1. Show the ping results to test reachability

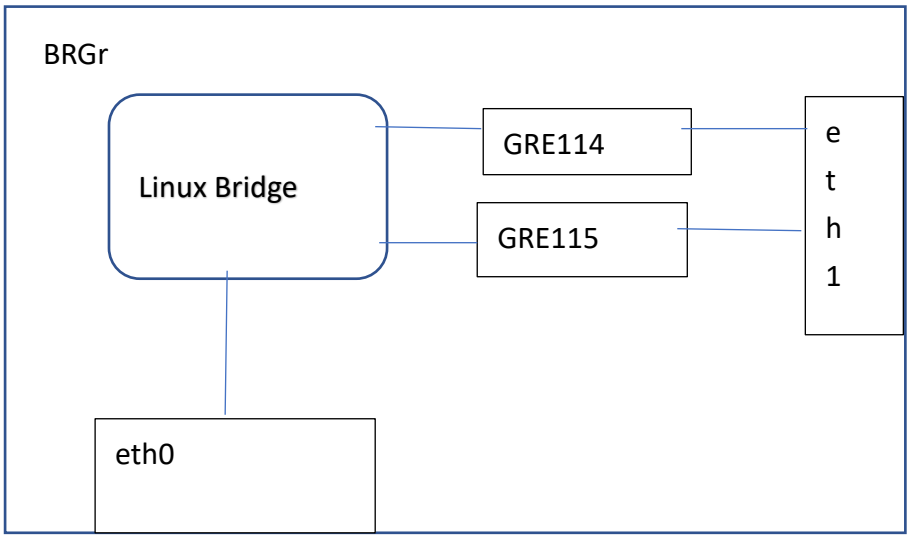
a) h1 and h2 ping GWr

```
mininet> h1 ping GWr -c 3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.138 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.076 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.070 ms

--- 10.0.0.3 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2032ms
rtt min/avg/max/mdev = 0.070/0.094/0.138/0.032 ms
mininet> h2 ping GWr -c 3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.104 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.066 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.070 ms

--- 10.0.0.3 ping statistics ---
```

2. Show all interfaces of Node BRGr after h1 and h2 can ping GWr

```
mininet> BRGr ip link show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: gre0@NONE: <NOARP> mtu 1452 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/gre 0.0.0.0 brd 0.0.0.0
3: gretap0@NONE: <BROADCAST,MULTICAST> mtu 1462 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff
4: erspan0@NONE: <BROADCAST,MULTICAST> mtu 1450 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff
5: BRGr-eth0@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br0 state UP mode DEFAULT group default
qlen 1000
    link/ether 6a:16:de:6b:70:7d brd ff:ff:ff:ff:ff:ff link-netnsid 0
6: BRGr-eth1@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode DEFAULT group default qlen 1000
    link/ether ce:d7:6d:75:65:ba brd ff:ff:ff:ff:ff:ff link-netnsid 1
7: br0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1462 qdisc noqueue state UP mode DEFAULT group default qlen 1000
    link/ether 32:0b:04:e5:65:1d brd ff:ff:ff:ff:ff:ff
8: GRE114@NONE: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1462 qdisc fq_codel master br0 state UNKNOWN mode DEFAULT group defa
ult qlen 1000
    link/ether 8e:95:58:f1:22:81 brd ff:ff:ff:ff:ff:ff
9: GRE115@NONE: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1462 qdisc fq_codel master br0 state UNKNOWN mode DEFAULT group defa
ult qlen 1000
    link/ether 32:0b:04:e5:65:1d brd ff:ff:ff:ff:ff:ff
```

