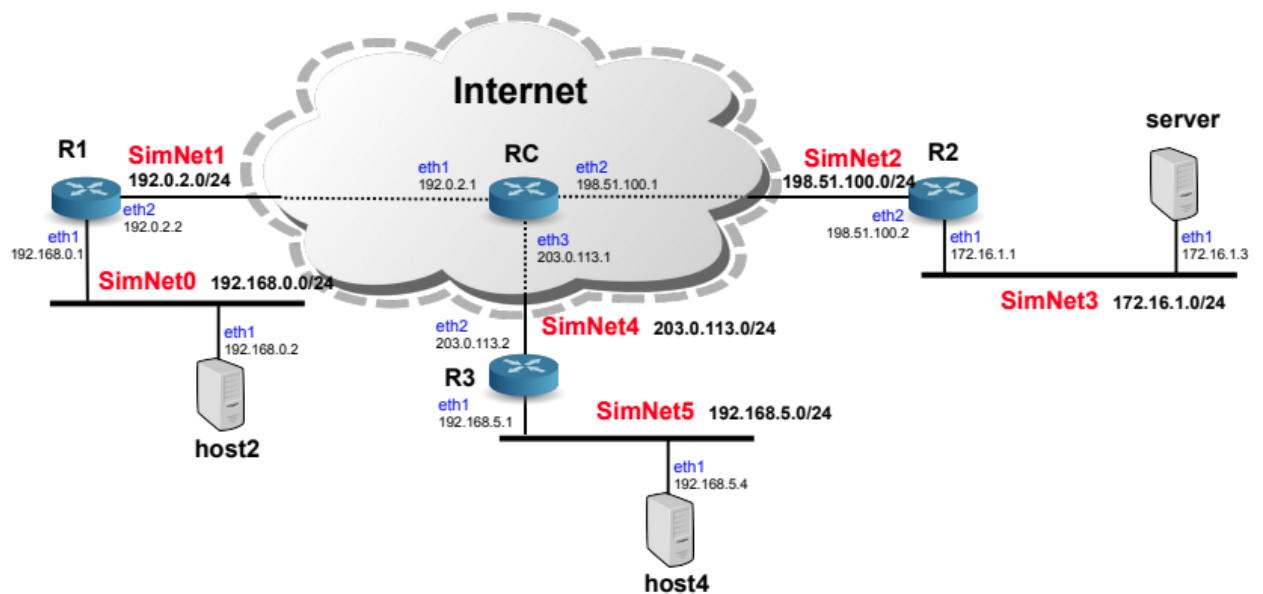


P10: Multicast



0.3 Starting the scenario using simctl

```
//from terminal  
simctl ipmulticast sh  
start
```

```
//from terminal  
host all-systems.mcast.net  
estamos preguntando al DNS la dirección que corresponde al nombre all-system.mcast.net.
```

```
host 224.0.0.22  
esta dirección concuerda con el nombre igmp.mcast.net que será usado para identificar router  
cuando se use IGMP.
```

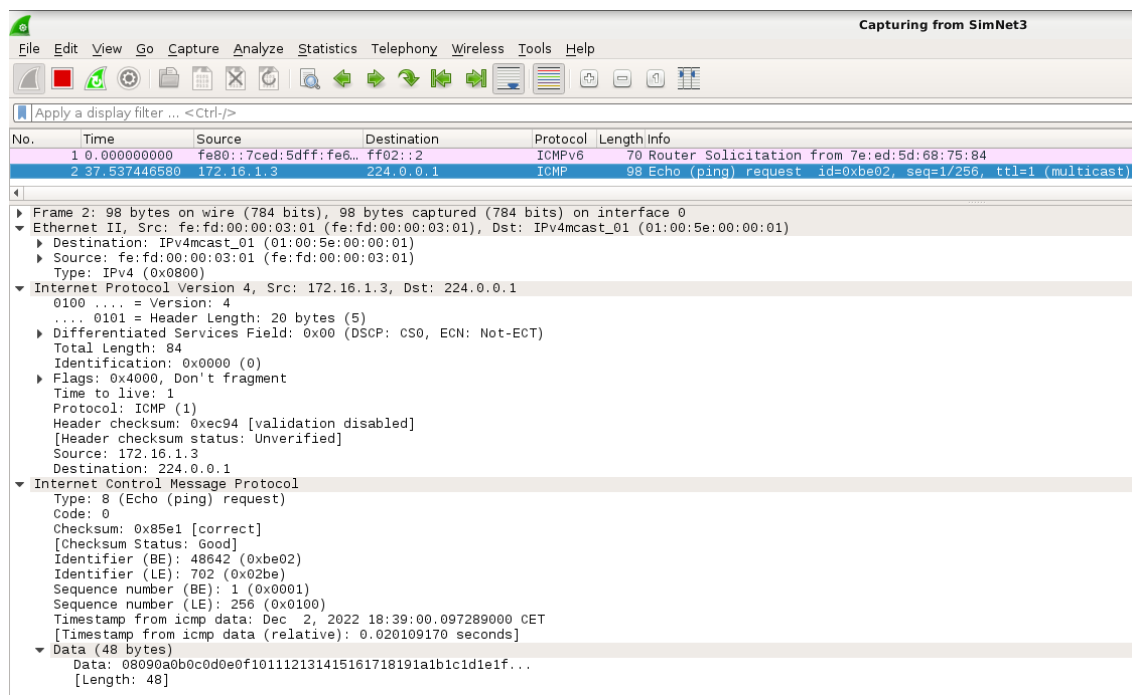
```
telem@debian:~$ host all-systems.mcast.net  
all-systems.mcast.net has address 224.0.0.1  
telem@debian:~$ host 224.0.0.22  
22.0.0.224.in-addr.arpa domain name pointer igmp.mcast.net.
```

0.5 MAC multicast addresses

//from server

ping -c1 224.0.0.1

```
server:~# ping -c1 224.0.0.1
PING 224.0.0.1 (224.0.0.1) 56(84) bytes of data.
--- 224.0.0.1 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms
```



1. How many ICMP packets can you see in SimNet3? What type of messages?

Un echo request multicast.

2. In the IP header, which is the TTL of this packets? What does this mean?

ttl=1, solo llega hasta R2 y ahí se pierde.

3. In the IP header, which are the source and destination addresses?

ip.src == 172.16.1.3, ip.dst == 224.0.0.1 (de server al multicast).

4. In the Ethernet header, which are the source and destination addresses?

eth.src == fe:fd:00:00:03:01, eth.dst == 01:00:5e:00:00:01.

5. Can you see the direct mapping in the MAC destination address?

Si porque direct mapping es dado la ip obtengo la dirección mac.

Entonces veo que el MAC se obtiene con la ip.

As you can see, the destination MAC address is constructed by using the prefix 01:00:5E (in hex). The 24 remaining bits correspond to 0+23 least significant bits of the multicast IP

address. In the particular case of the IP address 224.0.0.1, this corresponds to the MAC address 01:00:5E:00:00:01.

Put a wireshark listening in SimNet3.

- Execute the following command in the server:

//from server

ping -c1 232.0.0.1

1. In this ICMP packet, which is the destination MAC addresses?

eth.dst == 01:00:5e:00:00:01

2. Can you see any ambiguity in this mapping? Which other addresses cause also this ambiguity?

eth.dst == 01:00:5e:00:00:01. tienen la misma mac que el apartado anterior.

3. How can the system resolve this ambiguity?

Se resuelve porque la ip son distintas, da igual que sea la misma mac.

ip.dst == 232.0.0.1.

- Put a wireshark listening in SimNet3.

- Execute the following commands in the server:

//from server

echo 0 > /proc/sys/net/ipv4/icmp_echo_ignore_broadcasts

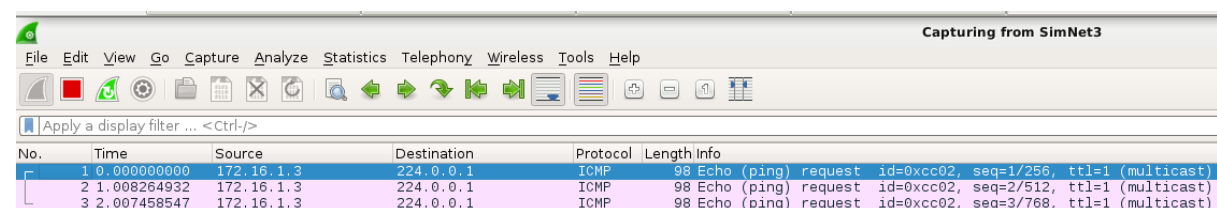
si esto esta en 1 no recibes el ping replay

desactivar el flag del icmp_echo_ignore_broadcasts

ping -c3 224.0.0.1

```
server:~# ping -c3 224.0.0.1
PING 224.0.0.1 (224.0.0.1) 56(84) bytes of data.
64 bytes from 172.16.1.3: icmp_seq=1 ttl=64 time=0.102 ms
64 bytes from 172.16.1.3: icmp_seq=2 ttl=64 time=0.062 ms
64 bytes from 172.16.1.3: icmp_seq=3 ttl=64 time=0.064 ms

--- 224.0.0.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2008ms
rtt min/avg/max/mdev = 0.062/0.076/0.102/0.018 ms
```



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.1.3	224.0.0.1	ICMP	98	Echo (ping) request id=0xcc02, seq=1/256, ttl=1 (multicast)
2	1.008264932	172.16.1.3	224.0.0.1	ICMP	98	Echo (ping) request id=0xcc02, seq=2/512, ttl=1 (multicast)
3	2.007458547	172.16.1.3	224.0.0.1	ICMP	98	Echo (ping) request id=0xcc02, seq=3/768, ttl=1 (multicast)

Is the ping working? Who is answering the ping?

Sí, porque te estás haciendo un ping a ti mismo. (loopback)

Can you see any reply message in SimNet3?

