
29 4.755635000 10.0.0.1	10.0.0.2	HTTP	145 GET / HTTP/1.1
30 4.755655000 10.0.0.2	10.0.0.1	TCP	68 8000-59075 [ACK] Seg=1 Ack=78 Win=29184 Len=0 TSval=9901861 TSecr=9901861
31 4.755663000 10.0.0.5	10.0.0.1	TCP	68 8000→59075 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9901861 TSecr=9901861
69 6.903525000 10.0.0.1	10.0.0.5	TCP	76 59076-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902398 TSecr=0 WS=512
70 6.903696000 10.0.0.1	10.0.0.5	OpenFlow	160 Type: OFPT PACKET IN
71 6.926489000 127.0.0.1	127.0.0.1	OpenFlow	172 Type: 0FPT FLOW MOD
72 6.926521000 127.0.0.1	127.0.0.1	TCP	68 47249-6633 [ACK] Seq=285 Ack=321 Win=86 Len=0 TSval=9902404 TSecr=9902404
73 6.926652000 10.0.0.1	10.0.0.3	TCP	76 59076-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902398 TSecr=0 WS=512
74 6.926671000 10.0.0.3	10.0.0.1	TCP	76 8000-59076 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=9902404 TSecr
75 6.926985000 10.0.0.3	10.0.0.1	OpenFlow	160 Type: 0FPT_PACKET_IN
76 6.927983000 127.0.0.1	127.0.0.1	0penFlow	172 Type: OFPT_FLOW_MOD
77 6.966034000 127.0.0.1	127.0.0.1	TCP	68 47249→6633 [ACK] Seq=377 Ack=425 Win=86 Len=0 TSval=9902414 TSecr=9902404
78 7.902013000 10.0.0.1	10.0.0.5	TCP TCP	76 [TCP Retransmission] 59076-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSVal=990
79 7.902399000 10.0.0.1	10.0.0.3 10.0.0.1	TCP	76 [TCP Spurious Retransmission] 59076-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1
80 7.902593000 10.0.0.3 81 7.902834000 10.0.0.5	10.0.0.1	TCP	76 [TCP Retransmission] 8000-59076 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM= 76 8000-59076 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9902648 TSecr
82 7.902898000 10.0.0.1	10.0.0.5	TCP	68 59076-8000 [ACK] Seq=1 Ack=1 Win=29696 Len=0 TSval=9902648 TSecr=9902648
83 7.902910000 10.0.0.1	10.0.0.3	TCP	68 59076-8000 [ACK] Seq=1 Ack=1 Win=29696 Len=0 TSval=9902648 TSecr=9902648
84 7.903287000 10.0.0.1	10.0.0.5	HTTP	145 GET / HTTP/1.1
85 7.903307000 10.0.0.1	10.0.0.3	HTTP	145 GET / HTTP/1.1
06 7 000000000 10 0 0			
86 7.903327000 10.0.0.3	10.0.0.1	TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648
86 7.903327000 10.0.0.3 87 7.903354000 10.0.0.5	10.0.0.1	TCP TCP	
			68 8000→59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648
			68 8000→59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648
87 7.903354000 10.0.0.5	10.0.0.1	TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648
87 7.903354000 10.0.0.5 125 8.953022000 10.0.0.1	10.0.0.1	ТСР	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512
87 7.993354000 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185000 10.0.0.1 127 8.967623000 127.0.0.1 128 8.967655000 127.0.0.1	10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1	TCP TCP OpenFlow OpenFlow TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT_FACK=T IN 172 Type: 0FPT_FLOW_MOD 68 47249-6633 [ACK] Seq=469 Ack=529 Win=86 Len=0 TSval=9902914 TSecr=9902914
87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185000 127.0.0.1 127 8.967623000 127.0.0.1 128 8.967655000 127.0.0.1 129 8.967782000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4	TCP TCP OpenFlow OpenFlow TCP TCP	68 8000-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: OFPT_PACKET_IN 172 Type: OFPT_FLOW_MOD 68 47249-6633 [ACK] Seq=469 ACK=529 Win=86 Len=0 TSval=9902914 TSecr=9902914 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512
87 7.993354000 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185900 10.0.0.1 127 8.967623000 127.0.0.1 128 8.967655000 127.0.0.1 129 8.967782000 10.0.0.1 130 8.967800000 10.0.0.4	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1	TCP TCP OpenFlow OpenFlow TCP TCP TCP	68 8080-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 172 Type: 0PFT FLOW MOD 68 47249-6633 [ACK] Seq=469 ACK=529 Win=86 Len=0 TSval=9902914 TSecr=9902914 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-99077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr=
87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185000 10.0.0.1 127 8.967623000 127.0.0.1 128 8.967655900 127.0.0.1 129 8.967782000 10.0.0.1 130 8.967800000 10.0.0.4 131 8.968186000 10.0.0.4	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1	TCP TCP OpenFlow OpenFlow TCP TCP TCP OpenFlow	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT_PACKET_IN 172 Type: 0FPT_PACKET_IN 172 Type: 0FPT_FLOW_MOD 68 47249-6633 [ACK] Seq=469 Ack=529 Win=86 Len=0 TSval=9902914 TSecr=9902914 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=9902914 TSecr=100 Type: 0FPT_PACKET_IN
87 7.993354900 10.0.0.5 125 8.953822000 10.0.0.1 126 8.953185000 10.0.0.1 127 8.967623000 127.0.0.1 129 8.967782000 127.0.0.1 130 8.967800000 10.0.0.4 131 8.968186000 10.0.4 132 8.969184000 127.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1	TCP OpenFlow OpenFlow TCP TCP TCP OpenFlow OpenFlow	68 8000-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 160 Type: OFPT_PACKET_IN 172 Type: OFPT_FLOW_MOD 68 47249-6633 [ACK] Seq=469 ACK=529 Win=86 Len=0 TSval=9902914 TSecr=9902914 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-59077 [SYN, ACK] Seq=0 ACK=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=9902914 TSecr=100 Type: OFPT_PACKET_IN 172 Type: OFPT_PACKET_IN 172 Type: OFPT_FLOW_MOD
87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185900 10.0.0.1 127 8.967623000 127.0.0.1 128 8.967655900 127.0.0.1 129 8.967782000 10.0.0.4 131 8.968186900 10.0.0.4 132 8.9691044000 127.0.0.1 133 9.066517000 127.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 10.0.0.1 127.0.0.1 127.0.0.1	TCP TCP OpenFlow OpenFlow TCP TCP TCP OpenFlow OpenFlow TCP	68 8080-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8080-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN 172 Type: OFPT FLOW MOD 68 47249-6633 [ACK] Seq=469 Ack=529 Win=86 Len=0 TSval=9902914 TSecr=9902914 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-89077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr 100 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN
87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185900 10.0.0.1 127 8.967623900 127.0.0.1 128 8.967655900 127.0.0.1 139 8.967782000 10.0.0.1 130 8.967880000 10.0.0.4 131 8.968186900 10.0.0.4 132 8.969104900 127.0.0.1 133 9.006517000 127.0.0.1 134 9.950458000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1	TCP TCP OpenFlow OpenFlow TCP TCP TCP OpenFlow OpenFlow TCP TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT PACKET IN 172 Type: 0FPT PACKET IN 172 Type: 0FPT PACKET IN 175 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-59077 [SYN, ACK] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT PACKET IN 172 Type: 0FPT PACKET IN 172 Type: 0FPT FLOW MOD 68 47249-6633 [ACK] Seq=561 Ack=633 Win=86 Len=0 TSval=9902924 TSecr=9902914 76 [TCP Retransmission] S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902914
87 7,993354900 10.0.0.5 125 8.953822000 10.0.0.1 126 8.95385900 127.0.0.1 128 8.967623900 127.0.0.1 129 8.967782000 10.0.0.1 130 8.967800000 10.0.0.4 131 8.968186000 10.0.0.4 132 8.969184000 127.0.0.1 133 9.066517000 127.0.0.1 134 9.950458000 10.0.0.1 135 9.95118000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1	TCP OpenFlow OpenFlow TCP TCP TCP OpenFlow OpenFlow TCP TCP TCP TCP TCP TCP	68 8000-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 ACK=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 160 Type: OFPT_PACKET_IN 172 Type: OFPT_FLOW_MOD 68 47249-6633 [ACK] Seq=469 ACK=529 Win=86 Len=0 TSval=9902914 TSecr=9902914 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-59077 [SYN, ACK] Seq=6 ACK=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=9902914 TSecr 160 Type: OFPT_PACKET_IN 172 Type: OFPT_FLOW_MOD 68 47249-6633 [ACK] Seq=561 ACK=633 Win=86 Len=0 TSval=9902924 TSecr=9902914 76 [TCP_RETransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=990 76 [TCP_Spurious_Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=990 76 [TCP_Spurious_Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1
