SUSE

SUSE Best Practices

SAP

# SAP Data Hub 2 on SUSE CaaS Platform 3

## Installation Guide

SUSE CaaS Platform 3
SUSE Linux Enterprise Server for SAP Applications 12 SP5 and 15 SP1
SAP Data Hub 2

Dr. Ulrich Schairer, SAP Solutions Architect (SUSE)
Christophe Le Dorze, ISV Solution Architect (SUSE)

SUSE

# SAP Data Hub 2 on SUSE CaaS Platform 3

Installation Guide

**Date**: 2024-12-12

SAP Data Hub 2 is a toolset to govern big amounts of data. SUSE CaaS Platform 3 is the Kubernetes base that makes deploying SAP Data Hub 2 easy. This document describes the installation and configuration of SUSE CaaS Platform 3 and SAP Data Hub 2.

# Contents

Today, more and more data is created in business and industry. Alongside data growth, there is an increasing necessity to manage and exploit this data. SAP Data Hub 2 is a tool that makes dealing with large amounts of data easier. SUSE Container as a Service Platform 3 (SUSE CaaS Platform 3) is the perfect foundation for SAP Data Hub 2.

# 1 Requirements

To install SAP Data Hub 2 on SUSE CaaS Platform 3, make sure to satisfy the following hardware and software requirements.

## 1.1 Hardware

### 1.1.1 SUSE CaaS Platform 3 Cluster

Hardware requirements (see SAP Data Hub Install Guide (https://help.sap.com/viewer/product/SAP_DATA_HUB/) ) See SAP's sizing recommendations:

- SAP Data Hub 2.3 (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.3.latest/en-US/79724de552db4b2b81c4a893f2c7ed18.html)
- SAP Data Hub 2.4 (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.4.latest/en-US/7e2a9bf62ec94e9694648e2b5d2ce882.html)
- SAP Data Hub 2.5 (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.5.latest/en-US)
- SAP Data Hub 2.6 (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.6.latest/en-US)

The minimum hardware requirements for installing SAP Data Hub 2 on premise are:

- 4 Kubernetes cluster nodes (1 master node and 3 worker nodes)

    - The master node should be a 4 core machine with > 32 GiB RAM
    - The three Kubernetes worker nodes should be a machine with 4 cores and with > 64 GiB RAM

- Access to a SUSE Enterprise Storage 5 system (see SAP Note Pre-requisites for installing SAP Data Hub (https://launchpad.support.sap.com/#/notes/2686169))

### 1.1.2 Management Host ("Jump Host")

It is recommended to do the installation of SAP Data Hub Foundation from an external jump host and not from within the SUSE CaaS Platform Cluster.

The hardware and operating system specifications for the jump host can be for example as follows:

- SUSE Linux Enterprise Server 12 SP5 or SUSE Linux Enterprise Server 15 (or even openSUSE Leap 15.X)
- 2 Cores
- 8 GiB RAM
- Disk space: 50 GiB for `/`, including the space for the SAP Data Hub 2 software and at least 20 GiB for `/var/lib/docker` (necessary for the SAP Data Hub 2 installation)
- Network connectivity to the SUSE CaaS Platform cluster (1 GBit/s)

## 1.2 Software Requirements

The following software is needed

- SUSE CaaS Platform 3
- SAP Data Hub 2
- optional: SAP Maintenance Planner
- optional: SAP Host Agent
- optional: Hadoop/Spark (see Vora's Spark extensions)

# 2 Relevant Documentation:

- SUSE
  - SUSE CaaS Platform 3 (https://documentation.suse.com/suse-caasp/3/)
  - SUSE Enterprise Storage 5.5 (https://documentation.suse.com/ses/5.5/)
- SAP
  - SAP Data Hub (https://help.sap.com/viewer/product/SAP_DATA_HUB/2.6.latest/en-US)
  - SAP Data Hub 2.6 release note (https://launchpad.support.sap.com/#/notes/2764652)
  - Pre-requisites for installing SAP Data Hub (https://launchpad.support.sap.com/#/notes/2686169)
  - SAP Data Hub 2: Specific Configurations for Installation on SUSE CaaS Platform (https://launchpad.support.sap.com/#/notes/2776522)

# 3 Installing SUSE CaaS Platform 3

## 3.1 Downloading the Installation Media

All installation media can be found at https://download.suse.com.

## 3.2 Acquiring a Subscription for SUSE CaaS Platform 3

To receive maintenance updates for SUSE products, you need a valid subscription for the respective products. For more information about subscriptions for SUSE CaaS Platform, see https://www.suse.com/support/?id=SUSE_CaaS_Platform.

## 3.3 Read the Deployment Guide for SUSE CaaS Platform 3

SUSE CaaS Platform is designed to make the installation of Kubernetes easy. For more information on this topic, see the SUSE CaaS Platform 3 *Deployment Guide* from https://documentation.suse.com. For further reference, a *Quick Start Guide* and an *Administrator's Guide* are available as well.

## 3.4 Installing SUSE CaaS Platform 3

This document describes the installation of SUSE CaaS Platform 3 from ISO images. Make sure that the host names you will use for the installation are resolvable via DNS. A static network setup is preferred.

Have the FQDN or IP address of your time server available. A reliable system time is required. Connect the media to your hardware and boot from the media.

From the GRUB menu, choose *Installation*.

### 3.4.1 Installing the Administration Node

1. After initializing the hardware, the YaST installer opens the network configuration dialog:

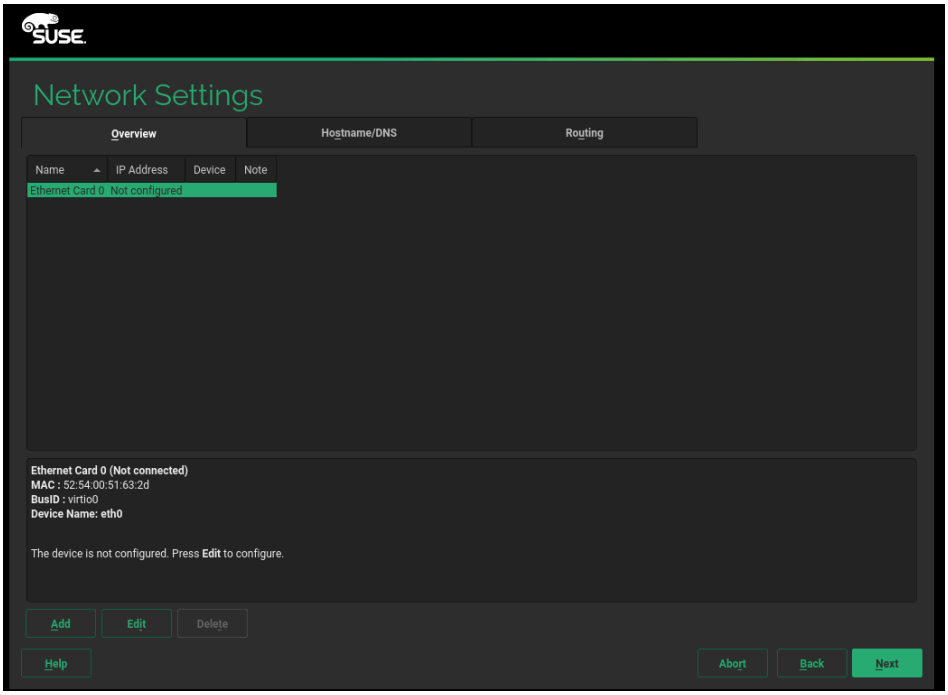


FIGURE 1: NETWORK CONFIGURATION ADMINISTRATION NODE

2. On the installation overview screen:

   - Select the keyboard layout and language according to your needs.
   - Specify your subscription credentials or the URL of your SMT/RMT server to register your installation.
   - Set the password for the root account.
   - Assign the role *Administration Node*.

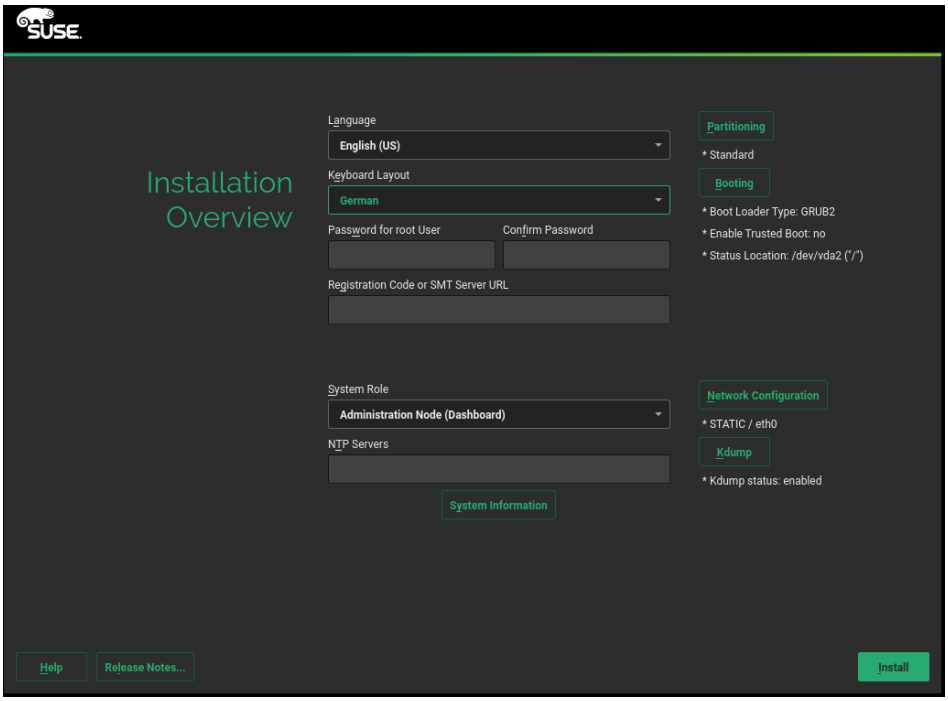


FIGURE 2: INSTALLATION OVERVIEW ADMINISTRATION NODE

### 3.4.2 Installing the Remaining Cluster Nodes

1. Boot the machine from the ISO image and select *Installation* from the GRUB boot menu.
2. The installer starts and the network configuration dialog is shown.

