Scibian 9 HPC Installation guide

CCN-HPC

Version 1.9, 2018-08-20

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About this document

Purpose

The present document presents the reference architecture, the bootstrap and installation procedures of an HPC system called Scibian HPC.

The main goal is to provide exhaustive information regarding the configuration and system settings based on the needs expressed by users. This information may be useful to business and technical stakeholders, as well as to all members of the scientific computing community at EDF.

Structure

This document is divided into five chapters:

1. About this document: refers to the present chapter.
2. Reference architecture: gives an overview of the software and hardware architecture of a Scibian HPC system. It also includes a detailed description of the boot sequence of the HPC System and some other advanced topics.
3. Installation procedures: describes how to install the Puppet-HPC software stack used to configure the administration and generic nodes of the HPC system. This chapter also explains how to use Ceph for sharing the configuration files across all the nodes and how to handle the virtual machines providing all the services needed to operate the HPC system.
4. Bootstrap procedures: contains all the procedures to boostrap all the crucial services for the Scibian HPC system: LDAP, Ceph, MariaDB with Galera, SlurmDBD, etc.
5. Production procedures: contains all the technical procedures to follow for regular operations occuring during the production phase of the supercomputer. This notably includes changing any encryption or authentication key, changing passwords, reinstalling nodes, etc.

Typographic conventions

The following typographic conventions are used in this document:

- Files or directories names are written in italics: */admin/restricted/config-puppet*.
- Hostnames are written in bold: **genbatch1**.
- Groups of hostnames are written using the nodeset syntax from clustershell. For example, **genbatch[1-2]** refers to the servers **genbatch1** and **genbatch2**.
- Commands, configuration files contents or source code files are set off visually from the surrounding text as shown below:

  ```
  $ cp /etc/default/rcS /tmp
  ```

Build dependencies

On a Scibian 9 system, these packages must be installed to build this documentation:

- asciidoctor >= 0.1.4
- asciidoctor-scibian-tpl-latex
- inkscape
- rubber
- texlive-latex-extra

License

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Reference architecture

This chapter gives an overview of the software and hardware architecture of a Scibian HPC system. It also includes a detailed description of the boot sequence of the HPC System and some other advanced topics.

Chapter 1. Hardware architecture

The following diagram represents at a high-level a simple typical hardware architecture supported on Scibian HPC clusters:

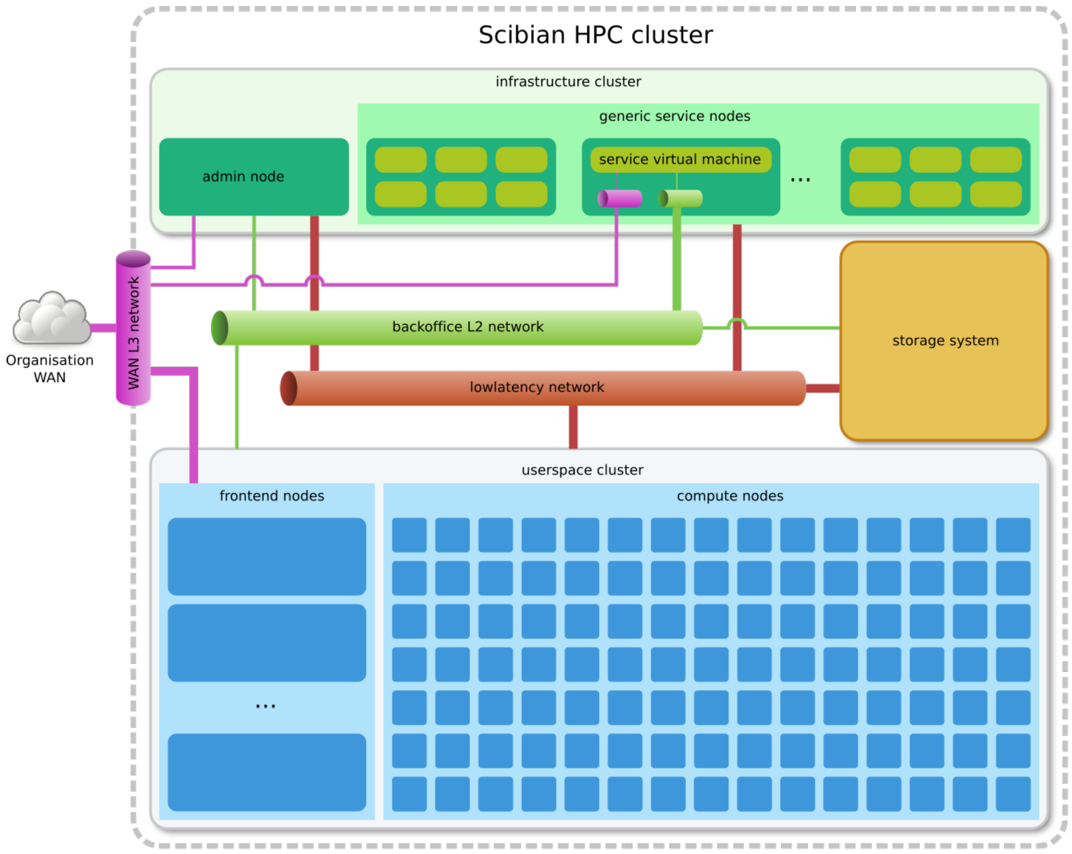


Figure 1. Scibian HPC cluster hardware typical architecture

1.1. Networks

The minimal network configuration supported on Scibian HPC clusters consists of two physically separated networks:

- The **WAN network**, an Ethernet based network with L3 network routers which connect the IP networks of the HPC cluster to the organization network.
- The **backoffice network** used for basically every other internal network communications: deployment, services, administrator operations, etc. It must be an Ethernet network with dedicated (level 2 or more) switches.

For performance reasons with distributed computing, HPC clusters generally have a third **low-latency network**. It is used for both I/O to the main storage system and distributed computing communications (typically MPI messages) between compute nodes. The hardware technologies of this network may vary upon performance requirements but it generally involves high bandwidth (10+GB/s) and low latency technologies such as InfiniBand, Omni-Path or 10GB Ethernet. In the absence of dedicated low-latency network, the **backoffice network** is also used for central storage system I/O and distributed computing communications.

It is recommended to split the **backoffice network** with four VLAN dedicated to the following groups of network interfaces:

- The system interfaces of the infrastructure cluster nodes,
- The system interfaces of the userspace cluster nodes,
- The management interfaces of the infrastructure cluster nodes (BMC [1: Baseboard Management Card]) and hardware equipments (switches, storage controllers, CMC [2: Chassis Management Card], etc),
- The management interfaces of the userspace cluster nodes.

In this setup, it is recommended to route IP subnetworks between the VLAN with L3 switche(s) on the **backoffice network**.

This setup has significant advantages both in terms of reliability and security:

- It significantly reduces the size of Ethernet broadcast domains which notably increases DHCP reliability and drops Ethernet switches load.
- It makes easier to restrict access to the infrastructure cluster and hardware equipments, notably in case of evil user attack.
- It gives the possibilty to fully adopt the **areas** feature of Puppet-HPC.

NOTE For more details about the **areas** feature, please refer to *Puppet-HPC Reference Documentation* (chapter *Software Architecture*, section *Cluster Definition*).

1.2. Infrastructure cluster

The infrastructure cluster is composed by two types of nodes: the **admin node** and the **generic service nodes**.

The **admin node** is the access node for administrators and the central point of administrative operations. All common administrative actions are performed on this node. It does not run any intensive workloads, just simple short-lived programs and it does not need to be very powerful. It does not store sensible data nor run critical services, so it does not need to be very reliable either. Example of hardware specifications:

CPU	1 x 4 cores
RAM	8GB ECC

Network	• 1 x 1GB bonding on backoffice network • 1 x 1GB bonding on WAN network • 1 link on low-latency network
Storage	2 x 300GB RAID1 SATA hard disk
PSU	Non-redundant

The **generic service nodes** run all critical infrastructure services (within service virtual machines) and manage all production administrative data. Scibian HPC requires a pool from 3 (minimum) to 5 (recommended) generic service nodes. The pool works in active cluster mode, the load is balanced with automatic fail-over. All generic service nodes of a cluster must be fairly identical for efficient load-balancing.

The generic service nodes manage the production data into a distributed object-storage system. It is highly recommended that the nodes have a dedicated block storage device for this purpose. The workload is mostly proportional to the number of compute nodes but the generic service nodes must be quite powerful to comfortably handle load peaks happening during some operations (**ex:** full cluster reboot). Also, since services are run into virtual machines, a fairly large amount of RAM is required. Services can generate a lot of traffic on the backoffice network, it is relevant to provide a network adapter with high bandwidth. Even though high-availability is ensured at the software level with automatic fail-over between generic service nodes, it is nevertheless recommended to get hardware redundancy on most devices of the generic service nodes to avoid always risky and hazardous service migrations as much as possible. Example of hardware specifications:

CPU	2 x 16 cores
RAM	64GB ECC
Network	• 2 x 10GB bonding on backoffice network • 2 x 1GB bonding on WAN network • 1 link on low-latency network
Storage	• 2 x 300GB RAID1 SATA hard disk for host • 2 x 1TB SSD SAS or NVMe PCIe for object-storage system
PSU	Redundant

All physical nodes must be connected to all three physical networks. There are virtual bridges on the host of the generic service nodes connected to the WAN and backoffice networks. The service virtual machines have connections to the virtual bridges upon their hosted service requirements.

1.3. User-space cluster

The user-space cluster is composed of **frontend nodes** and **compute nodes**.

The nodes of the user-space cluster are deployed with a diskless live system stored in RAM. It implies that, technically speaking, the nodes do not necessarily need to have local block storage devices.

The **frontend nodes** are the access hosts for users so they must be connected to all three physical networks. It is possible to have multiple frontend nodes in active cluster mode for load-balancing and automatic fail-over. The exact hardware specifications of the frontend nodes mostly depend on user needs and expectations. Users may need to transfer large amount of data to the cluster, it is therefore recommended to provide high-bandwidth network adapters for the WAN network. These nodes can also be designed to compile computational codes and in this case, they must be powerful in terms of CPU, RAM and local storage I/O.

The **compute nodes** run the jobs so they must provide high performances. Their exact hardware specifications totally depend on user needs. They must be connected to both the backoffice and the low-latency networks.

1.4. Storage system

The storage system is designed to host user data. It provides one or several shared POSIX filesystems. The evolved storage technologies depend on user needs ranging from a simple NFS NAS to a complex distributed filesystem such as Lustre or GPFS with many SAN and I/O servers.

Chapter 2. External services

A Scibian HPC cluster is designed to be mainly self contained and to continue running jobs even if it is cut off from the rest of the organization network. There is some limits to this though and some external services are needed. Critical external services are replicated inside the cluster though, to avoid losing availability of the cluster if the connection to external service is cut.

2.1. Base services

2.1.1. LDAP

The reference cluster architecture provides a highly available LDAP service, but it is only meant as a replica of an external LDAP service. The organization must provide an LDAP service with suitable replica credentials.

Only the LDAP servers (Proxy virtual machines) connect to these servers.

2.1.2. NTP

The generic service nodes are providing NTP servers for the whole cluster. Those servers must be synchronized on an external NTP source. This could be an organization NTP or a public one (eg. `spool.ntp.org`).

Only the NTP servers (Generic Service nodes) connect to these servers.

2.1.3. Package repositories

The normal way for a Scibian HPC Cluster to handle package repositories (APT) is to provide a proxy cache to organization or public distribution repositories. Alternatively, it is possible to mirror external repositories on the cluster (with `clara` and Ceph/S3).

Proxy cache needs less maintenance and is the preferred solution. Local mirrors can be used when reliable connection to external repositories is unreliable.

Only the Proxy Cache servers (Generic Service nodes) connect to these servers. In the mirror mode, only the admin node uses them.

2.1.4. DNS

External DNS service is not strictly necessary but is hard to not configure if the cluster must use organization or public services (License servers, NAS…).

The external DNS servers are configured as recursive in the local DNS server configuration.

Only the DNS servers (Generic Service nodes) connect to these servers.

2.2. Optional services

2.2.1. NAS

It is frequent to mount (at least on the frontend nodes) an external NAS space to copy data in and out of the cluster.

2.2.2. Graphite

In the reference architecture all system metrics collected on the cluster (by collectd) are pushed to an external graphite server. This is usually relayed by the proxy virtual machines.

2.2.3. InfluxDB

In the reference architecture all jobs metrics collected on the cluster are pushed to an external InfluxDB server. This is usually relayed by the proxy virtual machines.

2.2.4. HPCStats

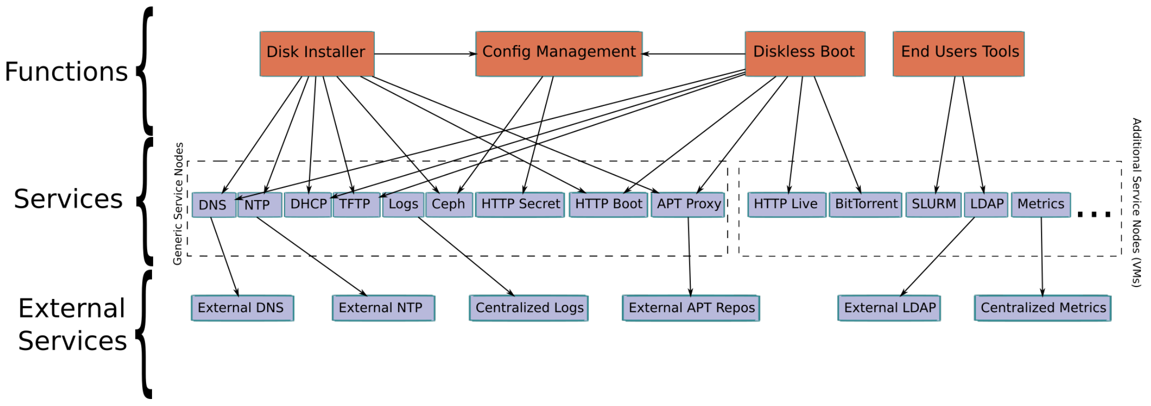
HPCStats is a tool that frequently connects to the frontend as a normal user to launch job. It also connects to the SlurmDBD database to get batch job statistics. The database connection needs a special NAT configuration on the Proxy virtual machines.

2.2.5. Slurm-Web Dashboard

The Slurm-Web Dashboard aggregates data coming from multiple clusters in the same web interface. To get those data, the client connect to an HTTP REST API that is hosted on the Proxy virtual machines.

Chapter 3. Software architecture

3.1. Overview



3.1.1. Functions

The software configuration of the cluster aims to deliver a set of functions. Functions can rely on each other, for example, the disk installer uses the configuration management to finish the post-install process.

The main functions provided by a Scibian HPC cluster are:

- **Configuration Management**, to distribute and apply the configuration to the nodes
- **Disk Installer**, to install an OS from scratch on the node disks through the network
- **Diskless Boot**, to boot a node with a live diskless OS through the network
- **Administrator Tools**, tools and services used by the system administrator to operate the cluster
- **User Tools**, tools and services used by end users

The Scibian HPC Cluster will use a set of services to deliver a particular function. If a cluster can provide **Configuration Management** and a **Disk Installer**, it is able to operate even if it cannot do something useful for the users. These two core functions permit to create a self sufficient cluster that will be used to provide other functions.

3.1.2. Services

The software services of the cluster are sorted into two broad categories:

- **Base Services**, necessary to provide core functions: install and configure a physical or virtual machine
- **Additional Services**, to boot a diskless (live) machine, provide all end user services (batch,

user directory, licenses…), and system services not mandatory to install a machine (monitoring, metrics…)

The Base Services run on a set of physical machines that are almost identical, those hosts are called **Service Nodes**. The services are setup to work reliably even if some of the service nodes are down. This means that a service node can be re-installed by other active service nodes.

The Additional Services can be installed on a set of other hosts that can be either physical or virtual. VMs (Virtual Machines) are usually used because those services do not need a lot of raw power and the agility provided by virtual machines (like live host migration) are often an advantage.

If the cluster is using virtualized machines for the Additional Services, the service nodes must also provide a consistent virtualization platform (storage and hosts). In the reference architecture, this is provided with Ceph RBD and Libvirtd running on service nodes.

A particular service runs on service nodes even if it is not mandatory for Disk Installer or Config Management: the low-latency network manager (Subnet Manager for InfiniBand, Fabric Manager for Intel Omni-Path). This exception is due to the fact that this particular service needs raw access to the low-latency network.

In the Puppet configuration, services are usually associated with **profiles**. For example, the puppet configuration configures the **DNS Server** service with the profile: `profiles::dns::server`.

3.2. Base Services

3.2.1. Infrastructure

Infrastructure-related services provide basic network operations:

- DHCP and TFTP for PXE Boot
- DNS servers, with forwarding for external zones
- NTP servers, synchronized on external servers

These services are configured the same way and running on each service nodes.

3.2.2. Consul

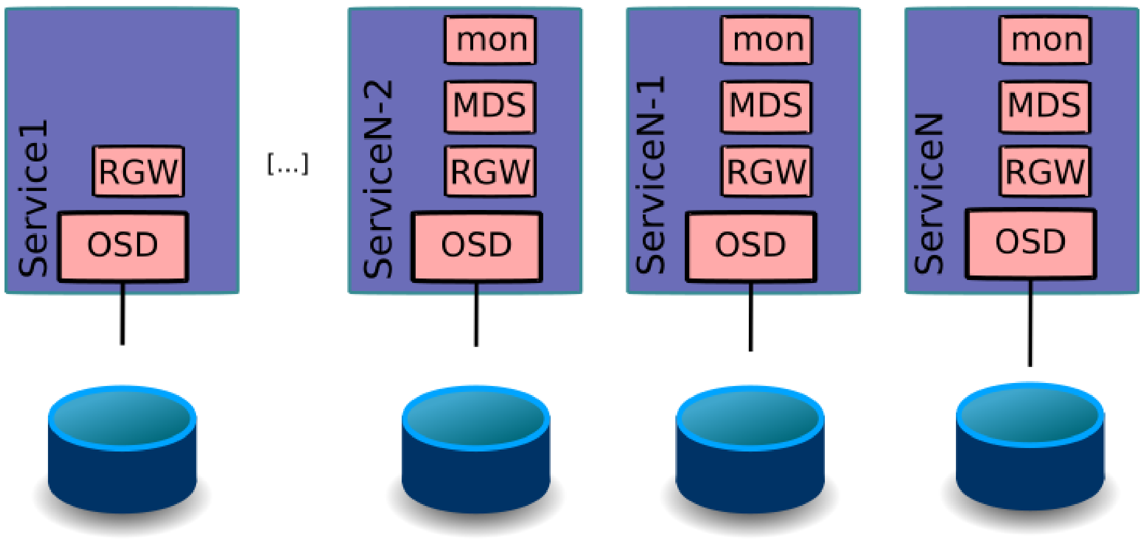
Consul is a service that permits to discover available services in the cluster. Client will query a special DNS entry (`xxx.service.virtual`) and the DNS server integrated with Consul will return the IP address of an available instance.

3.2.3. Ceph

Ceph provides an highly available storage system for all system needs. Ceph has the advantage to work with internal storage on service nodes. It does not require a storage system shared between servers (NAS or SAN).

Ceph provides:

- A Rados Block Device (RBD) that is used to store Virtual Machines disk images
- A Rados GateWay to provide storage for configuration management, Amazon S3 compatible REST API for write operations and plain HTTP for read.
- A Ceph FS that can provide a POSIX filesystem used for Slurm Controller state save location



A Ceph cluster is made of four kinds of daemons. All generic service nodes run the following daemons:

- **OSD**, Object Storage Daemons actually holding the content of the ceph cluster
- **RGW**, Rados GateWay (sometimes shortened radosgw) exposing an HTTP API like S3 to store and retrieve data in Ceph

Two other kind of service are only available on three of the generic service nodes:

- **MON**, Monitoring nodes, this is the orchestrator of the ceph cluster. A quorum of two active mon nodes must be maintained for the cluster to be available
- **MDS**, MetaData Server, only used by CephFS (the POSIX implementation above ceph). At least one must always be active.

With this configuration, any server can be unavailable. As long as at least two servers holding critical services are available, the cluster might survive losing another non-critical server.

3.2.4. Libvirt/KVM

Service nodes are also the physical hosts for the Virtual Machines of the cluster. Libvirt is used in combination with QEMU/KVM to configure the VMs. A Ceph RBD pool is used to store the image of the VMs. With this configuration, the only state on a service node is the VM definition.

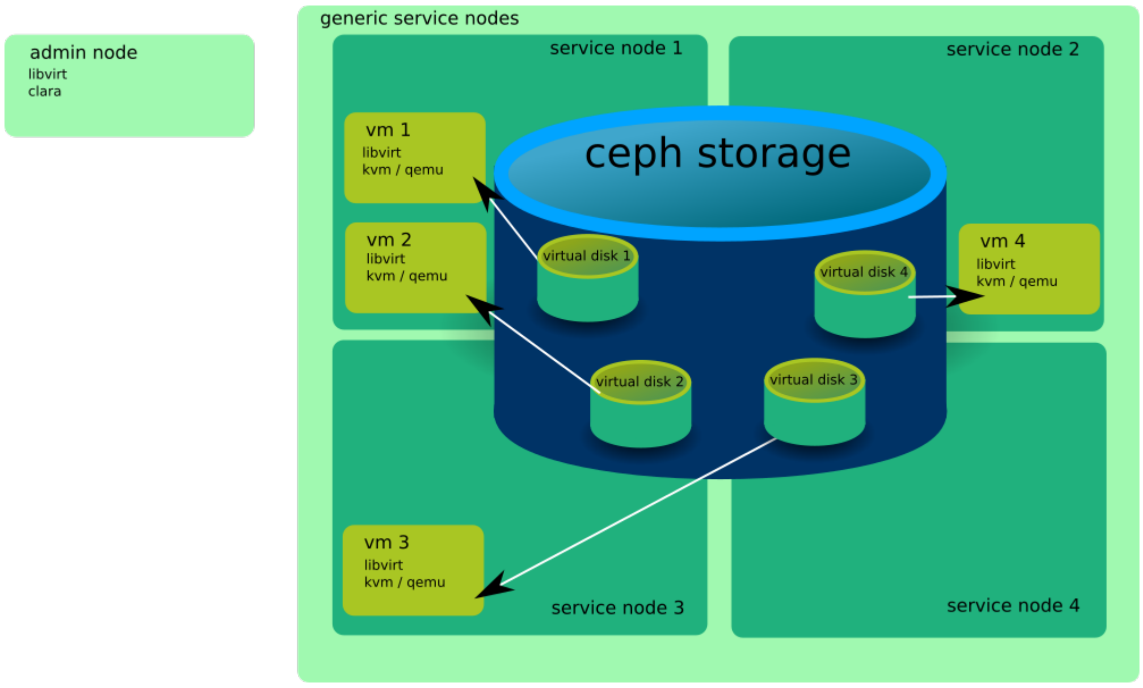


Figure 2. How the service machines, ceph and vm interact

Integration with Clara makes it easy to move VMs between nodes.

3.2.5. HTTP secret and boot

The process to boot a node needs a configuration obtained through HTTP and computed by a CGI (in Python). This is hosted on the service nodes and served by Apache. This is also used to serve files like the kernel, initrd and pre-seeded configuration.

A special Virtual Host on the Apache configuration is used to serve secrets (Hiera-Eyaml keys). This VHost is configured to only serve the files on a specific port. This port is only accessible if the client connects from a port below 1024 (is root), this is enforced by a Shorewall rule.

3.2.6. APT proxy

There is no full repository mirror on the cluster. APT is configured to use a proxy that will fetch data from external repositories and cache it. This permits to have always up-to-date packages without overloading external repositories and without having to maintain mirror sync (internally and externally).

3.2.7. Logs

Logs from all nodes are forwarded to a Virtual IP address running on the service nodes. The local rsyslog daemon will centralize those logs and optionally forward the result to an external location.

3.2.8. Low-latency network manager

The Low-latency network manager (InfiniBand Subnet Manager or Intel Omni-Path Fabric Manager) is not mandatory to achieve the feature set of Base Services (Configuration Management and Disk Installation) but it must run on a physical machine, so it is grouped with the Base Services to run on the service nodes.

3.2.9. NFS HA Service

A NFS HA Service can serve two purpose:

- Shared state for servicing using Posix to share their state (like **SlurmCtld**) when CephFS does not provided sufficient performance
- Shared storage for the users if a distributed file system like GPFS or Lustre is not used (only works for smaller cluster sizes)

The NFS HA Service is provided with a Keepalived setup.

3.3. Additional Services

3.3.1. LDAP

There is no standalone LDAP servers configured. The servers are replica from an external directory. This means that both are configured independently and are accessed only for read operations.

If the organization uses Kerberos, all Kerberos requests and password checks are done directly by the external Kerberos server.

