Vsebina

Prepare VirtualBox images

Start VirtualBox and change the MAC address of the machine network interface: `Settings > Network > Adapter 1 > Advanced > MAC Address > Generates a new random MAC address`.

Next, change the `Network adapter`:

- If you are on a home network or on university ethernet network: `Settings > Network > Adapter 1 > Attached to: Bridged`
- If you are on Eduroam, you cannot use bridged networking. In this case either connect your laptop to a university ethernet network and set the networking to bridged as described above, or create a new NAT network (`File > Preferences > Networks > NAT Networks > Add new NAT network`, leave all settings to defaults) and set the Adapter 1 to use the NAT network that you have created previously.

Onemogočanje IPv6

Dodaj v:

`sudo nano /etc/sysctl.conf`

```
net.ipv6.conf.all.disable_ipv6 = 1

net.ipv6.conf.default.disable_ipv6 = 1

net.ipv6.conf.lo.disable_ipv6 = 1
```

Potrdi spremembe z ukazom:

`sudo sysctl -p`

You should run this command each time you start up the image; IPv6 turns on by default at start.

Konfiguracija APACHE strežnika

Install packages that will be used for testing firewall rules

- `sudo apt-get install apache2 curl`
- Generate default digital certificates for Apache2: `sudo make-ssl-cert generate-default-snakeoil --force-overwrite`
- Enable Apache2 SSL Site: `sudo a2ensite default-ssl.conf`
- Enable Apache2 TLS/SSL module `sudo a2enmod ssl`
- Restart Apache server `sudo service apache2 restart`
- Check if Apache2 works by running the web browser and opening both `http://localhost` and `https://localhost`. Alternatively, test with `curl`.

Spreminjanje host nastavitev

`sudo nano /etc/hosts`

Dodamo: `127.0.1.1 ssh-server`
Uveljavimo sprmemebe: `sudo hostnamectl set-hostname ssh-server`

IPTABLES

(https://github.com/lem-course/isp-iptables) (https://www.digitalocean.com/community/tutorials/how-to-list-and-delete-iptables-firewall-rules) Change downloaded file's execution permissions: **chmod +x iptables1.sh**

Izpis aktivnih pravil: `sudo iptables -S`
Za določeno verigo: `sudo iptables -S TCP`

STATELESS

(https://ucilnica.fri.uni-lj.si/mod/page/view.php?id=8650)

```
# Disable INPUT
iptables --policy INPUT DROP

### Allow all trafic on localhost
iptables -A INPUT -i lo -j ACCEPT
iptables -A OUTPUT -o lo -j ACCEPT

### Allow DNS lookups as a client ### (1) Allow access to a particular DNS server. ###    The IP address of the DNS server is given in variable NAMESERVER
iptables -A OUTPUT -o $INET_IFACE -p udp -s $IPADDR --sport $UNPRIVPORTS -d $NAMESERVER --dport 53 -j ACCEPT
iptables -A INPUT  -i $INET_IFACE -p udp -s $NAMESERVER --sport 53 -d $IPADDR --dport $UNPRIVPORTS -j ACCEPT

### SSH
### (2) Allow outgoing SSH connections
iptables -A OUTPUT -p tcp --dport 22 -j ACCEPT
iptables -A INPUT  -p tcp ! --syn --sport 22 -j ACCEPT

### (3) Allow incoming SSH connections
iptables -A INPUT  -p tcp --dport 22 -j ACCEPT
iptables -A OUTPUT -p tcp --sport 22 -j ACCEPT
```

