Inmanta Documentation

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Inmanta NV

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CHAPTER

ONE

INTRODUCTION

Inmanta connect provides a means to seamlessly employ `MEF` standards covering `Carrier Ethernet` services. Carrier Ethernet is a service provided by ISPs to customers who want to extend their local networks over long (`MAN` and `WAN`) geographical locations.

The Carrier Ethernet service comes in three flavors:

- `Ethernet Virtual Private Line` or **E-Line**: a service connecting two customer Ethernet ports over a WAN.
- `Ethernet Virtual Private LAN` or **E-LAN**: a multi-point service connecting a set of customer endpoints, giving the appearance to the customer of a bridged Ethernet network connecting the sites.
- `Ethernet Virtual Private Tree` or **E-Tree**: a multi-point service connecting one or more roots and a set of leaves, but preventing inter-leaf communication.

More information regarding the Carrier Ethernet standards defined by MEF can be found here.

1.1 Prerequisites

This section provides the required information about the `connect` module, ultimately enabling you to interact with customers more efficiently and to propose a solution respectively.

Who this guide is intended for:

- Pre-sales Engineers
- Developers/Deployment Engineers
- Development Managers

1.1.1 Planning

There certain factors that you should consider when approaching a customer:

1. Number and location of their sites (campus, data center)
2. Number of networking gears (routers, multi-layer switches, firewalls, etc.) that they manage
3. Vendor and OS version of their network equipment
4. Features and technologies that they utilize for instance:
    - Epipe
    - L3VPN
    - LDP

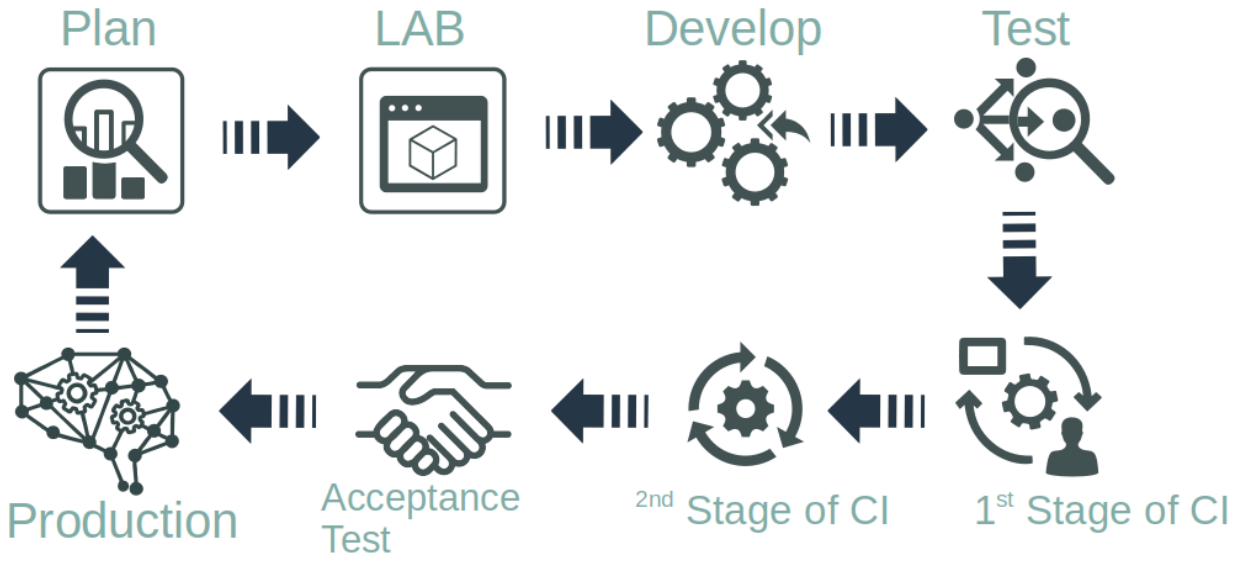
- etc…

5. `inventory` system in use:
   - Kind/brand
   - Quality of data in the inventory system
   - Does it support `API` calls? If so:
     - How is the quality of the API?
     - How is the response time of the API?
     - The slower the response, the more time it takes to develop/automate
   - Could Inmanta run it in a LAB environment?
   - Size of the data model
   - Interaction mode with the inventory:
     - transaction support
     - planning mode
     - etc…

1.1.2 Development

In general each developer will receive a virtual lab to develop and test on. Upon committing code, tests on that commit will run on our CI/CD solution. The CI server has one or more virtual lab instances of its own, for `on-commit` and `nightly` builds. If the LABs have components that can not be virtualized or are too expensive to have many, we share LABs, but that increases the cost of making the tests.

The figure below depicts our development workflow:



Under certain circumstances, we use physical LABs for our testing and development.

In order to set up a development environment, you need to follow these steps:

1. Check out our developer getting started guide
2. Set up a base project using this guide

3. Check out our supported *platforms and features*
4. Set up a test LAB using *this guide*
5. Develop or test the current module
6. Run tests using *this guide*

In case you could not find the answer to your question, please check out our FAQ *page*.

1.2 Supported Features and Platforms

Inmanta Connect supports the following platforms:

- Nokia SR-OS 20.10 or later through netconf/yang. This means that a recent version of SR-OS is required and MD-CLI has to be enabled.
- Juniper MX R18 or later through netconf/yang in rfc-compliant mode.
- Cisco XR 7.3 or later on ASR 9k through netconf/yang

We test our products against multiple vendors and versions. For specific versions and devices please contact sales or support for more details.

We are constantly developing new features and are adding more vendors to our arsenal. The table below depicts our current supported features and platforms:

Features	Cisco	Juniper	Nokia
Customization			
Configuration based	*	*	*
Template based	*	*	*
Network backend			
LDP	*	*	*
EVPN	*	*	*
EVPN - Multihoming	Planned	Planned	*
Services			
Point-to-point EVC	*	*	*
Multipoint EVC	Planned	*	*
L3VPN	Planned	Planned	Planned
Layer 1 connections	Planned	Planned	Planned
Testing and development			
Full test suite	*	*	*
Containerized lab	*	*	*

1.3 Inmanta Connect Lab

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1.3.1 Virtual Lab Setup

Summary

This guide describes the required steps to set up a lab using `Containerlab`. Containerlab enables us to quickly create a variety of topologies with support for different vendors using docker containers and experiment with Inmanta `Connect` module.

In this guide, we use a simple topology containing:

- 2 routers (or 4 if testing multihoming) from our supported vendors
- 4 clients (NFV-Test-API)
- Inmanta service orchestrator to test services which we deploy to the routers.

Set Up A Virtual Machine

1. Using the hypervisor of your choice, spin up a CentOS machine with either of the below specs:

System Requirements	CPU Cores	RAM (GB)	Disk Space (GB)
Minimum (only applicable for Nokia)	4	16	20
Recommended	4	32	35

2. Take note of the VM's IP address.
3. Once the VM is up, install `git` and `docker`:
   - Install `git`:

```
sudo yum update
sudo yum install git
```

   - Install `docker`:

```
sudo dnf config-manager --add-repo=https://download.docker.com/linux/centos/
↪docker-ce.repo
sudo dnf install docker-ce docker-ce-cli containerd.io
sudo systemctl enable --now docker
```

4. Check `docker` status:

```
sudo systemctl status docker
```

   The output should look like this:

```
$ sudo systemctl status docker
 docker.service - Docker Application Container Engine
 Loaded: loaded (/usr/lib/systemd/system/docker.service; enabled; vendor preset:␣
↪disabled)
```

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```
 Active: active (running) since Fri 2021-06-04 10:56:34 UTC; 3 days ago
   Docs: https://docs.docker.com
```

5. Add your user to `docker` group:

```
sudo usermod -aG docker $USER
```

Install Containerlab

1. Before installing Containerlab we need to update and reboot the VM:

```
sudo yum update
sudo reboot
```

2. Install Containerlab:

