IP routing
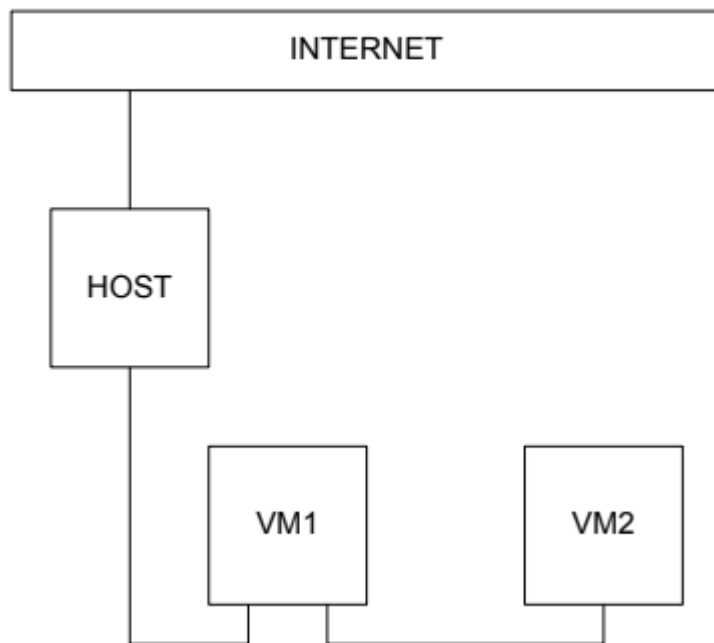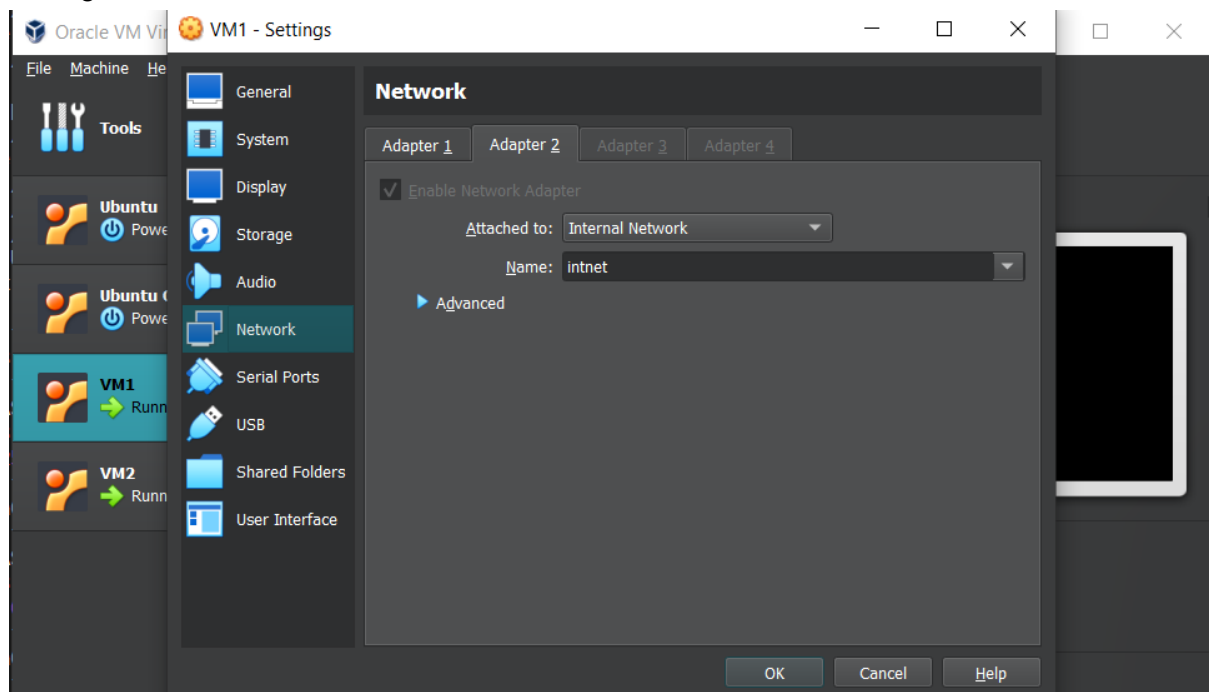