STATEFULL

(https://ucilnica.fri.uni-lj.si/mod/page/view.php?id=8751)

```
# (1) Allow all incoming packets that belong to ESTABLISHED or RELATED connections.
iptables -A INPUT -m state --state ESTABLISHED,RELATED -j ACCEPT

# (3) Allow outgoing DNS requests to the DNS server in variable NAMESERVER
iptables -A OUTPUT -p udp -d $NAMESERVER --dport 53 -m state --state NEW -j ACCEPT

# (4) TODO: Allow outgoing SSH connections to remote SSH servers
iptables -A OUTPUT -p tcp --dport 22 -m state --state NEW -j ACCEPT

# (5) TODO: Allow incomming connections to local SSH server
iptables -A INPUT -p tcp --dport 22 -m state --state NEW -j ACCEPT
```

FORWARD

```
# Do NAT for internet-bound traffic
iptables -t nat -A POSTROUTING -o $INET_IFACE -j MASQUERADE

# (14) Forward pings
iptables -A FORWARD -p icmp --icmp-type echo-request -m state --state NEW  -j ACCEPT

# (15) Forward DNS requests from subnets to Internet and permit in corresponding responses
iptables -A FORWARD -o $INET_IFACE -p udp -m multiport --ports 53 -m state --state NEW -j ACCEPT
```

SSH strežnik

(https://ucilnica.fri.uni-lj.si/mod/page/view.php?id=8957)

Install packages that will be used for testing firewall rules

- `sudo apt-get install openssh-server`
- Check if SSH server works by running `ssh localhost`, answer with `yes` and provide password `isp`. Press `ctrl+d` to exit.

Napredne nastavitve

Generiranje ključev za ssh server

```
sudo ssh-keygen -t ecdsa -f /etc/ssh/ssh_host_ecdsa_key

sudo ssh-keygen -t rsa   -f /etc/ssh/ssh_host_rsa_key

sudo ssh-keygen -t dsa   -f /etc/ssh/ssh_host_dsa_key

sudo ssh-keygen -t ed25519 -f /etc/ssh/ssh_host_ed25519_key
```

Izbira ključa:

Name the keys according to `HostKey` directive in `sudo nano /etc/ssh/sshd_config` file.

Preverjanje public ključev:

- For ECDSA key: `ssh-keygen -lf /etc/ssh/ssh_host_ecdsa_key.pub`
- For RSA key: `ssh-keygen -lf /etc/ssh/ssh_host_rsa_key.pub`
- For DSA key: `ssh-keygen -lf /etc/ssh/ssh_host_dsa_key.pub`

Odstranjevanje neveljavnih ssh public ključev:

Iz: `sudo nano ~/.ssh/known_hosts`

Generiranje ključev za klienta

Ključi za uporabnika se shranijo v mapo: `~/.ssh`

- `ssh-keygen -t rsa`
- `ssh-keygen -t dsa`
- `ssh-keygen -t ecdsa`

Prijava na ssh server s public ključem

`ssh -i ~/.ssh/id_rsa isp@$SERVER`

- To enable public key authentication, you have to (1) copy your public key to the remote computer and then (2) enable and link it to specific account. Both actions can be done with `ssh-copy-id` which copies public key to the chosen account and adds public key to authorized keys list. Simply run: `ssh-copy-id isp@$SERVER`.
- Once the key has been copied and added to the authorized_keys list, try connecting and authenticating using only public keys: `ssh $SERVER`. You should now login to server without providing password. (We can even omit the username, since the username on the server and on the client are the same.)
- Finally, let's disable password-based login attempts and always require client authentication with public keys. On the `ssh-server`, open file `/etc/ssh/sshd_config` and add command `PasswordAuthentication no`. Save the file and restart the SSH server with `sudo service ssh restart`.

Because we have already copied our public key to the server, our client will by default try to authenticate itself with the public key. So we have to explicitly state that we want to authenticate with the username/password pair, if we want to test the most recent change. Run the following on `ssh-client`: `ssh -o PreferredAuthentications=password -o PubkeyAuthentication=no $SERVER`. If you configured the sever correctly, the connection attempt should be rejected.

Reverse SSH Tunneling

A reverse SSH tunnel is similar to a normal SSH tunnel, the difference is in the agent that initiates the tunnel. In a reverse SSH tunnel, the machine that provides the service is also the machine that sets up the tunnel. (Contrary to the local port-forwarding where the tunnel was set up by the machine that consumed the provided service.)