3.3.2. Bittorrent

Diskless image files are downloaded by the nodes with the BitTorrent protocol. The cluster provides a redundant tracker service with OpenTracker and two server machines are configured to always seed the images.

An Apache server is used to serve the torrent files for the diskless images (HTTP Live).

3.3.3. Slurm

Slurm provides the job management service for the cluster. The controller service (SlurmCtld) runs in an Active/Passive configuration on a pair of servers (**batch** nodes). The state is shared between the controller nodes. This can be achieved with a CephFS mount or with an NFS HA server. CephFS does not permit to support a large number (thousands) of jobs yet.

The SlurmDBD service also runs on these two servers.

3.3.4. MariaDB/Galera

SlurmDBD uses a MySQL like database to store accounting information and limits. On Scibian HPC Clusters this is provided by a MariaDB/Galera cluster which provides an Active/Active SQL server compatible with MySQL.

This cluster is usually co-located with SlurmDBD service and Slurm Controllers (**batch** nodes).

3.3.5. Relays

The Additional Services include a set of relay services to the outside of the cluster for:

- Email (Postfix Relay)
- Network (NAT configured by Shorewall)
- Metrics (Carbon C Relay)

3.3.6. Monitoring

Cluster monitoring is done by Icinga2, the cluster is integrated inside an organization Icinga infrastructure. The cluster hosts a redundant pair of monitoring satellites that checks the nodes. The monitoring master is external to the cluster.

3.4. High-Availability

All services running on the cluster should be highly available (HA). Some services not critical for normal cluster operation can be not highly available, but this should be avoided if possible.

The following section lists the different techniques used to achieve high-availability of the cluster services.

3.4.1. Stateless

Stateless services are configured the same way on all servers and will give the same answer to all requests. These services include:

- **DHCP**
- **TFTP**
- **NTP**
- **DNS**
- **LDAP Replica**
- **HTTP Secret**
- **HTTP Boot**
- **HTTP Live**
- **Ceph RadosGW**
- **APT Proxy**
- **Carbon Relay**
- **Bittorrent Tracker**
- **Bittorrent Seeder**
- **SMTP Relay**

Clients can provide a list of potential servers that will be tried in turn. If the client do not automatically accept multiple servers, it is possible to use the Consul service to get a DNS entry (`xxx.service.virtual`) that will always point to an available instance of the service.

As a last resort and for services that do not need Active/Active (Load Balancing) capabilities, it is possible to use a Virtual IP address (VIP). **HTTP Live** and **Carbon Relay** uses this technique.

3.4.2. Native Active/Active

Some services have native internal mechanisms to share states between the servers. Contacting any server will have the same effect on the state of the service, or the service has an internal mechanism to get the right server. These services behave this way:

- **Ceph Rados**
- **MariaDB/Galera**
- **Consul**

3.4.3. Native Active/Passive

Services that have only one active server at any time, but the mechanism to select the active server is internal to the service. This means all servers are launched in the same way and not by an external agent like Keepalived or Pacemaker/Corosync. Services using this technique are:

- **Ceph MDS** (Posix CephFS server)
- **Slurm Controller**
- **Omni-Path Fabric Manager** or **InfiniBand Subnet Manager**

3.4.4. Controlled Active/Passive

The service can only have one active server at any one time and this failover must be controlled by an external service. On the current configuration the only service requiring this setup is:

- **NFS HA Server**

Chapter 4. Conventions

In order to restrain the complexity of the configuration of a Scibian HPC cluster, some naming and architecture conventions have been defined. Multiple components of the software stack expect these conventions to be followed in order to operate properly. These conventions are actually rather close to HPC cluster standards, then they should not seem very constraining.

- The operating system short hostname of the nodes must have the following format: `<prefix><role><id>`. This is required by the association logic used in Puppet-HPC to map a node to its unique Puppet role. This point is fully explained in the role section of Puppet-HPC reference documentation.
- The FQDN [3: Fully-Qualified Domain Name] hostnames of the nodes must be similar to their network names on the backoffice network. In other words, the IP address resolution on the cluster of the FQDN hostname of a node must return the IP address of this node on the backoffice network.

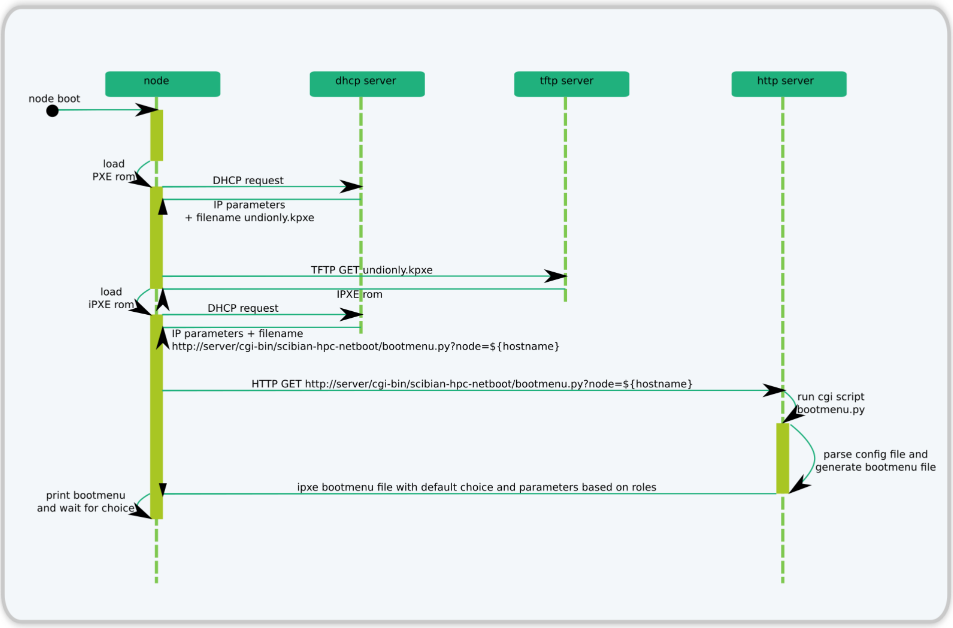
Chapter 5. Advanced Topics

5.1. Boot sequence

5.1.1. Initial common steps

The servers of the cluster can boot on their hard disks or via the network, using the PXE protocol. In normal operations, all service nodes are installed on hard disks, and all nodes of the userspace (**compute** and **frontend** nodes) use the network method to boot the diskless image. A service node can use the PXE method when it is being installed. The boot sequence between the `power on` event on the node and the boot of the initrd is identical regardless of the system booted (installer or diskless image).

The steps of the boot sequence are described on the diagram below:



When a node boots on its network device, after a few (but generally time-consuming) internal checks, it loads and runs the PXE ROM stored inside the Ethernet adapter. This ROM first sends a DHCP request to get an IP address and other network parameters. The DHCP server gives it an IP address alongside the filename parameter. This filename is the file the PXE ROM downloads using the TFTP protocol. This protocol, which is rather limited and unreliable is used here because the PXE ROM commonly available in Ethernet adapters only supports this network protocol.

The file to download depends on the type of nodes or roles. On Scibian HPC clusters when using the Puppet-HPC software stack, the required filename for the current node is set in Hiera in the `boot_params` hash. If not defined in this hash, the default filename is `undionly.kpxe` which is actually the PXE chainloaded version of iPXE for legacy BIOS systems. This filename can be altered to support specific node settings such as virtual machine and nodes booting in UEFI mode.

iPXE is open source network boot software with many advanced features (not available in NIC PXE ROM) such scripting/menu support, HTTP and DNS protocols support and many more. This way, it is used as a workaround to hardware PXE ROM limitations.

The virtual machines boot like any other node, except QEMU uses iPXE as the PXE implementation for its virtual network adapters. This means that the virtual machines go directly to this step.

The iPXE bootloader must perform another DHCP request since the IP settings are lost when the bootloader is loaded. The DHCP server is able to recognize this request originates from an iPXE ROM. In this case, it sets the filename parameter with an HTTP URL to a Python CGI script `bootmenu.py`.

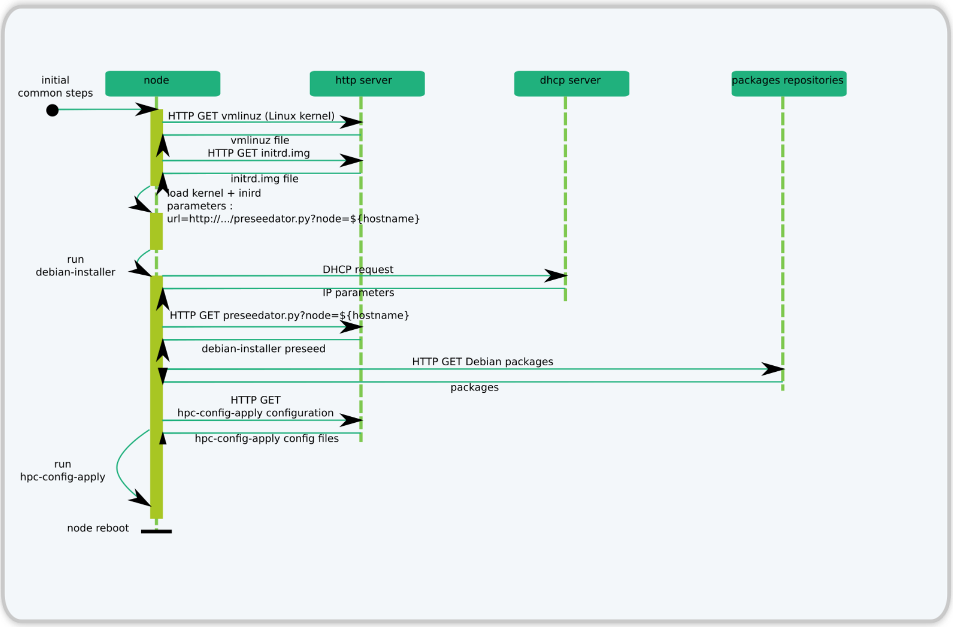
The iPXE bootloader sends the GET HTTP request to this URL. In this request, it also adds to the parameters its hostname as it was given by the DHCP server.

On the HTTP server side, the Python CGI script `bootmenu.py` dynamically generates an iPXE boot menu for the node, with all entries available on the cluster and the default entry set according to node settings. Please refer to the iPXE Bootmenu Generator section for detailed explanations about this script.

Without any action from the administrator, iPXE waits for the menu 3 seconds timeout, then automatically selects and loads the node default boot entry set by the CGI script.

5.1.2. Disk installation

Here is the sequence diagram of a Scibian server installation on disk, right after the PXE boot common steps:



The iPXE ROM downloads the Linux kernel and the initrd archive associated with the boot menu entry. The kernel is then run with all the parameters given in the menu entry.

The initrd archive contains the Debian Installer program. This program starts by sending a new DHCP request to get an IP address. Then, it downloads the Debian installer preseed file located at the URL found in the `url ` kernel parameter. This preseed file contains all the answers to the questions asked by the Debian Installer program. This way, the installation process is totally automated and does not require any interaction from the administrator.

By default on Scibian HPC clusters, this URL is directed to a Python CGI script `preseedator.py` which dynamically generates the preseed file for the node given in parameter. Please refer to Debian Installer Preseed Generator section for detailed explanations about this script.

During the installation, many Debian packages are retrieved from Debian repositories.

At the end of the installation, Debian Installer runs the commands set in the `late_command` parameter of the preseed file. On Scibian HPC clusters, this parameter is used to run the following steps:

- Download through HTTP the *hpc-config-apply* script,
- Run *hpc-config-apply* inside the chroot environment of the newly installed system.

Detailed functionning of the *hpc-config-apply* script is not described here, but it involves:

- downloading and installing additional Debian packages depending on the node role,

- executing various types of software
- and writing various configuration files on the installed system.

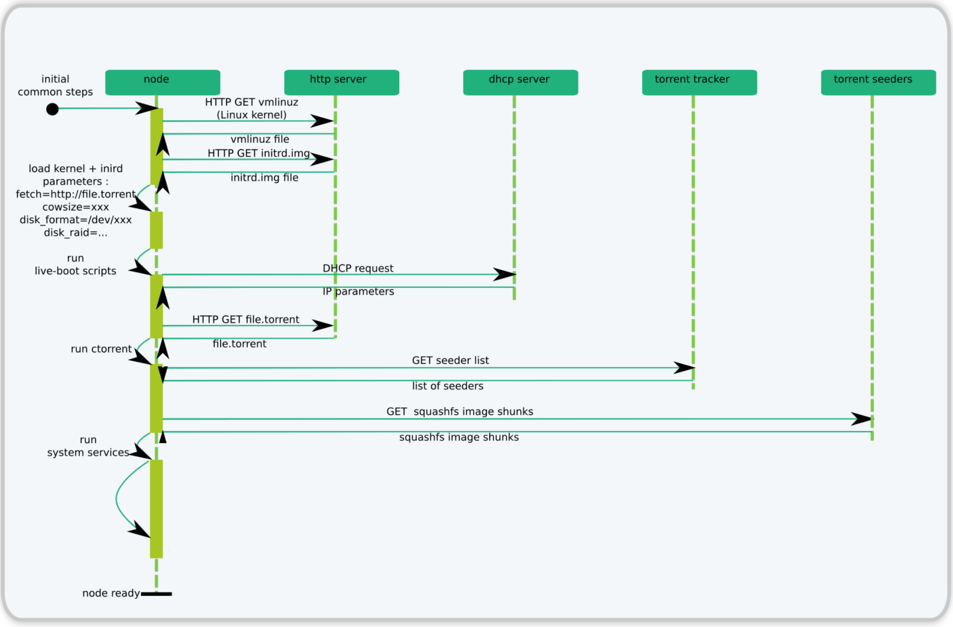
Please refer to `hpc-config-apply(1)` man page for a full documentation on how to use this script.

Finally, when the execution of the commands are over, the server reboots.

Once the servers are installed, they are configured through IPMI with Clara to boot on their disk devices first. Please refer to Clara documentation for further details.

5.1.3. Diskless boot

Here is the sequence diagram of the boot process for diskless nodes, right after the PXE boot common steps:



The iPXE bootloader downloads the Linux kernel and the initrd image defined within the default boot menu entry and runs them with the provided parameters. Among these parameters, there are notably:

- `fetch` whose value is an HTTP URL to a torrent file available on the HTTP server of the supercomputer,
- `cowsize` whose value is the size of the ramfs filesystem mounted on */lib/live/mount/overlay*,
- `disk_format` if this parameter is present the device indicated is formatted on node boot,

- `disk_raid` if this parameter is present a software raid is created with the parameters indicated on node boot.

Within the initrd images, there are several specific scripts that come from `live-boot`, `live-torrent` and specific Scibian Debian packages. Please refer to the following sub-section Advanced Topics, Generating diskless initrd for all explanations about how these scripts have been added to the initramfs image.

These scripts download the torrent file at the URL specified in the `fetch` parameter, then they launch the `ctorrent` BitTorrent client. This client extracts from the torrent file the IP address of the BitTorrent trackers and the names of the files to download using the BitTorrent protocol. There is actually one file to download, the SquashFS image, that the client will download in P2P mode by gathering small chunks on several other nodes. Then, once the file has been fully retrieved, the image is mounted after executing some preliminary tasks like formatting the disk or setting up a raid array if it has been indicated in the kernel options passed by the boot menu. Then, the real init system is started and it launches all the system services. One of these services is `hpc-config-apply.service` which runs the *hpc-config-apply* script.

As for the part regarding the installation with a disk, how the *hpc-config-apply* script works is not described here. Please refer to `hpc-config-apply(1)` man page for a full documentation on this topic.

Finally, the node is ready for production.

5.2. iPXE Bootmenu Generator

By default on Scibian HPC clusters, the DHCP servers sends as filename to iPXE ROM an HTTP URL to a Python CGI script `bootmenu.py` which is a iPXE bootmenu generator. Optionally, this behaviour can be altered by modifying `iscdhcp::bootmenu_url` parameter in Hiera repository.

The Python CGI script `bootmenu.py` is provided by `scibian-hpc-netboot-bootmenu` package.

On the HTTP server side, this script initially parses the nodes boot parameters configuration YAML file `/etc/scibian-hpc-netboot/boot-params.yaml`. This file provides all node specific boot parameters, including ethernet boot device, default OS, media and version, etc. When looking for a parameter (ex: `os`), the script first searches into the nodeset sections whose node is member (ex: node `fbcn02` is member of nodeset `fbcn[01-10]`). If not found, the parameter is finally read into the `defaults` section.

The `/etc/scibian-hpc-netboot/boot-params.yaml` file is deployed by Puppet-HPC based on the following inputs:

- the default values provided by Puppet-HPC *boothttp* module within `boot_params_defaults` parameter,

- the DNS nameservers and P2P tracker computed by Puppet-HPC `bootsystem::server` profile,
- the `boot_params` hash parameter in Hiera repository.

Then, the script *compiles* sequentially all the menu entries provided as YAML files in directory `/etc/scibian-hpc-netboot/menu/entries.d`. The YAML files must respect the following format:

```
<os>:
  <media>:
    <version>:
      label:  <label>
      [dir:   <dir>]
      initrd: <initrd>
      kernel: <initrd>
      opts:   <opts>
```

Where:

- `<os>` is the operating system name (ex: `scibian9`)
- `<media>` is the symbolic name of a media where the OS is deployed (`disk` or `ram`)
- `<version>` is a symbolic name of an entry version (ex: `main` or `test`)

An `<os>` can contain multiple `<media>`, a `<media>` can contain multiple `<version>`. An entry is defined by the concatenation of these 3 parameters, ex: `scibian9-disk-main`. Then, each entry is defined by the following parameters:

- `label`: the label of the entry visible in the boot menu
- `dir` (optional): the subdirectory of kernel and initrd files in the `${base-url}` (see below), default value is empty.
- `initrd`: the file name of the initrd archive
- `kernel`: the file name of the Linux kernel
- `opts`: the arguments given to the Linux kernel

The `${base-url}` is a iPXE placeholder defined by the CGI script for every entries. Its value mainly depends on the media of the entry:

- for `disk` media, the value is `http://<diskinstall_server>/disk/<os>`
- for `ram` media, the value is `http://<diskless_server>/<os>`

The `<*_server>` parameters are defined in nodes boot parameters YAML configuration file `/etc/scibian-hpc-netboot/boot-params.yaml`.

The parameters of an entry can be templated with all node boot parameters and the OS, media, version and initrd of the entry. As an example, here is a valid entry:

```
scibian9:
  disk:
    main:
      label:  Install {{ os }}
      dir:    debian-installer/amd64
      initrd: initrd.gz
      kernel: linux
      opts:   >
        initrd={{ initrd }}
        url=http://{{ diskinstall_server }}/cgi-bin/scibian-hpc-
netboot/preseedator.py?node=${hostname}
        console={{ console }}
        auto
        interface={{ boot_dev }}
        locale={{ locale }}
        console-keymaps-at/keymap={{ keymap }}
        keyboard-configuration/xkb-keymap={{ keymap }}
        languagechooser/language-name={{ language }}
        netcfg/get_domain={{ domain }}
        netcfg/get_nameservers="{{ nameservers|join(' ') }}"
        netcfg/no_default_route=true
        debian-installer/add-kernel-opts=console={{ console }}
        priority=critical
        scibian-installer
```

All the parameters between double curly braces (ex: `{{boot_dev}}`) are dynamically replaced by node boot parameters. This way, entries can be defined in a generic way.

The YAML entries files in directory `/etc/scibian-hpc-netboot/menu/entries.d` are read sequentially. The entries provided in the next files can override entries defined in previous files. In other words, only the last definition of an entry is considered. As an example, the entry `scibian9-disk-main` defined in `0_default.yaml` can be overriden in `1_other.yaml`.

The `scibian-hpc-netboot-menu` provides default entries with file `0_default.yaml`. All the entries defined in this file can be overriden with Puppet-HPC by setting the `profiles::bootsystem::menu_entries` hash parameter in Hiera repository.

5.3. Debian Installer Preseed Generator

By default on Scibian HPC clusters, the URL provided in the bootmenu entries for the Debian installer preseed (`scibian*-disk-*` entries) is actually directed to a Python CGI script `preseedator.py`. This behaviour can be altered by overriding the respective menu entries, please refer to iPXE Bootmenu Generator section for explanations.

This CGI script `preseedator.py` dynamically generate a preseed for Debian installer for the node given in parameter. This CGI script is provided by the `scibian-hpc-netboot-preseedator` package.

In the first place, the script reads the nodes boot parameters located in file `/etc/scibian-hpc-netboot/boot-params.yaml`. Please refer to iPXE Bootmenu Generator section to understand how this file is built.

Then, it parses its YAML configuration file `/etc/scibian-hpc-netboot/installer/installer.yaml`. This file basically contains all debian installer related parameters such as the URL to the APT mirror/proxy and the list of additional repositories. The content of this file is based on the following inputs:

- the default values provided by Puppet-HPC *boothttp* module within `installer_options_defaults` parameter,
- the list of additional APT repositories computed by Puppet-HPC `bootsystem::server` extracted from Hiera in `profiles::cluster::apt_sources` hash parameter.
- the `profiles::bootsystem::installer_options` hash parameter in Hiera repository.

Finally, the `preseedator.py` script generates the preseed based on the template file `/etc/scibian-hpc-netboot/installer/preseed.jinja2`. The template is filled with parameters previously loaded.

The template provides a mechanism to download an external partition schema file from the installation server (`diskinstall_server` in `boot-params.yaml`). The URL directs to an another Python CGI script `partitioner.py`. This script is also provided by `scibian-hpc-netboot-preseedator` package.

This script searches for a partition schema file in directory `/etc/scibian-hpc-netboot/installer/schemas` in the following order:

1. `nodes/<node>` where `<node>` is the hostname of the node,
2. `roles/<role>` where `<role>` is the role name of the node,
3. `common`

The first found file is returned by the script. By default, only the `common` file is provided by the package. With Puppet-HPC, it is possible to deploy node or role specific schemas by setting the `boothttp::partition_schemas` array in Hiera repository.

5.4. Frontend nodes: SSH load-balancing and high-availability

The frontend nodes offer a virtual IP address on the WAN network that features both an highly-available and load-balanced SSH service for users to access the HPC cluster. The load-balancing feature automatically distributes users on all available frontend nodes. This load-balancing is operated with persistence so that users (based on their source IP address) are always redirected to the same frontend node in a time frame. Behind the virtual IP address, the high-availability of the SSH service is also ensured in case of outage on a frontend node. These load-balancing and high-availability features are ensured by the Keepalived software.

For security reasons, a firewall is also set up on the frontend nodes to control outgoing network traffic. This firewall service is managed by Shorewall, a high-level configuration tool for Linux netfilter. Because of all the various network flows involved in Keepalived, it must be tightly integrated with the firewall rules. The following diagram illustrates both the network principles behind the high-availability/load-balancing mechanisms and the integration with the software components of the firewall:

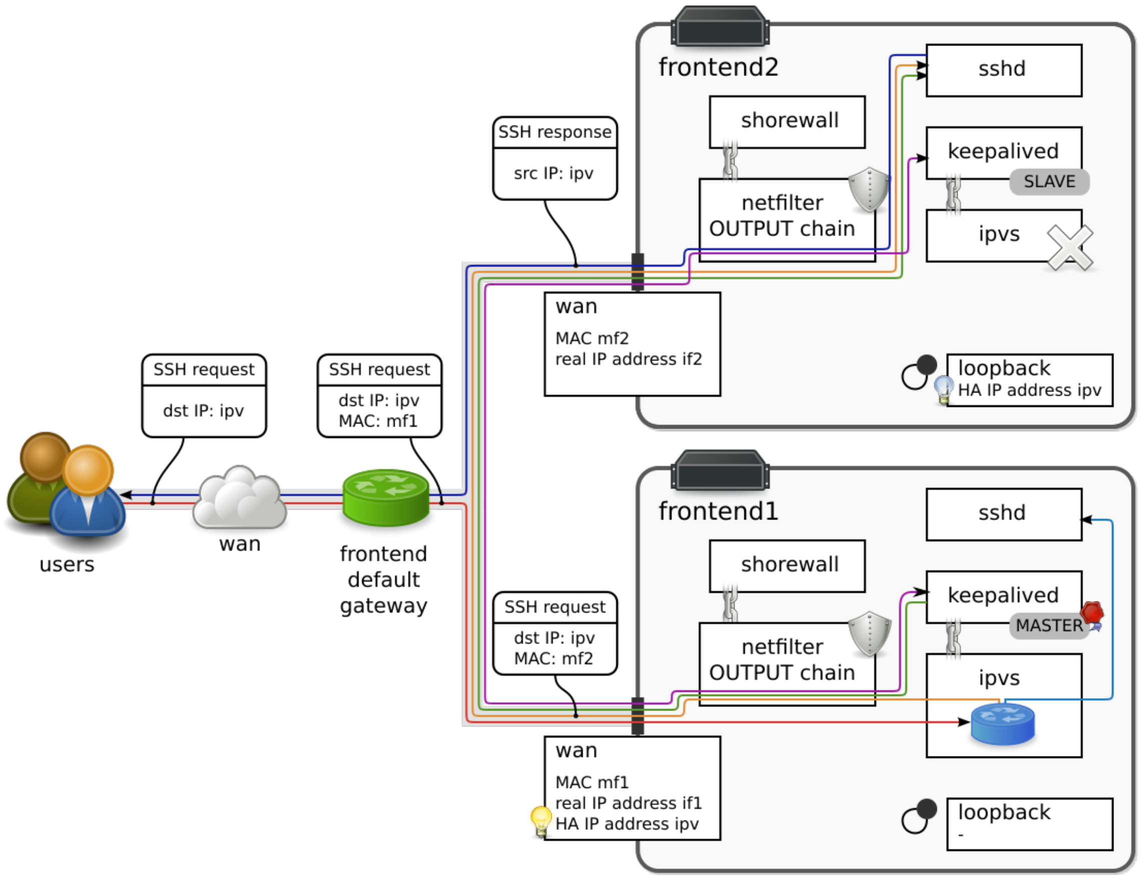


Figure 3. sshd load-balancing HA mechanism with firewall integration

The Keepalived sofware checks all the frontend nodes using the VRRP [4: Virtual Router Redundancy Protocol] protocol on the WAN network interfaces (purple arrow in the diagram). This protocol must be allowed in the OUTPUT chain of the firewall so that Keepalived can work properly.