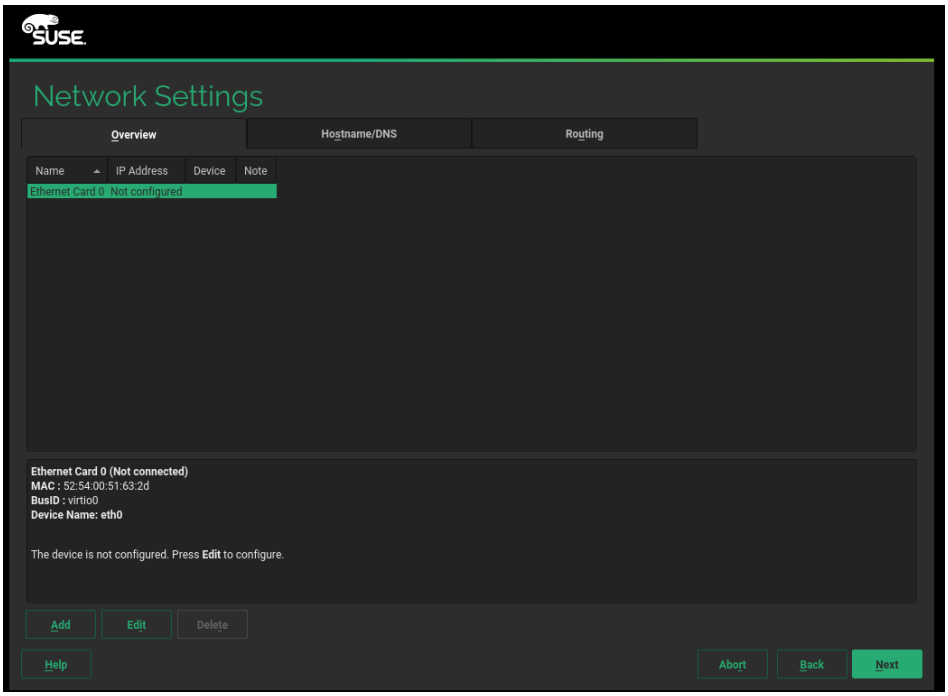


FIGURE 3: NETWORK CONFIGURATION CLUSTER NODES

3. Configure the network according to your needs.

4. On the installation overview screen:

   - Select the keyboard layout and language according to your needs.
   - Specify your subscription credentials or the URL of your SMT/RMT server to register your installation.
   - Set the password for the root account.
   - Assign the role *Cluster Node*.

