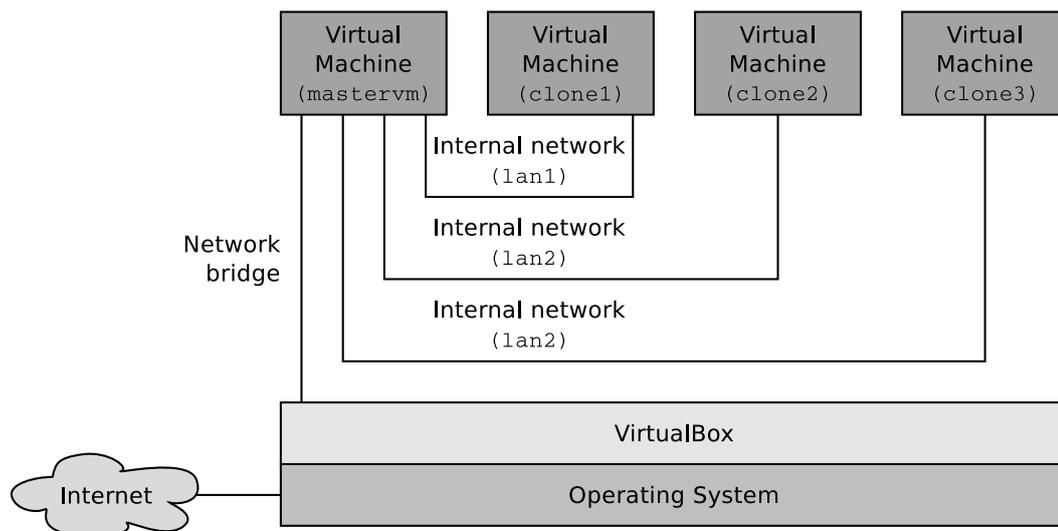


## Lab Exercise Sheet 4 – (Sample Solution)

Document and analyze your experimental procedures by using your Wireshark and terminal recordings. Note all relevant intermediate steps. Mark and explain all relevant information, such as protocol header fields, MAC addresses, IP addresses, port numbers. If you have little experience with Linux, you may need to do some research. **Send your self prepared experiment documentation in the PDF file format to [cocos@stud.fra-uas.de](mailto:cocos@stud.fra-uas.de) and [christianbaun@fb2.fra-uas.de](mailto:christianbaun@fb2.fra-uas.de). Alternatively, fill out the document, print it out, and submit it during one of the exercise sessions.**

### Sample Solution (No Guarantee !!!)

1. In the 2<sup>nd</sup> lab exercise you created four VMs (`mastervm` and `clonevm[1-3]`). You also configured the network infrastructure in a way that you have a logical Bridge or alternatively IP package forwarding (NAT-Masquerading).



Now, install a DHCP server (package `isc-dhcp-server`) and a DNS server (package `dnsmasq`) on the `mastervm`.

Configure the DHCP server in a way that `clonevm[1-3]` get their network configurations assigned automatically. You also need to modify the file `/etc/network/interfaces` on `clonevm[1-3]` in a way that these VMs use DHCP for their virtual network interfaces.

Configure the DNS server and the DHCP server on the `mastervm` in a way that `clonevm[1-3]` use the DNS server on the `mastervm` as name server.