On the master frontend node, the HA virtual IP address is set on the network interface attached to the WAN network. The Keepalived software configures the IPVS [5: IP Virtual Server] Linux kernel load-balancer to redirect new TCP connections with a Round-Robin algorithm. Therefore, a part of the TCP connections is redirected to the `sshd` daemon of other frontend nodes (orange arrow in the diagram). An exception must be specified in the OUTPUT chain of the firewall to allow these redirected connections.

To perform such redirections, IPVS simply changes the destination MAC address, to set the address of the real destination frontend, in the Ethernet layer of the first packet of the TCP connection. However, the destination IP address does not change: it is still the virtual IP address.

On the slave frontend nodes, the HA virtual IP address is set on the loopback interface. This is required to make the kernel accept the redirected packets from the master frontend node addressed to the virtual IP address. In order to avoid endless loops, the IPVS redirection rules are disabled on slave frontend nodes or else, packets would be redirected endlessly.

By default, the Linux kernel answers the ARP requests coming from any network device for any IP address attached to any network device. For example, on a system with two network devices: `eth0` with `ip0` and `eth1` with `ip1`, if an ARP request is received for `ip1` on `eth0`, the kernel positively responds to it, with the MAC address of `eth0`. Though it is convenient in many cases, this feature is annoying on the frontend nodes, since the virtual IP address is set on all of them. Consequently all frontend nodes answer the ARP requests coming from the WAN default gateway. In order to avoid this behaviour, the `net.ipv4.conf.<netif>.arp_ignore` and `net.ipv4.conf.<netif>.arp_announce` sysctl Linux kernel parameters, where `<netif>` is the network interface connected to the WAN network, are respectively set to 1 and 2. Please refer to the Linux documentation for more details on these parameters and their values: http://www.kernel.org/doc/Documentation/networking/ip-sysctl.txt

The Keepalived software also checks periodically if the `sshd` service is still available on all frontend nodes by trying to perform a TCP connection to their real IP addresses on the TCP/22 port (green arrow in the diagram). An exception must be present in the OUPUT chain of the firewall to allow these connections.

There is an unexplained behaviour in the Linux kernel where the Netfilter conntrack module considers that new TCP connections redirected by IPVS to the local `sshd` daemon have an invalid cstate. This point can be verified with well placed iptable rules using the LOG destination. This causes the TCP SYN/ACK answer from the `sshd` to be blocked by the OUTPUT chain since it considers the connection is new and not related to any incoming connections. To workaround this annoying behaviour, an exception has been added in the OUTPUT chain of the firewall to accept connections with a source port that is TCP/22 and a source IP address that is the virtual IP address. This is not totally satisfying in terms of security but there is no known easy or obvious way to exploit this security exception from a user perspective for other purposes.

If a slave frontend node becomes unavailable, Keepalived detects it either with VRRP checks, or with TCP checks in case only the `sshd` daemon is crashed. The IPVS rules are changed dynamically to avoid redirecting new TCP connections to this failing node.

If the master frontend node becomes unavailable, the Keepalived software selects a new master node within the other frontend nodes. Then, on this new master node, Keepalived restores the IPVS redirection rules (since they were previously disabled to avoid loops) and moves the virtual IP address from the loopback interface to the WAN network interface.

If a frontend node is scheduled to be turned of, it is possible to drain it.

5.5. Service nodes: DNS load-balancing and high-availability

This diagram gives an overview of the load-balancing and high-availability mechanisms involved in the DNS service of the Scibian HPC clusters:

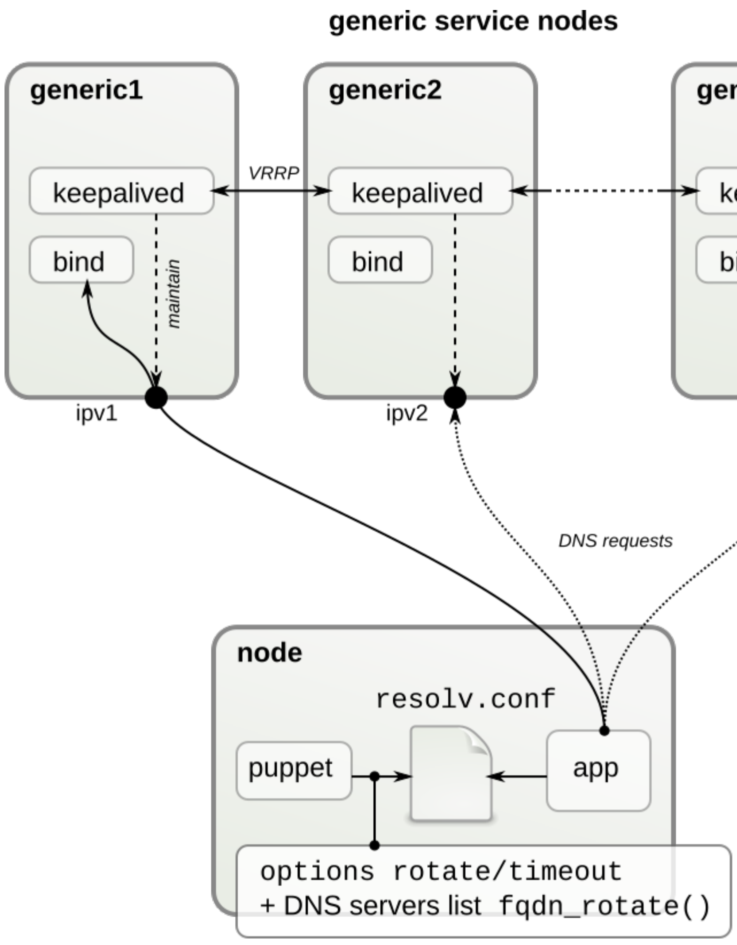


Figure 4. DNS service load-balancing and high-availability

On Linux systems, when an application needs to resolve a network hostname, it usually calls the `gethostbyname*()` and `getaddrinfo()` functions of the libc. With a common configuration of the Name Service Switch (in the file */etc/nsswitch.conf*), the libc searches for the IP address in the file */etc/hosts* and then fallbacks to a DNS resolution. The DNS solver gathers the IP address by sending a request to the DNS nameservers specified in the file */etc/resolv.conf*. If this file contains multiple nameservers, the solver sends the request to the first nameserver. If it does not get the answer before the timeout, it sends the request to the second nameserver, and so on . If the application needs another DNS resolution, the solver will follow the same logic, always trying the first nameserver in priority. It implies that, with this default configuration, as long as the first nameserver answers the requests before the timeout, the other nameservers are never requested and the load is not balanced.

This behavior can be slightly altered with additional options in the file */etc/resolv.conf*

- `options rotate`: this option tells the libc DNS solver to send requests to all the nameservers for successive DNS requests of a process. The DNS solver is stateless and loaded locally for the processes as a library, either as a shared library or statically in the binary. Therefore, the rotation status is local to a process. The first DNS request of a process will always be sent to the first nameserver. The rotation only starts with the second DNS request of a process. Notably, this means that a program which sends one DNS request during its lifetime, launched *n* times, will send *n* DNS requests to the first nameserver only. While useful for programs with long lifetime, this option can not be considered as an efficient and sufficient load-balancing technique.
- `options timeout:1`: this option reduces the request timeout from the default value i.e. 60 seconds to 1 second. This is useful when a nameserver has an outage since many processes are literally stuck waiting for this timeout when it occurs. This causes many latency issues. With this option, the libc DNS solver quickly tries the other nameservers and the side-effects of the outage are significantly reduced.

On Scibian HPC clusters, Puppet manages the file */etc/resolv.conf* and ensures these two options are present. It also randomizes the list of nameservers with the `fqdn_rotate()` function of the Puppet stdlib community module. This function randomizes the order of the elements of an array but uses the `fqdn` fact to ensure the order stays the same for a node with a given FQDN. That is, each node will get a different random rotation from this function, but a given node's result will be the same every time unless its hostname changes. This prevents the file content from changing with every Puppet runs. With this function, all the DNS nameservers are equivalently balanced on the nodes. Combined with the `options rotate`, it forms an efficient load-balancing mechanism.

The DNS servers are managed with the `bind` daemon on the generic service nodes. Each generic service nodes has a virtual IP address managed by a `keepalived` daemon and balanced between all the generic service nodes. The IP addresses of the nameservers mentioned in the file */etc/resolv.conf* on the nodes are these virtual IP addresses. If a generic service node fails, its virtual IP address is automatically routed to another generic service node. In combination with `options timeout:1`, this constitutes a reliable failover mechanism and ensures the high-availability of the DNS service.

5.6. Consul and DNS integration

This diagram illustrates how Consul and the DNS servers integrate to provide load-balanced and horizontally scaled network services with high-availability:

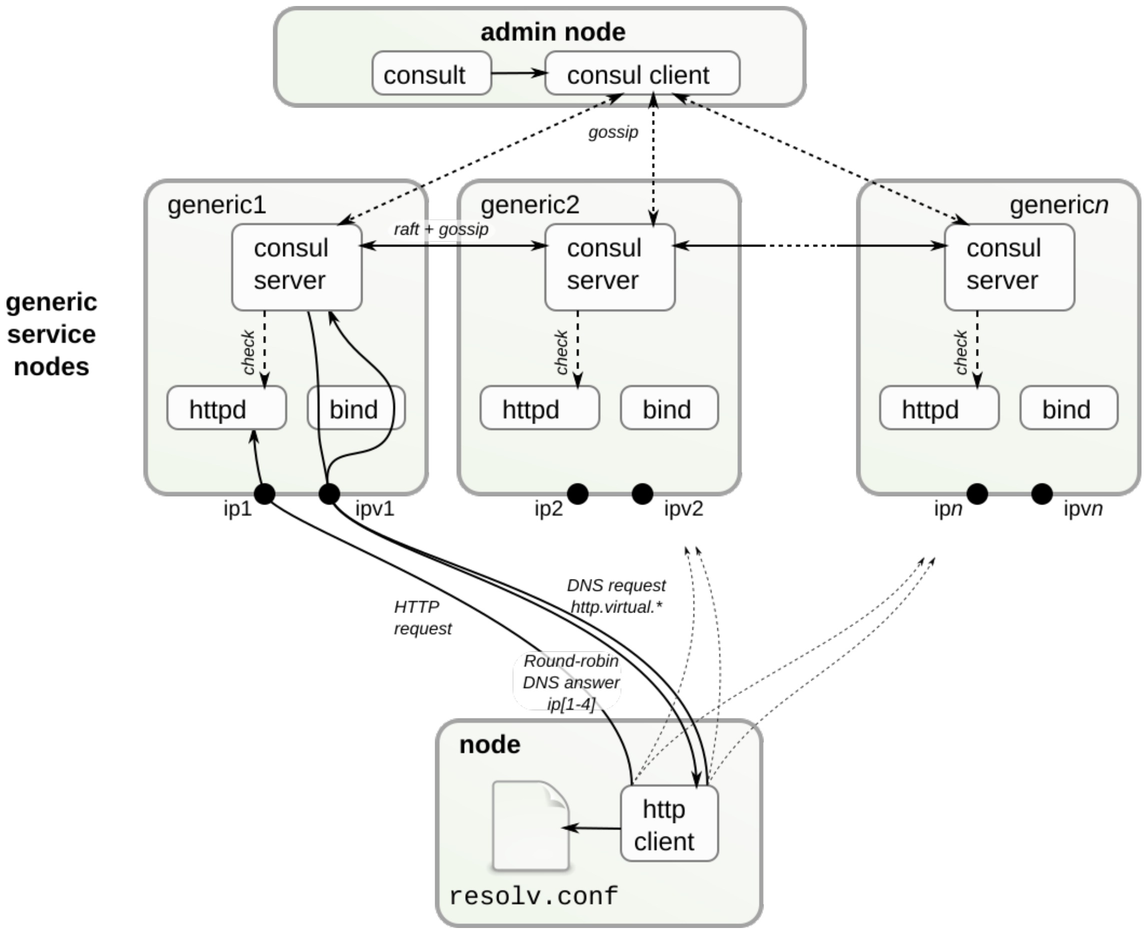


Figure 5. Consul, DNS server and services integration

The Consul agent daemon can run in two modes: server and client. The cluster of Consul servers maintains the state of the cluster using the raft protocol. The clients communicate with the servers to detect failures using the gossip protocol. Both agents expose the data of the Consul cluster through a HTTP REST API. On Scibian HPC clusters, the Consul servers run on the generic service nodes while the admin node runs a client agent.

As explained in the Software architecture section, Consul *discovers* network services on a pool of nodes. The services discovered by Consul on Scibian HPC clusters are hosted on the generic service nodes. Each Consul server is responsible for checking its locally running services, such as an HTTP server for example. The state being constantly shared by all Consul agents, every agent is actually able to tell where the services are available. Consul notably provides a DNS interface. Given a particular virtual hostname referring to a service, Consul can give the IP addresses of the servers currently running this service.

Consul is not designed to operate as a full DNS server. It listens for incoming requests on an alternative UDP port for a particular sub-domain `virtual.<domain>`, where `<domain>` is configurable and depends on the cluster.

On the nodes, the clients are configured to connect to services in this particular sub-domain, for example `http.virtual.<domain>` for the HTTP service. The DNS requests sent by the clients are received by the `bind` daemon through the virtual IP addresses of the generic service nodes, as explained in DNS Load-balancing and High-availability section. The DNS `bind` daemon is configured to forward the requests on the virtual sub-domain to the local Consul agent. The Consul agent answers the DNS request with the static IP address of the generic service nodes running this service, in random order.

In this architecture, both the DNS requests to the Consul servers and the services (*eg.* HTTP) requests are load-balanced on all the generic service nodes in high-availability mode. The same mechanism also applies to APT proxies, Ceph RADOS gateways, and so on.

The `Consult` utility is installed on the admin node to request the current status of the Consul cluster. It connects to the REST API of the Consul client running locally and prints the status on the standard output.

5.7. Scibian diskless initrd

5.7.1. The scibian-diskless-initramfs-config package

This package contains the necessary configuration in order to build an initramfs disk suitable for Scibian diskless nodes. It depends on the following packages:

- initramfs-tools
- live-torrent
- live-boot
- mdadm
- parted

initramfs-tools

`Initramfs-tools` is a Debian package that provides tools to create a bootable initramfs for Linux kernel packages. The initramfs is a compressed cpio archive. At boot time, the kernel unpacks that archive into RAM, mounts and uses it as the initial root file system. The mounting of the real root file system occurs in early user space.

live-boot

The `live-boot` package provides support for live systems. It depends on the `live-boot-initramfs-config` package, which is a backend for live-boot in initramfs config. In particular, it provides the "live" script in */usr/share/initramfs-tools/scripts/live*. This script is copied in the generated initramfs and can download and unpack live system images used as the root filesystem for diskles nodes.

live-torrent

The `live-torrent` package provides support for BitTorrent downloading for live systems. It depends on the `live-torrent-initramfs-tools` package, which provides the `ctorrent` binary (a bitorrent client) in the initramfs.

5.7.2. Generating the initramfs

With the packages described above installed on a Scibian system, it is possible to generate an initramfs able to download the root live system image via the BitTorrent protocol.

On a Scibian HPC cluster, it is recommended to use the `Clara` tool to generate the root live system image, and to generate the corresponding initramfs. It is possible to specify in the Clara configuration file which packages are mandatory in the image before generating the initramfs.

Here is an example of the "images" section of the Clara configuration file:

```
[images]
files_to_remove=/etc/udev/rules.d/70-persistent-
net.rules,/root/.bash_history,/etc/hostname
etc_hosts=10.0.0.1:service,10.0.0.2:admin1
extra_packages_image=hpc-config-apply,scibian-hpc-compute
packages_initrd=scibian-diskless-initramfs-config
```

With this configuration, `Clara` follows these steps to generate the initramfs:

1. Uncompress the squashfs image
2. Chroot in the directory created
3. Install the packages defined by the `packages_initrd` key in the Clara config file
4. Generate the initramfs
5. Do not re-compress the squashfs image

This method is used to guarantee consistency with the kernel in the squashfs image. It is also possible to generate an initramfs for an image based on Scibian9 with a machine installed on Scibian8, for example.

Installation procedure

This chapter describes how to install the Scibian HPC cluster software stack on a hardware infrastructure compliant with the reference architecture. The first section gives a quick overview of the main steps of the installation process. There are few requirements before starting the installation, they are listed in the following sections. Then, the successive steps are described in details. Finally, the chapter ends with the installation documentation of various optional features.

Chapter 6. Overview

The installation process of a Scibian HPC cluster starts with the administration cluster of the reference architecture. The administration cluster is composed of the admin node and a pool of generic services nodes. The generic services nodes run the base services required by all nodes, then they are the entry point of the installation procedure.

The first generic service node takes the role of the temporary installation in order to install all the other generic service nodes. When the generic services nodes are fully operational with the base software services stack, the admin node is installed. Then, the process continues with the services virtual machines and the set of additional services are installed.

Finally, the frontend and compute nodes of the userspace cluster are deployed and all the additional services are setup to make the Scibian HPC cluster fully operational.

Chapter 7. Requirements

There are a few requirements before starting up the cluster installation. This section aims to inventory all of these requirements, with example values.

NOTE For the sake of simplicity, the examples values are used all along the rest of the installation procedure documentation in various commands or code excerpts. These examples values must be replaced with values corresponding to your environment where appropriate.

Description	Example
Cluster name	`foobar` or `$CLUSTER`
Cluster prefix	`fb`
Network domain name	`hpc.example.org` or `$NETDOMAIN`
Remote Git internal configuration repository (cf. note)	`ssh://forge/hpc-privatedata`
DNS servers	• `1.1.1.1` • `2.2.2.2`
NTP servers	• `ntp1.example.org` • `ntp2.example.org`
SMTP servers	`smtp.example.org`
LDAP server	`ldap.example.org`
Groups of users in LDAP directory	• `grpusers1` • `grpusers2`

Description	Example
IP networks (with optional subnetworks) and adressing plan	4 IP networks (without subnetworks): • *backoffice*: `10.1.0.0/24` • *management*: `10.2.0.0/24` • *wan*: `10.3.0.0/24` • *lowlatency*: `10.4.0.0/24`
Areas (cf. note)	One *default* area with *backoffice* network or `$MAIN`
All MAC adresses	
Network interfaces configuration of all the nodes and equipments	Please refer to the following diagram for an example of generic service network configuration.
Local block storage configuration of all the nodes	For generic services nodes: * `sda` for system * `sdb` for Ceph

NOTE The deployment of Scibian HPC cluster is mainly based on Puppet-HPC. As explained in the *Software Architecture* chapter of Puppet-HPC documentation, it works in combination with an internal configuration repository containing all configuration settings and data specific to your organization. This Git repository does not have to be populated to proceed the installation. If it is empty, the Internal repository section of this chapter explains how to initialize it from scratch for Puppet-HPC.

NOTE The advanced network topologies support on Scibian HPC clusters, including subnetworks and areas, relies on the features provided by Puppet-HPC stack. For more details about areas concept and subnetworking possibilities, please refer to *Puppet-HPC Reference Documentation* (chapter *Software Architecture*, section *Cluster Definition*).

This diagram represents an exemple network interfaces configuration for the generic services nodes of a Scibian HPC cluster:

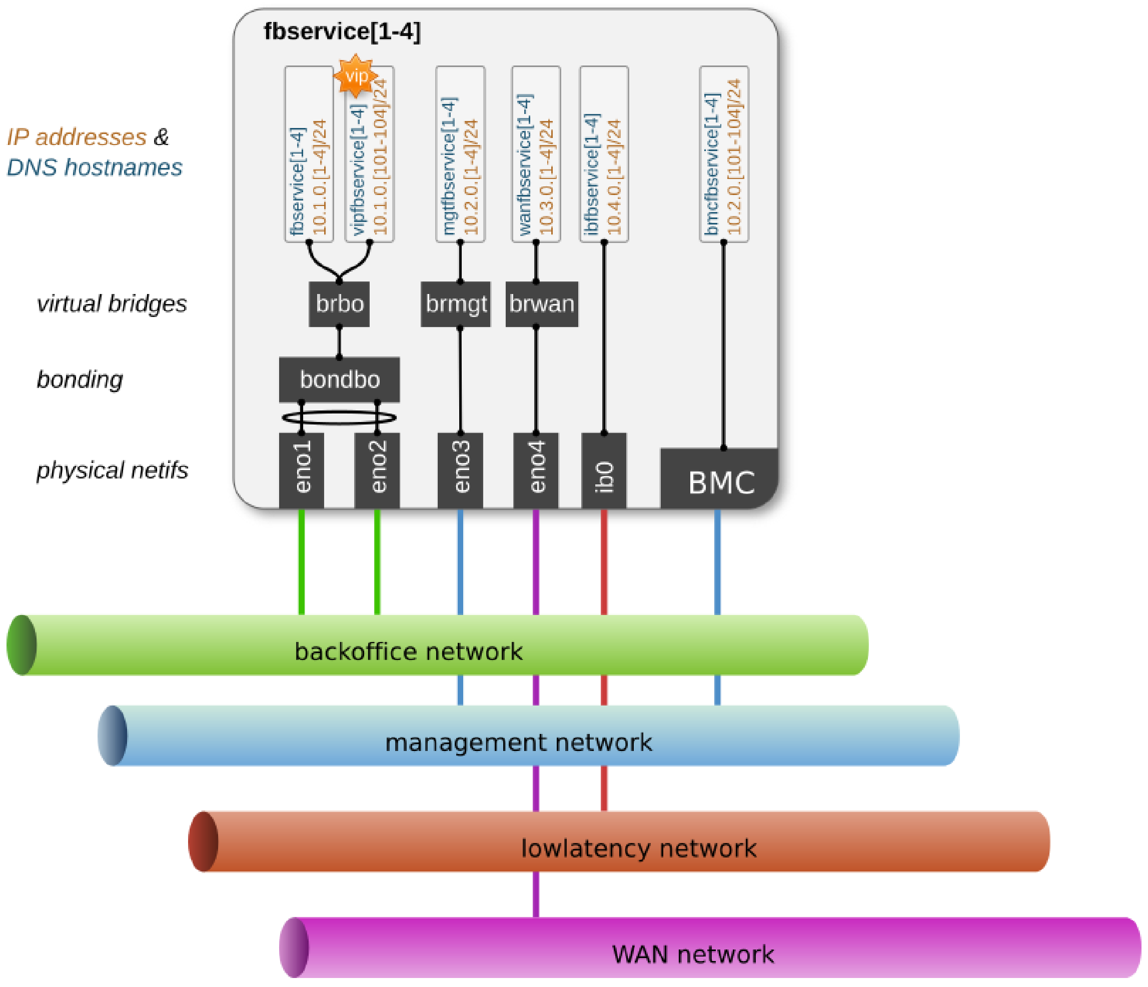

fbservice[1-4]
IP addresses & DNS hostnames
virtual bridges
bonding
physical netifs
vip
fbservice[1-4] 10.1.0.[1-4]/24
vipfbservice[1-4] 10.1.0.[101-104]/24
mgtfbservice[1-4] 10.2.0.[1-4]/24
wanfbservice[1-4] 10.3.0.[1-4]/24
ibfbservice[1-4] 10.4.0.[1-4]/24
bmcfbservice[1-4] 10.2.0.[101-104]/24
brbo
brmgt
brwan
bondbo
eno1
eno2
eno3
eno4
ib0
BMC
backoffice network
management network
lowlatency network
WAN network

Figure 6. Example generic service nodes network interfaces

Chapter 8. Temporary installation node

The first step of the installation process is to install the first generic service node. This node will ensure the role of temporary installation node for the other generic service nodes. Before the admin node is installed, all operations (unless explicitely stated) are realized on this temporary installation node.