No

•Now dissable the same flag in R2, and ping from server:

//from R2

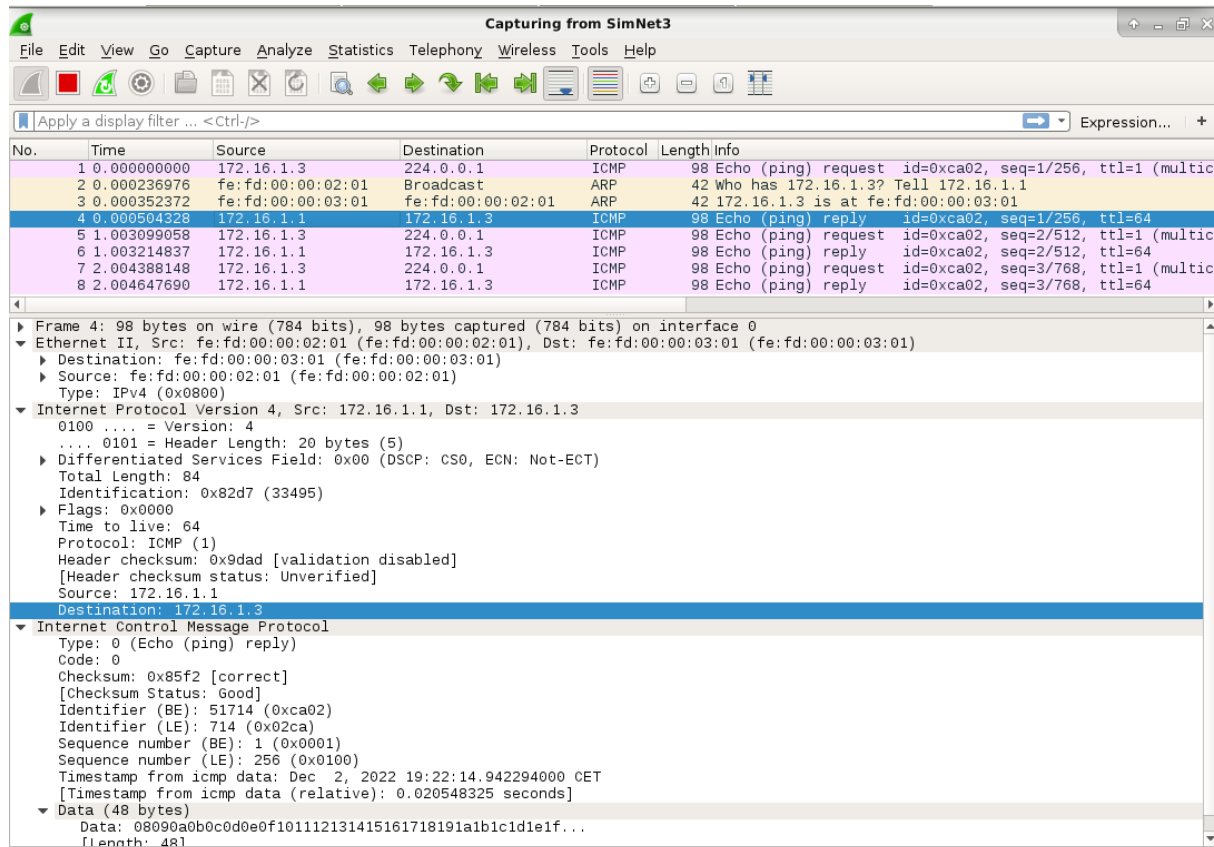
echo 0 > /proc/sys/net/ipv4/icmp_echo_ignore_broadcasts

//from server

ping -c3 224.0.0.1

```
server:~# ping -c3 224.0.0.1
PING 224.0.0.1 (224.0.0.1) 56(84) bytes of data.
64 bytes from 172.16.1.3: icmp_seq=1 ttl=64 time=0.052 ms
64 bytes from 172.16.1.1: icmp_seq=1 ttl=64 time=0.663 ms (DUP!)
64 bytes from 172.16.1.3: icmp_seq=2 ttl=64 time=0.064 ms
64 bytes from 172.16.1.1: icmp_seq=2 ttl=64 time=0.354 ms (DUP!)
64 bytes from 172.16.1.3: icmp_seq=3 ttl=64 time=0.075 ms

--- 224.0.0.1 ping statistics ---
3 packets transmitted, 3 received, +2 duplicates, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 0.052/0.241/0.663/0.239 ms
```



1. Who is now answering to the ping?

fe:fd:00:00:02:01, ip.src == 172.16.1.1, (eth1 de R2).

2. Can you see any reply message in SimNet3? 3. Are the answer packets sent in a multicast way?

Hay 3 respuestas, una por cada echo request. Estos echo request están enviados de forma unicast al origen.

0.6 Multicast transmission in a subnet

0.6.1 Multicast configuration

//from server

cat /proc/net/igmp #fichero que contiene los grupos en la cual el host se ha unido.

netstat -gn

```
server:~# cat /proc/net/igmp
Idx   Device   : Count Querier      Group    Users Timer      Reporter
1     lo       :    1    V3          010000E0  1 0:00000000          0
5     eth1     :    1    V3          010000E0  1 0:00000000          0
```

Esta configuracion, nos dice que las interfaces lo y eth1 estan unidos en 010000E0 (1.0.0.224 en hexadecimal).

```
server:~# cat /proc/net/ip_mr_vif
Interface    BytesIn PktsIn BytesOut PktsOut Flags Local  Remote
server:~# cat /proc/net/ip_mr_cache
Group  Origin  Iif    Pkts    Bytes    Wrong  Oifs
```

```
server:~# netstat -gn
IPv6/IPv4 Group Memberships
Interface    RefCnt Group
-----
lo           1      224.0.0.1
eth1         1      224.0.0.1
lo           1      ff02::1
tunl0        1      ff02::1
gre0         1      ff02::1
sit0         1      ff02::1
eth1         1      ff02::1:ff00:301
eth1         1      ff02::1
```

/proc/net/ip_mr_vif : este fichero nos muestra las interfaces involucradas en la operacion multicast en el router multicast . Al principio esta vacio porque la informacion solo se ve cuando hay intercambio de tramas multicast.

/proc/net/ip_mr_cache: este fichero muestra el contenido de la cache de multicast Forwarding. Para ello usamos el comando siguiente:

ip mroute show

0.6.2 Transport protocol

TCP no soporta multicast, porque multicast no es un mecanismo orientado a conexión. Multicast se usa básicamente para audio, video streaming entre otros. Por eso las **IP multicast utilizan UDP** como protocolo de la capa de transporte.

So, which is the transport protocol to send information when using multicast?

UDP no es un protocolo fiable, hay perdidas ... pero no supone un problema porque no hay control de error. En cambio TCP es problemático para multicast porque está orientado a conexión y si que tiene el control de errores y es un protocolo fiable.

0.6.3 udp-sender

udp-sender ofrece varias opciones para enviar vía broadcast o multicast, tanto unidireccional como bidireccional.

multicast group to send data: 232.43.211.234

multicast group to control and add reliability: 225.1.2.3

- Open another console of server, that will be used to see the status of this host meanwhile you are sending the video. Go to the HOST machine and execute:

//from terminal

simctl ipmulticast get server 1

//from server 1

cat /proc/net/igmp

```
server:~# cat /proc/net/igmp
Idx  Device  : Count Querier      Group    Users Timer    Reporter
1    lo      :    1   V3          010000E0  1 0:00000000  0
5    eth1    :    1   V3          010000E0  1 0:00000000  0
```

Esta configuración, nos dice que las interfaces lo y eth1 están unidos en 010000E0 (1.0.0.224 en hexadecimal).

Put a Wireshark listening in SimNet3.

- In this case, server will act as video server. So, go to console 0 and execute the following command:

//from server 0

udp-sender --file=./big_664.mpg --min-clients 1 --portbase 22345

--nopointopoint --interface eth1 --ttl 1 --mcast-addr 232.43.211.234

--mcast-all-addr 225.1.2.3

(hay q dar 2 veces al enter)

- **file:** Lee la información a transmitir desde el file./ la ruta relativa del fichero.
- **min-clients:** se inicia automáticamente tan pronto como se haya conectado un número mínimo de clientes.
- **portbase:** puerto para UDP multicast. Default:9000.(tiene que ser igual en sender y receiver)
- **pointopoint:** está permitido más de un receptor, aunque haya solo 1 receptor, la recepción punto a punto (unicast) no está permitida.

- **mcast-all-addr:** utiliza una dirección de multidifusión no estándar para la conexión de control (que utilizan el remitente y los receptores para "encontrarse" entre sí). Esta **no** es la dirección que se utiliza para transferir los datos.
- **mcast-addr:** utiliza la dirección dada para la multidifusión de datos. Si no se especifica, el programa derivará automáticamente una dirección de multidifusión de su propia IP (manteniendo los últimos 27 bits de la IP y luego agregando 232)

The previous command prepares server to transmit via multicast the locally stored video file big_664.mpg. Have a look to the manual of this command (man udp-sender) and explain each of the options used.

Capturing from SimNet3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.1.3	225.1.2.3	UDP	70	22346 → 22345 Len=28
2	0.010607810	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources
3	0.410448692	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources

Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
 Ethernet II, Src: fe:fd:00:00:03:01 (fe:fd:00:00:03:01), Dst: IPv4mcast-01:02:03 (01:00:5e:01:02:03)
 Internet Protocol Version 4, Src: 172.16.1.3, Dst: 225.1.2.3
 ... 0101 = Version: 4
 ... 0101 = Header Length: 20 bytes (5)
 Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 56
 Identification: 0x0000 (0)
 Flags: 0x4000, Don't fragment
 Time to live: 1
 Protocol: UDP (17)
 Header checksum: 0xe99d [validation disabled]
 [Header checksum status: Unverified]
 Source: 172.16.1.3
 Destination: 225.1.2.3
 User Datagram Protocol, Src Port: 22346, Dst Port: 22345
 Source Port: 22346
 Destination Port: 22345
 Length: 36
 Checksum: 0xf538 [unverified]
 [Checksum status: Unverified]
 Stream index: 0
 Data (28 bytes)
 Data: 05000000000001e82bd3ea68f1040880851740881b0508...
 [Length: 28]

Capturing from SimNet3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.1.3	225.1.2.3	UDP	70	22346 → 22345 Len=28
2	0.010607810	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources
3	0.410448692	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources
4	136.702165168	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
5	136.702228951	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
6	136.702265358	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
7	136.702299574	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
8	136.702332097	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
9	136.702365959	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
10	136.702398913	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
11	136.702431025	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
12	136.702463603	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
13	136.702495573	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
14	136.702528469	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
15	136.702561740	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
16	136.702593707	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
17	136.702627978	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
18	136.702715449	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
19	136.702747588	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
20	136.702779782	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
21	136.702811864	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
22	136.702843857	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
23	136.702876308	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
24	136.702908455	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
25	136.702940600	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
26	136.702973180	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
27	136.703005257	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
28	136.703037356	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
29	136.703069842	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
30	136.703101944	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
31	136.703133945	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
32	136.703166167	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
33	136.703198245	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
34	136.703230435	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
35	136.703262880	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
36	136.703295453	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
37	136.703328379	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
38	136.703378395	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
39	136.703412118	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
40	136.703451145	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
41	136.703485645	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
42	136.703519002	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472
43	136.703552497	172.16.1.3	232.43.211.234	UDP	1514	22346 → 22345 Len=1472

In SimNet3:

1. How many packets can you see? Which type of packets?

Hay como 130 paquetes UDP

2. In the UDP packet, which is the destination address? and the TTL?

La dirección destino es con TTL=1. ip.src == 172.16.1.3, ip.dst == 225.1.2.3

3. Which are the port numbers?

udp.srcport == 22346, udp.dstport == 22345

4. Can you see any IGMP packet? Which type of packet? Which is the IP destination address of this IGMP messages?

Si, 2(por redundancia) de tipo Membership Report/ join group(0x22). ip.dst == 224.0.0.22

Now have a look to the console 1 of server, and again see the contents of the file

//from serve 1

/proc/net/igmp.

```
server:~# cat /proc/net/igmp
Idx  Device  : Count Querier      Group    Users Timer    Reporter
1    lo      :    1    V3          010000E0  1 0:00000000  0
5    eth1    :    2    V3          030201E1  1 0:00000000  0
          010000E0  1 0:00000000  0
```

1. Can you see any difference?

Respecto al ejercicio anterior, vemos que eth1 tiene ahora otra entrada para otro grupo.

