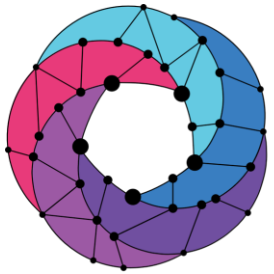
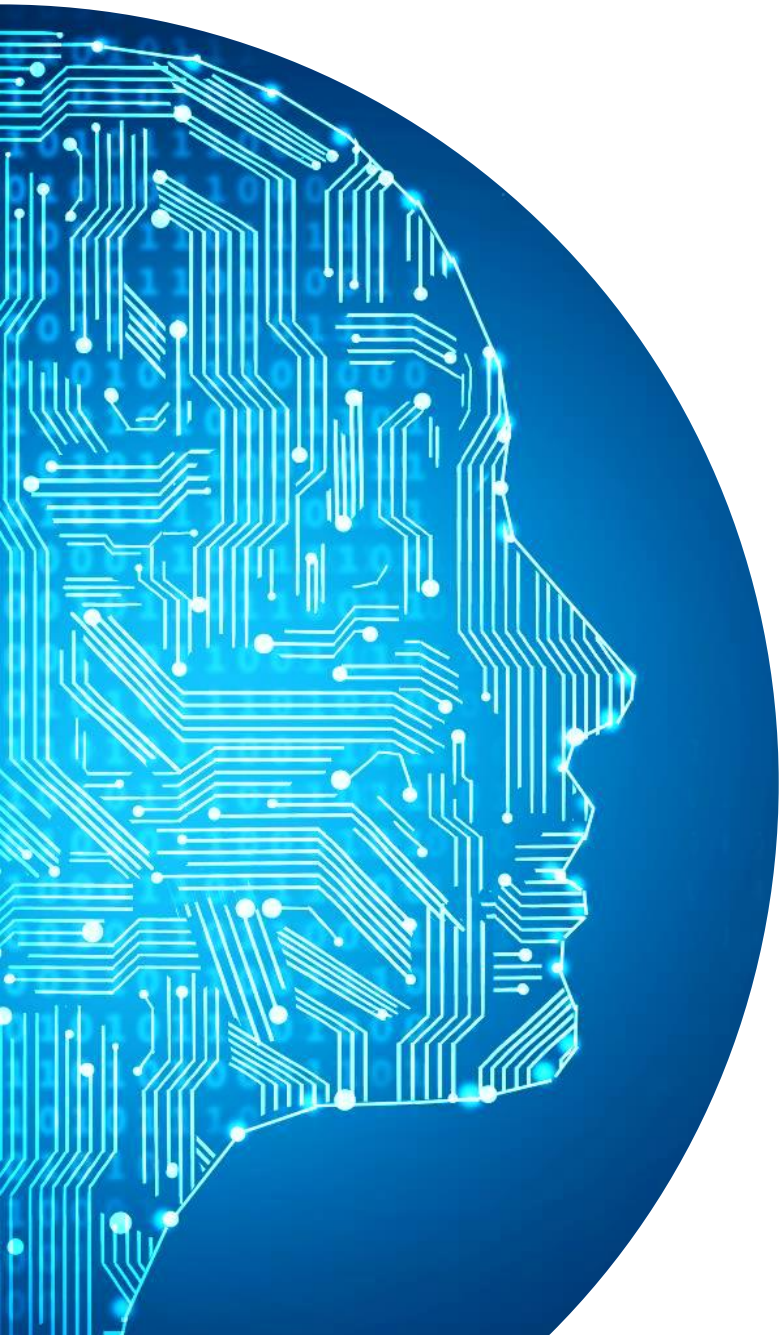


Open Source MANO by ETSI

OSM Release THIRTEEN Webinar

Francisco-Javier Ramón (Telefónica, ETSI OSM Chair)
Gerardo García (Telefónica, TSC Chair)
Mark Beierl (Canonical, TSC Member)

25/01/2023

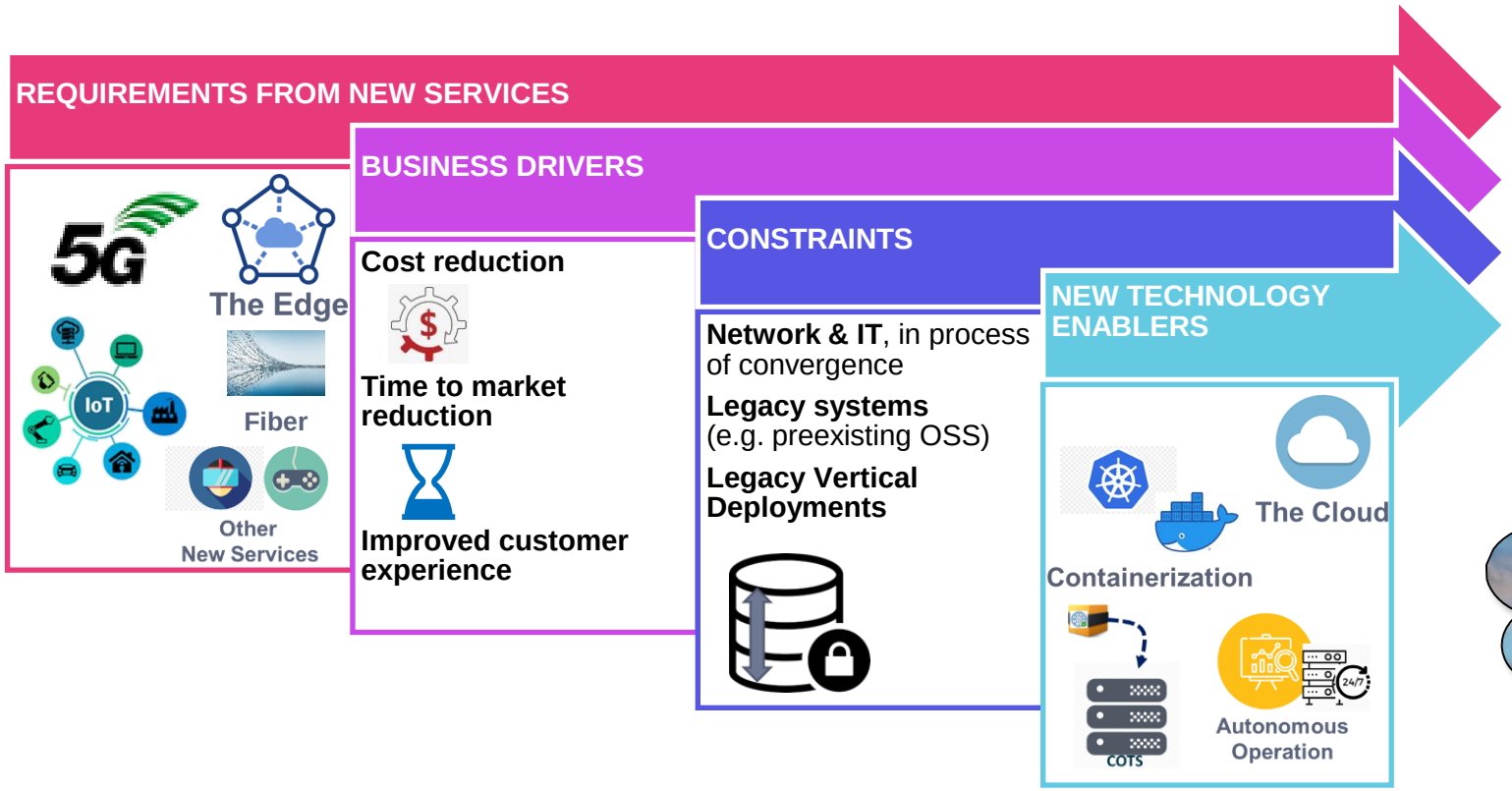


Agenda

- Why OSM?
- New closed-loop architecture. Overview and demo
- Enhanced management of persistent volumes. Demo

Some requirements for the evolution of Telco Clouds…

Open Source MANO



NEXT-GEN TELCO CLOUD

Open Source MANO

How OSM Simplifies Telco Cloud Management…

… while keeping flexibility

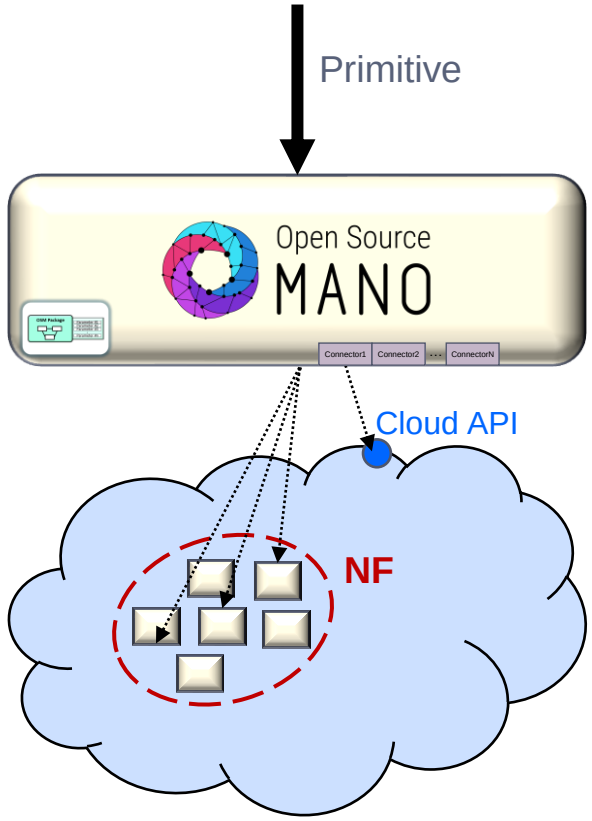
OSM provides a platform to create Networks as a Service and to manage them conveniently later…

OSM manages the low-level setup for Network Functions, so that they are ready for use.

- It covers in 100% the role of a kind of **specialized PaaS for Network Functions**, with 2 key features:
  1. **Complex connectivity** setup, including EPA and underlay scenarios.
  2. Solve **inter-NF relations**.

- Returns: **NS/NF ready for its use and properly connected**:
  - Exposes **the "function" and its lifecycle, not its components**.
  - Presented as a whole (i.e., abstracts from low-level details of the NF).
  - Easy (standardized) access to NF's lifecycle operations, via ***primitives***.

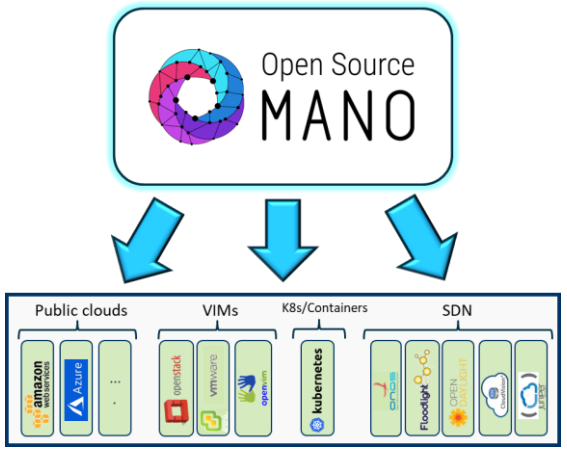
- This follows well-known paradigms in **IT** and **public clouds**.



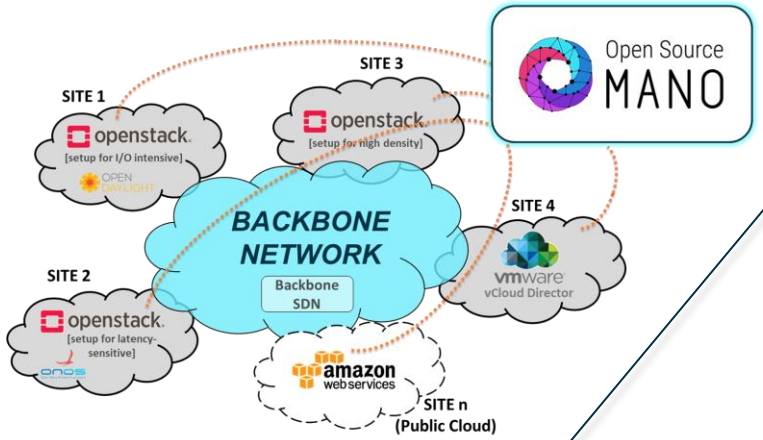
… on different types of infrastructure and across different locations…

Open Source MANO

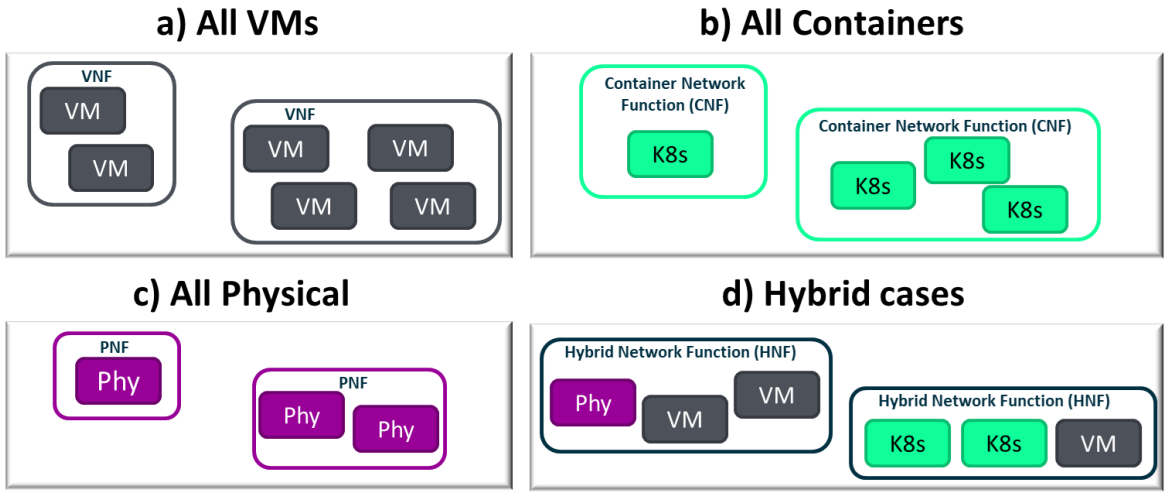
MULTI-VIM & MULTI-SDN



MULTI-SITE



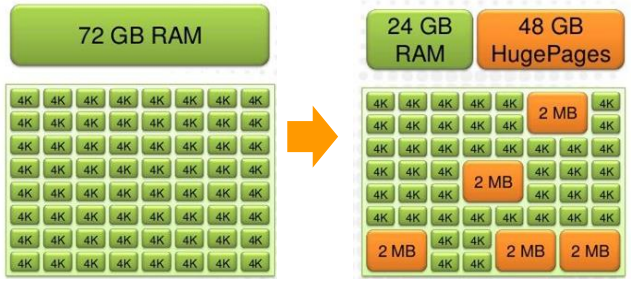
… with NFs composed of **VMs, containers** and/or **physical elements**…



