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Lightbits™ LightOS™ v2.x Installation and Configuration Guide

The Lightbits™ LightOS™ cluster storage solution distributes services and replicates data across different LightOS servers to guarantee service and data availability when one or more LightOS servers experience transient or permanent failures. A cluster of LightOS servers replicates data internally and keeps it fully consistent and available in the presence of failures. From the perspective of clients accessing the data, data replication is transparent, and server failover is seamless.

LightOS also protects the storage cluster from additional failures not related to the SSDs (e.g., CPU, memory, NICs) failures, software failures, network failures, or rack power failures. It provides additional data security through in-server Erasure Coding (EC) that protects servers from SSD failures and enables non-disruptive maintenance routines that temporarily disable access to storage servers (e.g., TOR firmware upgrades).
About the Installation Guide

This installation guide is for system administrators who are installing the LightOS storage server software. It includes instructions for installing the LightOS cluster software, installing the cluster client software, and connecting clients to the LightOS Cluster.

Use the information in this installation guide to:

- Learn about the Lightbits cluster software solution
- Plan for the LightOS cluster software installation in your environment
- Successfully install the software so that a cluster of LightOS servers is ready for use

Lightbits Labs™ recommends that you follow the installation instructions in the order that they are written to ensure a successful installation.
LightOS Cluster Overview

This section provides you with information about the major components of the LightOS cluster software solution and how they work together.

It also contains recommended best practice tips for collecting information required to use the automated installation script. For the installation script to download and install the LightOS software onto your system’s storage nodes, you must have details about your specific environment—such as your specific networking details.

LightOS Cluster Topology

The following is a basic diagram that shows the components and resources required to automatically install LightOS software onto your servers in your data center.

![Diagram of LightOS Cluster Resources]

Based on the numbers next to each component or resource in the diagram, see the following table for a description of the components and resources in the LightOS cluster topology diagram.

### LightOS Cluster Topology Components Table

<table>
<thead>
<tr>
<th>#</th>
<th>Component or Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dl.lightbitslabs.com</td>
<td>Lightbits supplied configuration files and installation tools via remote repository.</td>
</tr>
<tr>
<td>2</td>
<td>dl.lightbitslabs.com</td>
<td>The LightOS software is maintained in a password-protected software repository, referred to as “The Lightbits Repo”.</td>
</tr>
<tr>
<td>#</td>
<td>Component or Resource</td>
<td>Description</td>
</tr>
<tr>
<td>----</td>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
Planning for the LightOS Cluster Software Installation

At a very high level, the following command automatically installs a LightOS cluster:

```
ansible-playbook -i /tmp/inventory/hosts playbooks/deploy-lightos.yml
```

When this command completes, you will have a LightOS cluster.

To use this Ansible command successfully, you will need to provide the Ansible software with information about your data center's specific environment. This means you should gather some details and enter them into text files that Ansible uses during the LightOS installation operations.

The installation process generally follows the path in the following diagram. When Ansible runs, it reads the text files you configured (in step 3), connects to the Lightbits software repository (in step 1), and downloads LightOS software onto each storage server that will exist in the cluster (in step 4).

### LightOS Cluster Architecture

The Lightbits™ LightOS™ cluster storage solution distributes services and replicates data across different LightOS servers. This guarantees service and data availability when one or more LightOS servers experience transient or permanent failures. A cluster of LightOS servers replicates data internally and keeps it fully consistent and available in the presence of failures. From the perspective of clients accessing the data, data replication is transparent, and server failover is seamless.

LightOS also protects the storage cluster from additional failures not related to the SSDs (e.g., CPU, memory, NICs), software failures, network failures, or rack power failures. It provides additional data security through in-server Erasure Coding (EC) that protects servers from SSD failures and enables non-disruptive maintenance routines that temporarily disable access to storage servers (e.g., TOR firmware upgrades).

The following sections describe the failure domain and volume components used in the LightOS cluster architecture.

**Note:** For more information about LightOS cluster architecture, see the Deploying Reliable High-Performance Storage with LightOS Whitepaper.