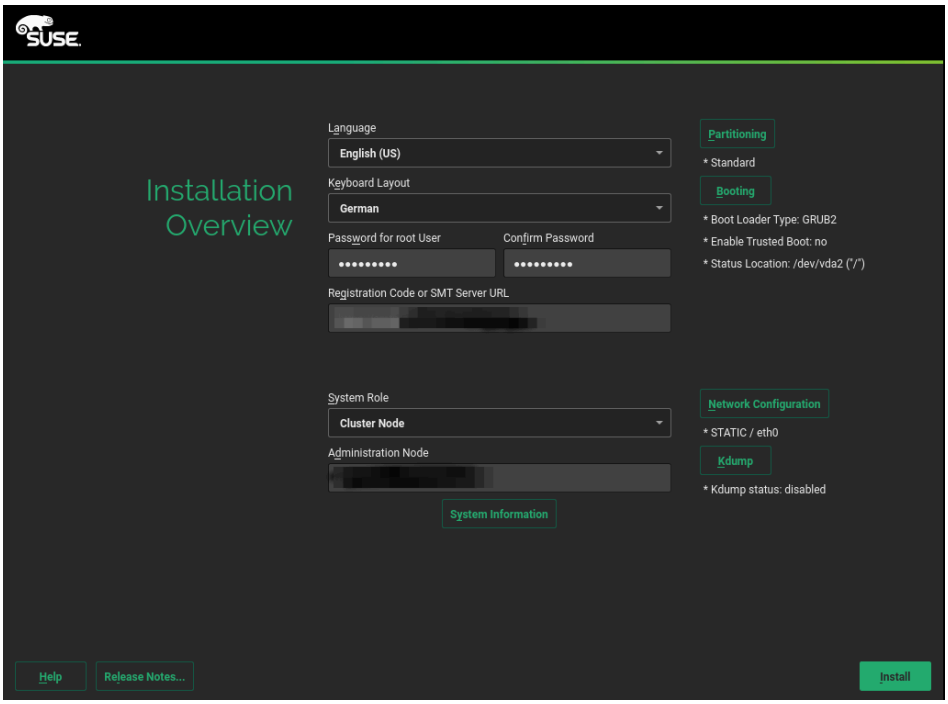


FIGURE 4: INSTALLATION OVERVIEW CLUSTER NODE

### 3.4.3 Bootstrapping the Kubernetes Cluster

1. After the installation of the administration node, open your browser and visit https://name.domain.tld.

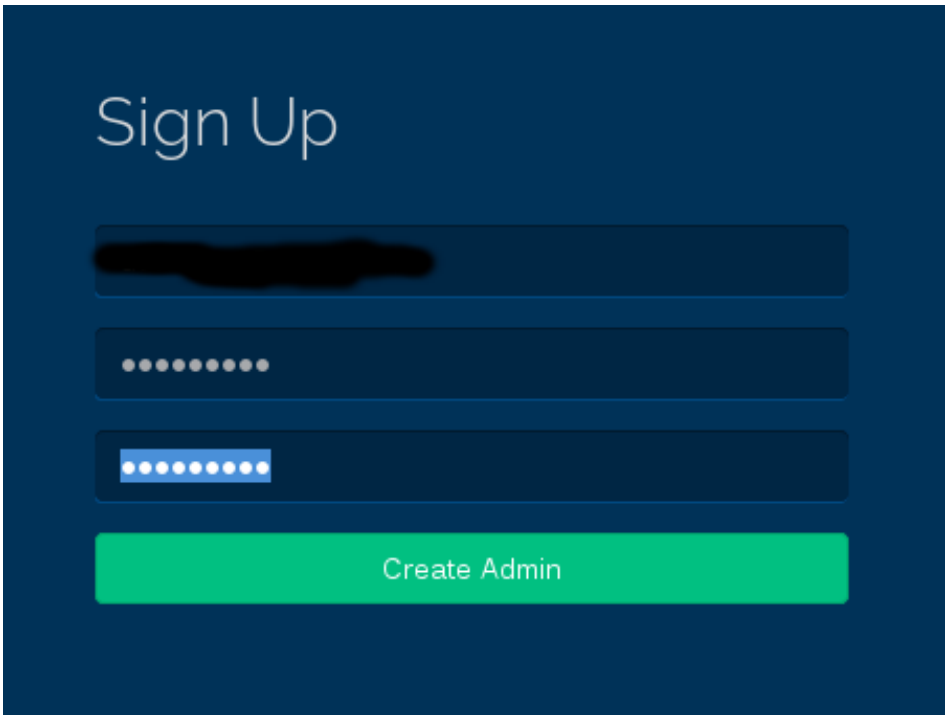


FIGURE 5: VELUM

2. Create the admin account and set the admin user name and password. Log in with the newly created admin credentials.

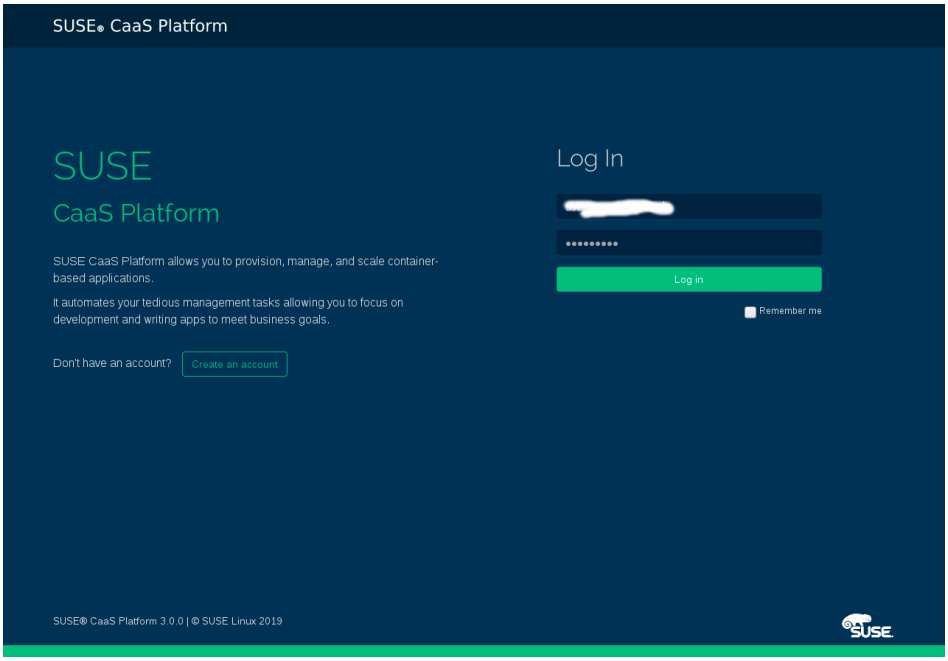


FIGURE 6: VELUM LOGIN

3. Configure SUSE CaaS Platform 3.

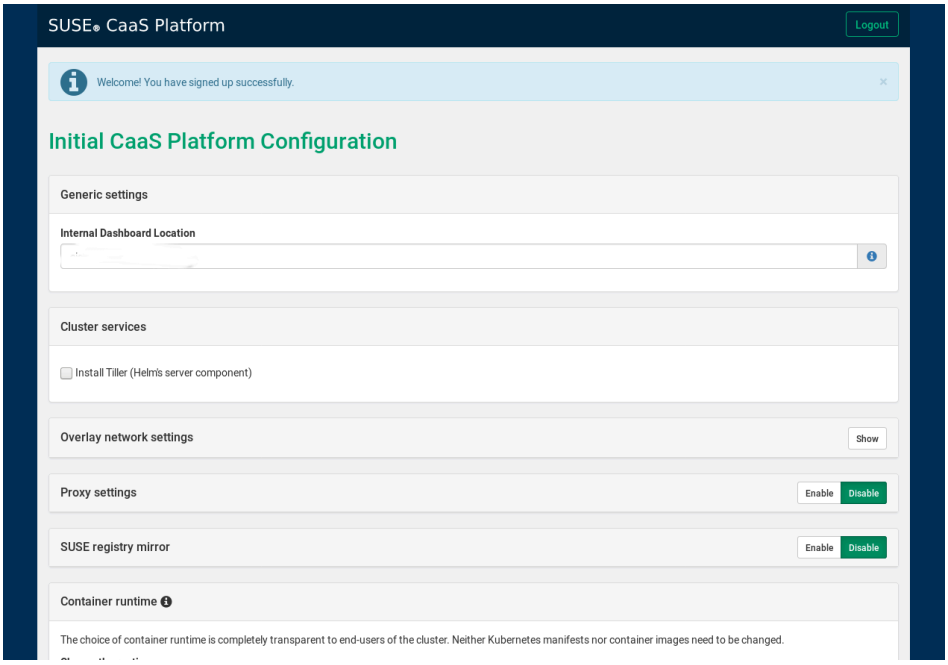


FIGURE 7: VELUM CLUSTER CONFIGURATION

4. Select the nodes to be included in the cluster.

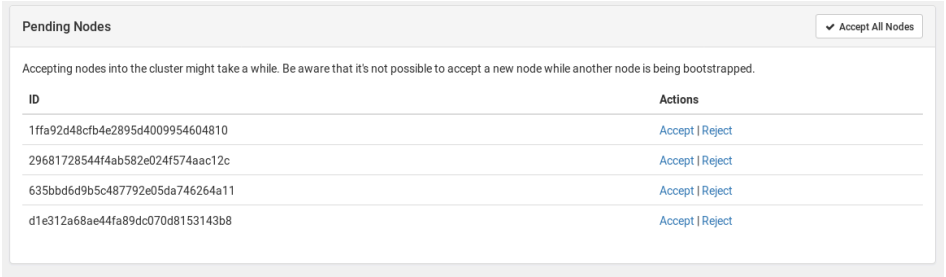


FIGURE 8: SELECT NODES AND ROLES 1

5. Assign roles (master/worker) according to your needs.

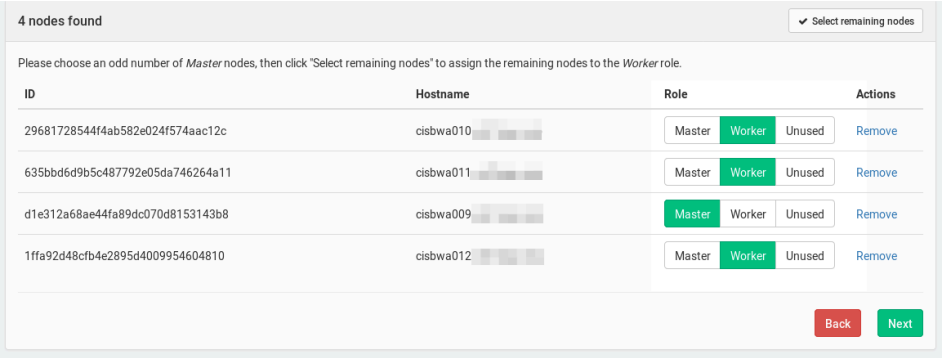


FIGURE 9: SELECT NODES AND ROLES 2

6. Bootstrap the Kubernetes cluster.

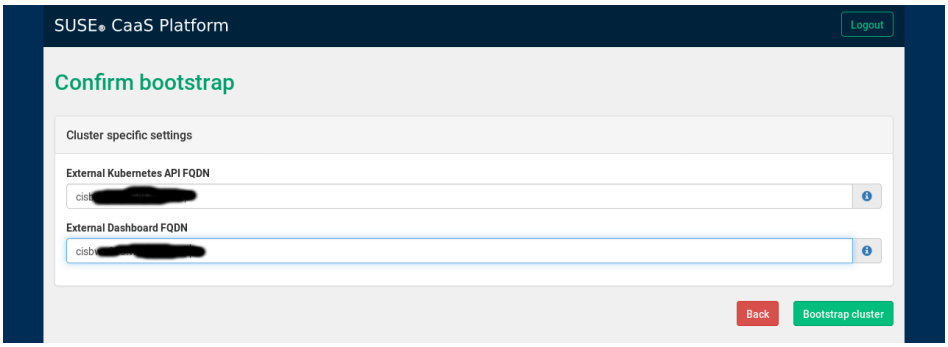


FIGURE 10: CONFIRM BOOTSTRAP

7. After a successful bootstrap, the screen below is shown.

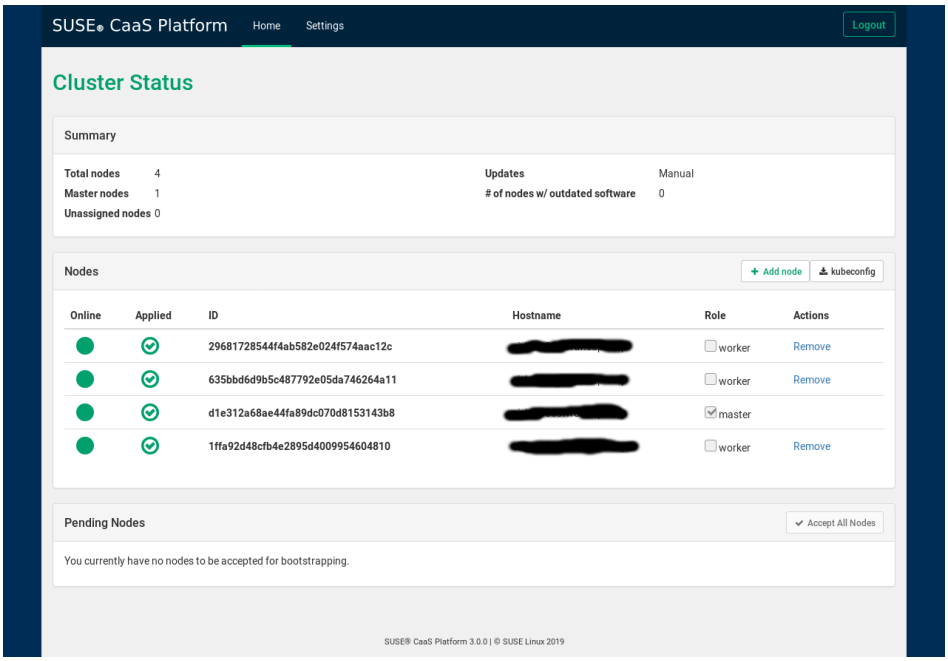


FIGURE 11: CLUSTER STATUS NODES

### 3.4.4 Installing the Jump Host

For further configuration and deployments on SUSE CaaS Platform it is highly recommended to install a jump host, also called a *management host*. This section describes installing the necessary tools to be able to deploy SAP Data Hub 2 on SUSE CaaS Platform.

1. Install SUSE Linux Enterprise Server 12 SP4+ or SUSE Linux Enterprise Server 15 as the operating system on the jump host.

2. Register your installation against the SUSE Customer Center (SCC) or your local SMT (Subscription Management Tool) or RMT (Repository Mirroring Tool).

3. Register the Container Module included in the SUSE Linux Enterprise Server subscription:

```
# SUSEConnect -p x86_64/SLE-Container-Module
```

4. Install Docker from the Container Module:

```
# zypper in docker
```

5. Download **kubectl** matching the Kubernetes version of your SUSE CaaS Platform installation. Download **kubectl 1.10.11** or higher.

```
$ curl -LO https://storage.googleapis.com/kubernetes-release/release/v1.10.11/bin/
linux/amd64/kubectl
$ sudo mv kubectl /usr/bin/kubectl
$ sudo chmod a+x /usr/bin/kubectl
```

6. Download the `kubeconfig` file from the Velum Dashboard. Click the button *kubeconfig*, log in to CaaS Platform, and accept the file download.

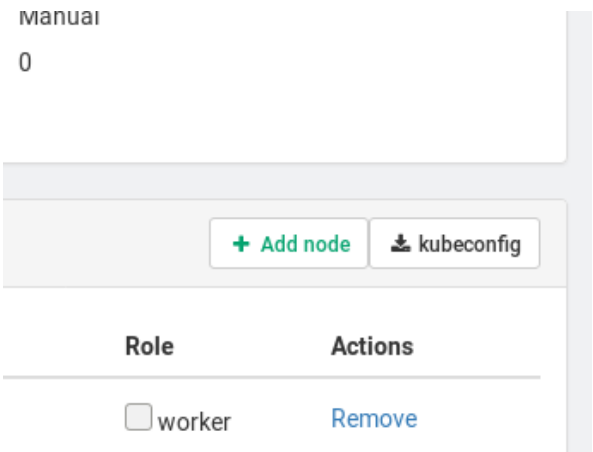


FIGURE 12: KUBECONFIG BUTTON

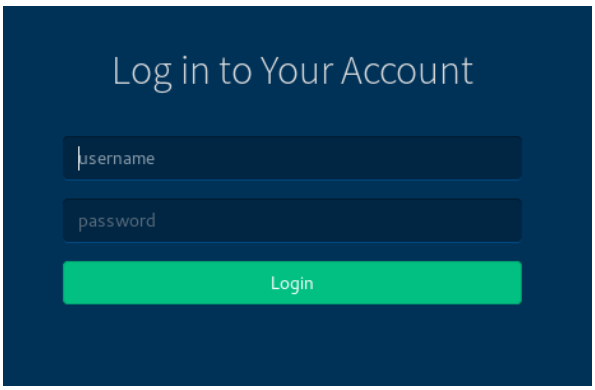


FIGURE 13: LOGGING IN TO CAAS PLATFORM

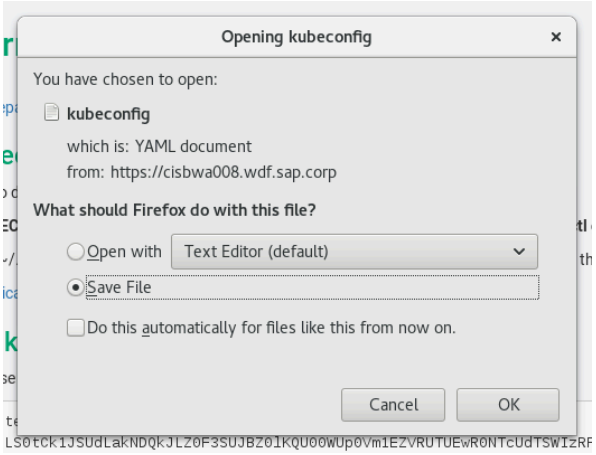


FIGURE 14: DOWNLOADING KUBECONFIG

7. Enable the downloaded `kubeconfig` by doing either of the following:

   - Configure the `KUBECONFIG` environment variable:

     ```
     $ export KUBECONFIG=<PATH/TO/YOUR/kubeconfig-file>/kubeconfig
     ```

   - Move it to default path:

     ```
     $ mv <PATH/TO/YOUR/kubeconfig-file>/kubeconfig ~/.kube/config
     ```

8. Connect to your Kubernetes cluster using **kubectl**:

```
$ kubectl get cluster-info

Kubernetes master is running at https://spwdfvml2054.example.com:6443
Dex is running at https://spwdfvml2054.example.com:6443/api/v1/namespaces/kube-
system/services/dex:dex/proxy
KubeDNS is running at https://spwdfvml2054.example.com:6443/api/v1/namespaces/kube-
system/services/kube-dns:dns/proxy
kubernetes-dashboard is running at https://spwdfvml2054.example.com:6443/api/v1/
namespaces/kube-system/services/https:kubernetes-dashboard:https/proxy
Tiller is running at https://spwdfvml2054.example.com:6443/api/v1/namespaces/kube-
system/services/tiller:tiller/proxy

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.
```

```
$ kubectl get nodes

NAME           STATUS   ROLES    AGE    VERSION
spwdfvml2054   Ready    master   301d   v1.10.11
```

```
spwdfvml2055   Ready    <none>   301d   v1.10.11
spwdfvml2056   Ready    <none>   301d   v1.10.11
spwdfvml2082   Ready    <none>   301d   v1.10.11
```

9. Download Helm from https://helm.sh. Install and configure the Helm client. The version should match the Tiller version deployed on your SUSE CaaS Platform installation.

```
$ curl https://raw.githubusercontent.com/helm/helm/master/scripts/get > get_helm.sh
$ chmod 700 get_helm.sh
$ ./get_helm.sh --version 2.8.2
$ mv helm ~/bin/helm
$ helm init --client-only
```

### 3.4.5 Deploying Optional Components in the SUSE CaaS Platform 3 Cluster

You can deploy some useful optional applications in your SUSE CaaS Platform 3 cluster:

- Heapster allows analyzing cluster performance
- The Kubernetes dashboard allows administrating and basic monitoring of the Kubernetes cluster

See also https://documentation.suse.com/suse-caasp/3/html/caasp-admin/.

1. Install Heapster:

```
$ helm install --name heapster-default --namespace=kube-system stable/heapster \
  --version=0.2.7 --set rbac.create=true
```

2. Install the Kubernetes dashboard:

```
$ helm install --namespace=kube-system \
  --name=kubernetes-dashboard stable/kubernetes-dashboard \
  --version=0.6.1
```

3. Start the Kubernetes API proxy:

```
$ kubectl proxy
```

4. Extract the **id-token** from the **kubeconfig** file:

```
$ grep id-token $KUBECONFIG | awk '{ print $2 }'
```

This token will allow you to log in in the next step.

