

A thick dark blue vertical bar is positioned on the left side of the page. A blue arrow-shaped banner points to the right from this bar, containing the date '7-11-2018'. In the bottom-left corner, there are several thin, curved lines in dark blue and light grey, resembling stylized grass or abstract brushstrokes.

7-11-2018

Tema4: Protocolo IP y encaminamiento

Escenario 2

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INDICE

Ejercicio _____	3
Configuración _____	4
Configuración de cada nodo _____	5
Configuración encaminamiento _____	7
Verificación de conectividad _____	8
Captura de tráfico en R0 _____	11

Ejercicio

Disponemos de Tres Host conectados a un router Linux.

Redes:

- 192.168.100.0/24
- 172.32.0.0/16
- 10.1.0.0/7

Tarea:

- Configurar los hosts y el router de forma que todos sean alcanzables.

Entrega:

- Esquema gráfico de la configuración.
- Comandos de configuración de cada nodo.
- Verificación de conectividad (ping) entre nodos.
- Captura de tráfico en el router durante una comunicación entre h1 y h3.

Configuración

Para hacernos una idea del ejercicio, lo plasmaremos en un diagrama, indicando las partes y su conexión:

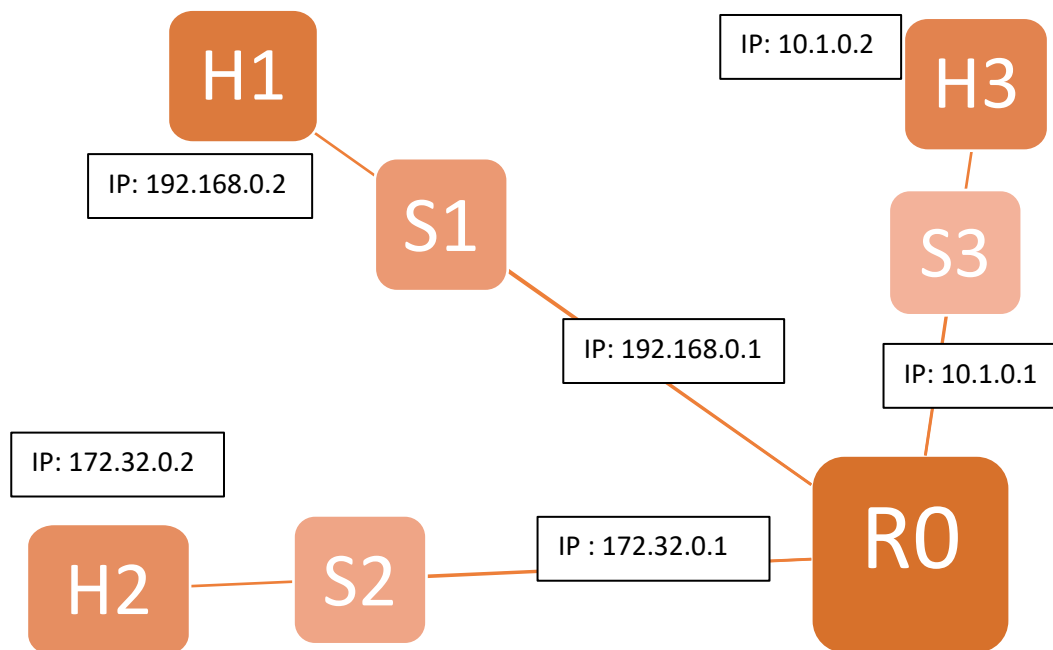


Ilustración 1

R0 → Router

S1, S2, S3 → Switches

H1, H2, H3 → Host

Configuración de cada nodo

En primer lugar, necesitamos configurar las direcciones Ip de cada Host y para ello usaremos el siguiente comando:

Ip a add {dirección Ip /máscara de red} dev {interfaz de red}

Por ejemplo, para el H1 sería:

```
root@mininet-vm:~# ip a add 192.168.100.2/24 dev h1-eth0
root@mininet-vm:~# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
2: h1-eth0@if6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 16:88:63:ee:81:04 brd ff:ff:ff:ff:ff:ff
    inet 192.168.100.2/24 scope global h1-eth0
        valid_lft forever preferred_lft forever
root@mininet-vm:~#
```

Ilustración 2

Y para H2 Y H3:

```
root@mininet-vm:~# ip a add 10.1.0.2/7 dev h3-eth0
root@mininet-vm:~# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
2: h3-eth0@if8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 1e:b9:12:dd:03:9d brd ff:ff:ff:ff:ff:ff
    inet 10.1.0.2/7 scope global h3-eth0
        valid_lft forever preferred_lft forever
root@mininet-vm:~#
```

Ilustración 3

```

root@mininet-vm:~# ip a add 10.1.0.2/7 dev h3-eth0
root@mininet-vm:~# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
2: h3-eth0@if8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 1e:b9:12:dd:03:9d brd ff:ff:ff:ff:ff:ff
    inet 10.1.0.2/7 scope global h3-eth0
        valid_lft forever preferred_lft forever
root@mininet-vm:~# █

```

Ilustración 4

Y, por último, necesitamos configurar las diferentes interfaces de red que tiene el router R0. Usaremos el mismo comando:

```

root@mininet-vm:~# ip a add 192.168.100.1/24 dev r0-eth1
root@mininet-vm:~# ip a add 172.32.0.1/12 dev r0-eth2
root@mininet-vm:~# ip a add 10.1.0.1/7 dev r0-eth3
root@mininet-vm:~# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
2: r0-eth1@if9: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 3e:6b:c9:e8:37:25 brd ff:ff:ff:ff:ff:ff
    inet 192.168.100.1/24 scope global r0-eth1
        valid_lft forever preferred_lft forever
3: r0-eth2@if10: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 3e:fa:8d:58:dc:41 brd ff:ff:ff:ff:ff:ff
    inet 172.32.0.1/12 scope global r0-eth2
        valid_lft forever preferred_lft forever
4: r0-eth3@if11: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether de:3a:47:a4:8f:12 brd ff:ff:ff:ff:ff:ff
    inet 10.1.0.1/7 scope global r0-eth3
        valid_lft forever preferred_lft forever
root@mininet-vm:~# █

```

Ilustración 5

Configuración encaminamiento

A continuación, con el siguiente comando crearemos la tabla de encaminamiento de cada nodo:

Ip r add {Ip de destino} via {Ip de origen}

En el caso de las tablas de encaminamiento de los Hosts, es mucho más cómodo usar:

Ip r add default via {Ip de destino}

Para H1:

```
root@mininet-vm:~# ip r add default via 192.168.100.1
root@mininet-vm:~# ip r
default via 192.168.100.1 dev h1-eth0
192.168.100.0/24 dev h1-eth0 proto kernel scope link src 192.168.100.2
root@mininet-vm:~# █
```

Ilustración 6

Y para H2 y H3 será:

```
root@mininet-vm:~# ip r add default via 172.32.0.1
root@mininet-vm:~# ip r
default via 172.32.0.1 dev h2-eth0
172.32.0.0/12 dev h2-eth0 proto kernel scope link src 172.32.0.2
root@mininet-vm:~# █
```

Ilustración 7

```
root@mininet-vm:~# ip r add default via 10.1.0.1
root@mininet-vm:~# ip r
default via 10.1.0.1 dev h3-eth0
10.0.0.0/7 dev h3-eth0 proto kernel scope link src 10.1.0.2
root@mininet-vm:~# █
```

Ilustración 8

Verificación de conectividad (ping)

Una vez hecha la tabla de encaminamiento, usaremos el comando:

Ping {Ip de destino}

Para comprobar que, efectivamente, nos llegan los paquetes de datos, usaremos el comando:

Tcpdump -i {interfaz de red}

En primer lugar, mandaremos ping de H1 Y H2 hacia H3:

The image shows four terminal windows from a Mininet VM environment, displaying network traffic captured with tcpdump. The windows are titled: "Node: h1 (on mininet-vm)", "Node: h2 (on mininet-vm)", "Node: h3 (on mininet-vm)", and "Node: r0 (on mininet-vm)".

