Practical Computer Networks and Applications

Exercise 2 – IP Version 6 Networks

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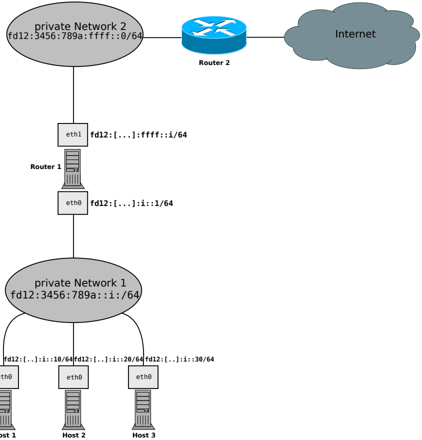
Network Topology – Exercise 2 – ULA



Network Topology of lab exercise 2 – Task 2 ULA

Private Network 1:

`fd12:3456:789a:i::0/64`

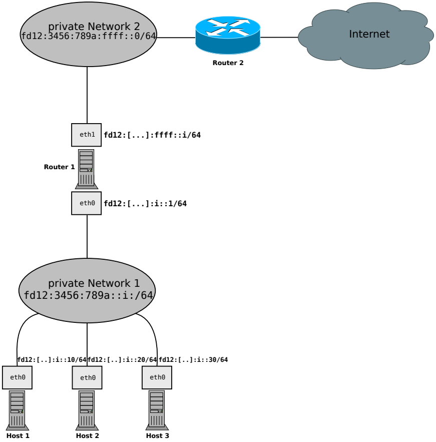
Private Network for host machines and router

Private Network 2:

`fd12:3456:789a:ffff::0/64`

Private Network spanning all networks

Network Topology – Private Network 2



Network Topology of lab exercise 2 – Task 2 ULA

Private Network 2:

`fd12:3456:789a:ffff::0/64`

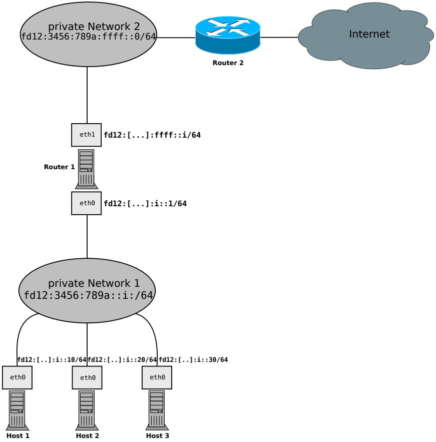
Router 2:

`fd12:3456:789a:ffff::ffff`

Router 2 is the gateway for all routers in private network 1!

The route to **Router 2** needs to be configured on **Router 1**!

Network Topology – Private Network 1



Network Topology of lab exercise 2 – Task 2 ULA

Private Network 1:

`fd12:3456:789a:i::0/64`

Router 1:

1. `eth0` – `fd12:3456:789a:i::1`
2. `eth1` – `fd12:3456:789a:ffff::i`

Host Network:

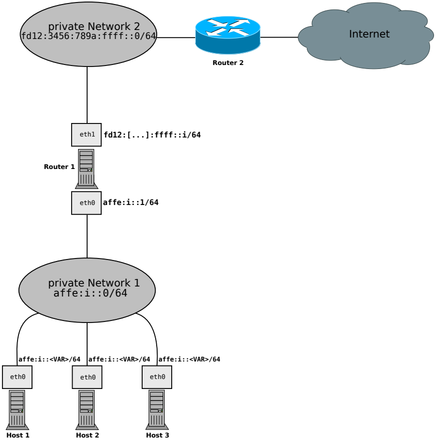
Router 1 – `fd12:3456:789a:i::1`

Host 1 – `fd12:3456:789a:i::10`

Host 2 – `fd12:3456:789a:i::20`

Host 3 – `fd12:3456:789a:i::30`

Network Topology – Exercise 2 – Autoconfiguration



Network Topology of lab exercise 2 – Task 3 Autoconfiguration

Private Network 1:

`affe:i::0/64`

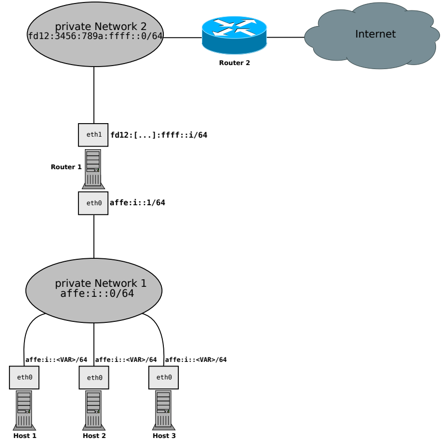
Private Network for host machines and router

Private Network 2:

`fd12:3456:789a:ffff::0/64`

Private Network spanning all networks

Network Topology – Private Network 2



Network Topology of lab exercise 2 – Task 3 Autoconfiguration

Private Network 2:

`fd12:3456:789a:ffff::0/64`

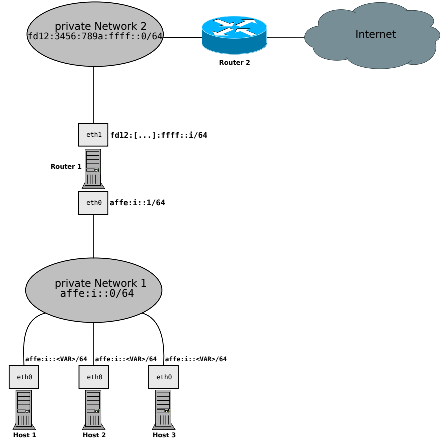
Router 2:

`fd12:3456:789a:ffff::ffff`

Router 2 is the gateway for all routers in private network 1!

The route to **Router 2** needs to be configured on **Router 1**!

Network Topology – Private Network 1



Network Topology of lab exercise 2 – Task 3 Autoconfiguration

Private Network 1:

`affe:i::0/64`

Router 1:

1. Interface `eth0` – `affe:i::0/64`
2. Interface `eth1` – `fd12:3456:789a:ffff::i`

Host Network:[1]

Router 1 – `affe:i::1`

Host 1 – `affe:i::<VAR>`

Host 2 – `affe:i::<VAR>`

Host 3 – `affe:i::<VAR>`

[1] `<VAR>` is the placeholder for a dynamically generated address!

Network Topology – Exercise 2 – Objectives

In the lab exercise you need to accomplish…

- ✓ a successful static configuration of the machines!
- ✓ successful autoconfiguration of the hosts!
- ✓ working static routing on the machines!
- ✓ reachability of all machines (all hosts including **Router 1** and **2**)!

Contents

IPv6 Addresses

Tabelle: IPv6 address ranges

IPv6 Address	Purpose
`2001:db8::/32`	Documentation prefix used for examples
`::1`	Localhost
`fc00::/7`	Unique Local Addresses (ULA) - also known as “Private” IPv6 addresses.[a]
`fd00::/8`	Unique Local Addresses (ULA) - **L-bit** set to **1** for local IPv6 address prefix
`fe80::/10`	Link Local addresses, only valid inside a single broadcast domain.
`2001::/16`	Global Unique Addresses (GUA) - Routable IPv6 addresses.
`ff00::0/8`	Multicast addresses

[a] Currently not used! See source: RFC 4193 Section 3.2

IPv6 Addresses

Multicast-Scope – `ff00::0/8` multicast groups for specific services in a network. Starting with `ff` and followed by two flag bits for specific services. `ff01` for local interface (not leaving interface), `ff02` for link local address space e.g.:

`ff0X::1` : all IPv6 stations
`ff0X::2` : all router
`ff0X::f` : UPnP
`ff0X::101` : all timeserver (NTP)
`ff0X::1:2` : DHCPv6 Server

IPv6 Addresses

There are four way of configuring IPv6 addresses:

- static adressing with ULA (RFC 4193)
- SLAAC (RFC 4862)
- Stable Private (RFC 7217)
- Privacy Extension (RFC 4941)

IPv6 Addresses in Linux

The `ip`[2] command:

- `ip addr` ... – configuration of IPv6 addresses
- `ip route` ... – configuration of IPv6 routes

`-6` option in `ip`

The option `-6` specifies the use of IPv6 addresses. It is important to use this option because without the parameter `ip` defaults to IPv4!

[2] The manpage of `ip` gives you the full list of functions and options!