5. In your browser, open `http://127.0.0.1:8001/api/v1/namespaces/kube-system/services/https:kubernetes-dashboard:/proxy/`.
   Use the ID you found in **kubeconfig** to log in to the Kubernetes dashboard.

# 4 Installing SAP Data Hub 2

The following sections describe the preparation and installation of SAP Data Hub 2 on the SUSE CaaS Platform 3 Cluster.

## 4.1 Preparing the SAP Data Hub 2 Installation

To install SAP Data Hub on SUSE CaaS Platform successfully, perform the actions detailed below.

### 4.1.1 Downloading the SAP Data Hub 2 Software Archive

1. Log in to SAP Launchpad Software Center at https://launchpad.support.sap.com/#/software-center, select *Installations and Downloads*, select alphabetical order, and choose the letter *D*. Scroll down in the list to the folder *SAP Data Hub*, open it and select the version to be installed.

2. Download the SAP Data Hub Foundation file, for example: `DHFOUNDATION03_3-80004015.ZIP` (SAP DATA HUB - FOUNDATION 2.3) or `DHFOUNDATION06_1-80004015.ZIP` (SAP DATA HUB - FOUNDATION 2.6)

3. Unzip the software archive onto your jump host.

There are two ways to install SAP Data Hub 2:

- Use the SL Plugin. There are two variants of doing so:
  - SL Plugin with Maintenance Planner (mpsl)
  - SL Plugin only (mpfree)
- Use the command line install.sh script.

This document will focus on the latter installation method.

### 4.1.2 Prerequisites on the SUSE CaaS Platform 3 Cluster

Where not stated otherwise, all of the following steps need to be performed on the jump host.

1. Create the namespace in the Kubernetes cluster to install SAP Data Hub 2:

```
$ kubectl create namespace datahub
```

2. On SUSE Enterprise Storage, create the storage class to provide volumes for SAP Data Hub 2.

3. Make sure you have the connection data for your SUSE Enterprise Storage at hand:

   - IP addresses and port number (defaults to 6789) of the monitor nodes of your SUSE Enterprise Storage
   - A data pool created (data hub in this example) on your SUSE Enterprise Storage for the use with SAP Data Hub 2

4. Edit the example below to fit your environment.

```
$ cat > storageClass.yaml <<EOF
apiVersion: storage.kubernetes.io/v1
kind: StorageClass
metadata:
  annotations:
    storageclass.kubernetes.io/is-default-class: "true"
  name: datahub
  namespace: default
parameters:
  adminId: admin
  adminSecretName: ceph-admin-secret
  adminSecretNamespace:  default
  imageFeatures: layering
  imageFormat: "2"
  monitors: <IP ADDRESS OF MONITOR 1>:6789, <IP ADDRESS OF MONITOR 2>:6789, <IP
 ADDRESS OF MONITOR 3 >:6789
  pool: datahub
  userId: admin
  userSecretName: ceph-user-secret
provisioner: kubernetes.io/rbd
reclaimPolicy: Delete
volumeBindingMode: Immediate
```

```
EOF

$ kubectl create -f storageClass.yaml
```

5. Create the secrets needed to access the storage.

   a. From SUSE Enterprise Storage, obtain the keys located in `ceph.admin.keyring` and `ceph.user.keyring`.

   b. Base64-encode the keys as follows:

   ```
   $ echo <YOUR KEY HERE> | base64
   ```

   c. Configure the encoded secrets:

   ```
   $ cat > ceph-admin-secret.yaml <<EOF
   apiVersion: v1
   kind: Secret
   metadata:
       name: ceph-admin-secret
   type: "kubernetes.io/rbd"
   data:
      key: <YOUR BASE64 ENCODED KEY HERE>
   EOF
   image::002-SCT-CaaSP.png
   $ cat > ceph-user-secret.yaml <<EOF
   apiVersion: v1
   kind: Secret
   metadata:
       name: ceph-user-secret
   type: "kubernetes.io/rbd"
   data:
      key: <YOUR BASE64 ENCODED KEY HERE>
   EOF

   $ kubectl create -f ceph-admin-secret.yaml
   $ kubectl create -f ceph-user-secret.yaml
   ```

## 4.2 Installation of SAP Data Hub 2 Using the Maintenance Planner with SL Plugin (mpsl Method)

The installation method via SL plugin is a Web-based installation method recommended by SAP, offering you an option to send analytics data and feedback to SAP. All necessary prerequisites are met by applying all the steps described above.

**Important**

You need to install the latest SAP Host Agent on the jump host. You can use the RPM package which can be downloaded from the SAP Software Download Center.

## 4.3 Installing SAP Data Hub 2 Using the SL Plugin (mpfree Method)

The Installation of SAP Data Hub 2 using the SL plugin is an alternative command-line-based installation method. Refer to the SAP Data Hub documentation (2.3)) / (2.4) / (2.5) / (2.6) for more information and the exact procedure.

## 4.4 Installing SAP Data Hub 2 from the Command Line (Manual Installation)

1. Unpack the SAP Data Hub 2.6 software archive on the jump host with the following command:

```
$ unzip DHFOUNDATION06_1-80004015.ZIP
```

2. Run the install command as described in SAP Data Hub 2 install guide at https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.6.latest/en-US.

```
$ cd SAP-Datahub-2.4.63-Foundation
$ export DOCKER_REGISTRY=<URI of your registry>
$ export NAMESPACE=datahub
$ ./install.sh
```

This interactive script configures the installation of SAP Data Hub. You should have the following information at a hand:

- Name and credentials of your SAP S-User
- Login credentials to your secure registry

## 4.5 Post-Installation Actions

After successful installation you can connect to the SAP Data Hub Web UI, identify the service IP and port of the SAP Data Hub UI:

```
$ kubectl get services
$ kubectl describe service
```

Point your browser to the IP and port you received from the commands above.

Use the login data you defined during the installation.

### 4.5.1 Post-Installation Work

Follow the documentation provided by SAP (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.6.latest/en-US/4c472c40595b450283a6ce039f71cfc6.html) to the post installation work.

- Create the **vflow-secret** for the modeler app as pointed out in the SAP documentation.
- Import necessary CAs, for example, the CA that signed the certificate of the secure registry.

# 5 Upgrading SAP Data Hub 2

To upgrade an existing SAP Data Hub 2 installation to a higher version (for example 2.3 to 2.4), follow the official instructions from SAP. You can choose between the following upgrade methods:

- Maintenance Planner: Upgrade SAP Data Hub 2 using the Maintenance Planner / SL Plugin and SAP Host Agent (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.6.latest/en-US/31079833a65f4f379d5a76957ff8073c.html)
- SL Plugin method: Upgrade SAP Data Hub 2 using the SL Plugin and SAP Host Agent (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.6.latest/en-US/ff37f3ccf6504bb38d7db53936fe8017.html)
- Command line method: Upgrade SAP Data Hub 2 using the install.sh script (https://help.sap.com/viewer/e66c399612e84a83a8abe97c0eeb443a/2.6.latest/en-US/aec679bc0209443ba4ae03a9018d4bd8.html)

# 6 Appendix

## 6.1 Installing a Secure Private Docker Registry

To meet the Data Hub requirements you also need a Docker Registry. The Portus project provides an easy way to build and manage an own Docker Registry. For more information, see the project homepage at http://port.us.org/.

To set up Portus in a dedicated virtual machine, do:

1. Create a suitable a virtual machine:

```
# sudo virt-install --name portus-dr --ram 8192 \
  --disk path=/var/lib/libvirt/VMS/portus-dr.qcow2,size=40 --vcpus 4 \
  --os-type linux --os-variant generic --network bridge=common --graphics none \
  --console pty,target_type=serial \
  --location '/var/lib/libvirt/isos/SLE-12-SP4-Server-DVD-x86_64-GM-DVD1.iso' \
  --extra-args 'console=ttyS0,115200n8 serial
 ifcfg=eth0=10.10.10.11/24,10.10.10.1,10.10.10.11,suse-sap.net hostname=portus-dr
 domain=suse-sap.net Textmode=1'
```

2. In this example, the Portus server will be connected to a local bridge providing common services (DNS, SMT, and Docker Registry) for the SAP Data Hub 2 stack. Our Portus deployment is container-based and orchestrated locally with `docker-compose`. Portus `docker-compose` deployment requires an up-to-date release of `docker-compose`. To install `docker-compose`, use:

```
# sudo curl -L "https://github.com/docker/compose/releases/download/1.24.1/docker-
compose-$(uname -s)-$(uname -m)" -o /usr/local/bin/docker-compose
# sudo chmod +x /usr/local/bin/docker-compose
# sudo ln -s /usr/local/bin/docker-compose /usr/bin/docker-compose
```

3. Clone the Portus Git repository:

```
# git clone https://github.com/SUSE/Portus.git /tmp/Portus-DR
# mv /tmp/Portus-DR/examples/compose ./portus
# cd portus
```

4. Adapt the configuration in the `.env`. As an example, a valid configuration may look like this:

```
# cat .env
```

```
MACHINE_FQDN=portus-dr.suse-sap.net
SECRET_KEY_BASE=b494a25faa8d22e430e843e220e424e10ac84d2ce0e64231f5b636d21251
eb6d267adb042ad5884cbff0f3891bcf911bdf8abb3ce719849ccda9a4889249e5c2
PORTUS_PASSWORD=XXXXXXXX
DATABASE_PASSWORD=YYYYYYYY
```

5. In the `nginx/nginx.conf` file, adapt the following section:

```
server {
    listen 443 ssl http2;
    server_name portus-dr.suse-sap.net;
    root /srv/Portus/public;
```

6. Download the latest `docker-compose.yml` for Portus:

```
# rm docker-compose.*
# wget https://gist.githubusercontent.com/Patazerty/
d05652294d5874eddf192c9b633751ee/raw/6bf4ac6ba14192a1fe5c337494ab213200dd076e/
docker-compose.yml
```

7. To secure your Docker Registry configuration, add TLS to your setup:

```
# echo "subjectAltName = DNS:portus-dr.suse-sap.net" > extfile.cnf

# openssl genrsa -out secrets/rootca.key 2048

# openssl req -x509 -new -nodes -key secrets/rootca.key -subj "/C=FR/ST=FR/O=SUSE" \
  -sha256 -days 1024 -out secrets/rootca.crt

# openssl genrsa -out secrets/portus.key 2048

# openssl req -new -key secrets/portus.key -out secrets/portus.csr \
  -subj "/C=FR/ST=FR/O=SUSE/CN

# openssl req -new -key secrets/portus.key -out secrets/portus.csr \
  -subj "/C=FR/ST=FR/O=SUSE/CN=portus-dr.suse-sap.net"

# openssl x509 -req -in secrets/portus.csr -CA secrets/rootca.crt \
  -extfile extfile.cnf -CAkey secrets/rootca.key -CAcreateserial \
  -out secrets/portus.crt -days 500 -sha256
```