- Node: h1 (on mininet-vm)**: Shows a series of ICMP echo requests (ping) from 10.1.0.2 to 172.32.0.2. Each line shows the packet details: "64 bytes from 10.1.0.2: icmp_seq=237 ttl=63 time=0.070 ms". The sequence numbers range from 237 to 259.
- Node: h2 (on mininet-vm)**: Shows a series of ICMP echo requests from 10.1.0.2 to 192.168.100.2. Each line shows the packet details: "64 bytes from 10.1.0.2: icmp_seq=230 ttl=63 time=0.078 ms". The sequence numbers range from 230 to 252.
- Node: h3 (on mininet-vm)**: Shows the received ICMP echo requests and replies. It includes details like "09:01:04.514274 IP 10.1.0.2 > 172.32.0.2: ICMP echo reply, id 2214, seq 250, length 64". It shows both requests and replies between the nodes.
- Node: r0 (on mininet-vm)**: Shows the root prompt "root@mininet-vm:~#".

Ilustración 8

Ahora, de H1 y H3 hacia H2:

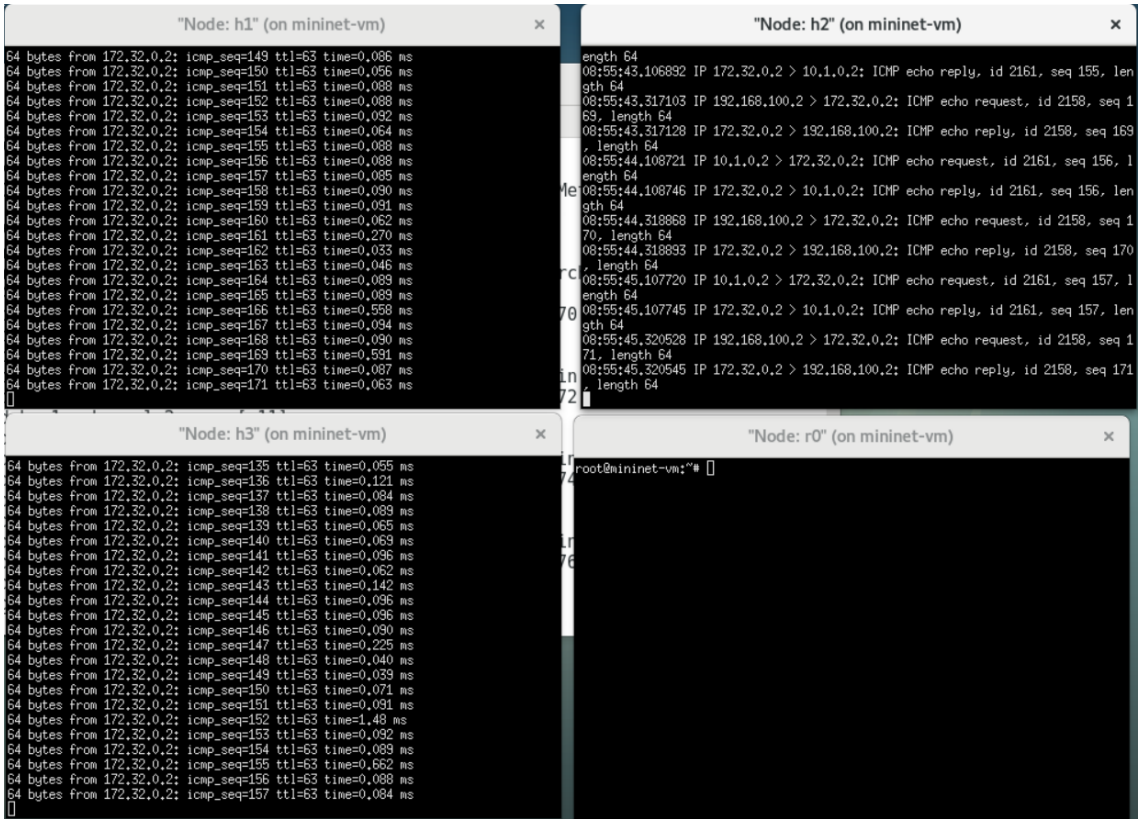


Ilustración 9

Y, por último, de H2 y H3 a H1:

```
"Node: h1" (on mininet-vn) x
, length 64
09:05:07.800769 IP 192.168.100.2 > 10.1.0.2: ICMP echo reply, id 2282, seq 194,
length 64
09:05:08.326968 IP 172.32.0.2 > 192.168.100.2: ICMP echo request, id 2285, seq 1
86, length 64
09:05:08.326991 IP 192.168.100.2 > 172.32.0.2: ICMP echo reply, id 2285, seq 186
, length 64
09:05:08.803376 IP 10.1.0.2 > 192.168.100.2: ICMP echo request, id 2282, seq 195
, length 64
09:05:08.803401 IP 192.168.100.2 > 10.1.0.2: ICMP echo reply, id 2282, seq 195,
length 64
09:05:09.328971 IP 172.32.0.2 > 192.168.100.2: ICMP echo request, id 2285, seq 1
87, length 64
09:05:09.328997 IP 192.168.100.2 > 172.32.0.2: ICMP echo reply, id 2285, seq 187
, length 64