Explain how you configured the DHCP and the DNS server on the `mastervm` and copy the relevant content of the configuration files into these fields:

```
#!/etc/network/interfaces

auto lo
iface lo inet loopback

# WAN Interface
auto enp0s3
iface enp0s3 inet dhcp

# LAN 1
auto enp0s8
iface enp0s8 inet static
address 192.168.1.1
netmask 255.255.255.0
broadcast 192.168.1.255

# LAN 2
auto enp0s9
iface enp0s9 inet static
address 192.168.2.1
netmask 255.255.255.0
broadcast 192.168.2.255

# LAN 3
auto enp0s10
iface enp0s10 inet static
address 192.168.3.1
netmask 255.255.255.0
broadcast 192.168.3.255

# Delete previous iptables configuration
up /sbin/iptables -F
up /sbin/iptables -X
up /sbin/iptables -t nat -F

# Enable NAT-Forwarding for all interfaces
up /sbin/iptables -A FORWARD -o enp0s3 -s 0.0.0.0/0 -m conntrack
  --ctstate NEW -j ACCEPT
up /sbin/iptables -A FORWARD -m conntrack --ctstate ESTABLISHED,
  RELATED -j ACCEPT
up /sbin/iptables -t nat -A POSTROUTING -o enp0s3 -j MASQUERADE
up /sbin/sysctl -w net.ipv4.ip_forward=1

# Enable dnsmasq
up /etc/init.d/dnsmasq restart
```

```
#!/etc/dnsmasq.conf

# enable DHCP-Server for the following interfaces
interface=enp0s8
interface=enp0s9
interface=enp0s10

# interface enp0s3 has no dhcp because it is the WAN-interface
no-dhcp-interface=enp0s3

# Define IP-Address Ranges for the interfaces
dhcp-range=interface:enp0s8,192.168.1.50,192.168.1.150,infinite
dhcp-range=interface:enp0s9,192.168.2.50,192.168.2.150,infinite
dhcp-range=interface:enp0s10,192.168.3.50,192.168.3.150,infinite

# assign IP-Address according to MAC-Address
dhcp-host=08:00:27:e8:a4:af,clone1,192.168.1.10,infinite
dhcp-host=08:00:27:a1:25:5c,clone2,192.168.2.20,infinite
dhcp-host=08:00:27:cb:0f:3e,clone3,192.168.3.30,infinite
listen-address=127.0.0.1
listen-address=192.168.1.1
listen-address=192.168.2.1
listen-address=192.168.3.1

#port=53
#domain-needed
#bogus-priv
#resolv-file=/etc/resolv.dnsmasq
#bind-interfaces
#domain=master.home
```

```
#!/etc/hosts

127.0.0.1 localhost master
#127.0.1.1 master

# The following lines are desirable for IPv6 capable hosts
::1 localhost ip6-localhost ip6-loopback
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

intranet.master.org master
192.168.1.10 intranet.clone1.org clone1
192.168.2.20 intranet.clone2.org clone2
192.168.3.30 intranet.clone3.org clone3
```

2. Install a web server software (e.g. nginx or the Apache HTTP server) on `clonevm[1-3]`. Install a HTTP load balancer software (e.g. nginx<sup>1</sup> or HAProxy<sup>2</sup>) on the `mastervm`. The Ubuntu Linux distribution provides packages for all these software solutions.

Configure the load balancer software on the `mastervm` in a way that incoming HTTP requests are forwarded (round-robin load balancing) to the web servers on `clonevm[1-3]`.

Explain how you configured the load balancer software on the `mastervm` and copy the relevant content of the configuration file(s) into these fields:

```
#!/etc/apache2/sites-available/000-default.conf

<VirtualHost *:80>

    ServerName master
    #DocumentRoot /var/www/html

    <Proxy balancer://mycluster/>

        BalancerMember http://master:80
        BalancerMember http://clone1:80
        BalancerMember http://clone2:80
        BalancerMember http://clone3:80

    </Proxy>

    #ProxyPreserveHost On

    ProxyPass / balancer://mycluster/
    ProxyPassReverse / balancer://mycluster/

    ServerAdmin webmaster@localhost
    DocumentRoot /var/www/html

    ErrorLog ${APACHE_LOG_DIR}/error.log
    CustomLog ${APACHE_LOG_DIR}/access.log combined

</VirtualHost>
```

---

<sup>1</sup>[http://nginx.org/en/docs/http/load\\_balancing.html](http://nginx.org/en/docs/http/load_balancing.html)

<sup>2</sup><http://www.haproxy.org>

The configuration above is used to configure the loadbalancer on the master. There we define the BalancerMembers `clone1` to `clone3` which are defined in the `/etc/hosts` File of the `mastervm`. To enable Loadbalancing on the master we have to install `apache2-utils` and enable the following modules:

```
- sudo a2enmod proxy
- sudo a2enmod proxy_http
- sudo a2enmod proxy_balancer
- sudo a2enmod lbmethod_byrequests
```

Then we restart the webserver with the following command:

```
- sudo systemctl restart apache2.service
```

We can test the webserver:

```
- lynx clone[1-3]
```

By enabling promiscuous mode in VirtualBox for the host we can access the webservers with:

```
- lynx http://<IP-Address of Master>
```

or

type `http://<IP-Address of Master>` into your webbrowser

**(See Screenshots 1 to 3!)**

Explain how you configured the web server software on `clonevm[1-3]` and copy the relevant content of the configuration file(s) into these fields:

Just install the webserver software `apache2`  
Then copy a new HTML Page to `/var/www/html/` and adjust the page  
Restart `apache` and then you are good to go!  
Here the HTML File used on the hosts `clone[1-3]`

```
<!DOCTYPE html PUBLIC "-//IETF//DTD HTML 2.0//EN">
<HTML>
<HEAD>
<TITLE>
A Small Hello From <Hostname>
</TITLE>
</HEAD>
<BODY>
<H1>Hi I am <Hostname></H1>
<P>This is very minimal "hello world" HTML document.</P>
</BODY>
</HTML>
```