8. Make the servers aware of the new certificate:

```
# cp -p secrets/rootca.crt /etc/pki/trust/anchors/.net-ca.crt
# scp secrets/rootca.crt root@jumpbox.suse-sap.net:/etc/pki/trust/anchors/portus-
dr.suse-sap.net-ca.crt
```

9. Update the certificate on all servers that will need to interact with the Docker registry:

```
# sudo update-ca-certificates
# sudo systemctl restart docker
```

10. Start your Portus setup with the following command:

```
# docker-compose up -d
```

11. Log in to Portus and set up the registry as shown below:

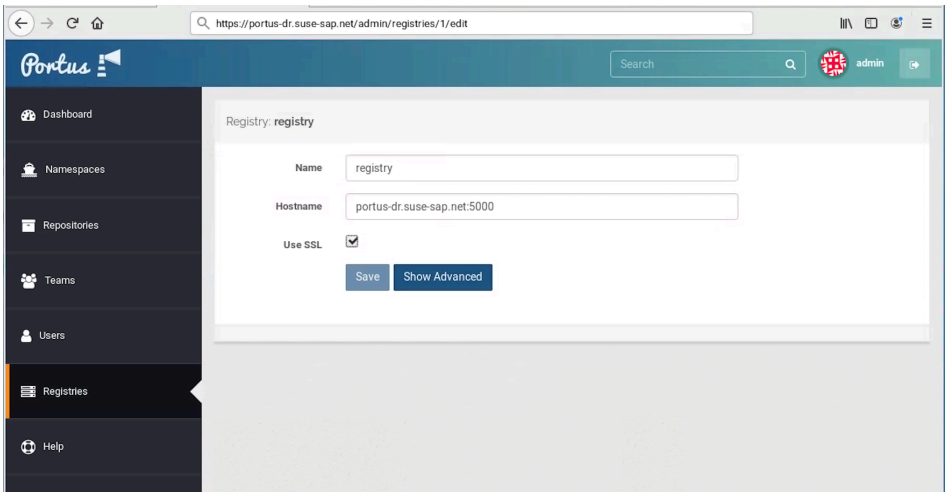


FIGURE 15: PORTUS REGISTRY

12. To install and configure a secure private registry using SUSE Linux Enterprise Server with the Container Module, the necessary components are Docker, Docker Registry, and Portus. Create SSL certificates as needed. Distribute the CA certificate to all your Kubernetes nodes. Run the command:

```
# update-ca-certificates
# systemctl restart docker
```

13. Create the namespaces on your registry that are needed for SAP Data Hub 2:

    - com.sap.hana.container
    - com.sap.datahub.linuxx86_64
    - com.sap.datahub.linuxx86_64.gcc6
    - consul
    - elasticsearch

- fabric8
- google_containers
- grafana
- kibana
- prom
- vora
- kaniko-project
- com.sap.bds.docker

## 6.2 SUSE Enterprise Storage

An SAP Data Hub 2 installation on premise requires SUSE Enterprise Storage 5 or higher. If you plan to use SUSE Enterprise Storage not only for your Kubernetes dynamic storage class but also for your Kubernetes Control plan, virtualized or not, reserve enough resources to address `etcd` requirements regarding etcd Hardware (https://github.com/etcd-io/etcd/blob/master/Documentation/op-guide/hardware.md).

The following steps show a minimalist, virtualized, test-oriented deployment of SUSE Enterprise Storage 5.5.

In the following example, we are going to build a 4 nodes (1 admin + 3 OSD) Ceph Cluster.

Before you start, be sure to:

- Collect your SUSE Linux Enterprise Server 12 SP3 and SUSE Enterprise Storage 5 registration code from https://scc.suse.com. Alternatively, have an SMT/RMT properly set up and already mirroring these products.
  - SCC (https://scc.suse.com)
  - SMT (https://documentation.suse.com/sles-12/html/SLES-all/book-smt.html)

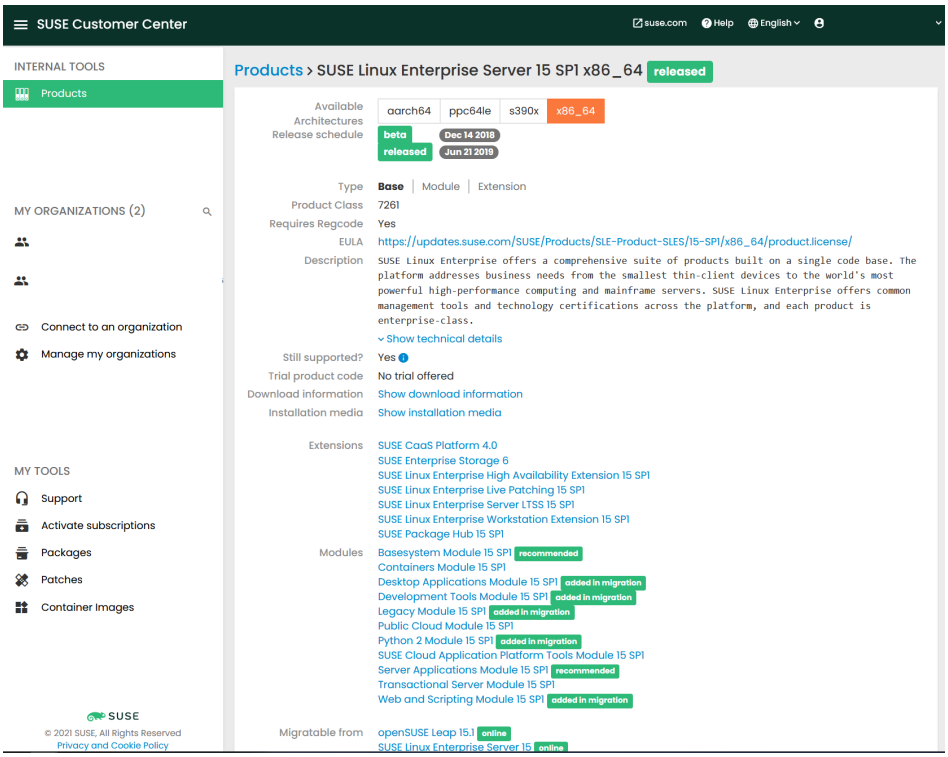


FIGURE 16: SUSE CUSTOMER CENTER PRODUCTS

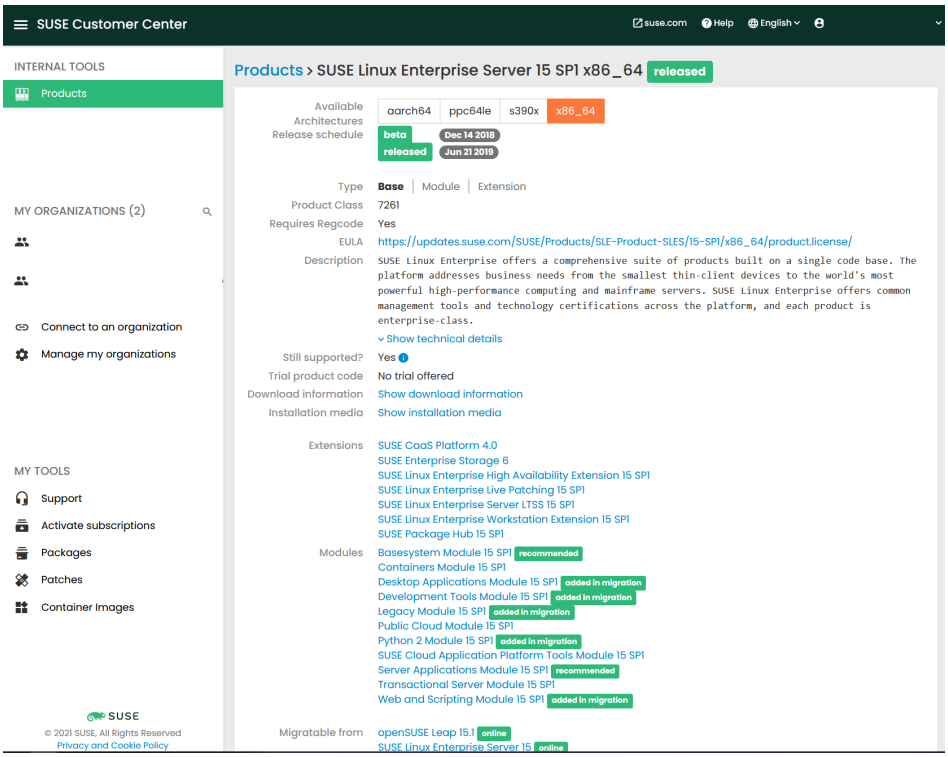


FIGURE 17: SUSE CUSTOMER CENTER REGISTRATION CODE

- Your DNS zone should already be set. In our example, where all Data Hub components are in the same DNS zone and subnet, it should look similar to the following:

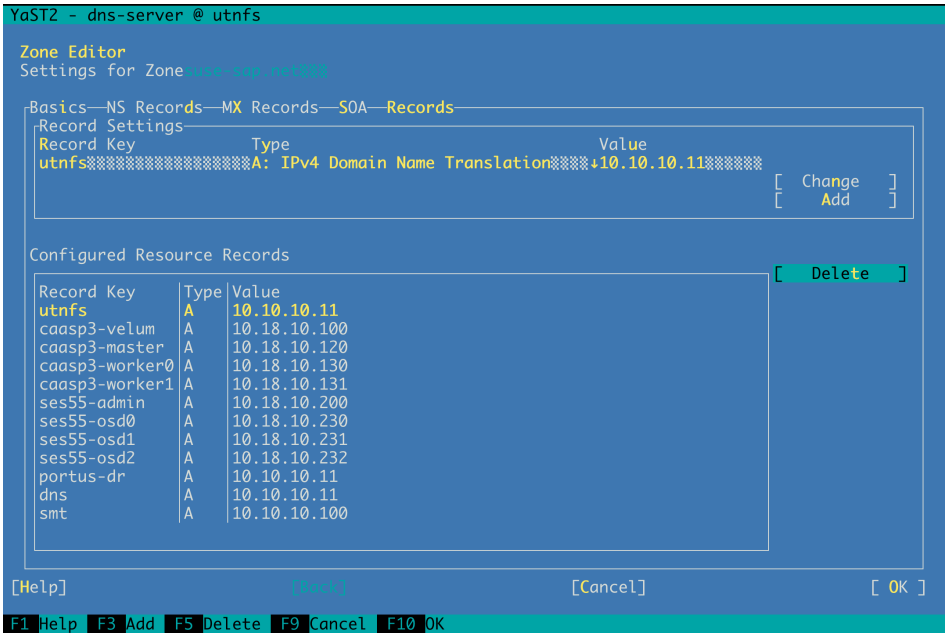


FIGURE 18: DNS SERVER

- Also, to be as efficient as possible when using an interactive shell-scripted infrastructure deployment, we recommend using an advanced terminal client or multiplexer which allows addressing multiple shells at once.