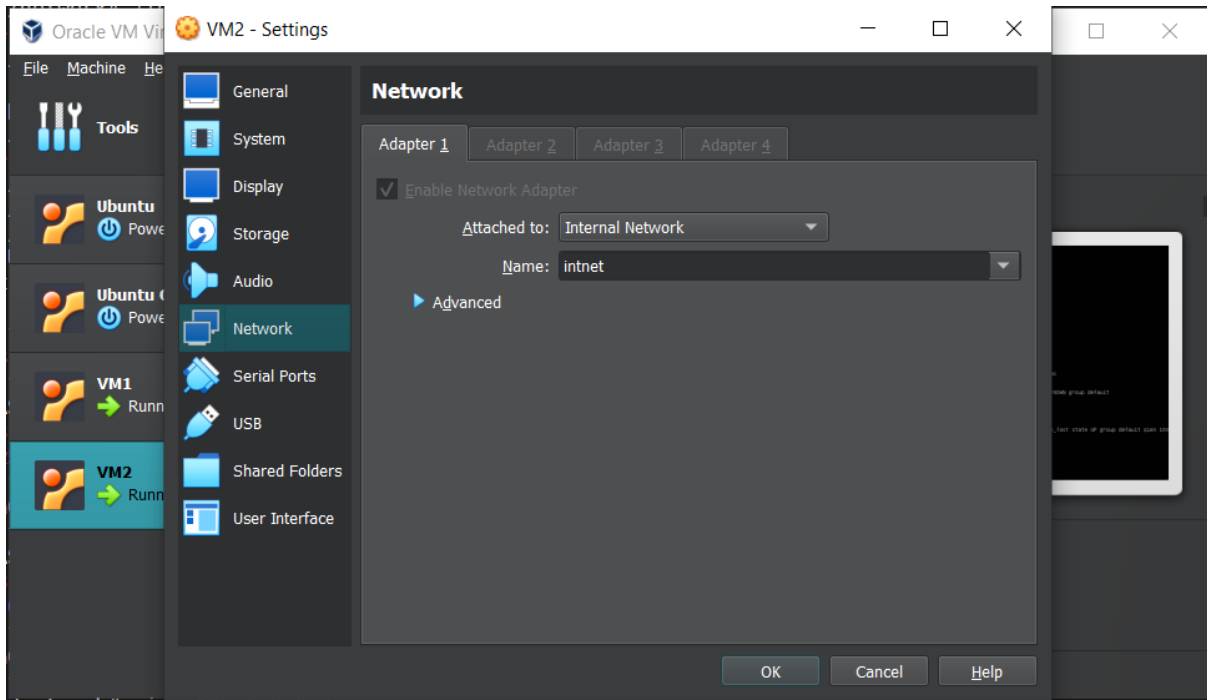1. Create virtual machines connection according to figure 1:

Figure 1 – VMs connection

Adding an internal network interface for the first VM:

And for the second (it would be the only interface):

2. VM2 has one interface (internal), VM1 has 2 interfaces (NAT and internal). Configure all network interfaces in order to make VM2 have access to the Internet (iptables, forward, masquerade).

Firstly, we need to specify static ip addresses for a VM2 - here, the only interface that is not a loopback is looking into the internal network, and VM2 has a static address of 192.168.0.2 with 192.168.0.1 being its default gateway and 8.8.8.8 a default nameserver address:

```
  GNU nano 2.2.6                      File: interfaces

# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
auto eth0
iface eth0 inet static
address 192.168.0.2
netmask 255.255.255.0
gateway 192.168.0.1
dns-nameservers 8.8.8.8




                                   [ Read 14 lines ]
^G Get Help    ^O WriteOut    ^R Read File   ^Y Prev Page   ^K Cut Text    ^C Cur Pos
^X Exit        ^J Justify     ^W Where Is    ^V Next Page   ^U UnCut Text  ^T To Spell
```

Also, we need to setup the second interface, eth1, into the VM1, to have a static address of
192.168.0.1, itself as a gateway and a same default nameserver:

```
 6. VM1                              ×      +

  GNU nano 2.2.6                                       File: interfaces

# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
auto eth0
iface eth0 inet dhcp

#auto eth1
iface eth1 inet static
address 192.168.0.1
netmask 255.255.255.0
gateway 192.168.0.1
dns-nameservers 8.8.8.8
```

After reloading the needed network interfaces, on VM1 and VM2, the aforementioned addresses, gateways etc. should be set up, checking by ip addr command:

VM1:

```
root@CsnKhai:/etc/network# ip addr
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
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:6c:48:31 brd ff:ff:ff:ff:ff:ff
    inet 172.21.253.229/20 brd 172.21.255.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fe6c:4831/64 scope link
       valid_lft forever preferred_lft forever
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:de:39:ef brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.1/24 brd 192.168.0.255 scope global eth1
       valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fede:39ef/64 scope link
       valid_lft forever preferred_lft forever
```

VM2:

```
root@CsnKhai:/etc/network# ip addr
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
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 100
0
    link/ether 08:00:27:d8:4c:39 brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.2/24 brd 192.168.0.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fed8:4c39/64 scope link
       valid_lft forever preferred_lft forever
root@CsnKhai:/etc/network# _
```

Checking basic connectivity by pinging VMs one from another:

From VM2 to VM1:

```
root@CsnKhai:/etc/network# ping 192.168.0.1
PING 192.168.0.1 (192.168.0.1) 56(84) bytes of data.
64 bytes from 192.168.0.1: icmp_seq=1 ttl=64 time=1.14 ms
64 bytes from 192.168.0.1: icmp_seq=2 ttl=64 time=1.35 ms
64 bytes from 192.168.0.1: icmp_seq=3 ttl=64 time=3.33 ms
64 bytes from 192.168.0.1: icmp_seq=4 ttl=64 time=3.12 ms
64 bytes from 192.168.0.1: icmp_seq=5 ttl=64 time=1.56 ms
64 bytes from 192.168.0.1: icmp_seq=6 ttl=64 time=2.26 ms
^C
--- 192.168.0.1 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5011ms
rtt min/avg/max/mdev = 1.144/2.129/3.335/0.854 ms
root@CsnKhai:/etc/network#
```

From VM1 to VM2:

```
root@CsnKhai:/etc/network# ping 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=64 time=2.51 ms
64 bytes from 192.168.0.2: icmp_seq=2 ttl=64 time=1.33 ms
64 bytes from 192.168.0.2: icmp_seq=3 ttl=64 time=1.51 ms
64 bytes from 192.168.0.2: icmp_seq=4 ttl=64 time=1.29 ms
64 bytes from 192.168.0.2: icmp_seq=5 ttl=64 time=2.54 ms
64 bytes from 192.168.0.2: icmp_seq=6 ttl=64 time=1.35 ms
^C
--- 192.168.0.2 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5016ms
```