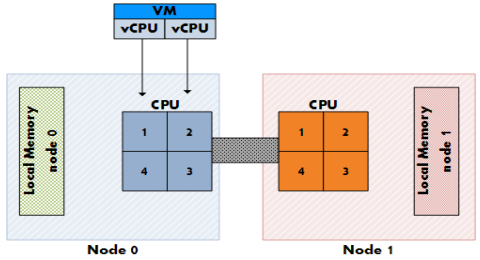
… and ready for network-specific workloads whenever needed

Open Source MANO

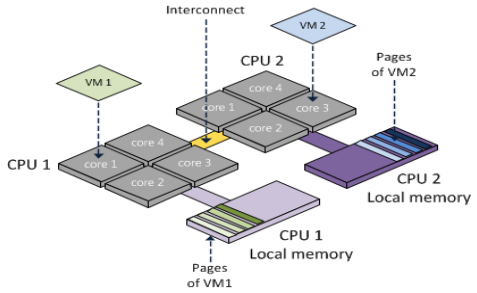
Huge Pages



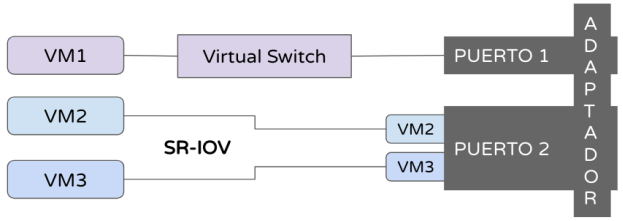
NUMA Topology Awareness

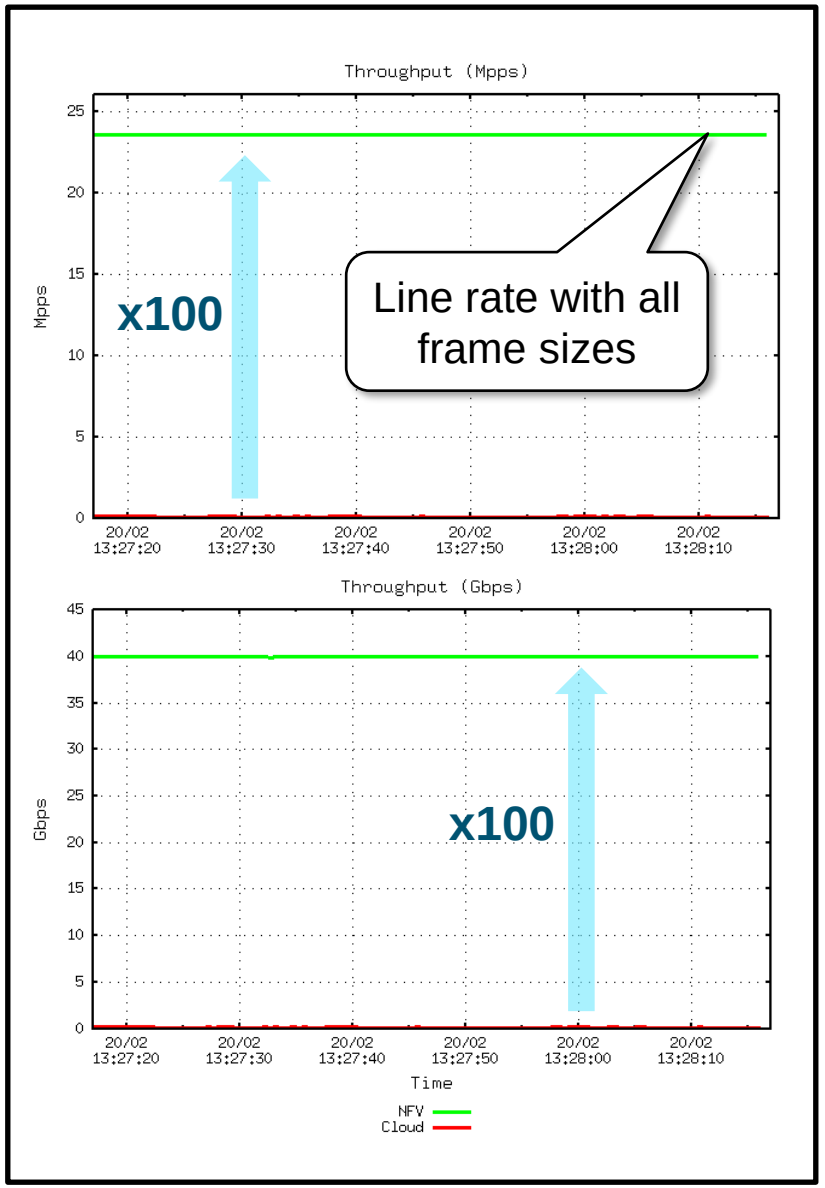


CPU Pinning

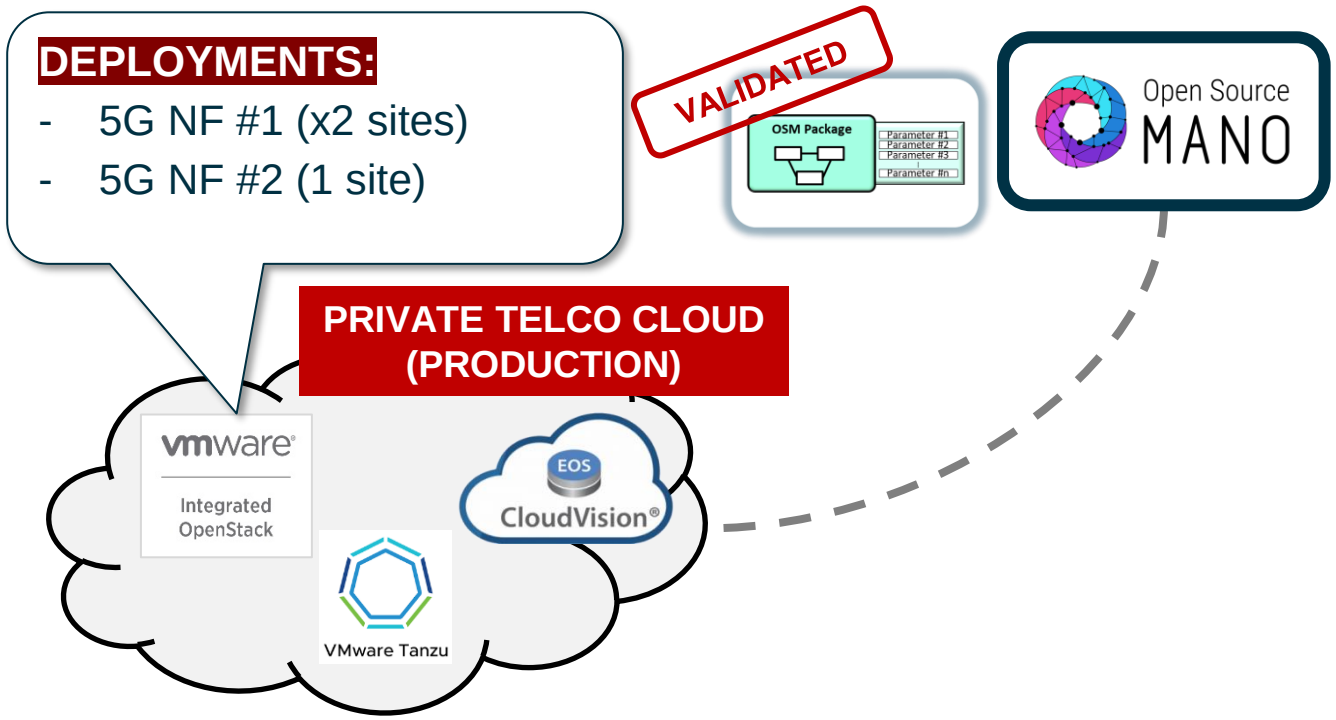


Data Plane assignment





Using the exact same packages, the same service can be deployed in multiple types of clouds and sites



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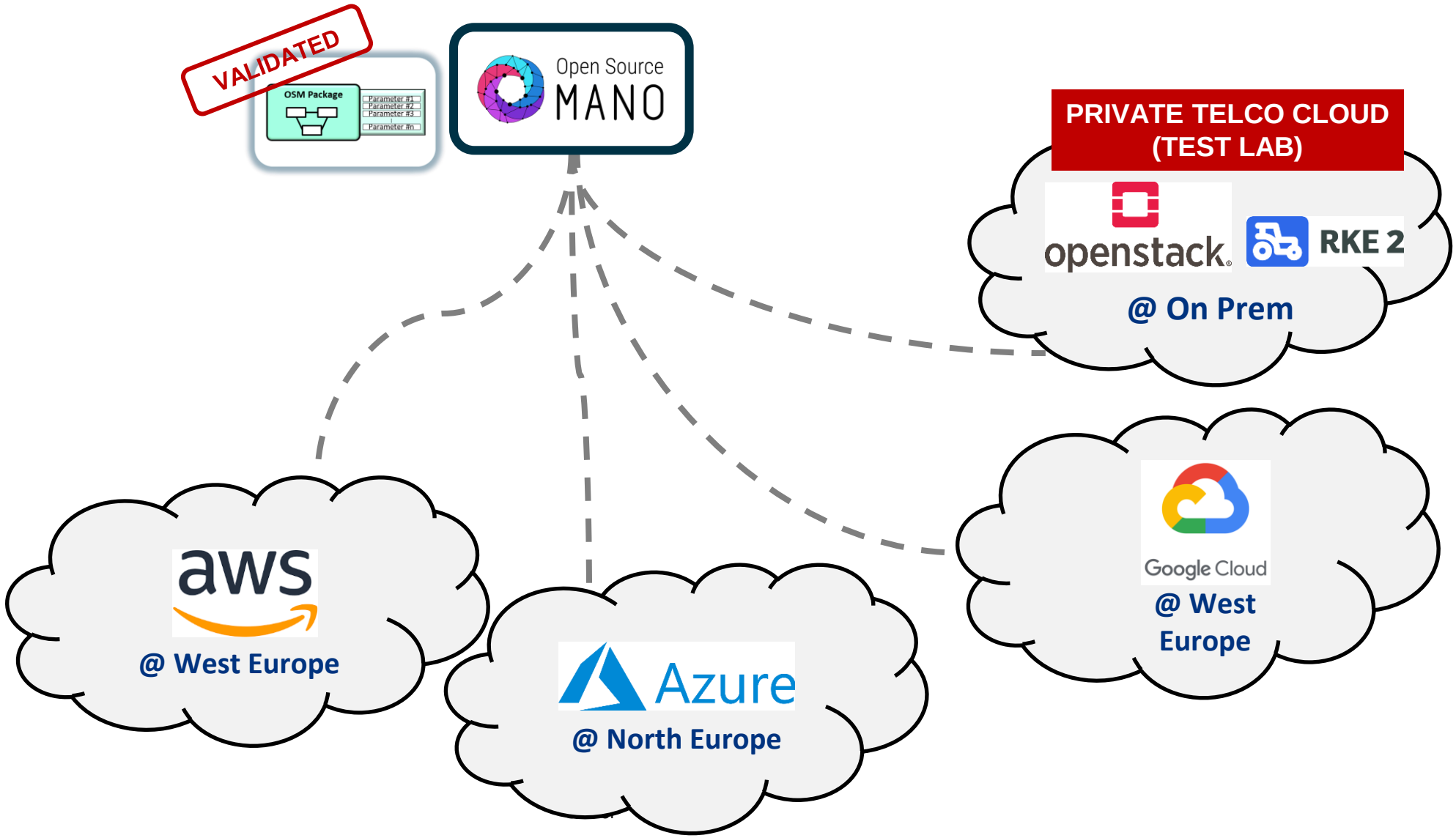


As a result, OSM brings big operational benefits for the challenges of a modern Telco Cloud

