

# *Project Netwerken*

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## 1 Network Topology

The main IP-address that needs to be divided into four subnets is: 58.89.30.111/24. The subnet consists of the following IP-addresses:

- **Subnet A:** 58.89.30.64/26

- A.1: 58.89.30.80/28
- A.2: 58.89.30.96/28

- **Subnet B:** 58.89.30.128/26

- B.1: 58.89.30.144/28
- B.2: 58.89.30.160/28

This is done by determining the subnet mask, calculating the subnet increment, calculating the new subnet mask and determining subnet ranges. In [Figure 1](#) is the whole network shown, which is made with *Cisco Packet Tracer*.

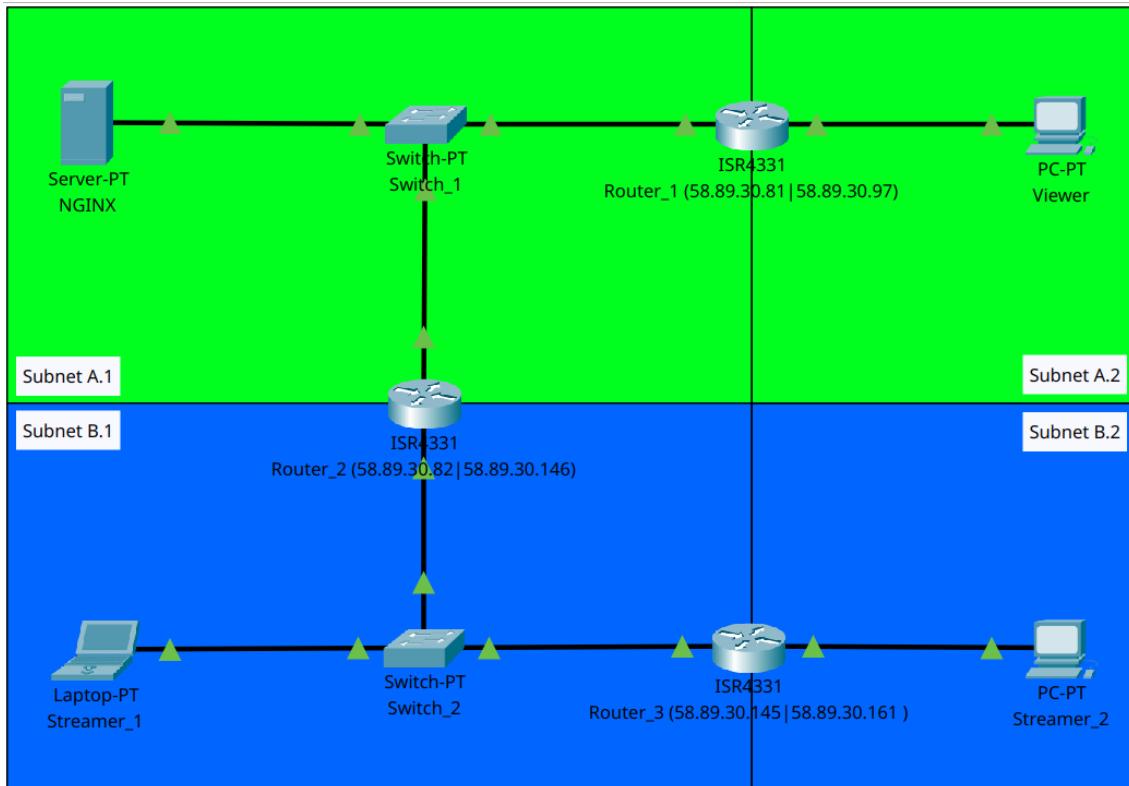


Figure 1: Our network made within *Cisco Packet Tracer*.

## 2 Roles

Our group for project network consists of four students and we all had a role:

- **Semih:**

- Router 2. Main role is the connectivity between subnet *A* and *B*;
- Streamer 1.

- **Ferhat:**

- Router 3. Main role is the connectivity between subnet *B.1* and *B.2*. Router 3 is also a DHCP-server;
- Streamer 2.

- **Marvin:**

- Nginx. This server is going to receive the media stream from the Raspberry Pi, decrypt it, authenticate and serve it as both HLS and Dash.

- **Thom:**

- Router 1. Main role is the connectivity between subnet *A.1* and *A.2*. Router 3 is also a DNS-server and DHCP-server;
- Viewer.

### 3 Streaming

My role is to be both *Router\_2* and *Streamer\_1* in subnet B.1 as seen in [Figure 1](#). *Router\_2* has IPv4-forwarding enabled to act as a router.

#### 3.1 Configuring IPv4-static routes

Adding an IP-route is important for connectivity between all the devices. This is done with the following Linux command: “*sudo ip route add (IP-1) via (IP-2)*”. *IP-1* and *IP-2* are both variable IPv4-addresses. There was also a static route added for *Router\_1* to redirect any packages going from:

- 58.89.30.128/26 (*subnet A*) via 58.89.30.82 (*router\_2*) with subnet mask 255.255.255.192.

There were also two static routes added for *Router\_2* to redirect any packages going from:

- 58.89.30.96/28 (*subnet A.2*) via 58.89.30.81 (*subnet A.1*) with subnet mask 255.255.255.240;
- 58.89.30.160/28 (*subnet B.2*) via 58.89.30.145 (*subnet B.1*) with subnet mask 255.255.255.240.

There was also a static route added for *Router\_3* to redirect any packages going from:

- 58.89.30.64/26 (*subnet B*) via 58.89.30.146 (*router\_2*) with subnet mask 255.255.255.192.

