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MANRS Lab

Exercise Creation Guide

Version 1 – 20 December 2018

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Client software requirements

Browser

The lab is accessed through a modern web browser. Current versions of Safari, Chrome and Firefox have been tested.

Installing GNS3 client software

To access the server securely an OpenVPN client is used. Instructions on how to use the VPN can be found on https://docs.gns3.com/1c2Iyiczy6efnv-TS_4Hc7p11gn03-ytz9ukgwFfckDk/index.html. Popular OpenVPN client applications are Viscosity and Tunnelblick.

Exercise creators then use the GNS3 client on their PC to get direct access to the lab configurations over the VPN. The client software can be downloaded from https://github.com/GNS3/gns3-gui/releases and instructions on how to configure it are at https://docs.gns3.com/1K_OVfincey0cUw6CP4dWVgs_pBXMdlJ6gdFGjNy8EZQ/index.html. Make sure to select the "Run everything on a remote server" option.

When downloading the GNS3 client software make sure you download the exact same version as is used on the server. If the versions do not match the client will refuse to connect to the server.

Simulated device images

For each type of (emulated) device that you are going to use in your exercise you will need a GNS3 Appliance. Some of those appliances may already have been installed on the GNS3 server, in which case you can use those. Using other types of appliances may need some appliance-specific installation steps.

GNS3 supports a large number of appliances. A list of appliances that are included by default can be found at https://docs.gns3.com/1FFbs5hOBbx8O855KxLetlCwlbymTN8L1zXXQzCqfmy4/index.html#h.appliances, and there is a marketplace at https://gns3.com/marketplace/appliances that offers even more appliances for download.

Please note that only text-based console connections are supported by the lab management system at this time. Devices that are managed through VNC of web based connections are not supported.

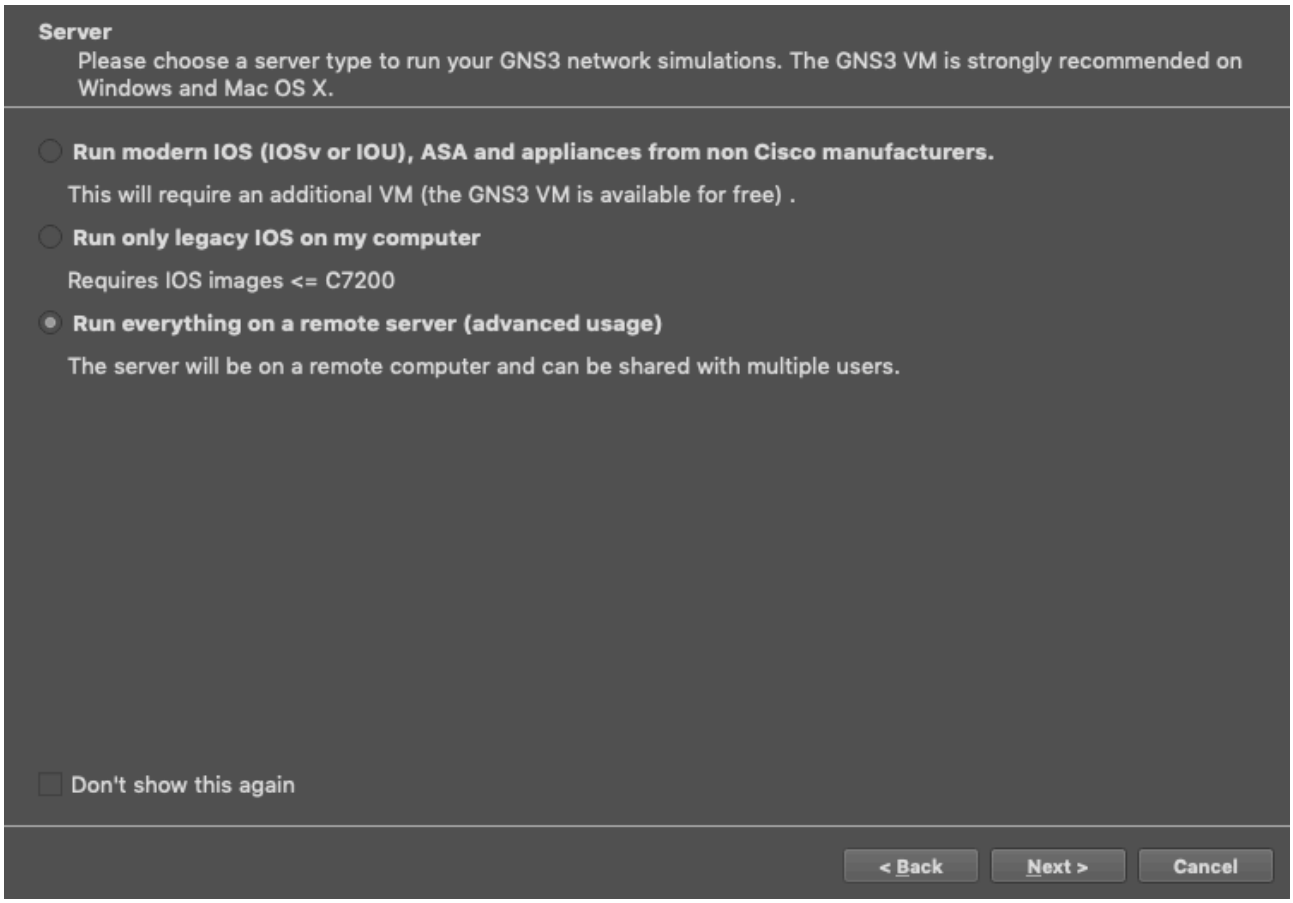
Instructions on how to install new appliances on the GNS3 server can be found in the **Server Installation Guide**.

Licenses

Many appliances need software images that are provided by device vendors. The appliance usually includes instructions on where to download the software. It is your responsibility however that any applicable licenses are present to let students use those software images.

Connecting the GNS3 Client

After creating a VPN connection to access the GNS3 server back-end, start the GNS3 client application. When starting it for the first time it will ask you which server to use:



Choose "Run everything on a remote server" here. The next screen will ask you for the host and port of the server. Enter the hostname or IP address provided to you by the server administrator. The port number is usually `3080`.

If the GNS3 client asks you to import any appliances you can do so if you want to. Otherwise press cancel here.

Building the GNS3 project

Creating and naming the project

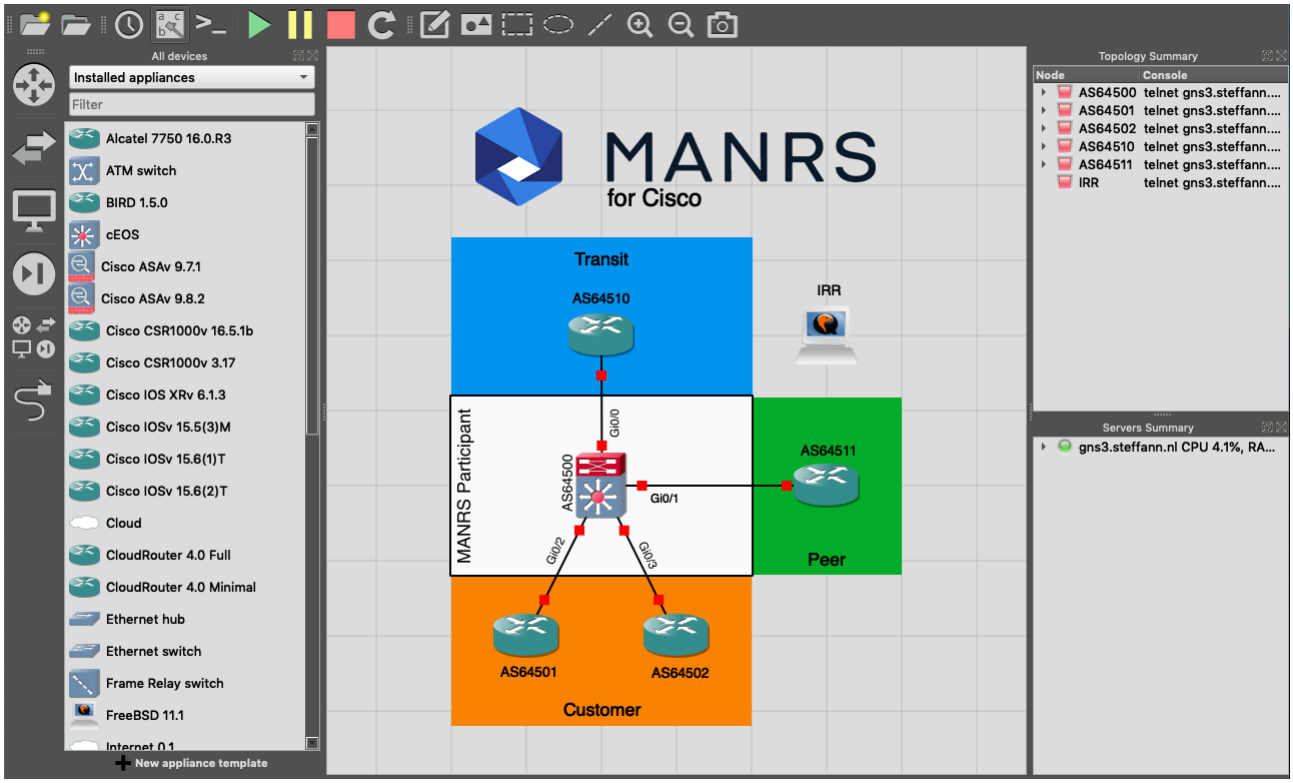
Every exercise will be based on a GNS3 project. A new exercise therefore needs a new GNS3 project. In the GNS3 client create a new project. When naming the project we recommend prefixing the name with "`Template: `". That way it is easier to identify which GNS3 projects are templates for exercises. The prefix will automatically be removed when showing it to users, so this is mostly for the convenience of exercise creators.

Generic advice

Almost everything in the GNS3 lab can be edited. Right-click on graphical elements, labels, devices and links to see the possibilities. Deleting an item can also be found there.

Adding devices

Devices are added by dragging them from the toolbar on the left to the drawing area in the middle of the screen:



If the list of device types is not visible it can be opened by clicking on one of the symbols on the left (from top to bottom: routers, switches, end devices, security devices and "all of the above") and selecting "Installed appliances" at the top.

Special device types

The MANRS lab provides two special device types:

- ISOC Lab IRR
- ISOC Lab Monitor

These device types are created specifically to exchange information between the student's lab environment and the lab management system.