```
sudo yum-config-manager --add-repo=https://yum.fury.io/netdevops/ && \
echo "gpgcheck=0" | sudo tee -a /etc/yum.repos.d/yum.fury.io_netdevops_.repo

sudo yum install containerlab
```

This is a short and starch-free version of `Containerlab` setup. For more information, you can visit its official docs:

- Installation
- Quick Start

Warning Due to some breaking changes in Containerlab `0.15`, Connect LAB with version >= 0.3.0 only works with clab version >= 0.15. If you want to use a Containerlab older than `0.15` you will need to install one of the earlier versions of Connect LAB.

You can check which version of Containerlab you have installed using the `clab version` command.

Download And Setup Images

The specific steps to download and setup the images of each vendor could be viewed in the following pages:

Cisco LAB Setup

Cisco Image

Please follow the steps here to set up a functioning virtual Cisco XRv router.

From now on, we will expect this image to be tagged as `containerlab/vr-xrv:6.3.1`:

```
$ docker images
REPOSITORY                    TAG       IMAGE ID       CREATED          SIZE
containerlab/vr-xrv           6.3.1     e006d956bb22   30 seconds ago   911MB
```

Cisco Base Configuration

At the time of this writing, `Containerlab` is not able to automatically place a base configuration for Cisco routers and this step has to be done manually:

- Head to `connect-lab/labs/config/cisco` directory.
- *Using this section*, connect to routers and paste the contents of for instance `east.cfg` file in `router-east`.

  Based on the desired topology, you need to paste a specific configuration to its respective router.

Juniper LAB Setup

Juniper Image

Please follow the steps here to set up a functioning virtual Juniper router.

From now on, we will expect this image to be tagged as `vrnetlab/vr-vmx:18.3R1.9`:

```
$ docker images
REPOSITORY                                    TAG         IMAGE ID       CREATED       ␣
↪ SIZE
vrnetlab/vr-vmx                               18.3R1.9    91e0035e6f3b   8 weeks ago   ␣
↪ 4.75GB
```

Juniper Base Configuration

At the time of this writing, `Containerlab` is not able to automatically place a base configuration for Juniper routers and this step has to be done manually:

- Head to `connect-lab/labs/config/juniper` directory.
- *Using this section*, connect to routers and paste the contents of for instance `east.cfg` file in in `router-east`.

  Based on the desired topology, you need to paste a specific configuration to its respective router.

Nokia LAB Setup

Nokia Image And License

Please follow the steps here to set up a functioning virtual Nokia router.

From now on, we will expect this image to be tagged `vrnetlab/vr-sros:20.10.R1`.

```
$ docker images
REPOSITORY                                    TAG         IMAGE ID       CREATED       ␣
↪      SIZE
vrnetlab/vr-sros                              20.10.R1    5835fa21ae15   About an hour␣
↪ago   992MB
```

Nokia routers need to have a **license** to function. Please visit here for more information.

`clab deploy` command for routers should be run from the directory that contains the license file. In this case `connect-lab/labs`.

Get The Connect LAB Resources

The Connect LAB project, containing the configuration files and `clab` topology files, can be downloaded from Inmanta packages repository:

```
DEFAULT_VERSION="1.0.5"
read -rp "Enter the version you want to install (defaults to $DEFAULT_VERSION): "␣
↪VERSION \
  && if [[ $VERSION == "" ]]; then VERSION=$DEFAULT_VERSION; echo "No version provided,␣
↪defaulting to $VERSION"; fi \
  && read -rsp "Enter your private token here: " TOKEN \
  && echo "" \
  && curl -1sO --fail https://packages.inmanta.com/$TOKEN/connect/raw/versions/$VERSION/
↪connect-lab-$VERSION.tar.gz \
  || ( \
     echo "FAILED to get package" \
     && cat connect-lab-$VERSION.tar.gz \
     && echo "" \
     && exit 1 \
  ) \
  && tar -zxf connect-lab-$VERSION.tar.gz \
  && echo "All done! The lab project is available under connect-lab-$VERSION/ directory"
```

Currently the `connect-lab` version that is used for this guide is `1.0.5`.

The project structure is as follows:

```
connect-lab/
├── docs
│   └── repair-a-lab.md
├── labs
│   ├── config
│   │   ├── cisco-evc-2R
│   │   │   ├── east.cfg
│   │   │   └── west.cfg
│   │   ├── cisco-evc-4R
│   │   │   ├── east.cfg
│   │   │   ├── north.cfg
│   │   │   ├── south.cfg
│   │   │   └── west.cfg
│   │   ├── juniper-evc-2R
│   │   │   ├── east.cfg
│   │   │   └── west.cfg
│   │   ├── juniper-evc-4R
│   │   │   ├── east.cfg
│   │   │   ├── north.cfg
│   │   │   ├── south.cfg
│   │   │   └── west.cfg
│   │   ├── nfv-test-api
│   │   │   └── config.yaml
│   │   ├── nokia-evc-2R
│   │   │   ├── east.cfg
│   │   │   └── west.cfg
│   │   └── nokia-evc-4R
```

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```
│   │   │   ├── east.cfg
│   │   │   ├── north.cfg
│   │   │   ├── south.cfg
│   │   │   └── west.cfg
│   │   ├── docker-orchestrator
│   │   │   ├── agent
│   │   │   │   └── env
│   │   │   └── server
│   │   │       ├── env
│   │   │       ├── license.cfg
│   │   │       └── server.cfg
│   │   ├── cisco-evc-2R.clab.yml
│   │   ├── cisco-evc-4R.clab.yml
│   │   ├── cisco-evc.clab.yml -> cisco-evc-2R.clab.yml
│   │   ├── juniper-evc-2R.clab.yml
│   │   ├── juniper-evc-4R.clab.yml
│   │   ├── juniper-evc.clab.yml -> juniper-evc-2R.clab.yml
│   │   ├── nokia-evc-2R.clab.yml
│   │   ├── nokia-evc-4R.clab.yml
│   │   └── nokia-evc.clab.yml -> nokia-evc-2R.clab.yml
├── 2R.svg
├── 4R.svg
├── CHANGELOG.md
└── README.md
```

Inmanta Service Orchestrator

Please contact us to get the required `service orchestrator` image and license.

Upon acquiring the image, there are a few prerequisites that has to be fulfilled before continuing:

- Copy the license to `connect-lab/labs/docker-orchestrator/server`.
- Copy the `public key` of the SSH key that you will use to run tests against the lab to `connect-lab/labs/docker-orchestrator/server/authorized_keys`.
- Check the config file of the server: `connect-lab/labs/docker-orchestrator/server/server.cfg`.

Verify the downloaded image by checking `Docker` images:

```
$ docker images
REPOSITORY                                                      TAG             IMAGE ID␣
↪     CREATED        SIZE
docker.cloudsmith.io/inmanta/containers/service-orchestrator   4               ␣
↪5139265d16e3   7 days ago     1.28GB
```

Starting the LAB

The topology consists of two routers; or four in case of multihoming, four clients, Inmanta service orchestrator and a DB for the orchestrator. Inmanta service orchestrator uses the `management` network to connect to the routers and the orchestrator DB.

Before you proceed, check that all the required images are present:

