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Information on Simulating Remote Control with an Artificial Delay

Luzern, 25. June 2021

Contents

This document describes how to simulate the IGLUNA remote control network. A script configures DHCP for the testbed and the control room, limits multicast, sets a MTU of 1300 bytes and creates an executable file to generate an artificial delay with an adjustable bandwidth.

The script supports two types of network simulation, one with internet access and one without internet access.

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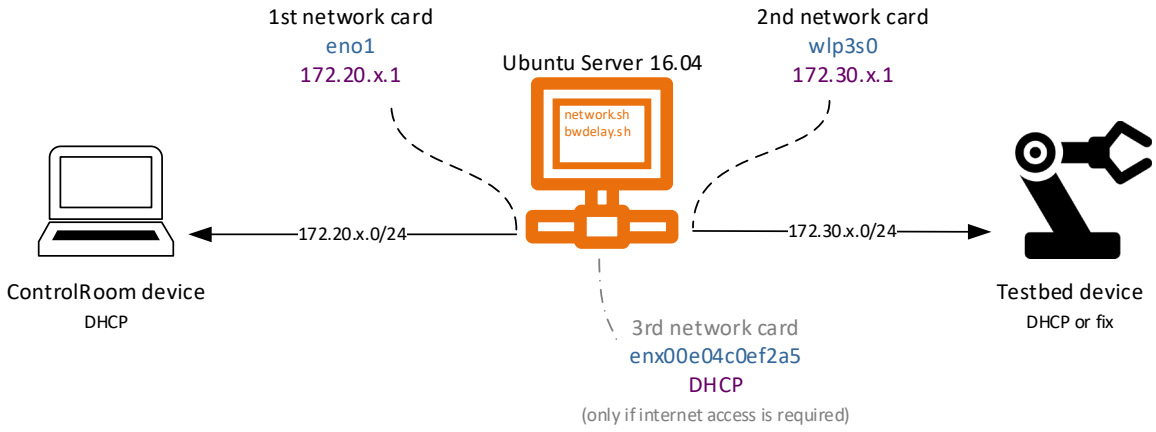
1. Setup Overview



2. Requirements

- A desktop or notebook with two (or three) network interfaces.
- Internet access (at least during system setup).
- Ubuntu Server **16.04** as operating system. Do **not** use a more recent version.
- The configuration script. Either directly from the web (https://bit.ly/3hpq8Sx) or from the Swiss Space Center file share (https://spacecenter.sharefile.eu > IGLUNA 2021 > 01_INSTRUCTIONS > IT_REMOTE-CONTROL > Remote Control Network Simulation > network_v2.sh).

3. Preparation

Install the Ubuntu operating system with its installation wizard.
Ensure that you are connected to the internet, otherwise you won't be able to download the latest updates, the DHCP server and the IGLUNA network simulation script.

After the installation, update the system and install the DHCP server with the commands below.

```
sudo apt update
sudo apt upgrade
sudo apt install isc-dhcp-server
```

4. Download the Script

Download the IGLUNA network simulation script directly to your test device (recommended!)

```
wget -O /home/{USER}/network.sh https://bit.ly/3hpq8Sx
```

Alternatively, download it from the Swiss Space Center file share and copy it to the test device.

https://spacecenter.sharefile.eu/ > IGLUNA 2021 > 01_INSTRUCTIONS > IT_REMOTE-CONTROL > Remote Control Network Simulation > network_v2.sh

In order to copy the file from an usb stick, mount a fat32 formatted usb-stick with:

```
sudo mount /dev/sd{x} /mnt
```

and copy the file to the test system

```
cp /mnt/network_v2.sh /home/{USER}/network.sh
```

5. Identify your Network Interfaces

The simulation needs two (or three) physical network interfaces to work. The names of the interfaces can be determined by the command

```
ip -c add
```

