All Beginnings are Difficult

You have started a new job as the network operator for a small startup.

There's no network infrastructure yet except for a connection to the Internet provided by the local ISP. Seems like you will have to build the network from scratch.

You will simulate the network build using GNS3, so start up GNS3 in the lab VM and create a new project.

18.1 Laying the Groundwork

To start your deployment you decide to set up the gateway router and the Internet connection first.

- Place a cloud node. (It is automatically configured to be bridged to `eth0` of the lab VM.)
- Place a HONLinux node and connect one of its interfaces to the cloud.

Start the nodes in your network and configure the HONLinux node:

- Change its hostname to `gateway`

Solution:

```
$ hostname gateway
$ echo "gateway" > /etc/hostname
$ echo "127.0.0.1 gateway localhost" > /etc/hosts
$ echo "::1       gateway localhost" >> /etc/hosts
```

- Setup the Internet connection (the ISP uses a DHCP server)

Solution:

Assuming eth0 is connected to the cloud node, add the following to /etc/network/interfaces:

```
auto eth0
iface eth0 inet dhcp
```

No extra configuration has to be done for DNS resolution. The DHCP client will take care of it.

- Verify your configuration by checking whether IP and DNS are working properly.

Solution:

It is sufficient to issue the `ping` command for e.g. `www.uni-saarland.de`.
In order to send echo requests the resolver will try to resolve the hostname to an IP address, therefore also verifying DNS is working.

```
$ ping www.uni-saarland.de
...
```

18.2 Departments

Next you decide to start setting up the internal network. You decide to setup two separate networks, one for the *engineering* team and one for the *accounting* department.

- Design a simple address plan using any of the RFC1918-ranges.

Solution:

Department	VLAN	Network	Gateway Address
Engineering	10	10.0.10.0/24	10.0.10.1
Accounting	20	10.0.20.0/24	10.0.20.1

- Update your network by adding the required nodes (switches, hosts) to represent the new department networks. Create *at least two workstations* per department.

  You can use *webterm*-nodes to represent workstations. You can edit the network configuration of the nodes from their GNS3 configuration dialog.

Solution: The reference network uses VLANs, so the gateway requires only one physical connection to `SW2` carrying data frames for both networks. This requires `SW2` to be aware of the VLANs and has to be configured appropriately.

`SW2` is configured to receive tagged frames on port 1 (*dot1q* mode) and only allows access to one specific VLAN (*Access* mode) to the corresponding department switches `SW3` and `SW4` connected to ports 2 and 3.

- Setup the gateway for the new networks.

Solution: On the gateway, update `/etc/network/interfaces` to assign addresses to the interfaces to which the department subnets are connected to. In the reference network these are the virtual interfaces for the corresponding VLAN.

```
# Bring up the physical interface used by the VLANs
# but do not configure it.
auto eth1
iface eth1 inet manual

# Engineering
auto eth1.10
iface eth1.10 inet static
    address 10.0.10.1
    netmask 255.255.255.0

# Sales
auto eth1.20
iface eth1.20 inet static
    address 10.0.20.1
    netmask 255.255.255.0
```

- Configure the workstations with a static IP address according to your address plan.

Solution:

```
# /etc/network/interfaces
# Example for the engineering department

auto eth0
iface eth0 inet static
  address 10.0.10.5
  netmask 255.255.255.0
  gateway 10.0.10.1
```

- Verify that the IP configuration is correct by making sure workstations in the same network can connect to each other and to the gateway.

Solution: Connectivity can be verified using a few `ping` commands from different PCs and/or the gateway.

18.3 The Route(r) to Success

After returning from lunch the first complaints are coming in.

Your colleages are complaining there's something wrong with the network. Both departments are complaining they are unable to access workstations in the other department

- Update your configuration, so that workstations from either department can communicate with each other.

Solution: To enable communication between separate departments, packets have to be routed between them. On `gateway` enable routing by adding the following line to `/etc/sysctl.conf`:

```
net.ipv4.ip_forward = 1
```

Note: In order for the change to take effect you need to change the setting in the running kernel (e.g. by restarting the gateway, rereading the file with sysctl or issuing a command writing the desired state to the corresponding sysctl file yourself).