87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185800 10.0.0.1 127 8.967623000 127.0.0.1 128 8.967655000 127.0.0.1 129 8.967782000 10.0.0.4 131 8.968186800 10.0.0.4 132 8.969104900 127.0.0.1 133 9.006517000 127.0.0.1 134 9.950458000 10.0.0.1 135 9.951117000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.1 10.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.1	TCP OpenFlow OpenFlow TCP TCP TCP OpenFlow TCP TCP TCP TCP TCP TCP TCP TCP TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT PACKET IN 172 Type: 0FPT FLOW_MOD 68 47249-6033 [ACK] Seq=469 Ack=529 Win=86 Len=0 TSval=9902914 TSecr=9902914 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-89077 [SYN, ACK] Seq=60 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr 100 Type: 0FPT PACKET IN 172 Type: 0FPT FLOW_MOD 68 47249-6633 [ACK] Seq=561 Ack=633 Win=86 Len=0 TSval=9902924 TSecr=9902914 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=990 76 [TCP Spurious Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 77 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1
87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185900 10.0.0.1 127 8.967623000 127.0.0.1 129 8.967623000 127.0.0.1 130 8.96782000 10.0.0.1 131 8.968186900 10.0.0.4 132 8.969104000 127.0.0.1 133 9.060517000 127.0.0.1 134 9.950458000 10.0.0.1 135 9.951118000 10.0.0.1 136 9.95170000 10.0.0.1 137 9.951386000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 10.0.0.1 10.0.0.1 10.0.0.1	TCP TCP OpenFlow OpenFlow TCP TCP OpenFlow OpenFlow TCP TCP TCP TCP TCP TCP TCP TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT PACKET IN 172 Type: 0FPT PACKET IN 172 Type: 0FPT PACKET IN 175 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-59077 [SYN, ACK] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT PACKET IN 172 Type: 0FPT FLOW MOD 68 47249-6633 [ACK] Seq=561 Ack=633 Win=86 Len=0 TSval=9902924 TSecr=9902914 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 76 [TCP Retransmission] 8000-59077 [SYN, ACK] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 76 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 76 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 77 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 78 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 78 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 78 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8
87 7,993354900 10.0.0.5 125 8.953822000 10.0.0.1 127 8.967623000 127.0.0.1 128 8.967623000 127.0.0.1 129 8.967782000 10.0.0.1 130 8.967800000 10.0.0.4 131 8.968186000 10.0.0.4 132 8.969184000 127.0.0.1 134 9.95045000 10.0.0.1 135 9.951178000 10.0.0.1 136 9.95170000 10.0.0.1 137 9.95136000 10.0.0.1 138 9.951393000 10.0.0.5 138 9.951393000 10.0.0.5	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1 127.0.0.1 10.0.0.5 10.0.0.4 10.0.0.1 10.0.0.5	TCP TCP OpenFlow OpenFlow TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 174 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 175 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr=0 WS=512 176 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr=100 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 173 Type: 0PFT PACKET IN 174 [TCP Retransmission] S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 175 [TCP Retransmission] S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 176 [TCP Retransmission] S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 176 [TCP Retransmission] S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 176 [TCP Retransmission] S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 176 [TCP Retransmission] S907-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 176 [TCP Retransmission] S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 177 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 178 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 170 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 179 [SVN] ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1
87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185900 10.0.0.1 127 8.967623000 127.0.0.1 129 8.967623000 127.0.0.1 130 8.96782000 10.0.0.1 131 8.968186900 10.0.0.4 132 8.969104000 127.0.0.1 133 9.060517000 127.0.0.1 134 9.950458000 10.0.0.1 135 9.951118000 10.0.0.1 136 9.95170000 10.0.0.1 137 9.951386000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 10.0.0.1 10.0.0.1 10.0.0.1	TCP TCP OpenFlow OpenFlow TCP TCP OpenFlow OpenFlow TCP TCP TCP TCP TCP TCP TCP TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT PACKET IN 172 Type: 0FPT PACKET IN 172 Type: 0FPT PACKET IN 175 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 76 8000-59077 [SYN, ACK] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0FPT PACKET IN 172 Type: 0FPT FLOW MOD 68 47249-6633 [ACK] Seq=561 Ack=633 Win=86 Len=0 TSval=9902924 TSecr=9902914 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 76 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 76 [TCP Retransmission] 8000-59077 [SYN, ACK] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 76 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 76 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 77 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 78 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 78 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 78 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 88 8
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87 7.993354900 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185900 10.0.0.1 127 8.967623900 127.0.0.1 128 8.967655900 127.0.0.1 129 8.967782000 10.0.0.4 131 8.968186900 10.0.0.4 132 8.969104000 127.0.0.1 134 9.959458000 10.0.0.4 135 9.95118000 10.0.0.1 136 9.95169000 10.0.0.1 137 9.95133600 10.0.0.1 137 9.95133600 10.0.0.1 139 9.95139000 10.0.0.1 139 9.95139000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1 127.0.0.1 120.0.5 10.0.5 10.0.6.5 10.0.0.4 10.0.0.1	TCP TCP OpenFlow OpenFlow TCP TCP TCP OpenFlow OpenFlow TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN 173 Type: OFPT PACKET IN 174 Type: OFPT PACKET IN 175 S9077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 176 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr 100 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN 172 Type: OFPT PACKET IN 172 Type: OFPT FLOW MOD 174 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 175 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 176 [TCP Retransmission] 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9903160 TSecr=900160 [ACK] Seq=1 Ack=1 Win=28960 Len=0 TSval=9903160 TSecr=9903160 185 S9077-8000 [ACK] Seq=1 Ack=1 Win=28960 Len=0 TSval=9903160 TSecr=9903160 185 Seq=1 Ack=1 Win=29696 Len=0 TSval=9903160 TSecr=9903160
87 7.993354000 10.0.0.5 125 8.953022000 10.0.0.1 126 8.953185000 10.0.0.1 127 8.967623000 127.0.0.1 128 8.967655000 127.0.0.1 129 8.967782000 10.0.0.4 131 8.967800000 10.0.0.4 132 8.969104000 127.0.0.1 134 9.95018000 10.0.0.1 135 9.951170000 10.0.0.1 136 9.951170000 10.0.0.1 137 9.951393000 10.0.0.5 138 9.95193000 10.0.0.5 138 9.95193000 10.0.0.5 138 9.95199000 10.0.0.1 140 9.95175000 10.0.0.1	10.0.0.1 10.0.0.5 10.0.0.5 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.1 127.0.0.1 127.0.0.1 10.0.0.5 10.0.0.4 10.0.0.1 10.0.0.5 10.0.0.4 10.0.0.1 10.0.0.5 10.0.0.1	TCP TCP OpenFlow OpenFlow TCP	68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 68 8000-59076 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=9902648 TSecr=9902648 76 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902910 TSecr=0 WS=512 100 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 174 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr=0 WS=512 175 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr=0 WS=512 176 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9902914 TSecr=100 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 172 Type: 0PFT PACKET IN 174 Type: 0PFT PACKET IN 175 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 176 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 176 [TCP Retransmission] 59077-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=990 176 [TCP Retransmission] 8000-59077 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9903160 TSecr=0 S9077-8000 [ACK] Seq=1 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=9903160 TSecr=0 S9077-8000 [ACK] Seq=1 Ack=1 Win=28960 Len=0 TSval=9903160 TSecr=9903160 145 GET / HTTP/1.1 145 GET / HTTP/1.1

