Setup Guide IPv6-DTN Testbed

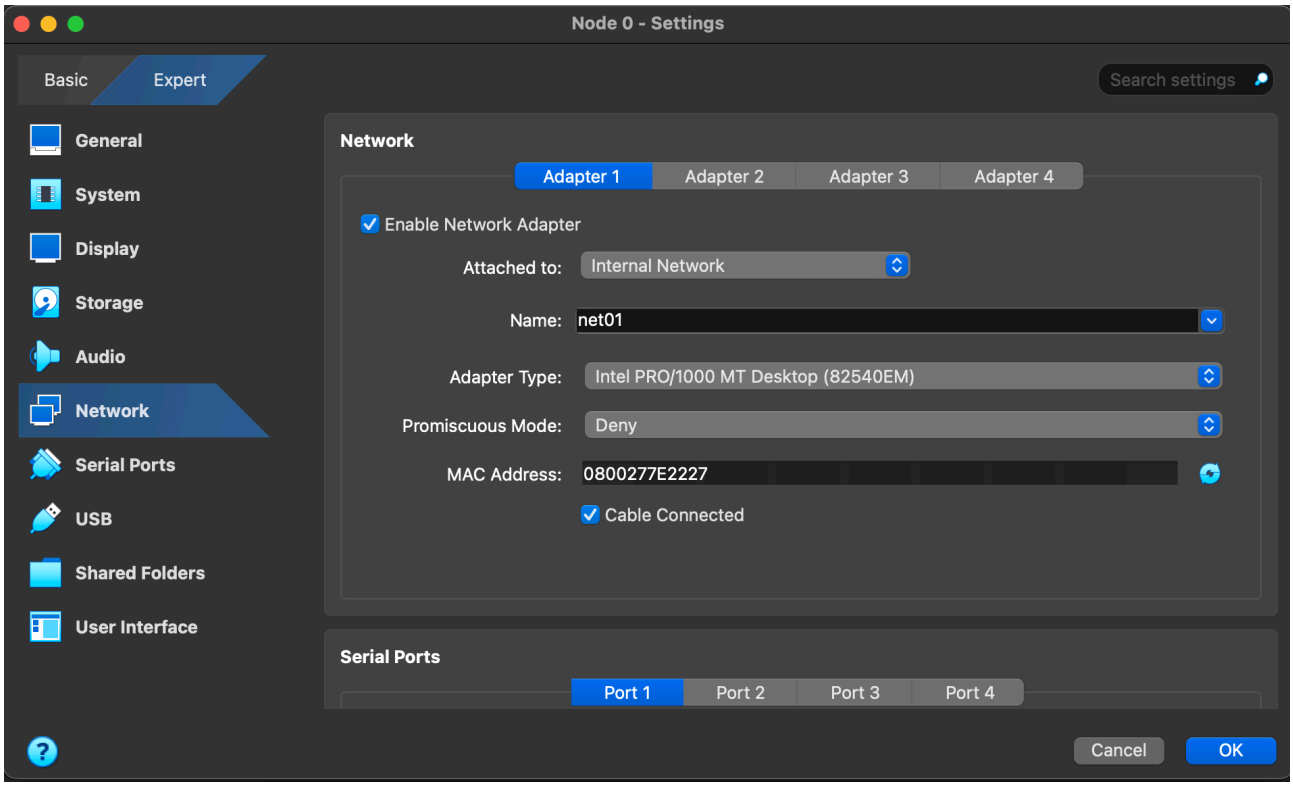
Step 1: Setting up the virtual machines

The virtual machines have to be set up to any desired scenario. For this setup guide, the following topology is assumed:

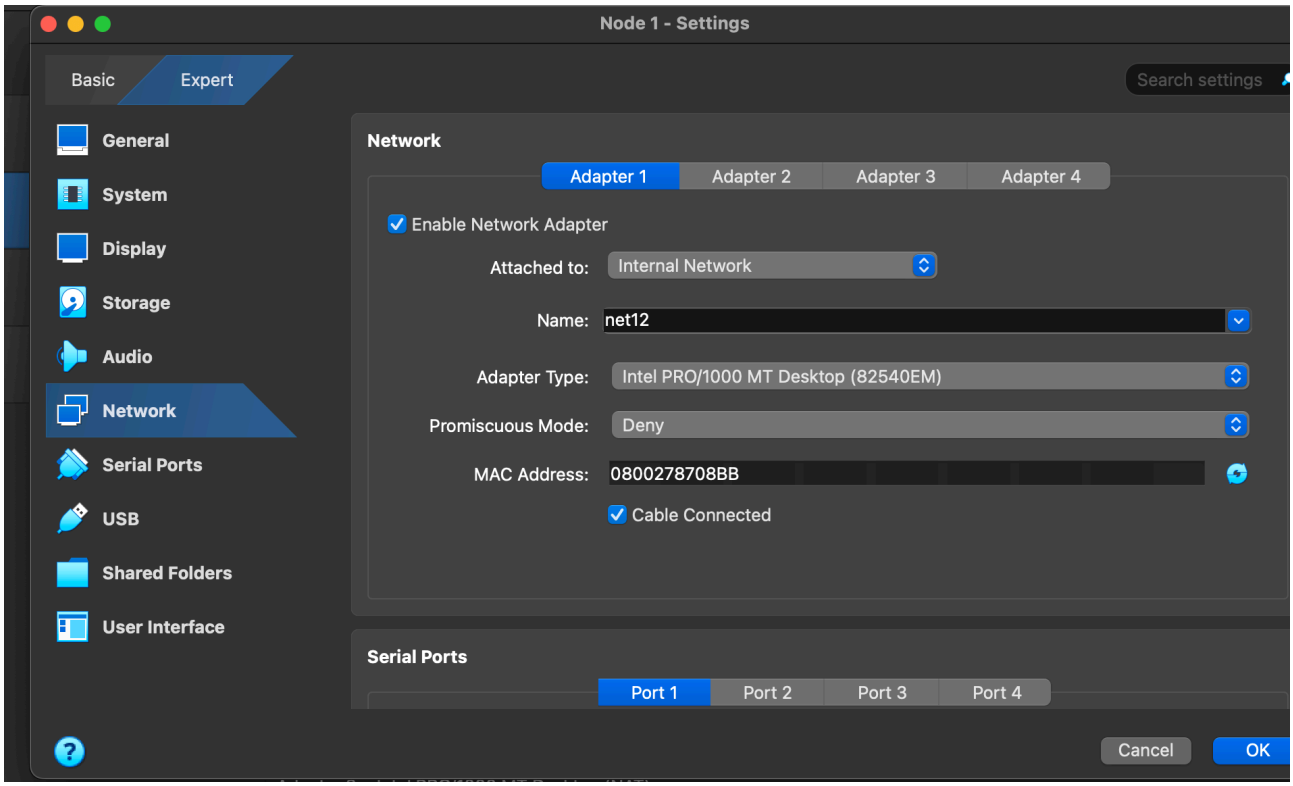
Each node represents one virtual machine. In this case, we use VirutalBox (https://www.virtualbox.org/). The code could also be run on actual devices like raspberries or other different devices using the linux tcp/ip stack.