### Nodes

Each server can be split into multiple logical nodes. Each logical node owns a specific set of SSDs and CPUs, and a portion of the RAM and NVRAM. The physical network can be shared or exclusive per node.

Nodes can be across NUMAs or per NUMA. There is no relation or limitation between a logical node and the NUMA of the resources used by the logical node.

Each storage server runs a single Node Manager service. The service controls all the logical nodes of the storage server.

**Note:** The current LightOS release only supports up to two logical nodes per server.
Volume Assignments

LightOS provides the following levels of protection for the volumes in a cluster:

- **Double-replica:**
  Volumes are stored on two storage nodes.

- **Triple-replica:**
  Volumes are stored on three storage nodes.

In double and triple replica protection, one of the storage nodes behaves as a primary (P) node for this volume, and the other volume’s storage nodes behave as secondary (S) nodes.

Each storage node that stores data of multiple volumes can act as a primary node of one volume or as a secondary node of another volume. A primary node appears in the accessible path of the client, handles all user IO requests, and replicates data to the secondary nodes. If a primary node fails, the NVMe/TCP multipath feature changes the accessible path and reassigns the primary replica to another node.

When a user creates a volume, LightOS transparently selects the nodes that hold the volume’s data and configures the primary and secondary roles. The node selection logic balances the volumes between nodes upon volume creation.

NVMe/TCP MultiPath

NVMe multipath I/O refers to two or more independent paths between a single host and a namespace. Each path uses its controller, although multiple controllers can share a subsystem port. Multipath I/O like namespace sharing requires that the NVM subsystem contains two or more controllers.

Multipath is part of NVMe specification and is used by the LightOS cluster software as follows:

1. The Primary node exposes the path to the volume.
2. Clients send read and write requests to the Primary node.
3. The Primary node replicates to the Secondary nodes.
4. If the Primary node fails, the Secondary node exposes a path to the client so the client can continue working with the Secondary node.

LightOS uses a proprietary protocol on top of TCP to replicate data between Primary and Secondary nodes, without requiring any changes to the client.
Figure 3: Volume Assignments
Figure 4: LightOS Clustering Multipath Replication Design
Failure Domains

Users define the Failure Domains (FD) based on data center topology and the level of protection that it strives to achieve. Each server in the cluster can be assigned to a set of FDs.

An example of an FD definition is separating racks of servers by FD labels. In this case, all servers in the same rack are assigned the same FD label, while servers in different racks are assigned distinct labels (e.g., FD label = rack ID). Two replicas of the same volume will not be located on two nodes in the same rack.

The system stores different replicas of the data on separate FDs to keep data protected from failures.

The definition of an FD is expressed by assigning FD labels to the storage nodes. Single or multiple FD labels can be assigned to every node.

Another example of an FD definition is grid topology in which every node is assigned a label of a row and a label of a column. In this case, the volume is not stored on two servers that are placed on the same row or on the same column.
LightOS Cluster Software Installation Process

The process of installing Lightbits products includes the installation of the LightOS software on the storage server. It can also include the installation of a new kernel on the client if the client’s kernel version is less than v5.3.5.

The following chart summarizes the steps for completing the LightOS cluster software installation and required actions on the clients.

![LightOS Cluster Software Installation Process Diagram](image)

**Figure 5: LightOS Clustering Multipath Replication Design**

Lightbits recommends you complete each of these steps in the order that they are written to ensure a successful software installation and connection between the LightOS Storage Server and the clients.

**Note:** To complete the installation process, you must have the **LightOS Installation - Customer Addendum** that was sent to you by Lightbits. The customer addendum contains customer-specific information and is referred to throughout the installation procedure.

### Installation Preparation

Before you begin the installation, Lightbits recommends that you use a reference table to list the networking and server names you will use for your LightOS cluster. The following is an example of a table you can use with the Configuring the Ansible Environment section.