09:05:09.802375 IP 10.1.0.2 > 192.168.100.2: ICMP echo request, id 2282, seq 196
, length 64
09:05:09.802398 IP 192.168.100.2 > 10.1.0.2: ICMP echo reply, id 2282, seq 196,
length 64
09:05:10.331177 IP 172.32.0.2 > 192.168.100.2: ICMP echo request, id 2285, seq 1
88, length 64
09:05:10.331201 IP 192.168.100.2 > 172.32.0.2: ICMP echo reply, id 2285, seq 188
, length 64

"Node: h2" (on mininet-vn) x
64 bytes from 192.168.100.2: icmp_seq=166 ttl=63 time=0.043 ms
64 bytes from 192.168.100.2: icmp_seq=167 ttl=63 time=0.066 ms
64 bytes from 192.168.100.2: icmp_seq=168 ttl=63 time=0.086 ms
64 bytes from 192.168.100.2: icmp_seq=169 ttl=63 time=0.090 ms
64 bytes from 192.168.100.2: icmp_seq=170 ttl=63 time=0.332 ms
64 bytes from 192.168.100.2: icmp_seq=171 ttl=63 time=0.090 ms
64 bytes from 192.168.100.2: icmp_seq=172 ttl=63 time=0.144 ms
64 bytes from 192.168.100.2: icmp_seq=173 ttl=63 time=0.092 ms
64 bytes from 192.168.100.2: icmp_seq=174 ttl=63 time=0.056 ms
64 bytes from 192.168.100.2: icmp_seq=175 ttl=63 time=0.245 ms
64 bytes from 192.168.100.2: icmp_seq=176 ttl=63 time=0.024 ms
64 bytes from 192.168.100.2: icmp_seq=177 ttl=63 time=0.063 ms
64 bytes from 192.168.100.2: icmp_seq=178 ttl=63 time=0.386 ms
64 bytes from 192.168.100.2: icmp_seq=179 ttl=63 time=0.092 ms
64 bytes from 192.168.100.2: icmp_seq=180 ttl=63 time=0.094 ms
64 bytes from 192.168.100.2: icmp_seq=181 ttl=63 time=0.143 ms
64 bytes from 192.168.100.2: icmp_seq=182 ttl=63 time=0.086 ms
64 bytes from 192.168.100.2: icmp_seq=183 ttl=63 time=0.089 ms
64 bytes from 192.168.100.2: icmp_seq=184 ttl=63 time=0.087 ms
64 bytes from 192.168.100.2: icmp_seq=185 ttl=63 time=0.087 ms
64 bytes from 192.168.100.2: icmp_seq=186 ttl=63 time=0.087 ms