ISOC Lab IRR

The IRR device contains a small IRR database that the student can query and update through the web interface.

ISOC Lab Monitor

The Monitor device provides eBGP sessions to announce and receive routes. It also sends and receives pings. It reports received routes and pings back to the management system. This is used to validate the student's progress in the exercise. To implement MANRS correctly each monitor must receive the correct routes and receive the correct ping packets. No more, no less.

Routes:

- If the monitor receives routes that it should not receive that means that the student is not properly filtering routes
- If the monitor doesn't receive routes that it should receive that means the student is filtering too aggressively

Pings:

- If the monitor receives pings that it shouldn't receive (for example with spoofed source addresses) then the student is not verifying source addresses in packets properly
- If the monitor doesn't receive pings that it should receive then the student is filtering too aggressively

Creating connections

The bottom icon in the toolbar on the left is for creating network connections. Click on the first device and select the interface to connect the link to, then do the same on the second device to connect the other side of the link.

Make sure that all devices have the correct number of network adapters configured (right-click on a device to configure it) before making connections. To change the number of interfaces later you would have to remove all connections, change the number, and re-add all the connections again. This can be an annoying limitation of the GNS3 client interface.

Configuring the devices

Once the lab has been created you can start it. GNS3 provides console access to devices. As an exercise creator you can access every device's console. Students will access the lab through the web interface and only have access to the consoles that you want to give them access to.

At this point configure all the devices so they are in the state that you want them to be at the beginning of the exercise. The student's starting position will be how you configure it here.

Configuring the ISOC Lab IRR

The IRR node contains an IRRd server. When creating a new node the database will be completely empty. To create some starting content for the student to work with it has to be filled. Connect to the console of the IRR node and log in with username `ubuntu` and

password `VerySecret`. This user has the required permissions for running `sudo`, which is required in the following steps.

To fill the database we use the same back-end tool that the web interface connects to, but we access it using the command line through the console. To start the tool run:

```
sudo /opt/lab_interface.py
```

This will dump some information about the state of the IRR database on the screen:

- NEIGHBORS: The import and export lines from AUTNUM AS64500[1]
- ASN IPv4: IPv4 routes that have a route object from AS64500
- ASN IPv6: IPv6 routes that have a route6 object from AS64500
- AS-SET IPv4: IPv4 routes that are included through AS-SET AS64500:AS-ALL[2]
- AS-SET IPv6: IPv6 routes that are included through AS-SET AS64500:AS-ALL

IRR updates are sent to the database by copy&pasting them into this command line tool. When all updates have been sent the tool can be close by pressing CTRL-C.

Updates have the following format:

```
*****[ UPDATE ]*****
mntner:       ROOT-MNT
descr:        Root Maintainer
admin-c:      SJMS-MANRS
auth:         CRYPT-PW nyN51fqqp/enQ
upd-to:       sander@steffann.nl
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
override:     administrator VerySecret
*****[ END ]*****
```

Every update must begin with `*****[ UPDATE ]*****` and end with `*****[ END ]*****`. These are the markers for the tool to know where the updates begin and end. Everything outside such a block is ignored.

An update usually consists of one IRR database object, but multiple objects can be updated in one go by putting them in one `UPDATE` block and separating them with an empty line.

All updates sent to the IRR database need to be authenticated. For normal modifications (as done by the student for example) the authentication is based on the password of the MNTNER object. When creating the MNTNER object itself that is of course not yet possible. This line overrides the normal authentication for such purposes:

```
override:     administrator VerySecret
```

To make filling the database for MANRS exercises easier a full configuration can be found at https://raw.githubusercontent.com/MANRS-Lab/labmgr/master/manrs/irr-initial.txt. A copy of that file is also included in the appendix. Copy&paste this into the tool to get to the standard MANRS IRR database starting point.

[1] The student's ASN is statically configured as AS64500. This may become configurable in the future.

[2] The AS-SET is statically configured as AS64500:AS-ALL. This may become configurable in the future.

Configuring an ISOC Lab Monitor

The Monitoring node consists of several scripts that work together. To simplify configuration all settings are stored in `/opt/settings.sh`. This file contains the following mandatory elements:

```
HOSTNAME="as64511-peer"

V4_INTERFACE="203.0.113.251/31"
V6_INTERFACE="2001:db8:1000:fffd::b/127"

ROUTER_ID="203.0.113.251"
LOCAL_ASN="64511"

PEER_ASN="64500"
PEER_ADDRESS_V4="203.0.113.250"
PEER_ADDRESS_V6="2001:db8:1000:fffd::a"
```

This configures the hostname, network interface (monitor nodes always have exactly one), and some basic BGP configuration. Most options speak for themselves.

After that there can be a list of prefixes to announce. For example:

```
V4_PREFIX1="0.0.0.0/0"
V4_PREFIX2="172.16.0.0/13"

V6_PREFIX1="::/0"
V6_PREFIX2="2001:db8:3000::/36"
V6_PREFIX3="2001:db8:6000::/36 65003"
V6_PREFIX4="2001:db8:7000::/37 65004 65002"
```

As many prefixes as necessary can be configured here. The software starts with `V4_PREFIX1` and counts up from there. As soon as it encounters a non-existent number it stops. And then it does the same for `V6_PREFIX1`.

After that a list of pings to send can be configured. It uses the same structure: starting with `PING1` and counting up from there. For example:

```
PING1="2001:db8:1000::1"
PING2="2001:db8:1001::1 2001:db8:3000::1"
PING3="203.0.113.1"
PING4="192.0.2.1 192.88.99.11"
```

Pings 1 and 2 are IPv6 pings and pings 3 and 4 are IPv4 pings. As you can see in pings 2 and 4, it is possible to optionally specify a source address as the second parameter. This source address may be spoofed to test whether the student properly filters source addresses. If no source address is specified the monitor node's interface address will be used as the source.

To make the configuration for the standard MANRS lab easier there is a script in the https://github.com/MANRS-Lab/labmgr repository called `manrs/monitor/generate_settings.py` for generating them. Pass the AS number of the monitor node to the script. For example:

```
./generate_settings.py 64501
```

The output of that script is also included in the appendix.

Layout

The layout fo the lab network in the web interface is based on the layout in the GNS3 client. Use descriptive labels, use graphical elements or images where appropriate etc.

Connecting the GNS3 project

Once the raw network project is set up it is time to connect it to the lab management system. This is done through the web interface.

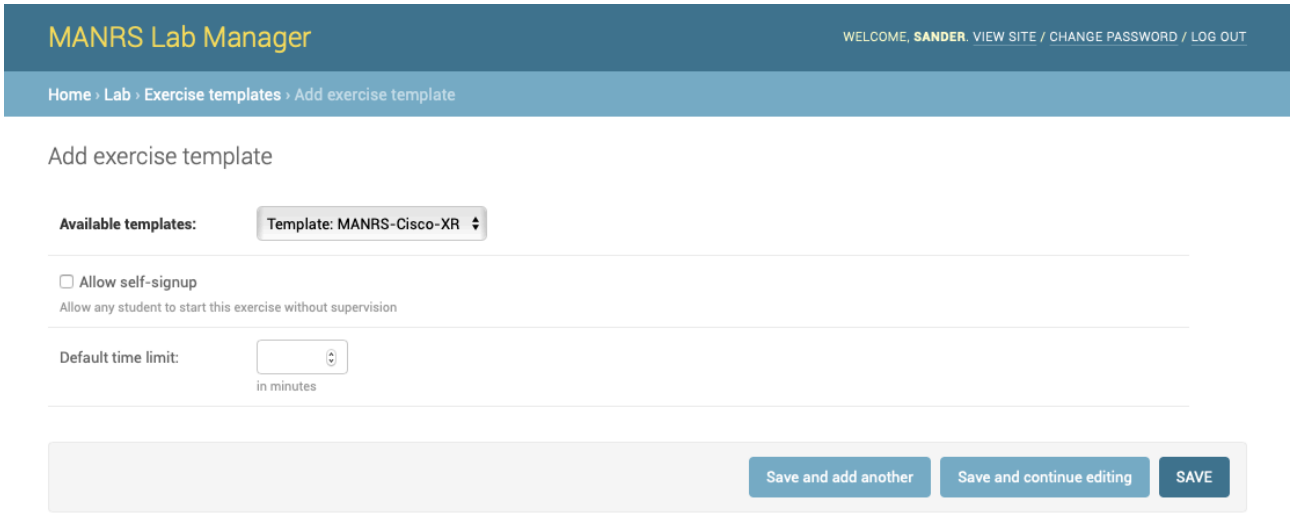
Logging in

Type the name of the server in your browser's address bar (in this example gns3.steffann.nl) and you should see a welcome screen.

Click the "Log in" link in the top right of the screen and log in with an account that has administrator privileges. You should now be at the welcome screen again with an "Admin interface" link available in the top right corner. Click that link. You should be presented with the admin home screen with links to edit Groups, Users, Exercise templates, Exercises, IRR templates and Monitor templates.

Connecting the project

Connecting the project to the management system is done through "Exercise templates". On the main admin screen click on the "Add" link to add an exercise template, or if you are already on the exercise templates overview list, click the "Add exercise template" button in the top right corner of the screen. This will take you to this page:



The "Available templates" list will show you all the GNS3 projects that are not yet connected to the management system. Select the one you just created.

The "Allow self-signup" checkbox determines whether this exercise is open to everybody, and everybody can start a new exercise for themselves or not. When allowing this it is strongly recommended that a time limit is set as well.