Practica 2:

Crear reglas en el switch openflow (partiendo de tutorial_I2_hub) para ofrecer la misma funcionalidad que en el caso inicial, pero con un mejor rendimiento. En lugar de realizar la difusión desde la aplicación, lo que implica que cada trama ethernet sea procesada a nivel de controlador, se deben instalar reglas en el switch que eviten ese procesamiento. Emplear el comando ping para evaluar el Hub inicial y el optimizado para conocer el retraso que introduce la primera versión.

Cambiamos of.ofp_packet_out por of.ofp_flow_mod.

Esto cambia el tiempo medio de 23,301 ms a 2,301 ms.

```
# msg = of.ofp_packet_out() # before
msg = of.ofp_flow_mod() # after
msg.buffer_id = event.ofp.buffer_id
msg.in_port = packet_in.in_port
```

```
mininet> h1 ping -c5 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=43.4 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=20.3 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=12.0 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=13.6 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=27.0 ms
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4004ms
rtt min/avg/max/mdev = 12.085/23.301/43.434/11.381 ms
```

```
mininet> h1 ping -c5 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=10.1 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.939 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.181 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.111 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.095 ms
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4007ms
rtt min/avg/max/mdev = 0.095/2.301/10.179/3.951 ms
```

Crear un Firewall a partir de un switch estándar (partiendo de l2_learning) para que bloquee tráfico:

Ver archivo "l2_learning_copy.py".

Desde un origen concreto a nivel IP.

```
# rule 1: block traffic from 10.0.0.1
ip_addr = msg.match.nw_src
if ip_addr is not None and ip_addr == "10.0.0.1":
    msg.actions.append(of.ofp_action_output(port = of.OFPP_NONE))
else:
    msg.actions.append(of.ofp_action_output(port = port))
```

```
9 2.157727000 127.0.0.1
                                                                                                        68 41906→20129 [ACK] Seq=487 Ack=25 Win=86 Len=0 TSval=10236262 TSecr=10236262
10 2.480580000 10.0.0.1
11 2.480829000 10.0.0.1
                                                     10.0.0.2
                                                                                                      100 Echo (ping) request id=0x2d1f, seq=1/256, ttl=64 (no response found!) 184 Type: OFPT PACKET_IN
                                                                                    ICMP
                                                                                    OpenFlow
                                                                                                      104 Type: OFPT_FLOW MOD
68 47272-6633 [ACK] Seq=125 Ack=89 Win=86 Len=0 TSval=10236348 TSecr=10236348
12 2.501016000 127.0.0.1
13 2.501044000 127.0.0.1
                                                                                    OpenFlow
TCP
                                                     127.0.0.1
                                                     127.0.0.1
14 3.480909000 10.0.0.1
15 4.312477000 127.0.0.1
                                                                                                     100 Echo (ping) request id=0x2d1f, seq=2/512, ttl=64 (no response found!)
311 41906-20129 [PSH, ACK] Seq=487 Ack=25 Win=86 Len=243 TSval=10236800 TSecr=10236262
                                                                                    ICMP
                                                     127.0.0.1
                                                                                    TCP
16 4.313126000 127.0.0.1
17 4.313169000 127.0.0.1
                                                                                                      80 20129-41906 [PSH, ACK] Seq=25 ACk=730 Win=2050 Len=12 TSval=10236801 TSecr=10236800 68 41906-20129 [ACK] Seq=730 Ack=37 Win=86 Len=0 TSval=10236801 TSecr=10236801
                                                     127.0.0.1
                                                     127.0.0.1
                                                                                    TCP
                                                                                                     100 Echo (ping) request id=0x2d1f, seq=3/768, ttl=64 (no response found!)
100 Echo (ping) request id=0x2d1f, seq=4/1024, ttl=64 (no response found!)
311 41906-20129 [PSH, ACK] Seq=730 ACK=37 Win=86 Len=243 TSval=10237326 TSecr=10236801
18 4.480804000 10.0.0.1
19 5.481052000 10.0.0.1
                                                     10.0.0.2
                                                                                    ICMP
20 6.412958000 127.0.0.1
                                                                                                      80 20129-41906 [PSH, ACK] Seq=37 Ack=973 Win=2050 Len=12 TSval=10237326 TSecr=10237326
21 6.413487000 127.0.0.1
                                                     127.0.0.1
                                                                                    TCP
22 6.413525000 127.0.0.1
                                                                                                       68 41906-20129 [ACK] Seq=973 Ack=49 Win=86 Len=0 TSval=10237326 TSecr=10237326
23 6.481731000 10.0.0.1
                                                     10.0.0.2
                                                                                    ICMP 100 Echo (ping) request id=0x2d1f, seq=5/1280, ttl=64 (no response found!)
OpenFlow 76 Type: OFPT_ECHO_REQUEST
24 7.109909000 127.0.0.1
```

```
mininet> h1 ping -c5 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 0 received, 100% packet loss, time 4001ms
```

Con un destino concreto a nivel IP.

```
# rule 2: block traffic to 10.0.0.1
ip_addr = msg.match.nw_dst
log.debug("ip_addr = %s" % (ip_addr))
if ip_addr is not None and ip_addr == "10.0.0.1":
    msg.actions.append(of.ofp_action_output(port = of.OFPP_NONE))
else:
    msg.actions.append(of.ofp_action_output(port = port))
```

```
16 6.434932000 127.0.0.1
                                                                                                                      68 41906-20129 [ACK] Seq=973 Ack=49 Win=86 Len=0 TSval=10294023 TSecr=10294023
                                                                                                                    100 Echo (ping) request id=0x2d3c, seq=1/256, ttl=64 (no response found!)
184 Type: OPTP_FACKET IN
148 Type: OPTP_FLOW MOD
68 47277-6633 [ACK] Seq=125 Ack=89 Win=86 Len=0 TSval=10294204 TSecr=10294204
17 7.148662000 10.0.0.2
18 7.148819000 10.0.0.2
                                                            10.0.0.1
                                                                                                ICMP
                                                             10.0.0.1
                                                                                                OpenFlow
19 7.158632000 127.0.0.1
                                                            127.0.0.1
                                                                                                OpenFlow
20 7.158660000 127.0.0.1
21 8.148917000 10.0.0.2
22 8.669828000 127.0.0.1
                                                                                                                    100 Echo (ping) request id=0x2d3c, seq=2/512, ttl=64 (no response found!)
311 41906-20129 [PSH, ACK] Seq=973 Ack=49 Win=86 Len=243 TSval=10294582 TSecr=10294023
                                                            10.0.0.1
                                                                                                ICMP
                                                                                                                     80 20129-41906 [PSH, ACK] Seq=49 Ack=1216 Win=2050 Len=12 TSval=10294582 TSecr=10294582 68 41906-20129 [ACK] Seq=1216 Ack=61 Win=86 Len=0 TSval=10294582 TSecr=10294582
23 8.670761000 127.0.0.1
                                                            127.0.0.1
                                                                                                TCP
24 8.670823000 127.0.0.1
                                                                                                TCP
                                                                                                                   100 Echo (ping) request id=0x2d3c, seq=3/768, ttl=64 (no response found!)
100 Echo (ping) request id=0x2d3c, seq=4/1024, ttl=64 (no response found!)
311 41906-20129 [PSH, ACK] Seq=1216 Ack=61 Win=86 Len=243 TSval=10295152 TSecr=10294582
80 20129-41906 [PSH, ACK] Seq=61 Ack=1459 Win=2050 Len=12 TSval=10295152 TSecr=10295152
25 9.149132000 10.0.0.2
                                                            10.0.0.1
                                                                                                ICMP
26 10.14873200( 10.0.0.2
                                                                                                ICMP
27 10.95182700( 127.0.0.1
                                                            127.0.0.1
                                                                                                TCP
28 10.95217900( 127.0.0.1
                                                            127.0.0.1
                                                                                                TCP
                                                                                                                    68 41906-20129 [ACK] Seq=1459 Ack=73 Win=86 Len=0 TSval=10295152 TSecr=10295152 100 Echo (ping) request id=0x2d3c, seq=5/1280, ttl=64 (no response found!)
29 10.95233800( 127.0.0.1
                                                            127.0.0.1
                                                                                                TCP
 30 11.14921300( 10.0.0.2
                                                                                                ICMP
                                                            10.0.0.1
31 11.35484400( 127.0.0.1
                                                            127.0.0.1
                                                                                                OpenFlow
                                                                                                                    76 Type: OFPT ECHO REQUEST
```

```
mininet> h2 ping -c5 h1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
--- 10.0.0.1 ping statistics ---
5 packets transmitted, 0 received, 100% packet loss, time 4000ms
```

Tráfico con el protocolo ICMP.

Para "match" los protocolos, he utilizado los números de protocolo IP.