3. Draw the interconnection diagram of interfaces and Linux bridge on BRGr. Explain your diagram with the screenshot of interface list of BRGr.



```
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1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: gre0@NONE: <NOARP> mtu 1452 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/gre 0.0.0.0 brd 0.0.0.0
3: gretap0@NONE: <BROADCAST,MULTICAST> mtu 1462 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff
4: erspan0@NONE: <BROADCAST,MULTICAST> mtu 1450 qdisc noop state DOWN mode DEFAULT group default qlen 1000
    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff
5: BRGr-eth0@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br0 state UP mode DEFAULT group default
qlen 1000
    link/ether 6a:16:de:6b:70:7d brd ff:ff:ff:ff:ff:ff link-netnsid 0
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    link/ether ce:d7:6d:75:65:ba brd ff:ff:ff:ff:ff:ff link-netnsid 1
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    link/ether 32:0b:04:e5:65:1d brd ff:ff:ff:ff:ff:ff
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ult qlen 1000
    link/ether 32:0b:04:e5:65:1d brd ff:ff:ff:ff:ff:ff
```

先設立Linux Bridge (br0) 連接eth0，而轉送GRE封包到140.114.0.1與140.115.0.1的GRE114與GRE115再連接上Bridge(br0)，最後由eth1連接外部網域。

4. Explain how Linux kernel of BRGr determines which gretap interface to forward packets from GWr to hosts (h1 or h2)?
Describe your answer with appropriate screenshot.

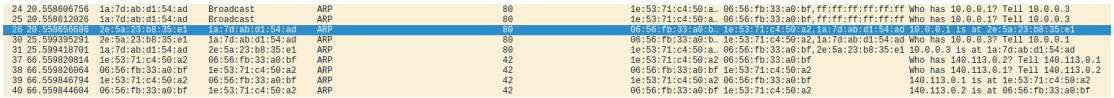
in eth0:

13 38.991202900	1a:7d:ab:d1:54:ad	Broadcast	ARP	42		1a:7d:ab:d1:54:ad Who has 10.0.0.1? Tell 10.0.0.3
14 38.991270810	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	42		2e:5a:23:b8:35:e1 10.0.0.1 is at 2e:5a:23:b8:35:e1
17 44.032019465	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	42		2e:5a:23:b8:35:e1 Who has 10.0.0.3? Tell 10.0.0.1
18 44.032026645	1a:7d:ab:d1:54:ad	2e:5a:23:b8:35:e1	ARP	42		1a:7d:ab:d1:54:ad 10.0.0.3 is at 1a:7d:ab:d1:54:ad
15 38.991272670	10.0.0.3	10.0.0.1	ICMP	98		1a:7d:ab:d1:54:ad Echo (ping) request id=0x49af, seq=1/25

in br0:

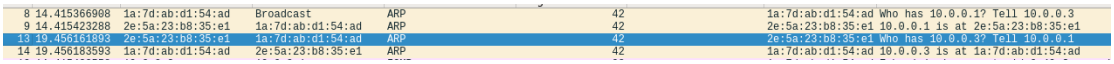
9 20.558611496	1a:7d:ab:d1:54:ad	Broadcast	ARP	42		1a:7d:ab:d1:54:ad Who has 10.0.0.1? Tell 10.0.0.3
10 20.558676156	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	42		2e:5a:23:b8:35:e1 10.0.0.1 is at 2e:5a:23:b8:35:e1
13 25.599414761	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	42		2e:5a:23:b8:35:e1 Who has 10.0.0.3? Tell 10.0.0.1
14 25.599435241	1a:7d:ab:d1:54:ad	2e:5a:23:b8:35:e1	ARP	42		1a:7d:ab:d1:54:ad 10.0.0.3 is at 1a:7d:ab:d1:54:ad

in eth1:



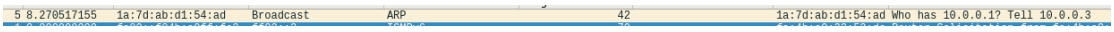
24 20.558606756	1a:7d:ab:d1:54:ad	Broadcast	ARP	80	1e:53:71:c4:50:a…	06:56:fb:33:a0:bf,ff:ff:ff:ff:ff:ff Who has 10.0.0.1? Tell 10.0.0.3
25 20.558612026	1a:7d:ab:d1:54:ad	Broadcast	ARP	80	1e:53:71:c4:50:a…	06:56:fb:33:a0:bf,ff:ff:ff:ff:ff:ff Who has 10.0.0.1? Tell 10.0.0.3
26 20.558656086	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	80	06:56:fb:33:a0:b…	1e:53:71:c4:50:a2,1a:7d:ab:d1:54:ad 10.0.0.1 is at 2e:5a:23:b8:35:e1
30 25.599395291	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	80	06:56:fb:33:a0:b…	1e:53:71:c4:50:a2,1a:7d:ab:d1:54:ad Who has 10.0.0.3? Tell 10.0.0.1
31 25.599418701	1a:7d:ab:d1:54:ad	2e:5a:23:b8:35:e1	ARP	80	1e:53:71:c4:50:a…	06:56:fb:33:a0:bf,2e:5a:23:b8:35:e1 10.0.0.3 is at 1a:7d:ab:d1:54:ad
37 66.559820814	1e:53:71:c4:50:a2	06:56:fb:33:a0:bf	ARP	42	1e:53:71:c4:50:a2	06:56:fb:33:a0:bf Who has 140.113.0.2? Tell 140.113.0.1
38 66.559826064	06:56:fb:33:a0:bf	1e:53:71:c4:50:a2	ARP	42	06:56:fb:33:a0:bf	1e:53:71:c4:50:a2 Who has 140.113.0.1? Tell 140.113.0.2
39 66.559846794	1e:53:71:c4:50:a2	06:56:fb:33:a0:bf	ARP	42	1e:53:71:c4:50:a2	06:56:fb:33:a0:bf 140.113.0.1 is at 1e:53:71:c4:50:a2
40 66.559844604	06:56:fb:33:a0:bf	1e:53:71:c4:50:a2	ARP	42	06:56:fb:33:a0:bf	1e:53:71:c4:50:a2 140.113.0.2 is at 06:56:fb:33:a0:bf

in GRE114:



8 14.415366908	1a:7d:ab:d1:54:ad	Broadcast	ARP	42		1a:7d:ab:d1:54:ad Who has 10.0.0.1? Tell 10.0.0.3
9 14.415423288	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	42		2e:5a:23:b8:35:e1 10.0.0.1 is at 2e:5a:23:b8:35:e1
13 19.456161893	2e:5a:23:b8:35:e1	1a:7d:ab:d1:54:ad	ARP	42		2e:5a:23:b8:35:e1 Who has 10.0.0.3? Tell 10.0.0.1
14 19.456183593	1a:7d:ab:d1:54:ad	2e:5a:23:b8:35:e1	ARP	42		1a:7d:ab:d1:54:ad 10.0.0.3 is at 1a:7d:ab:d1:54:ad

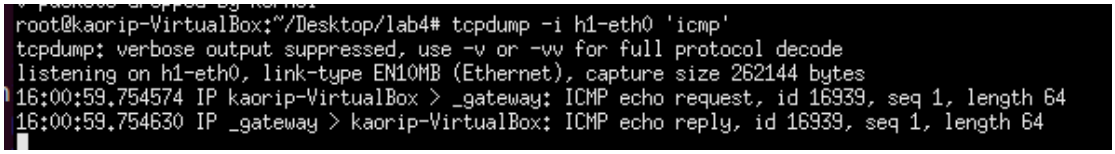
in GRE115:



5 8.270517155	1a:7d:ab:d1:54:ad	Broadcast	ARP	42		1a:7d:ab:d1:54:ad Who has 10.0.0.1? Tell 10.0.0.3

由上圖可以發現在 GWr 發出廣播之後，h1 的回傳封包經過 eth1 後會送往 GRE114，GRE115 並不會記錄 h1 的 MAC。另外，因為 wireshark 開啟時，GRE tunnel 的相關規則早已建立，無法及時觀察封包傳遞行為，若能接收觀察 filter 開啟時的封包，應該能更清楚看出 BRGr 決定封包傳遞的方式。

5. Run tcpdump on h1 to capture packet and take screenshot to explain why or why not h1 is aware of GRE tunneling.



由於 GRE tunneling 是在 BRG1 處理，h1 本身並不會有處理 GRE 封包的行為，所以不管是送出封包或接收封包，h1 不會收到 GRE 型態的封包，只會收到已經經過 BRG1 解析的封包。