2. What is the hex and the dot-decimal notation of the newly added multicast group?

030201E1, 0:00000000

• Go to console 0, and close the server by typing Control+C.

138	12621.510866...	172.16.1.3	224.0.0.22	IGMPv3	54 Membership Report / Leave group	225.1.2.3
139	12629.340613...	172.16.1.3	224.0.0.22	IGMPv3	54 Membership Report / Leave group	225.1.2.3

1. Can you see in SimNet3 any new IGMP message? Which type?

Si, IGMP de tipo, Membership Report/Leave group.

2. After closing, can you see again any change in the /proc/net/igmp file? As you can see, when closing udp-sender the sender leaves the control group by sending two IGMP Leave Messages. No answer will be sent to these messages as there is no multicast router.

```
server:~# cat /proc/net/igmp
Idx  Device  : Count Querier      Group    Users Timer    Reporter
1    lo      :    1    V3          010000E0  1 0:00000000  0
5    eth1    :    1    V3          010000E0  1 0:00000000  0
server:~#
```

Ahora el entry que se añadió antes al iniciar la transferencia ya no esta.

0.6.4 upd-receiver

Let us start testing upd-receiver:

- Open another console of R2, that will be used to see the status of this host meanwhile you are launching upd-receiver. Go to the HOST machine and execute:

1. Which interfaces in R2 are joined to group 224.0.0.1?

//from server R2

cat /proc/net/igmp

```
R2:~# cat /proc/net/igmp
Idx   Device   : Count Querier      Group      Users Timer      Reporter
1     lo       :      1      V3          010000E0    1 0:00000000    0
5     eth2     :      1      V3          010000E0    1 0:00000000    0
6     eth1     :      1      V3          010000E0    1 0:00000000    0
```

- Now open two wiresharks, one listening in SimNet2 and another one in SimNet3.
- In this case, R2 will act as a host, receiving the video. So, go to console 0 and execute the following command:

//from R2 0

udp-receiver --file=big_664.mpg --mcast-all-addr 225.1.2.3 --ttl 1 --portbase 22345

(el receptor no tiene que especificar por donde lo recibe?)

The top screenshot shows a Wireshark capture from SimNet2. The packet list contains four packets:

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	198.51.100.2	225.1.2.3	UDP	54	22345 → 22346 Len=12
2	0.000831431	198.51.100.2	225.1.2.3	UDP	54	22345 → 22346 Len=12
3	0.011255738	198.51.100.2	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources
4	0.094144783	198.51.100.2	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources

The packet details pane for the first packet shows:

- Ethernet II, Src: fe:fd:00:00:02:02 (fe:fd:00:00:02:02), Dst: IPv4mcast_01:02:03 (01:00:5e:01:02:03)
- Internet Protocol Version 4, Src: 198.51.100.2, Dst: 225.1.2.3
- User Datagram Protocol, Src Port: 22345, Dst Port: 22346

The bottom screenshot shows a Wireshark capture from SimNet3 with an empty packet list.

1. How many packets can you see in SimNet3? and in SimNet2?

SimNet2: 2 paquetes udp i 2 IGMPv3. SimNet3 no vemos nada.

2. Why do you think that these packets are in this network and not in the other?

No vemos nada en la SimNet3 porque R2 no hemos configurado para el multicast??

Later you will change this to make multicast packets to go through SimNet3, but now let us have a look to packets in SimNet2 using wireshark.

1. In the UDP packets, which is the destination address? and the TTL?

ip.src == 198.51.100.2, ip.dst == 225.1.2.3, ip.ttl == 1

2. Which are the port numbers? Are these numbers familiar to you?

udp.src.port == 22345, udp.dst.port == 22346 (son las mismas que el ejercicio anterior)

3. Can you see any IGMP packet?

Si vemos 2, de Membership report/ Join group

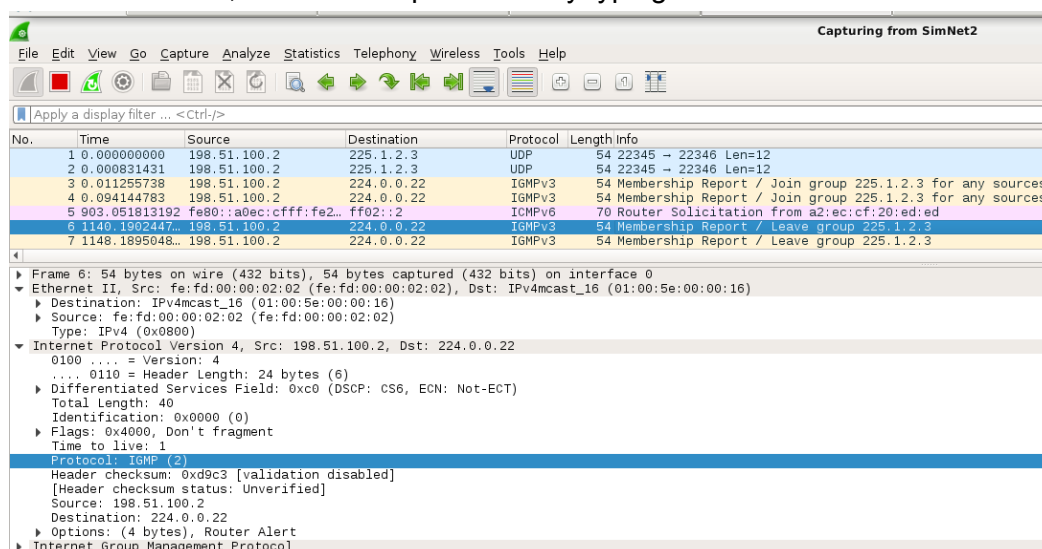
• Now have a look to the console 1 of R2, and again see the contents of the file **/proc/net/igmp**.

```
R2:~# cat /proc/net/igmp
Idx  Device   : Count Querier      Group    Users Timer   Reporter
1    lo      :    1      V3          010000E0  1 0:00000000  0
5    eth2    :    2      V3          030201E1  1 0:00000000  0
        010000E0  1 0:00000000  0
6    eth1    :    1      V3          010000E0  1 0:00000000  0
```

1. Can you see any difference?

Vemos que en la interfaz eth2 se ha añadido un nuevo grupo.

• Go to console 0, and close udp-receiver by typing Control+C.



1. Can you see in SimNet2 any new IGMP message? Which type?

2 IGMP Report message de tipo Leave.

2. After closing, can you see again any change in the **/proc/net/igmp** file?

la Eth2 vuelve a tener solo un grupo. Al terminar la transferencia se elimina el grupo.

0.6.5 Sending the video file in the subnet

- Put a wireshark listening in SimNet3.

Go to console 0 of server and execute again the following command:

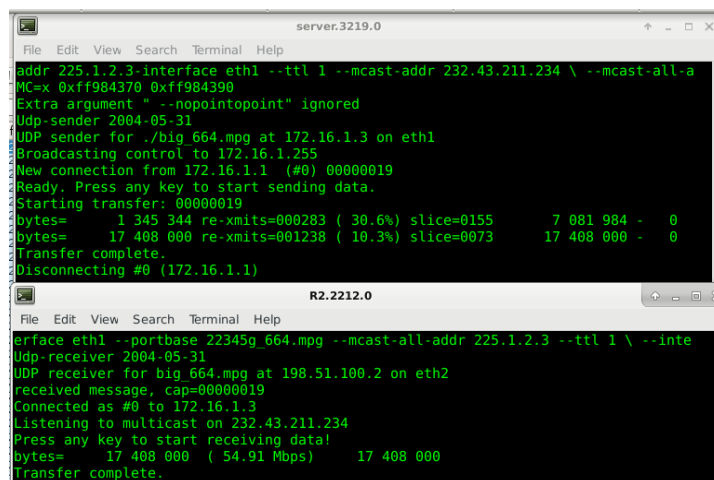
//from server 0

```
udp-sender --file=./big_664.mpg --min-clients 1 --portbase 22345 --nopointopoint
--interface eth1 --ttl 1 --mcast-addr 232.43.211.234 --mcast-all-addr 225.1.2.3
```

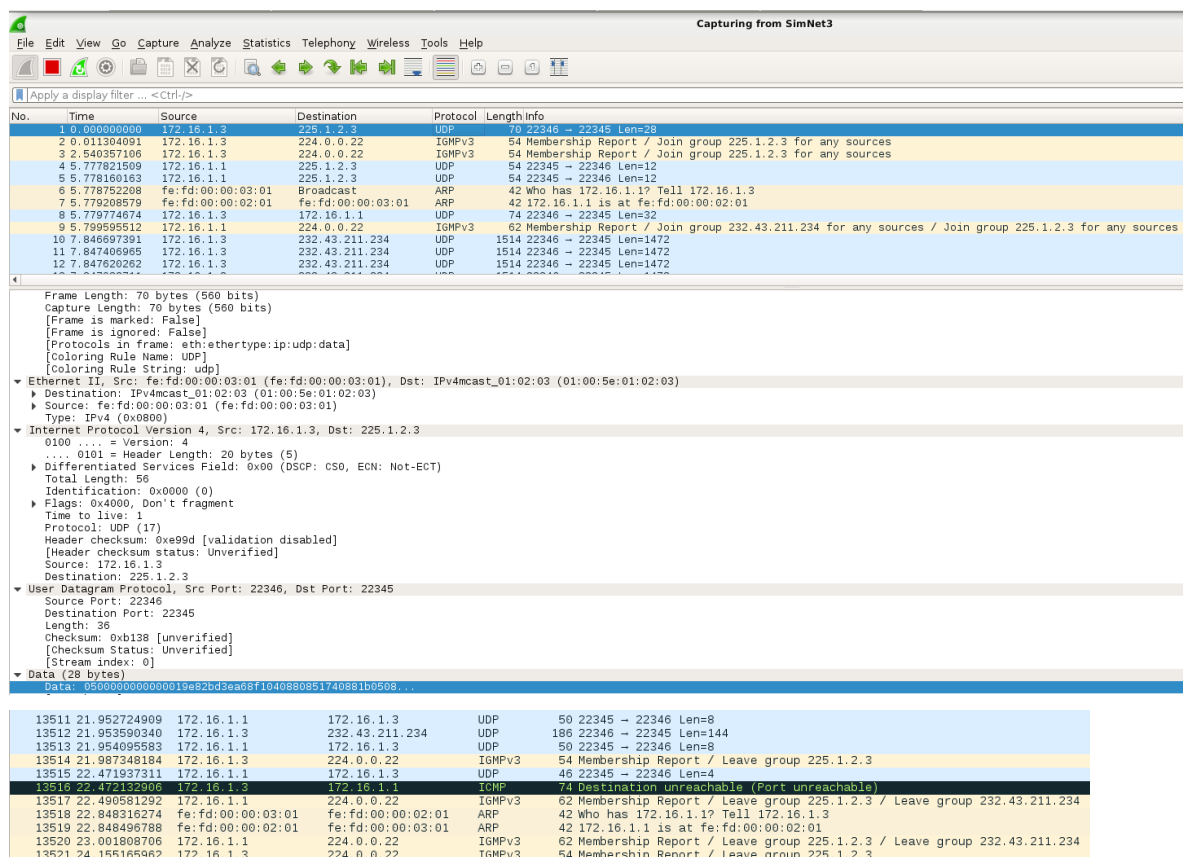
- Go to console 0 of R2 and execute the following command, now forcing the packets to be sent to the proper interface:

//from R2 0

```
udp-receiver --file=big_664.mpg --mcast-all-addr 225.1.2.3 --ttl 1 --interface eth1
--portbase 22345
```



The image shows two terminal windows. The top window, titled 'server.3219.0', displays the output of the 'udp-sender' command. It shows the command being executed, the file path, and the network parameters. The output indicates that the sender is ready and has started sending data. The bottom window, titled 'R2.2212.0', displays the output of the 'udp-receiver' command. It shows the command being executed, the file path, and the network parameters. The output indicates that the receiver is ready and has started receiving data.



The image shows a Wireshark packet capture from SimNet3. The top part of the window shows the packet list with columns for No., Time, Source, Destination, Protocol, and Length. The bottom part shows the packet details for the selected packet (No. 13511). The packet details show the Ethernet II header, Internet Protocol Version 4 header, and User Datagram Protocol header. The packet is a UDP packet from 172.16.1.3 to 225.1.2.3, port 22345. The packet length is 70 bytes (560 bits).

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	172.16.1.3	225.1.2.3	UDP	70	22345 → 22345 Len=28
2	0.011304091	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources
3	2.540357106	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Join group 225.1.2.3 for any sources
4	5.777821509	172.16.1.1	225.1.2.3	UDP	54	22345 → 22345 Len=12
5	5.778160163	172.16.1.1	225.1.2.3	UDP	54	22345 → 22345 Len=12
6	5.77852208	fe:fd:00:00:03:01	Broadcast	ARP	42	Who has 172.16.1.1? Tell 172.16.1.3
7	5.779208579	fe:fd:00:00:02:01	fe:fd:00:00:03:01	ARP	42	172.16.1.1 is at fe:fd:00:00:02:01
8	5.779774674	172.16.1.3	172.16.1.1	UDP	74	22345 → 22345 Len=32
9	5.780505512	172.16.1.1	224.0.0.22	IGMPv3	62	Membership Report / Join group 232.43.211.234 for any sources / Join group 225.1.2.3 for any sources
10	7.846697391	172.16.1.3	232.43.211.234	UDP	1514	22345 → 22345 Len=1472
11	7.847406905	172.16.1.3	232.43.211.234	UDP	1514	22345 → 22345 Len=1472
12	7.847620262	172.16.1.3	232.43.211.234	UDP	1514	22345 → 22345 Len=1472

Frame Length: 70 bytes (560 bits)
Capture Length: 70 bytes (560 bits)
[Frame is marked: False]
[Frame is ignored: False]
[Protocols in frame: eth:ethertype:ip:udp:data]
[Coloring Rule Name: UDP]
[Coloring Rule String: udp]
▼ Ethernet II, Src: fe:fd:00:00:03:01 (fe:fd:00:00:03:01), Dst: IPv4mcast_01:02:03 (01:00:5e:01:02:03)
► Destination: IPv4mcast_01:02:03 (01:00:5e:01:02:03)
► Source: fe:fd:00:00:03:01 (fe:fd:00:00:03:01)
Type: IPv4 (0x0800)
▼ Internet Protocol Version 4, Src: 172.16.1.3, Dst: 225.1.2.3
0100 = Version: 4
.... 0101 = Header Length: 20 bytes (5)
► Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 56
Identification: 0x0000 (0)
► Flags: 0x0000, Don't fragment
Time to live: 1
Protocol: UDP (17)
Header checksum: 0xe99d [validation disabled]
[Header checksum status: Unverified]
Source: 172.16.1.3
Destination: 225.1.2.3
▼ User Datagram Protocol, Src Port: 22346, Dst Port: 22345
Source Port: 22346
Destination Port: 22345
Length: 36
Checksum: 0xb138 [unverified]
[Checksum status: Unverified]
[Stream index: 0]
▼ Data (28 bytes)
Data: 050000000000000019e82bd3ea68f1040880851740881b6508...

No.	Time	Source	Destination	Protocol	Length	Info
13511	21.952724909	172.16.1.1	172.16.1.3	UDP	50	22345 → 22346 Len=8
13512	21.953590340	172.16.1.3	232.43.211.234	UDP	186	22346 → 22345 Len=144
13513	21.954095583	172.16.1.1	172.16.1.3	UDP	50	22345 → 22346 Len=8
13514	21.987348184	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Leave group 225.1.2.3
13515	22.497372111	172.16.1.1	172.16.1.3	UDP	46	22345 → 22346 Len=4
13516	22.472132906	172.16.1.3	172.16.1.1	ICMP	74	Destination unreachable (Port unreachable)
13517	22.490581292	172.16.1.1	224.0.0.22	IGMPv3	62	Membership Report / Leave group 225.1.2.3 / Leave group 232.43.211.234
13518	22.848316274	fe:fd:00:00:03:01	fe:fd:00:00:02:01	ARP	42	Who has 172.16.1.1? Tell 172.16.1.3
13519	22.848496788	fe:fd:00:00:02:01	fe:fd:00:00:03:01	ARP	42	172.16.1.1 is at fe:fd:00:00:02:01
13520	23.001808706	172.16.1.1	224.0.0.22	IGMPv3	62	Membership Report / Leave group 225.1.2.3 / Leave group 232.43.211.234
13521	24.155165962	172.16.1.3	224.0.0.22	IGMPv3	54	Membership Report / Leave group 225.1.2.3

1. Was the transmission ok?

Si,

2. How many packets can you see in wireshark?

13521.

• Let us start analyzing the four initial UDP packets of short-length.

1. What do you think is the purpose of these initial packets?

las primeras son para que el emisor y el receptor se identifiquen mutuamente.

2. In the first UDP packet sent by server, which is the IP destination address?

ip.src == 172.16.1.3(server), ip.dst == 255.1.2.3(multicast)

3. Do you recognize anything inside of the DATA field of this packet? Try to convert 232.43.211.234 in hex.

232.43.211.234(dec)=> e8.2b.d3.ea(hex).

data.data==05:00:00:00:00:00:00:19:e8:2b:d3:ea:68:f1:04:08:80:85:17:40:88:1b:05:08:05:b0:4a:ff

El campo de datos contiene la ip.

4. At the time this first packet was sent by the server, was R2 listening at the control multicast address?

No, escucha despues de que se haya establecido la conexion.

5. What do you think is the purpose of the second and third UDP packets (the ones sent by R2)?

Para conectar con el sever.

6. At this time, does R2 know which is the data multicast group that server is going to use to send the video?

No, antes de enviar no sabe solo sabe la ip del multicast de control (225.1.2.3). La ip multicast a la que se envian los datos es (232.43.211.234).

(pero deberia saberlo pq las primeras udp le han enviado la ip)

7. Have a look to the fourth UDP packet. Is it a multicast or unicast packet? What is the purpose of this message? Do you recognize anything in the data field of the packet?

Es un paquete unicast enviado des del server a R2 para decirle la ip multicast a la que se enviara los datos.232.43.211.234(dec)=> e8.2b.d3.ea(hex).

(es lo mismo que el 1er paquete, pero ahora destino no es multicast sino R2)

• Regarding the transmission of the video (look at packets that are full of information):

1. Which is the destination IP address of these packets?

232.43.211.234

2. What is the size of most of this data packets?

1514

3. There are some unicast packets from R2 to server. What do you think is the purpose of these feedback packets?

son de feedback (~acks).

0.7 Multicast and routing

In Fig 1 three multicast islands (SimNet0, SimNet3 and SimNet5), multicast routers (R1, R2 and R3), and a router without multicast capacities (RC).

haremos tunnel GRE entre **R1**↔**R2**, **R2**↔**R3**

0.7.1 Configuring GRE tunnels

- Configure the tunnel interface by means of the command `ip tunnel`. Tunnels have to work in gre mode.

- Send a ping from the server to host2.