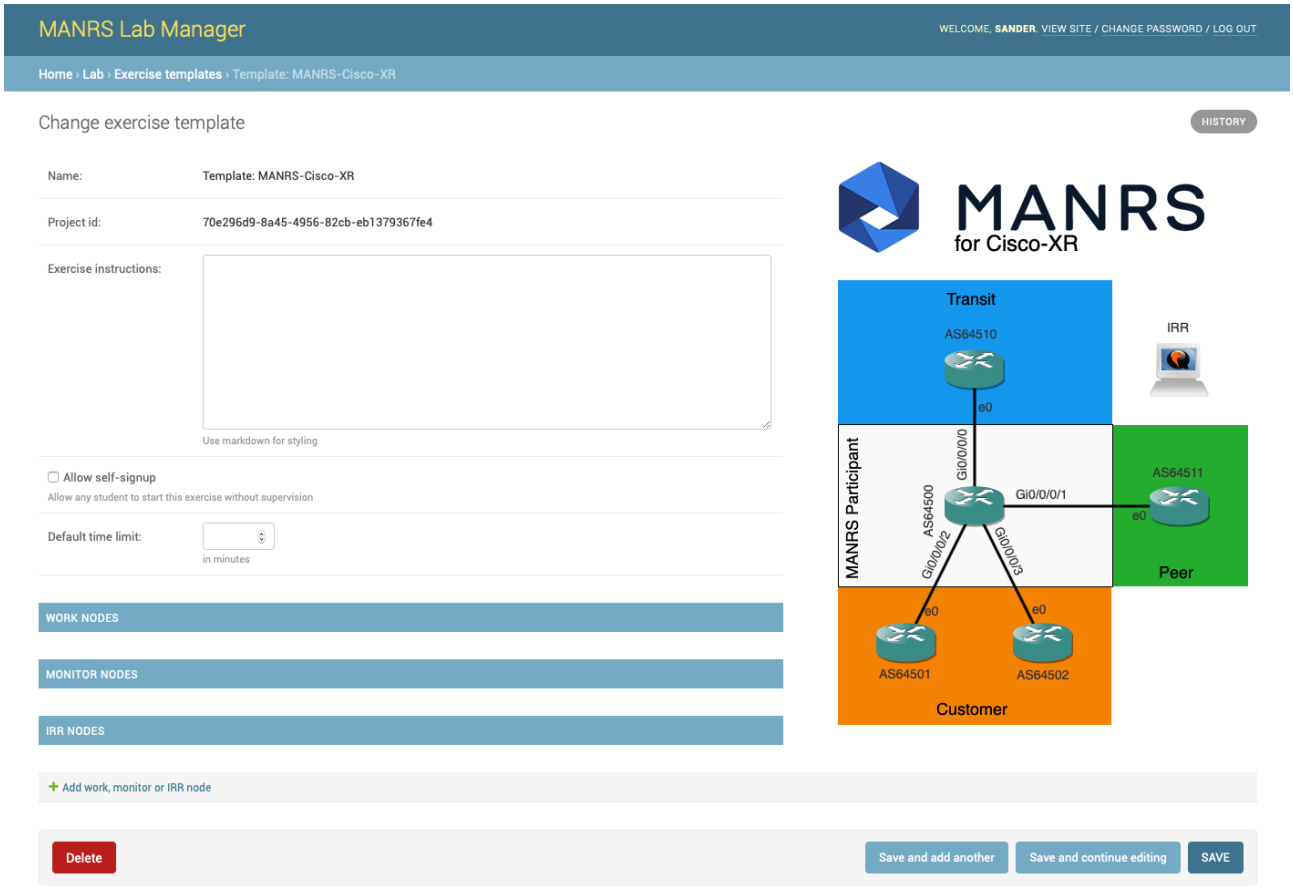
The "Default time limit" field determines how long an exercise will be available after it has been started. After the specified number of minutes the exercise is automatically shut down and the student can no longer work on it. The exercise data is retained for a week after the deadline has expired. Teachers and administrators can still re-start the exercise, remove or set a new deadline and grant the student access to the lab during that week. This can be used for example when a student needs more time and/or assistance, to debug problems or to be able to export the GNS3 project for offline usage.

After filling out this form click on the "Save and continue editing" link to continue.

Connecting the nodes

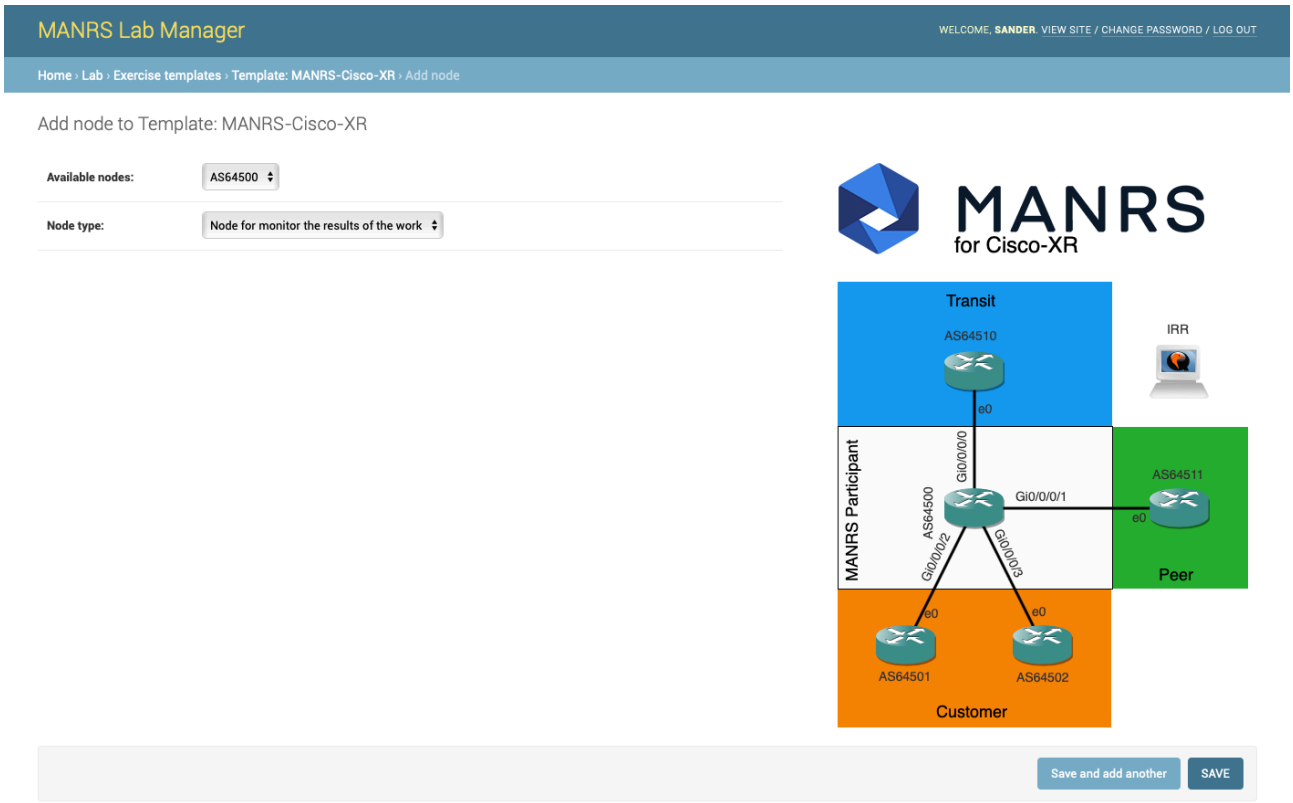
Once the project itself has been connected the management system needs to know what the different nodes are for: which nodes is the student allowed to access? Which nodes are monitor nodes that need to be observed? Etc.

You can do this on the edit page of the exercise template, which you should now see:



The diagram on the right is automatically generated from GNS3. Changes in GNS3 will show up here as well.

First we start by connecting the nodes. To do that click on the "Add work, monitor or IRR node" link at the bottom of the screen just above the bar with buttons. You will see a screen like this:



Either select a node from the "Available nodes" list, or click on the node in the network diagram on the right to select which node to connect. Then in the "Node type" list select what type of node it is: a node for the student to work on, a monitor node or an IRR node.

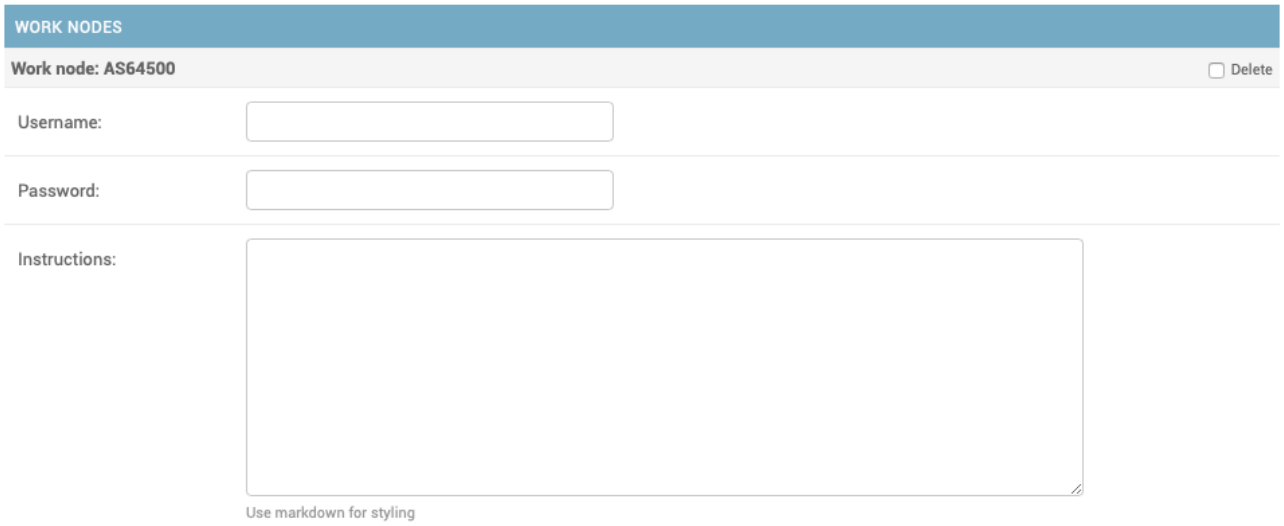
Then click on "Save and add another" to continue with the next node. The nodes you have already connected will be greyed out. Once you have reached the last node that you want to connect (if a node is of none of the above types it is perfectly fine to not connect it to the management system, it will just be ignored) click on "Save" and you will be taken back to the previous screen.

Filling in the exercise details

Now that the system knows about the exercise and the devices in it, it is time to add further details.

In the "Exercise instructions" field you can provide the information for the page that the student will see when starting the exercise. You can use markdown (see https://en.wikipedia.org/wiki/Markdown for more information) to format the information.