If you use an USB-to-Ethernet network adapter, make sure that the adapter is connected and supported by Linux.

```
gep@gep-Latitude-E6440:~$ ip -c addr
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
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eno1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 34:e6:d7:1a:a2:27 brd ff:ff:ff:ff:ff:ff
    inet 192.168.11.78/24 brd 192.168.11.255 scope global dynamic noprefixroute eno1
       valid_lft 86109sec preferred_lft 86109sec
    inet6 fd00::9808:61b9:573e:db51/64 scope global temporary dynamic
       valid_lft 6912sec preferred_lft 3312sec
    inet6 fd00::5e0c:e0d3:a037:a00b/64 scope global dynamic mngtmpaddr noprefixroute
       valid_lft 6912sec preferred_lft 3312sec
    inet6 fe80::8365:2d05:9c21:3283/64 scope link noprefixroute
       valid_lft forever preferred_lft forever
3: wlp3s0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN group default qlen 1000
    link/ether 80:00:0b:5f:b2:a7 brd ff:ff:ff:ff:ff:ff
4: enx00e04c0ef17e: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc fq_codel state DOWN group default qlen 1000
    link/ether 00:e0:4c:0e:f1:7e brd ff:ff:ff:ff:ff:ff
```

Your available network interfaces will be highlighted in a light blue colour. In this example, we use the on-board interface ***eno1*** and ***enx00e04c0ef17e***, which is an interface connected by an external USB-to-Ethernet adapter.

The interface ***lo*** (loopback interface) can be ignored as well as all interfaces starting with ***w…***, for example ***wlp3s0***. These interfaces are wireless adapters, which you will not need for the simulation.

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6. Run the Script

The script supports two network setups. One without internet access (a) and one with internet access (b).

Note: The script will modify network settings. Also make sure that external network adapters are connected to the system before running the script.

Before you can run the script, you will have to make it executable. To do so, execute the command:

```
chmod +x network.sh
```

a. Network Simulation without Internet Access

Launch the script with the command:

```
sudo ./network.sh interface1 interface2 groupnumber
```

For example:

```
sudo ./network.sh eno1 enx00e04c0ef17e 15
```

b. Network Simulation with Internet Access (third network interface required)

Make sure that the third adapter is the one, which is connected to the internet!

Launch the script with the command:

```
sudo ./network.sh interface1 interface2 groupnumber interface3
```

For example:

```
sudo ./network.sh eno1 enx00e04c0ef17e 19 enx00e04c0ef2a5
```

Press any key to restart the system.

7. Check Configuration

After the reboot check if the DHCP server is running.

```
service isc-dhcp-server status
```

```
gep@gep-Latitude-E6440:~$ service isc-dhcp-server status
● isc-dhcp-server.service - ISC DHCP IPv4 server
   Loaded: loaded (/lib/systemd/system/isc-dhcp-server.service; enabled; vendor preset: enabled)
   Active: active (running) since Tue 2020-01-14 12:29:04 CET; 33s ago
     Docs: man:dhcpd(8)
 Main PID: 1192 (dhcpd)
    Tasks: 1 (limit: 4915)
   Memory: 10.7M
   CGroup: /system.slice/isc-dhcp-server.service
           └─1192 dhcpd -user dhcpd -group dhcpd -f -4 -pf /run/dhcp-server/dhcpd.pid -cf /etc/dhcp/dhcpd.conf eno1 enx00e04c0ef17e
```

Look at the troubleshooting section if the DHCP server is not running.

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8. Connect your Devices

Connect your devices to the test system. If your control room and testbed devices have DHCP enabled, you will get an IP address from the appropriate network. Otherwise, you will have to assign a static IP address in advance.
Try to ping your remote device. If ICMP (ping) is allowed on your remote device you should get a reply.

For example:

```
C:\Users\igluna>ping 172.30.19.111

Pinging 172.30.19.111 with 32 bytes of data:
Reply from 172.30.19.111: bytes=32 time=1ms TTL=127
```

Before you move on to the next step, make sure that the communication between your devices is working.

9. Add an Additional Artificial Delay & Bandwidth Limit

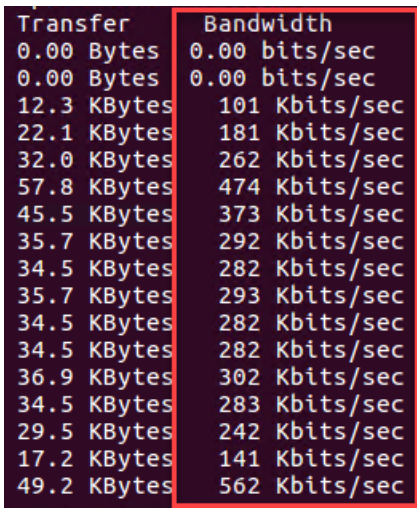
The IGLUNA network simulation script creates an executable file (bwdelay.sh) which allows you to add an artificial delay between the two networks and sets a maximal bandwidth.