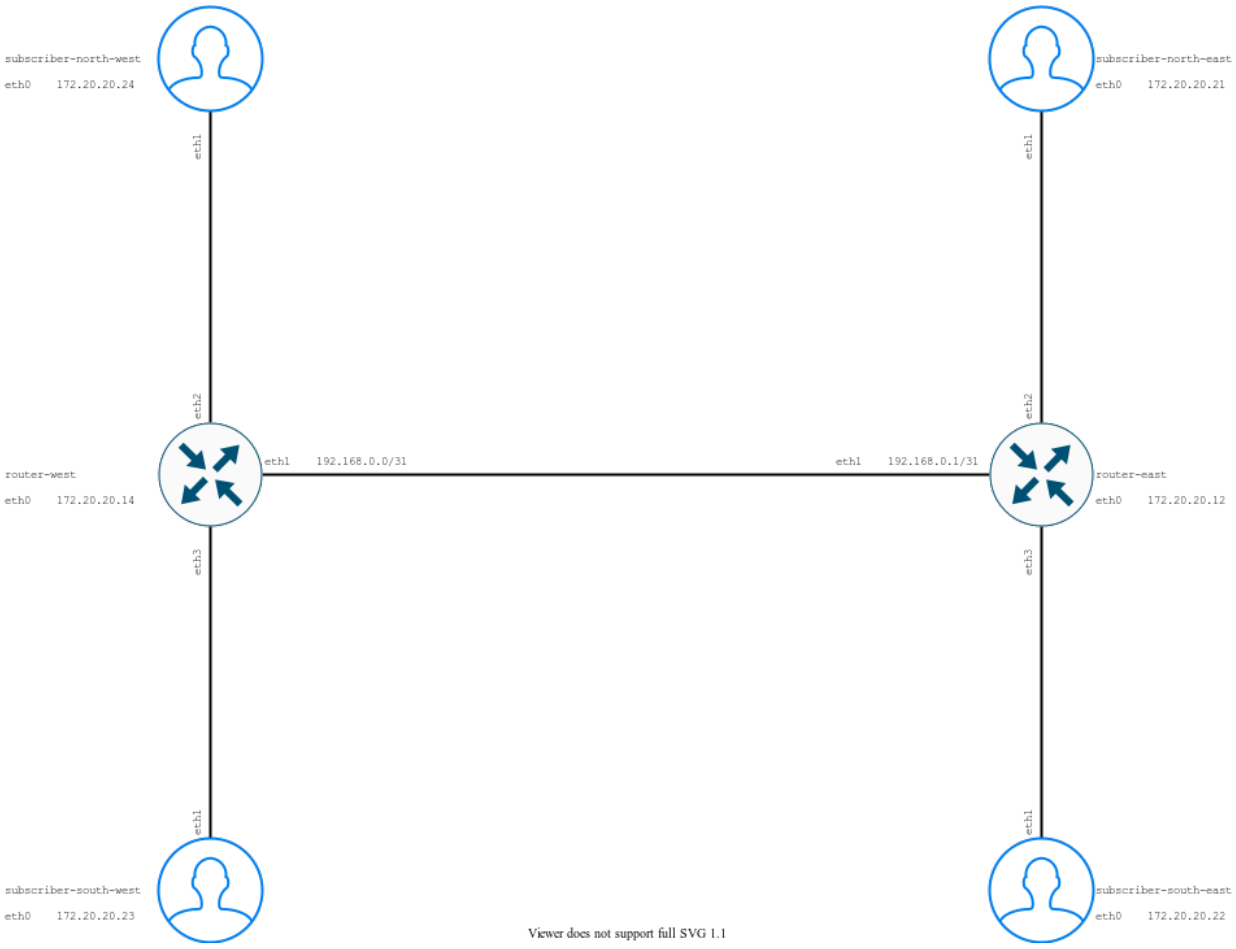
```
$ docker images
REPOSITORY                                                      TAG         IMAGE ID       ␣
↪CREATED         SIZE
docker.cloudsmith.io/inmanta/containers/service-orchestrator    4           5139265d16e3   ␣
↪7 days ago      1.28GB
vrnetlab/vr-sros                                                20.10.R1    0ff03483e5c4   ␣
↪6 weeks ago     994MB
```

Inside `connect-lab/labs` directory there are a bunch of `yaml` files starting with the name of a vendor; for instance, `cisco-evc.clab.yml`. Deploying the aforementioned `yaml` file will yield the topology with **2 routers** as depicted below.

Connection Map With 2 Routers

Name	Interface	Name	Interface
router-west	eth1	router-east	eth1
router-west	eth2	subscriber-north-west	eth1
router-west	eth3	subscriber-south-west	eth1
router-east	eth2	subscriber-north-east	eth1
router-east	eth3	subscriber-south-east	eth1

Topology With 2 Routers



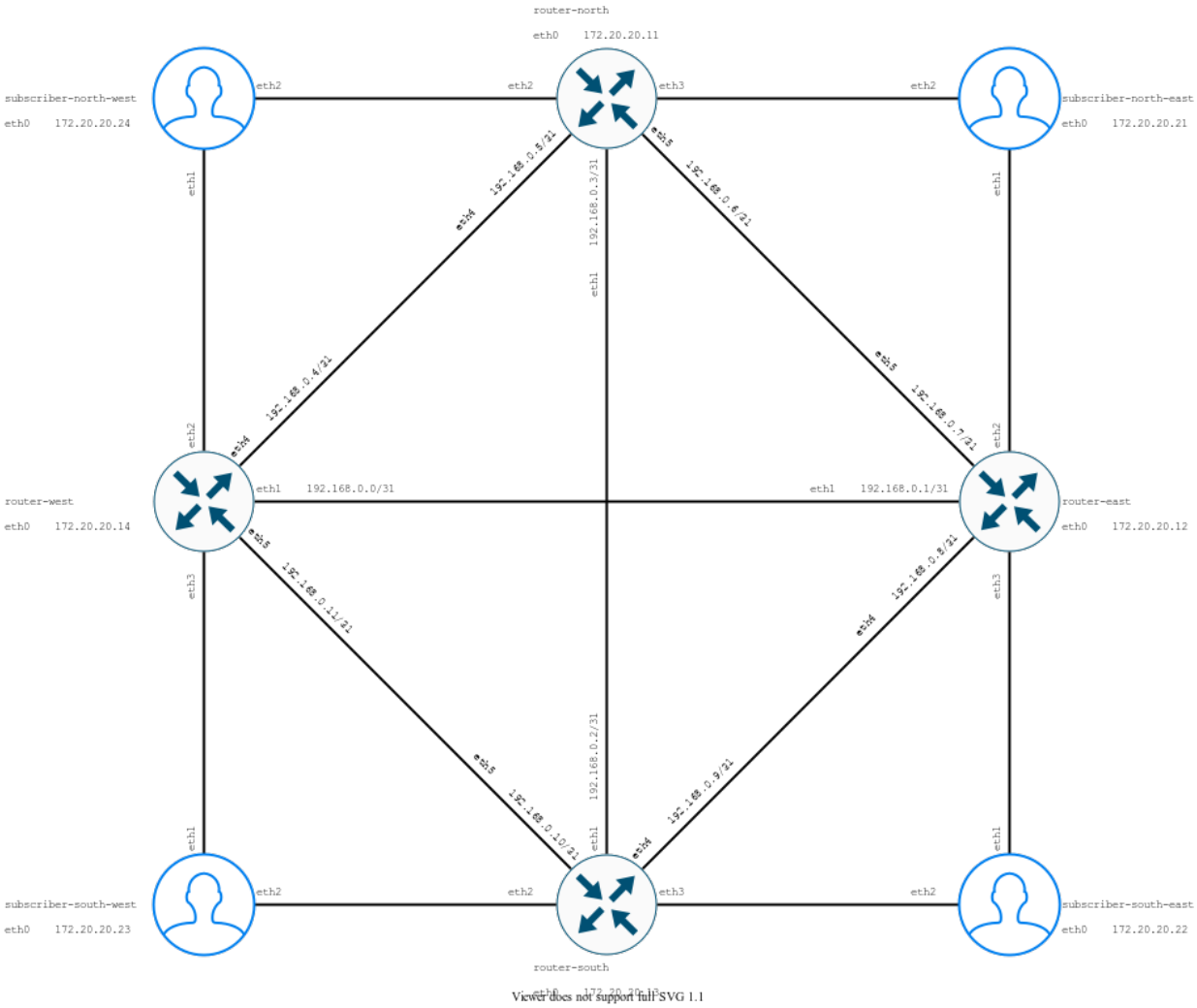
The rest of this document is based on `cisco-evc.clab.yml` deployment.

On the other hand, a **4 router** topology can be set up by deploying the files that have `4R` in their name. As an example for `cisco-evc-4R.clab.yml` the result is depicted as below.

Connection Map With 4 Routers

Name	Interface	Name	Interface
router-north	eth1	router-south	eth1
router-north	eth2	subscriber-north-west	eth2
router-north	eth3	subscriber-north-east	eth2
router-north	eth4	router-west	eth4
router-north	eth5	router-east	eth5
router-west	eth1	router-east	eth1
router-west	eth2	subscriber-north-west	eth1
router-west	eth3	subscriber-south-west	eth1
router-west	eth5	router-south	eth5
router-east	eth2	subscriber-north-east	eth1
router-east	eth3	subscriber-south-east	eth1
router-east	eth4	router-south	eth4
router-south	eth2	subscriber-south-west	eth2
router-south	eth3	subscriber-south-west	eth2

Topology With 4 Routers



NOTE:

- In this configuration Inmanta service orchestrator uses port `2222` of the VM for remote access.
- Router's initial configuration files are in the `connect-lab/labs/config/` directory. Currently non-Nokia routers require a manual copy and paste of their configuration in order to function. The procedure has been elaborated for each vendor *in this section*.