After configuring the routers properly, [Figure 2](#) and [Figure 3](#) confirm that I (as *Router\_2*) was able to ping every device in both subnet A and B.

#### 3.2 FFmpeg streaming

In order to stream something, *streamer\_1* and *streamer\_2* had to install a program called *FFmpeg*. FFmpeg is a great tool to compress, convert, edit videos and images. It can also be used to stream a webcam or desktop environment. In order to stream my webcam, I entered the following command (for both *streamer\_1* and *streamer\_2*):

```
ffmpeg -f v4l2 -i /dev/video0 \
    -c:v libx264 -pix_fmt yuv420p -framerate 15 -g 30 -b:v 500k \
    -preset ultrafast -tune zerolatency \
    -f flv "rtmp://58.89.30.83:4000/live/cam1?streamkey=123"
```

In this command above, we captured the video source from the webcam using Video4Linux, compresses it and streams it to the RTMP-server, which in this case is: *Nginx* (58.89.30.83) in subnet A.1 seen in [Figure 1](#). It is also possible to stream my desktop environment by using *x11grab* as shown in the following command below:

```
ffmpeg -video_size 1920x1080 -framerate 30 -f x11grab -i :0.0 \
    -c:v libx264 -pix_fmt yuv420p -framerate 15 -g 30 -b:v 500k \
    -preset ultrafast -tune zerolatency \
    -f flv "rtmp://58.89.30.83:4000/live/cam1?streamkey=123"
```

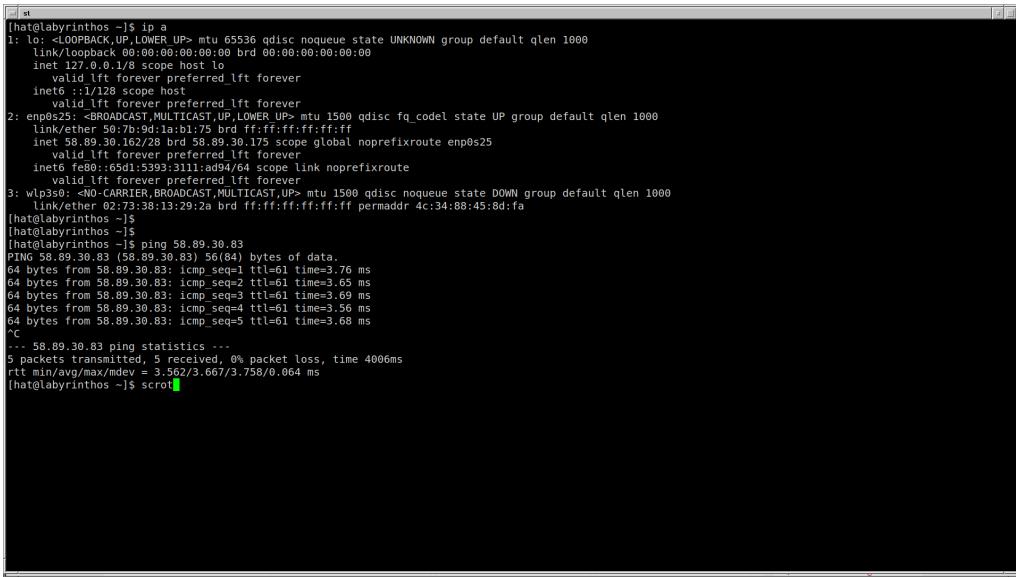
Both commands worked on *streamer\_1* as well for *streamer\_2*. The viewer was able to connect to the RTMP-server and fetch the stream successfully! It does work as shown in [Figure 5](#), [Figure 6](#), [Figure 7](#) and [Figure 8](#), unfortunately there is a lot of latency. In the real world however, this won't matter as much because the streamer and viewer won't be sitting in the same room anyway. So latency would not be noticed that rapidly.

```
semih@broodjesemih:~ $ ping 58.89.30.145
PING 58.89.30.145 (58.89.30.145) 56(84) bytes of data.
64 bytes from 58.89.30.145: icmp_seq=1 ttl=64 time=0.565 ms
64 bytes from 58.89.30.145: icmp_seq=2 ttl=64 time=0.483 ms
^C
--- 58.89.30.145 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1018ms
rtt min/avg/max/mdev = 0.483/0.524/0.565/0.041 ms
semih@broodjesemih:~ $ ping 58.89.30.161
PING 58.89.30.161 (58.89.30.161) 56(84) bytes of data.
64 bytes from 58.89.30.161: icmp_seq=1 ttl=64 time=0.562 ms
64 bytes from 58.89.30.161: icmp_seq=2 ttl=64 time=0.411 ms
^C
--- 58.89.30.161 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1008ms
rtt min/avg/max/mdev = 0.411/0.486/0.562/0.075 ms
semih@broodjesemih:~ $ ping 58.89.30.162
PING 58.89.30.162 (58.89.30.162) 56(84) bytes of data.
64 bytes from 58.89.30.162: icmp_seq=1 ttl=63 time=1.87 ms
64 bytes from 58.89.30.162: icmp_seq=2 ttl=63 time=1.90 ms
^C
--- 58.89.30.162 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 1.865/1.880/1.896/0.015 ms
semih@broodjesemih:~ $ ping 58.89.30.147
PING 58.89.30.147 (58.89.30.147) 56(84) bytes of data.
64 bytes from 58.89.30.147: icmp_seq=1 ttl=64 time=0.654 ms
64 bytes from 58.89.30.147: icmp_seq=2 ttl=64 time=0.751 ms
^C
--- 58.89.30.147 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.654/0.702/0.751/0.048 ms
semih@broodjesemih:~ $
```