#### Installation Planning Table

<table>
<thead>
<tr>
<th>Server Name</th>
<th>Role</th>
<th>Access Network IP</th>
<th>Data NIC Interface Name</th>
<th>Data NIC IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>server00</td>
<td>LightOS Storage Server 1</td>
<td>192.168.16.22</td>
<td>ens1</td>
<td>10.10.10.100</td>
</tr>
<tr>
<td>server01</td>
<td>LightOS Storage Server 2</td>
<td>192.168.16.92</td>
<td>ens1</td>
<td>10.10.10.101</td>
</tr>
<tr>
<td>server02</td>
<td>LightOS Storage Server 3</td>
<td>192.168.16.32</td>
<td>ens1</td>
<td>10.10.10.102</td>
</tr>
<tr>
<td>client00</td>
<td>client</td>
<td>192.168.16.45</td>
<td>ens1</td>
<td>10.10.10.103</td>
</tr>
</tbody>
</table>

This table appears throughout this installation guide to help you follow the LightOS installation process, to show the progress you have made to complete the installation, and to successfully configure a cluster of servers.

### LightOS Cluster Installation Process

- Confirm that Python v3.6 (or higher) is installed
- Review the LightOS installation process
- Setup the Ansible installation machine
- Verifying network connectivity
- Connecting to the Lightbits software repository
- Install the LightOS Storage Server
- Running the Ansible installation playbook
- Clustering client software installation
- Connecting the clustering client to LightOS
- Confirms the clustering client connection to LightOS
- Connecting to the clustering client RPM repository
- Installing the new kernel on CentOS
- Configuring the application server to boot from the new kernel
- Installing the Lightbits NVMe CLI
- Loading the NVMe/TCP host software
### System Requirements

Before you begin installing the LightOS product, you should be aware of the following installation considerations:

- The system administrator performing this installation must have the following permissions:
  - SSH accessibility (needed packages / permissions)
  - Root user permissions are required to complete the installation

- The Linux distribution (CentOS, RedHat or Ubuntu) that your clients use must have the NVMe/TCP client-side drivers. These drivers are included starting with Linux kernel v5.3.5 and above.

- If your system’s Linux distribution does not include this kernel version or a later version, download back-ported NVMe/TCP client side drivers for specific kernels and distributions from the Lightbits drivers webpage.

- Installing the LightOS 2 on the cluster storage server includes:
  - LightOS installation files
  - LightOS was verified with kernel version 4.14. If support for another kernel version is required, contact Lightbits support at support@lightbitslabs.com.

- If your LightOS storage servers use the LightField accelerator card, you must confirm that you have the correct LightField firmware version. Contact Lightbits support for more information.

Additionally:
- You must have Python v3.6 (or higher) installed on the Storage Server where you are installing LightOS.
- The LightOS software kernel requires a boot partition with at least 512 MB available.
- To complete the installation process, you will need information from your version of the **LightOS Installation-Customer Addendum**. If you don’t have the customer addendum, contact a Lightbits representative to receive a copy.
- For more information about which Python version supports Ansible, see the Ansible Installation Guide.

### Required Ports for Installation

The LightOS cluster software requires access to several ports to complete its installation process.

The following table lists the default ports used by the LightOS components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Access/Data NIC</th>
<th>Port (TCP)</th>
<th>Default location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management CLI</td>
<td>Access/Data NIC</td>
<td>443, 2380</td>
<td>None</td>
</tr>
<tr>
<td>etcd peer port</td>
<td>Access/Data NIC</td>
<td>8090, 4420,8009</td>
<td>roles/etcd/defaults/main.yml</td>
</tr>
<tr>
<td>Exporter port</td>
<td>Access/Data NIC</td>
<td>22226</td>
<td>roles/install-lightos/defaults/main.yml</td>
</tr>
<tr>
<td>DurosLight port</td>
<td>Access/Data NIC</td>
<td>Data</td>
<td>roles/install-lightos/defaults/main.yml</td>
</tr>
<tr>
<td>NVMe client connects to DurosLight via this port.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replicator port</td>
<td>Access/Data NIC</td>
<td>443</td>
<td>None</td>
</tr>
<tr>
<td>Other nodes connect for replication to the node via this port.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See the Open TCP ports and verify according to the examples below of how to open and test TCP ports.
You can use the following procedure with the open-source nmap program if you need to check a port’s accessibility:

1. Install the open-source nmap program with the following command: `bash $ yum install -y nmap`
2. Check a port’s accessibility with either of the following commands: `bash $ nc -v -z <ip> <start port>-<end port>` or `bash $ nc -v -u <ip> <start port>-<end port>`
3. You must have the netcat program running in listen mode on the server you are testing with the following command: `bash $ nc -l -p <port>`

**Relevant Lightbits Support Documentation**

This installation and configuration guide is part of a documentation set that provides complete information about using Lightbits products.

This document set includes the following LightOS Support documentation.

<table>
<thead>
<tr>
<th>Document</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LightOS Installation Guide (this document)</td>
<td>Contains the instructions to install the LightOS cluster software, installs the Linux cluster client software, and then connects the cluster client to LightOS.</td>
</tr>
<tr>
<td>Installation Guide - Customer Addendum</td>
<td>Includes customer-specific passwords to access installation files.</td>
</tr>
<tr>
<td>LightOS Administrator’s Guide</td>
<td>Provides detailed information about the operations you can perform using the Lightbits lbcli CLI command and REST API. <strong>Note:</strong> After you complete the installation process in this document, you should refer to the Administrator’s Guide for important management and automation instructions.</td>
</tr>
<tr>
<td>User’s Manual: LightOS REST and CLI API</td>
<td>Lists the low level details for the REST API and CLI command usage. This document is typically used as a reference manual when building and administering the system. <strong>Note:</strong> See the Administrator’s Guide for detailed examples for using the REST API and CLI commands.</td>
</tr>
</tbody>
</table>

The following diagram shows how to use the documents to install, test, and maintain Lightbits products, and how the above referenced documents can be used to support the typical user experience.

![Figure 6: LightOS Documentation Set](image-url)
LightOS Cluster Software Installation

This section includes:

Before You Begin
Connecting to the Lightbits Software Repository
Verifying Network Connectivity for the Servers in the Cluster
Configuring the Ansible Environment
Running the Ansible Installation Playbook to Install LightOS Cluster Software

Before You Begin

Lightbits recommends that you plan to use two networking interfaces for the LightOS cluster installation: one for control and another as a data storage node.

Also:
- The data interfaces must be on the same subnet (in pre-configured interfaces or as an input for Ansible).
- To install the cluster software, you need an Ansible module, and Ansible application-deployment tool v2.10 or later.
- The Python netaddr module, which is used to represent and manipulate network addresses.
- There is support for multiple Ansible tags (for cleanup for example), by using comma-separated tags.
- Based on the placement of SSDs in the server, check if you need to allow cross-NUMA devices in the profile.

The online installation requires an internet connection and the need to configure several files on your system. The file repository URL is accessible and the RPMs are updated.

Note: An offline installation method is available that does not require an internet connection to access the file repository URL. For more information, see Performing an Offline Installation.

Connecting to the Lightbits Software Repository

LightOS Cluster Installation Process

<table>
<thead>
<tr>
<th>#</th>
<th>Installation Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connecting your installation workstation to Lightbits’ software repository</td>
</tr>
<tr>
<td>2</td>
<td>Verifying the network connectivity of the servers used in the cluster</td>
</tr>
<tr>
<td>3</td>
<td>Setting up an Ansible environment on your installation workstation</td>
</tr>
<tr>
<td>4</td>
<td>Installing a LightOS cluster by running the Ansible installation playbook</td>
</tr>
<tr>
<td>5</td>
<td>Updating clients (if required)</td>
</tr>
<tr>
<td>6</td>
<td>Provisioning storage, connecting clients, and performing IO tests</td>
</tr>
</tbody>
</table>

Note: To proceed, see the Linux Repo File Customer TOKEN section in your LightOS Installation Customer Addendum, for the TOKEN that is required to access the yum repository. Access to this repository is required to install the Lightbits LightOS cluster software. Contact Lightbits support if you do not have this addendum document.