//from terminal

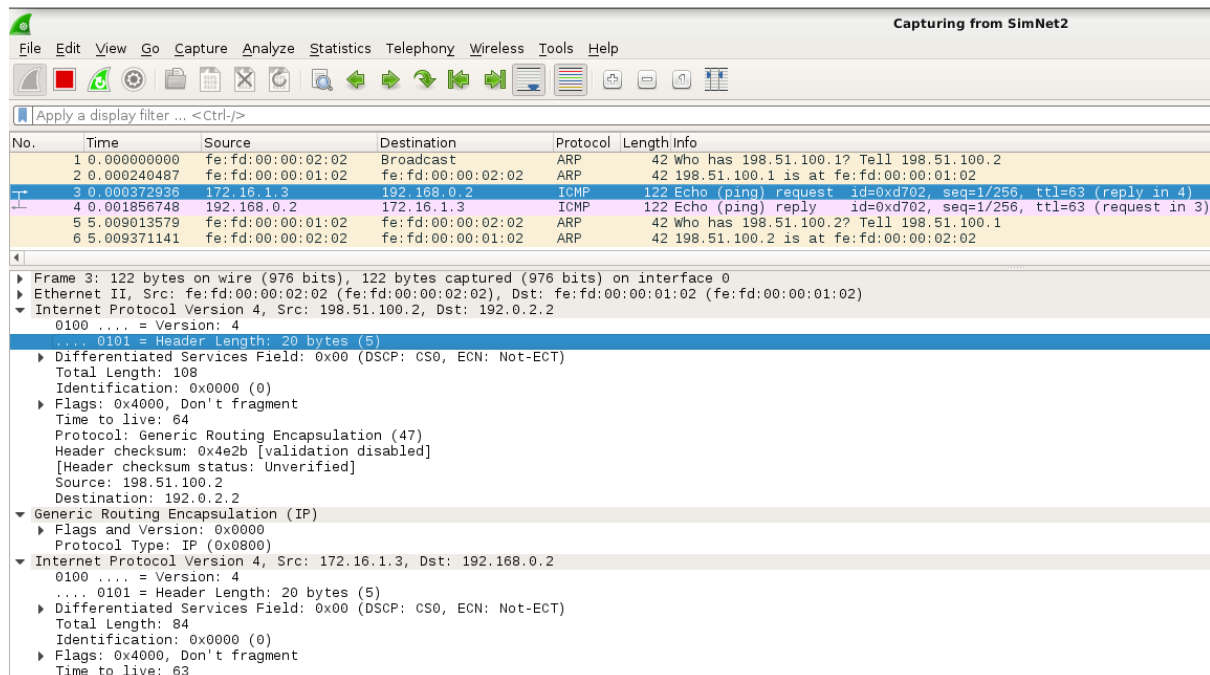
simctl ipmulticast exec addtun #para crear los 2 tunnels automaticamente

//from server

ping -c1 192.168.0.2

```
server:~# ping -c1 192.168.0.2
PING 192.168.0.2 (192.168.0.2) 56(84) bytes of data.
64 bytes from 192.168.0.2: icmp_seq=1 ttl=62 time=3.11 ms

--- 192.168.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 3.110/3.110/3.110/0.000 ms
```



The image shows a Wireshark packet capture titled "Capturing from SimNet2". The packet list shows six packets. Packet 3 is an ICMP Echo (ping) request from 172.16.1.3 to 192.168.0.2. Packet 4 is the corresponding ICMP Echo (ping) reply from 192.168.0.2 to 172.16.1.3. The packet details pane for packet 4 is expanded, showing the following structure:

- Frame 3: 122 bytes on wire (976 bits), 122 bytes captured (976 bits) on interface 0
- Ethernet II, Src: fe:fd:00:00:02:02 (fe:fd:00:00:02:02), Dst: fe:fd:00:00:01:02 (fe:fd:00:00:01:02)
- Internet Protocol Version 4, Src: 198.51.100.2, Dst: 192.0.2.2
 - 0100 = Version: 4
 - 0101 = Header Length: 20 bytes (5)
 - Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 - Total Length: 108
 - Identification: 0x0000 (0)
 - Flags: 0x4000, Don't fragment
 - Time to live: 64
 - Protocol: Generic Routing Encapsulation (47)
 - Header checksum: 0x4e2b [validation disabled]
 - [Header checksum status: Unverified]
 - Source: 198.51.100.2
 - Destination: 192.0.2.2
- Generic Routing Encapsulation (IP)
 - Flags and Version: 0x0000
 - Protocol Type: IP (0x0800)
- Internet Protocol Version 4, Src: 172.16.1.3, Dst: 192.168.0.2
 - 0100 = Version: 4
 - 0101 = Header Length: 20 bytes (5)
 - Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 - Total Length: 84
 - Identification: 0x0000 (0)
 - Flags: 0x4000, Don't fragment
 - Time to live: 63

1. Is the ping working?

SI

2. Can you see packets in the wireshark? What type of packets? Describe the headers you see.

2 paquetes ICMP, tenemos 3 cabeceras: 1 inner ip, 1 GRE y 1 outer ip.

3. Regarding the IP outer header, which are the source and destination addresses?

ip.src == 198.51.100.2(eth2 R2), ip.dst == 192.0.2.2 (eth2 R1), es del tunnel (R1-R2).

4. Which is the size of the GRE header?

**122(total)-20(outer h)-20(inner h)-14(ether h)-8(icmp)-8(timestamp)-48 (data)= 4 bytes.
cuando varia la cabecera??**

5. Which is the source and destination addresses in the inner header?

ip.src == 172.16.1.3(server), ip.dst == 192.168.0.2(host2).

- Send also a ping from the server to host4 to verify that tunnel1 works.

```
server:~# ping -c1 192.168.5.4
PING 192.168.5.4 (192.168.5.4) 56(84) bytes of data.
64 bytes from 192.168.5.4: icmp_seq=1 ttl=62 time=3.48 ms

--- 192.168.5.4 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 3.485/3.485/3.485/0.000 ms
```

0.7.2 Multicast and ICMP

ICMP no es solo para enviar pings, se utiliza tambien para el control de errores. Los mensajes tipicos son:

An ICMP error message (Destination Unreachable, Time Exceeded, Parameter Problem, Source Quench, or Redirect) is never generated in response to a datagram destined to an IP host group.

Pero con el trafico multicast no se utiliza mucho, porque no informa de errores en paquetes multicasts. No se recibe los Host unreachable, fragmentation needed....
Entonces hay que tener cuidado con el TTL, MTU.

0.7.3 Multicast static routing: smcroute

Have a look to the file /proc/net/ip_mr_vif in router R2. This file should be empty because the router has not yet taken any action.

- Open four wiresharks, listening from SimNet0 to SimNet3.
- Start the daemon smcroute in router R2.

See again the contents of /proc/net/ip_mr_vif. What changes do you see?

//from R2

cat /proc/net/ip_mr_vif

smcroute -d #empezar el daemon smcroute

cat /proc/net/ip_mr_vif

```

R2:~# cat /proc/net/ip_mr_vif
Interface      BytesIn  PktsIn  BytesOut PktsOut  Flags Local      Remote
R2:~# smcroute -d
R2:~# cat /proc/net/ip_mr_vif
Interface      BytesIn  PktsIn  BytesOut PktsOut  Flags Local      Remote
0 eth2          0        0         0         0  00000 026433C6 00000000
1 eth1          0        0         0         0  00000 010110AC 00000000
2 tunnel0       0        0         0         0  00000 016EA8C0 00000000
3 tunnel1       0        0         0         0  00000 026EA8C0 00000000

```

Smcroute= es un simple arbol multicast estatico para conectar SimNet3 y SimNet0.

Execute the following command in R2 to add a new multicast static route:

//from R2

smcroute -a eth1 0.0.0.0 232.43.211.234 tunnel0

#este commando encaminara los datagramas ip a traves de eth1 con cualquier direccion de origen y destino de la direccion del grupo multicast 232.43.211.234, es como dnst y snat (todo pasara por la eth2 del R2).

- Execute the following command to make R2 to join the entry interface eth1 to the multicast group 232.43.211.234:

//from R2

smcroute -j eth1 232.43.211.234 #to join group

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.1.1	224.0.0.22	IGMPv3	54	Membership Report / Join group 232.43.211.234 for any sources
2	9.816648679	172.16.1.1	224.0.0.22	IGMPv3	54	Membership Report / Join group 232.43.211.234 for any sources

```

R2:~# cat /proc/net/igmp
Idx  Device      : Count Querier      Group      Users Timer      Reporter
1    lo         :      1      V3          010000E0   1 0:00000000 0
5    eth2       :      1      V3          010000E0   1 0:00000000 0
6    eth1       :      2      V3          EAD32BE8   1 0:00000000 0
      :          :      1      V3          010000E0   1 0:00000000 0
7    tunnel0    :      1      V3          010000E0   1 0:00000000 0
8    tunnel1    :      1      V3          010000E0   1 0:00000000 0

```

1. View the content of the file /proc/net/igmp. What changes do you see in this file?

Vemos que los tunnels se han configurado correctamente. En eth1 se ha añadido un grupo grup (EAD32BE8 --> 234.211.43.232).

2. Have a look to SimNet3. Can you see any IGMP message in that interface?

Si, 2 de Membership Report de tipo Join group. 1 de cada tunnel.

- Now send a ping from server to the multicast group 232.43.211.234 with a scope of three hops.

//from server

ping -t3 -c1 232.43.211.234

```

server:~# ping -t3 -c1 232.43.211.234
PING 232.43.211.234 (232.43.211.234) 56(84) bytes of data.

--- 232.43.211.234 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms

```


Capturing from SimNet3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.1.3	232.43.211.234	ICMP	98	Echo (ping) request id=0xc802, seq=1/256, ttl=3 (multicast)
2	0.001153983	172.16.1.1	172.16.1.3	ICMP	98	Echo (ping) reply id=0xc802, seq=1/256, ttl=64
3	5.009979149	fe:fd:00:00:02:01	fe:fd:00:00:03:01	ARP	42	Who has 172.16.1.3? Tell 172.16.1.1
4	5.010336678	fe:fd:00:00:03:01	fe:fd:00:00:02:01	ARP	42	172.16.1.3 is at fe:fd:00:00:03:01

Capturing from SimNet2

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.1.3	232.43.211.234	ICMP	122	Echo (ping) request id=0xc802, seq=1/256, ttl=2 (multicast)
2	5.009286064	fe:fd:00:00:02:02	fe:fd:00:00:01:02	ARP	42	Who has 198.51.100.1? Tell 198.51.100.2
3	5.010019484	fe:fd:00:00:01:02	fe:fd:00:00:02:02	ARP	42	198.51.100.1 is at fe:fd:00:00:01:02
4	167.117168259	fe80::1489:a8ff:fea...	ff02::2	ICMPv6	70	Router Solicitation from 16:89:a8:ae:61:e9

Frame 1: 122 bytes on wire (976 bits), 122 bytes captured (976 bits) on interface 0
 Ethernet II, Src: fe:fd:00:00:02:02 (fe:fd:00:00:02:02), Dst: fe:fd:00:00:01:02 (fe:fd:00:00:01:02)
 Internet Protocol Version 4, Src: 198.51.100.2, Dst: 192.0.2.2
 0100 = Version: 4
 0101 = Header Length: 20 bytes (5)
 Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 108
 Identification: 0x0000 (0)
 Flags: 0x4000, Don't fragment
 Time to live: 64
 Protocol: Generic Routing Encapsulation (47)
 Header checksum: 0x4e2b [validation disabled]
 [Header checksum status: Unverified]
 Source: 198.51.100.2
 Destination: 192.0.2.2
 Generic Routing Encapsulation (IP)
 Flags and Version: 0x0000
 Protocol Type: IP (0x0800)
 Internet Protocol Version 4, Src: 172.16.1.3, Dst: 232.43.211.234
 Internet Control Message Protocol

Capturing from SimNet1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.1.3	232.43.211.234	ICMP	122	Echo (ping) request id=0xc802, seq=1/256, ttl=2 (multicast)
2	5.008915750	fe:fd:00:00:01:01	fe:fd:00:00:04:02	ARP	42	Who has 192.0.2.2? Tell 192.0.2.1
3	5.009214639	fe:fd:00:00:04:02	fe:fd:00:00:01:01	ARP	42	192.0.2.2 is at fe:fd:00:00:04:02
4	281.804882221	fe80::244f:fbff:fe1...	ff02::2	ICMPv6	70	Router Solicitation from 26:4f:fb:19:a6:90

Frame 1: 122 bytes on wire (976 bits), 122 bytes captured (976 bits) on interface 0
 Ethernet II, Src: fe:fd:00:00:01:01 (fe:fd:00:00:01:01), Dst: fe:fd:00:00:04:02 (fe:fd:00:00:04:02)
 Internet Protocol Version 4, Src: 198.51.100.2, Dst: 192.0.2.2
 0100 = Version: 4
 0101 = Header Length: 20 bytes (5)
 Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 108
 Identification: 0x0000 (0)
 Flags: 0x4000, Don't fragment
 Time to live: 63
 Protocol: Generic Routing Encapsulation (47)
 Header checksum: 0x4f2b [validation disabled]
 [Header checksum status: Unverified]
 Source: 198.51.100.2
 Destination: 192.0.2.2
 Generic Routing Encapsulation (IP)
 Flags and Version: 0x0000
 Protocol Type: IP (0x0800)
 Internet Protocol Version 4, Src: 172.16.1.3, Dst: 232.43.211.234
 Internet Control Message Protocol

1. Is the ping working? In which SimNets can you see ICMP packets?

Si. Se puede ver el paquete ICMP en SimNet 1,2 y 3.