Static IPv6 unique local addresses – ULA

Tabelle: RFC 4193 Addressing Scheme

Machine	Prefix/L	Global ID	Subnet ID	Interface ID
Router 1	fd00::/8	xx:xxxx:xxxx	**i**	0000:0000:0000:0001
Host 1	fd00::/8	xx:xxxx:xxxx	**i**	0000:0000:0000:0010
Host 2	fd00::/8	xx:xxxx:xxxx	**i**	0000:0000:0000:0020
Host 3	fd00::/8	xx:xxxx:xxxx	**i**	0000:0000:0000:0030

Static IPv6 unique local addresses – ULA

Tabelle: RFC 4193 Lab Exercise 2

Prefix/L	Global ID	Subnet ID	Interface ID
fd00::/8	**40 bits**	**16 bits**	**64 bits**
fd00::/8	12:3456:789a	:0001	0000:0000:0000:0001

Resulting IPv6 address: fd12:3456:789a:0001:0000:0000:0000:0001
Short IPv6 address: fd12:3456:789a:1::1

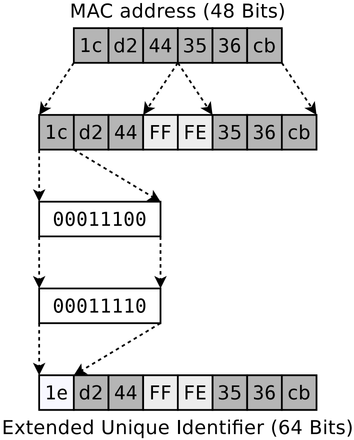
Stateless Address Autoconfiguration – SLAAC (RFC 4862)

- The RFC 4862 defines the automatic stateless address generation
- The Host uses its MAC address for the generation of the 64-bit Host-ID (**EUI-64**)
- The Network Prefix is defined by the scope and or the router (e.g. `fe80::/64` for link-local)
- **Benefit** → Stateless generation without an external router

Router Advertisement Daemon (`radvd`)

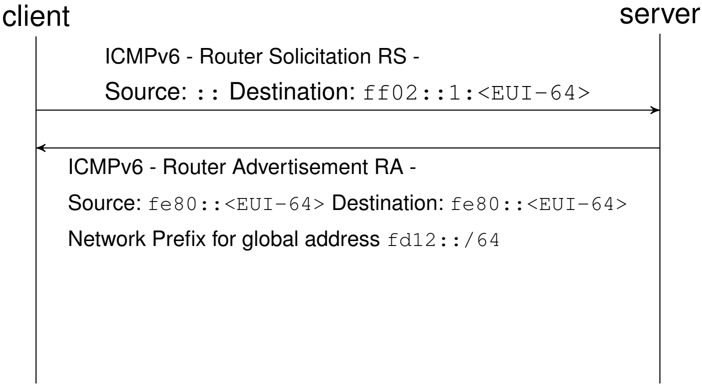
For the automatic assignment of Network prefixes the router needs a `radvd` for the management of network prefixes in the network. Without `radvd` the link local prefix `fe80::/64` is used!

Stateless Address Autoconfiguration – SLAAC (RFC 4862)



EUI-64 calculation

Stateless Address Autoconfiguration – SLAAC (RFC 4862)



Message Sequence Diagramm for Router Solicitation

Stable Privacy – RFC 7217

- The RFC 7217 defines the address generation without the use of a MAC address
- In RFC 7217 a random secret key is generated and used for the generation of the Interface-ID
- Once generated the Interface-ID is assigned and does not change anymore (until reboot!)
- **Benefit** $\rightarrow$ Increased security because no MAC address is used for generation!

Secret Key and Kernel parameter

The stable secret value is stored in the directory `/proc/sys/net/ipv6/conf/eth0/stable_secret` and is generated by setting the Kernel parameter `addr_gen_mode=3`!