Onemogoči IPv6.

Next, you may reuse the iptables script from the previous week's lab session. Modify the script to contain the following entries:

```
iptables -A INPUT -i lo -j ACCEPT
iptables -A OUTPUT -o lo -j ACCEPT
iptables -A INPUT  -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A OUTPUT -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A OUTPUT  -p tcp --dport 22 -m state --state NEW -j ACCEPT
```

Additionally, remove the Apache access control that we added in the previous assignment by commenting out (or deleting) the following lines in `/etc/apache2/sites-available/000-default.conf`:

```
<Directory /var/www/html>
    Require ip 127.0.0.1/8
</Directory>
```

Remember to reload the configuration once you have changed the file: `sudo service apache2 reload`.

At this point, you should be able to `curl localhost` on the `ssh-server` machine, while a `curl $SERVER` run on the `ssh-client` should fail. Moreover, you should also be unable to ssh into server from `ssh-client`; the firewall should block both HTTP and SSH access from the outside.

Now, the `ssh-server` machine is allowed to connect onto `ssh-client` and establish a reverse tunnel that will allow `ssh-client` to access the Apache pages on `ssh-server`. On the `ssh-server`, run the following:

```
ssh -R 127.0.0.1:8080:127.0.0.1:80 -N isp@$CLIENT
```

With the reverse tunnel set up, you should be able to `curl localhost:8080` on the `ssh-client` and access the contents of the Apache server pages on the `ssh-server` machine.

SCP

Ukaz za kopiranje prek scp-ja
scp file isp@ip:/home/isp
cp file /location/
mv file /location/

Izdelava lastne certifikatne agencije

First, **generate** a private key, the default generates a 2048 bit RSA key (if this command blocks, refer to **this note about hosts with low entropy**):

```
ipsec pki --gen > caKey.der
```

For a real-world setup, make sure to keep this key absolutely private.

Now **self-sign** a CA certificate using the generated key:

```
ipsec pki --self --in caKey.der --dn "C=CH, O=strongSwan, CN=strongSwan CA" --ca > caCert.der
```

For **each** peer, i.e. for all VPN clients and VPN gateways in your network, generate an individual private key and **issue** a matching certificate using your new CA:

```
ipsec pki --gen > branchKey.der
```

For instance, when creating the certificate for the branch router (whose identity is `@branch`), you can use the following command: `ipsec pki --pub --in branchKey.der | ipsec pki --issue --cacert caCert.der --cakey caKey.der --dn "C=SL, O=FRI-UL, CN=branch" --san @branch > branchCert.der`. (This command assumes that you have previously created the private key in file `branchKey.der` and that the CA's certificate and the corresponding private key are in files `caCert.der` and `caKey.der`.)