FIGURE 19: ADVANCED TERMINAL CLIENT - MULTI-SHELL

1. Create virtual machines:

```
# sudo virt-install --name ses55-admin --ram 16384 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-admin.qcow2,size=40 --disk bus=virtio,path=/var/
lib/libvirt/VMS/ses55-admin-osd0.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-admin-osd1.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-admin-osd2.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-admin-osd3.qcow2,size=20 --vcpus 4 --
os-type linux --os-variant generic --network bridge=caasp3 --
graphics none --console pty,target_type=serial --location '/var/lib/
libvirt/ISOS/SLE-12-SP3-Server-DVD-x86_64-GM-DVD1.iso' --extra-args
 'console=ttyS0,115200n8 serial autoyast-ses5=http://10.10.10.101/autoyast-ses5
 ifcfg=eth0=10.18.10.200/24,10.18.10.1,10.10.10.11,suse-sap.net domain=suse-
sap.net Textmode=1'

# sudo virt-install --name ses55-osd0 --ram 16384 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd0.qcow2,size=40 --disk bus=virtio,path=/var/
lib/libvirt/VMS/ses55-osd0-osd0.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd0-osd1.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd0-osd2.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd0-osd3.qcow2,size=20 --vcpus 4 --os-
type linux --os-variant generic --network bridge=caasp3 --graphics
 none --console pty,target_type=serial --location '/var/lib/
libvirt/ISOS/SLE-12-SP3-Server-DVD-x86_64-GM-DVD1.iso' --extra-args
 'console=ttyS0,115200n8 serial autoyast-ses5=http://10.10.10.101/autoyast-ses5
 ifcfg=eth0=10.18.10.230/24,10.18.10.1,10.10.10.11,suse-sap.net domain=suse-
sap.net Textmode=1'

# sudo virt-install --name ses55-osd1 --ram 16384 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd1.qcow2,size=40 --disk bus=virtio,path=/var/
lib/libvirt/VMS/ses55-osd1-osd0.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd1-osd1.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd1-osd2.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd1-osd3.qcow2,size=20 --vcpus 4 --os-
type linux --os-variant generic --network bridge=caasp3 --graphics
 none --console pty,target_type=serial --location '/var/lib/
libvirt/ISOS/SLE-12-SP3-Server-DVD-x86_64-GM-DVD1.iso' --extra-args
 'console=ttyS0,115200n8 serial autoyast-ses5=http://10.10.10.101/autoyast-ses5
 ifcfg=eth0=10.18.10.231/24,10.18.10.1,10.10.10.11,suse-sap.net domain=suse-
sap.net Textmode=1'

# sudo virt-install --name ses55-osd2 --ram 16384 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd2.qcow2,size=40 --disk bus=virtio,path=/var/
lib/libvirt/VMS/ses55-osd2-osd0.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd2-osd1.qcow2,size=20 --disk bus=virtio,path=/
var/lib/libvirt/VMS/ses55-osd2-osd2.qcow2,size=20 --disk bus=virtio,path=/
```

```
var/lib/libvirt/VMS/ses55-osd2-osd3.qcow2,size=20 --vcpus 4 --os-
type linux --os-variant generic --network bridge=caasp3 --graphics
 none --console pty,target_type=serial --location '/var/lib/
libvirt/ISOS/SLE-12-SP3-Server-DVD-x86_64-GM-DVD1.iso' --extra-args
 'console=ttyS0,115200n8 serial autoyast-ses5=http://10.10.10.101/autoyast-ses5
 ifcfg=eth0=10.18.10.232/24,10.18.10.1,10.10.10.11,suse-sap.net domain=suse-
sap.net Textmode=1'
```

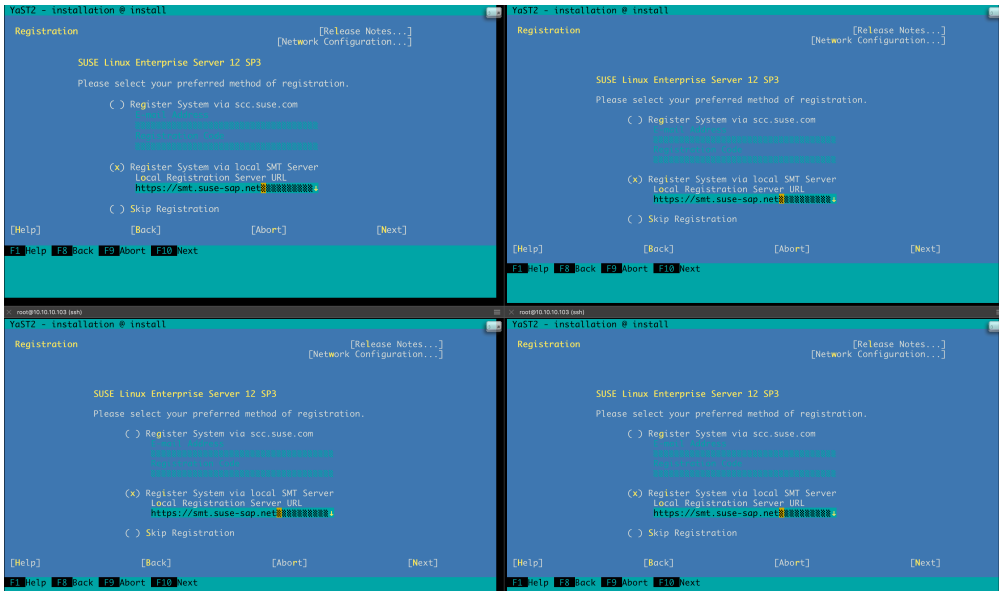


FIGURE 20: MULTI SHELL SMT

2. Select the SUSE Enterprise Storage 5 Extension.

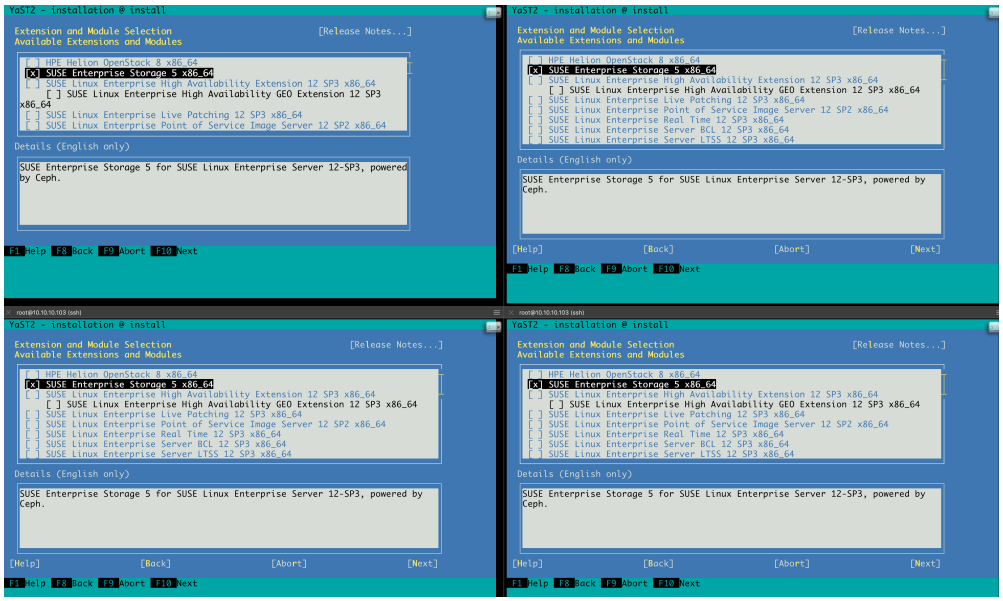


FIGURE 21: MULTI SHELL EXTENSIONS AND MODULES

3. On the hypervisor, you should also be able to route or bridge (either a traditional bridge using `brctl` or a virtual bridge) your upcoming SUSE Enterprise Storage 5.5 network segment. In our example, for simplicity, we are using the same bridge and network address as the SUSE CaaS Platform cluster, `--network bridge=caasp3`.