To enable the forwarding option for iptables, in file sysctl.conf, this line needs to be uncommented:

```
  GNU nano 2.2.6                                    File: sysctl.conf

#
# /etc/sysctl.conf - Configuration file for setting system variables
# See /etc/sysctl.d/ for additional system variables.
# See sysctl.conf (5) for information.
#

#kernel.domainname = example.com

# Uncomment the following to stop low-level messages on console
#kernel.printk = 3 4 1 3

###############################################################3
# Functions previously found in netbase
#

# Uncomment the next two lines to enable Spoof protection (reverse-path filter)
# Turn on Source Address Verification in all interfaces to
# prevent some spoofing attacks
#net.ipv4.conf.default.rp_filter=1
#net.ipv4.conf.all.rp_filter=1

# Uncomment the next line to enable TCP/IP SYN cookies
# See http://lwn.net/Articles/277146/
# Note: This may impact IPv6 TCP sessions too
#net.ipv4.tcp_syncookies=1

# Uncomment the next line to enable packet forwarding for IPv4
net.ipv4.ip_forward=1

# Uncomment the next line to enable packet forwarding for IPv6
#  Enabling this option disables Stateless Address Autoconfiguration
#  based on Router Advertisements for this host
#net.ipv6.conf.all.forwarding=1


##############################################################
# Additional settings - these settings can improve the network

^G Get Help          ^O WriteOut          ^R Read File          ^Y
^X Exit              ^J Justify           ^W Where Is           ^V
```

After that, setting up a rule for Masquerade nat forwarding using iptables on VM1:

```
root@CsnKhai:~# iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
root@CsnKhai:~# iptables -S
-P INPUT ACCEPT
-P FORWARD ACCEPT
-P OUTPUT ACCEPT
```

And some additional rules (without them, the dns surprisingly doesn't work):

```
root@CsnKhai:/etc# iptables -A FORWARD -i eth1 -o eth0 -m state --state RELATED,ESTABLISHED -j ACCEPT
root@CsnKhai:/etc# iptables -A FORWARD -i eth1 -o eth0 -j ACCEPT
root@CsnKhai:/etc# iptables -S
-P INPUT ACCEPT
-P FORWARD ACCEPT
-P OUTPUT ACCEPT
-A FORWARD -i eth1 -o eth0 -m state --state RELATED,ESTABLISHED -j ACCEPT
-A FORWARD -i eth1 -o eth0 -j ACCEPT
root@CsnKhai:/etc#
```

3. Check the route from VM2 to Host.

```
root@CsnKhai:/etc/network# ping 192.168.0.1
PING 192.168.0.1 (192.168.0.1) 56(84) bytes of data.
64 bytes from 192.168.0.1: icmp_seq=1 ttl=64 time=1.16 ms
64 bytes from 192.168.0.1: icmp_seq=2 ttl=64 time=1.42 ms
64 bytes from 192.168.0.1: icmp_seq=3 ttl=64 time=1.98 ms
64 bytes from 192.168.0.1: icmp_seq=4 ttl=64 time=1.45 ms
^C
--- 192.168.0.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3007ms
rtt min/avg/max/mdev = 1.164/1.506/1.988/0.303 ms
root@CsnKhai:/etc/network#
```

4. Check the access to the Internet, (just ping, for example, 8.8.8.8).

Now, the VM2 can ping outer internet addresses, such as 8.8.8.8:

```
root@CsnKhai:/etc/network# ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=116 time=18.5 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=116 time=20.1 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=116 time=19.5 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=116 time=18.8 ms
^C
--- 8.8.8.8 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 18.588/19.293/20.183/0.618 ms
root@CsnKhai:/etc/network#
```

5. Determine, which resource has an IP address 8.8.8.8.

```
root@CsnKhai:/etc# dig 8.8.8.8

; <<>> DiG 9.9.5-3ubuntu0.5-Ubuntu <<>> 8.8.8.8
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NXDOMAIN, id: 38742
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;8.8.8.8.                        IN      A

;; AUTHORITY SECTION:
.                       3600    IN      SOA     a.root-servers.net. nstld.verisign-grs.com. 20230821
00 1800 900 604800 86400

;; Query time: 12 msec
;; SERVER: 8.8.8.8#53(8.8.8.8)
;; WHEN: Mon Aug 21 18:27:22 UTC 2023
;; MSG SIZE  rcvd: 111

root@CsnKhai:/etc# _
```