8.1. Base installation

Install Debian 9 Stretch base system using any of the official Debian installation media (CD, DVD, USB key, PXE server, etc) at your convenience. Configure the network interfaces with static IP addresses in compliancy with the cluster IP adressing plan. Set the hostname following the architecture conventions, for example: `fbservice1`.

Once the node has rebooted on freshly installed system, add the Scibian 8 APT repositories to the configuration:

```
echo <<EOF >/etc/apt/sources.list.d/scibian9.list
deb http://scibian.org/repo/ scibian9 main
EOF
```

Download and enable Scibian repository keyring:

```
apt-get install --allow-unauthenticated scibian-archive-keyring
```

Update the packages repositories local database:

```
apt-get update
```

Install the following Scibian HPC administration node meta-package:

```
apt-get install scibian-hpc-admin
```

8.2. Administration environment

All the files manipulated during the installation process will be placed into a dedicated working directory. The location of this directory is arbitrary, for example: `~root/install`. This directory will be designated as `$ADMIN` in the following section of the installation procedure documentation.

```
export ADMIN=~root/install
mkdir $ADMIN && cd $ADMIN
```

Clone both Puppet-HPC and internal configuration repositories into this dedicated working directory:

```
git clone https://github.com/edf-hpc/puppet-hpc.git
git clone ssh://forge/hpc-privatedata.git
```

At this stage, the internal repository can be populated with all files and data initially required to install the cluster.

Chapter 9. Internal configuration repository

The internal configuration repository required by Puppet-HPC is designed to be shared upon multiple clusters in an organization. Then, it has to be initialized only for the first cluster installation. Its structure and content is fully explained in the *Software Architecture* chapter of Puppet-HPC documentation.

This section provides examples configurations snippets to quickstart this internal configuration repository from scratch.

9.1. Base directories

If the internal configuration repository is fully empty and is initialiazed from scratch, a few base directories must be created under its root.

IMPORTANT This step must not be realized if the internal configuration repository is not empty, typically if it has already been initialized for another cluster.

```
cd $ADMIN/hpc-privatedata
mkdir files hieradata puppet-config
```

9.2. Organization settings

Some settings are common to all HPC clusters of an organization, in particular settings regarding the external services. To avoid duplication of these settings in all HPC cluster configurations, they are defined once in the organization layer of the hiera repository shared by all HPC clusters.

IMPORTANT This step must be done only once for the organization. It can be skipped safely if the organization layer YAML file already exists.

Initialize the file `$ADMIN/hpc-privatedata/hieradata/org.yaml` with the following content:

```
##### Common #####

org:    'company' # lower-case name of the organization
locale: 'en_US'

##### DNS #####

domain: "%{::cluster_name}.hpc.example.org"

profiles::dns::client::search: "%{hiera('domain')} hpc.example.org"

profiles::dns::server::config_options:
  forwarders:
    - '1.1.1.1'
    - '2.2.2.2'

##### NTP #####

profiles::ntp::server::site_servers:
  - "ntp1.example.org"
  - "ntp2.example.org"

##### APT #####

profiles::cluster::apt_sources:
  scibian9:
    '30_scibian9':
      location:
"http://%{hiera('scibian_mirror_server')}/%{hiera('scibian_mirror_dir')}"
      release: 'scibian9'
      repos: 'main'
      pin:
        priority:   '1000'
        originator: 'Scibian'
      include:
        src: false
      architecture: 'amd64,i386'
    '50_stretch':
      location:
"http://%{hiera('debian_mirror_server')}/%{hiera('debian_mirror_dir')}"
      release: 'stretch'
      repos: 'main contrib non-free'
      pin:
        priority:   '500'
        originator: 'Debian'
      include:
        src: false
      architecture: 'amd64,i386'
    '50_stretch-updates':
      location:
"http://%{hiera('debian_mirror_server')}/%{hiera('debian_mirror_dir')}"
      release: 'stretch-updates'
      repos: 'main contrib non-free'
      pin:
        priority:   '500'
        originator: 'Debian'
      include:
        src: false
      architecture: 'amd64,i386'
    '50_stretch-security':
      location:
"http://%{hiera('debian_mirror_server')}/%{hiera('debian_sec_mirror_dir')}"
      release: 'stretch/updates'
      repos: 'main contrib non-free'
      pin:
        priority:   '500'
        originator: 'Debian'
      include:
        src: false
      architecture: 'amd64,i386'

##### SMTP/Postfix #####

profiles::postfix::relay::config_options:
  relay_domains:       '$mydestination example.org'
  relayhost:           'smtp.example.org'

##### LDAP/SSSD #####

ldap_external: 'ldap.example.org'
```

```
profiles::auth::client::sssd_options_domain:
  ldap_search_base:       'dc=example,dc=org'
  ldap_user_search_base:  'ou=people,dc=example,dc=org'
  ldap_group_search_base: 'ou=groups,dc=example,dc=org'
```

NOTE This configuration supposes the APT, NTP, SMTP, DNS and LDAP settings are similar on all the HPC clusters of your organization. This might not be true in some specific organization environments. In this case, the settings of the affected services must be defined in the cluster specific layers of the hiera repository instead.

The examples values must be replaced with the settings corresponding to your organization environment.

9.3. Cluster directories

Some directories are required to store cluster specific file and settings inside the internal configuration repository. Create these directories with the following command:

```
mkdir $ADMIN/hpc-privatedata/puppet-config/$CLUSTER \
      $ADMIN/hpc-privatedata/files/$CLUSTER \
      $ADMIN/hpc-privatedata/hieradata/$CLUSTER \
      $ADMIN/hpc-privatedata/hieradata/$CLUSTER/roles
```

9.4. Puppet configuration

The `hpc-config-push` Puppet-HPC utility expects to find a Puppet and Hiera configuration files for the cluster under the `puppet-config` directory of the internal configuration repository. Simply copy examples configuration files provided with Puppet-HPC:

```
cp $ADMIN/puppet-hpc/examples/privatedata/{puppet.conf,hiera.yaml} \
   $ADMIN/hpc-privatedata/puppet-config/$CLUSTER/
```

The `hiera.yaml` file notably specifies the layers of YAML files composing the hiera repository. It can eventually be tuned for additional layer to fit your needs.

Puppet-HPC requires the cluster name and prefix to be a declared a YAML file `cluster-nodes.yaml`. Technically speaking, this YAML file is deployed by `hpc-config` utilities on every nodes in `/etc/hpc-config` directory. It is then used as aconfiguration input file for the external node classifer (ENC) `cluster-node-classifier` provided with `hpc-config`. Define the file `$ADMIN/hpc-privatedata/puppet-config/$CLUSTER/cluster-nodes.yaml` with the following content:

```
---
cluster_name:   foobar
cluster_prefix: fb
```

If the cluster is composed of multiple *areas*, they must also be declared in this YAML file with their associated roles. For example:

```
areas:
  infra:
    - admin
    - service
  user:
    - front
    - cn
```

In this declaration, the *admin* and *service* roles are membered of the *infra* area, the *front* and *cn* roles are membered of the *user* area.

9.5. Cluster definition

The cluster specific layers of the Hiera repository must be initialized with a sufficient description of the HPC cluster. This description is the *cluster definition*.

9.5.1. Networks definition

A specific layer in the hiera repository stack is dedicated to all the networks settings of the HPC cluster. This layer is defined in file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/network.yaml`. Initialize this file with the following content:

```
profiles::network::ib_enable:  false
profiles::network::opa_enable: true

net_topology:
  wan:
    name:             'WAN'
    prefixes:         'wan'
    ipnetwork:        '10.3.0.0'
    netmask:          '255.255.255.0'
    prefix_length:    '/24'
    gateway:          '10.3.0.254'
    broadcast:        '10.3.0.255'
    ip_range_start:   '10.3.0.1'
    ip_range_end:     '10.3.0.254'
    firewall_zone:    'wan'
  backoffice:
    name:             'CLUSTER'
    ipnetwork:        '10.1.0.0'
    netmask:          '255.255.255.0'
    prefix_length:    '/24'
    gateway:          '10.1.0.0' # fbproxy
    broadcast:        '10.1.0.255'
    ip_range_start:   '10.1.0.1'
    ip_range_end:     '10.1.0.254'
    firewall_zone:    'clstr'
    pool0:
      ip_range_start: '10.1.0.1'
      ip_range_end:   '10.1.0.254'
  lowlatency:
    name:             'LOWLATENCY'
    prefixes:         'opa'
    ipnetwork:        '10.4.0.0'
    netmask:          '255.255.255.0'
    prefix_length:    '/24'
    broadcast:        '10.4.0.255'
    ip_range_start:   '10.4.0.1'
    ip_range_end:     '10.4.0.254'
    firewall_zone:    'clstr'
  management:
    name:             'MGT'
    prefixes:         'mgt'
    ipnetwork:        '10.2.0.0'
    netmask:          '255.255.255.0'
    prefix_length:    '/24'
    broadcast:        '10.2.0.255'
    ip_range_start:   '10.2.0.1'
    ip_range_end:     '10.2.0.254'
    firewall_zone:    'clstr'
  bmc:
    name:             'BMC'
    prefixes:         'bmc'
    ipnetwork:        '10.2.0.0'
    netmask:          '255.255.255.0'
    prefix_length:    '/24'
    broadcast:        '10.2.0.255'
    ip_range_start:   '10.2.0.1'
    ip_range_end:     '10.2.0.254'
    firewall_zone:    'clstr'

network::bonding_options:
  bondbo:
    slaves:
      - eno1
      - eno2
    options:     'mode=802.3ad primary=eth2 miimon=100 updelay=200 downdelay=200'
    description: 'service nodes on backoffice/mgt networks'

network::bridge_options:
  brbo:
    ports:
      - bondbo
    description: 'service nodes on backoffice network'
  brmgt:
    ports:
      - eno3
    description: 'service nodes on management network'
  brwan:
    ports:
      - eno4
    description: 'service nodes on WAN network'

master_network:
  fbservice1:
    fqdn: "fbservice1.%{hiera('domain')}"
    networks:
      backoffice:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:00'
        'IP':       '10.1.0.1'
        'device':   'brbo'
        'hostname': 'fbservice1'
      lowlatency:
        'IP':       '10.4.0.1'
        'device':   'ib0'
        'hostname': 'opafbservice1'
      bmc:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:01'
        'IP':       '10.2.0.101'
        'hostname': 'bmcfbservice1'
      management:
        'IP':       '10.2.0.1'
        'device':   'brmgt'
        'hostname': 'mgtfbservice1'
      wan:
        'IP':       '10.3.0.1'
        'device':   'brwan'
        'hostname': 'wanfbservice1'
  fbservice2:
    fqdn: "fbservice2.%{hiera('domain')}"
    networks:
      backoffice:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:02'
        'IP':       '10.1.0.2'
        'device':   'brbo'
        'hostname': 'fbservice2'
      lowlatency:
        'IP':       '10.4.0.2'
        'device':   'ib0'
        'hostname': 'opafbservice2'
      bmc:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:03'
        'IP':       '10.2.0.102'
        'hostname': 'bmcfbservice2'
      management:
        'IP':       '10.2.0.2'
        'device':   'brmgt'
        'hostname': 'mgtfbservice2'
      wan:
        'IP':       '10.3.0.2'
        'device':   'brwan'
        'hostname': 'wanfbservice2'
  fbservice3:
    fqdn: "fbservice3.%{hiera('domain')}"
    networks:
      backoffice:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:04'
        'IP':       '10.1.0.3'
        'device':   'brbo'
        'hostname': 'fbservice3'
      lowlatency:
        'IP':       '10.4.0.3'
        'device':   'ib0'
        'hostname': 'opafbservice3'
      bmc:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:05'
        'IP':       '10.2.0.103'
        'hostname': 'bmcfbservice3'
      management:
        'IP':       '10.2.0.3'
        'device':   'brmgt'
        'hostname': 'mgtfbservice3'
      wan:
        'IP':       '10.3.0.3'
        'device':   'brwan'
        'hostname': 'wanfbservice3'
  fbservice4:
    fqdn: "fbservice4.%{hiera('domain')}"
    networks:
```

```
      backoffice:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:06'
        'IP':       '10.1.0.4'
        'device':   'brbo'
        'hostname': 'fbservice4'
      lowlatency:
        'IP':       '10.4.0.4'
        'device':   'ib0'
        'hostname': 'opafbservice4'
      bmc:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:07'
        'IP':       '10.2.0.104'
        'hostname': 'bmcfbservice4'
      management:
        'IP':       '10.2.0.4'
        'device':   'brmgt'
        'hostname': 'mgtfbservice4'
      wan:
        'IP':       '10.3.0.4'
        'device':   'brwan'
        'hostname': 'wanfbservice4'

#### High-Availability Virtual IP addresses ######

vips:
  service1:
    network:    'backoffice'
    ip:         '10.1.0.101'
    hostname:   'vipfbservice1'
    router_id:  161
    master:     'fbservice1'
    members:    'fbservice[1-4]'
    secret:     "%{hiera('vips_secret')}"
    advert_int: '2'
  service2:
    network:    'backoffice'
    ip:         '10.1.0.102'
    hostname:   'vipfbservice2'
    router_id:  162
    master:     'fbservice2'
    members:    'fbservice[1-4]'
    secret:     "%{hiera('vips_secret')}"
    advert_int: '2'
  service3:
    network:    'backoffice'
    ip:         '10.1.0.103'
    hostname:   'vipfbservice3'
    router_id:  163
    master:     'fbservice3'
    members:    'fbservice[1-4]'
    secret:     "%{hiera('vips_secret')}"
    advert_int: '2'
  service4:
    network:    'backoffice'
    ip:         '10.1.0.104'
    hostname:   'vipfbservice4'
    router_id:  164
    master:     'fbservice4'
    members:    'fbservice[1-4]'
    secret:     "%{hiera('vips_secret')}"
    advert_int: '2'
```

The first `profiles::network::{ip,opa}_enable` define which high-performance interconnect network technology is involved in the HPC cluster (InfiniBand or Intel Omni-Path).

The `net_topology` hash basically define the adressing maps of the various IP networks of the clusters, along with some metadata such as the network hostname prefixes, the DHCP dynamic pools and the firewall zones associated to these IP networks.

The `network::bonding_options` and `network::bridge_options` hashes respectively define all the network interfaces bondings and virtual bridges involved on the nodes of the HPC cluster. Note that these settings are global to all nodes.

The `master_network` hash defines the list of nodes and all their network interfaces with the associated IP addresses, network hostnames and eventually MAC addresses (on the administration and bmc networks).

Finally, the `vips` hash define the virtual highly-available IP addresses (VIP) managed by nodes of the HPC cluster.

NOTE At this stage, the `vips` hash interpolates an undefined parameter `vips_secret`. It will be actually defined in Section 9.7.6, “VIP encryption keys” within the area hiera layer.

Initially, the YAML file must contain all the IP network definitions and the network settings of all the generic service nodes with their VIP.

9.5.2. General cluster settings

The cluster specific general parameters and services settings are located in file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml`. Initialize this file with the following content:

```
user_groups: # Array of user groups allowed to access to the cluster
  - 'grpusers1'
  - 'grpusers2'
admin_group: 'grpadmin'

###### Areas ######

# Optionlly define areas (with associated network/subnetworks) by
# uncommenting the following hash:
#
#areas:
#  infra:
#    network: backoffice
#    subnetwork: boinfra
#  user:
#    network: backoffice
#    subnetwork: bouser
#
# If using only the default area, this parameter does not need to be defined.

###### Installer ######
scibian_mirror_server: 'scibian.org'
scibian_mirror_dir:    'repo'
debian_mirror_server:  'deb.debian.org'  # debian geo mirror
debian_mirror_dir:     'debian'
```

```
###### DNS Cluster settings ######

profiles::dns::client::nameservers:
  - '10.1.0.101' # VIP addresses of generic service nodes on administration
  - '10.1.0.102' # network
  - '10.1.0.103'
  - '10.1.0.104'
profiles::dns::server::config_options:
  listen-on:
    - '127.0.0.1'
    - '10.1.0.1'   # Static IP addresses of generic service nodes on
    - '10.1.0.2'   # administration network
    - '10.1.0.3'
    - '10.1.0.4'
    - '10.1.0.101' # VIP addresses of generic service nodes on administration
    - '10.1.0.102' # network
    - '10.1.0.103'
    - '10.1.0.104'
    - '10.2.0.1'   # Static IP addresses of generic service nodes on
    - '10.2.0.2'   # management network
    - '10.2.0.3'
    - '10.2.0.4'

###### Bootsystem ######

boot_params:
  fbservice[1-4]:  # generic service nodes specific boot params
    boot_dev: 'eno0'

# hpc-config-apply configuration file downloaded by the debian-installer.
boothttp::hpc_files:
  "%{hiera('website_dir')}/disk/hpc-config.conf":
    source: "file:///etc/hpc-config.conf"

###### DHCP ######

profiles::dhcp::default_options:
  - 'INTERFACES=bradm' # bridge interfaces of the generic service nodes on the
                       # administration and management networks
profiles::dhcp::includes:
  bo-subnet:
    'pool_name':                   'subnet'
    'subnet_name':                 'backoffice-default'
    'tftp':                        true
    'pool':
      'use-host-decl-names':       'on'
      'deny':                      'unknown-clients'
      'max-lease-time':            '1800'
      # Range of IP addresses on the administration network
      'range':                     '10.1.0.1 10.1.0.254'
      'include':                   '/etc/dhcp/adm_subnet'
  mgt-subnet:
    'pool_name':                   'subnet'
    'subnet_name':                 'management-default'
    'tftp':                        false
    'pool':
      'use-host-decl-names':       'on'
      'deny':                      'unknown-clients'
      'max-lease-time':            '1800'
      # Range of IP addresses on the management network
      'range':                     '10.2.0.1 10.2.0.254'
      'include':                   "/etc/dhcp/mgt_subnet"
```

Additionally to some general parameters (`user_groups`, `admin_group`), the initial version of this file notably contains the configuration of the base services required to install nodes on disk

(DNS, TFTP, HTTP, DHCP, Debian installer, etc).

Also, in order to prevent user to access the cluster during the installation process, it is recommended to enable the maintenance mode in this file:

```
profiles::access::maintenance_mode: true
```

9.6. Service role

The Puppet role `service` associated to the generic service nodes must be defined with the corresponding profiles. This is achieved by initializing file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/roles/service.yaml` with the following content:

```
profiles:
  # common
  - profiles::cluster::common
  - profiles::systemd::base
  - profiles::ssmtp::client
  - profiles::network::base
  - profiles::dns::client
  - profiles::access::base
  - profiles::openssh::server
  - profiles::openssh::client
  - profiles::environment::base
  - profiles::environment::limits
  - profiles::environment::service
  - profiles::log::client
  # HW host
  - profiles::hardware::ipmi
  - profiles::hardware::admin_tuning
  # service
  - profiles::hpcconfig::push
  - profiles::hpcconfig::apply
  - profiles::ntp::server
  - profiles::openssh::client_identities
  - profiles::clush::client
  - profiles::ha::base
  - profiles::http::secret
  - profiles::http::system
  - profiles::apt::proxy
  - profiles::log::server
  - profiles::dns::server
  - profiles::bootsystem::server
  - profiles::dhcp::server

profiles::network::gw_connect: 'wan'
```

The first profiles (below the *common* comment) are common to all nodes of the cluster. The profiles after the *HW host* comment are common to all bare metal nodes. The last profiles, after the *service* comment, carry the base services hosted by the generic service nodes.

The last parameter `profiles::network::gw_connect` defines on which network's gateway the nodes use as their default route.

9.7. Authentication and encryption keys

Cluster configurations comprises many sensitive data such as passwords, private keys, confidential files, and so on. The Puppet-HPC stack provides an integrated mechanism for storing these data securily in the internal configuration repository. This mechanism is fully explained in the *Puppet-HPC Reference Documentation* (chapter *Software Architecture*, section *Sensitive Data Encryption*). Basically, these data are encrypted using two keys:

- asymmetric PKCS7 key pair for encrypting values in Hiera with eyaml,
- symmetric AES key, named as the *cluster password*, for encrypting files.

These keys are also used to decrypt data on nodes of the cluster *main area*. If the cluster is composed of only one area (ex: *default*), only these two keys are involved on the cluster. Otherwise, additional and dedicated keys are used by the other areas to decrypt their sensitive data.

IMPORTANT

In all cases, only **the keys of the main area are used to manipulate the sensitive data in the internal configuration repository**. The keys of the optional other areas are used dynamically and transparently by the hpc-config utilities in the Puppet-HPC stack.

9.7.1. Main area keys bootstrap

The PKCS7 eyaml key pair must be created initially. First, create the directory for these keys:

```
mkdir -p /etc/puppet/secure/keys
```

Then, setup the eyaml configuration to use this directory:

```
mkdir -p ~/.eyaml
cat << EOF > ~/.eyaml/config.yaml
---
  pkcs7_private_key: /etc/puppet/secure/keys/private_key.pkcs7.pem
  pkcs7_public_key: /etc/puppet/secure/keys/public_key.pkcs7.pem
EOF
```

And generate the keys with:

```
eyaml createkeys
```

Restrict modes and ownership properly on files and directories:

```
chmod 700 /etc/puppet/secure
chown -R puppet:puppet /etc/puppet/secure/keys
chmod -R 0500 /etc/puppet/secure/keys
chmod 0400 /etc/puppet/secure/keys/*.pem
```

Then, generate the *cluster password*:

```
openssl rand -base64 32
```

The output of this command must be saved encrypted with eyaml keys in the area layer of the internal Hiera repository. Create the directory of this layer and edit the area YAML file with `eyaml`:

```
mkdir $ADMIN/hpc-privatedata/hieradata/$CLUSTER/areas
eyaml edit $ADMIN/hpc-privatedata/hieradata/$CLUSTER/areas/$MAIN.yaml
```

Where `$MAIN` is the name of the main area (ex: `default` or `infra`).

In the editor, add a line like this, and save:

```
cluster_decrypt_password: DEC::PKCS7[<the password given by the openssl command>]!
```

Finally, store an encrypted archive of the eyaml keys in the internal configuration repository:

```
# create main area eyaml directory
mkdir -p $ADMIN/hpc-privatedata/files/$CLUSTER/$MAIN/eyaml/$MAIN

# build archive
tar cJf $ADMIN/hpc-privatedata/files/$CLUSTER/$MAIN/eyaml/$MAIN/keys.tar.xz \
    -C /etc/puppet/secure keys

# encrypt archive
$ADMIN/puppet-hpc/scripts/encode-file.sh \
    $ADMIN/hpc-privatedata $CLUSTER \
    $ADMIN/hpc-privatedata/files/$CLUSTER/$MAIN/eyaml/$MAIN/keys.tar.xz

# delete temporary unencrypted archive
rm $ADMIN/hpc-privatedata/files/$CLUSTER/$MAIN/eyaml/$MAIN/keys.tar.xz
```

9.7.2. Other areas encryption keys

This step can be skipped if the cluster is composed of only one area. Otherwise, this step **must be repeated** for all areas except the main one.

First, generate the *cluster password* of the area:

```
openssl rand -base64 32
```

Save the output into the area YAML file with `eyaml`:

```
eyaml edit $ADMIN/hpc-privatedata/hieradata/$CLUSTER/areas/$OTHER.yaml
```

Where `$OTHER` is the name of the other area (ex: `user`).

In the editor, add a line like this, and save:

```
cluster_decrypt_password: DEC::PKCS7[<the password given by the openssl command>]!
```

Set a shell variable `KEYS_DIR`, with the path of the other area keys directory, in order to simplify following commands:

```
export KEYS_DIR=$ADMIN/hpc-privatedata/files/$CLUSTER/$MAIN/eyaml/$OTHER
```

Create the directories for storing the area eyaml keys, including a `keys` temporary subdirectory:

```
mkdir -p $KEYS_DIR/keys
```

Generate the area eyaml keys:

```
eyaml createkeys \
  --pkcs7-private-key $KEYS_DIR/keys/private_key.pkcs7.pem \
  --pkcs7-public-key $KEYS_DIR/keys/public_key.pkcs7.pem
```

Build the archive and clean temporary files:

```
# build archive
tar cJf $KEYS_DIR/keys.tar.xz \
    -C $KEYS_DIR keys

# delete temporary keys subdirectory
rm -rf $KEYS_DIR/keys
```

Finally, encrypt the archive and remove the unencrypted version:

```
# encrypt archive
$ADMIN/puppet-hpc/scripts/encode-file.sh \
    $ADMIN/hpc-privatedata $CLUSTER \
    $KEYS_DIR/keys.tar.xz

# delete temporary unencrypted archive
rm $KEYS_DIR/keys.tar.xz
```

9.7.3. SSH host keys

The SSH host keys must stay consistent between node re-installations and/or diskless reboots. To ensure this, the SSH host keys are generated in the cluster's files directory of the internal configuration repository before their first installation and/or diskless boot.