To run the LAB for the first time:

```
cd connect-lab/docs/
sudo clab deploy --topo cisco-evc.clab.yml
```

To re-run the LAB after making modifications:

```
sudo clab deploy --topo cisco-evc.clab.yml --reconfigure
```

To delete the LAB:

```
sudo clab destroy --topo cisco-evc.clab.yml
```

After a few minutes, the router containers should be shown as healthy. In our example we use Nokia routers:

```
$ docker ps
CONTAINER ID   IMAGE                          COMMAND                  CREATED         ␣
↪STATUS                  PORTS                                                      ␣
↪                                                                                   ␣
↪NAMES
9472bfdf566e   vrnetlab/vr-sros:20.10.R1      "/launch.py --trace ..."   4 minutes ago  ␣
↪Up 4 minutes (healthy)   80/tcp, 443/tcp, 5000/tcp, 10000-10099/tcp, 57400/tcp, 161/
↪udp, 0.0.0.0:21022->22/tcp, :::21022->22/tcp, 0.0.0.0:21830->830/tcp, :::21830->830/
↪tcp   clab-nokia-nokia-west
f59435aa0ed6   vrnetlab/vr-sros:20.10.R1      "/launch.py --trace ..."   4 minutes ago  ␣
↪Up 4 minutes (healthy)   80/tcp, 443/tcp, 5000/tcp, 10000-10099/tcp, 57400/tcp, 161/
↪udp, 0.0.0.0:20022->22/tcp, :::20022->22/tcp, 0.0.0.0:20830->830/tcp, :::20830->830/
↪tcp   clab-nokia-nokia-east
fb201bf0beae   postgres:10                    "docker-entrypoint.s..."   4 minutes ago  ␣
↪Up 4 minutes             5432/tcp                                                   ␣
↪                                                                                   ␣
↪clab-nokia-inmanta-db
ec307468311c   inmantaci/nfv-test-api:0.6.1   "sh -c '/bin/sleep 5..."   4 minutes ago  ␣
↪Up 4 minutes             0.0.0.0:2002->8080/tcp, :::2002->8080/tcp                 ␣
↪                                                                                   ␣
↪clab-nokia-subscriber-south-east
448344a5ab1f   inmantaci/nfv-test-api:0.6.1   "sh -c '/bin/sleep 5..."   4 minutes ago  ␣
↪Up 4 minutes             0.0.0.0:2001->8080/tcp, :::2001->8080/tcp                 ␣
↪                                                                                   ␣
↪clab-nokia-subscriber-north-east
f56297c91866   inmantaci/nfv-test-api:0.6.1   "sh -c '/bin/sleep 5..."   4 minutes ago  ␣
↪Up 4 minutes             0.0.0.0:2003->8080/tcp, :::2003->8080/tcp                 ␣
↪                                                                                   ␣
↪clab-nokia-subscriber-north-west
de139aeef0c4   inmantaci/nfv-test-api:0.6.1   "sh -c '/bin/sleep 5..."   4 minutes ago  ␣
↪Up 4 minutes             0.0.0.0:2004->8080/tcp, :::2004->8080/tcp                 ␣
↪                                                                                   ␣
↪clab-nokia-subscriber-south-west
9f73ca4fd97e   service-orchestrator:4         "sh -c '/usr/bin/chm..."   4 minutes ago  ␣
↪Up 4 minutes             0.0.0.0:8888->8888/tcp, :::8888->8888/tcp, 0.0.0.0:2222->22/
↪tcp, :::2222->22/tcp                                                               ␣
↪  clab-nokia-inmanta-server
```

Accessing Containers

To access containers individually and remotely:

Container	Service	URL
orchestrator	WEB	http://vm_ip:8888
orchestrator	SSH	ssh://vm_ip:2222
subscriber-north-east	API	http://vm_ip:2001
subscriber-south-east	API	http://vm_ip:2002
subscriber-north-west	API	http://vm_ip:2003
subscriber-south-west	API	http://vm_ip:2004

To access containers individually on the VM:

Container	Access
nokia-east	ssh admin@clab-nokia-nokia-east
nokia-west	ssh admin@clab-nokia-nokia-west
subscriber-north-east	docker exec -ti clab-lab-subscriber-north-east bash
subscriber-south-east	docker exec -ti clab-lab-subscriber-south-east bash
subscriber-north-west	docker exec -ti clab-lab-subscriber-north-west bash
subscriber-south-west	docker exec -ti clab-lab-subscriber-south-west bash

Conclusion

This guide showed how to set up a small lab using `container lab` to test Inmanta `connect` module. If you are having any questions or suggestions regarding this guide, please get in touch.

1.3.2 External lab

This document describes how to use an external lab (physical or virtual) to evaluate, develop and test on Inmanta Connect. There are three steps in this process:

1. Ensure that the lab network supports Inmanta Connect
2. Installing the Inmanta Service Orchestrator
3. Load Inmanta Connect in the Inmanta Service Orchestrator

Support Inmanta Connect network

Inmanta Connect requires a number of things from your network:

1. Each device has a management interface that is reachable by the orchestrator. For each vendor the netconf interface needs to be reachable.
2. Inmanta Connect only manages the endpoints of the services. This means that it assumes that there is backbone connectivity between all routers on which endpoints are managed (PE routers). It also assumes that all the required peerings and protocols are enabled between all PEs. What this means depends on the selected network backends (LDP, EVPN, ...).
3. Document the endpoints in a *compatible inventory*. Inmanta Connect needs to know all the user connects to the network: ports (and ethernet segments), network elements (logical devices and management interface details).

The quickest way to get started is using our built-in yaml inventory and pick one of files included in the built-in lab.

Install the service orchestrator and connect

Inmanta Connect is built on the Inmanta Service Orchestrator. The first step is to install this orchestrator and then load Inmanta Connect. The current version of Inmanta Connect excepts version Inmanta Service Orchestrator 4. There are several options to install the orchestrator:

- On a (virtual) machine with a RHEL 7 or 8 compatable operating system and install it from RPM.
- Install it using containers on docker (or podman).

It is important to correctly set the router credentials. The inventory supplies Inmanta Connect with the names of the *environment variables*. These variables are set in the environment file of the service orchestrator (The documentation explains this for an RPM install and containers

Load Inmanta Connect

The final step is to load Inmanta Connect on the service orchestrator. There are mainly two methods to perform this:

- Customize the test suite and run it against the lab. The test suite will deploy Inmanta Connect with all your customizations.
- Customize the inmanta connect template project and load it in an environment.

Inmanta Connect is a solution that allows you to fully automate the deployment and management of connectivity services. We recommend and encourages to create a lab environment to test and validate Inmanta Connect and the customization you have made on top of it. There are several options:

- Use the built-in virtual lab. There are labs for each vendor. These labs also include the Inmanta Service Orchestrator on which Inmanta Connect was built.
- Use an external physical or virtual lab that already exists.

1.4 Inventory

Connect requires one or more inventories to function. The purpose of this document is to describe what the inventory is used for, which integrations are available and how to add additional integrations.

1.4.1 Purpose

The purpose of the inventory integration can be threefold:

1. A resource inventory to resolve a provided UNI reference to one or more ports in the network. This results in the port, the device, router ip, management ip, credentials, … Without this information Inmanta Connect will not be able to orchestrate any services.
2. Allocate identifiers for resources such as VLANs, service identifiers, … By default Inmanta Connect requires a range it can manage and allocate identifiers from. However, Inmanta Connect can also allocate them based on the inventory.
3. Document the orchestrated services in an external service inventory. All services are always available in the built-in service inventory of Inmanta Connect.

Resource inventory

Inmanta Connect uses the MEF reference model for requesting new services such as carrier ethernet services. This reference model uses the concept of a UNI (User Network Interface) reference. A UNI is an abstract concept to model the attachment of a customer (user) to the provider network. There can be a one-to-one mapping between a UNI and a port on a router or it could also model a LAG implemented using multi-homing in an EVPN network.

