

# PicoHub: the PicoNet in a Hosted JupyterLab Cloud

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\* dreamstime.com

## Why? How?

1. Lightweight on students laptop
2. Lightweight on lab provisioning

## 3. Fun labs!

### Old Physical Lab



### Intermediate Virtual Lab



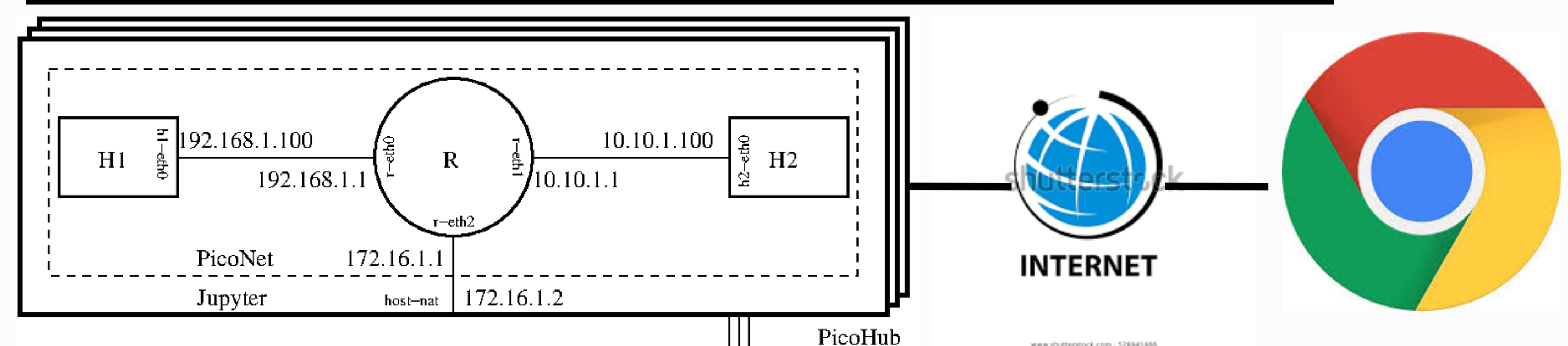
Works well in a Physical Lab, *not* on students laptop



Covid-19

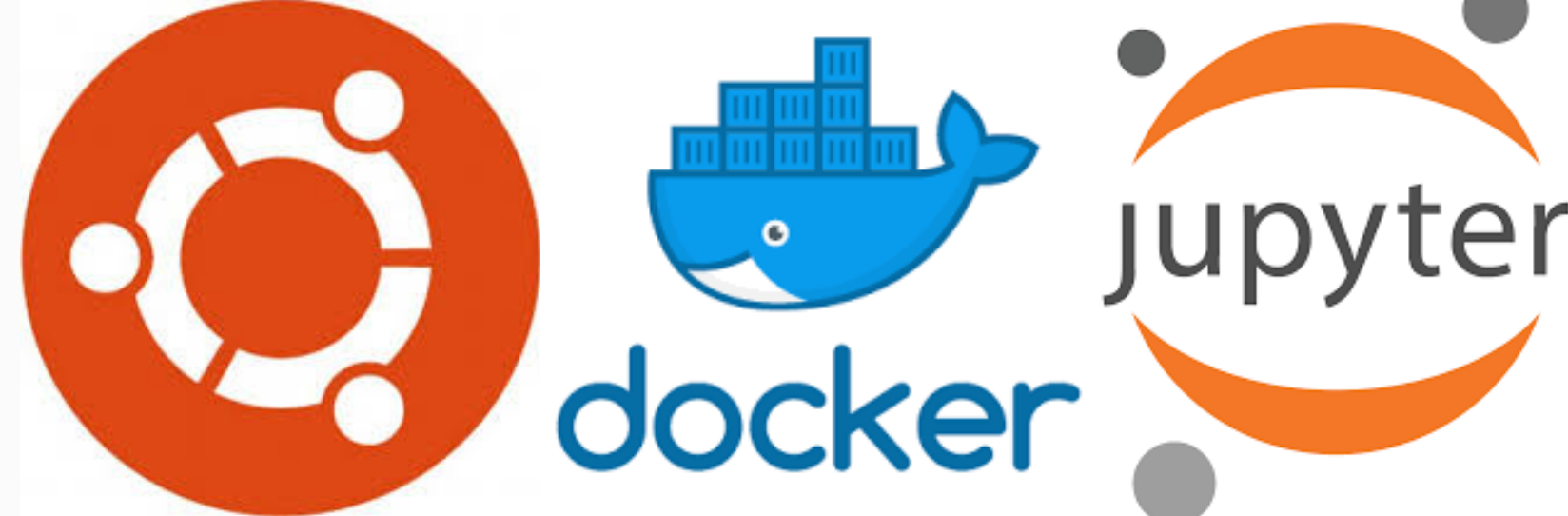
Physical Lab *not* accessible  
 VM too heavy on laptop  
 MiniNet too powerful