Work nodes



For each node that the student is allowed to work on, called work nodes, you can provide:

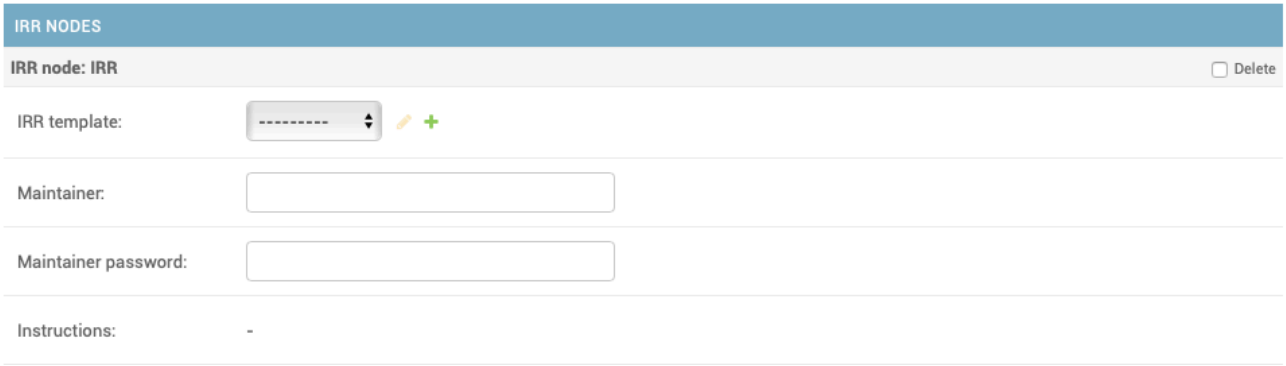
- Username: the username the student can use to log in to the device
- Password: the password the student can use to log in to the device
- Information: extra information shown on the tab in the student interface for this device, in markdown format

Monitor nodes

The monitor nodes will be connected to a monitor template. Because MANRS offers the same exercise on different platforms (Cisco, Juniper, Mikrotik etc) it would be very cumbersome to configure the monitor nodes for each one separately.

If an appropriate monitor template already exists for this node then select it from the list. Otherwise click on the + on the right side of the list. That will take you to the "Add monitor template" screen. You can give the monitor template a name and provide instructions for the student in markdown format. For now we will ignore the monitor goals and just save the template.

IRR nodes



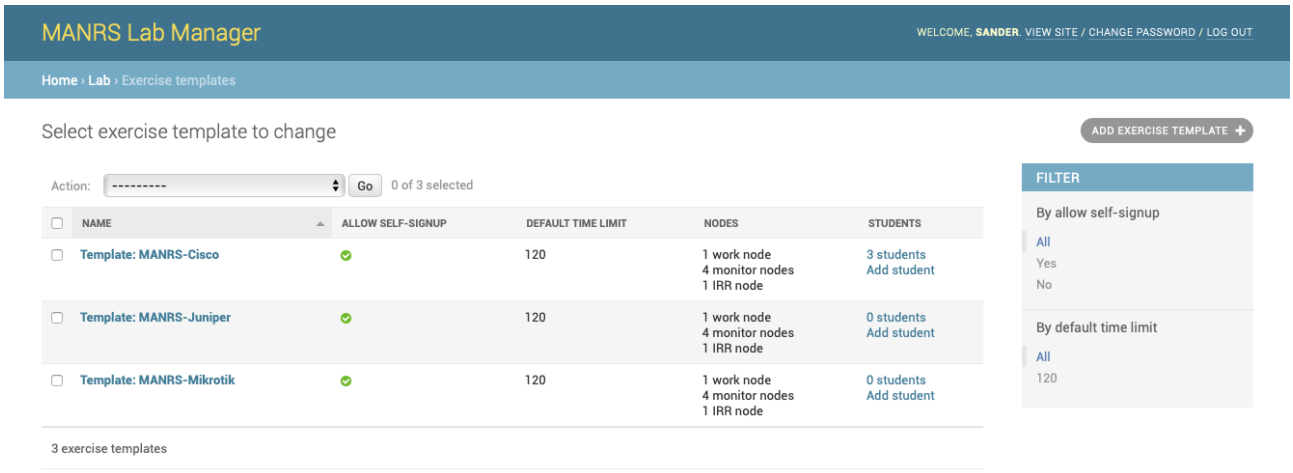
The IRR nodes are the ones that contain the IRR database. These use a similar template system as the monitor nodes. If an appropriate IRR template already exists for this node then select it from the list. Otherwise click on the + on the right side of the list. That will take you to the "Add IRR template" screen. You can give the IRR template a name and provide instructions for the student in markdown format. For now we will ignore the IRR goals and just save the template.

IRR nodes also contain:

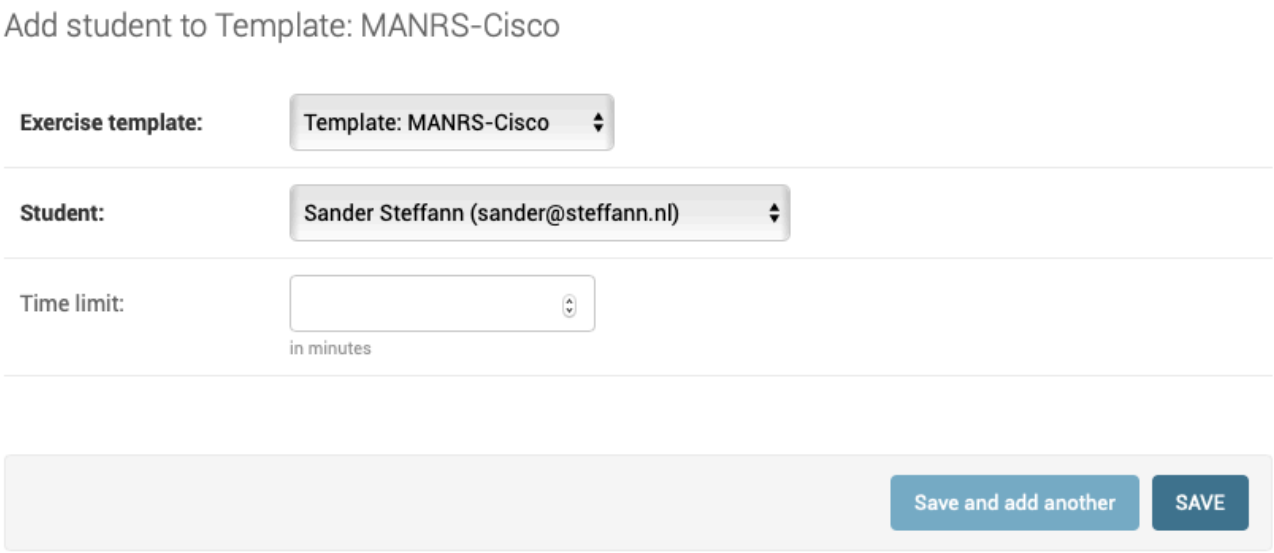
- Maintainer: the name of the MNTNER object the student can use
- Password: the password of that MNTNER object

Testing the exercise

At this point the system knows about the project and its nodes. Now is the time to see what it looks like from a student's point of view. Go back to the list of exercise templates:

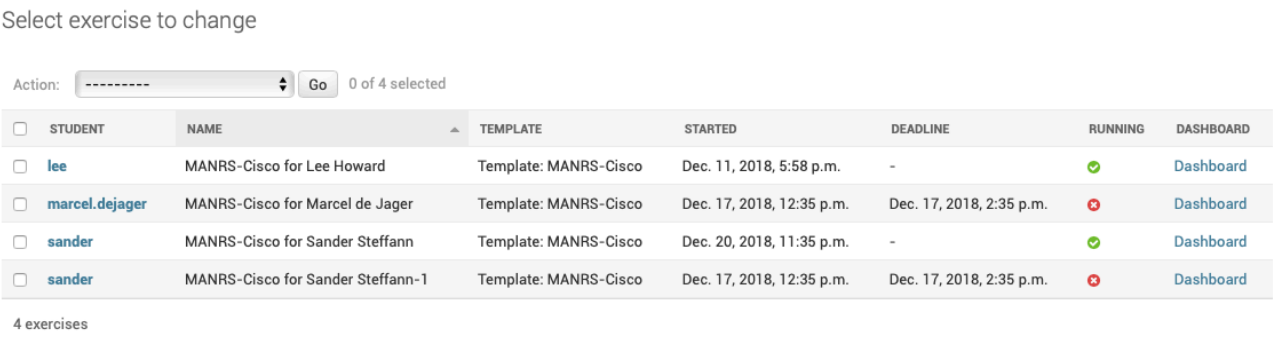


Now add yourself as a student and create an exercise based on the the exercise template you have just created. Click "Add student" for your exercise template. You will see:



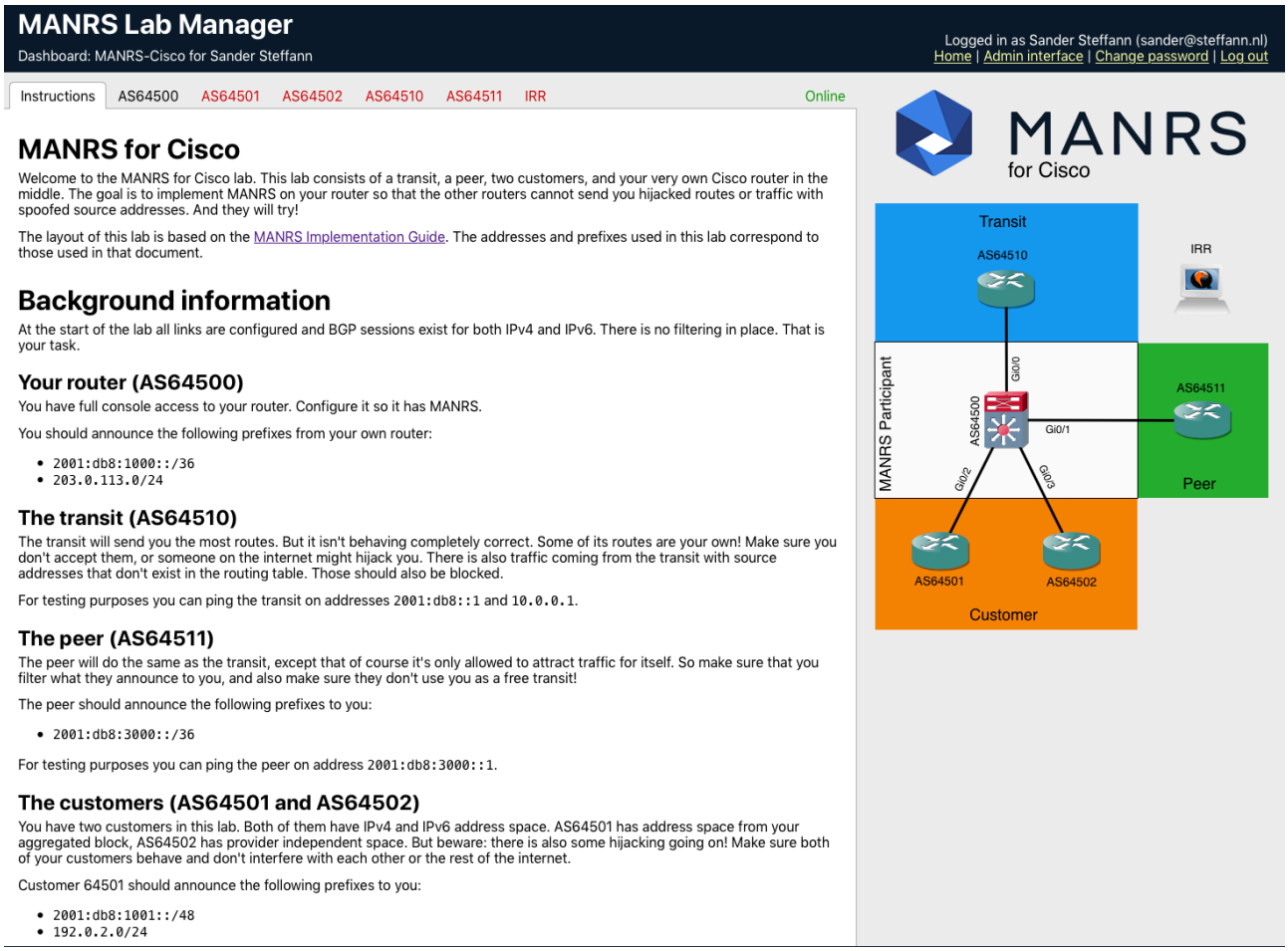
Select yourself as the student. It is recommended to **not** set a time limit for yourself at this point, so make sure the time limit field is empty.