Figure 2: It's possible to ping every device on the network (pt.1).

```
semih@broodjesemih:~ $ ping 58.89.30.97
PING 58.89.30.97 (58.89.30.97) 56(84) bytes of data.
64 bytes from 58.89.30.97: icmp_seq=1 ttl=64 time=1.58 ms
64 bytes from 58.89.30.97: icmp_seq=2 ttl=64 time=1.51 ms
^C
--- 58.89.30.97 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 1.513/1.545/1.578/0.032 ms
semih@broodjesemih:~ $ ping 58.89.30.81
PING 58.89.30.81 (58.89.30.81) 56(84) bytes of data.
64 bytes from 58.89.30.81: icmp_seq=1 ttl=64 time=1.57 ms
64 bytes from 58.89.30.81: icmp_seq=2 ttl=64 time=2.33 ms
^C
--- 58.89.30.81 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 1.565/1.947/2.330/0.382 ms
semih@broodjesemih:~ $ ping 58.89.30.82
PING 58.89.30.82 (58.89.30.82) 56(84) bytes of data.
64 bytes from 58.89.30.82: icmp_seq=1 ttl=64 time=0.148 ms
64 bytes from 58.89.30.82: icmp_seq=2 ttl=64 time=0.109 ms
^C
--- 58.89.30.82 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1006ms
rtt min/avg/max/mdev = 0.109/0.128/0.148/0.019 ms
semih@broodjesemih:~ $ ping 58.89.30.83
PING 58.89.30.83 (58.89.30.83) 56(84) bytes of data.
64 bytes from 58.89.30.83: icmp_seq=1 ttl=64 time=0.427 ms
64 bytes from 58.89.30.83: icmp_seq=2 ttl=64 time=0.229 ms
^C
--- 58.89.30.83 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1020ms
rtt min/avg/max/mdev = 0.229/0.328/0.427/0.099 ms
semih@broodjesemih:~ $
```

Figure 3: It's possible to ping every device on the network (pt.2).



```
[hat@labyrinthos ~]$ 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
        inet 127.0.0.1/128 scope host
            valid_lft forever preferred_lft forever
            valid_lft forever preferred_lft forever
2: enp0s25: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 50:7d:9d:1a:b1:75 brd ff:ff:ff:ff:ff:ff
        inet 58.89.30.162/24 brd 58.89.30.175 scope global noprefixroute enp0s25
            valid_lft forever preferred_lft forever
        inet6 fe80::65d1:5393:3111:ad94%enp0s25 brd ff:ff:ff:ff:ff:ff permaddr 5c:34:88:45:8d:fa
3: wlp3s0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN group default qlen 1000
    link/ether 02:73:38:13:29:2a brd ff:ff:ff:ff:ff:ff
[hat@labyrinthos ~]$ ping 58.89.30.83
[hat@labyrinthos ~]$ ping 58.89.30.83
PING 58.89.30.83 (58.89.30.83) 56(84) bytes of data.
64 bytes from 58.89.30.83: icmp_seq=1 ttl=61 time=3.76 ms
64 bytes from 58.89.30.83: icmp_seq=2 ttl=61 time=3.65 ms
64 bytes from 58.89.30.83: icmp_seq=3 ttl=61 time=3.69 ms
64 bytes from 58.89.30.83: icmp_seq=4 ttl=61 time=3.56 ms
64 bytes from 58.89.30.83: icmp_seq=5 ttl=61 time=3.68 ms
^C
... 58.89.30.83 ping statistics ...
5 packets transmitted, 5 received, 0% packet loss, time 4006ms
rtt min/avg/max/mdev = 3.562/3.667/3.758/0.064 ms
[hat@labyrinthos ~]$ scrot
```

Figure 4: It's possible to ping from subnet B to A.



Figure 5: Viewer watching gameplay of Samurai Shodown II (*streamer\_2*). Note that the compression artifacts does make the image quite smearly.

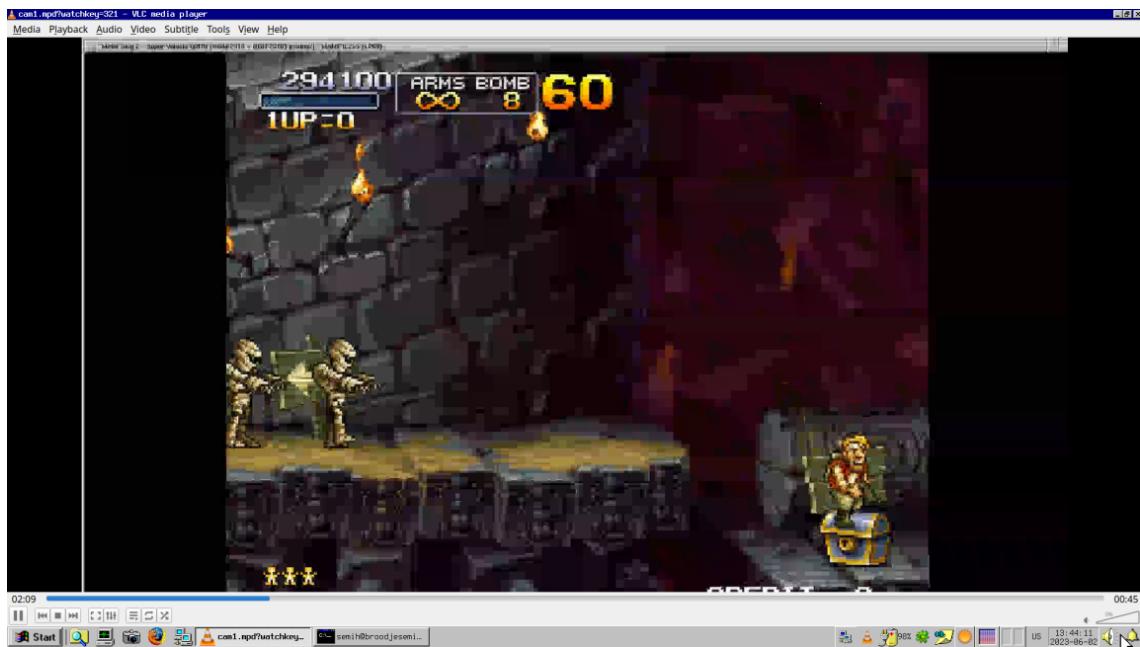


Figure 6: Viewer watching gameplay of Metal Slug 2 (*streamer\_2*). The compression artifacts is even worse on this one.