### New Lightweight Virtual Hosted Lab

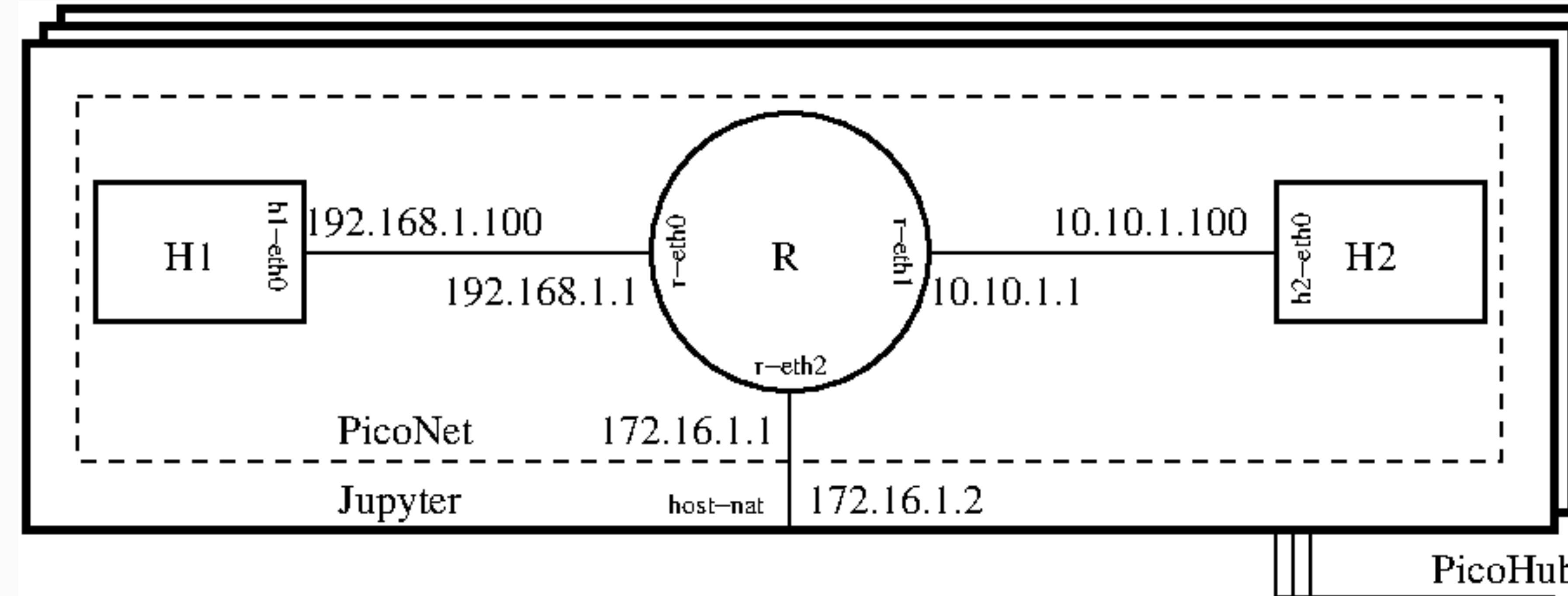


Hosted in the Cloud

Just a web browser on students laptop



### PicoNet: the Minimized MiniNet



<https://picohub.csc.uvic.ca>

```

File Edit View Run Kernel Tabs Settings Help
Terminal 1
root@h1:/home/jovyan# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
  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
  inet6 ::1/128 scope host
    valid_lft forever preferred_lft forever
5: h1-eth0@if4: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
  link/ether 72:f7:35:44:c5:39 brd ff:ff:ff:ff:ff:ff link-netns r
  inet 192.168.1.100/24 scope global h1-eth0
    valid_lft forever preferred_lft forever
  inet6 fe80::70f7:35f4:c539:64 scope link
    valid_lft forever preferred_lft forever
root@h1:/home/jovyan# ping -c 3 h2
PING h2 (10.10.1.100) 56(84) bytes of data:
64 bytes from h2 (10.10.1.100): icmp_seq=1 ttl=63 time=0.312 ms
64 bytes from h2 (10.10.1.100): icmp_seq=2 ttl=63 time=0.121 ms
64 bytes from h2 (10.10.1.100): icmp_seq=3 ttl=63 time=0.078 ms
--- h2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2046ms
rtt min/avg/max/mdev = 0.078/0.170/0.312/0.101 ms
root@h1:/home/jovyan#

Terminal 2
root@r:/home/jovyan# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
  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
  inet6 ::1/128 scope host
    valid_lft forever preferred_lft forever
7: h2-eth0@if6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
  link/ether ee:38:08:02:c6:4b brd ff:ff:ff:ff:ff:ff link-netns r
  inet 10.10.1.100/24 scope global h2-eth0
    valid_lft forever preferred_lft forever
  inet6 fe80::ee38:08ff:fe02:c64b scope link
    valid_lft forever preferred_lft forever
root@r:/home/jovyan#

Terminal 3
4: r-eth0@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
  link/ether f2:b0:63:6b:6d:9c brd ff:ff:ff:ff:ff:ff link-netns h1
  inet 192.168.1.1/24 scope global r-eth0
    valid_lft forever preferred_lft forever
  inet6 fe80::f0b0:63ff:fe6b:6d9c/64 scope link
    valid_lft forever preferred_lft forever
6: r-eth1@if7: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
  link/ether 1a:64:67:4b:72:6f brd ff:ff:ff:ff:ff:ff link-netns h2
  inet 10.10.1.1/24 scope global r-eth1
    valid_lft forever preferred_lft forever
  inet6 fe80::1a64:67ff:fe4b:726f/64 scope link
    valid_lft forever preferred_lft forever
9: r-eth2@if8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
  link/ether fec1:98:7f:c8:cf brd ff:ff:ff:ff:ff:ff link-netnsid 2
  inet 172.16.1.1/24 scope global r-eth2
    valid_lft forever preferred_lft forever
root@r:/home/jovyan#

Terminal 4
pan@jupyter:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
  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
  inet6 ::1/128 scope host
    valid_lft forever preferred_lft forever