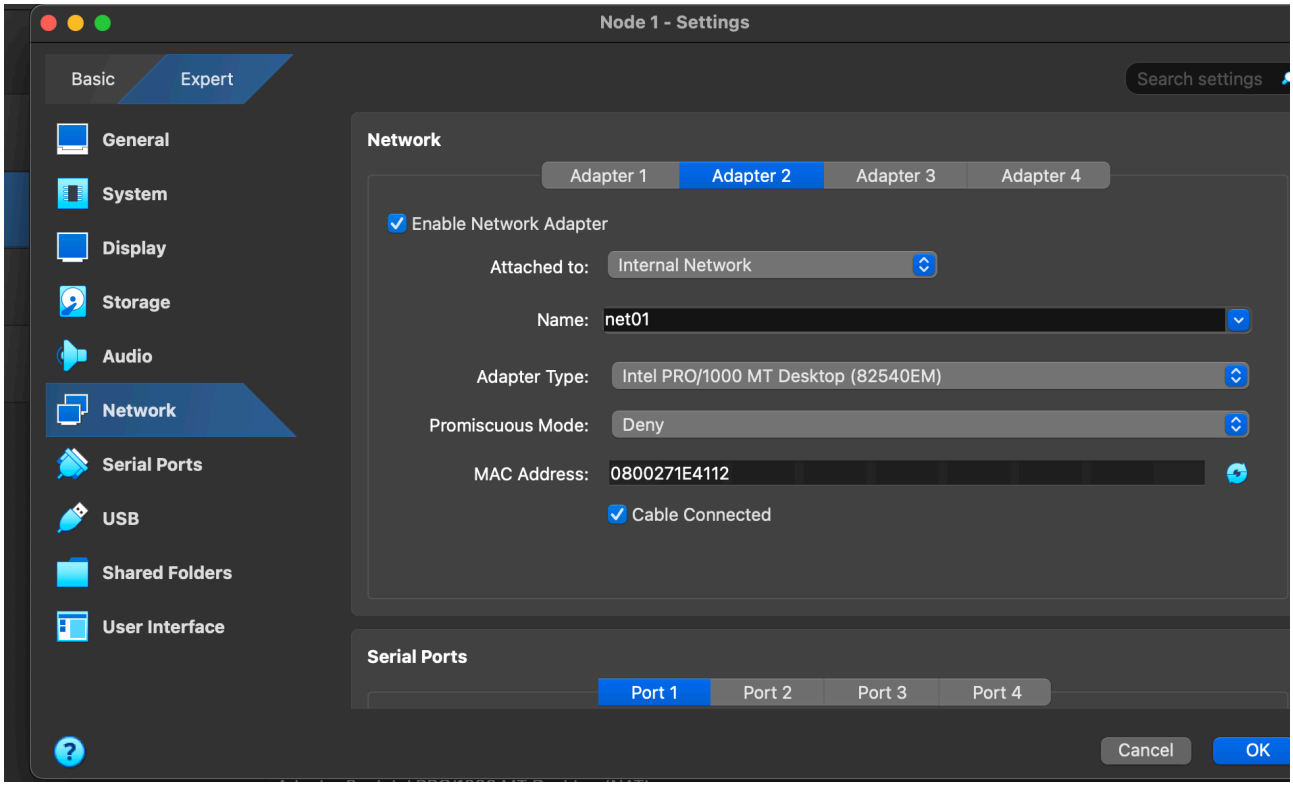
The virtual machines in virtual box have the following network settings to connect to each other via subnets.

Node 0:

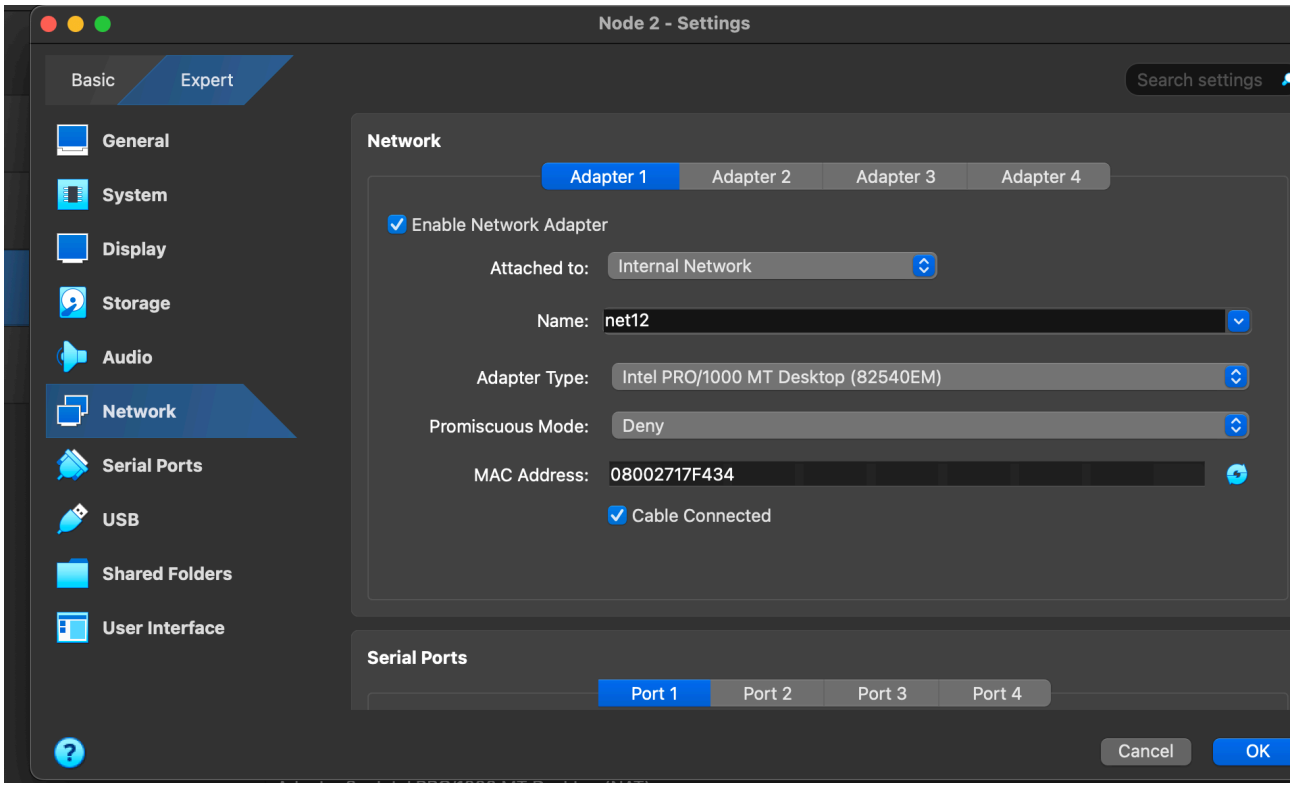


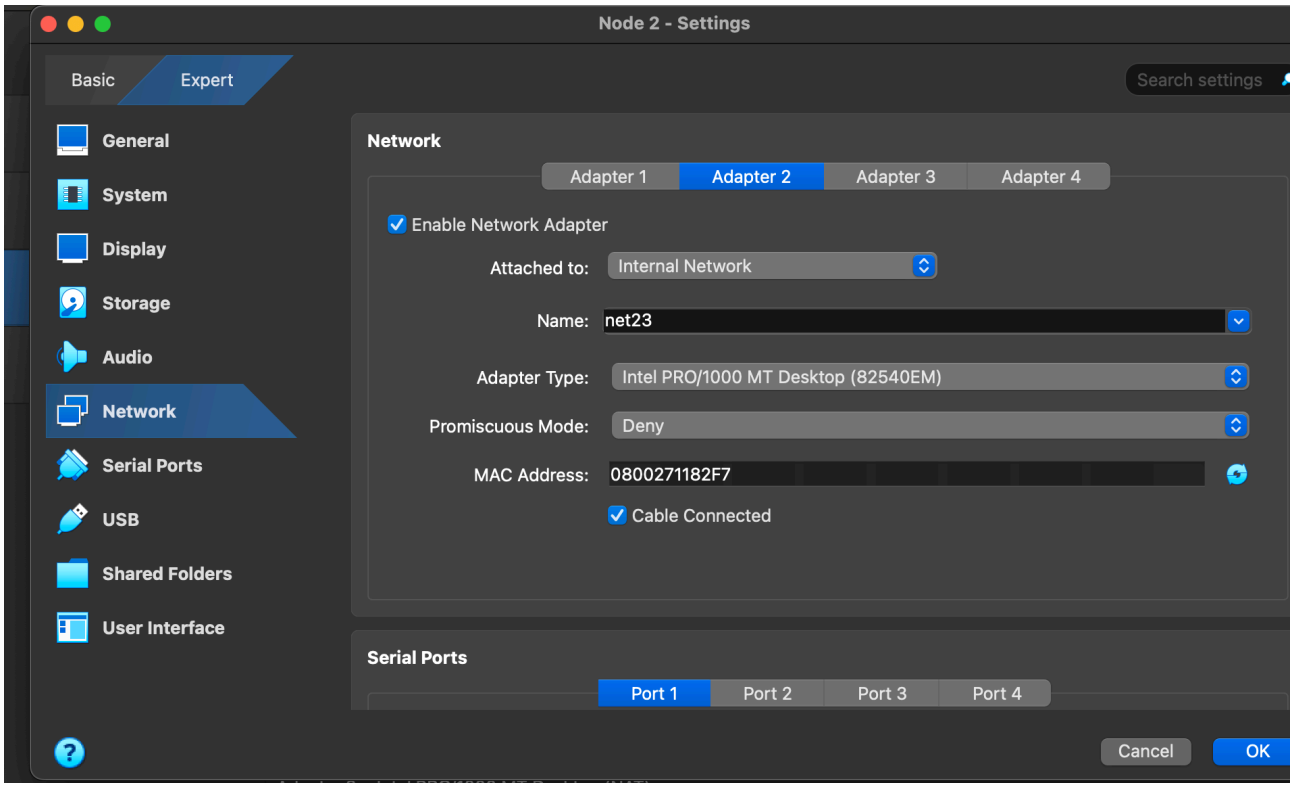
Node 1:


Node 1 - Settings
Basic
Expert
Search settings
General
System
Display
Storage
Audio
Network
Serial Ports
USB
Shared Folders
User Interface
Network
Adapter 1
Adapter 2
Adapter 3
Adapter 4
Enable Network Adapter
Attached to:
Internal Network
Name:
net12
Adapter Type:
Intel PRO/1000 MT Desktop (82540EM)
Promiscuous Mode:
Deny
MAC Address:
0800278708BB
Cable Connected
Serial Ports
Port 1
Port 2
Port 3
Port 4
Cancel
OK

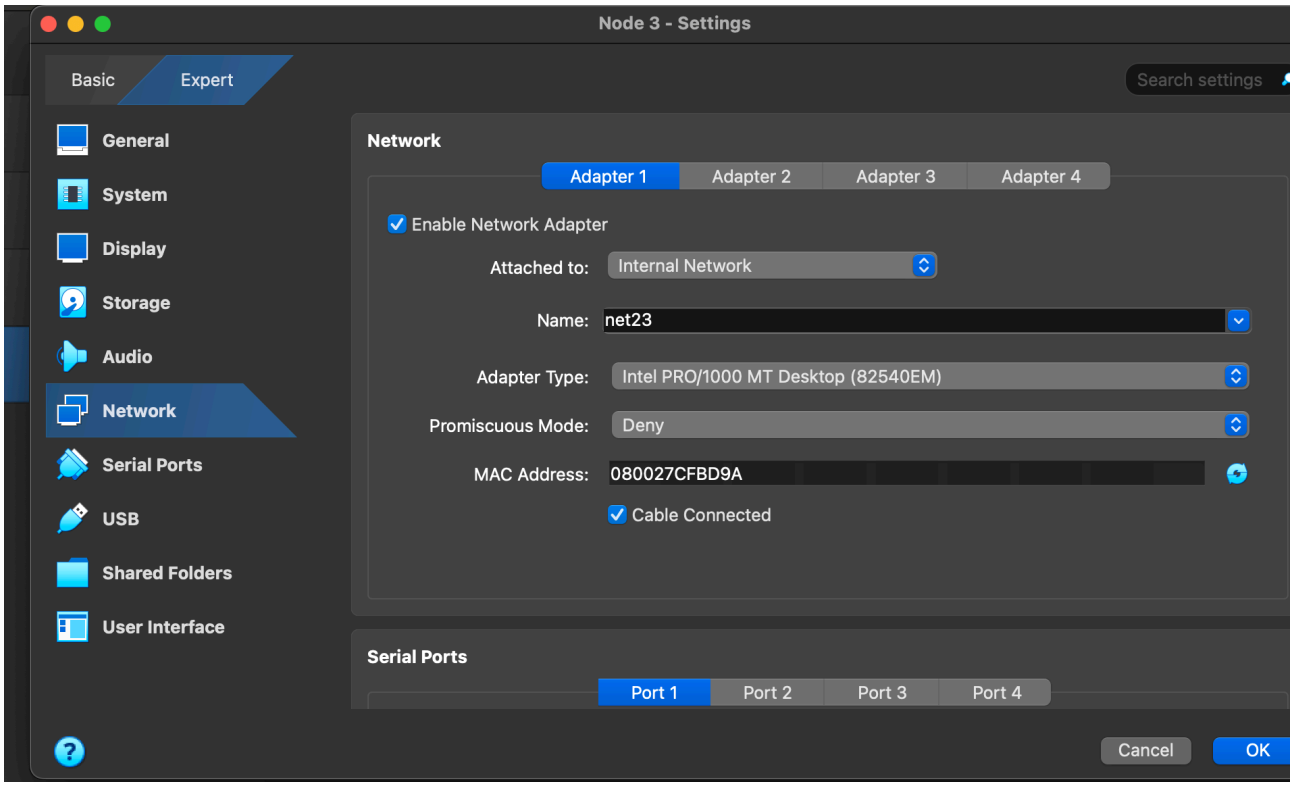

Node 1 - Settings
Basic
Expert
Search settings
General
System
Display
Storage
Audio
Network
Serial Ports
USB
Shared Folders
User Interface
Network
Adapter 1
Adapter 2
Adapter 3
Adapter 4
Enable Network Adapter
Attached to:
Internal Network
Name:
net01
Adapter Type:
Intel PRO/1000 MT Desktop (82540EM)
Promiscuous Mode:
Deny
MAC Address:
0800271E4112
Cable Connected
Serial Ports
Port 1
Port 2
Port 3
Port 4
Cancel
OK