After saving you will see the list with exercise templates again. From here click on the "students" link for your exercise template. It will probably say "1 student" at this point. This will take you to the list of exercises based on your template:

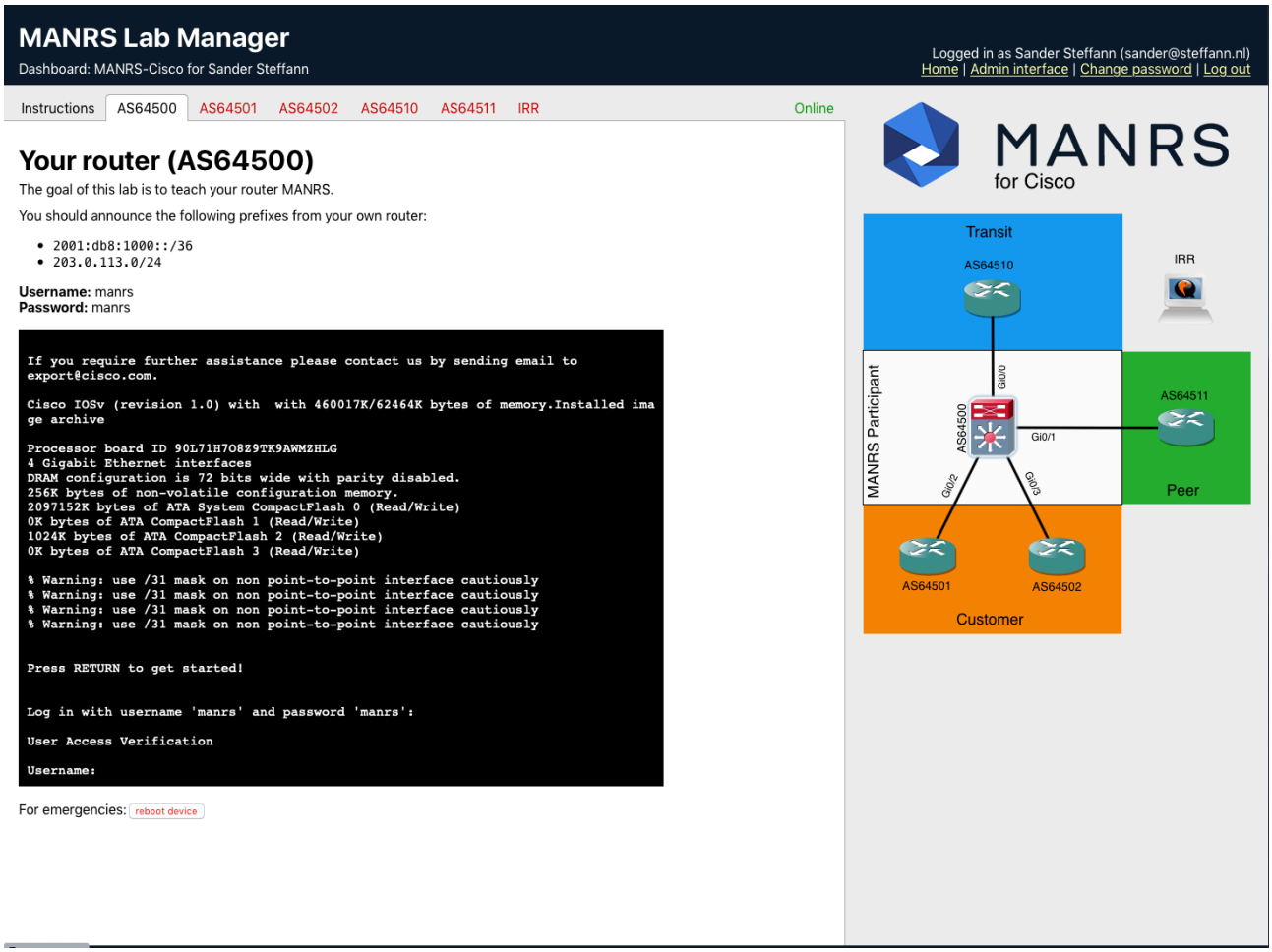


Here you can see all the exercises and whether they are running at the moment. Exercises whose deadline has expired will be automatically stopped.

Click on the "Dashboard" link for the exercise you just created, and you will be taken to the dashboard. This is the view that a student has of your exercise:



Click on the tab that corresponds to the work node, and you will see:



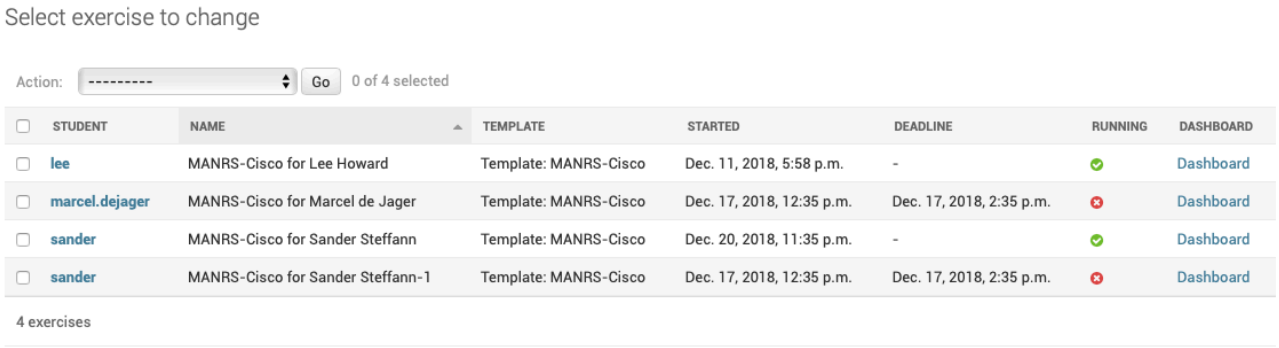
The terminal is fully functional and gives you access to the device's console.

At this point in time, perform the exercise as you would expect a student to perform it. Don't worry yet about the color of the monitor and IRR tabs.

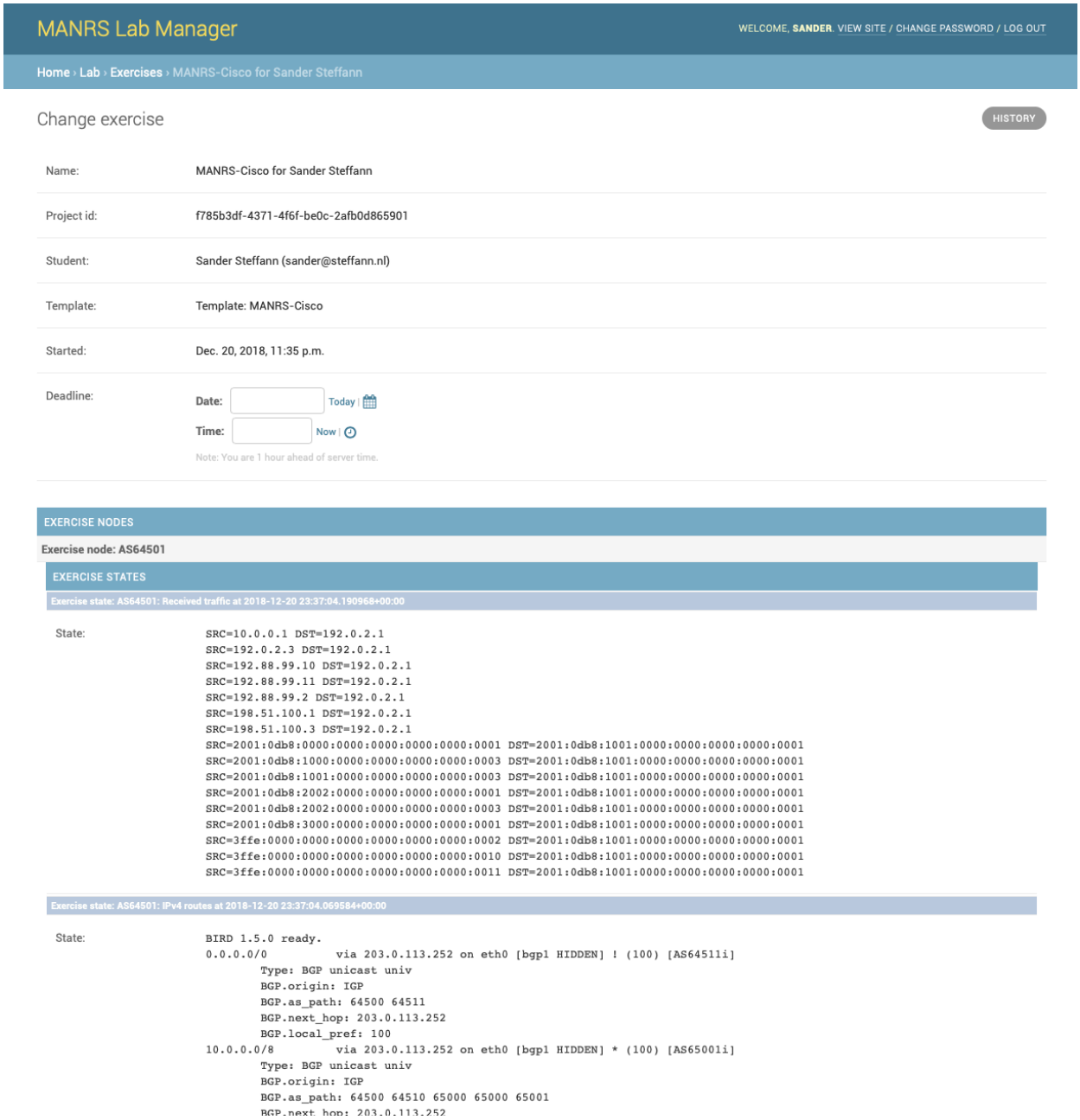
Setting the goals

Once you have performed the exercise, we will start defining the goals for students. After all: what you have just done corresponds to the goal you want the students to reach!