2. Can you see any encapsulation in the ICMP packet in SimNet1 and SimNet2? What is the size of a GRE header?

Si, es el mismo caso del ejercicio anterior Ltotal=122 y datos 48 → GRE header= 4B.

3. Have a look again to file /proc/net/ip_mr_vif. Do you see any change in the statistics related to tunnel0?

```
R2:~# cat /proc/net/ip_mr_vif
Interface      BytesIn  PktsIn  BytesOut PktsOut  Flags  Local      Remote
0 eth2          0        0        0         0  00000  026433C6  00000000
1 eth1         336        4        0         0  00000  010110AC  00000000
2 tunnel0        0        0       336         4  00000  016EA8C0  00000000
3 tunnel1        0        0        0         0  00000  026EA8C0  00000000
```

Podemos ver los cambios en BytesIn y BytesOuts.

4. Execute ip mroute show to see the Multicast Forwarding Cache. What is the meaning of all these parameters?

//from R2

ip mroute show

```
R2:~# ip mroute show
(172.16.1.3, 232.43.211.234)    Iif: eth1    Oifs: tunnel0
```

podemos ver @ip del emisor y destino (mcast), la ruta configurada. Tambien las interface de entrada y salida.

5. Why do you think R1 is not forwarding the packet?

R1 no funciona porque no esta configurado como router multicast.

Using smcroute, configure R1 to route IP datagrams entering through the tunnel with any origin address and destination address the multicast group 232.43.211.234 towards eth1. To do so, just follow the same procedure that you used in R2.

//from R1

echo 0 > /proc/sys/net/ipv4/icmp_echo_ignore_broadcasts

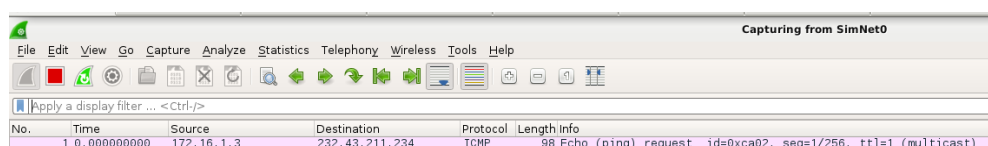
smcroute -d

smcroute -a tunnel0 0.0.0.0 232.43.211.234 eth1

smcroute -j tunnel0 232.43.211.234

//from server

ping -t3 -c1 232.43.211.234



En otras SimNets tenemos ping request y replay.

1. Can you see the packets in SimNet0? Which type of packets?

Si solo 1 echo request.

2. Can you see any ICMP Echo Reply? Why?

No porque nadie está escuchando al tráfico multicast. Pero el tunnel responde al ping. Por eso es exitoso.

3. Which is the TTL value of this packet in SimNet0?

TTL=1.

4. If you send the same ping from server but with TTL=2, would it work?

No, porque se pierde en RC.

0.7.4 Testing tools

ssmpping

Antes con el smcroute, hemos utilizado el ping, pero el ping no sirve para enviar informacion.

Ahora usaremos ssmpping, que permite verificar encaminamiento tanto unicast como multicast. Basicamente ssmpping permite verificar si el host puede recibir paquetes SSM(source Specific Multicast) des del otro host enviando paquetes UDP multicast y unicast.(TCP no soporta el trafico multicast)

//from server 0

ssmpping

//from host2 0

ssmpping 172.16.1.3

netstat -gn

```
server.28806.0
File Edit View Search Terminal Help
received request from 192.168.0.2
received request from 192.168.0.2
received request from 192.168.0.2
received request from 192.168.0.2
```

```
host2.30538.0
File Edit View Search Terminal Help
unicast from 172.16.1.3, seq=50 dist=2 time=2.103 ms
unicast from 172.16.1.3, seq=51 dist=2 time=2.047 ms
unicast from 172.16.1.3, seq=52 dist=2 time=2.168 ms
unicast from 172.16.1.3, seq=53 dist=2 time=1.886 ms
```

```
host2:~# netstat -gn
IPv6/IPv4 Group Memberships
Interface      RefCnt Group
-----
lo              1      224.0.0.1
eth1            1      232.43.211.234
eth1            1      224.0.0.1
lo              1      ff02::1
tunl0           1      ff02::1
gre0            1      ff02::1
sit0            1      ff02::1
eth1            1      ff02::1:ff00:501
eth1            1      ff02::1
```

```
server:~# netstat -gn
IPv6/IPv4 Group Memberships
Interface      RefCnt Group
-----
lo              1      224.0.0.1
eth1            1      224.0.0.1
lo              1      ff02::1
tunl0           1      ff02::1
gre0            1      ff02::1
sit0            1      ff02::1
eth1            1      ff02::1:ff00:301
eth1            1      ff02::1
```

Capturing from SimNet0					
No.	Time	Source	Destination	Protocol	Length Info
1	0.000000000	fe80::245f:78ff:fed::ff02::2	ff02::2	IGMPv6	70 Router Solicitation from 26:6f:78:d4:50:ca
2	227.328170188	fe80::245f:78ff:fed::ff02::2	ff02::2	IGMPv6	70 Router Solicitation from 26:6f:78:d4:50:ca
3	284.150821091	fe:fd:00:00:05:01	Broadcast	ARP	42 who has 192.168.0.1? Tell 192.168.0.2
4	284.151063292	fe:fd:00:00:04:01	fe:fd:00:00:05:01	ARP	42 192.168.0.1 is at fe:fd:00:00:04:01
5	284.151161882	192.168.0.2	172.16.1.3	UDP	80 53819 - 4321 Len=38
6	284.156012613	172.16.1.3	192.168.0.2	UDP	80 4321 - 53819 Len=38
7	284.167321019	192.168.0.2	224.0.0.22	IGMPv3	70 Membership Report / Group 232.43.211.234, new source {172.16.1.3} / Join group 232.43.211.234 for source {172.16.1.3}
8	285.154951399	192.168.0.2	172.16.1.3	UDP	80 53819 - 4321 Len=38
9	285.156915124	172.16.1.3	192.168.0.2	UDP	80 4321 - 53819 Len=38
10	286.166676620	192.168.0.2	172.16.1.3	UDP	80 4321 - 53819 Len=38

Capturing from SimNet1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::acb9:a5ff:fea...	ff02::2	ICMPv6	70	Router Solicitation from ae:b9:a5:a8:6a:4d
2	237.047267965	fe:fd:00:00:04:02	Broadcast	ARP	42	Who has 192.0.2.1? Tell 192.0.2.2
3	237.047448252	fe:fd:00:00:01:01	fe:fd:00:00:04:02	ARP	42	192.0.2.1 is at fe:fd:00:00:01:01
4	237.047591263	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
5	237.051739312	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
6	238.051250341	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
7	238.052686764	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
8	239.056432047	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
9	239.057821946	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
10	240.049609169	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
11	240.050958911	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
12	241.053781622	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
13	241.055101191	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
14	242.049079637	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
15	242.050413182	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38

Frame 4: 104 bytes on wire (832 bits), 104 bytes captured (832 bits) on interface 0
 Ethernet II, Src: fe:fd:00:00:04:02 (fe:fd:00:00:04:02), Dst: fe:fd:00:00:01:01 (fe:fd:00:00:01:01)
 Internet Protocol Version 4, Src: 192.0.2.2, Dst: 198.51.100.2
 Generic Routing Encapsulation (IP)
 Internet Protocol Version 4, Src: 192.168.0.2, Dst: 172.16.1.3
 User Datagram Protocol, Src Port: 53819, Dst Port: 4321
 Data (38 bytes)

Capturing from SimNet2

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::c3d:4fff:fe1b...	ff02::2	ICMPv6	70	Router Solicitation from 0e:3d:4f:1b:75:71
2	56.823632973	fe:fd:00:00:01:02	Broadcast	ARP	42	Who has 198.51.100.2? Tell 198.51.100.1
3	56.823847843	fe:fd:00:00:02:02	fe:fd:00:00:01:02	ARP	42	198.51.100.2 is at fe:fd:00:00:02:02
4	56.824003055	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
5	56.827456799	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
6	57.827523287	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
7	57.828415103	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
8	58.832421287	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
9	58.833605019	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
10	59.825598162	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
11	59.826738831	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
12	60.829801524	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
13	60.830854119	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38
14	61.825069168	192.168.0.2	172.16.1.3	UDP	104	53819 → 4321 Len=38
15	61.826193725	172.16.1.3	192.168.0.2	UDP	104	4321 → 53819 Len=38

Frame 4: 104 bytes on wire (832 bits), 104 bytes captured (832 bits) on interface 0
 Ethernet II, Src: fe:fd:00:00:01:02 (fe:fd:00:00:01:02), Dst: fe:fd:00:00:02:02 (fe:fd:00:00:02:02)
 Internet Protocol Version 4, Src: 192.0.2.2, Dst: 198.51.100.2
 Generic Routing Encapsulation (IP)
 Internet Protocol Version 4, Src: 192.168.0.2, Dst: 172.16.1.3
 User Datagram Protocol, Src Port: 53819, Dst Port: 4321
 Data (38 bytes)