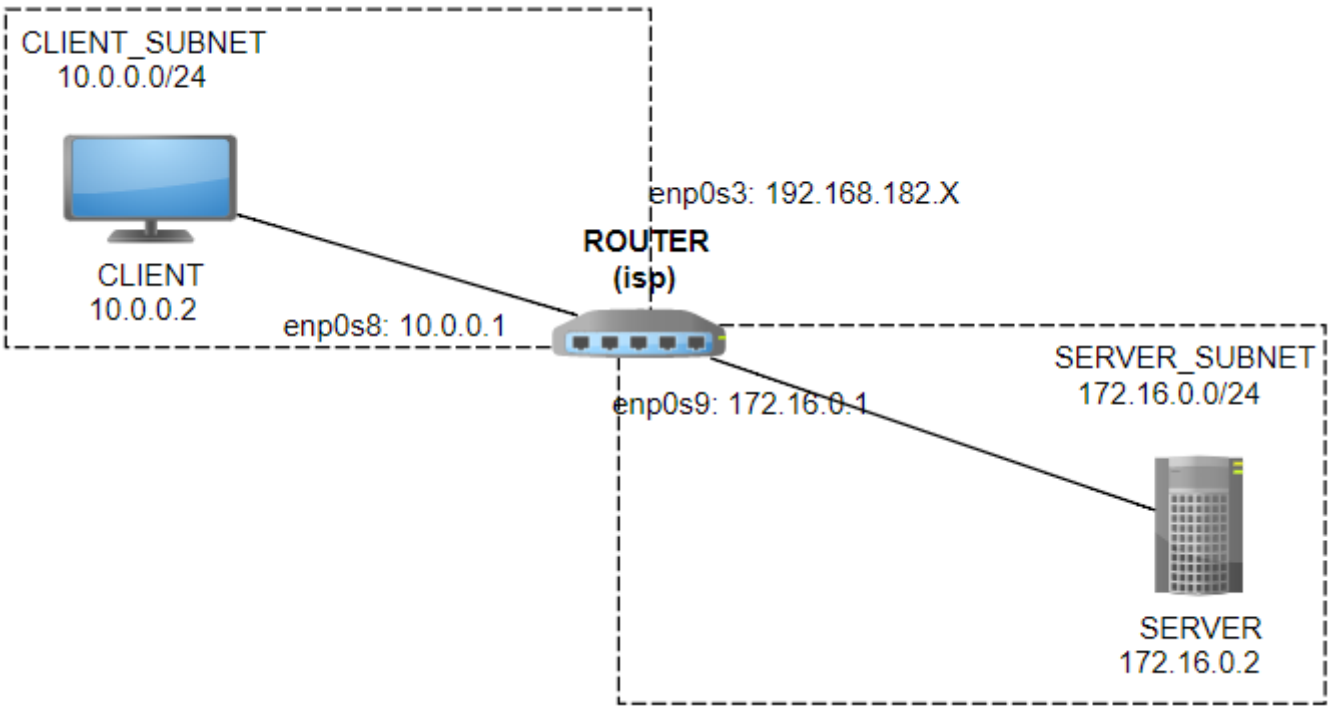
Next, copy the client's certificate and private key to the appropriate machines. Additionally, you will also have to copy the CA's certificate to both machines. Place files in the appropriate subfolders within `/etc/ipsec.d/`.

Kloniranje slike

- Right click on the (power off) image in VirtualBox and select `Clone (Ctrl+O)`;
- Choose `Expert mode`:
  - Give a name to the cloned image, for instance `isp-2`;
  - Select `Linked clone`;
  - Select the option to `Reinitialize the MAC address of all network cards`;
- Confirm by clicking `Clone`.

Nastaviteve za router virtualko

(https://ucilnica.fri.uni-lj.si/mod/page/view.php?id=8751)



Create two additional virtual images by cloning the existing image. Name the first clone `client` and the second `server`. (We'll assume that the image you have been using so far is named `isp`.) You may create linked clones. Do not forget to generate new MAC addresses for the newly created images.

Configure the `isp` machine to use two additional network interface cards (NICs): `Machine > Settings > Network > Adapter 2`. Tick `Enable Network Adapter`, select `Internal Network` and put `client_subnet` in `Name` field. Then switch to tab `Adapter 3` and repeat the process, but this time name the `Internal Network` card `server_subnet`.

The first netwok adapter on `isp` can be set to `NAT`, `Bridged Adapter` or `NAT Network`. It does not really matter which, as long as it provides Internet connectivity. Confirm the changes by clicking `OK`.

The `client` and the server machine will have only a single NIC. First, configure the NIC on the `client` by setting its network interface to `Internal Network` and selecting `client_subnet` as name.

Finally, configure the NIC on the `server` by setting its network interface to `Internal Network` and selecting `server_subnet` as name.