Open Source MANO

Reduction of complexity
- Via abstraction & layering

Reliable deployment in multiple locations

Independent of the type of cloud

Vendor-agnostic

Reliable and unambiguous testing
- Ideal for CI/CD

Error minimization

Minimal **Time to Market** for second deployments

Easier **capacity growth among clouds**

Ability to **move workloads** between clouds

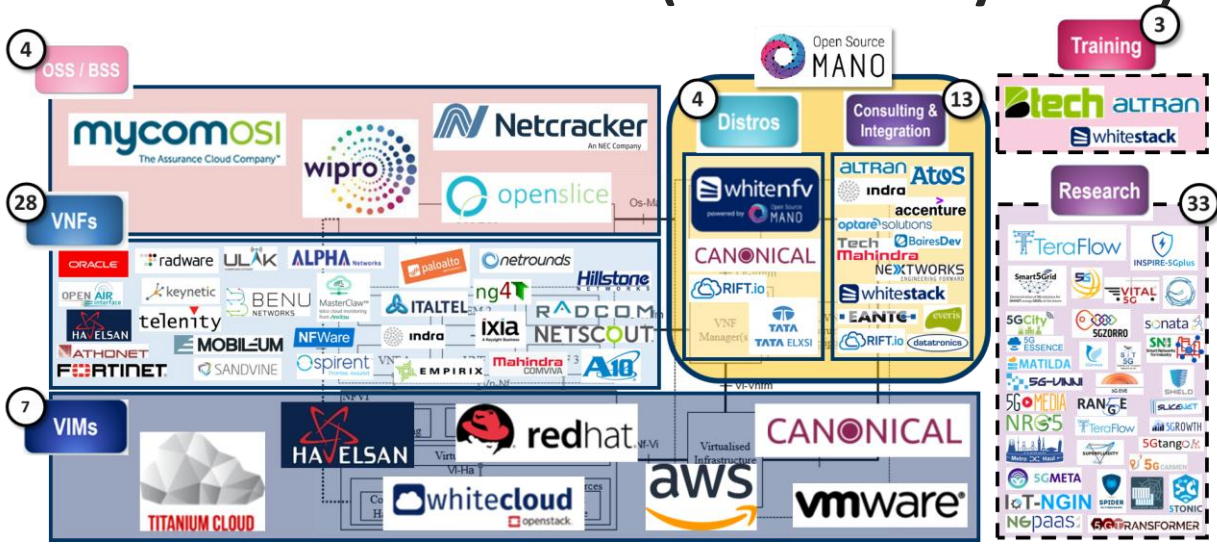
Allows for advanced **redundancy schemas**

Reduction of efforts

A Vibrant and Thriving Community

ETSI OSM community is really LARGE AND DIVERSE, with 148 members today

… with a significant number of commercial offers related to OSM ("OSM Ecosystem")

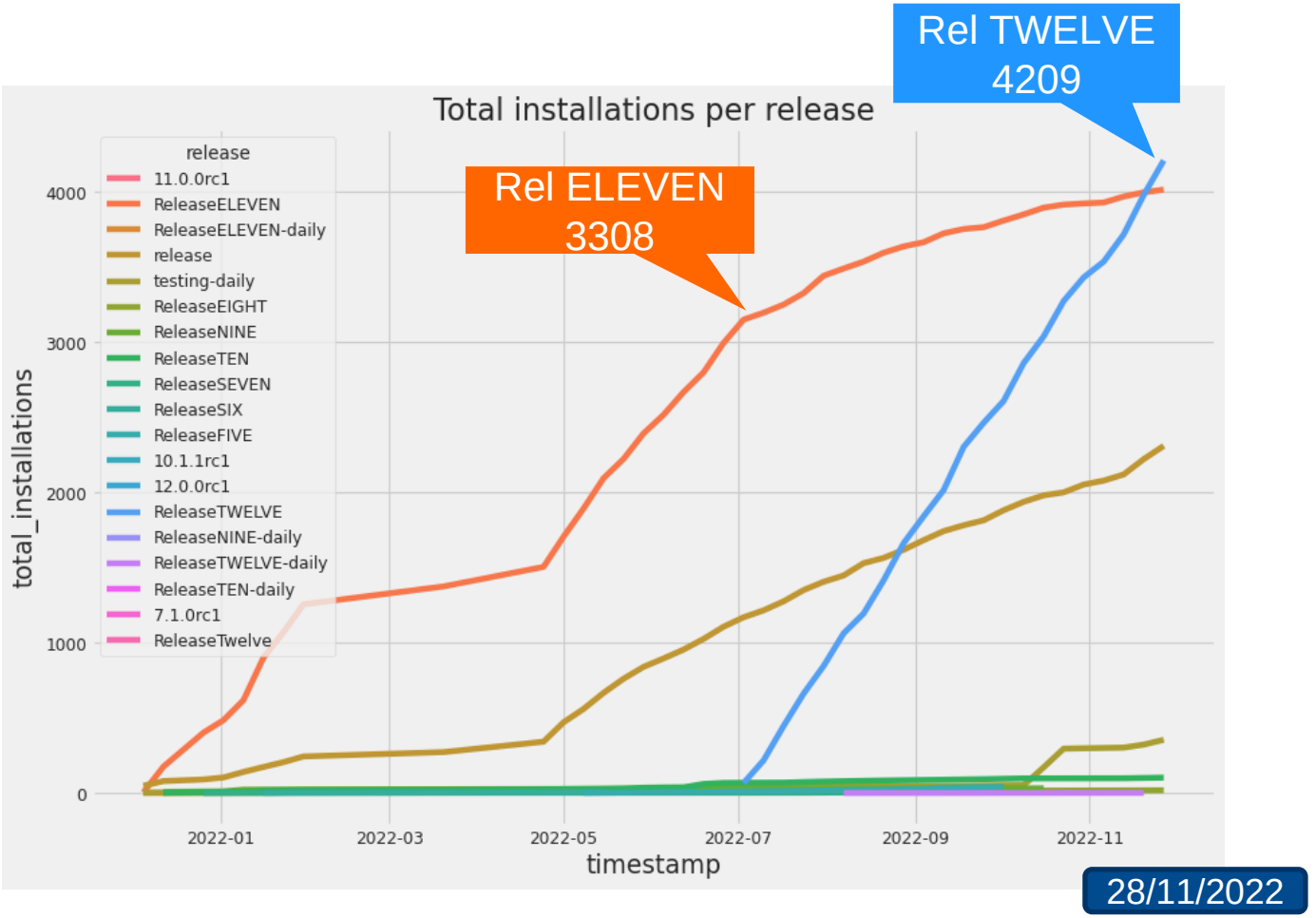


https://osm.etsi.org/wikipub/index.php/OSM_Ecosystem

… which benefit from the feedback of a strong user community, adding to existing commercial deployments…

Open Source MANO

Stats of OSM's community installer:



… and the large size of the research projects using OSM as their orchestrator of choice

Open Source MANO

Open Source MANO by ETSI

https://osm.etsi.org/wikipub/index.php/Research

Open Source MANO

And the new release!

Open Source MANO

Release THIRTEEN

Release THIRTEEN adds features well connected with key use cases and field demands

Open Source MANO
Release THIRTEEN

New closed-loop life cycle arch.

- VM status, NS topology and VIM status acquired via Airflow.
- Prometheus Rec. Rules to derive VNF and NS status.
- Configurable Prometheus scrape targets.

Internal LCM evolution

- Saga-based LCM Milestone 1
  - Configuration via configman library.
  - LCM-RO communication via Kafka.

Execution Environments (day-2)

- Server-side authenticated gRPC channel in Helm-based Execution Environments.
- Upgrade of helm-based EE in VNF instances.
- New convention for charms naming in OSM.

NS deployment

- Keeping persistent volumes of VNF.
- VIM CA certificates registered at VIM creation/update.
- Automatic WIM selection for inter-DC networks.

OSM installation experience

- Air-gapped installation.
- Optional installation of the new monitoring architecture.
- Automatic publication of charms in OSM CI/CD for charm-based installation.

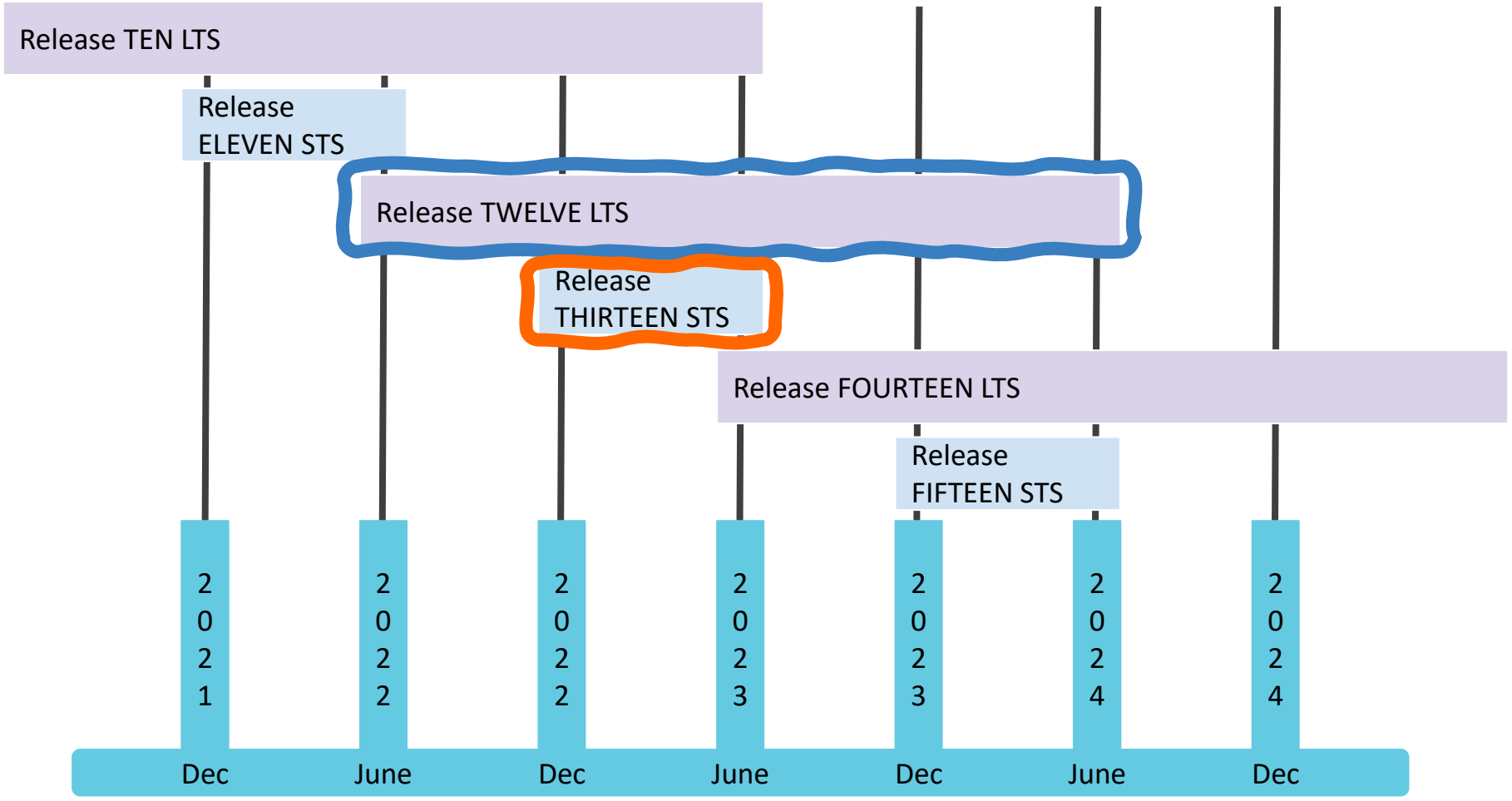
OSM client

- Refactor of osmclient commands.
- VIM configuration for Prometheus-based telemetry.

… which are added on top of an already long set of features…

Open Source MANO

… coexisting with the current LTS release

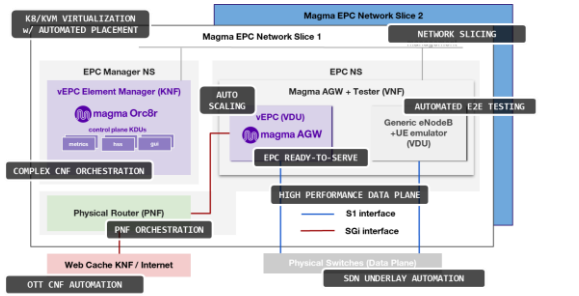


LTS Releases (Long Term Support)	STS Releases (Short Term Support)
24 months community support	6 months community support
Oriented to production	Oriented to innovation & development
Focus on stability	Focus on innovation & agility
Community grants upgrade between LTS's	Upgrade on a best effort basis

At this point, it is becoming easier explaining OSM features in practice

Open Source MANO

MAGMA EPC DEMO (2020)



https://osm.etsi.org/gitlab/vnf-onboarding/osm-packages/tree/master/magma

OSM#11 Hackfest

11 teams onboarding 8 NFs in just one week!