4. In the following example, each node is powered by 16 GB of RAM, 4 VCPU, 40 GB for the root disk, 4 * 20GB OSDB disk.

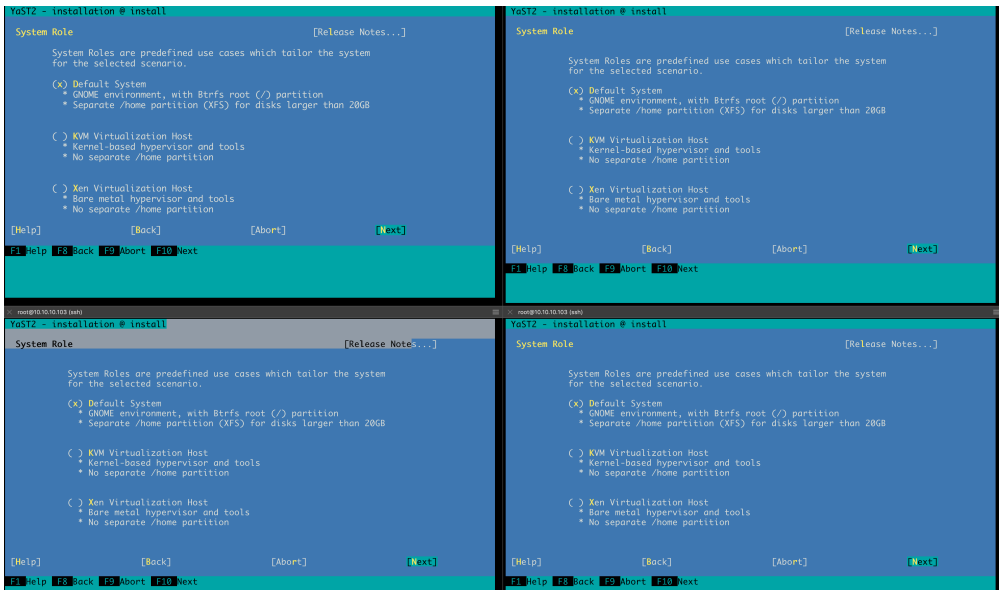


FIGURE 22: MULTI-SHELL DEFAULT SYSTEM

5. NTP must be configured on each node.

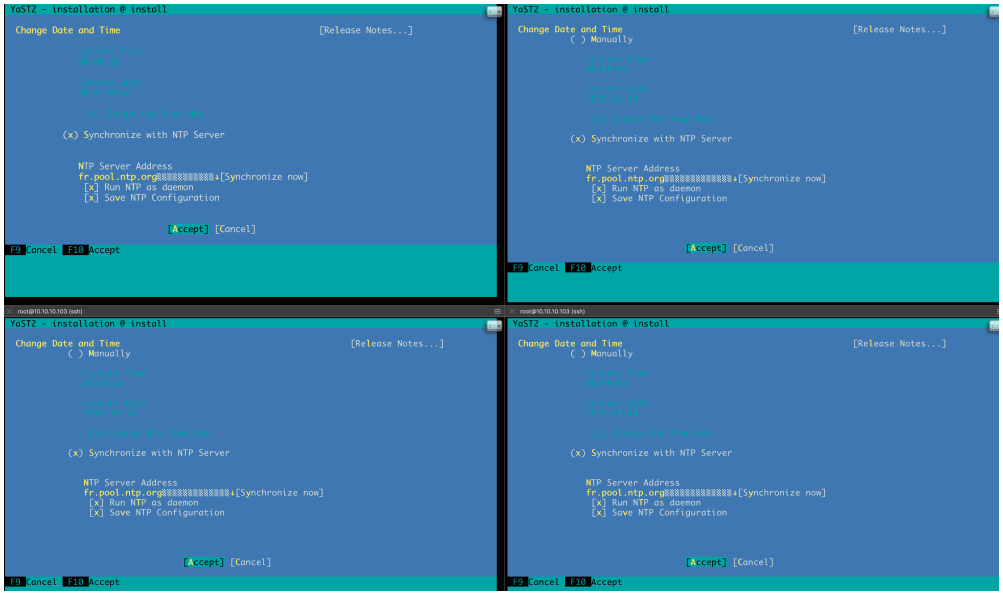


FIGURE 23: MULTI-SHELL NTP SERVER

6. Deselect AppArmor and unnecessary X and GNOME Patterns, but select the SUSE Enterprise Storage pattern.

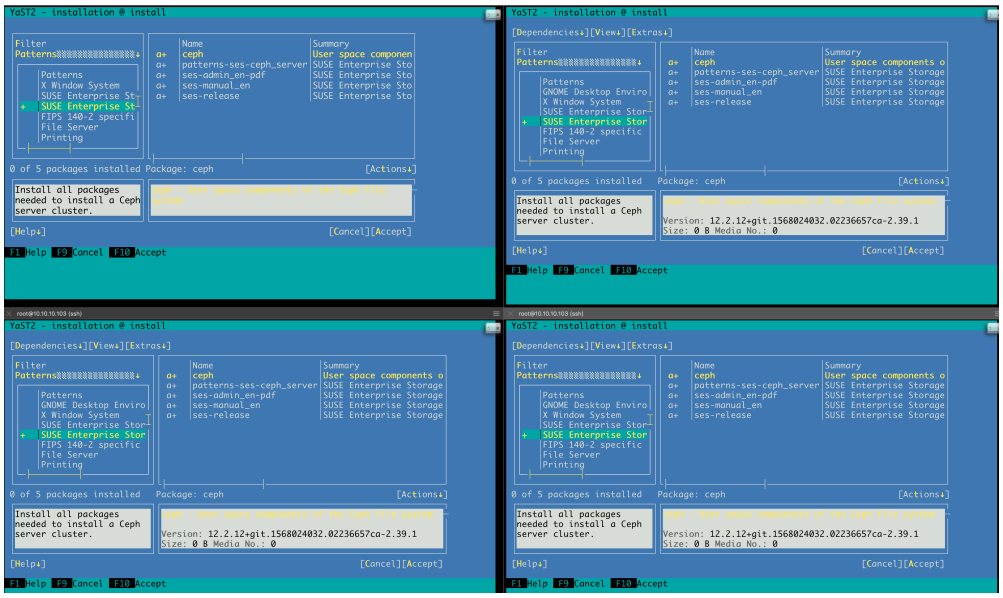


FIGURE 24: MULTI-SHELL PATTERNS

7. Deactivate the firewall on the nodes. Start the installation on all nodes.

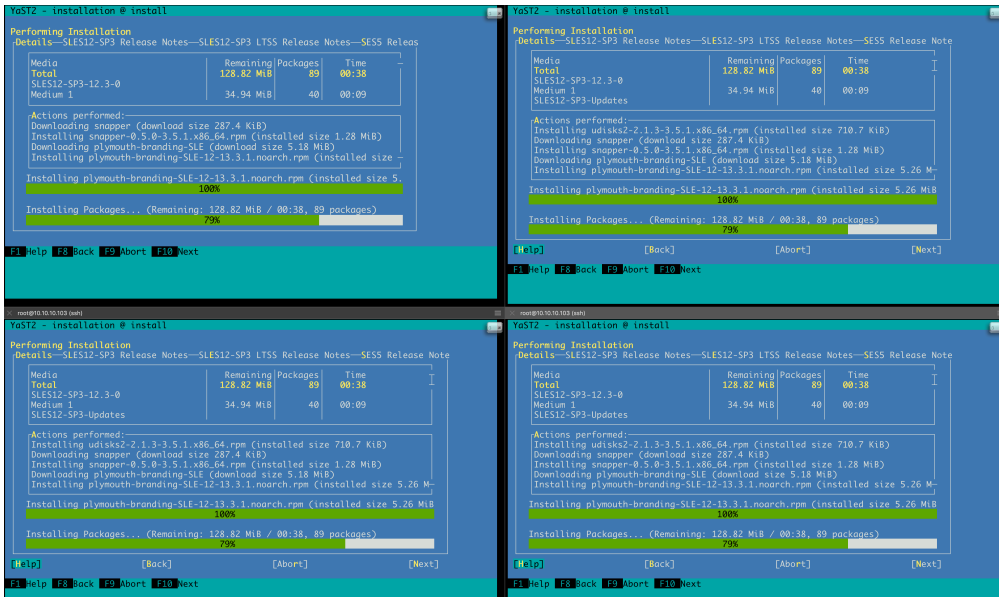


FIGURE 25: MULTI-SHELL INSTALLATION

8. When the nodes are rebooted, log in and finish the network/host name and NTP configurations so that `hostname -f` returns the FQDN of the nodes and `ntpq -p` returns a stratum less than 16.

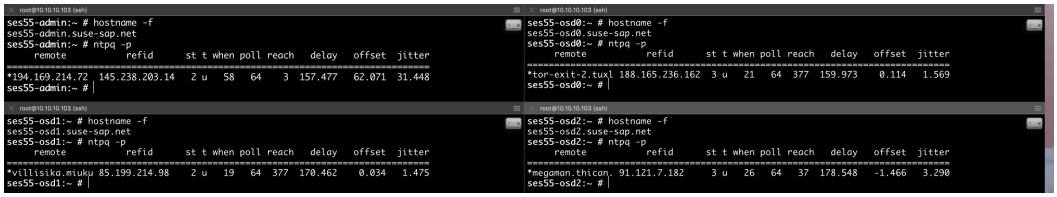


FIGURE 26: MULTI-SHELL HOST NAME

9. Using `ssh-keygen` and then `ssh-copy-id`, send your SUSE Enterprise Storage administration node SSH public key to all other nodes.

10. Verify that the drives you are going to allocate for SUSE Enterprise Storage OSDs are clean by wiping them. For more information, see SES Deployment Guide, section 4.3, step 12, Wipe disk (https://documentation.suse.com/ses/5.5/html/ses-all/ceph-install-saltstack.html#ceph-install-stack).

11. Install `salt-minion` on all nodes (including the administration node).

12. On the administration node (in our example, `ses55-admin.suse-sap.net`), additionally install `salt-master` and `deepsea`.

13. Restart `salt-minion` on all nodes and `salt-master` on the administration node.

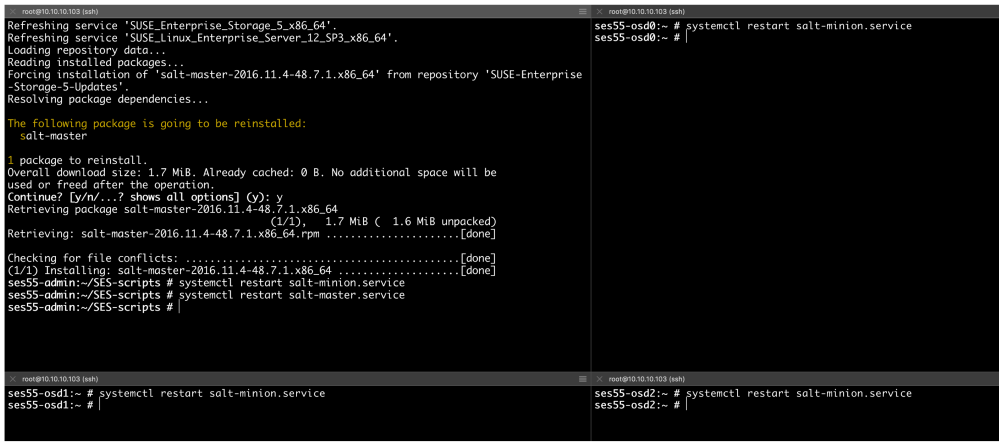


FIGURE 27: MULTI-SHELL SALT INSTALLATION

14. Accept related pending Salt keys:

```
# salt-key -L

Accepted keys:
ses55-admin.suse-sap.net
ses55-osd0.suse-sap.net
ses55-osd1.suse-sap.net
ses55-osd2.suse-sap.net
Denied keys:
Unaccepted keys:
Rejected keys:
```

Verify that `/srv/pillar/ceph/master_minion.sls` points to your administration node. In our example, it contains our `salt-master FQDN: master_minion: ses55-admin.suse-sap.net`.

15. Prepare the cluster:

```
# salt-run state.orch ceph.stage.0

Starting stage: ceph.stage.0
Parsing ceph.stage.0 steps... #

Parsing ceph.stage.0 steps... ✔

[...]
```

```
[14/14] ceph.updates on
        ses55-osd1.suse-sap.net..................................... ✔ (8s)
        ses55-admin.suse-sap.net.................................... ✔ (8s)
        ses55-osd0.suse-sap.net..................................... ✔ (9s)
        ses55-osd2.suse-sap.net..................................... ✔ (7s)

Ended stage: ceph.stage.0 succeeded=14/14 time=57.7s
```

16. Collect information about the nodes:

```
# salt-run state.orch ceph.stage.1

Starting stage: ceph.stage.1
Parsing ceph.stage.1 steps... #

Parsing ceph.stage.1 steps... ✔

[...]

[4/4]   proposal.populate.................................... ✔ (3s)

Ended stage: ceph.stage.1 succeeded=4/4 time=24.0s
```

17. Adapt the file `/srv/pillar/ceph/proposals/policy.cfg` to your needs.
    In our example, where the only deployed service is OpenAttic, it contains the following information:

```
cluster-ceph/cluster/ses55-osd2.suse-sap.net.sls
config/stack/default/ceph/cluster.yml
config/stack/default/global.yml
profile-default/cluster/ses55-admin.suse-sap.net.sls
profile-default/cluster/ses55-osd0.suse-sap.net.sls
profile-default/cluster/ses55-osd1.suse-sap.net.sls
profile-default/cluster/ses55-osd2.suse-sap.net.sls
profile-default/stack/default/ceph/minions/ses55-admin.suse-sap.net.yml
profile-default/stack/default/ceph/minions/ses55-osd0.suse-sap.net.yml
profile-default/stack/default/ceph/minions/ses55-osd1.suse-sap.net.yml
profile-default/stack/default/ceph/minions/ses55-osd2.suse-sap.net.yml
role-admin/cluster/ses55-admin.suse-sap.net.sls
role-admin/cluster/ses55-osd0.suse-sap.net.sls
role-admin/cluster/ses55-osd1.suse-sap.net.sls
role-admin/cluster/ses55-osd2.suse-sap.net.sls
role-master/cluster/ses55-admin.suse-sap.net.sls
role-mgr/cluster/ses55-osd0.suse-sap.net.sls
role-mgr/cluster/ses55-osd1.suse-sap.net.sls
role-mgr/cluster/ses55-osd2.suse-sap.net.sls
```

```
role-mon/cluster/ses55-osd0.suse-sap.net.sls
role-mon/cluster/ses55-osd1.suse-sap.net.sls
role-mon/cluster/ses55-osd2.suse-sap.net.sls
role-openattic/cluster/ses55-admin.suse-sap.net.sls
```