Go back to the admin interface and go to the exercises list:

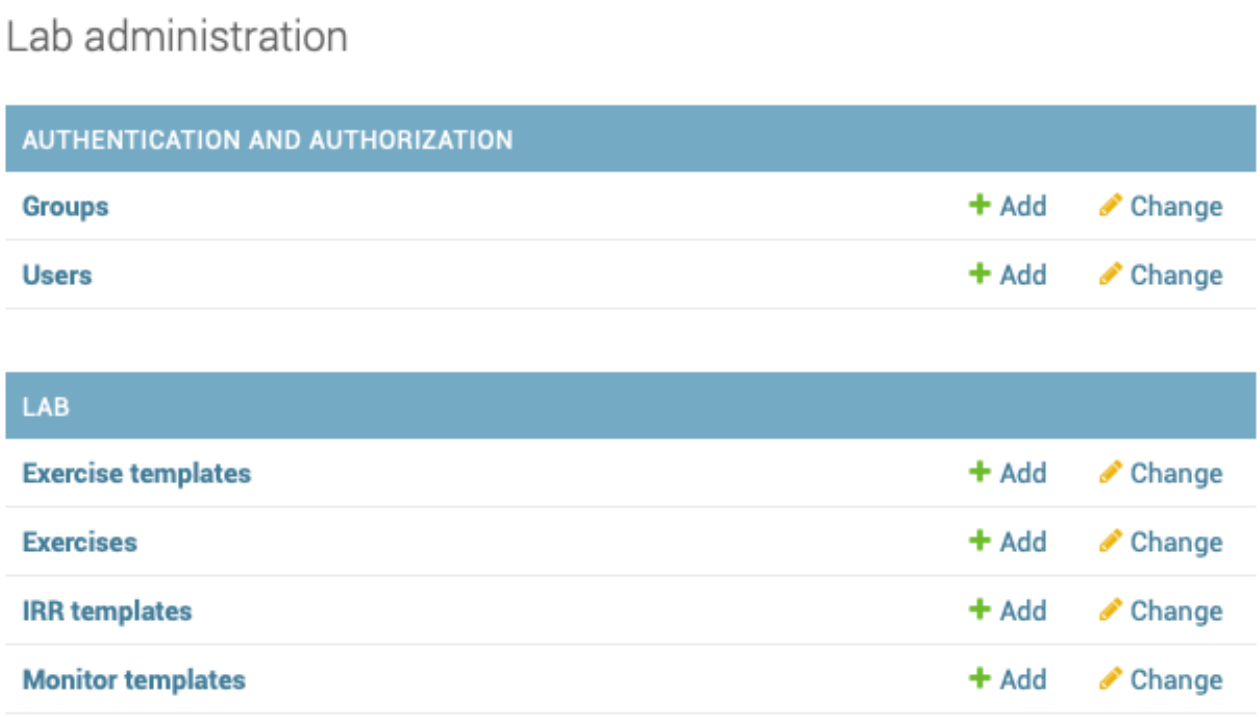


Now click on the name of the student of the exercise you have just performed, and you will be taken to the details of what the system sees of that exercise:

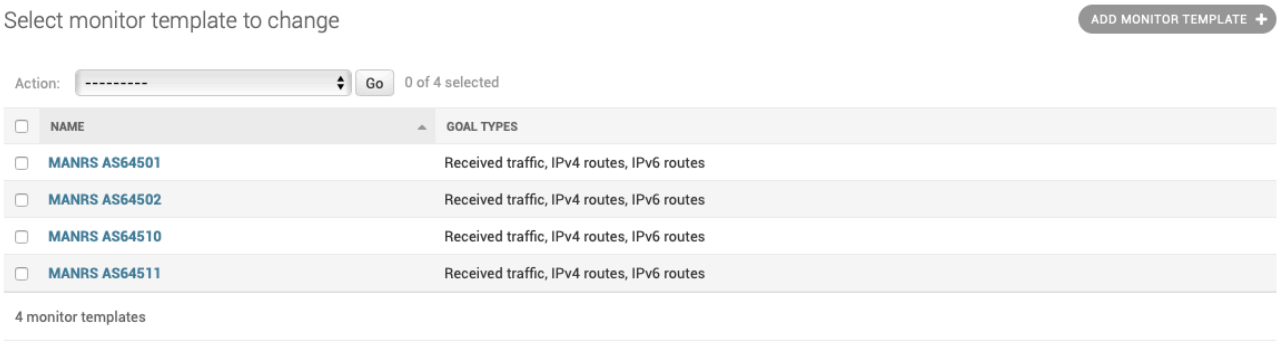


Here you can see the state of all the monitor nodes and what they see. Because this is now the state of a finished exercise, we will take these states and use them as the goals for our monitor templates and IRR templates.

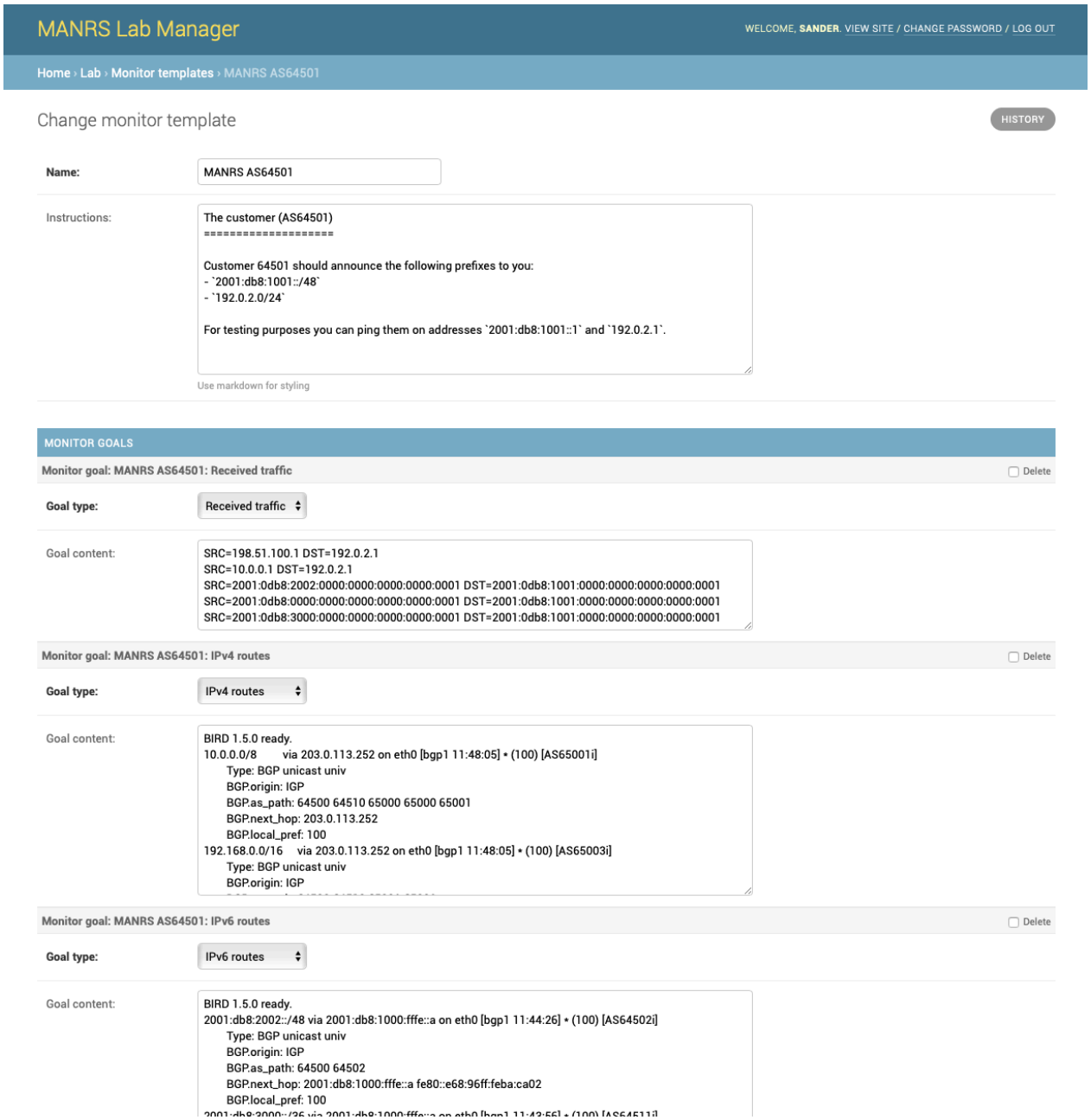
Open a new window and go to the admin screen:



Open the monitor templates list:



Here, open the monitor template you want to edit:



Select the goal type and copy&paste the state from your exercise into the corresponding goal content. Click "Add another Monitor goal" as often as required to add more goals.

Repeat this process for all the monitor and IRR templates until you have defined all the goals that you want the students to reach.

Once you have defined all the goals, reload your dashboard window and confirm that all the tabs have now turned green. This shows that your current exercise state corresponds to the defined goals. This should now be the case, as you have copied your current exercise state as the desired goal!

At this point your exercise template is ready for student to use!