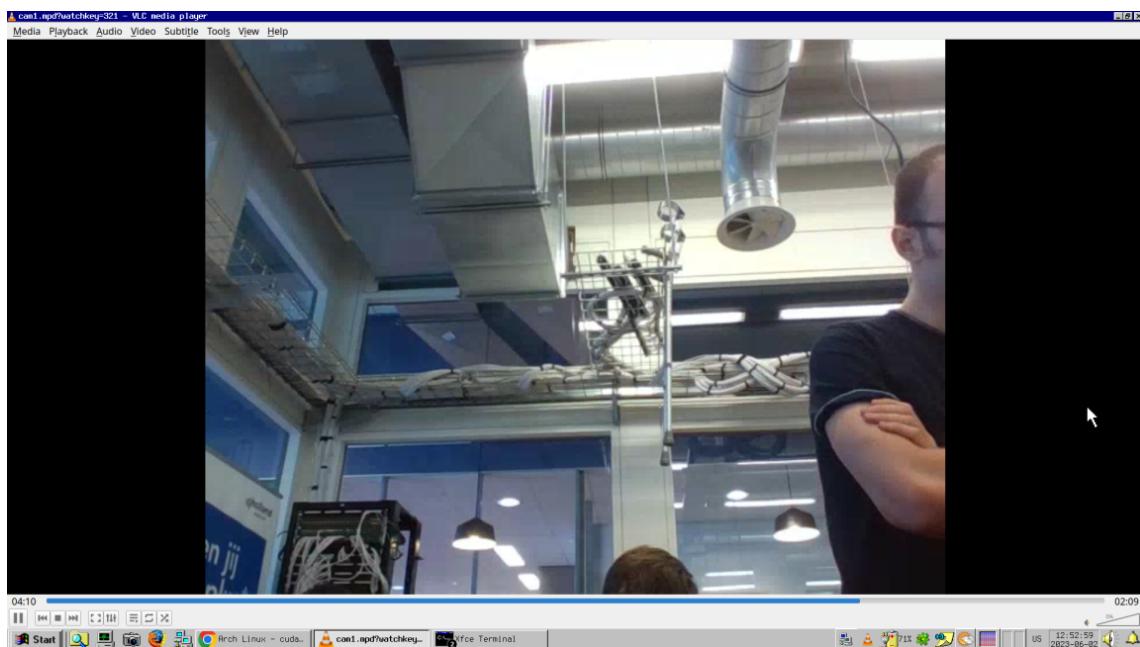


Figure 7: Viewer watching webcam of *streamer\_2*.



Figure 8: *streamer\_1* streaming and watching his own webcam.

## 4 Miscellaneous screenshots

```
pi@marvinPi:~$ nano 5.1
[GNOME Terminal]
/etc/nginx/nginx.conf

worker_processes auto;
pid /run/nginx.pid;
include /etc/nginx/modules-enabled/*.conf;

events {
    worker_connections 768;
    # multi_accept on;
}

stream {
    upstream rtmp_backend {
        server 127.0.0.1:4455;
    }

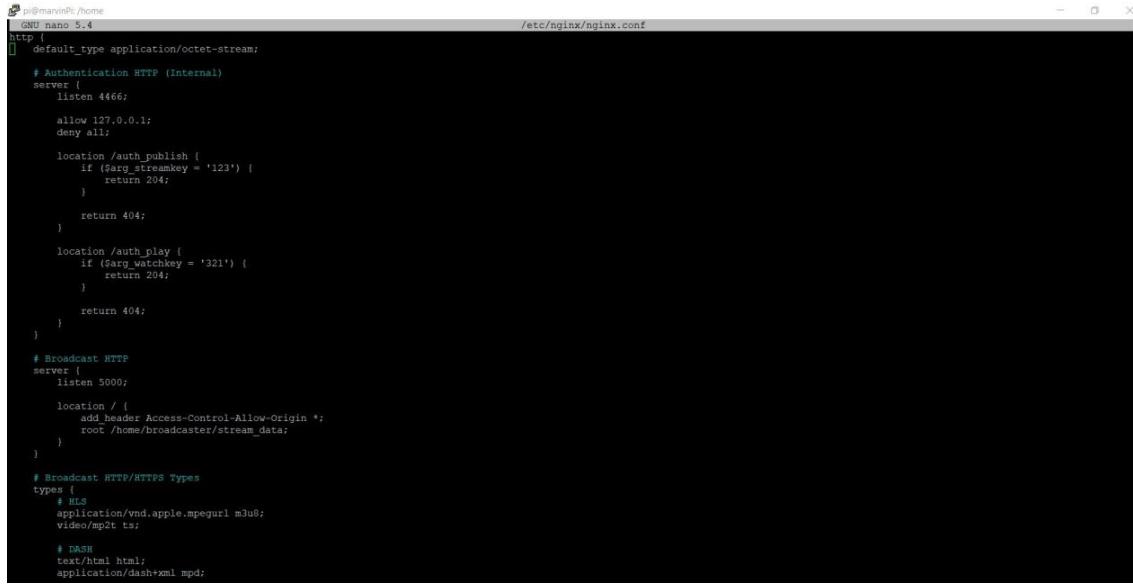
    server {
        listen 4000;
        proxy_pass rtmp_backend;
    }
}

rtmp {
    server {
        listen 4455;
        notify_method get;

        application live {
            live on;
            record off;
            interleave on;
            on_publish http://127.0.0.1:4466/auth_publish;
            on_play http://127.0.0.1:4466/auth_play;

            # HLS
            hls on;
            hls_path /home/broadcaster/stream_data/hls;
            hls_fragment 15s;
        }
    }
}
```