Hex	Protocol Number	Keyword
0x00	0	HOPOPT
0x01	1	ICMP
0x02	2	IGMP
0x03	3	GGP
0x04	4	IP-in-IP
0x05	5	ST
0x06	6	TCP
0x07	7	CBT
0x08	8	EGP
0x09	9	IGP
0x0A	10	BBN-RCC-MON
0x0B	11	NVP-II
0x0C	12	PUP
0x0D	13	ARGUS
0x0E	14	EMCON
0x0F	15	XNET
0x10	16	CHAOS
0x11	17	UDP
0x12	18	MUX

```
# rule 3: block ICMP traffic
if msg.match.nw_proto == 1:
    msg.actions.append(of.ofp_action_output(port = of.OFPP_NONE))
else:
    msg.actions.append(of.ofp_action_output(port = port))
```

```
9 3.038857000 127.0.0.1
                                                                                                           68 47280→6633 [ACK] Seq=9 Ack=9 Win=86 Len=0 TSval=10411009 TSecr=10411008
10 4.016701000 10.0.0.1
11 4.016863000 10.0.0.1
                                                       10.0.0.2
10.0.0.2
                                                                                       TCMP
                                                                                                         100 Echo (ping) request id=0x2d59, seq=1/256, ttl=64 (no response found!) 184 Type: OFPT_PACKET_IN
                                                                                       OpenFlow
12 4.054665000 127.0.0.1
                                                       127.0.0.1
                                                                                       TCP
                                                                                                          68 6633-47280 [ACK] Seg=9 Ack=125 Win=88 Len=0 TSval=10411263 TSecr=10411253
                                                                                                         148 Type: OFPT_FLOW_MOD
14 4.068461000 127.0.0.1
                                                       127 0 0 1
                                                                                       TCP
                                                                                                          68 47280-6633 [ACK] Seg=125 Ack=89 Win=86 Len=0 TSval=10411266 TSecr=10411266
15 4.347426000 127.0.0.1
                                                                                                         311 41906-20129 [PSH, ACK] Seq=487 Ack=25 Win=86 Len=243 TSval=10411336 TSecr=10410774
                                                                                       TCP
16 4.347759000 127.0.0.1
17 4.347782000 127.0.0.1
                                                                                                          80 20129-41906 [PSH, ACK] Seq=25 Ack=730 Win=2050 Len=12 TSval=10411336 TSecr=10411336 88 41906-20129 [ACK] Seq=730 Ack=37 Win=86 Len=0 TSval=10411336 TSecr=10411336
                                                       127.0.0.1
                                                                                       TCP
                                                                                                        100 Echo (ping) request id=0x2d59, seq=2/512, ttl=64 (no response found!)
100 Echo (ping) request id=0x2d59, seq=3/768, ttl=64 (no response found!)
18 5.025565000 10.0.0.1
                                                       10.0.0.2
                                                                                       ICMP
19 6.034005000 10.0.0.1
                                                                                                        311 41906-20129 [PSH, ACK] Seq=730 Ack=37 Win=86 Len=243 TSval=10411864 TSecr=10411336
80 20129-41906 [PSH, ACK] Seq=37 Ack=973 Win=2050 Len=12 TSval=10411864 TSecr=10411864
20 6.460838000 127.0.0.1
                                                       127.0.0.1
                                                                                       TCP
 21 6.461122000 127.0.0.1
                                                                                                        68 41986-20129 [ACK] Seq=973 Ack=49 Win=86 Len=0 TSval=10411864 TSecr=10411864 100 Echo (ping) request id=0x2d59, seq=4/1024, ttl=64 (no response found!) 100 Echo (ping) request id=0x2d59, seq=5/1280, ttl=64 (no response found!) 311 41906-20129 [PSH, ACK] Seq=973 Ack=49 Win=86 Len=243 TSval=10412385 TSecr=10411864
22 6.461141000 127.0.0.1
                                                       127.0.0.1
                                                                                       TCP
 23 7.041216000 10.0.0.1
                                                       10.0.0.2
24 8.049446000 10.0.0.1
                                                       10.0.0.2
25 8.546122000 127.0.0.1
```

```
mininet> h1 ping -c5 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 0 received, 100% packet loss, time 4032ms
```

Tráfico UDP a un puerto concreto.

```
# rule 4: block UDP traffic to port 5000
if msg.match.nw_proto == 17 and msg.match.tp_dst == 5000:
    msg.actions.append(of.ofp_action_output(port = of.OFPP_NONE))
else:
    msg.actions.append(of.ofp action output(port = port))
```

```
ubuntu@sdnhubvm:~/pox[17:03] (betta)$ iperf -c 10.0.0.1 -u -p 5000 -i 1
Client connecting to 10.0.0.1, UDP port 5000
Sending 1470 byte datagrams
UDP buffer size: 208 KByte (default)
  3] local 10.0.2.15 port 53323 connected with 10.0.0.1 port 5000
 ID] Interval
                    Transfer
                                 Bandwidth
     0.0- 1.0 sec 129 KBytes 1.06 Mbits/sec
      1.0- 2.0 sec 128 KBytes 1.05 Mbits/sec
      2.0- 3.0 sec
                    128 KBytes 1.05 Mbits/sec
      3.0- 4.0 sec
                     128 KBytes
                                1.05 Mbits/sec
  3]
                     128 KBytes
      4.0- 5.0 sec
                                1.05 Mbits/sec
      5.0- 6.0 sec
                     128 KBytes
                                1.05 Mbits/sec
  3]
      6.0- 7.0 sec
                     129 KBytes 1.06 Mbits/sec
      7.0- 8.0 sec
  3]
                     128 KBytes 1.05 Mbits/sec
     8.0- 9.0 sec
                     128 KBytes 1.05 Mbits/sec
      9.0-10.0 sec
                     128 KBytes 1.05 Mbits/sec
     0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec
   3] Sent 893 datagrams
     WARNING: did not receive ack of last datagram after 10 tries.
```

```
ubuntu@sdnhubvm:~/pox[17:03] (betta)$ iperf -u -s -p 5000
Server listening on UDP port 5000
Receiving 1470 byte datagrams
UDP buffer size: 208 KByte (default)
```

661 8.046141000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
662 8.046580000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)
663 8.057327000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
664 8.057625000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)
665 8.068549000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
666 8.068823000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)
667 8.079843000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
668 8.080085000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)
669 8.091164000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
670 8.091628000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)
671 8.105456000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
672 8.105722000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)
673 8.113376000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
674 8.113619000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)
675 8.127393000 10.0.2.15	10.0.0.1	UDP	1514 Source port: 53323 Destination port: 5000
676 8.127695000 10.0.2.2	10.0.2.15	ICMP	72 Destination unreachable (Network unreachable)

Tráfico con un destino a nivel IP y puerto TCP concretos.

```
# rule 5: block traffic to 10.0.0.1 and to TCP port 5000
if msg.match.nw_proto == 6 and packet.match.nw_dst == '10.0.0.1' and packet.match.tp_dst == 5000:
    msg.actions.append(of.ofp_action_output(port = of.0FPP_NONE))
else:
    msg.actions.append(of.ofp_action_output(port = port))
```

10 2.046730000 127.0.0.1	127.0.0.1	TCP	68 41906→20129 [ACK] Seq=487 Ack=25 Win=86 Len=0 TSval=10605559 TSecr=10605559
11 3.845081000 10.0.2.15	10.0.0.1	TCP	76 39590-5000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=10606009 TSecr=0 WS=512
12 4.082720000 127.0.0.1	127.0.0.1	TCP	311 41906-20129 [PSH, ACK] Seq=487 Ack=25 Win=86 Len=243 TSval=10606068 TSecr=10605559
13 4.082957000 127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=25 Ack=730 Win=2050 Len=12 TSval=10606068 TSecr=10606068
14 4.082971000 127.0.0.1	127.0.0.1	TCP	68 41906→20129 [ACK] Seq=730 Ack=37 Win=86 Len=0 TSval=10606068 TSecr=10606068
15 4.843789000 10.0.2.15	10.0.0.1	TCP	76 [TCP Retransmission] 39590-5000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=10606259 TSecr=0 WS=512
16 6.107708000 127.0.0.1	127.0.0.1	TCP	311 41906-20129 [PSH, ACK] Seq=730 Ack=37 Win=86 Len=243 TSval=10606575 TSecr=10606068
17 6.107847000 127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=37 Ack=973 Win=2050 Len=12 TSval=10606575 TSecr=10606575
18 6.107856000 127.0.0.1	127.0.0.1	TCP	68 41906→20129 [ACK] Seq=973 Ack=49 Win=86 Len=0 TSval=10606575 TSecr=10606575
19 6.808686000 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO REQUEST
20 6.809100000 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT ECHO REPLY
21 6.809125000 127.0.0.1	127.0.0.1	TCP	68 47283-6633 [ACK] Seq=17 Ack=17 Win=86 Len=0 TSval=10606750 TSecr=10606750
22 6.847664000 10.0.2.15	10.0.0.1	TCP	76 [TCP Retransmission] 39590-5000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=10606760 TSecr=0 WS=512
23 8.149920000 127.0.0.1	127.0.0.1	TCP	311 41906→20129 [PSH, ACK] Seq=973 Ack=49 Win=86 Len=243 TSval=10607085 TSecr=10606575
24 8.150122000 127.0.0.1	127.0.0.1	TCP	80 20129-41906 [PSH, ACK] Seq=49 Ack=1216 Win=2050 Len=12 TSval=10607085 TSecr=10607085