Check the relevant MAC addresses and write them into this table:

Your local Router to the internet:	34:31:c4:74:70:92
Physical network interface of your host:	4c:34:88:9e:4d:28
mastervm (bridged interface):	08:00:27:52:da:cd
mastervm (internal interface 1):	08:00:27:ff:6d:96
mastervm (internal interface 2):	08:00:27:33:3c:aa
mastervm (internal interface 3):	08:00:27:28:73:72
clonevm1 (internal interface):	08:00:27:e8:a4:af
clonevm2 (internal interface):	08:00:27:a1:25:5c
clonevm3 (internal interface):	08:00:27:cb:0f:3e

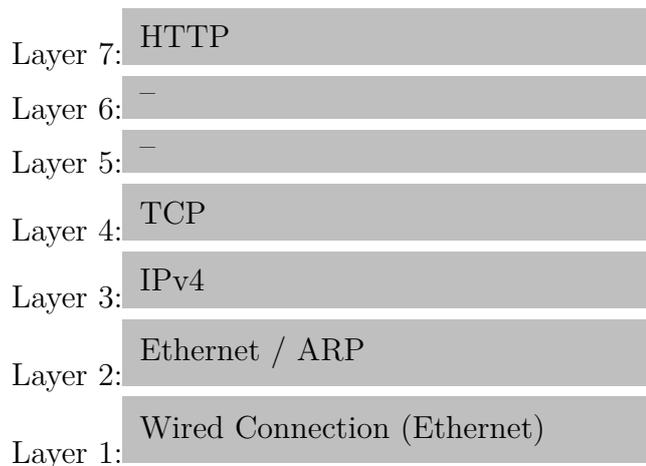
Check the relevant IP addresses and write them into this table:

Your local Router to the internet:	192.168.0.1
Physical network interface of your host:	192.168.0.8
mastervm (bridged interface):	192.168.0.10
mastervm (internal interface 1):	192.168.1.1
mastervm (internal interface 2):	192.168.2.1
mastervm (internal interface 3):	192.168.3.1
clonevm1 (internal interface):	192.168.1.10
clonevm2 (internal interface):	192.168.2.20
clonevm3 (internal interface):	192.168.3.30

Send HTTP requests from your physical host (in other words: send from your host operating system) to the running load balancer. Now, the load balancer should distribute the HTTP requests to the available web servers. Make this visible by slightly modifying the default web pages of the installed web server software.

Monitor with Wireshark on the `mastervm` the forwarding of the HTTP requests and the replies from the web servers.

Which network protocols are involved in the transmission of the HTTP requests/replies? Assign them to the protocol stack.