Asterisk

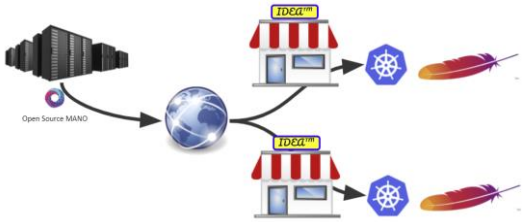
freeRADIUS

PowerDNS

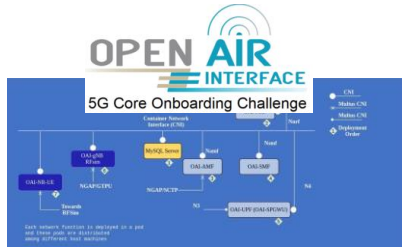
OPC UA

NetNumber

Release TEN Webinar
Edge orchestration with OSM

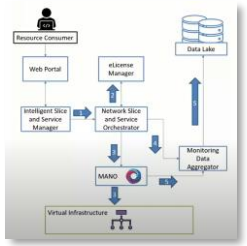


OSM-MR#11 Hackfest



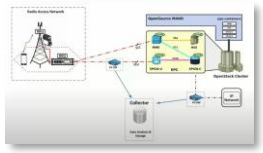
OSM Ecosystem Day 2022

Marketplace-driven 5G network slices

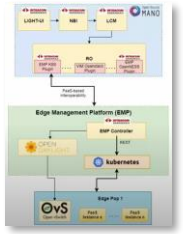


Deployment of MEC Applications

P4-based in-band telemetry



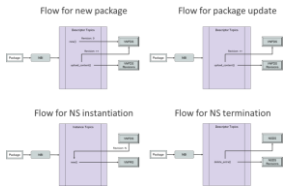
PaaS-driven interop



Release TWELVE Webinar

Healing & scaling in massive sports events

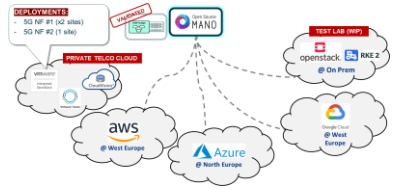
Live upgrade of a NF



Release ELEVEN Webinar

Resolution of inter-NF relations

Multi-Cloud Deployments

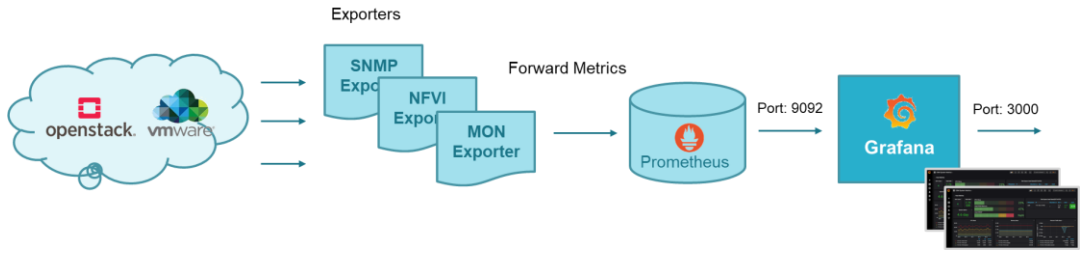


Open Source MANO

New closed-loop architecture
Overview and demo

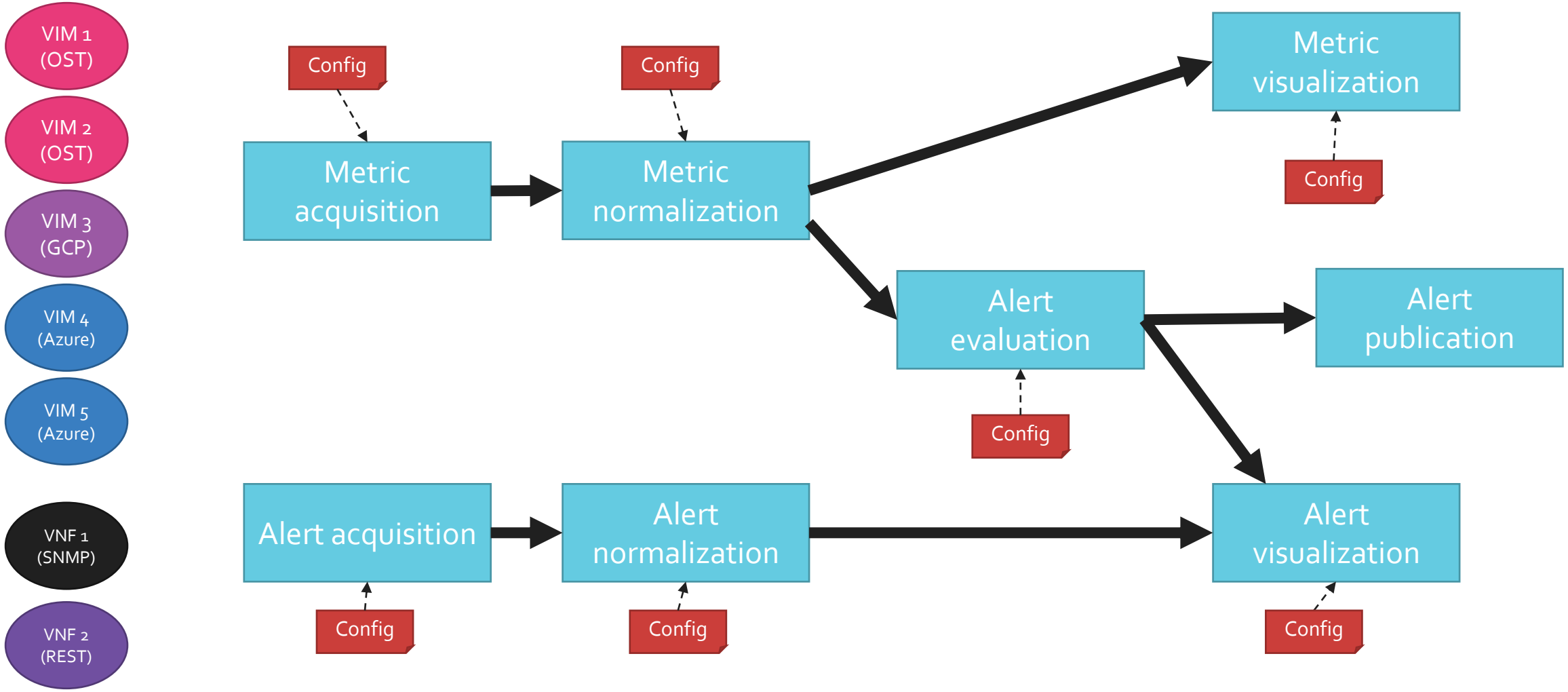
Limitations with current architecture

- Monolithic system
  - A single MON container deals with all the stages: metric acquisition, metric normalization, metric evaluation, dashboard generation, etc.
- Scalability
  - Metric acquisition in MON is a bottleneck and cannot be properly scaled-out (workload was not shared).
- Very difficult to add new capabilities
  - No clear split of tasks
  - Need of an easy way to incorporate new sources
- Too much focus on metric visualization



Analytics Pipeline Vision

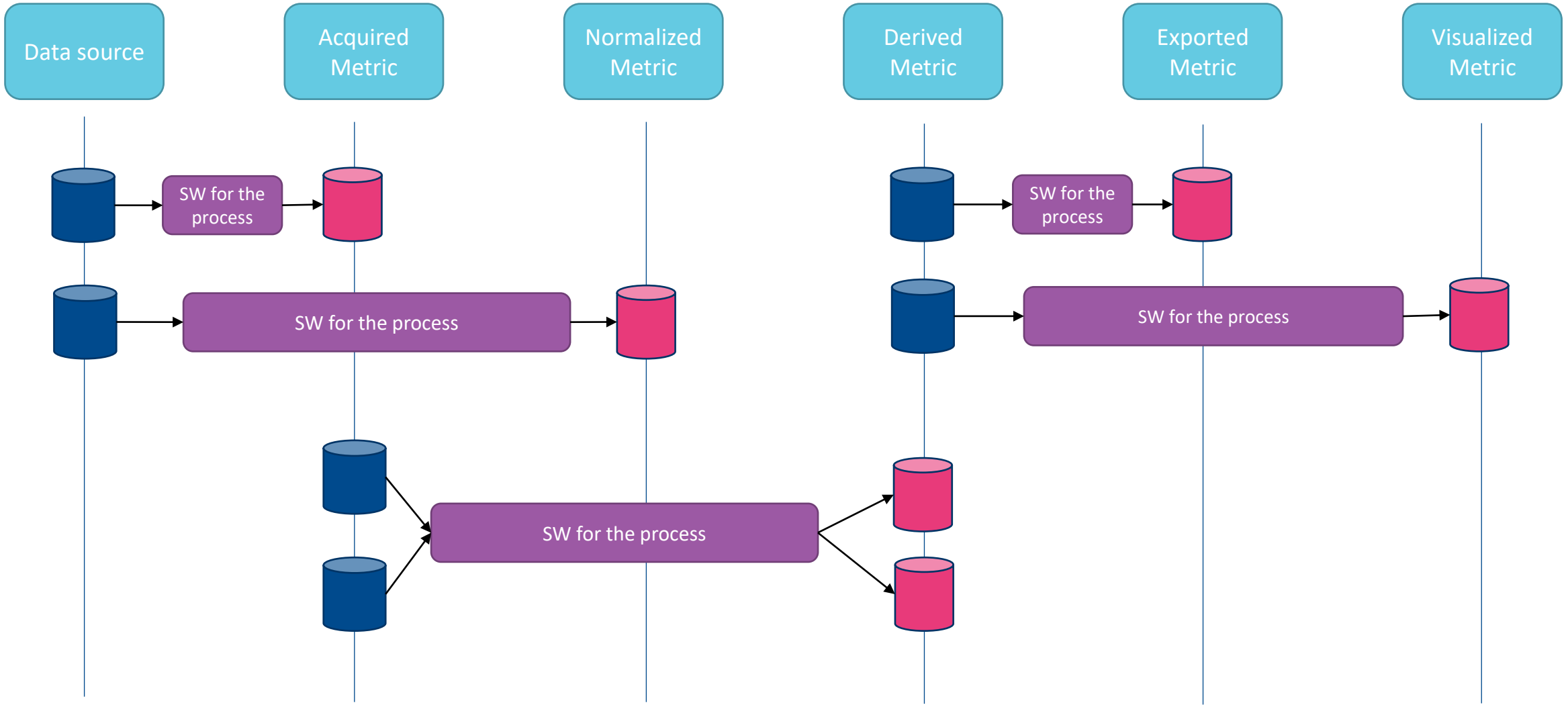
Metrics and alerts could be processed in a sequence of steps



Arrows do not mean copy of data (data are transferred by reference as much as possible)
Implicitly, storage might be required in some stages

Analytics Pipeline Vision

Each step can be done independently

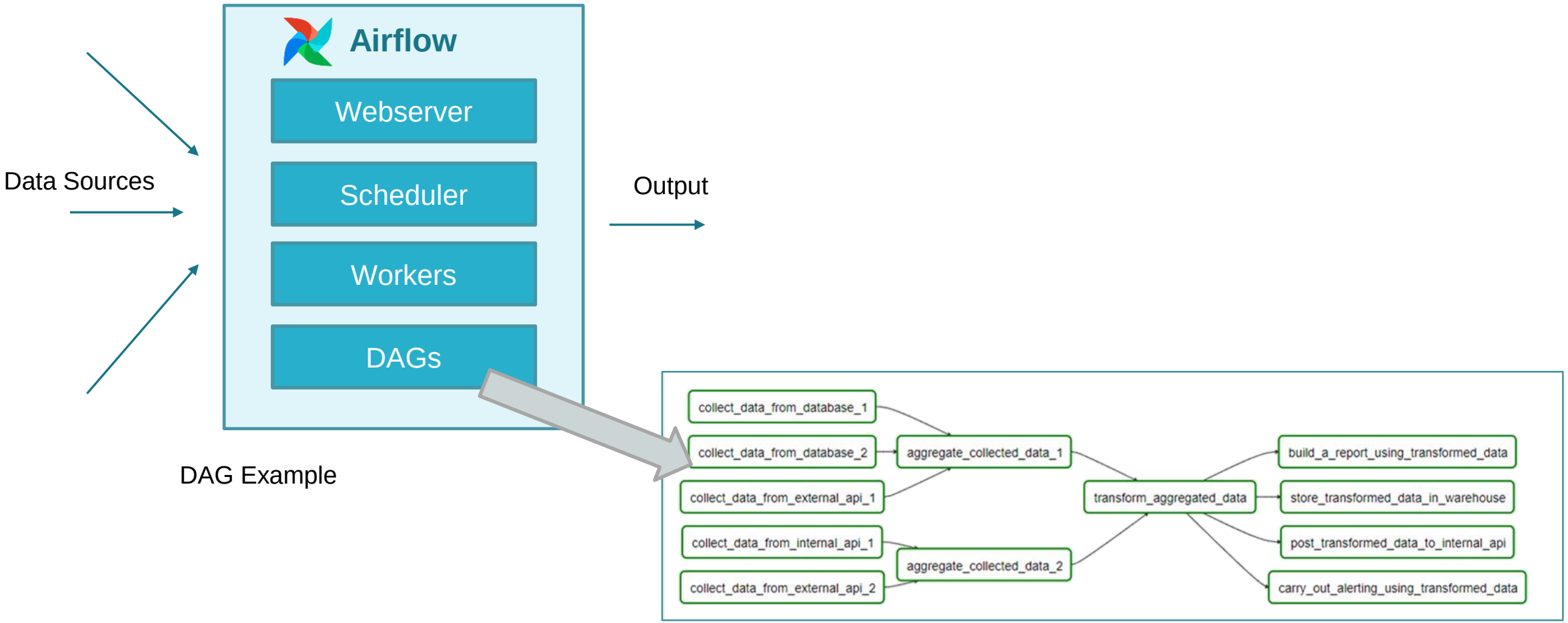


Building blocks

Recap on Apache Airflow

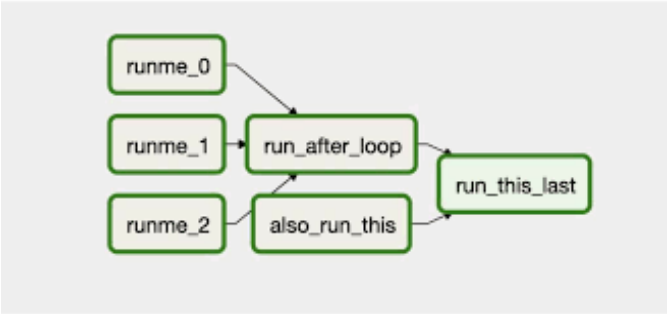
- Apache Airflow is an open-source **workflow management platform for data engineering pipelines**.
- It **started at Airbnb in October 2014** as a solution to manage the company's increasingly complex workflows. Creating Airflow allowed Airbnb to programmatically author and schedule their workflows and monitor them via the built-in Airflow user interface. From the beginning, the project was made open source, becoming an **Apache Incubator project in March 2016** and a **top-level Apache Software Foundation project in January 2019**.
- Airflow is written in Python, and **workflows are created via Python scripts**. Airflow is designed under the principle of "configuration as code". While other "configuration as code" workflow platforms exist using markup languages like XML, using Python allows developers to import libraries and classes to help them create their workflows.