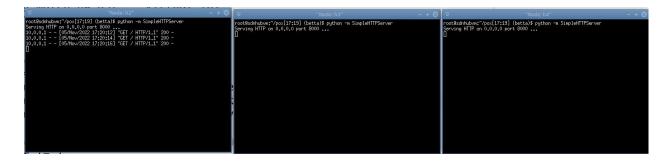
Practica 3:

Modificar el balanceador (aplicación tutorial_stateless_lb) para que:

Se envíen 3 peticiones seguidas hacia el mismo servidor.

Ver archivo "tutorial_stateless_lb_copy.py".

```
# 3 requests to the same host in a raw
counter += 1
if counter == 3:
    server_index += 1
    counter = 0
```



Detecte si un servidor web ha caído (aunque el ordenador sigue conectado a la red) y, en ese caso, eliminarlo de la lista de servidores del pool.

Ver archivo "tutorial_stateless_lb_copy.py". Lo importante es que cuando un servidor está caído y no puede ser alcanzado, se recibe un ACK RST.

```
msg = of.ofp flow mod()
msq.match = of.ofp match.from packet(packet)
 # remove server if down
 if packet.find('tcp').RST == True:
         for i in server:
                  if (server[i]['ip'] == msq.match.nw src):
                           del server[i]
                           total servers = total servers - 1
                           break
if total servers == 0:
          return EventContinue
           mininet> h1 curl 10.0.0.5:8000
           curl: (7) Failed to connect to 10.0.0.5 port 8000: Connection refused
           mininet> h1 curl 10.0.0.5:8000
           curl: (7) Failed to connect to 10.0.0.5 port 8000: Connection refused
           mininet> h1 curl 10.0.0.5:8000
           curl: (7) Failed to connect to 10.0.0.5 port 8000: Connection refused
ubuntu@sdnhubvm:~/pox[18:45] (betta)$ /home/ubuntu/pox/pox.py forwarding.tutorial_stateless_lb_copy
POX 0.1.0 (betta) / Copyright 2011-2013 James McCauley, et al.
INFO:forwarding.tutorial_stateless_lb_copy:Stateless LB running.
INFO:core:POX 0.1.0 (betta) is up.
INFO:openflow.of_01:[00-00-00-00-00-01 1] connected
Servers dictionnary: {0: {'ip': IPAddr('10.0.0.2'), 'mac': EthAddr('00:00:00:00:00:02'), 'outport': 2}, 1: {
'ip': IPAddr('10.0.0.3'), 'mac': EthAddr('00:00:00:00:00:03'), 'outport': 3}, 2: {'ip': IPAddr('10.0.0.4'),
'mac': EthAddr('00:00:00:00:00:00:04'), 'outport': 4}}
Servers dictionnary: {1: {'ip': IPAddr('10.0.0.3'), 'mac': EthAddr('00:00:00:00:00:03'), 'outport': 3}, 2: {
'ip': IPAddr('10.0.0.4'), 'mac': EthAddr('00:00:00:00:00:04'), 'outport': 4}}
Servers dictionnary: {2: {'ip': IPAddr('10.0.0.4'), 'mac': EthAddr('00:00:00:00:00:04'), 'outport': 4}}
```

13 4.259013000 10.0.0.1	10.0.0.5	TCP	76 59140-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=10772679 TSecr=0 WS=512
14 4.259230000 10.0.0.1	10.0.0.5	OpenFlow	160 Type: 0FPT_PACKET_IN
15 4.268741000 127.0.0.1	127.0.0.1	OpenFlow	172 Type: 0FPT_FLOW_MOD
16 4.268769000 127.0.0.1	127.0.0.1	TCP	68 47314-6633 [ACK] Seq=101 Ack=113 Win=86 Len=0 TSval=10772681 TSecr=10772681
17 4.268885000 10.0.0.1	10.0.0.2	TCP	76 59140-48000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=10772679 TSecr=0 WS=512
18 4.268900000 10.0.0.2	10.0.0.1	TCP	56 8000-59140 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
19 4.269389000 10.0.0.2	10.0.0.1	OpenFlow	140 Type: 0FPT_PACKET_IN
20 4.270086000 127.0.0.1	127.0.0.1	OpenFlow	172 Type: 0FPT_FLOW_MOD

Inspirarse en el balanceador de carga para crear una aplicación que implemente un traductor de direcciones (NAT).

Ver archivo "NAT.py". Funciona bien. Sólo he utilizado un servidor web (10.0.0.4), el router virtual (10.0.0.5) y tres hosts (10.0.0.1/2/3).

Ejecuto *h1 curl 10.0.0.4:8000*, luego *h2 curl 10.0.0.4:8000*, y finalmente *h3 curl 10.0.0.4:8000*.