3: eth0@if777: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1450 qdisc noqueue state UP group default qlen 1000
  link/ether 7e:ef:e4:6d:94:39 brd ff:ff:ff:ff:ff:ff link-netnsid 0
  inet 10.42.10.6/32 scope global eth0
    valid_lft forever preferred_lft forever
8: host-nat@if9: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
  link/ether b6:c0c0:0a:1a:64:67:4b:72:6f brd ff:ff:ff:ff:ff:ff link-netns r
  inet 172.16.1.2/32 scope global host-nat
    valid_lft forever preferred_lft forever
pan@jupyter:~$

Terminal 5
root@h1:/home/jovyan# tcpdump -n -l -i r-eth0
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on r-eth0, link-type EN10MB (Ethernet), capture size 262144 bytes
20:12:12.349144 ARP, Request who-has 192.168.1.1 tell 192.168.1.100, length 28
20:12:12.349212 IP 192.168.1.100 > 10.10.1.100: ICMP echo request, id 459, seq 1, length 64
20:12:12.349229 IP 10.10.1.100 > 192.168.1.100: ICMP echo reply, id=0x01cb, seq=1/256, ttl=64 (request in 3)
20:12:12.371459 IP 10.10.1.100 > 192.168.1.100: ICMP echo request, id 459, seq 2, length 64
20:12:12.371459 IP 10.10.1.100 > 192.168.1.100: ICMP echo reply, id=0x01cb, seq=2/256, ttl=64 (request in 3)
20:12:12.395130 IP 192.168.1.100 > 10.10.1.100: ICMP echo request, id 459, seq 3, length 64
20:12:12.395178 IP 10.10.1.100 > 192.168.1.100: ICMP echo reply, id=0x01cb, seq=3/768, ttl=64 (request in 5)
20:12:17.595073 ARP, Request who-has 192.168.1.100 tell 192.168.1.1, length 28
20:12:17.595131 ARP, Reply 192.168.1.100 is-at f2:b0:63:6b:6d:9c, length 28
root@h1:/home/jovyan#

Terminal 6
root@r:/home/jovyan# tcpdump -n -l -i r-eth0
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on r-eth0, link-type EN10MB (Ethernet), capture size 262144 bytes
^C10 packets captured
0 packets received by filter
0 packets dropped by kernel
root@r:/home/jovyan# mv /tmp/ping.cap .
root@r:/home/jovyan# tshark -r ping.cap
Running as user "root" and group "root". This could be dangerous.
  1  0.00000 1a:64:67:4b:72:6f → Broadcast ARP 42 Who has 10.10.1.100? Tell 10.10.1.1
  2  0.00034 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 10.10.1.100
  3  0.00041 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=1
  4  0.00109 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping) reply id=0x01cb, seq=1/256, ttl=64 (request in 3)
  5  1.022195 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=2
  6  1.022219 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping) reply id=0x01cb, seq=2/256, ttl=64 (request in 5)
  7  2.045924 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=3
  8  2.045941 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping) reply id=0x01cb, seq=3/768, ttl=64 (request in 7)
  9  5.245865 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 Who has 10.10.1.1? Tell 10.10.1.1
 10  5.245903 1a:64:67:4b:72:6f → ee:38:08:02:c6:4b ARP 42 10.10.1.1 is at 1a:64:67:4b:72:6f