Capturing from SimNet3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::401a:23ff:fe1...	ff02::2	ICMPv6	70	Router Solicitation from 42:1a:23:1a:96:2a
2	270.335969962	fe80::401a:23ff:fe1...	ff02::2	ICMPv6	70	Router Solicitation from 42:1a:23:1a:96:2a
3	278.008277443	fe:fd:00:00:02:01	Broadcast	ARP	42	Who has 172.16.1.3? Tell 172.16.1.1
4	278.008448887	fe:fd:00:00:03:01	fe:fd:00:00:02:01	ARP	42	172.16.1.3 is at fe:fd:00:00:03:01
5	278.008592635	192.168.0.2	172.16.1.3	UDP	80	53819 → 4321 Len=38
6	278.011378663	172.16.1.3	192.168.0.2	UDP	80	4321 → 53819 Len=38
7	278.012150630	172.16.1.3	232.43.211.234	UDP	80	4321 → 53819 Len=38
8	279.011786960	192.168.0.2	172.16.1.3	UDP	80	53819 → 4321 Len=38
9	279.012349269	172.16.1.3	192.168.0.2	UDP	80	4321 → 53819 Len=38
10	279.013091270	172.16.1.3	232.43.211.234	UDP	80	4321 → 53819 Len=38
11	280.016658459	192.168.0.2	172.16.1.3	UDP	80	53819 → 4321 Len=38
12	280.017607369	172.16.1.3	192.168.0.2	UDP	80	4321 → 53819 Len=38
13	280.018416891	172.16.1.3	232.43.211.234	UDP	80	4321 → 53819 Len=38
14	281.009813426	192.168.0.2	172.16.1.3	UDP	80	53819 → 4321 Len=38
15	281.010736622	172.16.1.3	192.168.0.2	UDP	80	4321 → 53819 Len=38

Frame 5: 80 bytes on wire (640 bits), 80 bytes captured (640 bits) on interface 0
 Ethernet II, Src: fe:fd:00:00:02:01 (fe:fd:00:00:02:01), Dst: fe:fd:00:00:03:01 (fe:fd:00:00:03:01)
 Internet Protocol Version 4, Src: 192.168.0.2, Dst: 172.16.1.3
 User Datagram Protocol, Src Port: 53819, Dst Port: 4321
 Data (38 bytes)

1. What output can you see in host2? and in server?

En host2 vemos los pings enviados y recibidos des del server.

En server recibe ping enviados desde 192.168.0.2 (host2) y envia el ping de vuelta al host2. y a la ip multicast. (R1 no puede enviar multicast, pq se tiene q ir al server?)

2. According to this output, do you consider that the multicast routing is working?

Si, porque en este caso ha funcionado.

Notice that ssm ping is able to test both unicast and multicast routing. Have a look to the UDP packets. Notice that the behavior is periodical, and groups of three UDP packets are sent every second.

1. What is the destination and origin address of the first packet? Is a unicast or multicast packet?

ip.src == 192.168.0.2, ip.dst == 172.16.1.3, Es unicast.

2. And the second one? What is the purpose of these two packets?

ip.src == 172.16.1.3, ip.dst == 192.168.0.2. el propósito es establecer conexion entre ellos.

3. Is the third packet different? Who is the origin and destination? Unicast or multicast? So, what is this packet testing? Unidirectional or bidirectional?

ip.src == 192.168.0.2, ip.dst == 172.16.1.3. Pero este es multicast porque se envia después de que se uniera al grupo multicast. Este paquete es unidireccional de host2 al server.

Regarding IGMP packets:

1. In SimNet0, can you see any IGMP Message? What kind of message? Which is the multicast group involved? (for easiness, put igmp in the Filter option available in the top-left corner of wireshark).

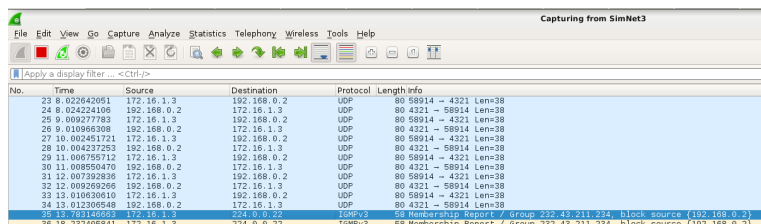
Si, vemos 2 mensajes IGMP de Membership Report de tipo Join group. El grupo multicast es 232.43.211.234.

2. Is this information coherent with what you see using netstat -gn?

SI.

3. Is there any other IGMP message in the rest of networks?

NO.



No.	Time	Source	Destination	Protocol	Length	Info
23	8.022642051	172.16.1.3	192.168.0.2	UDP	80	58914 → 4321 Len=38
24	8.024241006	192.168.0.2	172.16.1.3	UDP	80	4321 → 58914 Len=38
25	9.009277783	172.16.1.3	192.168.0.2	UDP	80	58914 → 4321 Len=38
26	9.010663008	192.168.0.2	172.16.1.3	UDP	80	4321 → 58914 Len=38
27	10.002451721	172.16.1.3	192.168.0.2	UDP	80	58914 → 4321 Len=38
28	10.004237253	192.168.0.2	172.16.1.3	UDP	80	4321 → 58914 Len=38
29	11.000757112	172.16.1.3	192.168.0.2	UDP	80	58914 → 4321 Len=38
30	11.009590470	192.168.0.2	172.16.1.3	UDP	80	4321 → 58914 Len=38
31	12.007393836	172.16.1.3	192.168.0.2	UDP	80	58914 → 4321 Len=38
32	12.009269266	192.168.0.2	172.16.1.3	UDP	80	4321 → 58914 Len=38
33	13.010808010	172.16.1.3	192.168.0.2	UDP	80	58914 → 4321 Len=38
34	13.012305460	192.168.0.2	172.16.1.3	UDP	80	4321 → 58914 Len=38
35	13.721140555	172.16.1.3	224.0.0.22	IGMPv2	58	Membership Report / group 232.43.211.234, block source (192.168.0.2)
36	18.232405841	172.16.1.3	224.0.0.22	IGMPv2	58	Membership Report / group 232.43.211.234, block source (192.168.0.2)

```
unicast:
  14 packets received, 0% packet loss
  rtt min/avg/max/std-dev = 1.776/2.177/4.753/0.731 ms
multicast:
  0 packets received, 100% packet loss
server:~#
```

Si intentamos cambiar los roles del server y del host2 . vemos que el host2 no es capaz de enviar el tráfico multicast al server porque no esta configurado el encaminamiento estático. Solo le llega el tráfico único.

mcsender and emcast (TO DO AT HOME)

It is also possible to verify the correct use of multicast static routing using the applications mcsender and emcast. Have a look to the manual of both applications to see how they work.

- Put wiresharks listening in all the involved networks.
- In server (acting as issuer) execute mcsender to send packets to the multicast group 232.43.211.234 using the UDP port 12345 with a scope of three hops.

//from server

mcsender -t3 232.43.211.234:1234

(envía paquetes al grupo 232.43.211.234, utilizando el puerto 1234 con 3 saltos.)

- In host2 (acting as receiver) execute emcast to join group 232.43.211.234 using UDP port 12345.

//from host2

emcast -t3 232.43.211.234:1234

1. What output can you see in host2? and in server?

En el host2 se ve: this is the test message from mclab/mcsender.7

En el server : nada

2. According to this output, do you consider that the multicast routing is working?

Si

3. What is the destination and origin address of the packets? Are they unicast or multicast?

ip.src == 172.16.1.3, ip.dst == 232.43.211.234.

4. Can you see any IGMP Message? Where? What kind of message? Which is the multicast group involved?

Si, en SimNet0 vemos 4 de IGMPs, 2 de Join group y 2 de Leave group. El grupo multicast es 232.43.211.234.

0.7.5 Trees with multiple branches

- Put wiresharks listening in all the involved networks.

//from R2

smcroute -k # kill prevoius daemon

smcroute -d # start new daemon

smcroute -a eth1 0.0.0.0 232.43.211.234 tunnel0 tunnel1

#adding list of interfaces used as output

smcroute -j eth1 232.43.211.234

#join the entry interface eht1 to multicast grup 232.43.211.434.

/from server

ssmpingd

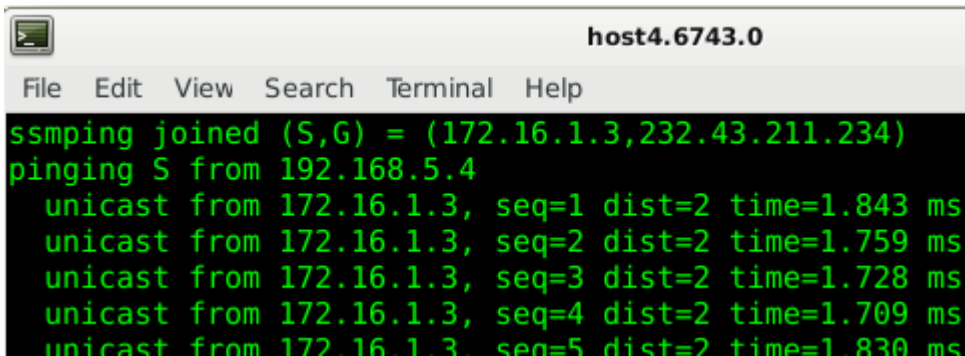
//from host2

ssmping 172.16.1.3

//from host4

ssmping 172.16.1.3

```
server:~# ssmpingd
received request from 192.168.0.2
received request from 192.168.0.2
received request from 192.168.0.2
received request from 192.168.5.4
received request from 192.168.0.2
received request from 192.168.5.4
received request from 192.168.0.2
received request from 192.168.5.4
```



```
host4.6743.0
File Edit View Search Terminal Help
ssmping joined (S,G) = (172.16.1.3,232.43.211.234)
pinging S from 192.168.5.4
  unicast from 172.16.1.3, seq=1 dist=2 time=1.843 ms
  unicast from 172.16.1.3, seq=2 dist=2 time=1.759 ms
  unicast from 172.16.1.3, seq=3 dist=2 time=1.728 ms
  unicast from 172.16.1.3, seq=4 dist=2 time=1.709 ms
  unicast from 172.16.1.3, seq=5 dist=2 time=1.830 ms
```

```
host2:~# ssmping 172.16.1.3
ssmping joined (S,G) = (172.16.1.3,232.43.211.234)
pinging S from 192.168.0.2
  unicast from 172.16.1.3, seq=1 dist=2 time=7.094 ms
multicast from 172.16.1.3, seq=1 dist=2 time=8.053 ms
  unicast from 172.16.1.3, seq=2 dist=2 time=2.739 ms
multicast from 172.16.1.3, seq=2 dist=2 time=2.744 ms
  unicast from 172.16.1.3, seq=3 dist=2 time=1.941 ms
multicast from 172.16.1.3, seq=3 dist=2 time=3.166 ms
```

1. Is ssmping working? What output message can you see in host2? host4? And in server?

El trafico multicast funciona entre host2 y server. Pero no entre host4 y server.