ROUTER

Start the `isp` machine. Notice that the machine has three NIC cards: run `ifconfig` and observe `enp0s3`, `enp0s8` and `enp0s9`. You'll see that only `enp0s3` managed to obtain an IP address, while `enp0s{8,9}` did not. The reason is that the subnets which `enp0s8` and `enp0s9` connect to, do not have DCHP servers. This means that we'll have to set up IPs manually.

Let's assign IPs to `isp` machine for `enp0s8` and `enp0s9`. Since the `client_subnet` uses addresses from `10.0.0.0/24` and `server_subnet` addresses from `172.16.0.0/24`, we'll use the first available address that come to mind: `10.0.0.1` for `enp0s8` and `172.16.0.1` for `enp0s9`.

Posodobimo interface omrežja

```
sudo nano /etc/network/interfaces
```

```
auto enp0s8

iface enp0s8 inet static

  address 10.0.0.1

  netmask 255.255.255.0


auto enp0s9

iface enp0s9 inet static

  address 172.16.0.1

  netmask 255.255.255.0
```

To apply these changes:

- Restart the network manager with `sudo service network-manager restart`, and
- bring up those two interfaces: `sudo ifup enp0s8` and `sudo ifup enp0s9`.
  - Confirm that the addresses have been successfully set by running `ifconfig`.
  - **Next, enable routing for IPv4** so that the `isp` will actually behave as a proper router: `echo 1 | sudo tee /proc/sys/net/ipv4/ip_forward`.

CLIENT

Configuring the client and the server is simpler. We have to do three things: assign them IP addresses (`10.0.0.2`), DNS servers (`8.8.8.8`) and instruct them to send packets through the `isp` (`10.0.0.1`) machine.

`sudo nano /etc/network/interfaces`

```
auto enp0s3

iface enp0s3 inet static

  # assign the IP address

  address 10.0.0.2

  # set the netmask /24

  netmask 255.255.255.0

  # set the default route through isp

  gateway 10.0.0.1

  # use Google's DNS

  dns-nameservers 8.8.8.8
```

```
sudo service network-manager restart
sudo ifup enp0s3
```

IPTABLES potek dela

A typical cycle goes as follows:

- Solve a task.
- Start the firewall rules script `sudo ./iptables1.sh start` or `sudo ./iptables1.sh restart`.
- Inspect which rules have been activated: `sudo iptables --list -nv`.
- Test rules by running the appropriate program. In some cases, you'll need the other machine for testing (for instance, to test requests to the local services (HTTP and alike)):
  - ICMP with `ping`;
  - DNS with dig, e.g. `dig www.fri.uni-lj.si`;
  - HTTP with `curl`, e.g. `curl google.com`;
  - SSH client: `ssh isp@ip-of-the-machine-your-are-connecting-to`.
- Clear all rules by running `sudo ./iptables1.sh reset`.

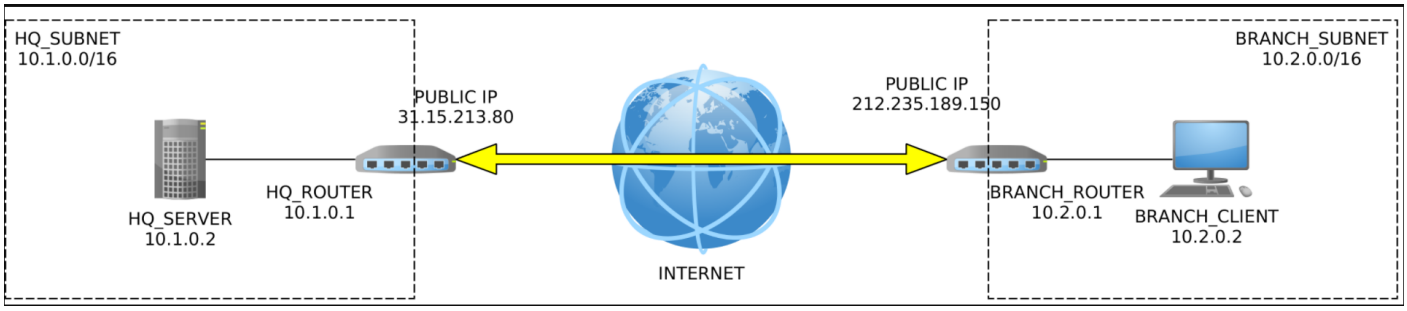
VPN

(https://ucilnica.fri.uni-lj.si/mod/page/view.php?id=9139)

```
sudo apt update

sudo apt install strongswan ipsec-tools apache2 wireshark
```