Figure 9: Nginx configuration for RTMP-server, which all has been done by Marvin (pt.1).



```

pi@marvinPi:/home/pi$ nano /etc/nginx/nginx.conf
GNU nano 5.4                               /etc/nginx/nginx.conf

http {
    default_type application/octet-stream;
    # Authentication HTTP (Internal)
    server {
        listen 4466;
        allow 127.0.0.1;
        deny all;
        location /auth_publish {
            if ($arg_streamkey = '123') {
                return 204;
            }
            return 404;
        }
        location /auth_play {
            if ($arg_watchkey = '321') {
                return 204;
            }
            return 404;
        }
    }
    # Broadcast HTTP
    server {
        listen 5000;
        location / {
            add_header Access-Control-Allow-Origin *;
            root /home/broadcaster/stream_data;
        }
    }
    # Broadcast HTTP/HTTPS Types
    types {
        # HLS
        application/vnd.apple.mpegurl m3u8;
        video/mp2t ts;
        # DASH
        text/html html;
        application/dash+xml mpd;
    }
}

```

Figure 10: Nginx configuration for RMTP-server, which all has been done by Marvin (pt.2).



```

pi@marvinPi:/home/pi$ systemctl status nginx
● nginx.service - A high performance web server and a reverse proxy server
   Loaded: loaded (/lib/systemd/system/nginx.service; enabled; vendor preset: enabled)
   Active: active (running) since Tue 2023-05-16 22:13:36 CEST; 1h 59min ago
     Docs: man:nginx(8)
 Process: 552 ExecStartPre=/usr/sbin/nginx -t -g daemon on; master_process on; (code=exited, status=0/SUCCESS)
 Process: 601 ExecStart=/usr/sbin/nginx -g daemon on; master_process on; (code=exited, status=0/SUCCESS)
 Main PID: 602 (nginx)
   Tasks: 6 (limit: 3933)
      CPU: 0ms
     CGroup: /system.slice/nginx.service
             └─602 nginx: master process /usr/sbin/nginx -g daemon on; master_process on;
                 ├─603 nginx: worker process
                 ├─604 nginx: worker process
                 ├─605 nginx: worker process
                 ├─606 nginx: worker process
                 └─607 nginx: cache manager process

May 16 22:13:35 marvinpi1 systemd[1]: Starting A high performance web server and a reverse proxy server...
May 16 22:13:36 marvinpi1 systemd[1]: Started A high performance web server and a reverse proxy server.
pi@marvinPi:/home/pi$ 

```

Figure 11: Proof of that the Nginx-server is running without any problems!