Appendix A: initial IRR database for MANRS

The root, simulating an RIR

```
*****[ UPDATE ]*****
mntner:       ROOT-MNT
descr:        Root Maintainer
admin-c:      SJMS-MANRS
auth:         CRYPT-PW nyN51fqqp/enQ
upd-to:       sander@steffann.nl
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
override:     administrator VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
role:         S.J.M. Steffann
address:      Tienwoningenweg 46
address:      7312 DN  Apeldoorn
address:      The Netherlands
phone:        +31-6-22660412
e-mail:       sander@steffann.nl
nic-hdl:      SJMS-MANRS
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
override:     administrator VerySecret
*****[ END ]*****
```

The student

```
*****[ UPDATE ]*****
mntner:       STUDENT-MNT
descr:        Student Maintainer
admin-c:      STUDENT-MANRS
auth:         CRYPT-PW UlENBuAl1d6kc
upd-to:       student@example.com
mnt-by:       STUDENT-MNT
changed:      sander@steffann.nl
source:       MANRS
override:     administrator VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
role:         Student
address:      Nowhere
phone:        +1-703-439-2120
e-mail:       student@example.com
nic-hdl:      STUDENT-MANRS
mnt-by:       STUDENT-MNT
changed:      student@example.com
source:       MANRS
password:     manrs
*****[ END ]*****

*****[ UPDATE ]*****
aut-num:      AS64500
as-name:      STUDENT-AS
```

```
descr:          Student's ASN
admin-c:        STUDENT-MANRS
tech-c:         STUDENT-MANRS
mnt-by:         ROOT-MNT
mnt-by:         STUDENT-MNT
Changed:        sander@steffann.nl
source:         MANRS
password:       manrs
*****[ END ]*****

*****[ UPDATE ]*****
inetnum:        203.0.113.0 - 203.0.113.255
netname:        Student-IPv4
descr:          Student's IPv4 space
status:         ASSIGNED PI
country:        NL
admin-c:        STUDENT-MANRS
tech-c:         STUDENT-MANRS
mnt-by:         ROOT-MNT
mnt-by:         STUDENT-MNT
changed:        sander@steffann.nl
source:         MANRS
password:       manrs
*****[ END ]*****

*****[ UPDATE ]*****
inet6num:       2001:db8:1000::/36
netname:        Student-IPv6
descr:          Student's IPv6 space
status:         ALLOCATED PA
country:        NL
admin-c:        STUDENT-MANRS
tech-c:         STUDENT-MANRS
mnt-by:         ROOT-MNT
mnt-by:         STUDENT-MNT
changed:        sander@steffann.nl
source:         MANRS
password:       manrs
*****[ END ]*****
```

AS64501

```
*****[ UPDATE ]*****
inetnum:        192.0.2.0 - 192.0.2.255
netname:        AS64501-IPv4
descr:          AS64501's IPv4 space
status:         ASSIGNED PI
country:        NL
admin-c:        SJMS-MANRS
tech-c:         SJMS-MANRS
mnt-by:         ROOT-MNT
changed:        sander@steffann.nl
source:         MANRS
password:       VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
inet6num:       2001:db8:1001::/48
netname:        AS64501-IPv6
descr:          AS64501's IPv6 space
```

```
status:       ASSIGNED PA
country:      NL
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
aut-num:      AS64501
as-name:      CUSTOMER1-AS
descr:        Customer 1's ASN
mp-export:    to AS64500 announce AS64501
mp-import:    from AS64500 accept ANY
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
Changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
route:        192.0.2.0/24
origin:       AS64501
descr:        IPv4 announced from AS64501
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
route6:       2001:db8:1001::/48
origin:       AS64501
descr:        IPv6 announced from AS64501
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****
```

AS64502

```
*****[ UPDATE ]*****
inetnum:      198.51.100.0 - 198.51.100.255
netname:      AS64502-IPv4
descr:        AS64502's IPv4 space
status:       ASSIGNED PI
country:      NL
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****
```

```
*****[ UPDATE ]*****
inet6num:     2001:db8:2002::/48
netname:      AS64502-IPv6
descr:        AS64502's IPv6 space
status:       ASSIGNED PI
country:      NL
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
aut-num:      AS64502
as-name:      CUSTOMER2-AS
descr:        Customer 2's ASN
mp-export:    to AS64500 announce AS64502
mp-import:    from AS64500 accept ANY
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
Changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
route:        198.51.100.0/24
origin:       AS64502
descr:        IPv4 announced from AS64502
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
route6:       2001:db8:2002::/48
origin:       AS64502
descr:        IPv6 announced from AS64502
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****
```

AS64510

```
*****[ UPDATE ]*****
aut-num:      AS64510
as-name:      TRANSIT-AS
descr:        Transit's ASN
mp-export:    to AS64500 announce ANY
mp-import:    from AS64500 accept AS64500:AS-ALL
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
Changed:      sander@steffann.nl
```

```
source:       MANRS
password:     VerySecret
*****[ END ]*****
```

AS64511

```
*****[ UPDATE ]*****
inet6num:     2001:db8:3000::/36
netname:      AS64511-IPv6
descr:        AS64511's IPv6 space
status:       ALLOCATED PA
country:      NL
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
aut-num:      AS64511
as-name:      PEER-AS
descr:        Peer's ASN
mp-export:    to AS64500 announce AS64511
mp-import:    from AS64500 accept AS64500:AS-ALL
admin-c:      SJMS-MANRS
tech-c:       SJMS-MANRS
mnt-by:       ROOT-MNT
Changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****

*****[ UPDATE ]*****
route6:       2001:db8:3000::/36
origin:       AS64511
descr:        IPv6 announced from AS64511
mnt-by:       ROOT-MNT
changed:      sander@steffann.nl
source:       MANRS
password:     VerySecret
*****[ END ]*****
```

Appendix B: Monitor node configurations for MANRS

AS64501

```
HOSTNAME="as64501-customer"

V4_INTERFACE="203.0.113.253/31"
V6_INTERFACE="2001:db8:1000:fffe::b/127"

ROUTER_ID="203.0.113.253"
LOCAL_ASN="64501"

PEER_ASN="64500"
PEER_ADDRESS_V4="203.0.113.252"
PEER_ADDRESS_V6="2001:db8:1000:fffe::a"

V4_PREFIX1="192.0.2.0/24"
V4_PREFIX2="172.16.66.0/24"
V4_PREFIX3="192.168.255.0/24"

V6_PREFIX1="2001:db8:1001::/48"
V6_PREFIX2="2001:db8:4567::/48"
V6_PREFIX3="2001:db8::/32"

# Pings to/from valid addresses
PING1="203.0.113.1 192.0.2.1"  # to 64500
PING2="198.51.100.1 192.0.2.1"  # to 64502
PING3="10.0.0.1 192.0.2.1"  # to 64510
PING4="2001:db8:1000::1 2001:db8:1001::1"  # to 64500
PING5="2001:db8:2002::1 2001:db8:1001::1"  # to 64502
PING6="2001:db8::1 2001:db8:1001::1"  # to 64510
PING7="2001:db8:3000::1 2001:db8:1001::1"  # to 64511

# Pings from bogus addresses to valid routes
PING8="203.0.113.1 192.88.99.1"  # to 64500
PING9="198.51.100.1 192.88.99.1"  # to 64502
PING10="10.0.0.1 192.88.99.1"  # to 64510
PING11="2001:db8:1000::1 3ffe::1"  # to 64500
PING12="2001:db8:2002::1 3ffe::1"  # to 64502
PING13="2001:db8::1 3ffe::1"  # to 64510
PING14="2001:db8:3000::1 3ffe::1"  # to 64511

# Pings from someone else's addresses to valid routes
PING15="203.0.113.1 203.0.113.3"  # to 64500
PING16="198.51.100.1 203.0.113.3"  # to 64502
PING17="10.0.0.1 203.0.113.3"  # to 64510
PING18="2001:db8:1000::1 2001:db8:3000::3"  # to 64500
PING19="2001:db8:2002::1 2001:db8:3000::3"  # to 64502
PING20="2001:db8::1 2001:db8:3000::3"  # to 64510
PING21="2001:db8:3000::1 2001:db8:3000::3"  # to 64511

# Pings from valid address to bogus address
PING22="192.88.99.2 192.0.2.1"  # to 64502
PING23="192.88.99.10 192.0.2.1"  # to 64510
PING24="192.88.99.11 192.0.2.1"  # to 64511
PING25="3ffe::2 2001:db8:1001::1"  # to 64502
PING26="3ffe::10 2001:db8:1001::1"  # to 64510
PING27="3ffe::11 2001:db8:1001::1"  # to 64511
```

```
# Pings from bogus address to bogus address
PING28="192.88.99.2 192.88.99.1"  # to 64502
PING29="192.88.99.10 192.88.99.1"  # to 64510
PING30="192.88.99.11 192.88.99.1"  # to 64511
PING31="3ffe::2 3ffe::1"  # to 64502
PING32="3ffe::10 3ffe::1"  # to 64510
PING33="3ffe::11 3ffe::1"  # to 64511

# Pings from some else's address to bogus address
PING34="192.88.99.2 203.0.113.3"  # to 64502
PING35="192.88.99.10 203.0.113.3"  # to 64510
PING36="192.88.99.11 203.0.113.3"  # to 64511
PING37="3ffe::2 2001:db8:3000::3"  # to 64502
PING38="3ffe::10 2001:db8:3000::3"  # to 64510
PING39="3ffe::11 2001:db8:3000::3"  # to 64511
```