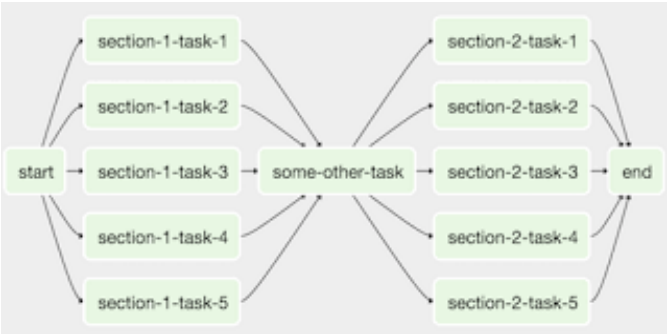
Building blocks
Apache Airflow



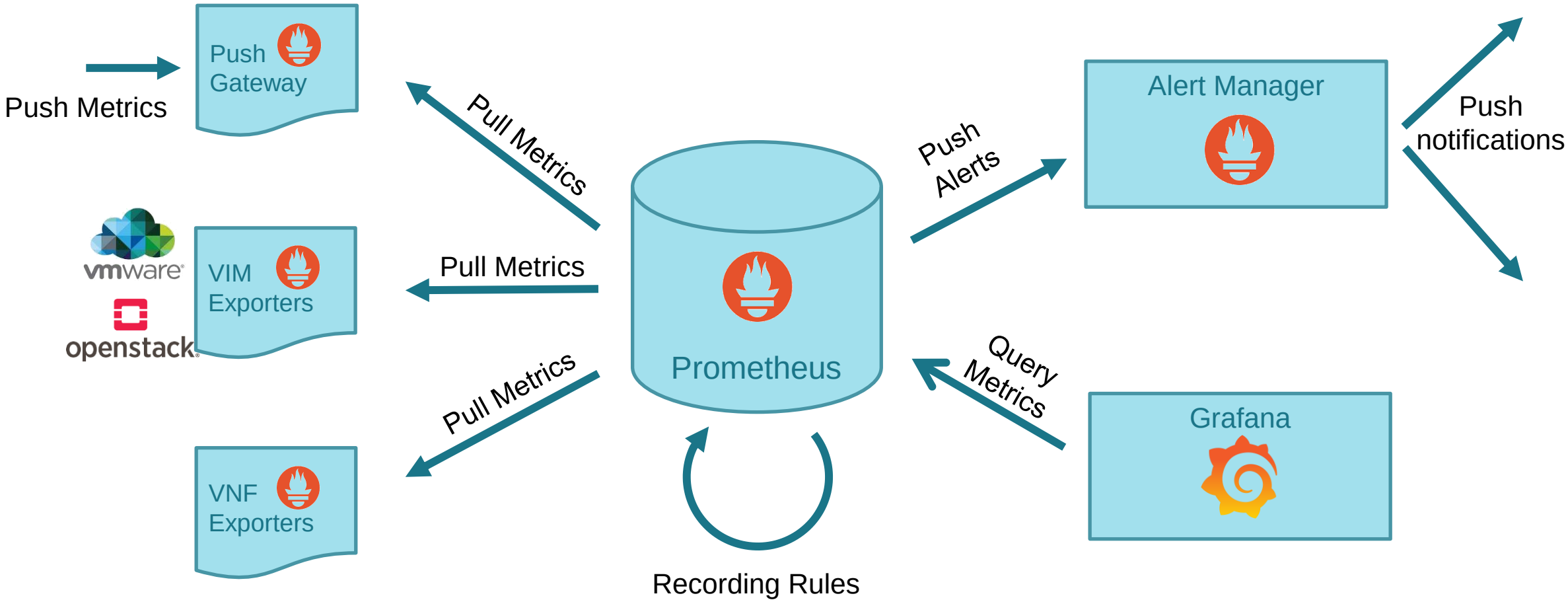
Recap on Apache Airflow

- DAG (Directed Acyclic Graph):
  - Collection of tasks
    - A lot of flexibility to create dependencies between tasks
  - Defined in Python
  - DAGs can be dynamically created, for instance:
    - One per VIM
    - One per NS
  - Tasks can be dynamically created inside a DAG, for instance:
    - One per VM
  - Designed to scale
    - Airflow workers run tasks in parallel
  - Scheduled independently





Building blocks
Prometheus Stack

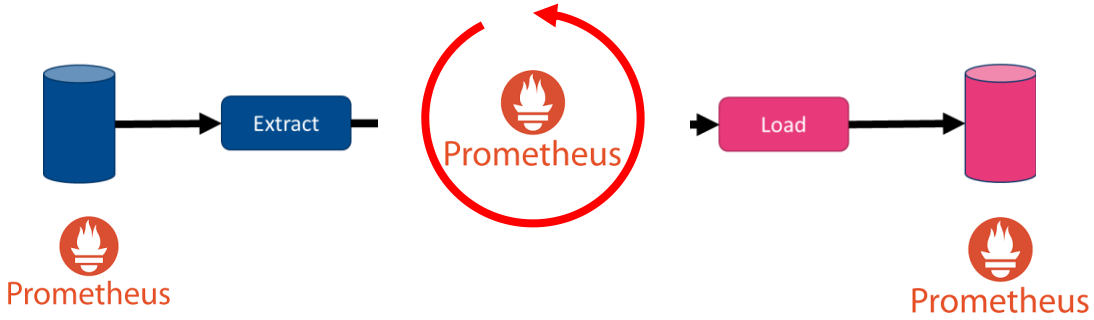


What comes with OSM Release THIRTEEN

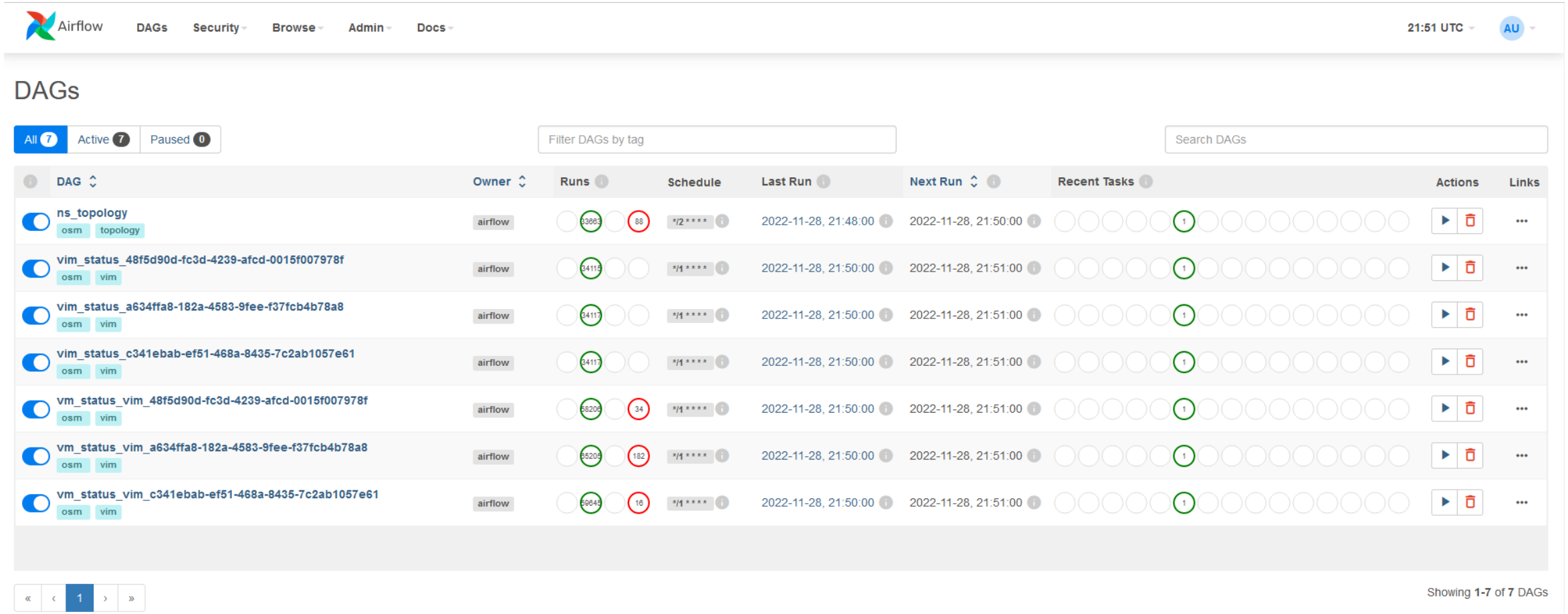
- Acquired metrics
  - NS topology:
    - From Mongo DB to Prometheus
    - SW used: Airflow DAG + Prometheus PushGateway
  - VM status:
    - From MongoDB and VIM to Prometheus
    - SW used: Airflow DAG per VIM + Prometheus PushGateway
  - VIM status
    - From MongoDB and VIM to Prometheus
    - SW used: Airflow DAG per VIM + Prometheus PushGateway

What comes with OSM Release THIRTEEN

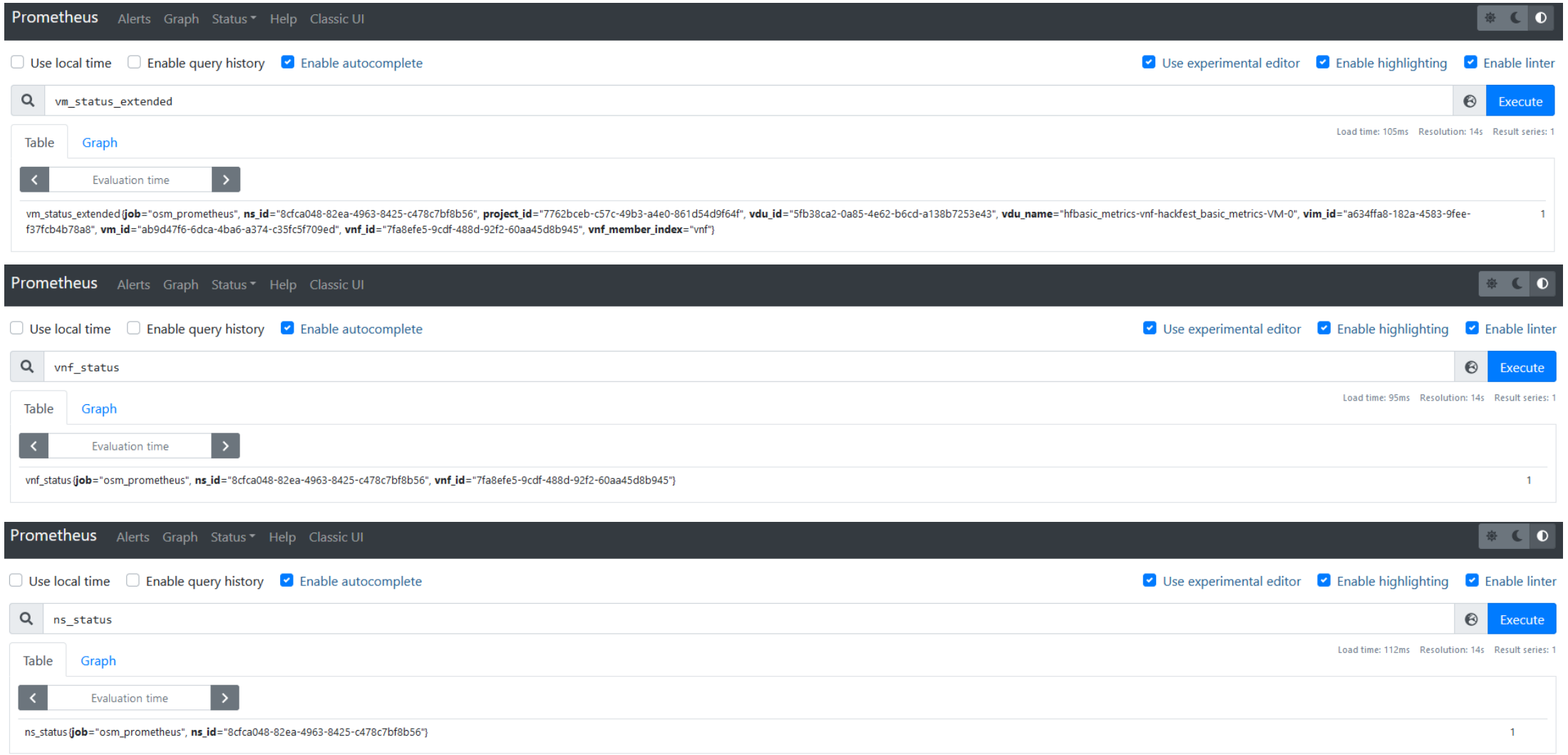
- Derived metrics
  - Extended VM status:
    - From Prometheus (NS topology, VM status) to Prometheus
    - SW used: Prometheus Recording Rules
  - VNF status:
    - From Prometheus (Extended VM status) to Prometheus
    - SW used: Prometheus Recording Rules
  - NS status:
    - From Prometheus (Extended VM status) to Prometheus
    - SW used: Prometheus Recording Rules