Time	Source	Destination	Protoco	l Length Info
12 4.489706000		127.0.0.1	TCP	68 41906-20129 [ACK] Seq=730 Ack=37 Win=86 Len=0 TSval=10878177 TSecr=10878177
13 5.538983000		10.0.0.4	TCP	76 53052-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=10878439 TSecr=0 WS=512
14 5.539181000		10.0.0.4	0penFlo	
15 5.565901000 16 5.565931000		127.0.0.1 127.0.0.1	OpenFlo TCP	w 196 Type: OFPT_FLOW_MOD 68 47431-6633 [ACK] Seq=101 Ack=137 Win=90 Len=0 TSval=10878446 TSecr=10878446
17 5.566079000		10.0.0.4	TCP	06 47431-0053 [ACT] SEQTEDI ACKIS7 WINESD LENED ISSUELUO/0400 ISECTELUO/0400 76 53052-0800 [SYN] Seqe0 Wine29200 LeneD MSS-1460 SACK PERMEI ISSUENBR/8439 TSECTED WS=512
18 5.566093000		10.0.0.5	TCP	76 8000-53052 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSya1=10878446 TSecr=10878439 WS=512
19 5.566151000		10.0.0.1	TCP	76 8000-53051 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=10878446 TSecr=10878439 WS=512
20 5.566163000	10.0.0.1	10.0.0.4	TCP	56 53051-8000 [RST] Seq=1 Win=0 Len=0
21 5.566201000	10.0.0.5	10.0.0.4	TCP	56 53051-8000 [RST] Seq=1 Win=0 Len=0
22 5.569789000		127.0.0.1	OpenFlo	
23 5.569814000 24 6.537044000		127.0.0.1 10.0.0.4	TCP TCP	68 47431-6633 [ACK] Seq=101 Ack=249 Win=90 Len=0 TSval=10878447 TSecr=10878447 76 [TCP Retransmission] 53052-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=10878689 TSecr=0 WS=512
25 6.537360000		10.0.0.4	TCP	76 [TCP Spurious Retransmission] 53052-8000 [SYN] 3049 Will-22200 Lene 0153-1400 3AAA; FEMP-1 1204(-1007)000 15041-0 015-140 015-140 015-1400 015-1
26 6.537402000		10.0.0.5		76 [TCP Retransmission] 8000-53052 [SYN, ACK] Seq-0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM-1 TSval=10878689 TSecr=10878439 WS
27 6.537532000		10.0.0.1	TCP	76 8000-53052 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=10878689 TSecr=10878439 WS=512
28 6.537576000		10.0.0.4	TCP	68 53052-8000 [ACK] Seq=1 Ack=1 Win=29696 Len=0 TSval=10878689 TSecr=10878689
29 6.537584000		10.0.0.4	TCP	68 53052-8000 [ACK] Seq=1 Ack=1 Win=29696 Len=0 TSval=10878689 TSecr=10878689
30 6.537887000		10.0.0.4	HTTP	145 GET / HTTP/1.1
31 6.537902000 32 6.537917000		10.0.0.4 10.0.0.5	HTTP TCP	145 GET / HTTP/1.1 68 8000-53052 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSval=10878689 TSecr=10878689
33 6.537923000		10.0.0.1	TCP	68 8080-53652 [ACK] Seq=1 Ack=78 Win=29184 Len=0 TSVal=10878005 13ECT=10878689
33 0.337323000	10.0.0.4	10.0.0.1	101	00 0000-33032 [Rick] 344-1 ACR-70 WIII-23104 Edil-0 1398C-10070003 13CC1-10070003
81 13.00315100€ 123 82 13.00319500€ 123	7.0.0.1	127.0.0.1	TCP 88	20129-41906 [PSH, ACK] Seq=73 Ack=1702 Win=2050 Len=12 TSval=10880305 TSecr=10880305 41906-20129 [ACK] Seo=1702 Ack=85 Win=86 Len=0 TSval=10880305 TSecr=10880305
83 13.58549286(10.		10.0.0.4		7390-2012 [Act, 3cq-1/2 Act-03 Win-9200 Lene MSS-1460 SACK PERM-I TSVal=10800435 TSecr=0 WS=512
84 13.58564700(10	.0.0.2	10.0.0.4	OpenFlow 160	Type: OFPT PACKET IN
85 13.61366488€ 123 86 13.61369388€ 123		127.0.0.1		Type: 0FPT_FLOW MOD
87 13.613993886 12		10.0.0.4	TCP 58	47431-6633 [ACK] Seq=201 Ack=385 Win=92 Len=0 TSval=10880458 TSecr=10880458 \$4911-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=10880451 TSecr=0 WS=512
88 13.613986886 10	.0.0.4	10.0.0.5	TCP 76	8080-54911 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=10880458 TSecr=10880451 WS=512
89 13.61408000(10		10.0.0.1		[TCP Spurious Retransmission] 8000-53052 [SYN, ACK] Seq=2871239992 Ack=3953334335 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=10880458 TSecr=10880451
98 13.614896886 10 91 13.614100886 10	.0.0.1	10.0.0.4 10.0.0.4	TCP 68	[TCP Dup ACK 66#1] 53052-8000 [ACK] Seq=79 Ack=791 Win=30720 Len=0 TSval=10880458 TSecr=10878694 [TCP Dup ACK 67#1] 53052-8000 [ACK] Seq=79 Ack=791 Win=30720 Len=0 TSval=10880458 TSecr=10878694
92 13.614108000 10	.0.0.4	10.0.0.5	TCP 56	8000-53052 [RST] Seq=791 Win=0 Len=0
93 13.61411000(10		10.0.0.1		8000-53052 [RST] Seq=791 Win=0 Len=0
94 13.615298886 123 95 13.615322886 123		127.0.0.1 127.0.0.1		Type: 0FPT_FLOW MDD 47831 6533 [ACV] 0000000 Acks/407 Mine(3) 10000 TS(3) 100000459 TS(3) 100000459
96 14.585195886 10		10.0.0.4	TCP 76	47431-6633 [ACK] Seq=201 Ack=497 Win=92 Len=0 TSval=10880458 TSecr=10880458 [TCP Retransmission] 54911-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=10880701 TSecr=0 WS=512
				[TCP Spurious Retransmission] 54911-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=10880701 TSecr=0 WS=512
98 14.58605200(10 99 14.58626300(10	.0.0.4	10.0.0.5	TCP 76	[TCP Retransmission] 8000-54911 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=10880701 TSecr=10880451 WS=512 8000-54911 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK PERM=1 TSval=10880701 TSecr=10880451 WS=512
100 14.58632800(10		10.0.0.4		0000-7091[274, AK] Seq=0 AKK-1 MIN-2090 Lene N35-400 SAN, PKN-1 SV41-10000/01 [SECT-10000431 N3-312 54911-8000 [AKK] Seq=1 AKK-1 Win-2090 Lene N53-4400 SAN, PKN-1 SV41-10000/01 [SECT-10000431 N3-312
101 14.58634000€ 10	.0.0.5	10.0.0.4	TCP 68	54911-8000 [ACK] Seq=1 Ack=1 Win=29696 Len=0 TSval=10880701 TSecr=10880701
102 14.58684500€ 10		10.0.0.4		GET / HTTP/1.1
103 14.58687400€ 10 104 14.58689700€ 10		10.0.0.4		GET / HTTP/1.1 8000-54911 [ACK] Seg=1 Ack=78 Win=29184 Len=0 TSval=10880701 TSecr=10880701
105 14.58690600€ 10		10.0.0.2		8080-5491 [ACK] Seq-1 Ack-78 Min-29184 Len=0 TSval-18880761 TSecr-18880761
			Wan.	
151 19.48730500€ 1 152 20.63193600€ 1		127.0.0.1 10.0.0.4	TCP TCP	68 41906-20129 [ACK] Seq=2431 Ack=121 Win=86 Len=0 TSval=10881926 TSecr=10881926 76 58783-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=10882212 TSecr=0 WS=512
153 20.63216400(1		10.0.0.4	OpenFlow	70 30703-0000 (311) 3-000 1811-2-2-200 ECH-0 H33-1400 3KKK-FEH-1 13VK-10002212 13-CCH-0 H3-312
154 20.64365000€ 1		127.0.0.1	OpenFlow	196 Type: OFPT FLOW MOD
155 20.643683006 1		127.0.0.1	TCP	68 47431-6633 [ACK] Seq=301 Ack=633 Win=94 Len=0 TSval=10882215 TSecr=10882215
156 20.64381400(1		10.0.0.4	TCP	76 58703-8000 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK PERM=1 TSval=10882212 TSecr=0 WS=512
157 20.64382900€ 1 158 20.64408700€ 1	10.0.0.4	10.0.0.5	TCP	76 8000-58703 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=10882215 TSecr=10882212 WS=512 76 [TCP Previous segment not captured] 8000-54911 [SYN, ACK] Seq=643651020 Ack=3845069748 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=10