root@r:/home/jovyan#

Terminal 7
root@h2:/home/jovyan# tcpdump -i h2-eth0 -Z root -w /tmp/ping.cap
tcpdump: listening on h2-eth0, link-type EN10MB (Ethernet), capture size 262144 bytes
^C10 packets captured
10 packets received by filter
0 packets dropped by kernel
root@h2:/home/jovyan# mv /tmp/ping.cap .
root@h2:/home/jovyan# tshark -r ping.cap
Running as user "root" and group "root". This could be dangerous.
  1  0.00000 1a:64:67:4b:72:6f → Broadcast ARP 42 Who has 10.10.1.100? Tell 10.10.1.1
  2  0.00034 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 10.10.1.100
  3  0.00041 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=1
  4  0.00109 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping) reply id=0x01cb, seq=1/256, ttl=64 (request in 3)
  5  1.022195 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=2
  6  1.022219 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping) reply id=0x01cb, seq=2/256, ttl=64 (request in 5)
  7  2.045924 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=3
  8  2.045941 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping) reply id=0x01cb, seq=3/768, ttl=64 (request in 7)
  9  5.245865 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 Who has 10.10.1.1? Tell 10.10.1.1
 10  5.245903 1a:64:67:4b:72:6f → ee:38:08:02:c6:4b ARP 42 10.10.1.1 is at 1a:64:67:4b:72:6f
root@h2:/home/jovyan#

Terminal 8
termshark 2.0.3 | ping.cap Analysis Misc
Filter: <Apply> <Recent>
No. Time Source Destination Protocol Length Info
  1  0.0000 1a:64:67:4b:72:6f → Broadcast ARP 42 Who has 10.10.1.100? Tell 10.10.1.1
  2  0.0003 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 10.10.1.100 is at ee:38:08:02:c6:4b
  3  0.0004 192.168.1.1 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=1
  4  0.0010 10.10.1.100 192.168.1.1 ICMP 98 Echo (ping) reply id=0x01cb, seq=1/256, ttl=64 (request in 3)
  5  1.0221 192.168.1.1 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=2
  6  1.0222 10.10.1.100 192.168.1.1 ICMP 98 Echo (ping) reply id=0x01cb, seq=2/256, ttl=64 (request in 5)
  7  2.0459 192.168.1.1 10.10.1.100 ICMP 98 Echo (ping) request id=0x01cb, seq=3
  8  2.0459 10.10.1.100 192.168.1.1 ICMP 98 Echo (ping) reply id=0x01cb, seq=3/768, ttl=64 (request in 7)
  9  5.2458 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 Who has 10.10.1.1? Tell 10.10.1.1
 10  5.2459 1a:64:67:4b:72:6f → ee:38:08:02:c6:4b ARP 42 10.10.1.1 is at 1a:64:67:4b:72:6f
[+] Frame 1: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface eth0
[+] Ethernet II, Src: 1a:64:67:4b:72:6f (1a:64:67:4b:72:6f), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
[+] Address Resolution Protocol (request)
0000 ff ff ff ff ff 1a 64 67 4b 72 6f 08 06 00 01 .....d gKro....
0010 08 00 06 04 00 01 1a 64 67 4b 72 6f 0a 0a 01 01 .....d gKro....
0020 00 00 00 00 00 00 0a 0a 01 64 .....d