Inmanta Connect expects a reference to a UNI that it can resolve in a resource inventory to one or more ports in the network. This reference is a URI that points to the corresponding resource in the resource inventory. Example of a such a reference are:

- UNI 123-852-456 in the built-in inventory of connect: `inmanta:123-852-456`
- UNI 1234 in Netbox: `netbox:1234`
- UNI with name `customer1` in a TMF639 compliant inventory: `tmf639://192.0.2.42/api/resource/?@type=type$UNI$&name=customer1`

The inventory integration will provide Inmanta Connect with parameters such as:

- The name of the port
- The name of the router
- The mgmt ip
- …

Identifier allocation

Inmanta Connect requires unique identifiers to work correctly. For example a circuit id, which needs to be unique within the network. The default mode of operation is assigning a range of identifiers to Inmanta Connect. Connect allocates an available identifier from the provided range. See the configuration settings for more details. By default only service ids are allocated from a range. Identifiers such as VLANs have to be provided when the a service instance is created.

This behaviour can be customized by developing a custom allocator. This allocator can then use an external inventory to find an available VLAN, service id or other identifier.

Service inventory

Inmanta Connect can integrate with external service inventories to document the created services. Inmanta Connect currently does not offer out of the box integrations. The orchestration model behind Inmanta Connect has been built to easily add service documentation.

1.4.2 Inventory integration

Inmanta Connect can integrate with any inventory that has an external API. The default settings enable the built-in resource inventory. Other inventories can be enabled or integrated. Multiple inventories can be enabled at the same time.

Built-in resource inventory

The built-in resource inventory loads the inventory from a yaml file. Inmanta Connect also contains the topologies to work with the connect reference labs. The inventory contains only the data required for Connect to orchestrate new services.

The inventory models `Device`, `Network Element (NE)` and `User Network Interface (UNI)` resources in a yaml file. The default location for this file is `/files/connect-inventory.yaml`, in the inmanta project. The inventory path can be modified using the `main.inventory_path` attribute of the configuration.

The snippet below shows an example of the contents in an inventory file:

```
devices:
  dev-2:
    mgmt_ip: 172.20.20.12
    mgmt_port: 830
    vendor: Nokia
    model: 7750 SR
    os: TiMos
    version: "20.10"
    username_env: NETCONF_DEVICE_USER
    password_env: NETCONF_DEVICE_PASSWORD
  dev-4:
    mgmt_ip: 172.20.20.14
    mgmt_port: 830
    vendor: Nokia
    model: 7750 SR
    os: TiMos
    version: "20.10"
    username_env: NETCONF_DEVICE_USER
    password_env: NETCONF_DEVICE_PASSWORD

ne:
  - id: "2"
    name: router-east
    router_ip: 10.255.255.2
    device: ref#devices.dev-2
  - id: "4"
    name: router-west
    router_ip: 10.255.255.4
    device: ref#devices.dev-4

port:
  - id: "3"
    name: 1/1/c2/1
    network_element: ref#ne[id=2]
  - id: "4"
    name: 1/1/c3/1
    network_element: ref#ne[id=2]
  - id: "7"
    name: 1/1/c2/1
    network_element: ref#ne[id=4]
  - id: "8"
    name: 1/1/c3/1
```

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```
    network_element: ref#ne[id=4]

uni:
  - id: inmanta:456-852-789
    ports:
      - ref#port[id=3]
  - id: inmanta:456-985-752
    ports:
      - ref#port[id=4]
  - id: inmanta:123-852-456
    ports:
      - ref#port[id=8]
  - id: inmanta:456-852-798
    ports:
      - ref#port[id=7]
```

Built-in resources

Below are the built-in resources that the built-in inventory models:

- **devices**: The network devices in the inventory. Its attributes are:
  - mgmt_ip: the ip address Inmanta Connect should use to access the netconf/yang interface of this device
  - mgmt_port: the port the netconf/yang interface is running
  - vendor: the name of the vendor. Inmanta Connect uses this to determine what vendor a device is. Currently Cisco, Nokia and Juniper are supported.
  - model: the router model to which is begin deployed. For example: ASR9001 or MX480. This value is currently not used and is only there for reference.
  - os: the operating system running on the device. For example Junos, SR-OS, ... This value is currently not used and is only there for reference.
  - version: the version of the os running on the device. This is used for version specific work arounds.
  - username_env: The environment variable on the orchestrator to fetch the device username from.
  - password_env: The environment variable on the orchestrator to fetch the device password from.
- **ne**: The network elements in the inventory. This represents the logical router running on the **device**. Its attributes are:
  - id: A reference for the network element that is used internaly in the inventory
  - name: The name of the network element.
  - router_ip: The loopback ip of the router. This ip is used for example for LDP configuration.
  - device: A reference to a device **device** resource.
- **port**: A port on a network element. A customer can connect to one or more ports (see uni):
  - id: An identifier used in the inventory to reference the port.
  - name: The name of the port on a device. The orchestrator uses this value to reference the port.
  - network_element: A reference to the network element this port belongs to.
- **uni**: A user network interface models how a user is connected to the network. Its attributes are:

- `id`: An identifier used to reference this UNI. The built-in resolver will use this identifer when used as a uni reference. The resolver is used when the URI scheme is `inmanta:`.
- `ports`: A list of references to the ports that make up this UNI.
- `[es_name]`: An optional attribute (combined with `es_id`). When multi-homing is used with EVPN, it is important to configure ethernet segments. When this is enabled in the configuration, this value is used.
- `[es_id]`: See `es_name`

The inventory supports internal references to other resources. These references start with `ref#`. After that a dictpath expression is used.

1.5 Testing

This guide includes:

By following the steps *here*, you should have a `virtual environment` and a clone of `connect` module locally.

1.5.1 Constructing A LAB File

All the tests are parametrized so that multiple developers can execute them on the same LAB without interfering with each other. The user specific data is presented in the LAB file, under `tests/labs/user/` directory.

To select a LAB when running the tests, use the `--lab` option, specifying in argument the name of the file, except the `.yaml` extension. All LAB files should end with the `.yaml` extension.

Example

Here is an example of the LAB file, you can copy it in this directory, and modify the values.

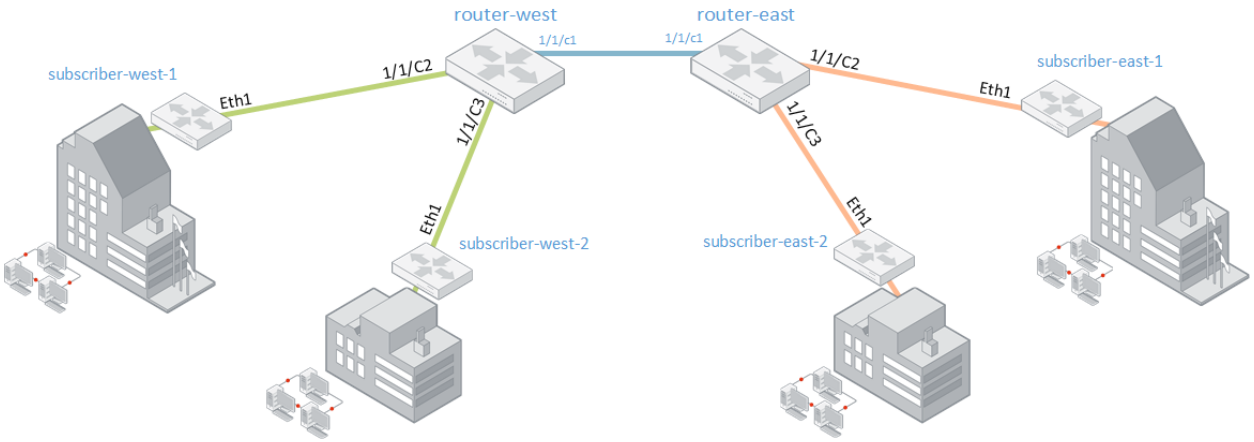
```
prefix: IC  # Change this
service_id_range:
  from: 600  # Change this
  to: 700  # Change this
vlan_id_range:
  from: 600  # Change this
  to: 605  # Change this
```

1.5.2 LAB Topology Constraints

In the test cases some assumptions are made on the structure of the lab. Those assumptions are checked when the tests using the LAB manager are setup. Here are the assumptions:

1. The topology file contains at least four subscribers, named: `subscriber-1`, `subscriber-2`, `subscriber-3` and `subscriber-4`.
2. Side A (`subscriber-1` and `subscriber-2`) are connected to the same provider router.
3. Side B (`subscriber-3` and `subscriber-4`) are connected to the same provider router.
4. Side A and B do not have a direct connection
5. All routers in the LAB have the same vendor.

Here is a visual representation of the topology:



1.5.3 Vendor specific tests

Some tests can only be executed with a specific topology file because they test the behavior of the module against a specific vendor. To avoid running this test case in unsupported configurations, pytest's markers can be used.

Example

This is already the case for two test cases:

- `tests/test_model/test_carrier_ethernet_evc_nokia/test_LDP`
- `tests/test_model/test_carrier_ethernet_evc_nokia/test_EVPN`

These verify that the generated yang config contains the desired information. In order to mark those tests as suitable only for Nokia topology, they get marked with the marker `nokia_only`:

```
@pytest.mark.nokia_only
def test_LDP(project: Project, lab_config: LabConfig) -> None:
```

This marker can be reused for any test that requires a Nokia topology file.

By default those tests will be skipped. If you are running the tests with a topology file containing only Nokia devices, you can either set the environment variable `INMANTA_CONNECT_LAB_VENDOR` or the cli parameter `--lab-vendor` to *Nokia*. In that case, and in that case only, those two tests will be executed.

Adding New Markers

To add some additional markers, i.e. when other vendor-specific tests are added apart from Nokia, there are three things to do:

1. Extend the `pytest_configure` function in *tests/conftest.py* to support the additional marker.
2. Extend the `pytest_runtest_setup` function in *tests/conftest.py* to skip the test if the marker is detected but the vendor is not the one we want.
3. Add the marker on top of the test you wish to limit to the specific vendor.

1.5.4 Topology File Structure

The topology file should contain four main entries:

- `routers`: A dictionary containing the routers of the LAB.
- `subscribers`: A dictionary containing the subscribers of the LAB.
- `links`: A list containing the links between different element (routers and subscribers) in the LAB.
- `inventory`: A dictionary containing a valid inventory that can be given to the module for this LAB.

Here is an example of the topology file:

```
routers:
  nokia-east:
    vendor: Nokia
    mgmt_address: 192.168.2.33
    netconf_port: 20830
    ssh_port: 20022
    mgmt_username_env: NETCONF_DEVICE_USER
    mgmt_password_env: NETCONF_DEVICE_PASSWORD

  nokia-west:
    vendor: Nokia
    mgmt_address: 192.168.2.33
    netconf_port: 21830
    ssh_port: 21022
    mgmt_username_env: NETCONF_DEVICE_USER
    mgmt_password_env: NETCONF_DEVICE_PASSWORD

subscribers:
  subscriber-1:
    mgmt_address: 192.168.2.33
    api_port: 2001
    uni: inmanta:456-852-789
  subscriber-2:
    mgmt_address: 192.168.2.33
    api_port: 2002
    uni: inmanta:456-985-752
  subscriber-3:
    mgmt_address: 192.168.2.33
    api_port: 2003
    uni: inmanta:123-852-456
```

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```
  subscriber-4:
    mgmt_address: 192.168.2.33
    api_port: 2004
    uni: inmanta:652-784-963

links:
  - endpoints:
    - type: router
      device: nokia-east
      interface: eth1
    - type: subscriber
      device: subscriber-1
      interface: eth1
      namespace: east1
  - endpoints:
    - type: router
      device: nokia-east
      interface: eth2
    - type: subscriber
      device: subscriber-2
      interface: eth1
      namespace: east1
  - endpoints:
    - type: router
      device: nokia-west
      interface: eth1
    - type: subscriber
      device: subscriber-3
      interface: eth1
      namespace: west1
  - endpoints:
    - type: router
      device: nokia-west
      interface: eth2
    - type: subscriber
      device: subscriber-4
      interface: eth1
      namespace: west1

inventory:
  devices:
    dev-1:
      mgmt_ip: 172.20.20.31
      mgmt_port: 22
      vendor: Nokia
      model: 7750 SR
      os: TiMos
      version: "20.10"
      username_env: NETCONF_DEVICE_USER
      password_env: NETCONF_DEVICE_PASSWORD
    dev-2:
      mgmt_ip: 172.20.20.21
```

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```
    mgmt_port: 22
    vendor: Nokia
    model: 7750 SR
    os: TiMos
    version: "20.10"
    username_env: NETCONF_DEVICE_USER
    password_env: NETCONF_DEVICE_PASSWORD

ne:
  - id: "1"
    name: Nokia_west
    router_ip: 10.255.255.2
    device: ref#devices.dev-1
  - id: "2"
    name: Nokia_east
    router_ip: 10.255.255.1
    device: ref#devices.dev-2

uni:
  - id: inmanta:456-985-752
    port: 1/1/c3/1
    network_element: ref#ne[id=1]
  - id: inmanta:456-852-789
    port: 1/1/c2/1
    network_element: ref#ne[id=1]
  - id: inmanta:652-784-963
    port: 1/1/c3/1
    network_element: ref#ne[id=2]
  - id: inmanta:123-852-456
    port: 1/1/c2/1
    network_element: ref#ne[id=2]
```

Here are some notes about parametrized values:

- Some values in the file can be parametrized using the prefix `opt:` prefix.
- The remaining part of the value will be extracted and resolved.
- The remaining value should match the key of one of the `TestParameter` object set in the tests `conftest.py` file.

For instance, if you set `opt:inm_con_lab_mgmt_ip` as a value for `routers.nokia-east.mgmt_address`, when the topology file is loaded, this value will be replaced by the value passed to the `--lab-mgmt-ip` argument or set in `INMANTA_CONNECT_LAB_MGMT_IP`. Please note that CLI arguments have more priority than `env variables`.

1.5.5 Assembling A Basic Test

We also need to make a temporary directory for the tests and utilize it by environment variables:

```
mkdir /tmp/env
export INMANTA_TEST_ENV=/tmp/env
```

The most basic type of testing is a `compile` test which can be conducted like:

```
import uuid
import pytest
from pytest_inmanta.plugin import Project

def test_basics(project: Project) -> None:
    """
    Simple example of instantiation of a CarrierEthernetEvc entity.  We just try to␣
↪compile it.
    """
    model = f"""
        import connect
        import connect::infra as infra
        import connect::mock

        connect::CarrierEthernetEvc(
            identifier="my-evc-001",
            connectionType="POINT_TO_POINT",
            ext_networkBackend=connect::Ext_networkBackend(type="EVPN"),
            evcEndPoints=[
                connect::CarrierEthernetEvcEndPoint(
                    identifier="my-evc-ep-1",
                    egressBandwidthProfilePerEndPoint=[
                        connect::EgressBwpFlow(
                            cir=1,
                        ),
                        connect::EgressBwpFlow(
                            cir=2,
                        ),
                    ],
                    evcEndPointMap=connect::VlanIdListOrUntag(
                        type="LIST",
                        vlanIdList=[
                            connect::VlanId(vlanId=200),
                        ],
                    ),
                    ␣
↪carrierEthernetSubscriberUni=connect::CarrierEthernetSubscriberUniRef(
                        href="inmanta:456-985-752",
                    ),
                    _uni=infra::UserNetworkInterface(
                        id="inmanta:456-985-752",
                        port="1/1/c3/1",
                        network_element=infra::NetworkElement(
                            id="1",
                            name="ne-1",
```

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```
                            router_ip="1.2.3.4",
                            device=infra::Device(
                                mgmt_ip="1.2.3.4",
                                mgmt_port=22,
                                vendor="Nokia",
                                model="7750 SR",
                                os="TiMos",
                                version="20.10",
                                username_env="NETCONF_DEVICE_USER",
                                password_env="NETCONF_DEVICE_PASSWORD",
                            )
                        )
                    ),
                ),
                connect::CarrierEthernetEvcEndPoint(
                    identifier="my-evc-ep-2",
                    egressBandwidthProfilePerEndPoint=[
                        connect::EgressBwpFlow(
                            cir=1,
                        ),
                        connect::EgressBwpFlow(
                            cir=2,
                        ),
                    ],
                    evcEndPointMap=connect::VlanIdListOrUntag(
                        type="LIST",
                        vlanIdList=[
                            connect::VlanId(vlanId=201),
                        ],
                    ),
                    carrierEthernetSubscriberUni=connect::CarrierEthernetSubscriberUniRef(
                        href="inmanta:652-784-963",
                    ),
                    _uni=infra::UserNetworkInterface(
                        id="inmanta:652-784-963",
                        port="1/1/c3/1",
                        network_element=infra::NetworkElement(
                            id="2",
                            name="ne-2",
                            router_ip="1.2.3.5",
                            device=infra::Device(
                                mgmt_ip="1.2.3.5",
                                mgmt_port=22,
                                vendor="Nokia",
                                model="7750 SR",
                                os="TiMos",
                                version="20.10",
                                username_env="NETCONF_DEVICE_USER",
                                password_env="NETCONF_DEVICE_PASSWORD",
                            )
                        )
```