	10.0.0.2	10.0.0.4	TCP	70 [ICP Previous segment not captured] 0000-04911 [31M, ALK] Seq=043051020 ALK=3043009740 MIHE/20900 LeHH9 M55=1400 SALK_PENNH1 ISV8L=10 68 [TCP Dup ACK 138#1] 54911-8800 [ACK] Seq=79 AKK=791 Min=30720 LeH=0 TSVal=1888275 TSccr=10880706
159 20.644101000 1				68 [TCP Dup ACK 139#1] 54911-8000 [ACK] Seq=79 ACk=791 Win=30720 Len=0 TSval=10882215 TSecr=10880706
159 28.644181886 1 168 28.644184886 1	10.0.0.5	10.0.0.4		
159 20.64410100(1 160 20.64410400(1 161 20.64411000(1	10.0.0.4	10.0.0.4 10.0.0.5	TCP	56 8000-54911 [RST] Seq=791 Win=0 Len=0
159 20.64410100(1 160 20.64410400(1 161 20.64411000(1 162 20.64411200(1	10.0.0.4 10.0.0.4	10.0.0.4 10.0.0.5 10.0.0.2	TCP TCP	56 8000-54911 [RST] Seq=791 Win=0 Len=0 56 8000-54911 [RST] Seq=791 Win=0 Len=0
159 20.64410100(1 160 20.64410400(1 161 20.64411000(1 162 20.64411200(1 163 20.64805600(1	10.0.0.4 10.0.0.4 127.0.0.1	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1	TCP TCP OpenFlow	56 8080-54911 [RST] Seq=791 Win=0 Len=0 56 8000-54911 [RST] Seq=791 Win=0 Len=0 180 Type: OPPT-FLOW MOO
159 20.64410100(1 160 20.64410400(1 161 20.64411000(1 162 20.64411200(1 163 20.64805600(1 164 20.64807800(1	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1 127.0.0.1	TCP TCP OpenFlow TCP	56 8080-49911 [RST] Seq=731 Winne Len=0 180 Type: 0PFT FLOW MO0 68 47631-6803 [AKC] Seq=301 Ack=745 Winn=94 Len=0 TSval=10882216 TSecr=10882216
159 29.64410199(1 169 29.64410499(1 161 29.64411099(1 162 29.64411299(1 163 29.64895699(1 164 29.64897899(1 165 21.69971099(1	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1	TCP TCP OpenFlow	56 8080-54911 [RST] Seq=791 Win=0 Len=0 56 8000-54911 [RST] Seq=791 Win=0 Len=0 180 Type: OPPT-FLOW MOO
159 28.644184881 1 160 29.644184881 1 161 28.644118881 1 162 28.644112881 1 163 28.648878881 1 164 28.648878881 1 165 21.68071888 1 166 21.681383881 1 167 21.681424881 1	18.0.0.4 18.0.9.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1	TCP TCP OpenFlow TCP TCP TCP	56 8080-45911 [RST] Seq=791 Winse Lene0 56 8080-45911 [RST] Seq=791 Winse Lene0 180 Type: 0FFT_FLOW_MOD 61 4731-4693 [ACK] Seq=301 Ack=745 Win=94 Lene0 TSval=10882216 TSecr=10882216 631 4731-4693 [ACK] Seq=301 Ack=745 Win=96 Lene-243 TSval=10882454 TSecr=10881926 80 20129-41996 [PSH, ACK] Seq=2431 Ack=2674 Win=86 Lene-243 TSval=10882455 TSecr=10882454 68 41906-29219 [ACK] Seq=2747 Ack=132 Min=86 Lene1 TSval=10882455 TSecr=10882455
159 29.644104090 1 169 29.644104090 1 161 29.644110900 1 162 29.644112090 1 163 29.644912090 1 164 29.64897890 1 165 21.609710000 1 166 21.60138390 1 167 21.60138390 1 168 21.645597000 1	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1	TCP TCP OpenFlow TCP TCP TCP TCP TCP	56 8080-45911 [AST] Seq=731 Winne Lene0 180 Type: 0PFT FLOW MOD 68 47631-6633 [AKK] Seq=391 Ack=745 Winne94 Lene0 TSval=10882216 TSecr=10882216 311 41966-29129 [PSH, ACK] Seq=2341 Ack=212 Winne96 Lene-243 TSval=10882245 TSecr=10881926 88 27129-41596 [PSH, ACK] Seq=212 Ack=745 Winne96 Lene-12 TSval=10882454 TSecr=10881926 68 27129-47196 [PSH, ACK] Seq=212 Ack=674 Winne269 Lene-12 TSval=10882455 TSecr=10882454 68 41966-29129 [ACK] Seq=2714 Ack=073 Winne96 Lene-07 TSval=10882455 TSecr=10882456 68 1996-29129 [ACK] Seq=2714 Ack=073 Winne96 Lene-07 TSval=10882455 TSecr=10882456 68 1996-29129 [ACK] Seq=2714 Ack=073 Winne96 Lene-07 TSval=10882455 TSecr=10882456 68 1996-29129 [ACK] Seq=2714 Ack=073 Winne96 Lene-07 TSval=10882455 TSecr=10882456
159 20.6441016001 1 160 20.644110901 1 161 20.644112001 1 162 20.644112001 1 163 20.648056001 1 164 20.6480760001 1 165 21.609710001 1 166 21.601333001 1 167 21.601424001 1 169 21.6460980001 1	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.3 10.0.0.5	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.4	TCP TCP OpenFlow TCP TCP TCP TCP TCP TCP TCP TCP	56 800-45911 [RST] Seq=791 Winne Lene 180 Type: 0FFT FLOW MOD 68 47431-6833 [ACK] Seq=301 Ack=745 Winne Lene 180 Type: 0FFT FLOW MOD 68 47431-6833 [ACK] Seq=301 Ack=745 Winne Lene 111 41906-20129 [PSH, ACK] Seq=2451 Ack=121 Winne Lene 122 Type: 0FFT FLOW MOD 68 20129-41906 [PSH, ACK] Seq=2451 Ack=121 Winne Lene 123 Type: 0FFT FLOW MOD 68 20129-41906 [PSH, ACK] Seq=2451 Ack=2674 Winne 2696 Lene 12 Type: 1082454 TSecr=10882454 68 21906-20129 [ACK] Seq=2747 Ack=132 Winne Lene 123 Type: 10824545 TSecr=10882454 76 [TOP Retransmission] 55703-8009 [SYN] Seq=0 Winne 29208 Lene 76 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 76 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 76 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 76 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 76 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 76 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Septious Retransmission] 55703-8000 [SYN] Seq=0 Winne 29208 Lene 77 [TOP Se
159 20.6441010001 160 20.644101001 161 20.6441100001 162 20.644112001 163 20.644112001 164 20.648078001 165 21.600710001 166 21.601330001 167 21.601330001 167 21.64604001 169 21.6459570001 170 21.64614401 170 21.646144001 170 2	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.3 10.0.0.5 10.0.0.4	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.4	TCP TCP OpenFlow TCP	56 8080-45911 [AST] Seg-731 Winne Lene0 180 Type: 0PFT FLOW MOD 68 47031-6333 [AKK] Seg-391 Ack=745 Winne94 Lene0 TSval=10882216 TSecr=10882216 311 41966-29129 [PSH, ACK] Seg-231 Ack=212 Winne96 Lene-243 TSval=10882245 TSecr=10881926 81 27129-41596 [PSH, ACK] Seg-212 Ack=745 Winne96 Lene-243 TSval=10882454 TSecr=10881926 80 27129-41596 [PSH, ACK] Seg-212 Ack=747 Winne960 Lene-12 TSval=10882455 TSecr=10882454 68 41966-29129 [ACK] Seg-2674 Ack=743 Winne96 Lene-01 TSval=10882455 TSecr=10882455 76 [TOP Entransisission] S6703-80800 [SVN] Seg-00 Winne92000 Lene MSS-1406 SACK PERM=1 TSVal=10882460 TSecr=0 WS-512 76 [TOP Fotorransission] S6703-80800 [SVN] Seg-00 Winne92000 Lene MSS-1406 SACK PERM=1 TSVal=10882460 TSecr=0 WS-512 76 [TOP Fotorransission] S6703-80800 [SVN] Seg-00 Winne92000 Lene MSS-1406 SACK PERM=1 TSVal=10882460 TSecr=0 WS-512 76 [TOP Fotorransission] S6800-85703 [SVN], ACK] Seg-00 Acks Winne9300 SACK PERM=1 TSVal=10882460 TSecr=10882212 WS-512