2. What will deduce from this output messages? What do you consider is missing?

El host4 no recibe tramas multicast debido que la R3 no está configurado para trafico multicast. (lo de echo o ignore....)

3. Have a look to SimNet4, what type of messages can you see? unicast or multicast? And in SimNet5?

En SimNet4 hay trafico multicast pero en SimNet5 no, porque R3 bloquea trafico multicast.

- Make the necessary changes to make the multicast routing work so you can send a multicast flow from SimNet0 to both SimNet3 and SimNet5.

//from R3

echo 0 > /proc/sys/net/ipv4/icmp_echo_ignore_broadcasts

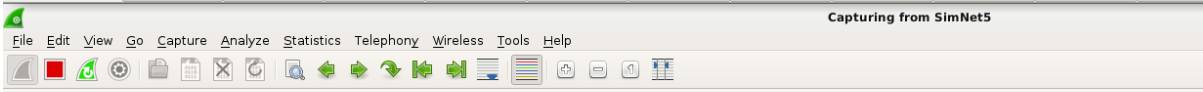
smcroute -d

smcroute -a tunnel1 0.0.0.0 232.43.211.234 eth1

smroute -j tunnel1 232.43.211.234

```
//from server
ssmpingd
//from host4
ssmping 172.16.1.3
```

```
//from server
mcsender -t3 232.43.211.234:12345
//from host4
emcast 232.43.211.234:12345
```



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.5.4	172.16.1.3	UDP	80	41501 → 4321 Len=38
2	0.003227776	fe:fd:00:00:06:01	Broadcast	ARP	42	Who has 192.168.5.4? Tell 192.168.5.1
3	0.003645759	fe:fd:00:00:07:01	fe:fd:00:00:06:01	ARP	42	192.168.5.4 is at fe:fd:00:00:07:01
4	0.003761787	172.16.1.3	192.168.5.4	UDP	80	4321 → 41501 Len=38
5	0.014595201	192.168.5.4	224.0.0.22	IGMPv3	58	Membership Report / Join group 232.43.211.234 for source {172.16.1.3}
6	1.003733260	192.168.5.4	172.16.1.3	UDP	80	41501 → 4321 Len=38
7	1.005716514	172.16.1.3	192.168.5.4	UDP	80	4321 → 41501 Len=38
8	2.008297443	192.168.5.4	172.16.1.3	UDP	80	41501 → 4321 Len=38
9	2.009962608	172.16.1.3	192.168.5.4	UDP	80	4321 → 41501 Len=38
10	2.157380653	192.168.5.4	224.0.0.22	IGMPv3	58	Membership Report / Join group 232.43.211.234 for source {172.16.1.3}
11	3.005444608	192.168.5.4	172.16.1.3	UDP	80	41501 → 4321 Len=38

0.7.6 Sending the video

- Configure the multicast routers for the control group 225.1.2.3, exactly in the same way you did previously with the data group 232.43.211.234.

```
//from R2
smcroute -a eth1 0.0.0.0 225.1.2.3 tunnel0 tunnel1
smcroute -j eth1 225.1.2.3
```

```
//from R1
smcroute -a tunnel0 0.0.0.0 225.1.2.3 eth1
smcroute -j tunnel0 225.1.2.3
```

```
//from R3
smcroute -a tunnel1 0.0.0.0 225.1.2.3 eth1
smcroute -j tunnel1 225.1.2.3
```

- Test that this control group 225.1.2.3 is properly transmitted by the multicast tree from SimNet0 to both SimNet3 and SimNet5.

- Start udp-receiver in both host2 and host4:

```
//from host2
udp-receiver --file=big_664_in_host2.mpg --mcast-all-addr 225.1.2.3 --ttl 3 --interface eth1 --portbase 22345
```

```
//from host4
udp-receiver --file=big_664_in_host4.mpg --mcast-all-addr 225.1.2.3 --ttl 3 --interface eth1 --portbase 22345
```

- Start upd-sender to transmit the video big_664.mpg from server. Remember that your multicast routing tree is unidirectional, and hence you will not receive any feedback from the receivers (for that reason we use the options autostart and max-bitrate. Notice also that you need to put the proper ttl and blocksize values to properly traverse the tunnels. Execute:

//from server

```
udp-sender --file=./big_664.mpg --portbase 22345 --nopointpoint --interface eth1 --ttl 3 --mcast-addr 232.43.211.234 --mcast-all-addr 225.1.2.3 --nokbd --async --max-bitrate 900K --autostart 1 --blocksize 1400
```

The image shows two terminal windows. The left window, titled 'server.3279.0', shows the execution of the 'udp-sender' command and its output, including a warning about async mode and a table of transfer statistics. The right window, titled 'host4.6743.0', shows the output of the 'udp-receiver' command, including statistics for packets received and lost, and the file 'big_664.mpg' being received.

```
server.3279.0
File Edit View Search Terminal Help
Warning: Async mode but no forward error correction
Transmission may fail due to packet loss
Add "-fec 8x8" to commandline
UDP-sender 2004-05-31
UDP sender for ./big_664.mpg at 172.16.1.3 on eth1
Broadcasting control to 225.1.2.3
Starting transfer: 00000039
bytes= 1 433 600 re-xmits=000000 ( 0.0%) slice=1024 5 734 400 - 0
bytes= 11 468 800 re-xmits=000000 ( 0.0%) slice=1024 17 203 200 - 0
bytes= 17 408 000 re-xmits=000000 ( 0.0%) slice=1024 17 408 000 - 0
Transfer complete.
server:~#
server:~#
server:~#
server:~#
server:~#
server:~#

host4.6743.0
File Edit View Search Terminal Help
Receiving S from 192.168.5.4
unicast from 172.16.1.3, seq=1 dist=2 time=3.929 ms
unicast from 172.16.1.3, seq=2 dist=2 time=2.192 ms
unicast from 172.16.1.3, seq=3 dist=2 time=1.848 ms
unicast from 172.16.1.3, seq=4 dist=2 time=1.764 ms
unicast from 172.16.1.3, seq=5 dist=2 time=1.666 ms
unicast from 172.16.1.3, seq=6 dist=2 time=2.421 ms
unicast from 172.16.1.3, seq=7 dist=2 time=1.077 ms
--- 172.16.1.3 ssmtp statistics ---
packets transmitted, time 6777 ms
unicast:
7 packets received, 0% packet loss
rtt min/avg/max/std-dev = 1.666/2.242/3.929/0.731 ms
multicast:
0 packets received, 100% packet loss
host4:~# emcast -t3 232.43.211.234:1234
host4:~# udp-receiver --file=big_664.in host4.mpg --mcast-all-addr 225.1.2.3
l 3 --interface eth1 --portbase 22345
udp-receiver 2004-05-31
UDP receiver for big_664 in host4.mpg at 192.168.5.4 on eth1
Connected as #0 to 172.16.1.3
Listening to multicast on 232.43.211.234
```

The image shows three terminal windows. The first window, 'server:~#', shows the command 'ls' and the output 'big_664.mpg'. The second window, 'host4:~#', shows the command 'ls' and the output 'big_664.in host4.mpg'. The third window, 'host2:~#', shows the command 'ls' and the output 'big_664.in host2.mpg'.

```
server:~# ls
big_664.mpg
server:~#

host4:~# ls
big_664.in host4.mpg
host4:~#

host2:~# ls
big_664.in host2.mpg
host2:~#
```

En todas las SimNets salen mensajes udps, luego IGMP Membership/join group y luego udps de datos. (como en los anteriores).

0.7.7 Bidirectional tree (TO DO AT HOME)

0.7.8 Live streaming (TO DO AT HOME)

0.7.9 The end of the overlay (TO DO AT HOME)

teoria

Direccionamiento Multicast (RFC5771)

Mapping entre IP de grupo y dirección MAC:

Todas las MACs multicast existen en el rango 01-00-5E-00-00-00 y 01-00-5E-7F-FF-FF

1. Tomar los últimos 3 octetos de la dirección IP (24 bits)
2. Cambiar el primer bit de la izquierda a 0 si es que es 1, y si es 0 se deja en 0.
3. Se convierten los 3 bytes a hexadecimal y se agregan al prefijo 01:00:5E

Ejemplo 1:

1. 224.64.16.1 = 1110 0000.0100 0000.0001 0000.0000 0001
2. 4 0 1 0 0 1
3. MAC FINAL = 01:00:5E:40:10:01

Ejemplo 2:

1. 224.192.16.1 = 1110 0000.1100 0000.0001 0000.0000 0001
2. 4 0 1 0 0 1
3. MAC FINAL = 01:00:5E:40:10:01

Internet Group Management Protocol (IGMP)

IGMPv1: Cuando un host quiere unirse a un grupo Mcast, envía un mensaje IGMP Report Message al router indicando que quiere recibir tráfico de ese grupo. El router envía mensajes IGMP Query cada 60 segs para determinar el host aún quiere estar en el grupo. Los mensajes se envían a 224.0.0.1 (todos los hosts)

IGMPv2: Los routers envían mensajes a grupos específicos y los hosts pueden enviar mensajes "Leave" cuando quieran abandonar un grupo, lo cual permite optimizar recursos de la red.

IGMPv3: Si existe más de un origen Multicast para el mismo grupo, los routers pueden decidir cual de los orígenes escogen mediante el envío de mensajes "Source" (SSM o Source Specific Multicast).

IGMPv1=el host envía una query cada 60s para determinar si el router aun quiere formar parte del grupo. Si abandona el grupo el router, el host no sabe hasta q envia la query.ttl=1

IGMPv2= Se introdujo el mensaje Leave, cuando el router no quiere formar parte del grupo, envia un leave y yata.ttl=1

IGMPv3= funciona como la IGMPv2 pero ahora permite definir multiples orígenes. 2 servidores enviando al mismo ip multicast, el host puede decidir en que server conectarte.ttl=1

L2 MULTICAST ADDRESSING

Mapping L3 to L2

1110

$$\begin{array}{r} 32 \\ - 4 \\ \hline 28 \\ - 23 \\ \hline 5 \\ 2^5 = 32 \end{array}$$

- For IP multicast, there is a well-known MAC OUI that is used exclusively 00000000 0 48-24-1=23
 - 01-00-5E $\phi \leftarrow 1/6 \rightarrow 1$
- Of the remaining 24 bits, the most significant bit is fixed to 0
 - This leaves 23 bits to map the L3 IP
- LO 23 bits of the IP are simply copied to LO 23 bits of the MAC
 - Since 28 bits of the IP are being mapped onto 23 bits of the MAC, there is ambiguity
 - As 5 bits are left unmapped, 32 (2^5) IPs map to the same MAC
 - Eg. 230.1.2.3, 230.129.2.3 and 239.1.2.3 all map to:
 - 0100-5E01-0203 /8 \rightarrow 2
- A savings of about \$15,500 in 1989 dollars