18. Prepare the final state of the configuration files set:

```
# salt-run state.orch ceph.stage.2

Starting stage: ceph.stage.2
Parsing ceph.stage.2 steps... #

Parsing ceph.stage.2 steps... ✔

[...]

[15/15] advise.osds..................................................... ✔
 (0.5s)

Ended stage: ceph.stage.2 succeeded=15/15 time=40.7s
```

19. You can now deploy your configuration:

```
# salt-run state.orch ceph.stage.3

Starting stage: ceph.stage.3
Parsing ceph.stage.3 steps... #

Parsing ceph.stage.3 steps... ✔

[...]

[50/50] ceph.osd.restart on
        ses55-osd2.suse-sap.net..................................... ✔ (2s)

Ended stage: ceph.stage.3 succeeded=50/50 time=246.1s
```

20. When the stage 3 has been successfully passed, check the cluster health to ensure that everything is running properly:

```
# ceph -s

  cluster:
    id:     <UUID>
    health: HEALTH_OK
```

```
  services:
    mon: 3 daemons, quorum ses55-osd0, ses55-osd1, ses55-osd2
    mgr: ses55-osd0(active), standbys: ses55-osd1, ses55-osd2
    osd: 16 osds: 16 up, 16 in

  data:
    pools:   0 pools, 0 pgs
    objects: 0 objects, 0B
    usage:   16.1GiB used, 302GiB / 318GiB avail
    pgs:
```

21. To benefit from the OpenAttic Web UI you have to initiate the **ceph.stage.4** which will install the OpenAttic service:

```
# salt-run state.orch ceph.stage.4

Starting stage: ceph.stage.4
Parsing ceph.stage.4 steps... #

Parsing ceph.stage.4 steps... ✔

[...]

[7/7]   ceph.openattic.restart on
        ses55-admin.suse-sap.net..................................... ✔ (3s)

Ended stage: ceph.stage.4 succeeded=7/7 time=105.2s
```

22. You can now manage your cluster through the Web UI:

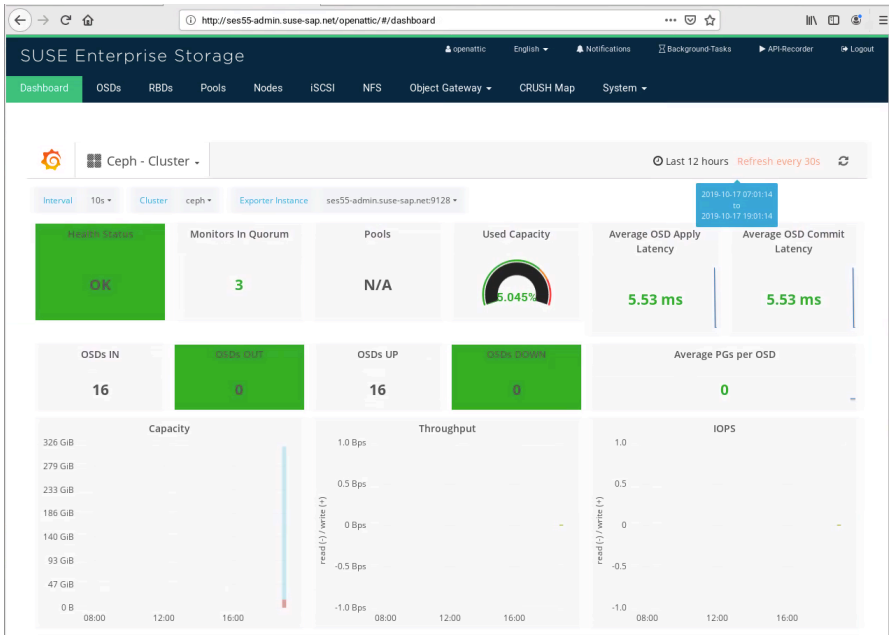


FIGURE 28: SUSE ENTERPRISE STORAGE WEB UI

23. To provide a SAP Data Hub RBD device, create a pool for it:

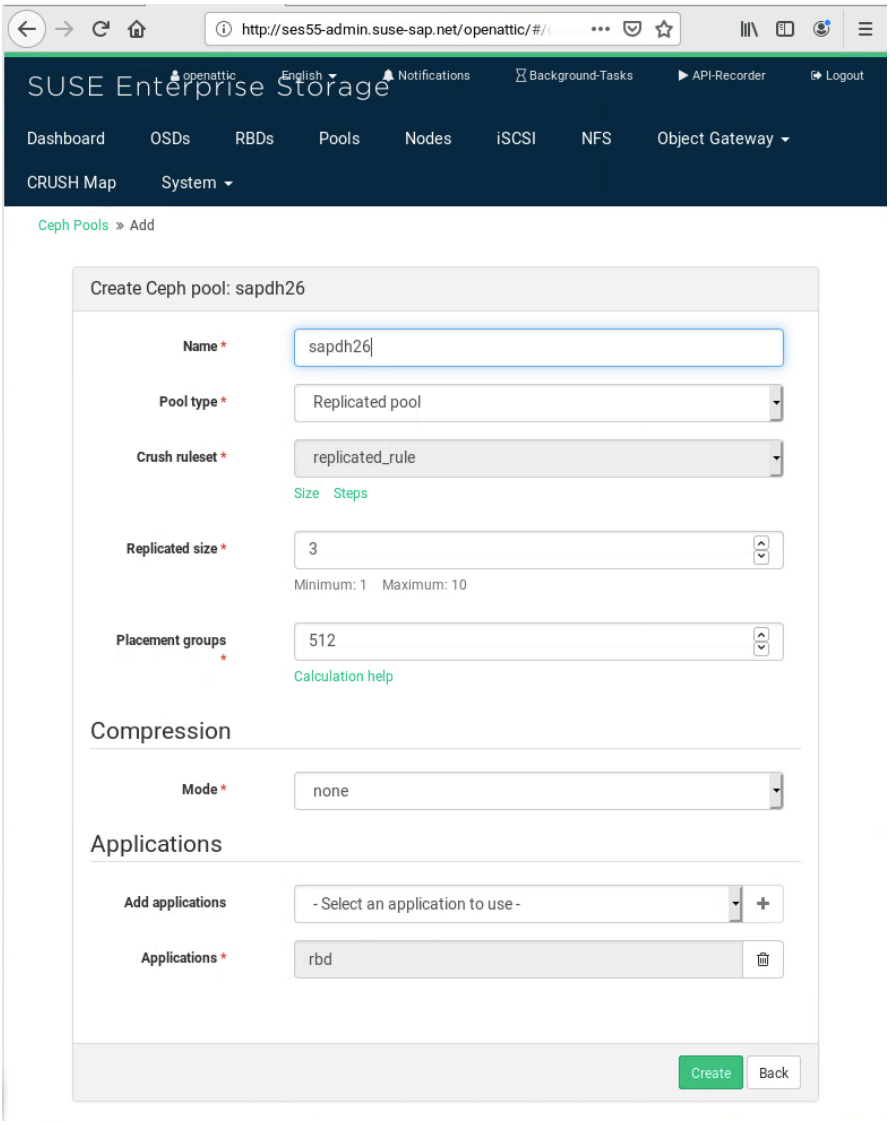


FIGURE 29: CEPH POOL

24. Now provide access to this pool through an RBD device.

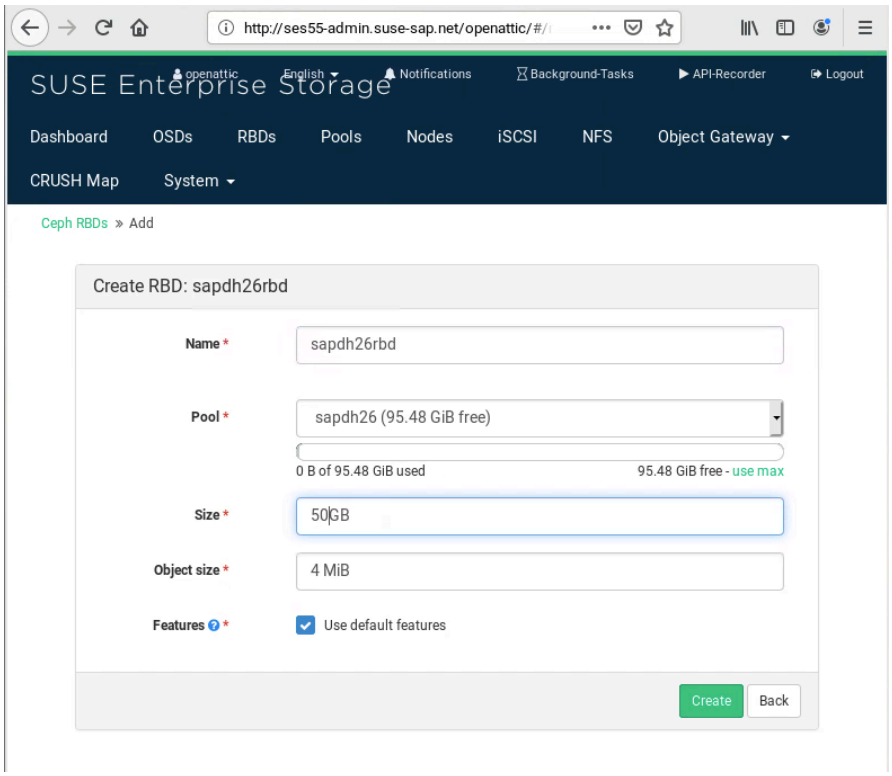


FIGURE 30: CEPH RBD

25. You can now proceed to *Section 4.1.2, "Prerequisites on the SUSE CaaS Platform 3 Cluster"*.

# 7 Legal Notice

# 8 GNU Free Documentation License



## 0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document "free" in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondarily, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of "copyleft", which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

## 1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The "Document", below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as "you". You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A "Modified Version" of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A "Secondary Section" is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document's overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The "Invariant Sections" are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The "Cover Texts" are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A "Transparent" copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not "Transparent" is called "Opaque".

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The "Title Page" means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, "Title Page" means the text near the most prominent appearance of the work's title, preceding the beginning of the body of the text.

A section "Entitled XYZ" means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as "Acknowledgements", "Dedications", "Endorsements", or "History".) To "Preserve the Title" of such a section when you modify the Document means that it remains a section "Entitled XYZ" according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

## 2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

## 3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

## 4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.

B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.

C. State on the Title page the name of the publisher of the Modified Version, as the publisher.

D. Preserve all the copyright notices of the Document.

E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.

F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.

G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.

H. Include an unaltered copy of this License.

I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.

K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.

L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.

N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.

O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

## 5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements".

## 6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

## 7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

# 8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all

Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

## 9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided for under this License. Any other attempt to copy, modify, sublicense or distribute the Document is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

## 10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See http://www.gnu.org/copyleft/.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation.

## ADDENDUM: How to use this License for your documents

```
Copyright (c) YEAR YOUR NAME.
   Permission is granted to copy, distribute and/or modify this document
   under the terms of the GNU Free Documentation License, Version 1.2
```

```
   or any later version published by the Free Software Foundation;
   with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts.
   A copy of the license is included in the section entitled “GNU
   Free Documentation License”.
```

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “ with… Texts.” line with this:

```
with the Invariant Sections being LIST THEIR TITLES, with the
   Front-Cover Texts being LIST, and with the Back-Cover Texts being LIST.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.