Screenshot of Airflow monitoring pipelines



Screenshot of the new derived metrics



The new monitoring pipeline architecture can be optionally installed with OSM

Open Source MANO

./install_osm.sh --ng-sa

```
$ helm -n osm ls
NAME            NAMESPACE       REVISION        UPDATED                                 STATUS          CHART                           APP VERSION
airflow         osm             1               2022-11-24 14:36:13.973601205 +0000 UTC deployed        airflow-1.6.0                   2.3.0
pushgateway     osm             1               2022-11-23 15:56:57.43961967 +0000 UTC  deployed        prometheus-pushgateway-1.18.2   1.4.2
```

```
$ kubectl -n osm get pods
NAME                                        READY   STATUS    RESTARTS         AGE
airflow-postgresql-0                        1/1     Running   0                4d7h
airflow-redis-0                             1/1     Running   0                4d7h
airflow-scheduler-cdf7499d5-jzfn7           3/3     Running   6 (7h47m ago)    4d7h
airflow-statsd-75f567fd86-xgcbk             1/1     Running   0                4d7h
airflow-triggerer-6fd957b4b8-4w2xw          2/2     Running   11 (4h41m ago)   4d7h
airflow-webserver-58d9ccc9b9-4msd2          1/1     Running   0                4d7h
airflow-worker-0                            3/3     Running   6 (24m ago)      4d7h
grafana-5799c4d4b4-t7m64                    2/2     Running   0                5d6h
kafka-0                                     1/1     Running   0                5d6h
keystone-5659b79cd4-5nsbq                   1/1     Running   0                5d6h
lcm-6b5fddf5db-58v4x                        1/1     Running   0                5d6h
modeloperator-59cb47b44c-k6wd5              1/1     Running   0                5d6h
mon-6fc5b75944-9vls5                        1/1     Running   0                5d
mongodb-k8s-0                               1/1     Running   0                5d6h
mongodb-k8s-operator-0                      1/1     Running   0                5d6h
mysql-0                                     1/1     Running   0                5d6h
nbi-7b689c4dcd-9flbw                        1/1     Running   5 (5d6h ago)     5d6h
ng-ui-d9dc4c686-dp9v9                       1/1     Running   0                5d6h
pol-b95d89578-x7f8w                         1/1     Running   6 (5d6h ago)     5d6h
prometheus-0                                2/2     Running   0                4d23h
pushgateway-prometheus-pushgateway-6f9dc6cb4d-brgvt   1/1   Running   0        5d6h
ro-5fbcbbdf77-n8g25                         1/1     Running   6 (5d6h ago)     5d6h
zookeeper-0                                 1/1     Running   0                5d6h
```

The new monitoring pipeline architecture can be optionally installed with OSM

Open Source MANO

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```

```
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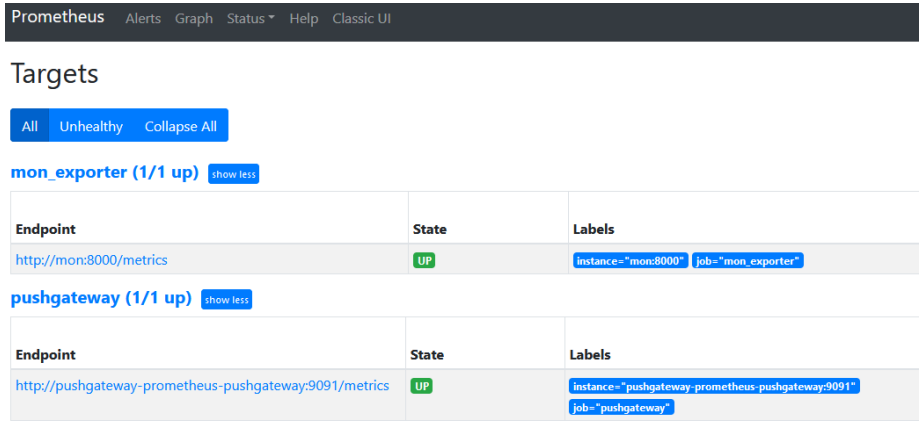
airflow-postgresql-0                                1/1     Running   0               4d7h
airflow-redis-0                                     1/1     Running   0               4d7h
airflow-scheduler-cdf7499d5-jzfn7                   3/3     Running   6 (7h47m ago)   4d7h
airflow-statsd-75f567fd86-xgcbk                     1/1     Running   0               4d7h
airflow-triggerer-6fd957b4b8-4w2xw                  2/2     Running   11 (4h41m ago)  4d7h
airflow-webserver-58d9ccc9b9-4msd2                  1/1     Running   0               4d7h
airflow-worker-0                                    3/3     Running   6 (24m ago)     4d7h
grafana-5799c4d4b4-t7m64                            2/2     Running   0               5d6h
kafka-0                                             1/1     Running   0               5d6h
keystone-5659b79cd4-5nsbq                           1/1     Running   0               5d6h
lcm-6b5fddf5db-58v4x                                1/1     Running   0               5d6h
modeloperator-59cb47b44c-k6wd5                      1/1     Running   0               5d6h
mon-6fc5b75944-9vls5                                1/1     Running   0               5d
mongodb-k8s-0                                       1/1     Running   0               5d6h
mongodb-k8s-operator-0                              1/1     Running   0               5d6h
mysql-0                                             1/1     Running   0               5d6h
nbi-7b689c4dcd-9flbw                                1/1     Running   5 (5d6h ago)    5d6h
ng-ui-d9dc4c686-dp9v9                               1/1     Running   0               5d6h
pol-b95d89578-x7f8w                                 1/1     Running   6 (5d6h ago)    5d6h
prometheus-0                                        2/2     Running   0               4d23h
pushgateway-prometheus-pushgateway-6f9dc6cb4d-brgvt 1/1     Running   0               5d6h
ro-5fbcbbdf77-n8g25                                 1/1     Running   6 (5d6h ago)    5d6h
zookeeper-0                                         1/1     Running   0               5d6h
```

MON and POL still running, co-existing with the new architecture

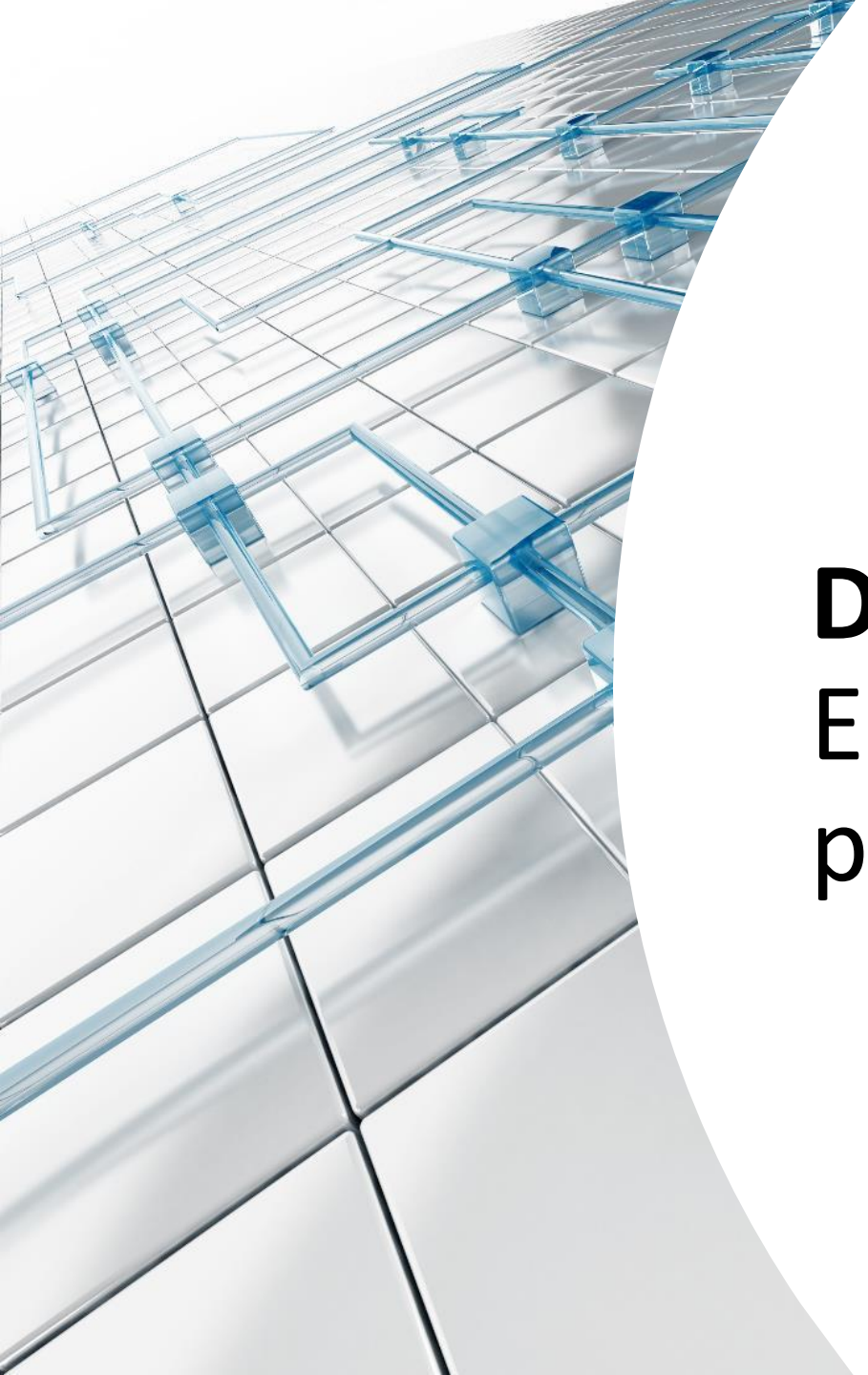


Demo

- Overview of the installed components
- Instantiation of first NS in first cloud
- Metrics acquired and derived with the new framework
  - Airflow DAGs for NS topology, VM status and VIM status
  - Prometheus Recording Rules and Metrics for extended VM status, VNF status, NS status
- Instantiation of second NS in second cloud
  - Dynamic Airflow DAGs
  - Automatic generation of metrics for the second NS

MON and POL functionality will be gradually transferred to the new architecture

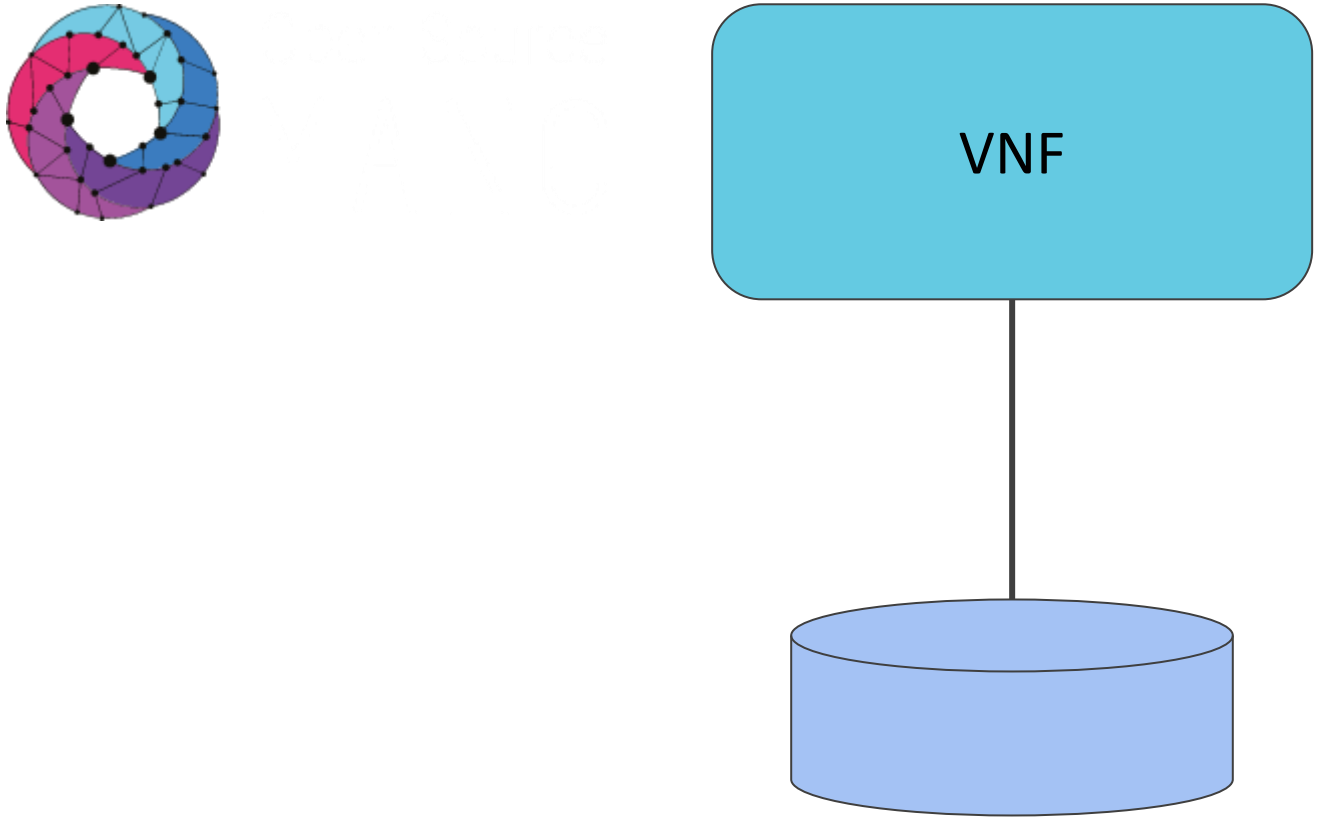
- Work items
  - Metric acquisition
    - xNF resource consumption in VIM and K8s clusters using Prometheus Exporters or dedicated Airflow DAGs
    - xNF metric collection from NF using Prometheus Exporters
    - SDN status, K8s cluster status, etc.
  - Alerting
    - Generation of alerts: failed VM, failed networks, resource consumption thresholds
    - xNF alert webhooks
  - Closed Loops
    - Auto-healing
    - Auto-scaling
  - Presentation of basic indicators (VNF status, NS status, VIM status, etc.) through GUI and OSM client