6. Determine, which IP address belongs to resource epam.com.

It also can be done using the dig command:

```
; <<>> DiG 9.9.5-3ubuntu0.5-Ubuntu <<>> epam.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 15016
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 6, ADDITIONAL: 8

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;epam.com.                       IN      A

;; ANSWER SECTION:
epam.com.               3196    IN      A       3.214.134.159

;; AUTHORITY SECTION:
epam.com.               9566    IN      NS      a14-66.akam.net.
epam.com.               9566    IN      NS      a1-195.akam.net.
epam.com.               9566    IN      NS      a11-65.akam.net.
epam.com.               9566    IN      NS      a20-67.akam.net.
epam.com.               9566    IN      NS      a7-64.akam.net.
epam.com.               9566    IN      NS      a10-64.akam.net.

;; ADDITIONAL SECTION:
a7-64.akam.net.         9659    IN      A       23.61.199.64
a1-195.akam.net.        1259    IN      A       193.108.91.195
a10-64.akam.net.        7882    IN      A       96.7.50.64
a11-65.akam.net.        4150    IN      A       84.53.139.65
a14-66.akam.net.        9519    IN      A       184.26.161.66
a20-67.akam.net.        8737    IN      A       95.100.175.67
a20-67.akam.net.        6304    IN      AAAA    2a02:26f0:67::43

;; Query time: 16 msec
;; SERVER: 8.8.8.8#53(8.8.8.8)
;; WHEN: Mon Aug 21 18:27:55 UTC 2023
;; MSG SIZE  rcvd: 310

root@CsnKhai:/etc# _
```

7. Determine the default gateway for your HOST and display routing table.

Default gateway stands by the words "default via":

```
root@CsnKhai:/etc# ip route
default via 192.168.0.1 dev eth0
192.168.0.0/24 dev eth0   proto kernel   scope link   src 192.168.0.2
root@CsnKhai:/etc#
```

8. Trace the route to google.com.

So, the first entry here is VM1 with an address of 192.168.0.1, the second is my laptop hardware network adapter, the third one is a router and so on:

```
root@CsnKhai:/etc# traceroute google.com
traceroute to google.com (216.58.215.78), 30 hops max, 60 byte packets
 1  192.168.0.1 (192.168.0.1)  1.530 ms  1.111 ms  0.742 ms
 2  172.21.240.1 (172.21.240.1)  7.555 ms  7.191 ms  6.738 ms
 3  192.168.31.1 (192.168.31.1)  6.071 ms  5.693 ms  6.197 ms
 4  local-gw.142.teremki.kiev.ua (195.211.142.1)  5.812 ms  5.491 ms  7.971 ms
 5  inet-ua.teremki.net.ua (194.31.47.193)  7.609 ms  16.083 ms  15.634 ms
 6  ae-20g-969.19.gw.as6723.net (178.255.178.11)  6.026 ms  9.272 ms  8.870 ms
 7  ae-20G-1714.19.gw.as6723.net (194.44.88.21)  4.195 ms  4.018 ms  3.543 ms
 8  209.85.168.96 (209.85.168.96)  4.946 ms  5.335 ms  4.924 ms
 9  108.170.248.155 (108.170.248.155)  4.327 ms  3.800 ms  4.289 ms
10  72.14.239.111 (72.14.239.111)  5.805 ms  5.138 ms  4.663 ms
11  108.170.250.209 (108.170.250.209)  18.254 ms 142.250.46.55 (142.250.46.55)  17.812 ms  18.240 ms
12  108.170.250.209 (108.170.250.209)  17.878 ms  20.136 ms 108.170.234.103 (108.170.234.103)  19.75
7 ms
13  108.170.234.103 (108.170.234.103)  19.382 ms waw02s16-in-f14.1e100.net (216.58.215.78)  18.762 m
s 108.170.234.103 (108.170.234.103)  18.706 ms
root@CsnKhai:/etc#
```