`Should non-superusers be able to capture packets?`, select `yes`.



Naredimo in konfiguriramo hq_subnet in branch subnet.

Checkpoint

Let's make a sanity check before continuing. Assure that you can do the following:

- Send (and receive) pings between `hq_router` and `hq_server` (network `10.1.0.0/16`);
- Send (and receive) pings between `branch_router` and `branch_client` (network `10.2.0.0/16`);
- Send (and receive) pings between `hq_router` and `branch_router`. In this case, you should ping the *public* addresses of `hq_router` and `branch_router`. By public, I refer to the IPs assigned to routers on the `enp0s3` interfaces. At university, these are the IP addresses from the `192.168.182.0/24`. (These are in fact **private** IP addresses, but if we were setting up a real network, they'd be public. So for pedagogical purposes, we'll pretend they are public.) From here on, I'll refer the the public IPs of the routers with `$HQ_IP` and `$BRANCH_IP` for the IPs of the `hq_router` and the `branch_router` respectively.

VPN IPsec tunnel

hq_router

At the `hq_router` open the `sudo nano /etc/ipsec.conf` and fill it with the following content.

```
config setup


conn %default
        ikelifetime=60m
        keylife=20m
        rekeymargin=3m
        keyingtries=1
        keyexchange=ikev2
        authby=secret


conn net-net
        leftsubnet=10.1.0.0/16
        leftfirewall=yes
        leftid=@hq
        right=$BRANCH_IP
        rightsubnet=10.2.0.0/16
        rightid=@branch
        auto=add
```

Next, open file `sudo nano /etc/ipsec.secrets` and add the following line.

```
@hq @branch : PSK "secret"
```

Finally, restart the IPsec `sudo ipsec restart` so that the changes get loaded.

branch_router

`sudo nano /etc/ipsec.conf`

```
config setup


conn %default
        ikelifetime=60m
        keylife=20m
        rekeymargin=3m
        keyingtries=1
        keyexchange=ikev2
        authby=secret
```

```
conn net-net
        leftsubnet=10.2.0.0/16
        leftid=@branch
        leftfirewall=yes
        right=$HQ_IP
        rightsubnet=10.1.0.0/16
        rightid=@hq
        auto=add
```

you can set multiple CIDR values, if you separate them with a comma – for instance: `leftsubnet=10.1.0.0/16,10.2.0.0/16`.

`sudo nano /etc/ipsec.secrets`

```
@hq @branch : PSK "secret"
```

`sudo ipsec restart`

Which cipher suites are being used? Run sudo ipsec statusall to find out. Now change the configuration files /etc/ipsec.conf on both routers so that the the ESP and the IKE traffic will be secured with the following cipher suite: AES_GCM_16_256. You may find this StrongSwan example useful.

https://www.strongswan.org/testresults.html

v seznamu klikneš na ikev2, nato klikneš na alg-aes-gcm (nasplošno pa tist algoritem, ki je zahtevan v navodilih)

nato klikneš na ipsec.conf (od moon - če gledaš za router), da vidiš vsebino

```
config setup


conn %default
        ikelifetime=60m
        keylife=20m
        rekeymargin=3m
        keyingtries=1
        keyexchange=ikev2
        authby=secret
        ike=aes256gcm16
        esp=aes256gcm16


conn net-net
        leftsubnet=10.1.0.0/16
        leftfirewall=yes
        leftid=@hq
        right=10.0.2.13
        rightsubnet=10.2.0.0/16
        rightid=@branch
        auto=add
```