This cluster nodes classifier utility is run by the SSH hostkeys generation script to get the area of the nodes. Initially, copy the configuration file of this utility to its target path:

```
cp $ADMIN/hpc-privatedata/puppet-config/$CLUSTER/cluster-nodes.yaml \
  /etc/hpc-config/cluster-nodes.yaml
```

To generate the hostkeys, the script needs to know the local domain name of the cluster. By default, the script will use the local domain of the machine where it runs by default. If this is not correct you must provide the domain in argument. Run the script with the following command:

```
cd $ADMIN && puppet-hpc/scripts/sync-ssh-hostkeys.sh \
  hpc-privatedata $CLUSTER [$CLUSTER.$NETDOMAIN]
```

This script ensures that all nodes present in the `master_network` hash have valid SSH host keys. During this step, the `known_hosts` file will also be synchronized with the generated keys. This file will be stored in `hpc-privatedata/files/$CLUSTER/cluster/ssh/known_hosts`.

9.7.4. SSH root key

For password-less SSH authentication from the admin and generic service nodes to all the other nodes of the cluster, SSH authentication keys pair are deployed for root on the nodes.

First, create the `rootkeys` sub-directory in the cluster's files directory of the internal configuration repository:

```
cd $ADMIN && mkdir -p hpc-privatedata/files/$CLUSTER/$MAIN/rootkeys
```

Then, generate the key pair:

```
ssh-keygen -t rsa -b 2048 -N '' -C root@$CLUSTER \
  -f hpc-privatedata/files/$CLUSTER/$MAIN/rootkeys/id_rsa_root
```

Key type and size can be adjusted. Encode the private key with the following helper script provided by Puppet-HPC:

```
puppet-hpc/scripts/encode-file.sh hpc-privatedata $CLUSTER \
  hpc-privatedata/files/$CLUSTER/$MAIN/rootkeys/id_rsa_root
```

Do not forget to remove the generated unencrypted private key:

```
rm hpc-privatedata/files/$CLUSTER/$MAIN/rootkeys/id_rsa_root
```

Finally, publish the public key with the following parameter in the cluster specific layer of the hiera repository `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml`:

```
openssh::server::root_public_key: <pubkey>
```

9.7.5. Root password

The root password is stored hashed in Hiera repository and encrypted with eyaml keys. Set the root password on the temporary installation node (using `passwd` command) then extract the resulting hash from `/etc/shadow` file. Get the whole second field:

```
root:<long password hash>:17763:0:99999:7:::
```

Then paste the hash into the main area Hiera layer using `eyaml` command:

```
eyaml edit $ADMIN/hpc-privatedata/hieradata/$CLUSTER/areas/$MAIN.yaml
```

Then add this line in the editor:

```
profiles::cluster::root_password_hash: DEC::PKCS7[<long password hash>]!
```

The `profiles::cluster::root_password_hash` must be defined in all areas of the cluster. If the cluster is composed of multiple areas, you must repeat the steps for all other areas. It is obviously more secure if the password is different in each area, since an area will not be able to access the hash of the root password of the nodes in other areas.

9.7.6. VIP encryption keys

The `keepalived` service relies on a shared key to authenticate the nodes sharing a VRRP instance to manage a virtual IP address (VIP).

With Puppet-HPC, this key is common to all VIP instances of an area. Sensitive data being local to an area, keys must be generated for each area that includes nodes sharing a VIP.

Generate a random password with the following command:

```
makepasswd --minchars=16 --maxchars=16
```

Edit the area YAML file with `eyaml`:

```
eyaml edit $ADMIN/hpc-privatedata/hieradata/$CLUSTER/areas/$AREA.yaml
```

And save the output of the `makepasswd` command with the following parameter:

```
vips_secret: DEC::PKCS7[<password>]!
```

This procedure must be repeated for all areas that include nodes sharing a VIP.

Chapter 10. Generic service nodes

10.1. Temporary installation services

The goal of this section is to configure the Temporary Installation Services on the Temporary Installation Node. This process is done in two steps:

- A First Run only using local files or external services
- A Second Run reconfiguring the Temporary Installation Node to use the services setup during the First Run with values that will also be used to install the other generic nodes remotely.

10.2. First Run

Consul is not available because the consul cluster needs quorum to work. Quorum can only be achieved when more than half of the generic service nodes are configures. The DNS server is therefore configured to only returns the temporary installation node for all requests on the consul domain. This is done simply by adding temporarily the following parameters in file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml`:

```
dns::server::virtual_relay: false
install_server_ip: '10.1.0.1' # static IP address of the temporary
                              # installation node on the administration
                              # network
```

Technically speaking, these parameters makes bind authorative on the *virtual* DNS zone before Consul service discovery utility is available. The virtual zone contains all the symbolic names to the network services (*ex:* `http.virtual`). This way, all services will be directed to the temporary installation node with the IP address provided in `install_server_ip` parameter.

The first run also needs to work properly without a local DNS server and without a local repository cache proxy. These services will be configured during this first run. Local repositories must also be disabled during the first run.

```
# The normal values must be searched in cluster.yaml and commented out
apt::proxy_host:   ''
profiles::dns::client::nameservers:
  - '172.16.1.1' # External DNS server
hpcconfig::push::config_options:
  global:
    cluster:     "%{::cluster_name}"
    areas:       '<AREAS>'
    mode:        'posix'
    destination: "%{hiera('profiles::http::system::docroot')}/hpc-config"
```

Where <AREAS> must be replaced with the comma separated list of areas on the cluster (ex:

`infra`, `user` or `default`).

The configuration will be pushed on local files while the temporary installation is used. The settings above configures this, but the first push must use a configuration that will be created manually in the file: `/etc/hpc-config/push.conf`.

```
[global]
environment=production
version=latest
areas=<AREAS>
destination=/var/www/system/hpc-config
cluster=<CLUSTER NAME>
mode=posix
```

The directory where the keys were generated cannot be used as a key source for apply because it will be overwritten during the apply. So it must be copied before doing the apply. To deploy the configuration of the temporary installation node, run the following commands:

```
cd $ADMIN
hpc-config-push
mkdir $ADMIN/keys
chmod 700 $ADMIN/keys
tar cJf  $ADMIN/keys/keys.tar.xz -C/etc/puppet/secure keys
hpc-config-apply --source file:///var/www/system/hpc-config \
                   --keys-source=file://$ADMIN/keys \
                   [--area <AREA>]
                   --verbose
rm -rf $ADMIN/keys
```

The area parameter is required if the service node is not in *default* area.

If the run returned no error, there is some checks to do before proceeding. In the following commands IP1 is the IP address of the current node. VIP[1-4] are the IP addresses of the VIP for the service nodes.

You should check the following commands return no errors:

```
# wget -O /dev/null http://<IP1>:3139/hpc-config
# dig +short @VIP1 apt.service.virtual
IP1
# dig +short @VIP2 apt.service.virtual
IP1
# dig +short @VIP3 apt.service.virtual
IP1
# dig +short @VIP4 apt.service.virtual
IP1
```

With these commands we are now sure that:

- The Apache System service is responding properly
- The DNS service on the current node is working and always return the `install_server_ip` for all the `.virtual` requests

- The virtual IP addresses are up and all responding on the current service node.

10.3. Second Run

The goal of this run is to switch `hpc-config-apply` to download files through apache and not just get them locally. We also change the local DNS client configuration to use the newly configured local DNS server.

To change the `hpc-config-apply` source, do these changes in cluster.yaml:

```
hpcconfig::apply::config_options:
  DEFAULT:
    source:
      value: "http://web-
system.service.virtual:%{hiera('profiles::http::system::port')}/hpc-config"
    keys_source:
      value:
"http://secret.service.%{hiera('virtual_domain')}:%{hiera('secret_port')}/%{::area}"
```

To switch to the local DNS server, remove the `profiles::dns::client::nameservers` added for the first run and uncomment the normal one that was commented out. Also remove the temporary `apt::proxy_host` setting to use the configured apt-cacher-ng.

Do the actual run:

```
cd $ADMIN && hpc-config-push && hpc-config-apply -v
```

If the two commands run without error, the initial setup succeeded.

At this stage, the temporary installation service are fully configured and available to install other generic service nodes.

10.4. Base system installation

The other generic service nodes must now be rebooted in PXE mode to run the Debian installer and configure the base system:

```
for BMC in $(nodeset -O bmc%s -e service[2-4]); do
    ipmitool -I lanplus -U ADMIN -P ADMIN -H $BMC chassis bootdev pxe
    ipmitool -I lanplus -U ADMIN -P ADMIN -H $BMC power reset
done
```

Replace the BMC credentials with the appropriate values.

IMPORTANT Scibian provides a default network installation system designed to work in most situations. However, at this point, you may need to tune this system to make it work on your cluster and its hardware setup. Please refer to Chapter 26, *Network Boot and Installation Tuning* for the procedures.

Once the base system is fully installed, the nodes reboot and become available with SSH. Check this with:

```
# clush -bw fbservice[2-4] uname
---------------
fbservice[2-4] (3)
---------------
Linux
```

At this stage, all generic services nodes are available to host the configuration environments. The parameters of the `hpc-config-push` utility can be updated to switch from *posix* to *sftp*. In this mode, the utility will upload the configuration environment on all generic service nodes. Edit `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml` file to update the `hpconfig::push::config_options` hash with the following changes:

```
 hpcconfig::push::config_options:
   global:
     cluster:     "%{::cluster_name}"
-    mode:        'posix'
+    mode:        'sftp'
     destination: "%{hiera('profiles::http::system::docroot')}/hpc-config"
     areas:       'infra,user'
+  sftp:
+    hosts:       'fbservice1,fbservice2,fbservice3,fbservice4'
+    private_key: '/root/.ssh/id_rsa_root'
```

Then push and apply the configuration on the first service node:

```
cd $ADMIN && hpc-config-push && hpc-config-apply -v
```

This will update `/etc/hpc-config/push.conf` configuration file.

Then run this command again to upload the configuration environment on all service nodes:

```
cd $ADMIN && hpc-config-push
```

Starting from now, all generic service nodes can be used as a valid source for the configuration environments.

10.5. Ceph deployment

Deployment is based on a tool called `ceph-deploy`. This tool performs the steps on a node to setup a ceph component. It is only used for the initial setup of the Ceph cluster. Once the cluster is running, the configuration is reported in the Puppet configuration in case it is re-deployed.

The reference configuration uses one disk (or hardware RAID LUN) to hold the system (`/dev/sda`) and another to hold the Ceph OSD data and journal (`/dev/sdb`). Three or five nodes must be chosed to setup the **MON** and **MDS** services, the remaining nodes are used only as **OSD** and **RadosGW** nodes.

The `ceph-deploy` utility generates authentication keys for Ceph. Once the cluster is running, theses keys are manually collected and encrypted with `eyaml` to be included in the **hiera** configuration.

In the following example MONs/MDS are installed on nodes `fbservice[2-4]` while the node `fbservice1` only has OSD and RGW.

10.5.1. Packages installation

Install the `ceph-deploy` utility and the S3 CLI client `s3cmd`:

```
apt-get install ceph-deploy s3cmd
```

The deployment of Ceph cluster generates a bunch of files (keyrings, configuration file, etc). Create a temporary directory to store these files:

```
mkdir ~root/ceph-deploy && cd ~root/ceph-deploy
```

Install the Ceph software stack on all nodes of the Ceph cluster:

```
ceph-deploy install --no-adjust-repos $(nodeset -e @service)
```

10.5.2. Cluster bootstrap

Initialize the cluster with the first MON server of the Ceph cluster in parameter:

```
ceph-deploy new \
    --public-network <administration network address> \
    --cluster-network <administration network address> \
    fbservice2
ceph-deploy mon create-initial
```

Install admin credentials

```
ceph-deploy admin $(nodeset -e @service)
```

Create the MON servers:

```
ceph-deploy mon add fbservice3
ceph-deploy mon add fbservice4
```

Create the OSD servers:

```
ceph-deploy disk zap $(nodeset -O %s:sdb -e @service)
ceph-deploy osd prepare $(nodeset -O %s:sdb -e @service)
```

Create the MDS servers:

```
ceph-deploy mds create $(nodeset -e fbservice[2-4])
```

Check the Ceph cluster status:

```
ceph status
```

The command must report `HEALTH_OK`.

10.5.3. RadosGW

Enable RadosGW with the following command:

```
ceph-deploy rgw create $(nodeset -e @service)
```

10.5.4. Libvirt RBD pool

The virtual machines will use a specific libvirt storage pool to store the disk images. This libvirt storage pool uses ceph RBD, so a specific ceph pool is necessary. This is not handled by `ceph-deploy`:

```
ceph osd pool create libvirt-pool 64 64
```

If the cluster has five OSDs or more, the numbers of PG and PGP can be set to 128 instead of 64.

The client credentials must be manually generated:

```
ceph auth get-or-create client.libvirt \
    mon 'allow r' \
    osd 'allow class-read object_prefix rbd_children, allow rwx pool=libvirt-pool'
```

10.5.5. CephFS initialization

In high-availability mode, Slurm controller requires a shared POSIX filesystem between the primary and the backup controllers. In the Scibian HPC cluster reference architecture, CephFS is used for this filesystem. Create this CephFS filesystem with the following commands:

```
# ceph osd pool create cephfs_data 64 64
pool 'cephfs_data' created
# ceph osd pool create cephfs_metadata 64 64
pool 'cephfs_metadata' created
# ceph fs new cephfs cephfs_metadata cephfs_data
new fs with metadata pool 15 and data pool 14
```

If the cluster has five OSDs or more, the numbers of PGs can be set to 128 for data and metadata pool.

10.5.6. RadosGW S3

A user must be created to access the RadosGW S3 API:

```
radosgw-admin user create --uid=hpc-config --display-name="HPC Config push"
```

This commands gives an `access_key` and a `secret_key` that can be used by `hpc-config-push(1)` or `s3cmd(1)`.

Create a temporary configuration file for s3cmd with these keys:

```
# cat <<EOF >~/.s3cfg
[default]
access_key=<ACCESS_KEY>
secret_key=<SECRET_KEY>
host_bucket=%(bucket)s.service.virtual:7480
host_base=rgw.service.virtual:7480
use_https=False
EOF
```

With the `access_key` and the `secret_key` provided by `radosgw-admin user create` command.

To work properly with Amazon S3 tools and consul DNS, RadosGW must be configured to accept requests on `rgw.service.virtual` and on `<bucket_name>.service.virtual`. To configure this, it is necessary to re-define the default realm, region and zonegroup.

The region is configured by writing a JSON region file (`rgw-region.json`):

```
{"name": "default",
 "api_name": "",
 "is_master": "true",
 "endpoints": [],
 "hostnames": ["rgw.service.virtual", "service.virtual"],
 "master_zone": "",
 "zones": [
   {"name": "default",
    "endpoints": [],
    "log_meta": "false",
    "log_data": "false"}
  ],
 "placement_targets": [
   {"name": "default-placement",
    "tags": [] }],
 "default_placement": "default-placement"
}
```

Inject this region file into RadosGW configuration:

```
radosgw-admin realm create --rgw-realm=default --default
radosgw-admin region set --infile rgw-region.json
radosgw-admin region default --rgw-zonegroup=default
radosgw-admin zonegroup add --rgw-zonegroup=default --rgw-zone=default
```

Define default zone and zonegroup:

```
radosgw-admin zone default --rgw-zone=default
radosgw-admin zonegroup default --rgw-zonegroup=default
```

Update the period:

```
radosgw-admin period get
radosgw-admin period update --commit
```

After this step the RadosGW daemons must be restarted on every nodes:

```
clush -g service 'systemctl restart ceph-radosgw@rgw.${HOSTNAME}.service'
```

Finally, create the bucket with `s3cmd`:

```
# s3cmd mb --acl-public s3://s3-system
Bucket 's3://s3-system/' created
```

10.5.7. Transfer to Hiera

When the Ceph cluster is fully initialized, its configuration must be reported to the Hiera repository. First, general topology information must be reported into the cluster specific layer of the hiera repository `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml`, for example:

```
profiles::ceph::config_options:
  global:
    fsid:                     '<fsid>'
    mon_initial_members:      'fbservice2, fbservice3, fbservice4'
    mon_host:                 'fbservice2, fbservice3, fbservice4'
    auth_cluster_required:    'cephx'
    auth_service_required:    'cephx'
    auth_client_required:     'cephx'

ceph::mon_config:
  - fbservice2
  - fbservice3
  - fbservice4

ceph::mds_config:
  - fbservice2
  - fbservice3
  - fbservice4

ceph::rgw_config:
  - fbservice1
  - fbservice2
  - fbservice3
  - fbservice4
```

In this example, the `<fsid>` must be replaced with the value obtained with the following command:

```
ceph fsid
```

Then, all keyrings must be reported in the area YAML file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/areas/$AREA.yaml` whose generic service nodes are members (ex: *default* or *infra*), using `eyaml` :

```
ceph_client_admin_key: <eyaml encrypted key>

ceph::keyrings:
  client.admin.keyring:
    client.admin:
      key: "%{hiera('ceph_client_admin_key')}"
  ceph.mon.keyring:
    'mon.':
      key: <eyaml encrypted key>
      'caps mon': 'allow *'
  ceph.bootstrap-mds.keyring:
    client.bootstrap-mds:
      key: <eyaml encrypted key>
  ceph.bootstrap-osd.keyring:
    client.bootstrap-osd:
      'key': <eyaml encrypted key>
  ceph.bootstrap-rgw.keyring:
     client.bootstrap-rgw:
        key: <eyaml encrypted key>

ceph::osd_config:
  fbservice1:
    id:     '0'
    device: '/dev/sdb1'
    key:    <eyaml encrypted key>
  fbservice2:
    id:     '1'
    device: '/dev/sdb1'
    key:    <eyaml encrypted key>
  fbservice3:
    id:     '2'
    device: '/dev/sdb1'
    key:    <eyaml encrypted key>
  fbservice4:
    id:     '3'
    device: '/dev/sdb1'
    key:    <eyaml encrypted key>

ceph::mds_keyring:
  fbservice2:
    mds.fbservice2:
      key: <eyaml encrypted key>
  fbservice3:
    mds.fbservice3:
      key: <eyaml encrypted key>
  fbservice4:
    mds.fbservice4:
      key: <eyaml encrypted key>

ceph::rgw_client_keyring:
  fbservice1:
    client.rgw.fbservice1:
      key: <eyaml encrypted key>
  fbservice2:
    client.rgw.fbservice2:
      key: <eyaml encrypted key>
  fbservice3:
    client.rgw.fbservice3:
      key: <eyaml encrypted key>
  fbservice4:
    client.rgw.fbservice4:
      key: <eyaml encrypted key>
```

The bootstrap keys have been generated in the temporary Ceph deployment directory:

```
cd ~root/ceph-deploy
cat ceph.client.admin.keyring
cat ceph.mon.keyring
cat ceph.bootstrap-mds.keyring
cat ceph.bootstrap-osd.keyring
cat ceph.bootstrap-rgw.keyring
```

The OSD keys can be gathered with:

```
clush -bg service 'cat /var/lib/ceph/osd/ceph-?/keyring'
```

The MDS keys can be gathered with:

```
clush -bg service 'cat /var/lib/ceph/mds/ceph-${HOSTNAME}/keyring'
```

The RGW keys can be gathered with:

```
clush -bg service 'cat /var/lib/ceph/radosgw/ceph-rgw.${HOSTNAME}/keyring'
```

Then, add the `ceph::server` profile into the service role:

```
--- a/hpc-privatedata/hieradata/foobar/roles/service.yaml
+++ b/hpc-privatedata/hieradata/foobar/roles/service.yaml
@@ -28,5 +28,6 @@
   - profiles::bootsystem::server
   - profiles::dhcp::server
   - profiles::environment::limits
+  - profiles::ceph::server

 profiles::network::gw_connect: 'wan'
```

Then push the new configuration:

```
hpc-config-push
```

Theoritically, at this stage, the Ceph cluster can be fully configured with Puppet. It is really recommended to check this by re-installing one of the generic service nodes (excepting the temporary installation node) before going further. Please mind that in case of generic service node reinstallation after the initial configuration, bootstrap steps may be necessary:

- **MDS** and **RadosGW**, those services have no state outside of Rados, so no additional bootstrap is necessary
- **Mon** Always necessary to bootstrap
- **OSD** Must be bootstraped if the OSD volume (`/dev/sdb`) is lost.

Please refer to the bootstrap procedure section for all details.

Once the re-installation of a generic service node with Ceph is validated, the `ceph-deploy` temporary directory can be removed from the temporary installation node:

```
rm -r ~root/ceph-deploy
```

10.5.8. Network restrictions

By default with Puppet-HPC, Ceph daemons socket are binded to the administration network interface of the generic service nodes. This setup is done on purpose for security reasons and avoid access to the Ceph cluster from outside of the administration network (typically from the wan network, outside of the cluster).

However, this can be easily changed by overriding this parameter in the hiera repository:

```
profiles::ceph::listen_network: 'wan' # Make ceph listen the wan network for
                                      # connections, default is 'administration'
```

It is also possible to totally disable the network restriction settings on Ceph daemons with:

```
ceph::restrict_network: false
```

10.6. Consul deployment

All the base services are now deployed on all the generic service nodes. It is time to enable load-balancing and high-availability with Consul service discovery tool.

Consul needs a shared secret key to encrypt communication between its distributed agents. Generate this key with:

```
dd if=/dev/urandom bs=16 count=1 2>/dev/null | base64
```

The output of this command must be reported in the area layer of the hiera repository `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/areas/$AREA.yaml` whose generic service nodes are members (ex: *default* or *infra*) using `eyaml`:

```
consul::key: DEC::PKCS7[<key>]!
```

Add `consul::server` profile to the *service* role:

```
--- a/hpc-privatedata/hieradata/foobar/roles/service.yaml
+++ b/hpc-privatedata/hieradata/foobar/roles/service.yaml
@@ -29,5 +29,6 @@
   - profiles::dhcp::server
   - profiles::environment::limits
   - profiles::ceph::server
+  - profiles::consul::server

 profiles::network::gw_connect: 'wan'
```

Then, run Puppet on all services nodes:

```
hpc-config-push && clush -bg service hpc-config-apply -v
```

Check that all the generic service nodes are members of the Consul cluster with this command:

```
# clush --pick 1 -Ng service consul members
Node         Address         Status  Type    Build  Protocol  DC
fbservice1  10.1.0.1:8301  alive   server  0.6.4  2         foobar
fbservice2  10.1.0.2:8301  alive   server  0.6.4  2         foobar
fbservice3  10.1.0.3:8301  alive   server  0.6.4  2         foobar
fbservice4  10.1.0.4:8301  alive   server  0.6.4  2         foobar
```

The output should report that all the services nodes are members and *alive*.

Remove `dns::server::virtual_relay` and `install_server_ip` parameters from `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml`:

```
--- a/hpc-privatedata/hieradata/foobar/cluster.yaml
+++ b/hpc-privatedata/hieradata/foobar/cluster.yaml
@@ -225,8 +225,3 @@
       # Static IP addresses of the generic service nodes on the management network
       'domain-name-servers':       '10.2.0.1, 10.2.0.2, 10.2.0.3, 10.2.0.4'
      'broadcast':                 "%{hiera('net::management::broadcast')}"
-
-dns::server::virtual_relay: false
-install_server_ip: '10.1.0.1' # static IP address of the temporary
-                              # installation node on the administration
-                              # network
```

With this new configuration, Bind DNS server relays all DNS requests on the *virtual* zone to Consul DNS interface.

Push and the apply the new configuration:

```
hpc-config-push && clush -bg service hpc-config-apply -v
```

Finally, check DNS requests on virtual zone are managed by Consul with:

```
# dig +short web-system.service.virtual
10.1.0.4
10.1.0.2
10.1.0.3
```

The output must report multiple generic service nodes static IP addresses in random order.

10.7. Temporary installation node sweep

Since the beginning of the installation process, the temporary installation node hosts installation files and services required to install the other generic service nodes. Now, all the other generic service nodes host the same files and services. Finally, the temporary installation node must be re-installed to be strictly identical to the other generic service nodes in terms of configuration.

NOTE The disks of the temporary installation node are going to be formatted and all data hosted of this node will be lost. Then, it is probably time to backup all the manual modifications realized on this node and push all modifications in the remote internal configuration Git repository.

Reboot the node in PXE mode through its BMC:

```
export BMC=bmcfbservice1
ipmitool -I lanplus -U ADMIN -P ADMIN -H $BMC chassis bootdev pxe
ipmitool -I lanplus -U ADMIN -P ADMIN -H $BMC power reset
```

Wait for the network installation to proceed and the node to reboot on the system freshly installed on its disks.