Open Source MANO

Demo:
Enhanced management of persistent volumes

Openstack Persistent Volumes



VNF Descriptor

```
virtual-storage-desc:
- id: root-volume
  type-of-storage: persistent-storage
  size-of-storage: 10
- id: persistent-volume
  type-of-storage: persistent-storage
  size-of-storage: 1
  vdu-storage-requirements:
    - key: keep-volume
      value: 'true'
- id: ephemeral-volume
  type-of-storage: ephemeral-storage
  size-of-storage: 2
```

New

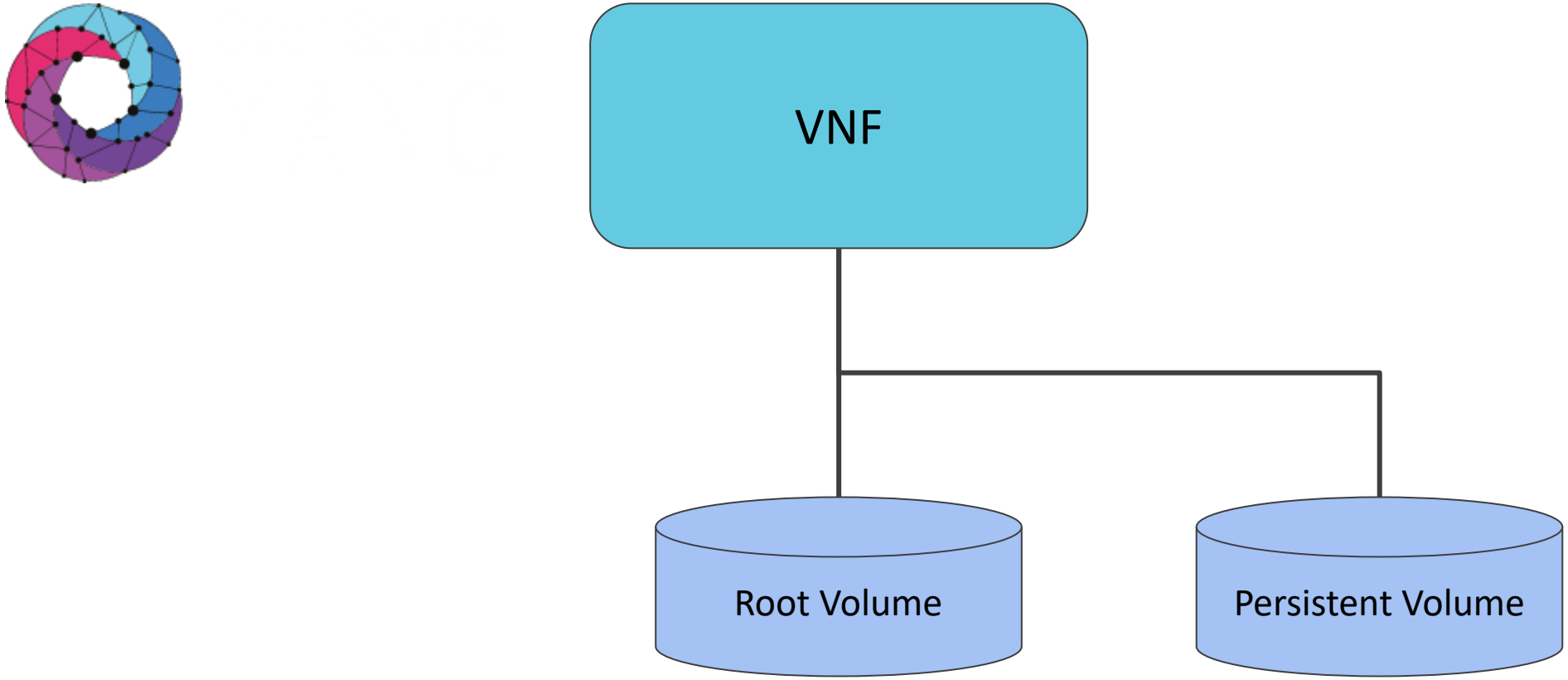
Creating Network Service

```
ubuntu@osm-webinar:~$ # An Openstack VIM has been added to our OSM:
ubuntu@osm-webinar:~$ osm vim-list
+-----------+--------------------------------------+--------------------+
| vim name  | uuid                                 | operational state |
+-----------+--------------------------------------+--------------------+
| openstack | 2c092c27-1cf8-4ba5-9138-a579d90fee3b | ENABLED           |
+-----------+--------------------------------------+--------------------+
ubuntu@osm-webinar:~$ # Our openstack tenant does not have any VMs in it
ubuntu@osm-webinar:~$ openstack server list

ubuntu@osm-webinar:~$ # Nor does it have any volumes at this time
ubuntu@osm-webinar:~$ openstack volume list

ubuntu@osm-webinar:~$ # Our OSM packages have already been uploaded
ubuntu@osm-webinar:~$ osm nsd-list
osm vnfd-list
+----------------------+--------------------------------------+
| nsd name             | id                                   |
+----------------------+--------------------------------------+
| persistent_volumes-ns | 26f0989f-09fc-4337-8a6e-3b0a7b4aba95 |
+----------------------+--------------------------------------+
ubuntu@osm-webinar:~$ osm vnfd-list
+---------------------------+--------------------------------------+-----------+
| nfpkg name                | id                                   | desc type |
+---------------------------+--------------------------------------+-----------+
| keep_persistent-volumes-vnf | 37d3c1e8-5f87-4a11-b770-3199868ff2f5 | sol006    |
+---------------------------+--------------------------------------+-----------+
ubuntu@osm-webinar:~$ # Now, let's deploy that Network Service
ubuntu@osm-webinar:~$ osm ns-create --ns_name create_data \
>     --nsd_name persistent_volumes-ns \
>     --vim_account openstack \
>     --config '{vld:[{name: mgmtnet, vim-network-name: osm-ext}]}' \
>     --ssh_keys .ssh/id_rsa.pub
578f563e-7754-48ec-86c2-90f15038e757
ubuntu@osm-webinar:~$ _
```

Openstack Persistent Volumes



Examine Created Resources

```
ubuntu@osm-webinar:~$ # The network service has been created
ubuntu@osm-webinar:~$ osm ns-list
+------------------+--------------------------------------+---------------------+----------+-------------------+---------------+
| ns instance name | id                                   | date                | ns state | current operation | error details |
+------------------+--------------------------------------+---------------------+----------+-------------------+---------------+
| create_data      | 578f563e-7754-48ec-86c2-90f15038e757 | 2023-01-21T06:23:32 | READY    | IDLE (None)       | N/A           |
+------------------+--------------------------------------+---------------------+----------+-------------------+---------------+
To get the history of all operations over a NS, run "osm ns-op-list NS_ID"
For more details on the current operation, run "osm ns-op-show OPERATION_ID"
ubuntu@osm-webinar:~$ # Let's check what is in Openstack
ubuntu@osm-webinar:~$ openstack server list
+--------------------------------------+-----------------------------------------------------+--------+-------------------------+-------------+---------------------------------------------------+
| ID                                   | Name                                                | Status | Networks                | Image       | Flavor                                            |
+--------------------------------------+-----------------------------------------------------+--------+-------------------------+-------------+---------------------------------------------------+
| cb6b3ccd-46e0-49e4-a48e-aacceea8488d | create_data-vnf-persistent-v-keep-persistent-vol-VM-0 | ACTIVE | osm-ext=172.21.248.86 | ubuntu20.04 | keep-persistent-vol-VM-vnf-persistent-volumes-1-flv |
+--------------------------------------+-----------------------------------------------------+--------+-------------------------+-------------+---------------------------------------------------+
ubuntu@osm-webinar:~$ # And list the volumes
ubuntu@osm-webinar:~$ openstack volume list
+--------------------------------------+-------------------------------------------------------+--------+------+--------------------------------------------------------------------------+
| ID                                   | Name                                                  | Status | Size | Attached to                                                              |
+--------------------------------------+-------------------------------------------------------+--------+------+--------------------------------------------------------------------------+
| dbcfd327-f5ba-4e9f-9897-cf0654598d80 | create_data-vnf-persistent-v-keep-persistent-vol-VM-0vdb | in-use |    1 | Attached to create_data-vnf-persistent-v-keep-persistent-vol-VM-0 on /dev/vdc |
| 05ebbe40-5c68-4b04-8719-f54763851d08 | create_data-vnf-persistent-v-keep-persistent-vol-VM-0vda | in-use |   10 | Attached to create_data-vnf-persistent-v-keep-persistent-vol-VM-0 on /dev/vda |
+--------------------------------------+-------------------------------------------------------+--------+------+--------------------------------------------------------------------------+
ubuntu@osm-webinar:~$ # Let's get the IP address of the VNF with the attached storage
ubuntu@osm-webinar:~$ osm vnf-list

+--------------------------------------+------+--------------------------------------+------------------------+----------------------------+--------------------------------------+---------------+
| vnf id                               | name | ns id                                | vnf member index       | vnfd name                  | vim account id                       | ip address    |
+--------------------------------------+------+--------------------------------------+------------------------+----------------------------+--------------------------------------+---------------+
| b281334c-01a8-4d55-ba10-2cd58e8c61e5 | -    | 578f563e-7754-48ec-86c2-90f15038e757 | vnf-persistent-volumes | keep_persistent-volumes-vnf | 2c092c27-1cf8-4ba5-9138-a579d90fee3b | 172.21.248.86 |
+--------------------------------------+------+--------------------------------------+------------------------+----------------------------+--------------------------------------+---------------+
ubuntu@osm-webinar:~$
ubuntu@osm-webinar:~$ _
```

Write to Volumes in VNF

```
ubuntu@osm-webinar:~$ # Log into the VNF and examine the volumes
ubuntu@osm-webinar:~$ ssh 172.21.248.86
The authenticity of host '172.21.248.86 (172.21.248.86)' can't be established.
ECDSA key fingerprint is SHA256:y7bBmGCxpv4+88/WQRHj+A5+rPDbrCqTDogqaQ/f/1g.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '172.21.248.86' (ECDSA) to the list of known hosts.
Welcome to Ubuntu 20.04.4 LTS (GNU/Linux 5.4.0-107-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

  System information as of Sat Jan 21 06:29:47 UTC 2023

  System load:  0.08              Processes:             104
  Usage of /:   14.0% of 9.52GB   Users logged in:       0
  Memory usage: 21%               IPv4 address for ens3: 172.21.248.86
  Swap usage:   0%

1 update can be applied immediately.
To see these additional updates run: apt list --upgradable


The list of available updates is more than a week old.
To check for new updates run: sudo apt update


The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

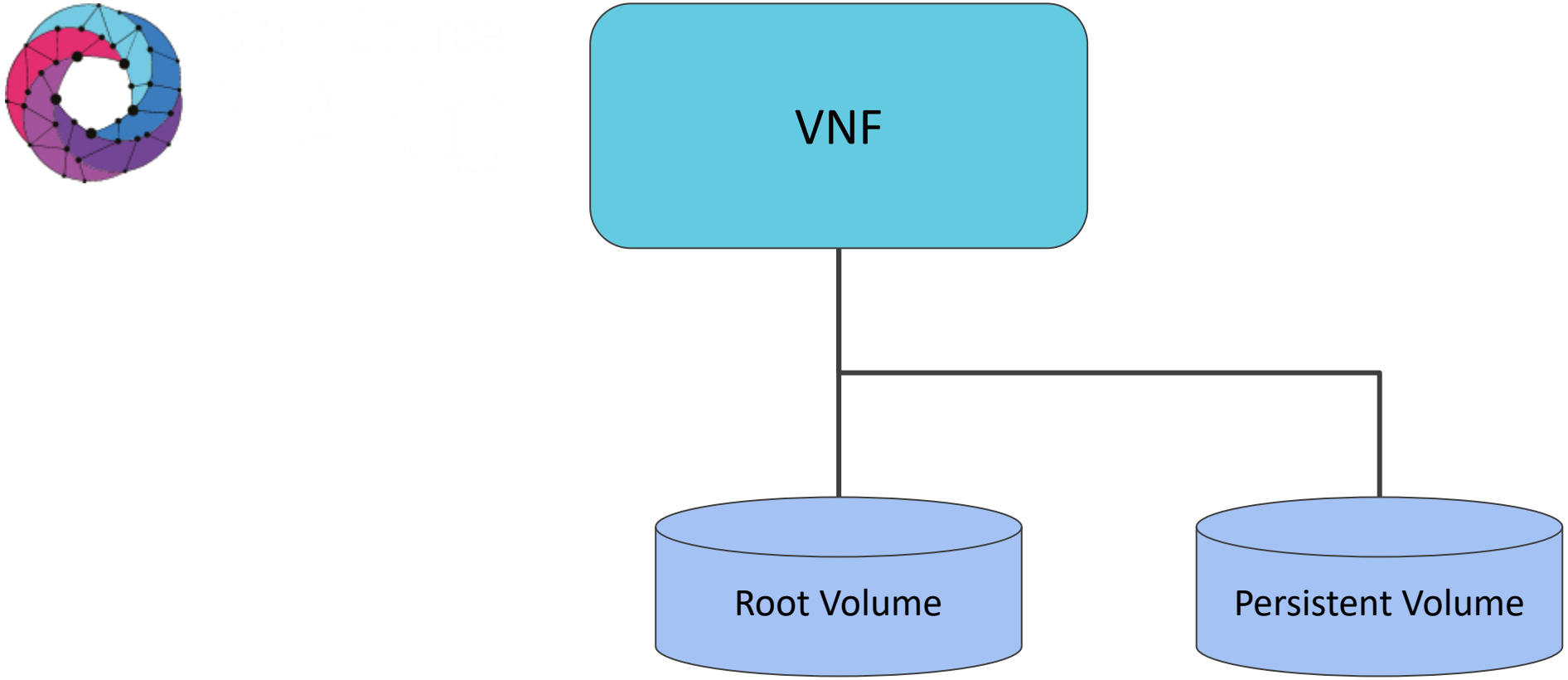
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Root volume is mounted under /
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ df -h /
Filesystem      Size  Used Avail Use% Mounted on
/dev/vda1       9.6G  1.4G  8.2G  15% /
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Ephemeral storage was mounted under /mnt
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ df -h /mnt
Filesystem      Size  Used Avail Use% Mounted on
/dev/vdb        2.0G  4.0K  2.0G   1% /mnt
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Let's write some data to emphemral storage
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ echo "This file is not persisted" | sudo tee /mnt/emphemral.txt
This file is not persisted
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ _
```

```
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Show the contents
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ ls -al /mnt
total 12
drwxr-xr-x  2 root root 4096 Jan  1  1970 .
drwxr-xr-x 19 root root 4096 Jan 21 06:24 ..
-rwxr-xr-x  1 root root   27 Jan 21 06:30 emphemral.txt
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ cat /mnt/emphemral.txt
This file is not persisted
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # The additional volume is present at /dev/vdc, but it is not formatted
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ sudo mkdir /data
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ sudo mount /dev/vdc /data
mount: /data: wrong fs type, bad option, bad superblock on /dev/vdc, missing codepage or helper program, or other error.
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Format the volume
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ sudo mkfs.ext4 /dev/vdc
mke2fs 1.45.5 (07-Jan-2020)
Discarding device blocks: done
Creating filesystem with 262144 4k blocks and 65536 inodes
Filesystem UUID: f68c1541-71dc-4258-8bb7-dfa41370adcd
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376

Allocating group tables: done
Writing inode tables: done
Creating journal (8192 blocks): sudo done
Writing superblocks and filesystem accounting information: modone

ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ sudo mount /dev/vdc /data
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Now let's write some data into the volume
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ echo "Hello from the OSM Thirteen Webinar" | sudo tee /data/hello.txt
Hello from the OSM Thirteen Webinar
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Show the contents
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ ls -al /data
total 28
drwxr-xr-x  3 root root  4096 Jan 21 06:31 .
drwxr-xr-x 20 root root  4096 Jan 21 06:30 ..
-rw-r--r--  1 root root    36 Jan 21 06:31 hello.txt
drwx------  2 root root 16384 Jan 21 06:31 lost+found
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ cat /data/hello.txt
Hello from the OSM Thirteen Webinar
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Logout
ubuntu@create-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ logout
Connection to 172.21.248.86 closed.
ubuntu@osm-webinar:~$ _
```