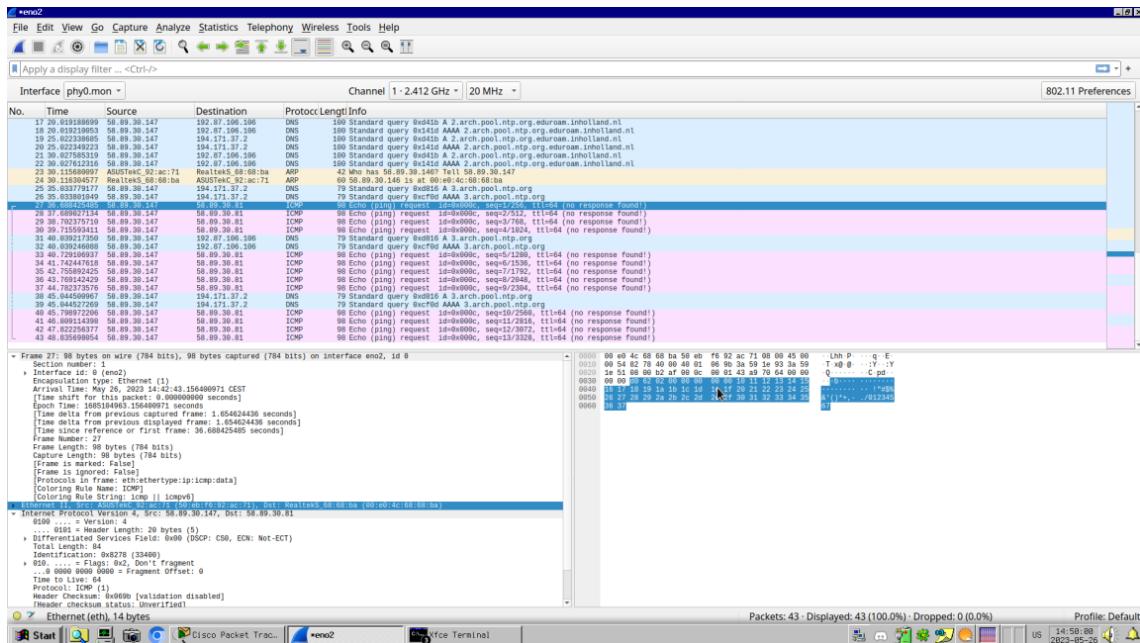


Figure 12: Here was I (Semih) troubleshooting the ICMP (ping) request via my laptop (58.89.30.147) to *router\_1* (58.89.30.81).

```
Jun 02 14:24:05 pino dnsmasq-dhcp[8635]: DHCPACK(eth1) 58.89.30.168 50:7b:9d:la:8
Lines 1-22/22 (END), skipping...
● dnsmasq.service - dnsmasq - A lightweight DHCP and caching DNS server
    Loaded: loaded (/lib/systemd/system/dnsmasq.service; enabled; vendor preset: enabled)
      Active: active (running) since Fri 2023-06-02 14:23:43 CEST; 51s ago
        Process: 8621 ExecStartPre=/etc/init.d/dnsmasq checkconfig (code=exited, status=0/SUCCESS)
        Process: 8628 ExecStart=/etc/init.d/dnsmasq systemd-exec (code=exited, status=0/SUCCESS)
        Process: 8636 ExecStartPost=/etc/init.d/dnsmasq systemd-start-resolvconf (code=exited, status=0/SUCCESS)
      Main PID: 8635 (dnsmasq)
        Tasks: 1 (limit: 3933)
          CPU: 177ms
        CGroup: /system.slice/dnsmasq.service
            └─ 8635 /usr/sbin/dnsmasq -x /run/dnsmasq/dnsmasq.pid -u dnsmasq -r /run/dnsmasq/resolv.conf -7 /etc/dnsmasq.d,.dpkg-dist,.dpkg-old,.dpkg-new --l

Jun 02 14:23:43 pino dnsmasq[8635]: using nameserver 194.171.37.2#53
Jun 02 14:23:43 pino dnsmasq[8635]: using nameserver 192.87.106.106#53
Jun 02 14:23:43 pino dnsmasq[8635]: read /etc/hosts - 5 addresses
Jun 02 14:23:43 pino systemd[1]: Started dnsmasq - A lightweight DHCP and caching DNS server.
Jun 02 14:24:05 pino dnsmasq-dhcp[8635]: DHCPDISCOVER(eth1) 12.0.0.32 50:7b:9d:la:b1:75
Jun 02 14:24:05 pino dnsmasq-dhcp[8635]: DHCPOfferer(eth1) 58.89.30.168 50:7b:9d:la:b1:75
Jun 02 14:24:05 pino dnsmasq-dhcp[8635]: DHCPDISCOVER(eth1) 12.0.0.32 50:7b:9d:la:b1:75
Jun 02 14:24:05 pino dnsmasq-dhcp[8635]: DHCPOfferer(eth1) 58.89.30.168 50:7b:9d:la:b1:75
Jun 02 14:24:05 pino dnsmasq-dhcp[8635]: DHCPREQUEST(eth1) 58.89.30.168 50:7b:9d:la:b1:75
Jun 02 14:24:05 pino dnsmasq-dhcp[8635]: DHCPACK(eth1) 58.89.30.168 50:7b:9d:la:b1:75 labyrinthos
```

Figure 13: DHCP-server is working fine in subnet B.2 (*router\_3*).

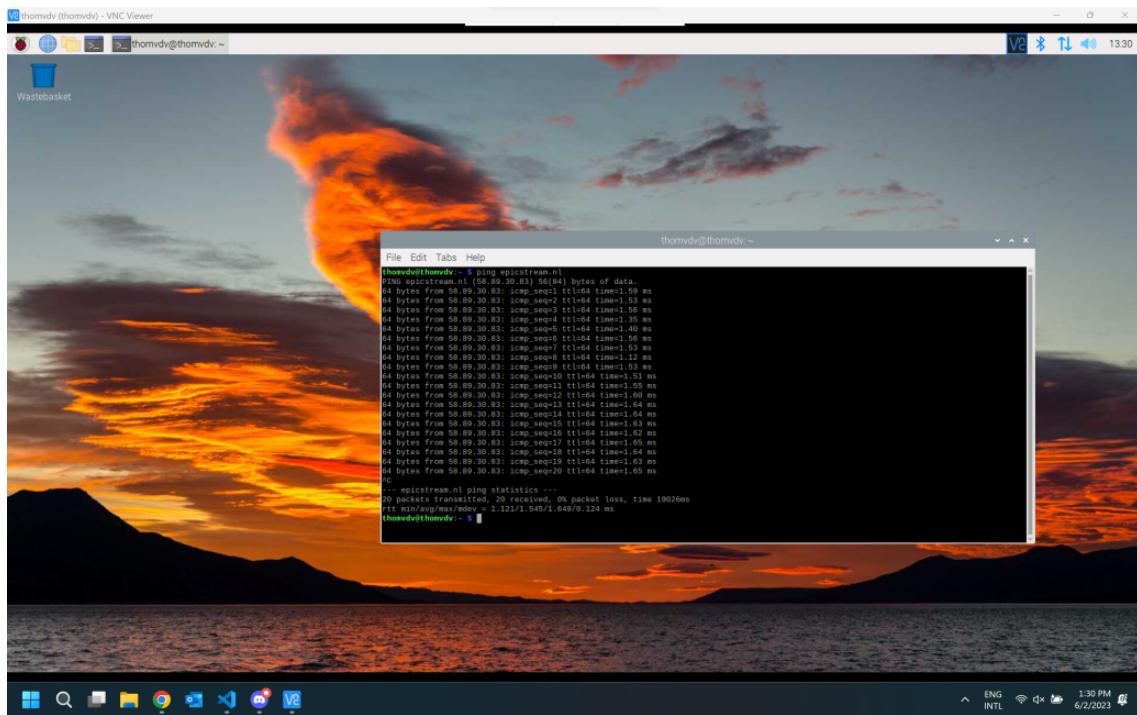


Figure 14: DNS-server is working fine in subnet A.1 *router\_1*.

```
# Example static IP configuration:  
interface eth1  
static ip_address=58.89.30.146/28  
static routers=58.89.30.145  
#static domain_name_servers=58.89.30.81  
#static routers=58.89.30.82  
  
interface eth0  
static ip_address=58.89.30.82/28  
static routers=58.89.30.81  
#static domain_name_servers=58.89.30.81  
#static routers=58.89.30.146
```