Chapter 11. Admin node

Once the Service nodes are fully configured (Ceph, DNS, Consul, DHCP, TFTP, HTTP for boot…), the cluster is able to reinstall any physical or virtual machine with load-balancing and high-availability.

The first other node to install is the admin node, the central point of the HPC cluster administration.

11.1. Base system

Add the *admin* role by creating the file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/roles/admin.yaml` with the following content:

```
profiles:
  # common
  - profiles::cluster::common
  - profiles::systemd::base
  - profiles::ssmtp::client
  - profiles::network::base
  - profiles::dns::client
  - profiles::access::base
  - profiles::openssh::server
  - profiles::openssh::client
  - profiles::environment::base
  - profiles::environment::limits
  - profiles::environment::service
  - profiles::log::client
  # HW host
  - profiles::hardware::ipmi
  - profiles::hardware::admin_tuning
  # admin
  - profiles::hpcconfig::push
  - profiles::hpcconfig::apply
  - profiles::ntp::client
  - profiles::openssh::client_identities
  - profiles::clush::client
  - profiles::consul::client
  - profiles::conman::client
  - profiles::clara::base
  - profiles::ceph::client
  - profiles::s3::s3cmd
  - profiles::jobsched::client

profiles::network::gw_connect: 'wan'

profiles::environment::service::packages:
 - scibian-hpc-admin
```

The profiles listed after the *admin* comment carry the software required on the admin node. The `profiles::environment::service::packages` has a specific value for this role in order to install the admin meta-package.

Append the node definition in the `master_network` hash, for example:

```
master_network:
  [...]
  fbadmin1:
    fqdn: "fbadmin1.%{hiera('domain')}"
    networks:
      administration:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:08'
        'IP':       '10.1.0.10'
        'device':   'eno0'
        'hostname': 'fbadmin1'
      management:
        'IP':       '10.2.0.10'
        'device':   'eno1'
        'hostname': 'mgtfbadmin1'
      lowlatency:
        'IP':       '10.4.0.10'
        'device':   'ib0'
        'hostname': 'opafbadmin1'
      bmc:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:09'
        'IP':       '10.2.0.110'
        'hostname': 'bmcfbadmin1'
      wan:
        'IP':       '10.2.0.10'
        'device':   'eno2'
        'hostname': 'wanfbadmin1'
```

Optionally, adjust the node boot parameters in the `boot_params` hash, for example:

```
boot_params:
  [...]
  fbadmin1:
    os:      'scibian9'
    media:   'disk'
    console: 'ttyS0,115200n8'
```

Synchronize SSH host keys:

```
puppet-hpc/scripts/sync-ssh-hostkeys.sh hpc-privatedata $CLUSTER
```

Push and apply the new configuration:

```
hpc-config-push && clush -bg service hpc-config-apply -v
```

And reboot the node in PXE mode to proceed the network installation:

```
export BMC=bmcfbadmin1
ipmitool -I lanplus -U ADMIN -P ADMIN -H $BMC chassis bootdev pxe
ipmitool -I lanplus -U ADMIN -P ADMIN -H $BMC power reset
```

Wait for the network installation to proceed. Once the installation is over, the node reboot on its freshly installed system on its disks and it becomes available through SSH. Starting from this point, all the following operations of the installation process are realized from this admin node.

11.2. Administration environmnent

The administration environment must be re-created following the same instructions given in the temporary installation node administration environmnet section.

The Clara utility is available on the admin node. Its ipmi plugin can be configured with this small snippet added with eyaml to the cluster specific layer of the hiera repository:

```
##### Clara #####

clara::ipmi_options:
  prefix:  'bmc'

clara::password_options:
  ASUPASSWD:   "%{hiera('cluster_decrypt_password')}"
  IMMUSER:     "%{hiera('ipmi_user')}"
  IMMPASSWORD: "%{hiera('ipmi_password')}"
```

Then add the IPMI identifiers to the admin node area layer (ex: *default* or *infra*) of the Hiera repository using `eyaml`:

```
ipmi_user:     DEC::PKCS7[<user>]!
ipmi_password: DEC::PKCS7[<password>]!
```

Push and apply configuration on the admin node:

```
hpc-config-push && hpc-config-apply -v
```

Then, the clara ipmi plugin can be used as explained in its documentation (`man clara-ipmi (1)`).

Chapter 12. Service virtual machines

On Scibian HPC clusters, the additional services are hosted inside virtual machines for more flexibility and better resources partitionning. These service virtual machines run on the generic service nodes. On the generic services nodes, the virtual machines are managed by Libvirt service. The ditributed instances of Libvirt are controlled centrally from the admin node with Clara utility. The following sub-sections explain how to setup these software components.

12.1. Libvirt settings

The Libvirt service must create various virtual networks to connect the virtual machines to the HPC cluster and a storage pool on Ceph RDB interface to store the virtual disks of the virtual machines. These virtual resources are setup with the following configuration in the cluster specific layer of the hiera repository:

```
virt_ceph_uuid: '<uuid>'

profiles::virt::networks:
  'administration':
    'mode': 'bridge'
    'interface': 'br0'
  'management':
    'mode': 'bridge'
    'interface': 'br1'
  'wan':
    'mode': 'bridge'
    'interface': 'br2'

profiles::virt::pools:
  'rbd-pool':
    'type': 'rbd'
    'hosts':
      - 'fbservice2'
      - 'fbservice3'
      - 'fbservice4'
    'auth':
      'type':     'ceph'
      'username': 'libvirt'
      'uuid':     "%{hiera('virt_ceph_uuid')}"
```

The `<uuid>` is an arbitrary UUID [6: Universally Unique IDentifier, a 128-bit number used to identify information in computer systems] to identify uniquely the secret. For example, it can be generated with this command:

```
python  -c 'import uuid; print uuid.uuid1()'
```

Add the libvirt Ceph client identifiers with the following hash into the generic service nodes area layer (ex: *default* or *infra*) of the Hiera repository using `eyaml`:

```
profiles::virt::secrets:
  'client.libvirt':
    'type':  'ceph'
    'uuid':  "%{hiera('virt_ceph_uuid')}"
    'value': DEC::PKCS7[<key>]!
```

The <key> is given by the following command:

```
ceph auth get-key client.libvirt
```

The profile `profiles::virt::host` must be added to service nodes role definition.

Push and apply configuration on the generic service nodes:

```
hpc-config-push && clush -bg service hpc-config-apply
```

12.2. Clara configuration

Clara has dedicated configuration for its *virt* plugin. This configuration is set with the following two hashes in the cluster specific layer of the hiera repository:

```
clara::virt_options:
  'nodegroup:default':
    'default':                  'true'
    'nodes':                    'fbservice1,fbservice2,fbservice3,fbservice4'
  'pool:default':
    'default':                  'false'
  'pool:rbd-pool':
    'default':                  'true'
    'vol_pattern':              '{vm_name}_{vol_role}'
  'template:default':
    'default':                  'true'
    'xml':                      'domain_default_template.xml'
    'vol_roles':                'system'
    'vol_role_system_capacity': '60000000000'
    'networks':                 'administration'

clara::virt_tpl_hpc_files:
  '/etc/clara/templates/vm/domain_default_template.xml':
    source: "%{::private_files_dir}/virt/domain_default_template.xml"
```

The `clara::virt_options` hash notably specifies the list of generic services nodes that hosts the virtual machines and the domain templates and parameters associated to each service virtual machine. For the moment, only the default domain template and parameters are set. The second hash `clara::virt_tpl_hpc_files` defines the templates of Libvirt XML domains definitions. In this example, there is one default domain XML template for all virtual machines which should be fine for most Scibian HPC clusters.

The domain XML template must be located in `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/virt/domain_default_template.xml`, where

$AREA is the area of the generic service nodes. Here is a full example of this file:

```xml
<domain type='kvm'>
  <name>{{ name }}</name>
  <memory unit='KiB'>{{ memory_kib }}</memory>
  <currentMemory unit='KiB'>{{ memory_kib }}</currentMemory>
  <vcpu placement='static'>{{ core_count }}</vcpu>
  <resource>
    <partition>/machine</partition>
  </resource>
  <os>
    <type arch='x86_64' machine='pc-i440fx-2.1'>hvm</type>
    <bootmenu enable='yes'/>
    <boot dev='hd'/>
    <boot dev='network'/>
  </os>
  <features>
    <acpi/>
    <apic/>
    <pae/>
  </features>
  <cpu mode='host-model' match='exact'> </cpu>
  <clock offset='utc'>
    <timer name='rtc' tickpolicy='catchup'/>
    <timer name='pit' tickpolicy='delay'/>
    <timer name='hpet' present='no'/>
  </clock>
  <on_poweroff>destroy</on_poweroff>
  <on_reboot>restart</on_reboot>
  <on_crash>restart</on_crash>
  <pm>
    <suspend-to-mem enabled='no'/>
    <suspend-to-disk enabled='no'/>
  </pm>
  <devices>
    <emulator>/usr/bin/kvm</emulator>
    <disk type='network' device='disk'>
      <source protocol='rbd' name='{{ volumes.system.path }}'>
        <host name='<ip_mon_server_1>' />
        <host name='<ip_mon_server_2>' />
        <host name='<ip_mon_server_3>' />
      </source>
      <auth username='libvirt'>
        <secret type='ceph' uuid='<uuid>'/>
      </auth>
      <target dev='vda' bus='virtio'/>
      <alias name='virtio-disk0'/>
    </disk>
    <disk type='block' device='cdrom'>
      <driver name='qemu' type='raw'/>
      <backingStore/>
      <target dev='hda' bus='ide'/>
      <readonly/>
      <alias name='ide0-0-0'/>
    </disk>
    <controller type='usb' index='0' model='ich9-ehci1'>
      <alias name='usb0'/>
    </controller>
    <controller type='usb' index='0' model='ich9-uhci1'>
      <alias name='usb0'/>
      <master startport='0'/>
    </controller>
    <controller type='usb' index='0' model='ich9-uhci2'>
      <alias name='usb0'/>
      <master startport='2'/>
    </controller>
    <controller type='usb' index='0' model='ich9-uhci3'>
      <alias name='usb0'/>
      <master startport='4'/>
    </controller>
    <controller type='pci' index='0' model='pci-root'>
      <alias name='pci.0'/>
    </controller>
    <controller type='ide' index='0'>
      <alias name='ide0'/>
    </controller>
    <controller type='virtio-serial' index='0'>
      <alias name='virtio-serial0'/>
    </controller>
    {% for network_name, network in networks.iteritems() %}
    <interface type='network'>
      <mac address='{{ network.mac_address }}'/>
      <source network='{{ network_name }}'/>
      <model type='virtio'/>
    </interface>
    {% endfor %}
    <!--
    <serial type='tcp'>
      <source mode='bind' host='{{ serial_tcp_host }}' service='{{ serial_tcp_port
}}'/>
      <protocol type='telnet'/>
      <target port='0'/>
      <alias name='serial0'/>
    </serial>
      -->
    <serial type='pty'>
      <target port='0'/>
      <alias name='serial0'/>
    </serial>
    <channel type='spicevmc'>
      <target type='virtio' name='com.redhat.spice.0'/>
    </channel>
    <input type='tablet' bus='usb'>
      <alias name='input0'/>
    </input>
    <input type='mouse' bus='ps2'/>
    <input type='keyboard' bus='ps2'/>
    <graphics type='spice' port='5901' autoport='yes' listen='127.0.0.1'>
      <listen type='address' address='127.0.0.1'/>
    </graphics>
    <sound model='ich6'>
      <alias name='sound0'/>
    </sound>
    <video>
      <model type='qxl' ram='65536' vram='65536' heads='1'/>
      <alias name='video0'/>
    </video>
    <redirdev bus='usb' type='spicevmc'>
      <alias name='redir0'/>
    </redirdev>
    <redirdev bus='usb' type='spicevmc'>
      <alias name='redir1'/>
    </redirdev>
    <redirdev bus='usb' type='spicevmc'>
      <alias name='redir2'/>
    </redirdev>
    <redirdev bus='usb' type='spicevmc'>
      <alias name='redir3'/>
    </redirdev>
    <memballoon model='virtio'>
      <alias name='balloon0'/>
    </memballoon>
    <rng model='virtio'>
      <backend model='random'>/dev/random</backend>
      <alias name='rng0'/>
    </rng>
  </devices>
</domain>
```

In this example, the following values must be replaced:

- `<ip_mon_server_*>` are the static IP addresses of the Ceph MON servers on the administration network.
- `<uuid>` is the UUID for Libvirt Ceph RBD secret generated in the previous sub-section.

Deploy these new settings by pushing and applying the configuration on the admin node:

```
hpc-config-push && hpc-config-apply -v
```

12.3. Virtual machine definitions

Now that Libvirt and Clara virt plugin are properly setup, the various service virtual machines can be defined. The steps to define the service virtual machines are mostly generic and common to all of them. As an example for this documentation, the two service virtual machines `fbdoe[1-2]` will be defined.

Optionally, define specific `boot_params` for the virtual machines in `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml` if the defaults parameters are not appropriate:

```
boot_params:
  [...]
  fbdoe[1-2]:
    disk:    'disk'
    ipxebin: 'ipxe_noserial.bin'
```

Also, in the same file, an additional domain template and parameters association can be appended to the `clara::virt_options` for these new virtual machines, if the default domain parameters are not appropriate:

```
clara::virt_options:
  [...]
  'template:proxy':
    'vm_names':                 'fbdoe[1-2]'
    'xml':                      'domain_default_template.xml'
    'vol_roles':                'system'
    'vol_role_system_capacity': '60000000000'
    'networks':                 'administration,wan'
    'core_count':               '16'
    'memory_kib':               '16777216'
```

In this example, the following settings are overriden from the defaults:

- the virtual block storage device has a size of 60GB,
- 2 network devices attached to the *administration* and *wan* networks,
- 16 virtual CPU cores,
- 16GB of RAM.

Then, the new role *doe* must be defined in file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/roles/doe.yaml` with all the appropriate profiles.

Push and apply configuration on admin node:

```
hpc-config-push && hpc-config-apply -v
```

Extract MAC address of the virtual machine on the administration network:

```
clara virt getmacs <VM>
```

Then add the network settings of the virtual machines in the `master_network` hash with their MAC addresses:

```
master_network:
  fbdoe1:
    fqdn: "fbdoe1.%{hiera('domain')}"
    networks:
      administration:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:0a'
        'IP':       '10.1.0.11'
        'device':   'eno0'
        'hostname': 'fbdoe1'
      wan:
        'IP':       '10.3.0.11'
        'device':   'eno1'
        'hostname': 'wanfbdoe1'
  fbdoe2:
    fqdn: "fbdoe2.%{hiera('domain')}"
    networks:
      administration:
        'DHCP_MAC': 'aa:bb:cc:dd:ee:0b'
        'IP':       '10.1.0.12'
        'device':   'eno0'
        'hostname': 'fbdoe2'
      wan:
        'IP':       '10.3.0.12'
        'device':   'eno1'
        'hostname': 'wanfbdoe2'
```

Eventually, virtual IP addresses can also be defined for the virtual machines in the `vips` hash of the same file.

Generate the SSH host keys in synchronization with the `master_network`:

```
puppet-hpc/scripts/sync-ssh-hostkeys.sh hpc-privatedata $CLUSTER
```

Push and apply the new configuration on the generic service nodes:

```
hpc-config-push && clush -bg service hpc-config-apply -v
```

Define the new virtual machines with Clara on the generic service node of your choice, for example `fbservice1`:

```
clara virt define fbdoe[1-2] --host=fbservice1
```

NOTE The choice of the generic service node is not critical as the service virtual machines can be migrated from one generic service node to another at any time.

Then start the virtual machine by wiping its virtual block storage devices and boot in PXE mode:

```
clara virt start fbdoe[1-2] --wipe
```

Eventually, watch the serial console with:

```
ssh -t fbservice1 -- virsh console fbdoe1
```

12.4. Required virtual machines

You are free to define the service virtual machines you want on Scibian HPC clusters. The service virtual machines can run any software services you would like. However, some specific generic virtual machines are required in the reference architecture to run some mandatory additional services.

The required service virtual machines are:

- two (or more) **proxy** virtual machines with the `auth::replica` profile for managing the LDAP directory replica. The installation of the LDAP directory replica of the *proxy* nodes is documented in Section 13.1, “Directory replica” of the *LDAP Authentication* section of this installation procedure.
- two **batch** virtual machines with the `jobsched::server` and `db::server` profiles for Slurm controller, SlurmDBD accounting service and MariaDB galera database. The installation of the Slurm server-side components on the *batch* nodes is documented in Chapter 14, *Slurm*.
- two **p2p** virtual machines with the `p2p::seeder`, `p2p::tracker` and `http::diskless`

profiles for serving files to boot diskless nodes with Bittorrent. The installation of the *p2p* nodes is pretty straightforward as long as the required profiles are enabled. The creation of the diskless environment is documented in Section 15.1, “Diskless image generation” of the *Frontend and compute nodes* section of the installation procedure.

Chapter 13. LDAP Authentication

13.1. Directory replica

User authentication on Scibian HPC clusters is based on LDAP directory using ldaps protocol (LDAP over SSL/TLS). This protocol requires the LDAP replica to have valid SSL certificate and asymmetric keys.

For production use, it is recommended to obtain a certificate signed by a valid PKI CA [7: Public Key Infrastructure Certicate of Authority, an entity that issues digital certificates], either a public CA on the Internet or a CA internal to your organization. Otherwise, it is possible to use self-signed certificates.

Copy the private key and the certificate under the following paths:

- certificate: `$ADMIN/hpc-privatedata/files/$CLUSTER/cluster/auth/$CLUSTER_ldap.crt`
- private key: `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/auth/$CLUSTER_ldap.key`

Where $AREA is the area of the LDAP replica nodes (ex: *default* or *infra*).

Encrypt these files with clara *enc* plugin:

```
clara enc $ADMIN/hpc-privatedata/files/$CLUSTER/cluster/auth/$CLUSTER_ldap.crt
clara enc $ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/auth/$CLUSTER_ldap.key
```

Remove the unencrypted files:

```
rm $ADMIN/hpc-privatedata/files/$CLUSTER/cluster/auth/$CLUSTER_ldap.crt
rm $ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/auth/$CLUSTER_ldap.key
```

Then, append the `auth::replica` profile and set certificate owner to `openldap` in the *proxy* role:

```
--- a/hieradata/foobar/roles/proxy.yaml
+++ b/hieradata/foobar/roles/proxy.yaml
@@ -14,7 +14,7 @@ profiles:
   # Proxy
   - profiles::ntp::client
   - profiles::network::wan_nat
+  - profiles::auth::replica
   - profiles::postfix::relay
   - profiles::ha::base
   - profiles::hardware::admin_tuning
@@ -30,3 +30,24 @@ profiles:

 profiles::network::gw_connect: 'wan'
 shorewall::ip_forwarding:      true
+
+certificates::certificates_owner: 'openldap
```

Push and apply the configuration on the proxy nodes:

```
hpc-config-push && clush -bg proxy hpc-config-apply -v
```

Finally, follow the steps documented in Chapter 17, *LDAP bootstrap*.

13.2. Clients setup

Once the LDAP replica are bootstrapped and operational, it is possible to setup NSS LDAP backend and PAM LDAP authentication on the nodes.

On Scibian HPC clusters, NSS LDAP backend and PAM authentication over LDAP are both setup with the same `auth::client` profile. This profile must be used in combination with the `access::base` profile. This profile controls the remote access rules to the nodes. By default, the profile prevents remote access to the nodes with LDAP accounts. The access rules must explicitely whitelist users and/or administrators to allow remote access with SSH.

There are two main access whitelist parameters:

- `profiles::access:base_options` is the list of permanent access rules.
- `profiles::access:production_options` is the list of access rules disabled in maintenance mode.

The administrators related access rules must be listed in the `base_options` while the users related access rules must only be present in the `production_options` list. This way, only administrators can access the HPC cluster in maintenance mode. For example:

```
profiles::access::base_options:
  - "+ : (admins) : ALL"
profiles::access::production_options:
  - "+ : (grpusers1) : ALL"
  - "+ : (grpusers2) : ALL"
```

These parameters must be set in the roles specific layer of the hiera repository as access rules depends on the role of the nodes. For example, users may access the frontend nodes but not the admin node.

Additionally, it is also possible to setup sudo rules with the `sudo::base` profile and the `sudo::sudo_config_opts` list. This parameter is basically a list of sudo rules. For example, to allow the group of administrator to sudo any command on the admin node, add the following excerpt to file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/roles/admin.yaml`:

```
profiles::sudo::sudo_config_opts:
  - "%admins ALL = (ALL) ALL"
```

By default, the PAM and NSS LDAP backend connect to the HPC cluster internal LDAP replica. This replica is hosted by service virtual machine. In order to make LDAP authentication on the admin nodes and generic service nodes possible for the administrators when the virtual machines are offline (typically during maintenances), it is possible to add the following parameter in the associated roles:

```
profiles::auth::client::external_ldap: true
```

This way, the nodes will connect to the organization reference LDAP directory instead of the internal LDAP replica.

Push and apply the configuration on all the affected nodes with:

```
hpc-config-push && clush -bg all hpc-config-apply
```

Chapter 14. Slurm

Slurm workload manager is distributed among the HPC cluster nodes with multiple daemons and clients software. On Scibian HPC clusters, the server part of Slurm, *ie.* the controller and the accounting services, run in high-availability mode on the *batch* nodes. These components are managed by the `jobsched::server`. The *batch* nodes also need the `db::server`, and the `ceph::client` or `nfs::mount` that respectively setup the MariaDB galera RDBMS [8: Relational Database Management System], and CephFS or NFS filesystem client.

14.1. Base Configuration

Slurm communications between nodes are secured using Munge which is based on a secret shared key. Generate this munge key with the following command:

```
mkdir -p $ADMIN/hpc-privatedata/files/$CLUSTER/cluster/munge
dd if=/dev/urandom bs=1 count=1024 > \
  $ADMIN/hpc-privatedata/files/$CLUSTER/cluster/munge/munge.key
```

Encrypt the key using Clara:

```
clara enc encode $ADMIN/hpc-privatedata/files/$CLUSTER/cluster/munge/munge.key
```

Remove the unencrypted key:

```
rm $ADMIN/hpc-privatedata/files/$CLUSTER/cluster/munge/munge.key
```

Setup the nodes and partitions managed by Slurm in the `slurm::partitions_options` hash in the cluster specific layer of the Hiera repository. For example:

```
slurm::partitions_options:
  - 'NodeName=fbcn[01-04] Sockets=2 CoresPerSocket=14 RealMemory=64000
State=UNKNOWN'
  - 'NodeName=fbgn01 Sockets=2 CoresPerSocket=4 RealMemory=64000 Gres=gpu:k80:2
State=UNKNOWN'
  - 'PartitionName=cn Nodes=fbcn[01-04] Default=YES MaxTime=INFINITE State=UP'
  - 'PartitionName=gn Nodes=fbgn01 MaxTime=INFINITE State=UP'
  - 'PartitionName=all Nodes=fbcn[01-04],fbgn01 MaxTime=INFINITE State=UP'
```

Please refer to Slurm documentation for more details about these settings.

In the same, setup the LDAP/SlurmDBD users synchronization utility, for example:

```
profiles::jobsched::server::sync_options:
  main:
    cluster: "%{::cluster_name}"
    org:     "%{hiera('org')}"
    policy:  'global_account'
  global_account:
    name:    'users'
    desc:    'Main users account'
```

Please refer to the example configuration file for more details.

14.2. Shared State Location

Still in the cluster specific layer of the Hiera repository, setup the shared storage directory.

14.2.1. CephFS

If you are using CephFS, configure the client mount with the following excerpt:

```
profiles::jobsched::server::ceph::keys:
  client:
    key: "%{hiera('ceph_client_admin_key')}"

profiles::jobsched::server::ceph::mounts:
  slurmctld:
    servers: # list of Ceph MON servers
      - fbservice2
      - fbservice3
      - fbservice4
    device:     '/slurmctld'
    mountpoint: "%{hiera('slurm_state_save_loc')}"
    user:       'admin'
    key:        'client'
    mode:       'kernel'
```

14.2.2. NFS

If you are using an NFS HA Server:

```
profiles::jobsched::server::ceph::enabled: false

profiles::jobsched::slurm_config_options:
  [...]
  StateSaveLocation:         '/admin/restricted/backup/slurm_state_save'
```

For NFS HA, at the role level, configure the NFS mount:

```
profiles:
  [...]
  - profiles::nfs::mounts

profiles::nfs::to_mount:
  home:
    server:     'fbnas'
    exportdir:  '/srv/admin'
    mountpoint: '/admin'
    options:    'bg,rw,hard,vers=4'
```

14.3. Miscellaneous Tuning

Eventually, it is possible to tune Slurm, GRES, SlurmDBD, job submit LUA script with the following parameters:

```
profiles::jobsched::slurm_config_options:
  PrivateData:              'jobs,reservations,usage'
  AccountingStorageEnforce: 'associations,limits,qos'
  GresTypes:                'gpu'
  SlurmCtldDebug:           'verbose'
  PriorityFlags:            'FAIR_TREE'

slurm::gres_options:
  - 'NodeName=fbgn01 Name=gpu Type=k80 File=/dev/nvidia0'

profiles::jobsched::server::slurmdbd_config_options:
  PrivateData: 'accounts,jobs,reservations,usage,users'

slurm::ctld::submit_lua_options:
  CORES_PER_NODE:  '28'
```

14.4. MariaDB security hardening

14.4.1. Settings

By default, the MariaDB server is setup with parameters to harden its security. Notably, the following settings are deployed by default:

- `max_user_connections` to 100 (default is 0 ie. unlimited), in order to prevent one user from grabbing all 151 available `max_connections` (default MariaDB value).
- `secure_file_priv` is set to an empty value in order to disable potentially dangerous command `LOAD DATA INFILE`.
- the client histfile `~/.mysql_history` is disabled by default.