OSM Terminates Network Service



Deleting Network Service

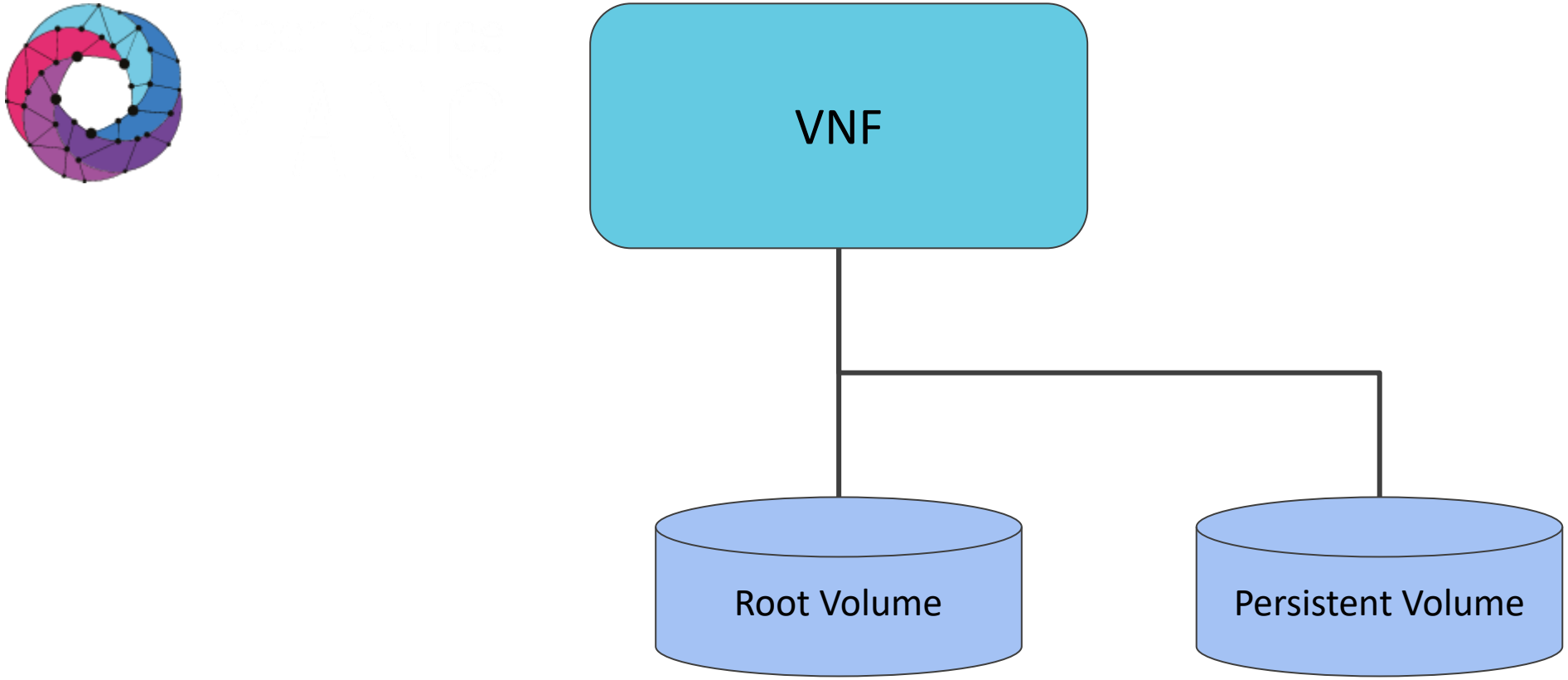
```
ubuntu@osm-webinar:~$ # Now we delete the Network Service
ubuntu@osm-webinar:~$ osm ns-delete create_data
_Deletion in progress
ubuntu@osm-webinar:~$ _
```

Examine Environment

```
ubuntu@osm-webinar:~$ # There are no servers left in Openstack
ubuntu@osm-webinar:~$ openstack server list

ubuntu@osm-webinar:~$ # And just the one volume that we asked OSM to persist
ubuntu@osm-webinar:~$ openstack volume list
+--------------------------------------+--------------------------------------------------------------+-----------+------+-------------+
| ID                                   | Name                                                         | Status    | Size | Attached to |
+--------------------------------------+--------------------------------------------------------------+-----------+------+-------------+
| dbcfd327-f5ba-4e9f-9897-cf0654598d80 | create_data-vnf-persistent-v-keep-persistent-vol-VM-0vdb | available |    1 |             |
+--------------------------------------+--------------------------------------------------------------+-----------+------+-------------+
ubuntu@osm-webinar:~$ _
```

OSM Creates NS With Existing Volume



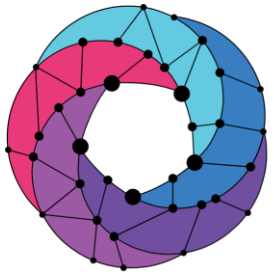
Launch New Network Service

```
ubuntu@osm-webinar:~$ # Get the volume ID from Openstack
ubuntu@osm-webinar:~$ openstack volume list
+--------------------------------------+-----------------------------------------------------------+-----------+------+-------------+
| ID                                   | Name                                                      | Status    | Size | Attached to |
+--------------------------------------+-----------------------------------------------------------+-----------+------+-------------+
| dbcfd327-f5ba-4e9f-9897-cf0654598d80 | create_data-vnf-persistent-v-keep-persistent-vol-VM-0vdb | available |    1 |             |
+--------------------------------------+-----------------------------------------------------------+-----------+------+-------------+
ubuntu@osm-webinar:~$ # Launch the Network Service, this time specifying the volume to use
ubuntu@osm-webinar:~$ osm ns-create --ns_name use_data \
>     --nsd_name persistent_volumes-ns \
>     --vim_account openstack \
>     --config '{
>         vld: [ {name: mgmtnet, vim-network-name: osm-ext} ],
>         vnf: [ {
>             member-vnf-index: vnf-persistent-volumes,
>             vdu: [ {
>                 id: keep-persistent-vol-VM,
>                 volume: [
>                     {"name": persistent-volume, vim-volume-id: dbcfd327-f5ba-4e9f-9897-cf0654598d80}
>                 ] } ] } ] }' \
>         --ssh_keys ~/.ssh/id_rsa.pub
9bed4433-2127-4f1c-acf0-59f791148d9b
ubuntu@osm-webinar:~$ _
```

Examine Volume Attached to VNF

```
ubuntu@osm-webinar:~$ # The new network service has been created
ubuntu@osm-webinar:~$ osm ns-list
+------------------+--------------------------------------+---------------------+----------+-------------------+---------------+
| ns instance name | id                                   | date                | ns state | current operation | error details |
+------------------+--------------------------------------+---------------------+----------+-------------------+---------------+
| use_data         | 9bed4433-2127-4f1c-acf0-59f791148d9b | 2023-01-21T06:38:33 | READY    | IDLE (None)       | N/A           |
+------------------+--------------------------------------+---------------------+----------+-------------------+---------------+
To get the history of all operations over a NS, run "osm ns-op-list NS_ID"
For more details on the current operation, run "osm ns-op-show OPERATION_ID"
ubuntu@osm-webinar:~$ # We can see the volume is attached once again
ubuntu@osm-webinar:~$ openstack volume list
+--------------------------------------+----------------------------------------------------------+--------+------+------------------------------------------------------------------------+
| ID                                   | Name                                                     | Status | Size | Attached to                                                            |
+--------------------------------------+----------------------------------------------------------+--------+------+------------------------------------------------------------------------+
| 7516501d-03fa-4f77-9ee1-e604ca5ab725 | use_data-vnf-persistent-v-keep-persistent-vol-VM-0vda    | in-use |   10 | Attached to use_data-vnf-persistent-v-keep-persistent-vol-VM-0 on /dev/vda |
| dbcfd327-f5ba-4e9f-9897-cf0654598d80 | create_data-vnf-persistent-v-keep-persistent-vol-VM-0vdb | in-use |    1 | Attached to use_data-vnf-persistent-v-keep-persistent-vol-VM-0 on /dev/vdc |
+--------------------------------------+----------------------------------------------------------+--------+------+------------------------------------------------------------------------+
ubuntu@osm-webinar:~$ # Let's get the IP address of the VNF with the attached storage
ubuntu@osm-webinar:~$ osm vnf-list
+--------------------------------------+------+--------------------------------------+-----------------------+-----------------------------+--------------------------------------+--------------+
| vnf id                               | name | ns id                                | vnf member index      | vnfd name                   | vim account id                       | ip address   |
+--------------------------------------+------+--------------------------------------+-----------------------+-----------------------------+--------------------------------------+--------------+
| f12720e0-5bf8-4ff8-9bb1-3e56b4abf844 | -    | 9bed4433-2127-4f1c-acf0-59f791148d9b | vnf-persistent-volumes | keep_persistent-volumes-vnf | 2c092c27-1cf8-4ba5-9138-a579d90fee3b | 172.21.249.6 |
+--------------------------------------+------+--------------------------------------+-----------------------+-----------------------------+--------------------------------------+--------------+
ubuntu@osm-webinar:~$ # Log into that server and look around
ubuntu@osm-webinar:~$ ssh 172.21.249.6
The authenticity of host '172.21.249.6 (172.21.249.6)' can't be established.
ECDSA key fingerprint is SHA256:lv/tphPqgI5fQudRS13zO5vpE1DIBzIzzS3Gh3aOIKQ.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
```

```
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Root volume is mounted under /
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ df -h /
Filesystem      Size  Used Avail Use% Mounted on
/dev/vda1       9.6G  1.4G  8.2G  15% /
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Ephemeral storage was mounted under /mnt
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ df -h /mnt
Filesystem      Size  Used Avail Use% Mounted on
/dev/vdb        2.0G  4.0K  2.0G   1% /mnt
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Remember our data we wrote to emphemral?  It's gone
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ ls -al /mnt
total 8
drwxr-xr-x  2 root root 4096 Jan  1  1970 .
drwxr-xr-x 19 root root 4096 Jan 21 06:39 ..
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Let's mount our persisted volume
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ sudo mkdir /data
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ sudo mount /dev/vdc /data
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ ls -al /data
total 28
drwxr-xr-x  3 root root  4096 Jan 21 06:31 .
drwxr-xr-x 20 root root  4096 Jan 21 06:42 ..
-rw-r--r--  1 root root    36 Jan 21 06:31 hello.txt
drwx------  2 root root 16384 Jan 21 06:31 lost+found
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Our data is there
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ cat /data/hello.txt
Hello from the OSM Thirteen Webinar
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ # Logout and cleanup
ubuntu@use-data-vnf-persistent-v-keep-persistent-vol-vm-0:~$ exit
logout
Connection to 172.21.249.6 closed.
```



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MANO
by ETSI

Thank You!

osm.etsi.org
osm.etsi.org/docs/user-guide
osm.etsi.org/wikipub