64 bytes from 192.168.100.2: icmp_seq=187 ttl=63 time=0.134 ms
64 bytes from 192.168.100.2: icmp_seq=188 ttl=63 time=0.086 ms

"Node: h3" (on mininet-vn) x
64 bytes from 192.168.100.2: icmp_seq=174 ttl=63 time=0.086 ms
64 bytes from 192.168.100.2: icmp_seq=175 ttl=63 time=0.095 ms
64 bytes from 192.168.100.2: icmp_seq=176 ttl=63 time=0.084 ms
64 bytes from 192.168.100.2: icmp_seq=177 ttl=63 time=0.086 ms
64 bytes from 192.168.100.2: icmp_seq=178 ttl=63 time=0.087 ms
64 bytes from 192.168.100.2: icmp_seq=179 ttl=63 time=0.525 ms
64 bytes from 192.168.100.2: icmp_seq=180 ttl=63 time=0.077 ms
64 bytes from 192.168.100.2: icmp_seq=181 ttl=63 time=0.068 ms
64 bytes from 192.168.100.2: icmp_seq=182 ttl=63 time=0.092 ms
64 bytes from 192.168.100.2: icmp_seq=183 ttl=63 time=0.095 ms
64 bytes from 192.168.100.2: icmp_seq=184 ttl=63 time=0.283 ms
64 bytes from 192.168.100.2: icmp_seq=185 ttl=63 time=0.148 ms
64 bytes from 192.168.100.2: icmp_seq=186 ttl=63 time=0.097 ms
64 bytes from 192.168.100.2: icmp_seq=187 ttl=63 time=0.382 ms
64 bytes from 192.168.100.2: icmp_seq=188 ttl=63 time=0.093 ms
64 bytes from 192.168.100.2: icmp_seq=189 ttl=63 time=0.094 ms
64 bytes from 192.168.100.2: icmp_seq=190 ttl=63 time=0.088 ms
64 bytes from 192.168.100.2: icmp_seq=191 ttl=63 time=0.084 ms
64 bytes from 192.168.100.2: icmp_seq=192 ttl=63 time=0.087 ms
64 bytes from 192.168.100.2: icmp_seq=193 ttl=63 time=0.087 ms
64 bytes from 192.168.100.2: icmp_seq=194 ttl=63 time=0.087 ms
64 bytes from 192.168.100.2: icmp_seq=195 ttl=63 time=0.092 ms
64 bytes from 192.168.100.2: icmp_seq=196 ttl=63 time=0.084 ms

"Node: r0" (on mininet-vn) x
root@mininet-vn:~#
```