```

```

root@h1:/home/jovyan# ping -c 3 h2
PING h2 (10.10.1.100) 56(84) bytes of data:
64 bytes from h2 (10.10.1.100): icmp_seq=1 ttl=63 time=0.312 ms
64 bytes from h2 (10.10.1.100): icmp_seq=2 ttl=63 time=0.121 ms
64 bytes from h2 (10.10.1.100): icmp_seq=3 ttl=63 time=0.078 ms
--- h2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2046ms
rtt min/avg/max/mdev = 0.078/0.170/0.312/0.101 ms

```

```

root@r:/home/jovyan# tcpdump -n -l -i r-eth0
tcpdump: verbose output suppressed, use -v or -vv for full protocol
listening on r-eth0, link-type EN10MB (Ethernet), capture size 262144
20:12:12.349144 ARP, Request who-has 192.168.1.1 tell 192.168.1.100,
20:12:12.349212 IP 192.168.1.100 > 10.10.1.100: ICMP echo request, id
20:12:12.349353 IP 10.10.1.100 > 192.168.1.100: ICMP echo reply, id
20:12:13.371383 IP 192.168.1.100 > 10.10.1.100: ICMP echo request, id
20:12:13.371459 IP 10.10.1.100 > 192.168.1.100: ICMP echo reply, id
20:12:14.395130 IP 192.168.1.100 > 10.10.1.100: ICMP echo request, id
20:12:14.395178 IP 10.10.1.100 > 192.168.1.100: ICMP echo reply, id
20:12:17.595073 ARP, Request who-has 192.168.1.100 tell 192.168.1.1,
20:12:17.595131 ARP, Reply 192.168.1.100 is-at f2:b0:63:6b:6d:9c,
^C
10 packets captured
10 packets received by filter
0 packets dropped by kernel