18.4 Making things more Dynamic

Meanwhile the engineering department started their work. They brought in a lot of additional hardware which needs to be connected to the network. In order to make it easier for them to add new devices to the network, they ask you to set up some form of dynamic address configuration. You decide to set up a DHCP service for all the departments, since this will make your job easier as well.

- Setup DHCP service to provide IP addresses for both departments.

Solution: We can use Dnsmasq to offer DHCP for the internal networks. The easiest way to do so is to configure Dnsmasq on `gateway`.

At the very least you will have to add two address ranges to `/etc/dnsmasq.conf` from which addresses will be assigned:

```
# Engineering
dhcp-range=10.0.10.10,10.0.10.100,5m

# Sales
dhcp-range=10.0.20.10,10.0.20.20,5m
```

After changing the configuration start Dnsmasq and make sure it is started automatically at boot:

```
service dnsmasq start
rc-update add dnsmasq default
```

Alternatively you can setup a separate host using the *dnsmasq* appliance (which may present some additional challenges later however).

- Reconfigure the workstations to use DHCP to obtain IP addresses and verify your setup.

Solution: To make sure workstations acquire an IP address using DHCP, replace the contents of `/etc/network/interfaces` (using the configuration dialog of the appliance) with the following lines:

```
auto eth0
iface eth0 inet dhcp
```

18.5 Watch your Six

You recently met with Scott, a friend from your old job. He tells you about a network protocol all of the techies at the old place are talking about. Intrigued about the idea of a new shiny toy, you inquire further and find out he is talking about IPv6. After reading up a little bit about IPv6 you decide to implement it at the office.

Since your ISP is not offering IPv6 at the moment you decide to run IPv6 **locally on your network** using unique local addresses.

- Generate a random prefix in the ULA-range (e.g. using http://simpledns.com/private-ipv6).

Solution: For this solution we will be using the ULA prefix `fdae:889e:ec80::/48`.

- Update your address plan for IPv6 using the generated prefix. Make sure the subnets can be used for IPv6 autoconfiguration using SLAAC.

Solution: To support SLAAC in a subnet we have to make sure the network prefix has a length of **exactly 64 bit**. The updated address plan could e.g. look like this:

Department	VLAN	Network	Gateway Address
Engineering	10	10.0.10.0/24	10.0.10.1
		fdae:889e:ec80:a::/64	fdae:889e:ec80:a::1
Accounting	20	10.0.20.0/24	10.0.20.1
		fdae:889e:ec80:14::/64	fdae:889e:ec80:14::1

- Configure your gateway to support IPv6 (i.e. configure IPv6 addresses for its internal interfaces).

Solution: To configure IPv6 on gateway simply add IPv6 addresses to the interfaces. The IPv4 configuration does not require changing.

```
iface eth1.10 inet6 static
  address fdae:889e:ec80:a::1
  netmask 64

iface eth1.10 inet6 static
  address fdae:889e:ec80:14::1
  netmask 64
```

In order to enable communication between subnets we also have to enable routing for IPv6. You can either enable routing globally (i.e. between all IPv6 interfaces) or just for the internal interfaces:

```
# Enable IPv6 forwarding for all interfaces
sys.net.ipv6.conf.all.forwarding = 1

# Enable IPv6 forwarding for internal interfaces only
sys.net.ipv6.conf.eth1.10.forwarding = 1
sys.net.ipv6.conf.eth1.20.forwarding = 1
```

- Update your Dnsmasq configuration to support IPv6 using SLAAC. You can find more information on how to setup dynamic IPv6 addressing in `/etc/dnsmasq.conf` or in the Dnsmasq manpage (available only in the lab VM, not in the HONLinux appliance).

Solution: To enable IPv6 on the internal networks, add the corresponding IP ranges to `/etc/dnsmasq.conf`.

```
dhcp-range=fdae:889e:ec80:a::,ra-stateless
dhcp-range=fdae:889e:ec80:14::,ra-stateless
```

This will cause IPv6 aware devices to use SLAAC to obtain an IPv6 address.

- Verify your setup. Also make sure departments can communicate with each other using IPv6.

Solution: For SLAAC, no changes are required to the workstations. The Linux kernel (and in fact most operating systems) will automatically derive an address for the local subnet.

When using DHCPv6, the interface configuration in `/etc/network/interfaces` has to be updated:

```
iface eth0 inet6 dhcp
```

You can verify your IPv6 configuration using e.g. the `ping6` command.