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```
                    ),
                ),
            ],
            purge_resources=false,
            instance_id="{uuid.uuid4()}",
        )
    """

    project.compile(model, no_dedent=False)
```

1.5.6 Running Tests

```
# The env.sh script loads some environment variables common to any developer of the␣
↪module
# If you wish to load some env variables automatically, this script looks for the␣
↪existence
# of personal_env.sh file and executes it, if found. You can add all private envs you␣
↪require there.
source env.sh
export INMANTA_LSM_ENVIRONMENT=""  # An environment on mentioned orchestrator (if not␣
↪added to personal_env.sh)

pytest tests \ # Name of your test file
    --use-module-in-place \
    --lab <your-lab-name> \
    --topology nokia-evc \
    --log-cli-level=debug \
    tests/ # The directory containing the test files
```

1.5.7 Running Mypy Type Check

The use of Mypy is encouraged since it makes the code easier to read and debug should a problem occur. Mypy is an optional static type checker for Python that aims to combine the benefits of dynamic or "duck" typing and static typing.

```
# Check typing in the plugins
make mypy-plugins

# Check typing in the tests
make mypy-tests

# Check typing in both plugins and tests
make mypy
```

To see if you improved the typing, do `make mypy-save` before you make changes and `make mypy-diff` afterwards

1.6 Configuration and Customization

Connect can be configuration and customized using configuration files and templates:

- Topologies
- Hardware/vendors
- Allocation Policies
- UNI Resolvers
- Naming conventions
- Etc.

The `connect` module will load its configuration from a file named `connect-config.yaml`, which should be located in the `files` folder of the project using this module. The project's structure is depicted as below:

```
connect-project/
├── files
│   └── connect-config.yaml
├── libs
│   └── connect/
├── main.cf
└── project.yml
```

1.6.1 General Structure

The `configuration` module hosts all the settings related to the `connect` module. These ever-expanding settings are:

- NokiaConfig: Contains all the specific config for Nokia routers, E.g. use of SDP.
- LabelDistributionProtocolConfig: Contains all the specific config for LDP.
- ServiceIdConfig: Contains all the specific config for allocating an EVC service ID.
- CarrierEthernetEvcConfig: Contains all the specific config for Ethernet Virtual Connections.
- MainConfig: Contains elements transient to the whole module usage.
- ConnectConfig: This is the root of the configuration. Each entry in the configuration file should correspond to one of the embedded Config objects. If called by its `default` method, it'll return configuration with all default values.
- Configuration: Operates on `connect-config.yaml` file.

1.6.2 Configuration File Content

The available configuration fields in `connect-config.yaml` file are:

`main`: The main config, it contains elements transient to the whole module usage. The available options are:

1. `inventory_path`: The path to the inventory file on the machine where the orchestrator runs.

`carrier_ethernet_evc`: The CarrierEthernetEvc config. The available options are:

1. `service_id`: EVC service ID. Determines range and allocation strategy.
    - `start`: Start of the service id range. (Value included in the range)

- `end`: End of the service id range. (Value included in the range)
- `strategy`: Strategy to use to determine the next service_id to allocate.
  - **`next`**: Take the first available id in the range.
  - **`any`**: Take any available id in the range.

2. `backend`: The CarrierEthernetEvc backend config. Currently the available options are `LDP` and `EVPN`.
   - `default`: The default backend to use if none is specified.
   - `enabled`: The list of supported backends that can be selected.

     If the backend type is not provided, `LDP` is selected as the default value. In case the provided backend value is not supported an exception will be raised.

`label_distribution_protocol`: The LDP config. The available options are:

- TBD

`nokia`: The Nokia config. The available options are:

1. `customer_id`: Customer id or path to a template that allows to render the customer id with some parameters (service instance)
2. `netconf_retry_count`: Number of retries before a failure.
3. `netconf_retry_interval`: Interval time in seconds between retries.
4. `epipe`: Nokia's Epipe configuration:

   Please note that unless stated otherwise, all the elements below have an `instance` attribute that is the **CarrierEthernetEvcEndPoint instance using this template, as a DynamicProxy**. For the sake of brevity it has been omitted and replaced with **`takes instance`**: **true**.

   - `enable_sdp`: Controls the creation of Epipe with SDP.
   - `service_name`: Epipe service name or path to a template that allows to generate it. The values available to the template are:
     - **`takes instance`**: **true**
     - **`vcid`**: The service id of the Epipe, as an integer.
   - `qos_ingress`: QoS configuration for Epipe (ingress):
     - `policy_name`: Epipe policy name or a path to a template that allows to generate it. The values available to the template are:
       - **`takes instance`**: **true**
     - `policer_id`: Epipe policer id or a path to a template that allows to generate it. The values available to the template are:
       - **`takes instance`**: **true**
     - `cbs`: Epipe cbs or a path to a template that allows to generate it. The values available to the template are:
       - **`takes instance`**: **true**
     - `mbs`: Epipe mbs or a path to a template that allows to generate it. The values available to the template are:
       - **`takes instance`**: **true**

  - `pir`: Epipe pir or a path to a template that allows to generate it. The values available to the template are:
    * **takes instance**: **true**
- `qos_egress`: QoS configuration for Epipe (egress):
  - `policy_name`: Epipe policy name or a path to a template that allows to generate it. The values available to the template are:
    * **takes instance**: **true**
  - `queue_id`: Epipe queue id or a path to a template that allows to generate it. The values available to the template are:
    * **takes instance**: **true**
  - `cbs`: Epipe cbs or a path to a template that allows to generate it. The values available to the template are:
    * **takes instance**: **true**
  - `mbs`: Epipe mbs or a path to a template that allows to generate it. The values available to the template are:
    * **takes instance**: **true**
  - `pir`: Epipe pir or a path to a template that allows to generate it. The values available to the template are:
    * **takes instance**: **true**
- `evpn`: EVPN configuration for Nokia
  - `bgp`: BGP configuration for Nokia
    * `resolution`: Resolution method for tunnel selection
    * `tagging`: Enable/disable enforcement of strict tunnel tagging
    * `filters`: Resolution filters for auto-bind-tunnel
      - `ldp`: Enable/disable setting LDP type for auto-bind-tunnel
      - `rsvp`: Enable/disable setting RSVP-TE type for auto-bind-tunnel
      - `sr_isis`: Enable/disable setting SR-ISIS type for auto-bind-tunnel
      - `sr_te`: Enable/disable setting SR-TE type for auto-bind-tunnel

This is how the configuration looks like:

```
carrier_ethernet_evc:
  backend:
    default: LDP
    enabled:
    - LDP
    - EVPN
  service_id:
    start: 1
    end: 100
    strategy: next
label_distribution_protocol: {}
main:
```

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```
  inventory_path: inmanta:///connect-inventory.yaml
nokia:
  customer_id: '1'
  epipe:
    enable_sdp: true
    service_name: template://connect/nokia/epipe_service_name.j2
    qos_egress:
      policy_name: default-policy
      queue_id: 3
      cbs: auto
      mbs: auto
      pir: max
    qos_ingress:
      policy_name: default-policy
      policer_id: 3
      cbs: auto
      mbs: auto
      pir: max
    evpn:
      bgp:
        resolution: any
        tagging: True
        filters:
          ldp: False
          rsvp: False
          sr_isis: False
          sr_te: False
  netconf_retry_count: 5
  netconf_retry_interval: 5
```

Controlling the virtual circuit identifier (vcid) with service_id

Each deployment of a CarrierEthernetEvc using LDP backend will need to receive an unused `vcid`. This id is then used for configurations such as the `Epipe` and `sdp` id. This value is not passed on via the API, the model will receive it through allocation. The allocator is given a range of values that can be used, it is aware of the values it has already allocated and based on this and the allocation strategy (`next`, for sequential allocation, or `any`, for random allocation) will pick the allocated `vcid`.