Obviously, these settings can be altered in the hiera repository. Here is an example yaml excerpt to change these default values:

```
mariadb::disable_histfile: false
mariadb::galera_conf_options:
  mysqld:
    max_user_connections: '0' # unlimited
    secure_file_priv:      '/'
```

14.4.2. TLS/SSL connections

It is also possible to setup SSL/TLS on MariaDB. First, create the `ssl` directory if missing in the files hierarchy of the cluster:

```
mkdir -p $ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/ssl
```

Where $AREA is the area of the MariaDB servers.

Generate and copy host SSL certificate and encryption key to the following paths respectively:

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/ssl/ssl-cert-batch.pem`
- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/ssl/ssl-cert-batch.key`

Encrypt the key using Clara and remove unencrypted file:

```
clara enc encode $ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/ssl/ssl-cert-batch.key
rm $ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/ssl/ssl-cert-batch.key
```

Finally, set the following `mariadb` module parameter to `true` either at the organization layer or the cluster layer of the Hiera repository, according to your need:

```
mariadb::enable_ssl: true
```

14.5. Bootstrap

Some software components need to be manually bootstrapped on the *batch* nodes before being started:

- MariaDB database
- SlurmDBD service

The shared storage can be on CephFS or on NFS HA, the suitable bootstrap procedure must be performed:

- CephFS filesystem
- NFS HA filesystem

Please refer to the Bootstrap procedure chapter of this document for all details.

14.6. Configuration deployment

Once the configuration is set in the Hiera repository, push and apply the configuration on the *admin* and *batch* nodes:

```
hpc-config-push && clush -bg admin,batch hpc-config-apply -v
```

Check Slurm is available by running the `sinfo` command on the admin node. If the command report the nodes and partitions state without error, Slurm is properly running.

Chapter 15. Frontend and compute nodes

On Scibian HPC clusters, the frontend and compute nodes download at boot time a system image in deployed in RAM which notably gives possibility to have diskless nodes. For more details about this technique, please refer to Section 5.1.3, “Diskless boot” in the *Advanced Topics* section of the Architecture chapter of this document. The diskless image must be generated with Clara *images* plugin on the *admin* node before booting the frontend and the compute nodes. These steps are explained in the following sub-sections.

15.1. Diskless image generation

The diskless image is generated by the Clara *images* plugin. This plugin need some configuration in the cluster specific layer of the Hiera repository. Here is an example of such configuration:

```
clara_images_target_dir: "%{hiera('admin_dir')}/scibian9"

clara::common_options:
  allowed_distributions:
    value: 'scibian9'

clara::images_options:
  extra_packages_image: "scibian-archive-keyring,hpc-config-apply,scibian-hpc-
commons"
  packages_initrd:      "scibian-diskless-initramfs-config"
  etc_hosts:
"10.1.0.101:vipfbservice1,10.1.0.101:apt.service.virtual,10.1.0.10:fbadmin1"

clara::config_options:
  images-scibian9:
    debiandist:                 'stretch'
    debmirror:
"http://%{hiera('debian_mirror_server')}/%{hiera('debian_mirror_dir')}"
    kver:                       "4.9.0-4-amd64"
    list_repos:                 "deb [arch=amd64,i386]
http://%{hiera('debian_mirror_server')}/"
    trg_dir:                    "%{hiera('clara_images_target_dir')}"
    trg_img:
"%{hiera('clara_images_target_dir')}/scibian9.squashfs"
    preseed_file:
"%{hiera('clara_images_config_dir')}/scibian9/preseed"
    package_file:
"%{hiera('clara_images_config_dir')}/scibian9/packages"
    script_post_image_creation:
"%{hiera('clara_images_config_dir')}/scibian9/post.sh"
    list_files_to_install:
"%{hiera('clara_images_config_dir')}/scibian9/filelist"
    dir_files_to_install:
"%{hiera('clara_images_config_dir')}/scibian9/files_dir"
    foreign_archs:              'i386'

clara::live_dirs:
  "%{hiera('clara_images_config_dir')}":
    ensure: directory
  "%{hiera('clara_images_config_dir')}/scibian9":
    ensure: directory
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir":
    ensure: directory

clara::live_files:
  "%{hiera('clara_images_config_dir')}/scibian9/post.sh":
    source: "%{::private_files_dir}/boot/live/scibian9/post.sh"
    mode: '755'
  "%{hiera('clara_images_config_dir')}/scibian9/preseed":
    source: "%{::private_files_dir}/boot/live/scibian9/preseed"
  "%{hiera('clara_images_config_dir')}/scibian9/filelist":
    source: "%{::private_files_dir}/boot/live/scibian9/filelist"
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir/resolv.conf":
    source: "%{::private_files_dir}/boot/live/scibian9/files_dir/resolv.conf"
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir/no-cache":
    source: "%{::private_files_dir}/boot/live/scibian9/files_dir/no-cache"
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir/no-recommends":
    source: "%{::private_files_dir}/boot/live/scibian9/files_dir/no-recommends"
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir/interfaces":
    source: "%{::private_files_dir}/boot/live/scibian9/files_dir/interfaces"
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir/proxy":
    source: "%{::private_files_dir}/boot/live/scibian9/files_dir/proxy"
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir/mk_ipmi_dev.sh":
    source: "%{::private_files_dir}/boot/live/scibian9/files_dir/mk_ipmi_dev.sh"
  "%{hiera('clara_images_config_dir')}/scibian9/files_dir/hpc-config.conf":
    source: "%{::private_files_dir}/boot/live/scibian9/files_dir/hpc-config.conf"
```

The `clara::live_files` parameter contains a list of files deployed under the configuration directory of Clara. Their files are:

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/post.sh` (where $AREA is the area of the admin node) is a post-generation script run by Clara inside the image environment:

```
#!/bin/bash -e

# Fix Timezone data
echo GMT > /etc/timezone
dpkg-reconfigure -f noninteractive tzdata

# Fix hostname
echo "localhost" > /etc/hostname

# Create needed directory for Puppet
mkdir -p /var/lib/puppet/facts.d/

# Enable setuid on /bin/ping to let users run it because AUFS does not support
# xattr and therefore capabilities.
chmod 4755 /bin/ping
```

This script can notably be used to customize the image or set files and directories that are required very early in the live boot process before Puppet run.

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/preseed` contains the answers to the Debconf packages configuration questions:

```
console-common console-data/keymap/full select en
console-common console-data/keymap/policy select Select keymap from full list
console-data console-data/keymap/full select en
console-data console-data/keymap/policy select Select keymap from full list
console-setup console-setup/charmap47 select UTF-8
locales locales/default_environment_locale select en_US.UTF-8
locales locales/locales_to_be_generated multiselect en_US.UTF-8 UTF-8, en_US ISO-
8859-1
keyboard-configuration keyboard-configuration/layout select English
keyboard-configuration keyboard-configuration/variant select English
keyboard-configuration keyboard-configuration/unsupported_layout boolean true
keyboard-configuration keyboard-configuration/model select International (with dead
keys)
keyboard-configuration keyboard-configuration/layoutcode string  intl
keyboard-configuration keyboard-configuration/ctrl_alt_bksp boolean false
keyboard-configuration keyboard-configuration/variantcode string oss
keyboard-configuration keyboard-configuration/modelcode string  pc105
postfix postfix/main_mailer_type select  No configuration
tzdata tzdata/Areas select Europe
tzdata tzdata/Zones/Europe select London
libpam-runtime libpam-runtime/conflicts error
mdadm mdadm/start_daemon boolean false
postfix postfix/mailname string localdomain
```

- `$ADMIN/hpc-`

`privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/filelist` specifies the list of files to copy inside the generated image:

```
hpc-config.conf     etc/            0644
resolv.conf     etc/            0644
proxy           etc/apt/apt.conf.d/ 0644
no-cache        etc/apt/apt.conf.d/ 0644
no-recommends       etc/apt/apt.conf.d/ 0644
interfaces      etc/network/        0644
mk_ipmi_dev.sh      usr/local/sbin/     0755
```

All the files under the `files_dir` directory are copied without modification into the image. The required files are:

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/files_dir/resolv.conf` is the configuration file for DNS solvers with the virtual IP addresses of the cluster's internal DNS servers:

```
domain foobar.hpc.example.org
search foorbar.hpc.example.org hpc.example.org
nameserver 10.1.0.101
nameserver 10.1.0.102
nameserver 10.1.0.103
nameserver 10.1.0.104
```

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/files_dir/no-cache` disables packages local caching in APT package manager:

```
Dir::Cache::srcpkgcache "";
Dir::Cache::pkgcache "";
```

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/files_dir/no-recommends` disables *recommends* soft-dependencies installation in APT package manager:

```
APT::Install-Recommends "0";
```

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/files_dir/interfaces` is a default network interfaces configuration file to enable DHCP on `eno0` interface:

```
auto lo
iface lo inet loopback

auto eno0
iface eno0 inet dhcp
```

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/files_dir/proxy` setup cluster's internal packages proxy in APT configuration:

```
Acquire::http::Proxy "http://apt.service.virtual:3142";
```

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/files_dir/mk_ipmi_dev.sh` is a workaround script to create the BMC devices inodes the `/dev` virtual filesystem very early in the diskless nodes boot process:

```
#!/bin/sh

DEVICE='/dev/ipmi0'

if [ -e ${DEVICE} ]
then
  exit 0
else
  MAJOR=$(grep ipmidev /proc/devices | awk '{print $1}')
  mknod --mode=0600 ${DEVICE} c ${MAJOR} 0
fi
```

- `$ADMIN/hpc-privatedata/files/$CLUSTER/$AREA/boot/live/scibian9/files_dir/hpc-config.conf` is a configuration file for Puppet-HPC `hpc-config-apply` utility:

```
[DEFAULT]
environment=production
source=http://s3-system.service.virtual:7480/hpc-config
keys_source=http://secret.service.virtual:1216
# Using /var/tmp to more easily manipulate /tmp mount
# point during a puppet run.
tmpdir=/var/tmp
```

Once all these files have been added to the cluster specific files directory, push and apply the configuration on the admin node:

```
hpc-config-push && hpc-config-apply
```

Now that Clara is setup, the image can be created with the following command:

```
clara images create scibian9
```

Also create the associated initrd environment:

```
clara images initrd scibian9
```

Deploy the generate image and initrd to the *p2p* nodes with:

```
clush -g p2p mkdir -p /var/www/diskless/scibian9
clush -g p2p \
  --copy /var/cache/admin/scibian9/{initrd-4.9.0-4-amd64,vmlinuz-4.9.0-4-amd64} \
  --dest /var/www/diskless/scibian9
clush -g p2p \
  --copy /var/cache/admin/scibian9/{scibian9.squashfs.torrent,scibian9.squashfs} \
  --dest /var/www/diskless/scibian9
```

Restart peer-to-peer services to load new files:

```
clara p2p restart
```

The diskless environment is finally ready and available to frontend and compute nodes.

15.2. Boot nodes

Before booting the frontend and compute nodes, they must be declared in the internal configuration repository in the first place. Append the nodes to the `boot_params` hash in `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/cluster.yaml`:

```
boot_params:
  [...]
  fbfront[1-2],fbgn01:
    cowsize:  '8G'
    media:    'ram'
  fbcn[01-04]:
    media:    'ram'
```

The `cowsize` must be increased to 8GB from default 2GB on frontend and graphical nodes because these nodes need much more packages to be installed at boot time.

Then define the roles associated to the frontend and the compute nodes, for example `front`, `cn` and `gn`. For these roles definitions, keep in mind the following rules:

- The frontend role must include the `jobsched::client` while the compute nodes require the `jobsched::exec` profile instead.
- The `profiles::environment::userspace::packages` must include the `scibian-hpc-frontend` meta-package in the frontend nodes role, `scibian-hpc-compute` meta-package in the standard compute nodes and `scibian-hpc-graphical` meta-package on the graphical nodes.

The nodes must be added into the `master_network` hash in file `$ADMIN/hpc-privatedata/hieradata/$CLUSTER/network.yaml` with all their network interfaces and the MAC addresses of their network interface connected to the *administration* and their BMC.

Generate all the SSH host keys:

```
puppet-hpc/scripts/sync-ssh-hostkeys.sh hpc-privatedata $CLUSTER
```

Push and apply the configuration to the admin and generic service nodes:

```
hpc-config-push && clush -bg admin,service hpc-config-apply -v
```

Finally, boot all the nodes in PXE mode with Clara:

```
clara ipmi pxe @front,@cn,@gn
clara ipmi boot @front,@cn,@gn
```

Chapter 16. Optional features

16.1. Tuning

TBD

16.2. Firewall

TBD

16.3. Kerberos

TBD

16.4. Internal APT repository

TBD

16.5. Storage Multipath

TBD

16.6. Monitoring

TBD

16.7. Metrics

TBD

16.8. HPCStats

TBD

16.9. Slurm WCKeys

TBD

16.10. Slurm-web REST API

Slurm-web is both a web interface and REST API service to get and visualize the current status of the jobs and ressources managed by Slurm.

Puppet-HPC is able to deploy the REST API component of Slurm.

```
mkdir hpc-privatedata/files/$CLUSTER/$AREA/slurmweb
head -c 48 /dev/urandom | base64 > files/$CLUSTER/$AREA/slurmweb/secret.key
clara enc encode hpc-privatedata/files/$CLUSTER/$AREA/slurmweb/secret.key
rm hpc-privatedata/files/$CLUSTER/$AREA/slurmweb/secret.key
```

Where $AREA is the area of the nodes hosting the REST API.

Then, define XML cluster racking description file `hpc-privatedata/files/$CLUSTER/$AREA/slurmweb/racks.xml` according to Slurm-web documentation.

Add `profiles::http::slurmweb` profile in the role of the nodes hosting the REST API.

Finally, push and apply the new configuration on the admin node and on the nodes hosting the profile:

```
hpc-config-push
hpc-config-apply
clush -bg admin,hpc_profiles:http::slurm-web \
  hpc-config-apply -v
```

16.11. NFS High-Availability

TBD

16.12. Slurm power management

Generate and encrypt the SSH key used to poweroff the nodes from the batch nodes:

```
mkdir hpc-privatedata/files/$CLUSTER/$AREA/pwmgt
ssh-keygen -N '' -C root@pwmgt -f hpc-privatedata/files/$CLUSTER/
$AREA/pwmgt/id_rsa_slurm
clara enc encode hpc-privatedata/files/$CLUSTER/$AREA/pwmgt/id_rsa_slurm
rm hpc-privatedata/files/$CLUSTER/$AREA/pwmgt/id_rsa_slurm
```

Where $AREA is the area of the batch nodes.

Then add those settings in the cluster specific layer of the hiera repository:

```
profiles::jobsched::pwmgt::enabled: true
slurmutils::pwmgt::ctld::config_options:
   ipmi:
     prefix:   "%{hiera('ipmi_prefix')}"
     user:     "%{hiera('ipmi_user')}"
     password: "%{hiera('ipmi_password')}"
slurmutils::pwmgt::ctld::priv_key_enc:
"%{::private_files_dir}/pwmgt/id_rsa_slurm.enc"
slurmutils::pwmgt::ctld::decrypt_passwd: "%{hiera('cluster_decrypt_password')}"

slurmutils::pwmgt::exec::pub_key: <PUBKEY>
```

Where <PUBKEY> is the public key in file `hpc-privatedata/files/$CLUSTER/$AREA/pwmgt/id_rsa_slurm.pub`.

Finally, apply the new configuration on the batch nodes and all the compute nodes:

```
hpc-config-push
clush -bg batch hpc-config-apply -v
clush -bg compute hpc-config-apply -v
```

Bootstrap procedures

This chapter contains all the procedures to boostrap all the crucial services for a Scibian HPC system: LDAP, Ceph, MariaDB with Galera, SlurmDBD, etc.

Chapter 17. LDAP bootstrap

As stated in external services section of the Reference Architecture chapter, a central LDAP directory server external to the Scibian HPC cluster is required. The LDAP directory server on the cluster is just is a *replica* of this central external server.

The Puppet-HPC `openldap` module expects a LDIF file containing a full dump of the LDAP replica configuration. The easiest way to produce this bootstrap LDIF file is to install and configure an LDAP server replica manually and dump the live configuration.

First, install an LDAP server with common LDAP utilities:

```
# apt-get install slapd ldap-utils
```

Select the HDB database backend. Then, configure the base DN, the domain name, the organization name according to your environment, and set the administration password.

Write the LDAP replication configuration LDIF file `syncrepl_config.ldif`, similarly to this example:

```
dn: olcDatabase={1}hdb,cn=config
changetype: modify
add: olcSyncrepl
olcSyncrepl: rid=001 provider=<LDAP_SERVER_URL> bindmethod=simple timeout=0
  tls_cacert=<CA_CRT_CHAIN>
  network-timeout=0 binddn="<BIND_DN>" credentials="<BIND_PASSWORD>"
  searchbase="dc=calibre,dc=edf,dc=fr"
  schemachecking=on type=refreshAndPersist retry="60 +"
-
add: olcUpdateref
olcUpdateref: <LDAP_SERVER_URL>
```

Where:

- `LDAP_SERVER_URL` is the URL to the organization central LDAP server, *ex:* `ldaps://ldap.company.tld`.
- If using TLS/SSL, `CA_CRT_CHAIN` is the absolute path to the CA certificate chain (up-to root CA certificate), *ex:* `/usr/local/share/ca-certificates/ca-chain.crt`
- `BIND_DN` is the replication user DN, *ex:* `cn=replication,dc=company,dc=tld`
- `BIND_PASSWORD` is the password of the replication user

Inject this LDIF replication configuration file into the LDAP server:

```
# ldapmodify -a -Y EXTERNAL -H ldapi:// -f syncrepl_config.ldif
```

Using the same technique, configure to your needs the indexes, ACLs, TLS/SSL, password policy, kerberos, etc. Finally, generate the full LDAP config dump with:

```
# slapcat -b cn=config > config_replica.ldif
```

or:

```
# ldapsearch -Y EXTERNAL -H ldapi:/// -b cn=config > config-replica.ldif
```

The `config_replica.ldif` file must be deployed encrypted within Puppet-HPC private files directory. Please refer to Puppet-HPC Reference Documentation for more details.

After a fresh installation the cluster's services virtual machines that host the LDAP directory replicas, the `config_replica.ldif` is deployed by Puppet and the LDAP replication must be bootstraped with this script:

```
# make_ldap_replica.sh
```

The script will ask you to confirm by typing YES and press enter.

Chapter 18. MariaDB/Galera bootstrap

The Puppet-HPC `mariadb` module configures an active/active MariaDB cluster based on galera replication library. On the service virtual machines that host this database system, the corresponding `mariadb` system service will not start unless it is already started on another service virtual machine. If it is not running anywhere else, the service must bootstraped with this command:

```
# galera_new_cluster
```

This command starts the MariaDB service on the local host in *new cluster* mode. The state of the local service can be checked with this command:

```
# systemctl status mariabd.service
```

This command must report on running `mysqld` process. In some case, typically when a MariaDB/Galera was not properly stopped, the command may fail and report this error:

```
[ERROR] WSREP: It may not be safe to bootstrap the cluster from this node. It
was not the last one to leave the cluster and may not contain all the updates.
To force cluster bootstrap with this node, edit the grastate.dat file manually
and set safe_to_bootstrap to 1 .
```

In this case, and if you are totally sure that MariaDB service is stopped on all nodes, the error can be ignored with the following command:

```
# sed -i 's/safe_to_bootstrap: 0/safe_to_bootstrap: 1/' /var/lib/mysql/grastate.dat
```

Then, the MariaDB/Galera cluster can be started again with `galera_new_cluster`.

Once the service is started on all service virtual machines, you can check the cluster replication status with:

```
# mysql -e "SHOW STATUS LIKE 'wsrep_cluster_size'"
```

This result must be the number of expected active nodes in the MariaDB/Galera cluster (*ex:* 2).

Chapter 19. SlurmDBD bootstrap

After its first installation on the cluster, the SlurmDBD accounting database is empty. First, the cluster must be created in the database:

```
# sacctmgr --immediate add cluster <name>
```

Where `<name>` is the name of the cluster.

Then, once the `sync-accounts` utility is configured, run it to create all accounts and users:

```
# slurm-sync-accounts
```

Then, it is possible to create QOS and configure fair-share depending upon your needs.

If using wckeys, they must be bootstrapped by adding the first key manually using the `sacctmgr` command and then run the importation script:

```
# sacctmgr -i add user root wckey=<init>
# slurm_wckeys_setup.sh
```

Chapter 20. Ceph

20.1. Ceph Deploy

The `ceph-deploy` directory is created during the initial ceph installation, to use the `ceph-deploy` again or from another service or admin node, it must be recreated.

```
# mkdir ceph-deploy
# cd ceph-deploy
# ceph-deploy config pull fbservice1
# ceph-deploy gatherkeys fbservice1
```

20.2. Mon

After the reinstallation of one of the generic service nodes with a mon, it must be re-initialized. This procedure only works on a running cluster, the initial mon creation uses another command.

From an **admin** node:

```
# cd <ceph deploy directory>
# ceph-deploy --overwrite-conf mon add <mon hostname>
```

20.3. OSD

This procedure only applies if the content of an OSD volume is lost. If the node is reinstalled without erasing the content of the OSD volume, the configuration in puppet will be enough to start the osd volume again.

The relevant OSD ID can be retrieved with:

```
# ceph osd tree
```

Before doing this procedure, make sure the OSD is really down and not mounted on the OSD node.

20.3.1. Removing old OSD

The old OSD must be removed from the configuration (stored by the MON).

```
# ceph osd crush remove osd.X
# ceph auth del osd.X
# ceph osd rm X
```

20.3.2. Re-creating the OSD

```
# cd <ceph deploy directory>
# ceph-deploy osd prepare clserviceY:sdb
# ceph-deploy disk zap clserviceY:sdb
```

The OSD id and authentication key should be updated on the hiera configuration. In most cases, the new OSD will take the same ID as the old one. You can get the new ID and the new key with:

```
# ceph osd tree
# ceph auth print-key osd.X
```

20.4. CephFS

CephFS filesystem is used between the batch nodes to shared Slurm controller state. The filesystem must be initialized before being used by Slurm.

First, mount temporarily the CephFS filesystem:

```
# mount -t ceph -o name=admin,secretfile=/etc/ceph/client.key
fbservice2,fbservice3,fbservice4:/ /mnt
```

Create a subdirectory for Slurm controller, set its ownership and restrict its mode:

```
# mkdir /mnt/slurmctld
# chown slurm: /mnt/slurmctld
# chmod 0700 /mnt/slurmctld
```

Finally, umount it:

```
# umount /mnt
```

Puppet-HPC is now able to use this filesystem for Slurm on batch nodes.

Chapter 21. NFS HA bootstrap

The shared storage of the NFS server contains a directory that holds the state of the clients (mainly the locks). When the shared NFS storage is created, it must be formated and this state directory must be created.

The shared storage must be on a specific LVM Volume Group. What the PVs are for this volume group and how they are configured depends on the hardware available.

In the following example, the PV/LV is `VG_NAS/LV_NAS` and is to be mounted as `/srv/admin`.

```
# mkfs.ext4 /dev/VG_NAS/LV_NAS
# mkdir /srv/admin
# mount /dev/VG_NAS/LV_NAS /srv/admin
# mkdir -p /srv/admin/restricted/state/nfs/v4recovery
# umount /srv/admin
```

After these steps, the keepalived daemon can be started on the nodes. The MASTER node will mount the storage and export it.

Production procedures

In this chapter are listed all the technical procedures to follow for regular operations occurring during the production phase of the supercomputer. This notably includes changing any encryption or authentication key, changing passwords, reinstalling nodes, etc.