```

```

root@h2:/home/jovyan# tcpdump -i h2-eth0 -Z root -w /tmp/ping.cap
tcpdump: listening on h2-eth0, link-type EN10MB (Ethernet), capture
size 262144 bytes
^C10 packets captured
10 packets received by filter
0 packets dropped by kernel
root@h2:/home/jovyan# mv /tmp/ping.cap .
root@h2:/home/jovyan# tshark -r ping.cap
Running as user "root" and group "root". This could be dangerous.
  1  0.00000 1a:64:67:4b:72:6f → Broadcast ARP 42 Who has
  2  0.00034 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 10.10.1.100
  3  0.00041 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping)
  4  0.00109 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping)
  5  1.022195 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping)
  6  1.022219 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping)
  7  2.045924 192.168.1.100 → 10.10.1.100 ICMP 98 Echo (ping)
  8  2.045941 10.10.1.100 → 192.168.1.100 ICMP 98 Echo (ping)
  9  5.245865 ee:38:08:02:c6:4b → 1a:64:67:4b:72:6f ARP 42 Who has
 10  5.245903 1a:64:67:4b:72:6f → ee:38:08:02:c6:4b ARP 42 10.10.1.1

```

termshark 2.0.3 | ping.cap Analysis Misc

Filter: <Apply> <Recent>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.0000	1a:64:67:4b:72:6f	Broadcast	ARP	42	Who has 10.10.1.100? Tell 10.10.1.1
2	0.0003	ee:38:08:02:c6:4b	1a:64:67:4b:72:6f	ARP	42	10.10.1.100 is at ee:38:08:02:c6:4b
3	0.0004	192.168.1.1	10.10.1.100	ICMP	98	Echo (ping) request id=0x01cb, seq=1
4	0.0010	10.10.1.100	192.168.1.1	ICMP	98	Echo (ping) reply id=0x01cb, seq=1/256, ttl=64 (request in 3)
5	1.0221	192.168.1.1	10.10.1.100	ICMP	98	Echo (ping) request id=0x01cb, seq=2
6	1.0222	10.10.1.100	192.168.1.1	ICMP	98	Echo (ping) reply id=0x01cb, seq=2/256, ttl=64 (request in 5)
7	2.0459	192.168.1.1	10.10.1.100	ICMP	98	Echo (ping) request id=0x01cb, seq=3
8	2.0459	10.10.1.100	192.168.1.1	ICMP	98	Echo (ping) reply id=0x01cb, seq=3/768, ttl=64 (request in 7)
9	5.2458	ee:38:08:02:c6:4b	1a:64:67:4b:72:6f	ARP	42	Who has 10.10.1.1? Tell 10.10.1.1
10	5.2459	1a:64:67:4b:72:6f	ee:38:08:02:c6:4b	ARP	42	10.10.1.1 is at 1a:64:67:4b:72:6f

[+] Frame 1: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface eth0  
 [+] Ethernet II, Src: 1a:64:67:4b:72:6f (1a:64:67:4b:72:6f), Dst: Broadcast (ff:ff:ff:ff:ff:ff)  
 [+] Address Resolution Protocol (request)

```

0000 ff ff ff ff ff 1a 64 67 4b 72 6f 08 06 00 01 .....d gKro....
0010 08 00 06 04 00 01 1a 64 67 4b 72 6f 0a 0a 01 01 .....d gKro....
0020 00 00 00 00 00 00 0a 0a 01 64 .....d

```

More Lab modules on  
 HTTP, DNS, TCP, UDP  
 IP, NAT, ICMP, routing  
 Ethernet, ARP  
 and more at  
<http://tinyurl.com/picohub>

Thanks: Mantis, Miguel, Tomas  
 Victoria, Zhiming, Rui, Wenjun