For login with certificate: (https://www.strongswan.org/testing/testresults/ikev2/net2net-cert/)

moon.ipsec.conf

```
config setup

conn %default
        ikelifetime=60m
        keylife=20m
        rekeymargin=3m
        keyingtries=1
        keyexchange=ikev2
        mobike=no

conn net-net
        left=192.168.0.1
        leftcert=moonCert.pem
        leftid=@moon.strongswan.org
        leftsubnet=10.1.0.0/16
        leftfirewall=yes
        right=192.168.0.2
        rightid=@sun.strongswan.org
        rightsubnet=10.2.0.0/16
        auto=add
```

moon.ipsec.secrets

```
# /etc/ipsec.secrets - strongSwan IPsec secrets file

: RSA moonKey.pem
```

Namesto pem datotek imamo lahko der.

Odprava težave z delovanjem spletne povezave

če ti internet ne dela na branch_client / hq_server

moraš na routerjih pognat: sudo iptables -t nat -A POSTROUTING -o enp0s3 -j MASQUERADE

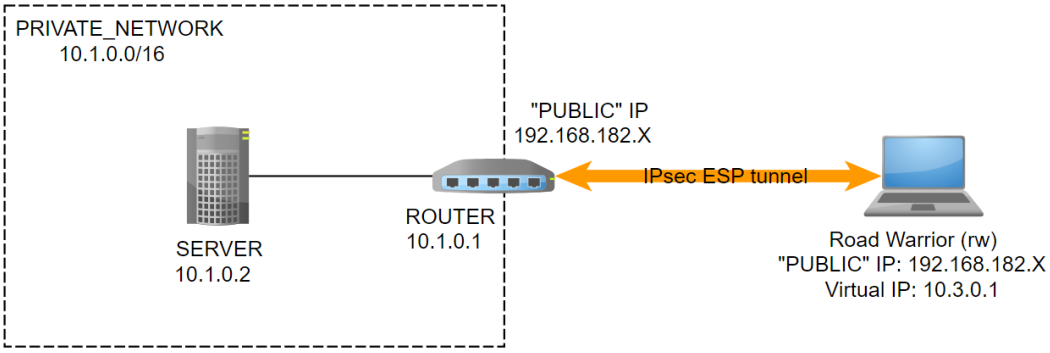
odgovor na tole z vaj za VPN

FreeRADIUS

```
sudo apt update

sudo apt install freeradius freeradius-utils apache2 libapache2-mod-auth-radius
```

Power-off `isp` machine. Configure it to have a single NIC: go to `Machine > Settings > Network` and disable all Adapters except `Adapter 1`. Set it to either `Bridged` or `NAT network` (do not use `NAT`).



radius1

First, let's register a new client (network access server, NAS) to the Radius server. Open `sudo nano /etc/freeradius/clients.conf` and make sure it contains the following entry. (The entry should already be there, this is just to be sure.)

```
client localhost {

    ipaddr = 127.0.0.1

    secret = testing123

    require_message_authenticator = no

    nastype = other

}
```

Next, let's add a new supplicant (end-user) to the database. We'll manage the database in a file. Open `sudo nano /etc/freeradius/users` and add the lines below. Make sure that you indent the second line with a tab.

```
"alice" Cleartext-Password := "password"

    Reply-Message = "Hello, %{User-Name}"
```

```
echo "User-Name=alice, User-Password=password" | radclient 127.0.0.1 auth testing123 -x
```

Debuging

First, stop the service with `sudo service freeradius stop`.

It may be best that you start FreeRADIUS in a new terminal window, or alternatively, in a new tab of the existing terminal widow by pressing `ctrl+shift+t`. This will allow you to monitor the output of the server, while also give you the ability to run additional commands. Start the server in the foreground with all logging and debugging turned on: `sudo freeradius -X -d /etc/freeradius`.