Node 2:


Node 2 - Settings
Basic
Expert
Search settings
General
System
Display
Storage
Audio
Network
Serial Ports
USB
Shared Folders
User Interface
Network
Adapter 1
Adapter 2
Adapter 3
Adapter 4
Enable Network Adapter
Attached to:
Internal Network
Name:
net12
Adapter Type:
Intel PRO/1000 MT Desktop (82540EM)
Promiscuous Mode:
Deny
MAC Address:
08002717F434
Cable Connected
Serial Ports
Port 1
Port 2
Port 3
Port 4
Cancel
OK


Node 2 - Settings
Basic
Expert
Search settings
General
System
Display
Storage
Audio
Network
Serial Ports
USB
Shared Folders
User Interface
Network
Adapter 1
Adapter 2
Adapter 3
Adapter 4
Enable Network Adapter
Attached to:
Internal Network
Name:
net23
Adapter Type:
Intel PRO/1000 MT Desktop (82540EM)
Promiscuous Mode:
Deny
MAC Address:
0800271182F7
Cable Connected
Serial Ports
Port 1
Port 2
Port 3
Port 4
Cancel
OK

Node 3:



Step 2: Settings inside the virtual machines

In order to achieve the desired behavior and provide the necessary interfaces to the program, inside the virtual machines the following steps have to be taken:

- Enable IPv6 forwarding
- Create a persistent TUN interface on startup
- Assign the correct addresses to all interfaces with gateways
- Create rules to pass all traffic trough TUN

To achieve this, we have to adjust “/etc/network/interfaces” on all virtual machines and create “/etc/systemd/system/tun0.service” and “/usr/local/sbin/setup-tun0.sh” on all virtual machines.

Node 0:

For /etc/network/interfaces we have to add:

```
auto enp0s8
iface enp0s8 inet6 static
    address fd00:01::1
    netmask 64
    gateway fd00:01::2

post-up sysctl -w net.ipv6.conf.all.forwarding=1
post-up ip -6 route add fd00:12::/64 via fd00:01::2
post-up ip -6 route add fd00::/64 via fd00:01::2
post-up ip -6 route add fd00:22::/64 via fd00:01::2
post-up ip -6 route add fd00:33::/64 via fd00:01::2
```

Node 1:

For /etc/network/interfaces we have to add:

```
auto enp0s8
iface enp0s8 inet6 static
    address fd00:12::1
    netmask 64
    gateway fd00:12::2
    post-up ip -6 route add fd00:23::/64 via fd00:12::2
    post-up ip -6 route add fd00:33::/64 via fd00:12::2
    post-up ip -6 route add fd00:22::/64 via fd00:12::2

auto enp0s9
iface enp0s9 inet6 static
    address fd00:01::2
    netmask 64

post-up sysctl -w net.ipv6.conf.all.forwarding=1
```

We create /etc/systemd/system/tun0.service with:

```
[Unit]
Description=Set up tun0 interface
After=network.target

[Service]
Type=oneshot
ExecStart=/usr/local/sbin/setup-tun0.sh
ExecStop=/usr/bin/ip link delete tun0
RemainAfterExit=yes

[Install]
WantedBy=multi-user.target
```

And we create /usr/local/sbin/setup-tun0.sh with:

```
#!/bin/bash
set -e

ip tuntap add dev tun0 mode tun || true
ip addr add 10.0.0.1/24 dev tun0 || true
ip -6 addr add fd00::1/64 dev tun0 || true
ip link set tun0 up

ip6tables -t mangle -F PREROUTING
ip -6 rule del prio 10000 fwmark 1 table 100 2>/dev/null || true

ip6tables -t mangle -A PREROUTING -i enp0s8 -m addrtype ! --dst-type LOCAL -j MARK --set-
mark 1

ip6tables -t mangle -A PREROUTING -i enp0s9 -m addrtype ! --dst-type LOCAL -j MARK --set-
mark 1

if ! ip -6 rule list | grep -q "fwmark 1.*lookup 100"; then
    ip -6 rule add fwmark 1 table 100 priority 10000
fi

ip -6 route replace default via fd00::2 dev tun0 table 100
```