159 20.644101801 1 161 20.644110901 1 162 28.644112001 1 162 28.649112001 1 163 20.648956001 1 164 28.648978001 1 165 21.699710001 1 166 21.691383001 1 167 21.691424001 1 169 21.64597001 1 169 21.646980001 1 171 21.646322001 1	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.3 10.0.0.5 10.0.0.4	19. 9. 9. 4 19. 9. 9. 5 19. 9. 9. 5 19. 9. 9. 1 127. 9. 9. 1 127. 9. 9. 1 127. 9. 9. 1 127. 9. 9. 1 10. 9. 9. 4 10. 9. 9. 4 10. 9. 9. 5 10. 9. 9. 5 10. 9. 9. 5	TCP TCP OpenFlow TCP	56 8008-3911 [RST] Seq=731 Winse Lene 180 Type: 0FPT FLOW MOD 68 47631-6633 [ACK] Seq=301 Ack=748 Winse4 Lene 180 Type: 0FPT FLOW MOD 68 47431-6633 [ACK] Seq=301 Ack=748 Winse4 Lene 68 47431-6633 [ACK] Seq=301 Ack=748 Winse4 Lene 68 27431-6633 [ACK] Seq=311 Ack=212 Winse6 Lene243 TSys12-10802245 TSecr=1080126 88 20129-41906 [PSH, ACK] Seq=213 Ack=212 Winse6 Lene243 TSys12-10802455 TSecr=10802454 68 41906-20129 [ACK] Seq=2674 Ack=338 Winse6 Lene0 TSys12-10802455 TSecr=10802454 70 [TCP Retransmission] 58703-3000 [STW] Seq=0 Winse2900 Lene0 Winse1400 SACK, PERM-1 TSys12-10802466 TSecr=0 WS-512 76 [TCP Retransmission] 58703-8000 [STW] Seq=0 Ack=1 Winse2900 Lene0 MSS=1460 SACK, PERM-1 TSys12-10802466 TSecr=0 WS-512 76 [TCP Retransmission] 58703-8000 [STW] Seq=0 Ack=1 Winse2900 Lene0 MSS=1460 SACK, PERM-1 TSys12-10802466 TSecr=10802212 WS-512 76 [000-08703 [STW] ACK] Seq=0 Ack=1 Winse2800 Lene0 MSS=1460 SACK PERM-1 TSys12-10802466 TSecr=10802212 WS-512
159 20.6441010001 160 20.644101001 161 20.6441100001 162 20.644112001 163 20.644112001 164 20.648078001 165 21.600710001 166 21.601330001 167 21.601330001 167 21.64604001 169 21.6459570001 170 21.64614401 170 21.646144001 170 2	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.3 10.0.0.5 10.0.0.4 10.0.0.4	10.0.0.4 10.0.0.5 10.0.0.2 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.4 10.0.0.4	TCP TCP OpenFlow TCP	56 8080-45911 [AST] Seg-731 Winne Lene0 180 Type: 0PFT FLOW MOD 68 47031-633 [AKK] Seg-391 Ack=745 Winne94 Lene0 TSval=10882216 TSecr=10882216 311 41966-20129 [PSH, ACK] Seg-231 Ack=212 Winne66 Lene-243 TSval=10882245 TSecr=10881226 81 20129-41996 [PSH, ACK] Seg-212 Ack=745 Winne96 Lene-12 TSval=10882454 TSecr=1088126 80 20129-41996 [PSH, ACK] Seg-212 Ack=747 Winne260 Lene-12 TSval=10882455 TSecr=10882454 68 41966-20129 [ACK] Seg-2674 Ack=133 Winne66 Lene-0 TSval=10882455 TSecr=10882455 76 [TOP FCTATIONSISSION] S6703-80800 [SVN] Seg-00 Winne29200 Lene MSS-1406 SACK PERM=1 TSVal=10882466 TSecr=0 WS-512 76 [TOP FCTATIONSISSION] S6703-80800 [SVN] Seg-00 Winne29200 Lene MSS-1406 SACK PERM=1 TSVal=10882466 TSecr=0 WS-512 76 [TOP FCTATIONSISSION] S0800-58703 [SVN], ACK] Seg-00 ACK=1 Winne2800 Lene MSS-1406 SACK PERM=1 TSVal=10882466 TSecr=10882212 WS-512 76 S080-38703 [SVN, ACK] Seg-00 Ack=1 Winne2800 Lene MSS-1406 SACK PERM=1 TSVal=10882466 TSecr=10882212 WS-512 76 S080-38703 [SVN, ACK] Seg-00 Ack=1 Winne2800 Lene MSS-1406 SACK PERM=1 TSVal=10882466 TSecr=10882212 WS-512
159 20.644101801 1 161 29.644110901 1 162 20.644112001 1 163 20.648956001 1 164 20.648978001 1 165 21.609710001 1 166 21.601333001 1 167 21.601424001 1 169 21.646938001 1 179 21.646932001 1 171 21.646373001 1 172 21.646373001 1	10.0.0.4 10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.3 10.0.0.5 10.0.0.4 10.0.0.3 10.0.0.4	19. 9. 9. 4 19. 9. 9. 5 18. 9. 9. 2 127. 9. 9. 1 127. 9. 9. 1 127. 9. 9. 1 127. 9. 9. 1 127. 9. 9. 1 10. 9. 9. 4 10. 9. 9. 4 10. 9. 9. 5 10. 9. 9. 3 10. 9. 9. 3 10. 9. 9. 3	TCP TCP OpenFlow TCP	56 8008-3911 [RST] Seq=731 Winse Lene 180 Type: 0FPT FLOW MOD 68 47631-6633 [ACK] Seq=301 Ack=748 Winse4 Lene 180 Type: 0FPT FLOW MOD 68 47431-6633 [ACK] Seq=301 Ack=748 Winse4 Lene 68 47431-6633 [ACK] Seq=301 Ack=748 Winse4 Lene 68 27431-6633 [ACK] Seq=311 Ack=212 Winse6 Lene243 TSys12-10802245 TSecr=1080126 88 20129-41906 [PSH, ACK] Seq=213 Ack=212 Winse6 Lene243 TSys12-10802455 TSecr=10802454 68 41906-20129 [ACK] Seq=2674 Ack=338 Winse6 Lene0 TSys12-10802455 TSecr=10802454 70 [TCP Retransmission] 58703-3000 [STW] Seq=0 Winse2900 Lene0 Winse1400 SACK, PERM-1 TSys12-10802466 TSecr=0 WS-512 76 [TCP Retransmission] 58703-8000 [STW] Seq=0 Ack=1 Winse2900 Lene0 MSS=1460 SACK, PERM-1 TSys12-10802466 TSecr=0 WS-512 76 [TCP Retransmission] 58703-8000 [STW] Seq=0 Ack=1 Winse2900 Lene0 MSS=1460 SACK, PERM-1 TSys12-10802466 TSecr=10802212 WS-512 76 [000-08703 [STW] ACK] Seq=0 Ack=1 Winse2800 Lene0 MSS=1460 SACK PERM-1 TSys12-10802466 TSecr=10802212 WS-512
159 20.644101801 1 161 29.644110901 1 162 29.644112001 1 162 29.644112001 1 163 20.648056001 1 164 29.648078001 1 165 21.690710001 1 166 21.691383001 1 167 21.691424001 1 169 21.646938001 1 170 21.646144001 1 171 21.646322001 1 172 21.646373001 1 173 21.646334001 1 173 21.646334001 1	10.0.0.4 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 127.0.0.1 10.0.0.3 10.0.0.5 10.0.0.4 10.0.0.5 10.0.0.3 10.0.0.3	10. 9. 0. 4 10. 9. 0. 5 10. 0. 0. 2 127. 0. 0. 1 127. 0. 0. 1 10. 0. 0. 4 10. 0. 0. 5 10. 0. 0. 3 10. 0. 0. 4 10. 0. 0. 4	TCP TCP OpenFlow TCP	56 8008-3911 [RST] Seg-731 Winse Lene 180 Type: 0FFF FLOW MOD 68 47431-6931 [RST] Seg-731 Winse Lene 180 Type: 0FFF FLOW MOD 68 47431-6933 [ACK] Seg-301 Ack=745 Winse Lene 181 Type: 0FFF FLOW MOD 68 47431-6933 [ACK] Seg-301 Ack=745 Winse Lene 68 47431-6933 [ACK] Seg-301 Ack=745 Winse Lene 68 27012-41906 [PSH, ACK] Seg-231 Ack=212 Minse Lene 68 27012-41906 [PSH, ACK] Seg-231 Ack=212 Minse Lene 68 27012-41906 [PSH, ACK] Seg-231 Ack=213 Minse Lene 68 27012-41906 [PSH, ACK] Seg-2674 Ack=133 Minse Lene 68 1906-620129 [ACK] Seg-2674 Ack=133 Minse Lene 68 1906-620129 [ACK] Seg-2674 Ack=133 Minse Lene 68 1908-620129 [ACK] Seg-2674 Ack=133 Minse Lene 68 1908-620129 [ACK] Seg-2674 Ack=133 Minse Lene 68 1908-8909 SACK, PERM=1 Taval=10882465 TSecr=0 WS-512 76 [TCP Retransmission] S0703-8000 [STM], ACK] Seg-8 Ack=1 Winse 2500 Lene 68 1908-8909 [STM, ACK] Seg-8 Ack=1 Winse 2500 Lene 68 1908-8909 [STM], ACK] Seg-8 Ack=1 Winse 2500 Lene 68 1908-8909 [STM], ACK] Seg-8 Ack=1 Winse 2500 Lene 68 1908-8900 [ACK] Seg-1

```
"Node: h4"

root@sdnhubvm: "/pox[17:22] (betta)$ python -m SimpleHTTPServer

Serving HTTP on 0.0.0.0 port 8000 ...

10.0.0.5 - - [05/Nov/2022 17:31:05] "GET / HTTP/1.1" 200 -

10.0.0.5 - - [05/Nov/2022 17:31:13] "GET / HTTP/1.1" 200 -

10.0.0.5 - - [05/Nov/2022 17:31:20] "GET / HTTP/1.1" 200 -
```