The user of the module can influence the behavior of the allocator with three parameters in the configuration file:

- `carrier_ethernet_evc.service_id.start`: The lowest value that can be allocated.
- `carrier_ethernet_evc.service_id.end`: The highest value that can be allocated.
- `carrier_ethernet_evc.service_id.strategy`: The strategy to use when selecting the next allocated value. Possible values are:
  - `next`: Select the first free value in the range.
  - `any`: Select any free value in the range.

Controlling the ethernet virtual interconnect (evi) with service_id

Each deployment of a CarrierEthernetEvc using EVPN backend will need to receive an unused `evi`. This id is then used for configs such as the `Epipe` and `evi` id. This value is not passed on via the API, the model will receive it through allocation. The allocator is given a range of values that can be used, it is aware of the values it has already allocated and based on this and the allocation strategy (`next`, for sequential allocation, or `any`, for random allocation) will pick the allocated `evi`.

The behavior of the allocator can be influenced similar to the *vcid*, by editing the `carrier_ethernet_evc.service_id` part of the configuration.

1.6.3 Generating A Default Configuration File

Running the following command will generate a default configuration file using the `configuration` plugin:

```
python connect/docs/configuration/new_conf.py <path_to_store_config_file>
```

For example:

```
python connect/docs/configuration/new_conf.py /home/user/connect-project/files/connect-
↪config.yaml
```

1.6.4 Special values

Most of the configuration fields accept a specific primitive type while others have stricter requirements. Moreover, three additional types which are of primitive constraints are introduced:

- `InmantaPath`: A string prefixed by `inmanta://`. The rest of the string should be a path to a file in an Inmanta module or project. *NOTE:* All files should be located in the `files/` folder of the module or the project
- `SystemPath`: A string prefixed by `file://`. The rest of the string should be an absolute path to a file on the system where the compiler is running.
- `TemplatePath`: A string prefixed by `template://`. The rest of the string should be a path to a template in an inmanta module or project. (All templates should be located in the `templates/` folder of the module or project)

In the specific case of `InmantaPath` and `TemplatePath`, the part past the prefix will be treated in this way:

- If the path starts with `/`, the path is in the project's files (or templates) folder. For example, `inmanta:///example/inventory.yaml` points to a file located in `files/example/inventory.yaml` at the root of the project using this module.
- If the path doesn't start with `/`, the part of the string before the first `/` is the name of the module in the `files` directory in which the inventory is located. For example, `inmanta://example/inventory.yaml` points to a file located in `files/inventory.yaml` at the root of the module named example.

1.6.5 Using templates

Some configuration fields accept a path to a template located in an inmanta module or project. Those fields accept a value of type `TemplatePath`, and can also accept a simpler value of a primitive type. In the former case, the path should point to a `Jinja2` template (the extension of the file doesn't matter, but the content does). This template will be rendered at compile time when calling one of the `get_config_template_value` plugins (there is one by primitive type of the inmanta language). The values used for the rendering are provided in the plugin parameters.

Example: A template has already been added to this module: nokia/epipe_service_name.j2.

- The template path to reach it is: `template://connect/nokia/epipe_service_name.j2`. This is the default value of `nokia.epipe_service_name` in the configuration.
- The template content is `epipe-{{ vcid }}`
- This template is used to generate the name of the Epipe service, from the `vcid`.
- In the model, the template is rendered and accessed like this:

```
connect::get_config_template_value_as_string(
    "nokia.epipe_service_name",
    instance=self,
    kwargs={
        "vcid": vc_id,
    },
),
```

  The plugins takes three parameters:

  - `dict_path`: The path to the configuration value in which the template path should be found.
  - `instance`: (Optional) An inmanta instance, in this case the one in which implementation we call the plugin from.
  - `kwargs`: (Optional) A dict, containing key-value pairs, values can only be inmanta primitive types (no entities).

1.7 Extension

Extending the `Connect` module requires the following steps:

- Reading the MEF standard specification for your desired feature
- Translating the `MEF` specification to Inmanta model
- Extending the `LSM`
- Developing `plugins`
- Writing unit tests

There are circumstances where you need to introduce additional features to the `Connect` API which are not part of the `MEF` standard. For instance, deploying `E-Line` with either `LDP` or `EVPN`. In such cases, we distinctively use the `Ext_` prefix for those `entities` and if required, define custom data types. In other words, by following these steps we update and extend the existing `LSM` API, and diverge from the `MEF` standard.

Let's take `L2 MPLS VPN` as an example to extend the existing API:

- Define the required `types`:

```
typedef connectivity_type as string matching self in ["VPWS", "VPLS"]
"""
L2 connectivity type. VPWS or VPLS.
"""
```

- Define a new `entity`, representing the service/technology:

```
entity Ext_L2MPLSType extends lsm::EmbeddedEntity:
    """
    The entity represents L2 MPLS VPN technology.
    :attr type: Can be VPWS or VPLS.
    """
    connectivity_type type
end
```

Please note that the `entity` is prefixed with `Ext_` and is **extending** the existing `lsm::EmbeddedEntity` object. All extensions to the API have to follow the same structure.

> EmbeddedEntity contains attributes that should be embedded into a ServiceEntity or another EmbeddedEntity.

- Define the implementations (`refinement`) for the `entities`:

```
implementation with_VPWS for Ext_L2MPLSType:
    """The specific VPWS implementation goes here"""
    std::print("VPWS selected")
end

implementation with_VPLS for Ext_L2MPLSType:
    """The specific VPLS implementation goes here"""
    std::print("VPLS selected")
end
```

In `with_VPLS` implementation, the attribute types declaration is omitted for brevity; however, the steps are the same as for the `with_VPWS` example.

- Implement the `refinements`:

```
implement Ext_L2MPLSType using with_VPWS when self.connectivity_type=="VPWS"

implement Ext_L2MPLSType using with_VPLS when self.connectivity_type=="VPLS"
```

The `implement` is used to construct and connect the `entities`, `refinements` and their attributes together. `when` is a compile time `if`, which gives us control over how the model should be constructed.

1.7.1 Developing Plugins

There are times when you need to perform some additional validation, modification or conversions on the input data. A very simple example would be converting the `connectivity_type` value provided by the user in lowercase to uppercase. `Plugins` can be used to provide the aforementioned functionalities.

Head to `__init__.py` file under the `plugins` directory and implement the solution:

```
from inmanta.plugins import plugin

@plugin
def transform_to_uppercase(word: "string?") -> "string":
    return word.upper()
```

There are a few point to note here:

- It is strongly advised to use type hinting; however, the types here are accommodated with **double quotes** since they differ from Python's built-in data types.
- The `@plugin` decorator makes the function available to Inmanta model and it can then be referenced inside your model. This decorated function (transform_to_uppercase) can utilize any other undecorated function defined inside the `__init__.py` file for further processing.

1.7.2 Writing Unit Tests

The most basic type of testing is a `compile` test in which an Inmanta model is fed to `project.compile()` and then compiler will run the initial assessments on our provided data/model.

```
import pytest
from pytest_inmanta.plugin import Project


def test_connectivity_type(project: Project) -> None:
    project.compile(
        """
            import connect

            backend = connect::Ext_L2MPLSType(
                type="VPWS"
            )
        """
    )
```

1.8 Frequently Asked Questions (FAQ)

This section contains the frequently asked questions to gain a better understanding of our solution and customers needs.

1. I don't see my `platform` or `vendor` in the supported *platforms* and *features* what should I do?
    - We are always developing and also offer custom-tailored developments. If your platform is not in the list, please get in touch with us.
2. Where can I read about Inmanta language?
    - In this page you will find Inmanta's language reference.

3. Where can I learn more about Inmanta Service Orchestrator?
    - Inmanta Service Orchestrator is documented here.
4. As a developer, how can I get started with Inmanta and how can I set up a basic project?
    - Check out our developer getting started guide
    - Set up a base project using this guide.
5. What are the available testing frameworks?
    - pytest
    - pytest-inmanta
    - pytest-inmanta-lsm
6. When should I escalate back to Inmanta core team upon facing an error?
    - If you are certain that your model is valid, passes the tests and the error is raised by internal Inmanta modules.

For further information, please get in touch with us.

CHAPTER

TWO

ADDITIONAL RESOURCES

- Inmanta User Mailinglist
- Inmanta Developer Mailinglist
- Inmanta Twitter

CHAPTER

THREE

PDF VERSION

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