Stable Privacy – RFC 7217

Example of a generated stable private address:

```
MAC: 86:3a:ea:8a:a7:d9
stable-privacy -> inet6 fe80::6f6d:80e:ab6c:65a0/64
link local -> inet6 fe80::843a:eaff:fe8a:a7d9/64
```

Example of `stable secret` parameter:

```
$ cat /proc/sys/net/ipv6/conf/eth0/stable_secret
c8c8:036d:9312:71e2:eadc:7c9f:0535:649a
```

Stable Privacy – RFC 7217

In contrast to SLAAC RFC 7217 brings the following benefits:

+ Host’s MAC address is not exposed!
+ The address is stable for the Host

Privacy Extension – RFC 4941

- The RFC 4941 defines the address generation with a random number
- It is using the address in a temporary manner
- A new Interface-ID is getting generated periodically
- Old Interface-IDs can still be used for established connections
- **Benefit** → Increased security because no MAC address is used for generation!
- **Drawback** → Address is not stable!

Random generation of Interface-ID

The RFC 4941[a] defines a scheme for the generation of addresses where values for the lifetime are defined and the valid lifetime is calculated with the formula:

`CREATION_TIME + TEMP_PREFERRED_LIFETIME - DESYNC_FACTOR`

Where `CREATION_TIME` is the time at which the address was created, `TEMP_PREFERRED_LIFETIME` (the maximum time of validity) and `DESYNC_FACTOR` (a random number in the range of 0 to 600 seconds)!

[a] Source: `https://datatracker.ietf.org/doc/html/rfc4941#page-13`

Privacy Extension – RFC 4941

Example of a random generated address:

```
MAC: 86:3a:ea:8a:a7:d9
privacy-extension -> inet6 fd12::8992:3c03:d6e2:ed72/64
link local -> inet6 fe80::843a:eaff:fe8a:a7d9/64
```

Random generation of Interface-ID

The address shown above is generated randomly and temporary and cannot be traced back to any host characteristics!

Privacy Extension – RFC 4941

In contrast to SLAAC RFC 4941 brings the following benefits:

- \+ Host's MAC address is not exposed!
- \+ The address is generated dynamically over time!

  Benefit → Increased security because no MAC address is used for generation!

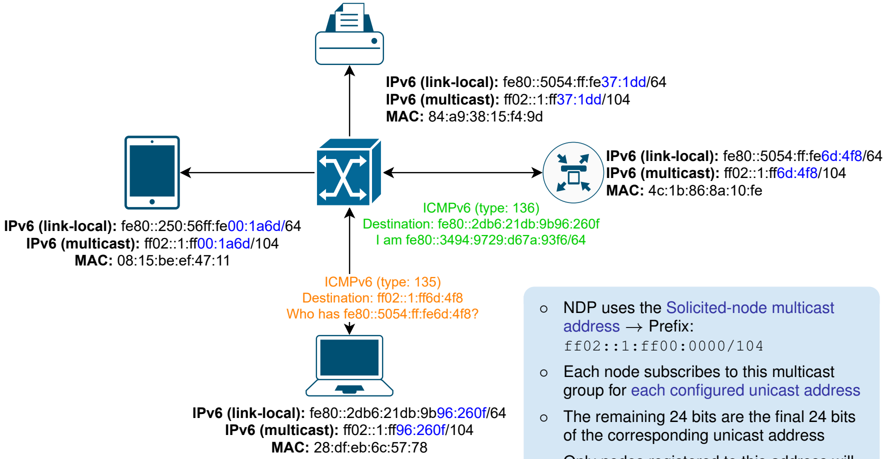
In contrast to Stable Privacy RFC 4941 brings the following benefits:

- \+ Host address is changed over time, therefore increased security!

  Benefit → Increased security because address expires!

  Drawback → Address is not stable!

Neighbor Discovery Protocol – NDP



- NDP uses the Solicited-node multicast address → Prefix: `ff02::1:ff00:0000/104`
- Each node subscribes to this multicast group for each configured unicast address
- The remaining 24 bits are the final 24 bits of the corresponding unicast address
- Only nodes registered to this address will receive the ICMP message

Configuration of the machines

Please follow these rules:

Make your configurations statically! Use the tool `ip` **exclusively!**

Save your configuration on file! Use an USB-Drive for the extraction!

Test your setup and document it accurately! Demonstrate it in the lab exercise!

Make slides of your configurations! Use the command-line snippets, screenshots and Wireshark captures for your documentation!

Non persistent configuration on machines

Please be aware, that the configurations on the machines are static and will be deleted after a reboot! Make sure to save your progress on an external drive!