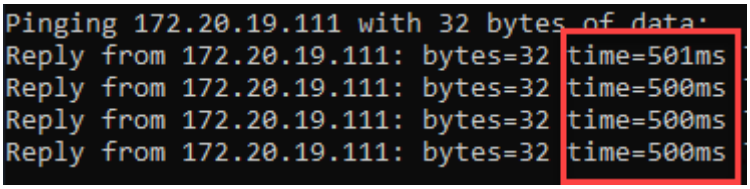
To add a bandwidth limit of 300 kbit/s and a delay of 500ms execute:

```
sudo ./bwdelay.sh 300 250
```

➔ Delay must be set half of the roundtrip time. (500/2)

Please note that bandwidth limit is only an approximate value, it may differ from the defined bandwidth limit. (~300kbit/s)





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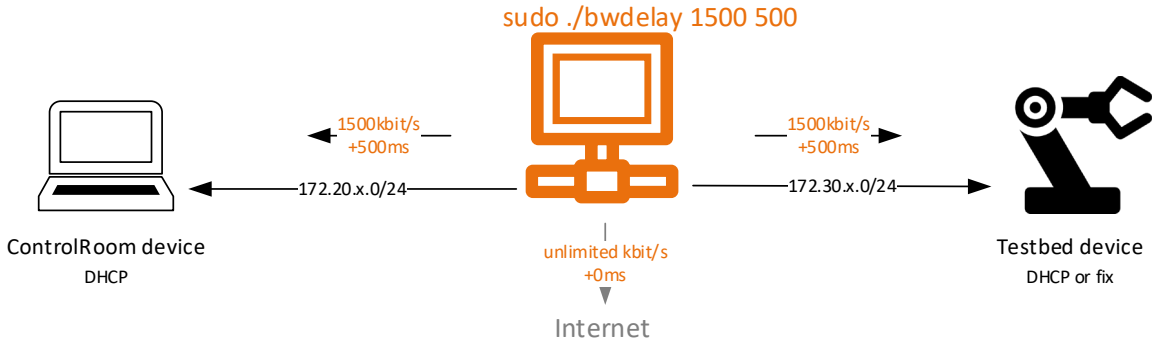

The currently configured delay per interface can be shown with:

```
tc qdisc show | grep delay
```

The currently configured bandwidth limit per interface can be shown with:

```
tc qdisc show | grep rate
```

Note: The additional delay and the bandwidth limit is not persistent. You have to apply it again after a system restart.

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Test your communication again with the ping command. You should now have an additional delay of a second (+ 2x 250ms).

```
C:\Users\igluna>ping 172.30.19.111

Pinging 172.30.19.111 with 32 bytes of data:
Reply from 172.30.19.111: bytes=32 time=501ms TTL=127
```

Internet access (if available) is also delayed, but only one-way.

```
C:\Users\igluna>ping spacecenter.ch

Pinging spacecenter.ch [80.74.145.40] with 32 bytes of data:
Reply from 80.74.145.40: bytes=32 time=253ms TTL=51
```

Important Advice: Do not start with a too high delay and a too small bandwidth, and remember that with the TCP protocol, speed decreases quickly with higher latency!
https://www.switch.ch/network/tools/tcp_throughput/

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10. Troubleshooting

Problem: Network adapter is not listed in ***`ip -c add`***
Solution: Make sure that your adapter is supported by Ubuntu 16.04 and connected to the test device.

Problem: The isc-dhcp-server service isn't running
Solution: Check if you used the correct interface parameters with ***`ip -c add`*** command. If not, run the script again and check the status.

Problem: The network adapter doesn't receive an IP address.
Solution: (a) This can happen if you unplug and plug in your external network adapter after system start-up. Restart your system.

(b) Check with ***`ip -c add`*** if your network cards have the correct network IPs configured. Especially when you configured three network adapters.

Problem: What IP leases are already assigned by the DHCP server?
Solution: Check with ***`dhcp-lease-list --lease /var/lib/dhcp/dhcpd.leases`***

If you still have problems, write a message on slack in the channel called #it_remote-control.