Node 2:

/etc/network/interfaces:

```
auto enp0s8
iface enp0s8 inet6 static
    address fd00:12::2
    netmask 64
    post-up ip -6 route add fd00::/64 via fd00:12::1
    post-up ip -6 route add fd00:01::/64 via fd00:12::1

auto enp0s9
iface enp0s9 inet6 static
    address fd00:23::2
    netmask 64
    post-up ip -6 route add fd00:33::/64 via fd00:23::3

post-up sysctl -w net.ipv6.conf.all.forwarding=1
```

/etc/systemd/system/tun0.service:

```
[Unit]
Description=Set up tun0 interface
After=network.target

[Service]
Type=oneshot
ExecStart=/usr/local/sbin/setup-tun0.sh
ExecStop=/usr/bin/ip link delete tun0
RemainAfterExit=yes

[Install]
WantedBy=multi-user.target
```

/usr/local/sbin/setup-tun0.sh:

```
#!/bin/bash
set -e
ip tuntap add dev tun0 mode tun || true
ip addr add 10.0.2.1/24 dev tun0 || true
ip -6 addr add fd00:22::1/64 dev tun0 || true
ip link set tun0 up

ip6tables -t mangle -F PREROUTING
ip -6 rule del prio 10000 fwmark 1 table 100 2>/dev/null || true

ip6tables -t mangle -A PREROUTING -i enp0s8 -m addrtype ! --dst-type LOCAL -j MARK --set-
mark 1

ip6tables -t mangle -A PREROUTING -i enp0s9 -m addrtype ! --dst-type LOCAL -j MARK --set-
mark 1

if ! ip -6 rule list | grep -q "fwmark 1.*lookup 100"; then
    ip -6 rule add fwmark 1 table 100 priority 10000
fi

ip -6 route replace default via fd00:22::2 dev tun0 table 100
```

Node 3:

/etc/network/interfaces:

```
auto enp0s8
iface enp0s8 inet6 static
    address fd00:23::3
    netmask 64
    gateway fd00:23::2
    post-up ip -6 route add fd00::/64 via fd00:23::2
    post-up ip -6 route add fd00:01::/64 via fd00:23::2
    post-up ip -6 route add fd00:12::/64 via fd00:23::2
    post-up ip -6 route add fd00:22::/64 via fd00:23::2

post-up sysctl -w net.ipv6.conf.all.forwarding=1
```

/etc/systemd/system/tun0.service:

```
[Unit]
Description=Set up tun0 interface
After=network.target

[Service]
Type=oneshot
ExecStart=/usr/local/sbin/setup-tun0.sh
ExecStop=/usr/bin/ip link delete tun0
RemainAfterExit=yes

[Install]
WantedBy=multi-user.target
```

/usr/local/sbin/setup-tun0.sh:

```
#!/bin/bash
set -e
ip tuntap add dev tun0 mode tun || true
ip addr add 10.0.0.2/24 dev tun0 || true
ip -6 addr add fd00:33::1/64 dev tun0 || true
ip link set tun0 up

ip6tables -t mangle -F PREROUTING
ip -6 rule del prio 10000 fwmark 1 table 100 2>/dev/null || true

ip6tables -t mangle -A PREROUTING -i enp0s8 -m addrtype ! --dst-type LOCAL -j MARK --set-
mark 1

if ! ip -6 rule list | grep -q "fwmark 1.*lookup 100"; then
    ip -6 rule add fwmark 1 table 100 priority 10000
fi

ip -6 route replace default via fd00:33::2 dev tun0 table 100
```

Step 3: Set values in the DTN application source code

Set all IP addresses to the desired values based on the topology you have. Also, add contacts to the routing table according to your topology and desired scenario. The files that have to be adjusted are:

- **dtn_controller.c** in lines 260 and 426. This is the address, on which the lwIP stack and the DTN program are accessible. So speaking from the perspective of the virtual machine the code is being adjusted on, this is “my” address of my user space.
- **dtn_routing.c.** Here, target nodes are added to the routing table. Define nodes in the beginning of the file.
- **main.c** needs the address for the devices TUN interface in line 53 and the address of the user space in multiple lines.
- **raw_socket.c** chooses the correct physical interface based on subnets. Adjust in the block starting from line 120.

Step 4: Running the code

Inside the project folder, run **make clean** and then **make.** Afterwards start the program with **sudo ./lwip_tun**