Figure 15: dhcpcd.conf file of *router\_2*.

```
pi@marvinPi:/home $ ls  
broadcaster broadcastercache pi  
pi@marvinPi:/home $ cd broadcaster  
pi@marvinPi:/home/broadcaster $ ls  
conf log run stream_data  
pi@marvinPi:/home/broadcaster $ █
```

Figure 16: ls command in MarvinPi (*Nginx*).

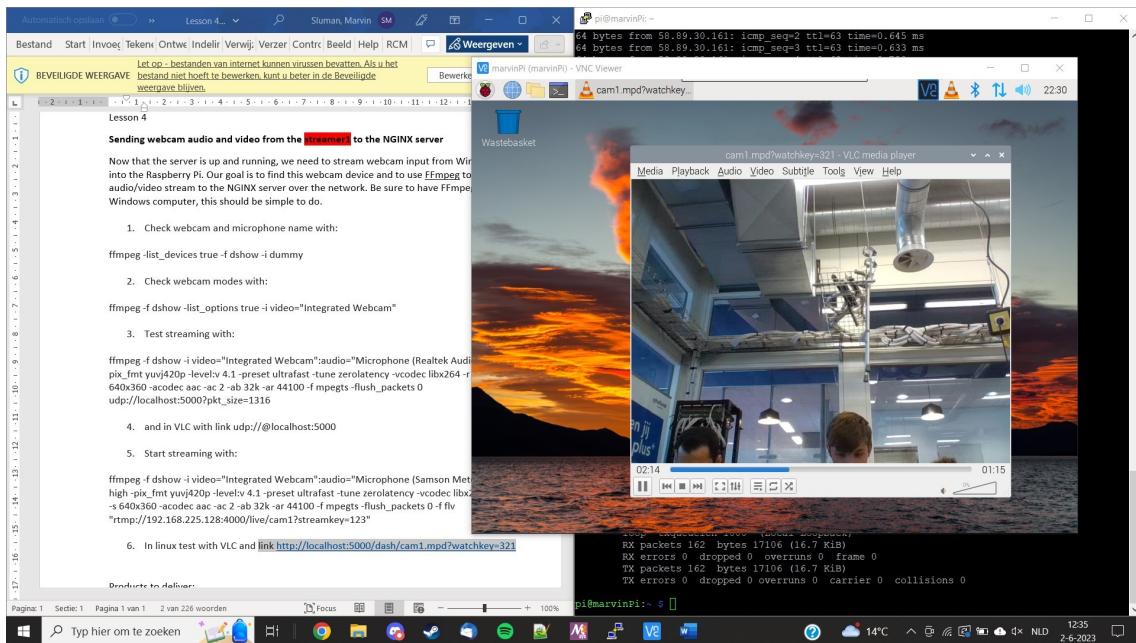


Figure 17: Marvin watching *streamer\_2* (via Nginx).