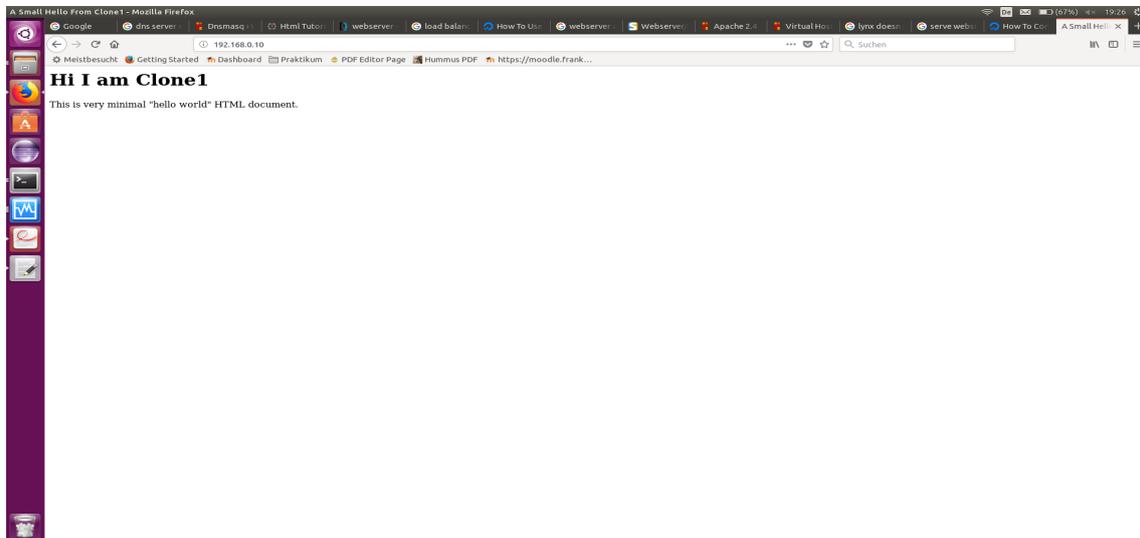


Abbildung 1: Screenshot of clone1

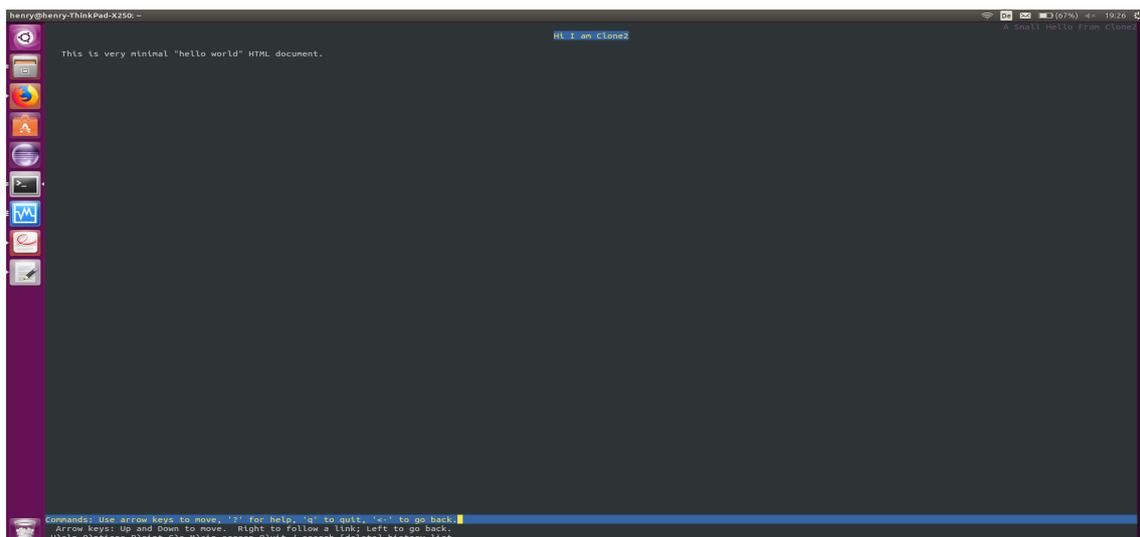


Abbildung 2: Screenshot of clone2

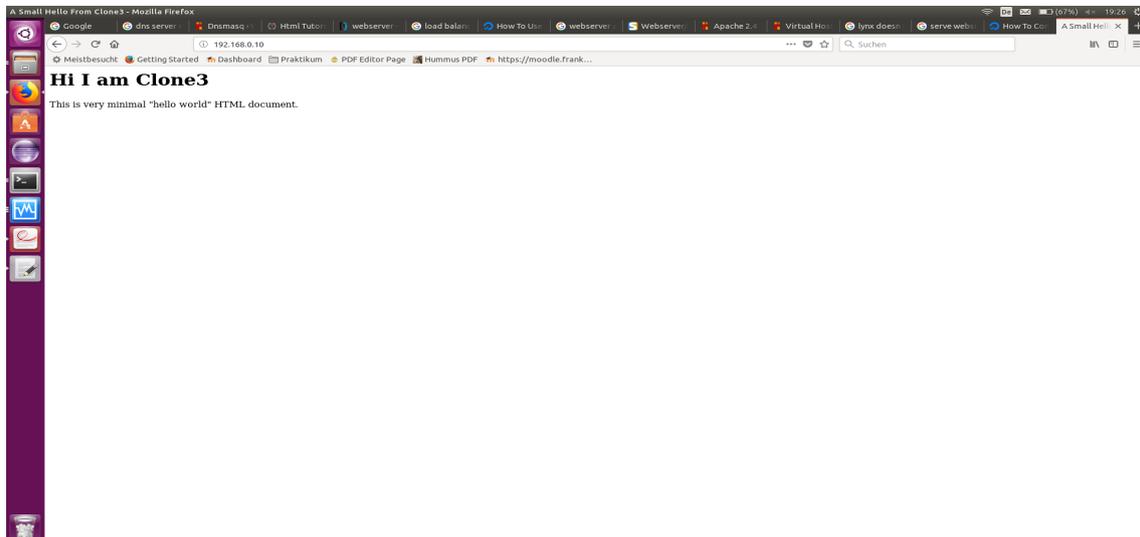


Abbildung 3: Screenshot of clone3