Ilustración 10

Captura de tráfico en R0

Para comprobar la conectividad, vamos a hacer un Tcpcdump en el router para comprobar la entrada y salida de los paquetes de datos:

The image shows four terminal windows from a Mininet VM environment. The top-left window, titled '"Node: h1" (on mininet-vm)', displays a list of ICMP echo replies received from 10.1.0.2, with sequence numbers ranging from 94 to 116 and times between 0.046 ms and 1.13 ms. The top-right window, titled '"Node: h2" (on mininet-vm)', shows a root prompt. The bottom-left window, titled '"Node: h3" (on mininet-vm)', also shows a root prompt. The bottom-right window, titled '"Node: r0" (on mininet-vm)', displays a detailed capture of network traffic, including timestamps, IP addresses, and ICMP echo request/reply details for sequence numbers 111 through 116.

```
"Node: h1" (on mininet-vm) x
64 bytes from 10.1.0.2: icmp_seq=94 ttl=63 time=0.046 ms
64 bytes from 10.1.0.2: icmp_seq=95 ttl=63 time=0.031 ms
64 bytes from 10.1.0.2: icmp_seq=96 ttl=63 time=0.066 ms
64 bytes from 10.1.0.2: icmp_seq=97 ttl=63 time=0.089 ms
64 bytes from 10.1.0.2: icmp_seq=98 ttl=63 time=0.086 ms
64 bytes from 10.1.0.2: icmp_seq=99 ttl=63 time=1.13 ms
64 bytes from 10.1.0.2: icmp_seq=100 ttl=63 time=0.079 ms
64 bytes from 10.1.0.2: icmp_seq=101 ttl=63 time=0.085 ms
64 bytes from 10.1.0.2: icmp_seq=102 ttl=63 time=0.088 ms
64 bytes from 10.1.0.2: icmp_seq=103 ttl=63 time=0.090 ms
64 bytes from 10.1.0.2: icmp_seq=104 ttl=63 time=1.66 ms
64 bytes from 10.1.0.2: icmp_seq=105 ttl=63 time=0.162 ms
64 bytes from 10.1.0.2: icmp_seq=106 ttl=63 time=0.037 ms
64 bytes from 10.1.0.2: icmp_seq=107 ttl=63 time=0.472 ms
64 bytes from 10.1.0.2: icmp_seq=108 ttl=63 time=0.090 ms
64 bytes from 10.1.0.2: icmp_seq=109 ttl=63 time=0.089 ms
64 bytes from 10.1.0.2: icmp_seq=110 ttl=63 time=0.089 ms
64 bytes from 10.1.0.2: icmp_seq=111 ttl=63 time=0.088 ms
64 bytes from 10.1.0.2: icmp_seq=112 ttl=63 time=0.086 ms
64 bytes from 10.1.0.2: icmp_seq=113 ttl=63 time=0.097 ms
64 bytes from 10.1.0.2: icmp_seq=114 ttl=63 time=0.086 ms
64 bytes from 10.1.0.2: icmp_seq=115 ttl=63 time=0.095 ms
64 bytes from 10.1.0.2: icmp_seq=116 ttl=63 time=0.082 ms

"Node: h2" (on mininet-vm) x
root@mininet-vm:~#

"Node: h3" (on mininet-vm) x
root@mininet-vm:~#

"Node: r0" (on mininet-vm) x
, length 64
09:08:48.077830 IP 10.1.0.2 > 192.168.100.2: ICMP echo reply, id 2352, seq 111,
length 64
09:08:49.078586 IP 192.168.100.2 > 10.1.0.2: ICMP echo request, id 2352, seq 112
, length 64
09:08:49.078628 IP 10.1.0.2 > 192.168.100.2: ICMP echo reply, id 2352, seq 112,
length 64
09:08:50.077844 IP 192.168.100.2 > 10.1.0.2: ICMP echo request, id 2352, seq 113
, length 64
09:08:50.077893 IP 10.1.0.2 > 192.168.100.2: ICMP echo reply, id 2352, seq 113,
length 64
09:08:51.078377 IP 192.168.100.2 > 10.1.0.2: ICMP echo request, id 2352, seq 114
, length 64
09:08:51.078419 IP 10.1.0.2 > 192.168.100.2: ICMP echo reply, id 2352, seq 114,
length 64
09:08:52.077884 IP 192.168.100.2 > 10.1.0.2: ICMP echo request, id 2352, seq 115
, length 64
09:08:52.077931 IP 10.1.0.2 > 192.168.100.2: ICMP echo reply, id 2352, seq 115,
length 64
09:08:53.080344 IP 192.168.100.2 > 10.1.0.2: ICMP echo request, id 2352, seq 116
, length 64
09:08:53.080383 IP 10.1.0.2 > 192.168.100.2: ICMP echo reply, id 2352, seq 116,
length 64
```

Ilustración 11