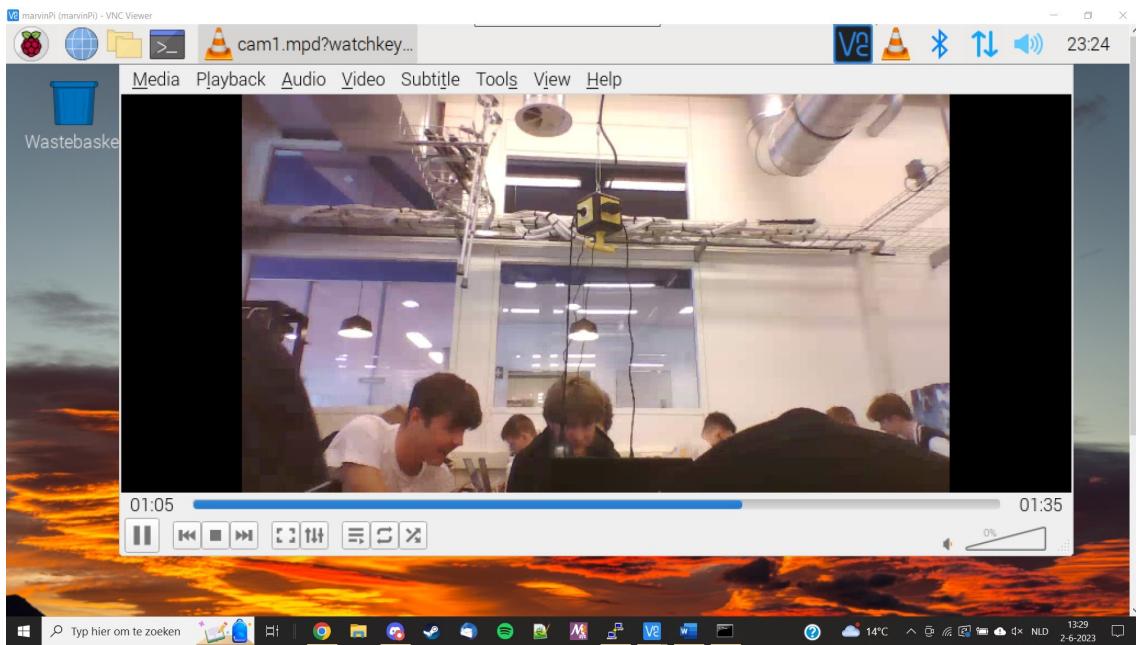
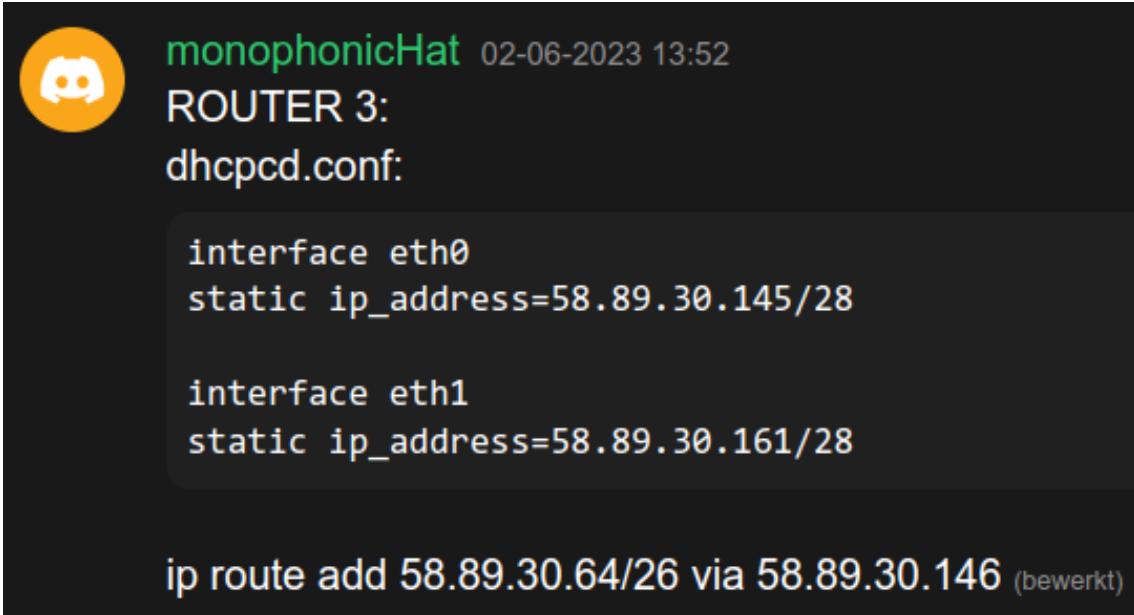


Figure 18: Marvin watching *streamer\_1* (via Nginx).



A screenshot of a terminal window titled "monophonicHat 02-06-2023 13:52". The window contains configuration files for dhcpcd. The first file, "dhcpcd.conf", defines static IP addresses for interfaces eth0 and eth1. The second file, "ip route add", adds a route via interface eth0.

```
interface eth0
static ip_address=58.89.30.145/28

interface eth1
static ip_address=58.89.30.161/28

ip route add 58.89.30.64/26 via 58.89.30.146 (bewerkt)
```

Figure 19: *Router\_3 dhcpcd.conf file.*

```

 broodjesemih 26-05-2023 10:14
semih@broodjesemih:~ $ route -v
Kernel IP routing table
Destination     Gateway         Genmask        Flags Metric Ref  Use Iface
default         58.89.30.81   0.0.0.0        UG    202   0    0 eth0
default         58.89.30.145  0.0.0.0        UG    203   0    0 eth1
default         145.81.128.1  0.0.0.0        UG    304   0    0 wlan0
58.89.30.80    0.0.0.0       255.255.255.240 U     202   0    0 eth0
58.89.30.144   0.0.0.0       255.255.255.240 U     203   0    0 eth1
145.81.128.0   0.0.0.0       255.255.240.0  U     304   0    0 wlan0

 monophonicHat 26-05-2023 10:14
Kernel IP routing table
Destination     Gateway         Genmask        Flags Metric Ref  Use Iface
default         clalh-145-81-12 0.0.0.0        UG    304   0    0 wlan0
58.89.30.144   0.0.0.0       255.255.255.240 U     202   0    0 eth0
58.89.30.160   0.0.0.0       255.255.255.240 U     203   0    0 eth1
145.81.128.0   0.0.0.0       255.255.240.0  U     304   0    0 wlan0

 thomvdv 26-05-2023 10:15
Kernel IP routing table
Destination     Gateway         Genmask        Flags Metric Ref  Use Iface
58.89.30.80    0.0.0.0       255.255.255.240 U     205   0    0 eth1
58.89.30.128   58.89.30.82   255.255.255.192 UG    0     0    0 eth1
link-local      0.0.0.0       255.255.0.0    U     202   0    0 eth0

```

Figure 20: All “route -v” outputs.

```
Router 1 settings:  
/etc/dhcpcd.conf:  
interface eth1  
static ip_address=58.89.30.81/28  
interface eth0  
inform 58.89.30.97/28  
  
/etc/dnsmasq.conf  
interface=eth0  
dhcp-range=58.89.30.100,58.89.30.110,24h  
conf-dir=/etc/dnsmasq.d  
  
/etc/dnsmasq.d/epicstream.conf  
address=/epicstream.nl/58.89.30.83  
  
/etc/sysctl.conf  
net.ipv4.ip_forward=1  
  
Na opstarten: sudo ip route add 58.89.30.128/26 via 58.89.30.82
```

Figure 21: *Router\_1* config files.