AS64502

```
HOSTNAME="as64502-customer"

V4_INTERFACE="203.0.113.255/31"
V6_INTERFACE="2001:db8:1000:ffff::b/127"

ROUTER_ID="203.0.113.255"
LOCAL_ASN="64502"

PEER_ASN="64500"
PEER_ADDRESS_V4="203.0.113.254"
PEER_ADDRESS_V6="2001:db8:1000:ffff::a"

V4_PREFIX1="198.51.100.0/24"
V4_PREFIX2="192.0.2.64/26"
V4_PREFIX3="192.0.2.128/25"

V6_PREFIX1="2001:db8:2002::/48"
V6_PREFIX2="2001:db8:1001:1000::/52"

# Pings to/from valid addresses
PING1="203.0.113.1 198.51.100.1"  # to 64500
PING2="192.0.2.1 198.51.100.1"  # to 64501
PING3="10.0.0.1 198.51.100.1"  # to 64510
PING4="2001:db8:1000::1 2001:db8:2002::1"  # to 64500
PING5="2001:db8:1001::1 2001:db8:2002::1"  # to 64501
PING6="2001:db8::1 2001:db8:2002::1"  # to 64510
PING7="2001:db8:3000::1 2001:db8:2002::1"  # to 64511

# Pings from bogus addresses to valid routes
PING8="203.0.113.1 192.88.99.2"  # to 64500
PING9="192.0.2.1 192.88.99.2"  # to 64501
PING10="10.0.0.1 192.88.99.2"  # to 64510
PING11="2001:db8:1000::1 3ffe::2"  # to 64500
PING12="2001:db8:1001::1 3ffe::2"  # to 64501
PING13="2001:db8::1 3ffe::2"  # to 64510
PING14="2001:db8:3000::1 3ffe::2"  # to 64511

# Pings from someone else's addresses to valid routes
PING15="203.0.113.1 192.0.2.3"  # to 64500
PING16="192.0.2.1 192.0.2.3"  # to 64501
PING17="10.0.0.1 192.0.2.3"  # to 64510
PING18="2001:db8:1000::1 2001:db8:1000::3"  # to 64500
```

```
PING19="2001:db8:1001::1 2001:db8:1000::3"  # to 64501
PING20="2001:db8::1 2001:db8:1000::3"  # to 64510
PING21="2001:db8:3000::1 2001:db8:1000::3"  # to 64511

# Pings from valid address to bogus address
PING22="192.88.99.1 198.51.100.1"  # to 64501
PING23="192.88.99.10 198.51.100.1"  # to 64510
PING24="192.88.99.11 198.51.100.1"  # to 64511
PING25="3ffe::1 2001:db8:2002::1"  # to 64501
PING26="3ffe::10 2001:db8:2002::1"  # to 64510
PING27="3ffe::11 2001:db8:2002::1"  # to 64511

# Pings from bogus address to bogus address
PING28="192.88.99.1 192.88.99.2"  # to 64501
PING29="192.88.99.10 192.88.99.2"  # to 64510
PING30="192.88.99.11 192.88.99.2"  # to 64511
PING31="3ffe::1 3ffe::2"  # to 64501
PING32="3ffe::10 3ffe::2"  # to 64510
PING33="3ffe::11 3ffe::2"  # to 64511

# Pings from some else's address to bogus address
PING34="192.88.99.1 192.0.2.3"  # to 64501
PING35="192.88.99.10 192.0.2.3"  # to 64510
PING36="192.88.99.11 192.0.2.3"  # to 64511
PING37="3ffe::1 2001:db8:1000::3"  # to 64501
PING38="3ffe::10 2001:db8:1000::3"  # to 64510
PING39="3ffe::11 2001:db8:1000::3"  # to 64511
```

AS64510

```
HOSTNAME="as64510-transit"

V4_INTERFACE="192.168.255.254/31"
V6_INTERFACE="2001:db8:f000:ffff::a/127"

ROUTER_ID="192.168.255.254"
LOCAL_ASN="64510"

PEER_ASN="64500"
PEER_ADDRESS_V4="192.168.255.255"
PEER_ADDRESS_V6="2001:db8:f000:ffff::b"

V4_PREFIX1="10.0.0.0/8 65001 65000 65000"
V4_PREFIX2="172.16.0.0/12 65001 65002"
V4_PREFIX3="192.168.0.0/16 65003 65002"
V4_PREFIX4="203.0.113.64/26"

V6_PREFIX1="2001:db8::/36 65001 65000 65000"
V6_PREFIX2="2001:db8:1200::/40"
V6_PREFIX3="2001:db8:4000::/36 65001 65002"
V6_PREFIX4="2001:db8:5000::/36 65003 65002"
V6_PREFIX5="2001:db8:6000::/36 65003 65002 65002"
V6_PREFIX6="2001:db8:7000::/36 65004 65004 65002"
V6_PREFIX7="2001:db8:8000::/36 65005 65004 65003 65002"
V6_PREFIX8="2001:db8:9000::/36 65003 65003 65003 65003 65003 65002"
V6_PREFIX9="2001:db8:a000::/36 65007 65006 65003 65003 65002"
V6_PREFIX10="2001:db8:b000::/36 65004 65003 65003 65002"
V6_PREFIX11="2001:db8:c000::/36 65007 65007 65007 65007 65006 65005 65004
  65003 65002"
```

```
V6_PREFIX12="2001:db8:d000::/36 65007 65006 65005 65004 65003 65003 65003
  65001"
V6_PREFIX13="2001:db8:e000::/36 65007 65006 65006 65005 65004 65004 65003
  65002"
V6_PREFIX14="2001:db8:f000::/36 65007 65006 65005 65004 65003 65002 65001"

# Pings to/from valid addresses
PING1="203.0.113.1 10.0.0.1"  # to 64500
PING2="192.0.2.1 10.0.0.1"  # to 64501
PING3="198.51.100.1 10.0.0.1"  # to 64502
PING4="2001:db8:1000::1 2001:db8::1"  # to 64500
PING5="2001:db8:1001::1 2001:db8::1"  # to 64501
PING6="2001:db8:2002::1 2001:db8::1"  # to 64502
PING7="2001:db8:3000::1 2001:db8::1"  # to 64511

# Pings from bogus addresses to valid routes
PING8="203.0.113.1 192.88.99.10"  # to 64500
PING9="192.0.2.1 192.88.99.10"  # to 64501
PING10="198.51.100.1 192.88.99.10"  # to 64502
PING11="2001:db8:1000::1 3ffe::10"  # to 64500
PING12="2001:db8:1001::1 3ffe::10"  # to 64501
PING13="2001:db8:2002::1 3ffe::10"  # to 64502
PING14="2001:db8:3000::1 3ffe::10"  # to 64511

# Pings from someone else's addresses to valid routes
PING15="203.0.113.1 198.51.100.3"  # to 64500
PING16="192.0.2.1 198.51.100.3"  # to 64501
PING17="198.51.100.1 198.51.100.3"  # to 64502
PING18="2001:db8:1000::1 2001:db8:1001::3"  # to 64500
PING19="2001:db8:1001::1 2001:db8:1001::3"  # to 64501
PING20="2001:db8:2002::1 2001:db8:1001::3"  # to 64502
PING21="2001:db8:3000::1 2001:db8:1001::3"  # to 64511

# Pings from valid address to bogus address
PING22="192.88.99.1 10.0.0.1"  # to 64501
PING23="192.88.99.2 10.0.0.1"  # to 64502
PING24="192.88.99.11 10.0.0.1"  # to 64511
PING25="3ffe::1 2001:db8::1"  # to 64501
PING26="3ffe::2 2001:db8::1"  # to 64502
PING27="3ffe::11 2001:db8::1"  # to 64511

# Pings from bogus address to bogus address
PING28="192.88.99.1 192.88.99.10"  # to 64501
PING29="192.88.99.2 192.88.99.10"  # to 64502
PING30="192.88.99.11 192.88.99.10"  # to 64511
PING31="3ffe::1 3ffe::10"  # to 64501
PING32="3ffe::2 3ffe::10"  # to 64502
PING33="3ffe::11 3ffe::10"  # to 64511

# Pings from some else's address to bogus address
PING34="192.88.99.1 198.51.100.3"  # to 64501
PING35="192.88.99.2 198.51.100.3"  # to 64502
PING36="192.88.99.11 198.51.100.3"  # to 64511
PING37="3ffe::1 2001:db8:1001::3"  # to 64501
PING38="3ffe::2 2001:db8:1001::3"  # to 64502
PING39="3ffe::11 2001:db8:1001::3"  # to 64511
```

AS64511

```
HOSTNAME="as64511-peer"
```

```
V4_INTERFACE="203.0.113.251/31"
V6_INTERFACE="2001:db8:1000:fffd::b/127"

ROUTER_ID="203.0.113.251"
LOCAL_ASN="64511"

PEER_ASN="64500"
PEER_ADDRESS_V4="203.0.113.250"
PEER_ADDRESS_V6="2001:db8:1000:fffd::a"

V4_PREFIX1="0.0.0.0/0"
V4_PREFIX2="172.16.0.0/13"

V6_PREFIX1="::/0"
V6_PREFIX2="2001:db8:3000::/36"
V6_PREFIX3="2001:db8:6000::/36 65003"
V6_PREFIX4="2001:db8:7000::/37 65004 65002"

# Pings to/from valid addresses
PING1="2001:db8:1000::1 2001:db8:3000::1"  # to 64500
PING2="2001:db8:1001::1 2001:db8:3000::1"  # to 64501
PING3="2001:db8:2002::1 2001:db8:3000::1"  # to 64502
PING4="2001:db8::1 2001:db8:3000::1"  # to 64510

# Pings from bogus addresses to valid routes
PING5="203.0.113.1 192.88.99.11"  # to 64500
PING6="192.0.2.1 192.88.99.11"  # to 64501
PING7="198.51.100.1 192.88.99.11"  # to 64502
PING8="10.0.0.1 192.88.99.11"  # to 64510
PING9="2001:db8:1000::1 3ffe::11"  # to 64500
PING10="2001:db8:1001::1 3ffe::11"  # to 64501
PING11="2001:db8:2002::1 3ffe::11"  # to 64502
PING12="2001:db8::1 3ffe::11"  # to 64510

# Pings from someone else's addresses to valid routes
PING13="203.0.113.1 198.51.100.3"  # to 64500
PING14="192.0.2.1 198.51.100.3"  # to 64501
PING15="198.51.100.1 198.51.100.3"  # to 64502
PING16="10.0.0.1 198.51.100.3"  # to 64510
PING17="2001:db8:1000::1 2001:db8:2002::3"  # to 64500
PING18="2001:db8:1001::1 2001:db8:2002::3"  # to 64501
PING19="2001:db8:2002::1 2001:db8:2002::3"  # to 64502
PING20="2001:db8::1 2001:db8:2002::3"  # to 64510

# Pings from valid address to bogus address
PING21="3ffe::1 2001:db8:3000::1"  # to 64501
PING22="3ffe::2 2001:db8:3000::1"  # to 64502
PING23="3ffe::10 2001:db8:3000::1"  # to 64510

# Pings from bogus address to bogus address
PING24="192.88.99.1 192.88.99.11"  # to 64501
PING25="192.88.99.2 192.88.99.11"  # to 64502
PING26="192.88.99.10 192.88.99.11"  # to 64510
PING27="3ffe::1 3ffe::11"  # to 64501
PING28="3ffe::2 3ffe::11"  # to 64502
PING29="3ffe::10 3ffe::11"  # to 64510

# Pings from some else's address to bogus address
PING30="192.88.99.1 198.51.100.3"  # to 64501
```

```
PING31="192.88.99.2 198.51.100.3"  # to 64502
PING32="192.88.99.10 198.51.100.3"  # to 64510
PING33="3ffe::1 2001:db8:2002::3"  # to 64501
PING34="3ffe::2 2001:db8:2002::3"  # to 64502
PING35="3ffe::10 2001:db8:2002::3"  # to 64510
```