Chapter 22. MAC address change

This procedure explains how to modify the Puppet-HPC configuration to change an hardware Ethernet address after a motherboard replacement, for example.

First, the yaml file in the hieradata repository containing the `master_network` hash must be edited to replace the old hardware address. A description of this hash can be found in the Installation section of this guide.

The modified configuration must be pushed to the shared administration directory with the `hpc-config-push` command:

```
# hpc-config-push
INFO: creating archive /tmp/puppet-config-push/tmp_ndq0ujz/puppet-config-
environment.tar.xz
INFO: S3 push: pushing data in bucket s3-system
```

Then apply the configuration on the `service` nodes, who runs the DHCP server:

```
# hpc-config-apply
```

NOTE It is not possible to run the `hpc-config-apply` command on all the service nodes at the same time exactly. A short delay must be respected as the Ceph service can be disturbed by a restart of the network service.

Chapter 23. Password/keys changes

23.1. Root password

The hashed root password is stored in the variable `profiles::cluster::root_password_hash` in yaml files. The value must be encrypted using eyaml. It can be simply changed using the `eyaml` command.

```
# eyaml edit cluster.yaml
...
profiles::cluster::root_password_hash: DEC::PKCS7[hashed_password]!
...
```

Once changed, the new configuration must be applied on all the machines of the cluster.

23.2. Root SSH key

The root SSH keys are stored in the internal repository. The privates keys must be encrypted. The SSH public rsa key is also in the variable `openssh::server::root_public_key`. It is necessary to change the files and the value of the variable at the same time. To avoid connections problems, it is necessary to follow these steps in this order:

1. Change the keys files and the variable `openssh::server::root_public_key` in the internal repository
2. Apply the configuration on all the machines exept the **admin** one
3. Apply the new configuration on the **admin** server.

NOTE In case of desynchronization between the keys on the **admin** node and those on the others nodes, it is always possible to use the root password to connect.

23.3. SSH host keys

The SSH host keys are stored, encrypted, in the internal repository. To avoid connections problems, it is necessary to follow these steps in this order:

1. Change the keys files in the internal repository
2. Apply the configuration on all the machines of the cluster, including the **admin** machine
3. Delete the file */root/.ssh/known_hosts* on the **admin** node.
4. When connecting to the nodes, */root/.ssh/known_hosts* will be automatically populated if the Scibian HPC default configuration is used.

23.4. Eyaml keys

Replacing the eyaml PKCS7 key pair consist in reality of two actions:

1. Generate a new pair of keys (`eyaml createkeys`)
2. Replace all the values encoded with the old pair with ones encoded with the new pair of keys.

NOTE As these operations implies decoding files and re-encoding them with another key pair, it is not possible to perform other administrative operations (like applying the configuration on nodes) on the cluster at the same time. The changing keys operation must be fully completed before resuming "normal" administrative operations.

These steps must be followed in order to safely change the eyaml keys:

Save the old keys:

```
# cp /etc/puppet/secure/keys/private_key.pkcs7.pem \
     /etc/puppet/secure/keys/private_key.pkcs7.pem.old
# cp /etc/puppet/secure/keys/public_key.pkcs7.pem \
     /etc/puppet/secure/keys/public_key.pkcs7.pem.old
```

Copy the new keys in */etc/puppet/secure/keys/*.

Decrypt all the yaml files encoded using the old keys:

```
# eyaml decrypt \
  --pkcs7-private-key /etc/puppet/secure/keys/private_key.pkcs7.pem.old \
  --pkcs7-public-key /etc/puppet/secure/keys/public_key.pkcs7.pem.old \
  -e hieradata/<cluster>/cluster.yaml \
  > hieradata/<cluster>/cluster.decrypt.yaml
```

The `decrypt.yaml` contains all the secret in plain text. It should be removed as soon as possible.

Encrypt the files with the new keys:

```
# eyaml encrypt -e hieradata/<cluster>/cluster.decrypt.yaml \
  > hieradata/<cluster>/cluster.yaml
# rm hieradata/<cluster>/cluster.decrypt.yaml
```

Remove the old saved keys from the **admin** node:

```
# rm /etc/puppet/secure/keys/private_key.pkcs7.pem.old \
     /etc/puppet/secure/keys/public_key.pkcs7.pem.old
```

Create a tarball, encode it with `clara enc` and add it to the *files* directory of the internal repository:

```
# tar cJf /tmp/keys.tar.xz -C /etc/puppet/secure keys
# clara enc encode /tmp/keys.tar.xz
# mv /tmp/keys.tar.xz.enc <internal repository>/files/<cluster>/eyaml
```

Where:

- <internal repository> is the directory that contains the clone of the internal repository.
- <cluster> is the name of the cluster.

At this stage, the keys are now stored encrypted in the internal repository and are available locally in the standard eyaml paths.

In the default Scibian-HPC configuration, the PKCS7 keys propagation service runs on all the generic service nodes. First, the encoded tarball must be manually copied on the nodes:

```
# scp <internal repository>/files/<cluster>/eyaml/keys.tar.xz <generic server
X>:/tmp
```

Where <generic server X> is the hostname of the generic service node.

Then apply the configuration using the new keys:

```
# hpc-config-apply -vv --keys-source=/tmp
```

This will copy the eyaml PKCS7 key pair in the right directory to be serviced by the propagation service to all others nodes when applying the puppet configuration. These last two operations must be executed on all the generic service nodes.

Don't forget to remove the keys from the `/tmp` directory on the admin node and on all the service nodes.

```
# rm /tmp/keys.tar.xz
# clush -w @service rm /tmp/keys.tar.xz
```

23.5. Internal repository encoding key

NOTE As these operations implies decrypting files and re-encrypting them with another key, it is not possible to perform other administrative operations (like applying the configuration on nodes) on the cluster at the same time. The changing key operation must be fully completed before resuming "normal" administrative operations.

Replacing the AES key used to encode files in the internal repository consist in several steps.

Generate a new AES key:

```
# openssl rand -base64 32
```

For each encoded file in the internal repository, it is necessary to decode it with the old key and re-encode it with the new one.

```
# clara enc decode <internal repository>/files/<cluster>/<filename>.enc
# openssl aes-256-cbc \
          -in <internal repository>/files/<cluster>/<filename> \
          -out <filename>.enc -k <AES KEY>
# rm <internal repository>/files/<cluster>/<filename>
```

Where:

- <internal repository> is the directory that contains the clone of the internal repository
- <cluster> is the name of the cluster
- <filename> is the path of the file to encode
- <AES KEY> is the random 256 bits key.

Using `clara` for both operations, decode and encode, is not possible as it support only one AES key.

This re-encryption step can be automated with the `reencode-file.sh` script in the `puppet-hpc` scripts dir:

```
# cd <internal repository>/files/<cluster>
# find -name "*.enc" \
  -exec <puppet-hpc path>/scripts/reencode-file.sh\
    /tmp/oldkey /tmp/newkey '{}' ';'
```

The files `/tmp/oldkey` and `/tmp/newkey` are files with just the old and new AES key respectively. This script does not depend on `clara` but basically performs the same steps as above.

The AES key must be placed in *cluster_decrypt_password* in the cluster layer of the Hiera repository:

```
# eyaml edit hieradata/<cluster>/cluster.eyaml
```

Replace the key:

```
cluster_decrypt_password: DEC::PKCS7[<AES KEY>]!
```

Apply the new configuration on the **admin** node, to update `clara` configuration:

```
# hpc-config-apply
```

23.6. Replication account password

The steps to change these credentials are described here:

1. Decode the configuration ldif file:

   ```
   # clara enc edit <internal repository>/files/<cluster>/<filename>.enc
   ```

2. The field to change is `olcSyncrepl:`, it contains all the necessary informations to connect to the master LDAP server (login, password, URI, etc ..)
3. Apply the new configuration on the **proxy** nodes.
4. Follow the LDAP bootstrap procedure as described in LDAP bootstrap on each **proxy** node. It is recommended to wait until the first ldap replicate is complete before attempting to update the second, to not disrupt authentication across the cluster.

NOTE It is possible to change others values with this procedure, for example the root LDAP password.

23.7. Monitoring certificates

The certificates used for monitoring are stored, encrypted, in the internal repository in *<internal repository>/files/<cluster>/icinga2/certs/*. Each host has a certificate and a key. The steps to follow to change them are:

1. Change the key and certificate files in the internal repository
2. Apply the configuration on the concerned node
3. Update the certificate on the Icinga2 server

23.8. Munge key

NOTE Scheduling service and jobs must be stopped to change the munge key.

WARNING This will kill running jobs.

1. Stop the `slurmd` and `slurmctld` daemons.
2. Stop the munge daemon on all nodes.
3. Encrypt the new key with `Clara` and place it in *<internal repository>/files/<cluster>/munge/munge.key.enc*
4. Apply the new configuration on all nodes.
5. restart the daemons.

23.9. Repo keyring

NOTE The packages must be saved in another place.

The cluster must use a private cluster keyring. This keyring is used to sign the local packages repository.

It is stored in the internal repository: *<internal repository>/files/<cluster>/repo/*

Here are the steps to follow to change it:

1. Generates a new keyring:

```
# LANG=C gpg --no-default-keyring \
--keyring <internal repository>/files/<cluster>/repo/cluster_keyring.gpg \
--secret-keyring <internal
repository>/files/<cluster>/repo/cluster_keyring.secret.gpg \
--gen-key
```

2. Encode the secret file with `clara encode`.
3. Apply the configuration on the **admin** node.
4. Delete the folder containing the local repository.
5. Re-create the repository with `clara`:

```
# clara repo key
# clara repo init scibian9-hpc
```

6. Add the previously saved packages with `clara`:

```
# clara repo add scibian9-hpc mypackage_1-2.dsc
# ...
```

23.10. MariaDB users

Generate passwords conform with your organization policy and edit the following parameters with `eyaml` in the hiera repository:

- `slurmdbd_slurm_db_password`
- `slurmdbd_slurmro_db_password`

These parameters correspond to the passwords of the MariaDB having respectively R/W and R/O grants on the SlurmDBD database.

Once modified, push and apply the configuration with the following commands:

```
# hpc-config-push && \
  clush --fanout=1 -bg batch hpc-config-apply -v
```

The `hpc-config-apply` command will perform the following steps, on each batch node:

- Update the passwords in the configuration file of the Slurm `mysql-setup` utility.
- Update the passwords in the MariaDB database
- Update SlurmDBD configuration (if R/W password changed)
- Restart SlurmDBD (if R/W password changed)

The `--fanout=1` parameter of the `clush` command makes sure the configuration is not applied simultaneously on both batch nodes. This could cause the SlurmDBD daemon to be restarted at the same time and make this service unavailable for a short period of time.

Chapter 24. Administration node re-installation

This procedure will wipe the first disk of the admin node, if some customizations are not in the Puppet configuration, this should be handled separately.

Before, powering off the administration node, check that:

- There is an alternative route to connect to the service node (can be the service nodes themselves)
- It is possible to connect to the BMC IPMI, and especially to the Serial Over LAN console
- It is possible to connect to the Ethernet administration network switch

The administration node has no critical service in the reference architecture, so it can simply be powered off:

```
# poweroff
```

NOTE In some Ethernet bonding setups, the node cannot do a PXE boot with an active bonding configuration on the Ethernet switch. If this is the case, refer to the documentation of the network switch to disable the bonding configuration.

To be re-installed, the administration node must perform a network boot. This can be configured with `ipmitool(1)` installed on a host that has access to the BMC network interface:

```
# ipmitool -I lanplus -H <bmc host> -U <bmc username> -P chassis bootdev pxe
# ipmitool -I lanplus -H <bmc host> -U <bmc username> -P chassis power on
```

Next steps will happen once the node is installed and has rebooted, the installation can be followed through serial console:

```
# ipmitool -I lanplus -H <bmc host> -U <bmc username> -P sol activate
```

NOTE If the Ethernet switch configuration had to be modified to setup PXE boot, the modification must be reverted to its nominal status.

Chapter 25. Service node re-installation

Before re-installing a Service node, active Virtual Machines on the nodes should be migrated away from the node. Clara can be used to list the active VMs and do the live migration.

Listing the VMs:

```
# clara virt list | grep clserviceX
```

Migrate the live VMs with the command:

```
# clara virt migrate <vmname> --dest-host clserviceY
```

These points should be checked before turning off a Service Node:

- The ceph cluster should be `HEALTH_OK` (`ceph health`), with at least three OSD `in`
- `consult` should return services as passing on at least three nodes
- On an Intel Omni-Path cluster, the `opafabricinfo` should return at least one Master and one Standby node

Once there is no VM remaining on the node, it can be powered off safely, the other Service node should ensure there is no service outage. The power off can be done from the node itself:

```
# poweroff
```

NOTE In some Ethernet bonding setups, the node cannot do a PXE boot with an active bonding configuration on the Ethernet switch. If this is the case, refer to the documentation of the network switch to disable the bonding configuration.

To be re-installed, the service node must perform a network boot. This can be configured with **clara**:

```
# clara ipmi pxe clserviceX
# clara ipmi on clserviceX
```

Next steps will happen once the node is installed and as rebooted, the installation can be followed through serial console:

```
# clara ipmi connect clserviceX
```

After a Service node re-installation, the ceph services: OSD, MDS and RadosGW should be reconfigured automatically by the Puppet HPC configuration. The Mon service (not present on every node), must be boot-strapped again. This procedure is described with other Ceph bootstrap procedures.

In order to validate the generic service node re-installation, there are some relevant checks to perform.

- High-Speed network manager (Intel Omni-Path):

```
# opafrabricinfo
```

The reinstalled node must appear as a **Master** or **Standby** node.

- Check the ceph cluster is healthy:

```
# ceph status
```

The cluster should be `HEALTH_OK` with all OSDs, Mons and MDSs.

- Consul:

```
# consult
```

All services on all nodes should have the state `passing`.

NOTE If the Ethernet switch configuration had to be modified to setup PXE boot, the modification must be reverted to its nominal status.

Chapter 26. Network Boot and Installation Tuning

Puppet-HPC deploys a network boot and installation system with sane default designed to work in most situations. However, you may need to tune the default setup for specific needs. The following sections how to alter the setting of all the network boot and installation components.

26.1. iPXE ROM

On Scibian HPC clusters, the default iPXE ROM is provided by the `ipxe` package. Alternatively, you can build a custom ROM following the instructions available on iPXE website and deploy it with Puppet-HPC.

First, copy the custom ROM (ex: `custom.kpxe`) in the `$ADMIN/hpc-privatedata/files/$CLUSTER/cluster/boot/ipxe/` directory.

Then, define the `boottftp::hpc_files` hash in the cluster layer of the Hiera repository to declare the file to deploy:

```
boottftp::hpc_files:
  "%{hiera('tftp_dir')}/custom.kpxe":
    source: "%{::private_files_dir}/boot/ipxe/custom.kpxe"
```

Then, set the `ipxebin` parameter accordingly in the `boot_params` hash of the cluster layer of the Hiera repository, for example:

```
boot_params:
  defaults:
    ipxebin: custom.kpxe
```

Finally, deploy configuration changes on DHCP and boot servers:

```
hpc-config-push && \
  clush -bg hpc_profiles:bootsystem::server,hpc_profiles:dhcp::server \
    hpc-config-apply
```

26.2. Bootmenu Entries

As explained in Section 5.2, "iPXE Bootmenu Generator", the bootmenu entries available in iPXE are declared in YAML files. Puppet-HPC provides a mechanism to deploy custom entries and optionally override the defaults provided by `scibian-hpc-netboot-bootmenu` package.

For this purpose, edit the cluster layer of the Hiera repository to declare the `bootsystem::menu_entries` hash profile parameter, for example:

```
profiles::bootsystem::menu_entries:
  scibian9:
    ram:
      test:
        label:  Run {{ os }} in RAM
        initrd: initrd
        kernel: vmlinuz
        opts:   >
          initrd={{ initrd }}
          console={{ console }}
          ethdevice={{ boot_dev }}
          ethdevice-timeout={{ dhcp_timeout }}
          cowsize={{ cowsize }}
          transparent_hugepage=always
          disk-format={{ disk_format }}
          disk-raid={{ disk_raid }}
          boot=live
          union=overlay
          fetch=${base-url}/{{ os }}.squashfs.torrent
          {{ kernel_opts }}
```

This declares an additional `scibian9-ram-test` entry. Optionally, it is also possible to set this entry as the default for some nodes in the `boot_params` hash of the cluster layer of the Hiera repository, for example:

```
boot_params:
  fbcn04:
    os: scibian9
    media: ram
    version: test
```

This way, the `fbcn04` node will boot this new entry by default.

Finally, deploy the configuration changes on boot servers:

```
hpc-config-push && \
  clush -bg hpc_profiles:bootsystem::server \
    hpc-config-apply
```

26.3. Debian Installer Environment

As explained in Section 5.1.2, “Disk installation”, the Debian installer environment is installed with `debian-install-*-netboot-amd64` packages. These packages are designed to work on most hardware, however it may be required to use alternate environment in some cases, notably if the hardware needs special non-free modules or firmwares during the installation.

For this purpose, Puppet-HPC lets the ability to deploy custom Debian Installer environment within an archive.

For information, it is possible to build a base archive using the packages, for example:

```
# install netboot package
apt-get install debian-installer-9-netboot-amd64

# create the base netboot archive
tar chzf $ADMIN/hpc-privatedata/files/$CLUSTER/cluster/boot/disk-
installer/scibian9/netboot.tar.gz \
  -C /usr/lib/debian-installer/images/9/amd64/text .
```

Starting from this point, the archive can be tuned upon your needs.

To deploy this archive on the boot servers, the `boothttp::archives` hash parameter must be defined accordingly in the cluster specific layer of the Hiera repository:

```
boothttp::archives:
  "%{hiera('website_dir')}/disk/scibian9/custom/netboot.tar.gz":
    source:       "%{::private_files_dir}/boot/disk-
installer/scibian9/netboot.tar.gz"
    extract_path: "%{hiera('website_dir')}/disk/scibian9/custom"
    extract:      true
```

Then, define a bootmenu entry, following the procedure in Section 26.2, “Bootmenu Entries”, to network boot this custom environment.

Finally, deploy the new configuration on the boot servers:

```
hpc-config-push && \
  clush -bg hpc_profiles:bootsystem::server \
    hpc-config-apply
```

26.4. Alternate Partition Schemas

As explained in Section 5.3, “Debian Installer Preseed Generator”, the preseed generator provides a link to a CGI script that generates dynamically for the node a partition schema (aka. *recipe*) for Debian installer partman utility.

By default, this script sends a partition schema common to all nodes. The default common partition schema is provided by `scibian-hpc-netboot-preseedator` package. It configures the `/dev/sda` disk with LVM physical volume and creates dedicated logical volumes for `/`, `/var`, `/tmp` and swap partitions. However, the script is able to send specific partitions schemas for a given host or role.

Puppet-HPC gives the ability to override the default common partition schema provided by the package and to deploy these specific partition schemas and

Once the alternate partman partition recipe is defined, copy the file into `$ADMIN/hpc-privatedata/files/$CLUSTER/cluster/boot/disk-installer/schemas/` directory.

NOTE The `debian-installer` package provides documentation to help writing partman recipes, in files `/usr/share/doc/debian-installer/devel/partman-auto*-recipe.txt*`.

Then, define the `boothttp::partition_schemas` hash parameter in cluster layer of the Hiera repository to declare the partition schemas to deploy, for example:

```
boothttp::partition_schemas:
  common:
    src:  "%{::private_files_dir}/boot/disk-installer/schemas/common"
    dest: 'common'
  proxy:
    src:  "%{::private_files_dir}/boot/disk-installer/schemas/roles/proxy"
    dest: 'roles/proxy'
  fbbatch2:
    src:  "%{::private_files_dir}/boot/disk-installer/schemas/nodes/fbbatch2"
    dest: 'nodes/fbbatch2'
```

In this example, the following partition schemas are deployed:

- An override of the common partition schema,
- A partition schema for all nodes having the *proxy* role,
- A partition schema specific to `fbbatch2` node.

Finally, deploy the new configuration on the boot servers:

```
hpc-config-push && \
  clush -bg hpc_profiles:bootsystem::server \
    hpc-config-apply
```

Chapter 27. Frontend access

27.1. Draining

To perform a scheduled reboot of a frontend it is better to avoid new connection going to the frontend node that will be rebooted. The new connections are highly available and load balanced with IPVS.

It is possible to remove a frontend from the pool of node accepting new connections without killing active connections with the `ipvsadm` command by setting the weight of a node to 0.

To list the current weight, on a frontend:

```
# ipvsadm -ln
IP Virtual Server version 1.2.1 (size=4096)
Prot LocalAddress:Port Scheduler Flags
  -> RemoteAddress:Port           Forward Weight ActiveConn InActConn
TCP  172.16.1.16:22 rr persistent 600
  -> 172.16.1.11:22              Route   1      10         0
  -> 172.16.1.12:22              Route   1      6          0
  -> 172.16.1.13:22              Route   1      1          0
  -> 172.16.1.14:22              Route   1      15         0
  -> 172.16.1.15:22              Route   1      1          0
```

To avoid a frontend node being attributed to new sessions, the weight of the node can be manually set to 0. This setting does not completely forbid new connection to go to the node, if a user already has a session, new session will go to the same node regardless of the weight. This setting also does not block connections made directly to the node and not the virtual IP address.

```
# ipvsadm -e -t 172.16.1.16:22 -r 172.16.1.11:22 -w 0
# ipvsadm -ln
IP Virtual Server version 1.2.1 (size=4096)
Prot LocalAddress:Port Scheduler Flags
  -> RemoteAddress:Port           Forward Weight ActiveConn InActConn
TCP  172.16.1.16:22 rr persistent 600
  -> 172.16.1.11:22              Route   0      10         0
  -> 172.16.1.12:22              Route   1      6          0
  -> 172.16.1.13:22              Route   1      1          0
  -> 172.16.1.14:22              Route   1      15         0
  -> 172.16.1.15:22              Route   1      1          0
```

The modification can be reversed by setting the weight back to 1 manually.

```
# ipvsadm -e -t 172.16.1.16:22 -r 172.16.1.12:22 -w 1
```

Chapter 28. NFS HA

28.1. Starting a node

When a node start is should not start the keepalived service automatically. This permits a failed node to be started without it becoming master with an remaining problem.

Before starting the **keepalived** service, the following conditions must be met:

- The **multipath-tools** service must be active with a running `multipathd` process.
- The **keepalived** service must be disabled

When these conditions are met, the service can be started:

```
# systemctl start keepalived
```

If the node is to become master (master node in the VIP configuration or other node is down), check that the first check goes well. It runs every minutes and logs are in `/var/log/user.log`. The message following message must appear:

```
Mar 17 17:19:01 fbnfs1 hpc_nfs_ha_server_check.sh.info: INFO: fbnfs1 All checks are
OK
```

28.2. Manual Fail Over

If the master node disappears, because it is turned off or because the keepalived service is stopped, the failover will happen, but it will take a bit of time (a little more than a minute). This timeout can be entirely avoided by doing a manual failover of the master node before cutting the keepalived service.

To do this, the keepalived configuration must be changed manually on the node. Edit the file `/etc/keepalived/keepalived.conf`. Find the configuration for the NFS VIP and change the priority to 40, and the role to `BACKUP`. The service must be reloaded:

```
# service keepalived reload
```

The failover should happen quickly. Once the node failed over, stop the keepalived service:

```
# systemctl stop keepalived
```

The original configuration must be restored before starting the service again. This will happen if you launch a **hpc-config-apply** manually or if you reboot the node.

Chapter 29. Services

This section contains usefull procedures for casual operations on infrastructure services.

29.1. Packages Caching purge

In order to invalidate and purge the packages caching service `apt-cacher-ng` cache content, run the following commands consecutively:

```
# clush -bg service systemctl stop apt-cacher-ng.service
# clush -bg service rm -rf /var/cache/apt-cacher-ng
# clush -bg service mkdir /var/cache/apt-cacher-ng
# clush -bg service chown apt-cacher-ng: /var/cache/apt-cacher-ng
# clush -bg service systemctl start apt-cacher-ng.service
```

Chapter 30. Virtual Machines

This section contains procedure related with virtual machines management with clara.

30.1. Deleting a Virtual Machine

A Virtual Machine is composed of two mostly independant objects:

- The disk image
- The definition on a host

The two objects must be deleted separately.

The first step is to stop the Virtual Machine:

```
# clara virt stop <vm_name>
```

Once it is in the state `SHUTOFF` you can undefine it:

```
# clara virt undefine <vm_name>
```

The VM will still appear on `clara virt list` with the state: `MISSING`. It means clara still sees the disk image but not the Virtual Machine definition.

You can then proceed with deleting the disk image, by checking the full disk image name with `clara virt list --details`, you must find the volume name and the pool name.

On a physical host:

```
# virsh vol-delete --pool <pool_name> <volume_name>
```

On all other physical hosts:

```
# virsh pool-refresh <pool_name>
```