HTTP Basic authentication with Apache and FreeRADIUS

First, enable `auth_radius` module for apache and restart the apache server.

```
sudo a2enmod auth_radius

sudo service apache2 restart
```

Next, configure Apache Radius settings in `sudo nano /etc/apache2/ports.conf`. Add the following lines.

```
# FreeRADIUS runs on localhost:1812 (standard RADIUS port).

# Apache will authenticate itself to the AAA server with PSK 'testing123'.

# The request shall time-out after 5 seconds, and retry at most 3 times.
```

```
AddRadiusAuth localhost:1812 testing123 5:3


# Next line configures the time (in minutes) in which the authentication cookie

# set by the Apache server expires

AddRadiusCookieValid 1
```

Next, tell Apache which pages require authentication. Open `sudo nano /etc/apache2/sites-available/000-default.conf` and add the following lines inside `<VirtualHost *:80>` block. (Since, folder `/var/www/html` represents Apache's HTTP root folder, this in effect covers all pages.)

```
<Directory /var/www/html>

    Options Indexes FollowSymLinks MultiViews

    AllowOverride None


    # ADD LINE 1

    # Use basic password authentication

    # AuthType Digest won't work with RADIUS

    AuthType Basic


    # ADD LINE 2

    # Tell the user the realm to which they are authenticating.

    AuthName "RADIUS Authentication for my site"


    # ADD LINE 3

    # Set RADIUS to be provider for this basic authentication

    AuthBasicProvider radius


    # ADD LINE 4

    # Require that mod_auth_radius returns a valid user,

    # otherwise access is denied.

    Require valid-user

</Directory>
```

Reload Apache's configuration file with `sudo service apache2 reload`.

Finally, start the FreeRADIUS server in the foreground with `sudo freeradius -X -d /etc/freeradius`.

Roaming

Start `radius2`. Assert the IP addresses of both machines. Let `$RADIUS1` and `$RADIUS2` denote the IP addresses of `radius1` and `radius2`, respectively.

On `radius1`, create a new domain (or realm) called `finland`. Open `sudo nano /etc/freeradius/proxy.conf` and add the following.

```
home_server hs_finland {
        type = auth+acct
        ipaddr = $RADIUS2
        port = 1812
        secret = testing123
}

home_server_pool pool_finland {
        type = fail-over
        home_server = hs_finland
}

realm finland {
        pool = pool_finland
        nostrip
}
```

On `radius2`, create a new (local) domain called `finland`. Open `sudo nano /etc/freeradius/proxy.conf` and add the following two lines.

```
realm finland {
}
```

On `radius2`, define a new AAA client (AAA proxy) and define its credentials. Open `sudo nano /etc/freeradius/clients.conf` and add the following lines.

```
client $RADIUS1 {
    secret = testing123
}
```

On `radius2`, create a new supplicant (end-user). Open `sudo nano /etc/freeradius/users` and define his or hers credentials. An instance is given below. Make sure the second line is tab-indented.

```
"pekka" Cleartext-Password := "password"
    Reply-Message = "Hello, %{User-Name}"
```

Everything should now be set up. Make sure the FreeRADIUS server is running on both machines and in both cases in the foreground with `sudo freeradius -X -d /etc/freeradius`.

If you get an error stating that the port is already taken, stop the running instance of the server. If it is running in the background, you can stop it with `sudo service freeradius stop`. If it is running in the foreground, navigate to the terminal that shows the server output console and press `ctrl+c`.

Use the first machine to test whether the scenario works. Open a web browser and navigate to `http://localhost`. The browser should require you log-in. This time, log-in with `pekka@finland` and the appropriate password.

Hint. If you are using a normal browser, make use of private browsing for fast log-outs -- to log-out simply close the window. Alternatively, you can test using the terminal `curl --user pekka@finland:password http://localhost -v`