If you are using the offline installation method, you can skip this step and proceed to Verifying Network Connectivity for the Servers in the Cluster.

Verify that you have the TOKEN for the Lightbits RPM Repository 2X and log in to your installation workstation.

1. In your preferred text editor, open a new file in the workstation’s following CentOS directory: `bash $ /etc/yum.repos.d/lightos.repo`
2. Copy the following template into the file.  
```bash
# Lightbits repository [lightbits-lightos-2-<Minor Ver>-x-ga] name=lightbits-lightos-2-<Minor Ver>-x-ga baseurl=https://dl.lightbitslabs.com/<YOUR_TOKEN>/lightos-2-<Minor Ver>-x-ga/rpm/el/7/$basearch repo_gpgcheck=0 enabled=1 gpgcheck=0 autorefresh=1 type=rpm-md
```

For the `<YOUR_TOKEN>`, enter the Lightbits TOKEN that was included in your copy of the LightOS Installation Customer Addendum.

3. Save the `lightos.repo` file.

4. Verify your system’s connectivity to the repository by entering the `yum repolist` command. This command displays the enabled software repositories; for example:

```
$ yum repolist
lightbits-lightos-2-<Minor Ver>-x-ga
```

### Verifying Network Connectivity for the Servers in the Cluster

#### LightOS Cluster Installation Process

<table>
<thead>
<tr>
<th>#</th>
<th>Installation Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connecting your installation workstation to Lightbits’ software repository</td>
</tr>
<tr>
<td>2</td>
<td><strong>Verifying the network connectivity of the servers used in the cluster</strong></td>
</tr>
<tr>
<td>3</td>
<td>Setting up an Ansible environment on your installation workstation</td>
</tr>
<tr>
<td>4</td>
<td>Installing a LightOS cluster by running the Ansible installation playbook</td>
</tr>
<tr>
<td>5</td>
<td>Updating clients (if required)</td>
</tr>
<tr>
<td>6</td>
<td>Provisioning storage, connecting clients, and performing IO tests</td>
</tr>
</tbody>
</table>

Lightbits recommends that you verify the network connectivity for the servers you plan to use in the LightOS cluster before you run the Ansible playbook. To simply confirm the connectivity status, use a ping command for each of the access NIC IPs and data NIC IPs in the servers.

Referring back to the Installation Planning Table, the example uses three LightOS servers. Each server has an access IP.

Before proceeding with the installation, enter the following ping command at the installation workstation to confirm that each LightOS server is accessible, and that the client via the “192.xxx.xxx.xxx” network IP that was set up on each server’s GbE NIC ports is connected.

```
$ ping -c 1 192.168.16.22
PING 192.168.16.22 (192.168.16.22) 56(84) bytes of data.
64 bytes from 192.168.16.22: icmp_seq=1 ttl=64 time=0.208 ms
--- 192.168.16.22 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.208/0.208/0.208/0.000 ms
```

Continuing with the example, a ping command is sent to each of the access network IPs and data network IPs.

<table>
<thead>
<tr>
<th>Server</th>
<th>Access Network IP</th>
<th>Data Network IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LightOS server00</td>
<td>ping -c 1 192.168.16.22</td>
<td>ping -c 1 10.10.10.100</td>
</tr>
<tr>
<td>LightOS server01</td>
<td>ping -c 1 192.168.16.92</td>
<td>ping -c 1 10.10.10.101</td>
</tr>
<tr>
<td>LightOS server02</td>
<td>ping -c 1 192.168.16.32</td>
<td>ping -c 1 10.10.10.102</td>
</tr>
</tbody>
</table>
Configuring the Ansible Environment

LightOS Cluster Installation Process

<table>
<thead>
<tr>
<th>#</th>
<th>Installation Steps</th>
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This section includes:

Prepare Installation Workstation (Ansible Controller)
Copying the Ansible Environment Tarball
Creating the Inventory Structure and Adding the Ansible Hosts File
Multi-Tenancy
Configuring Global Variables in Ansible
Verifying Hosts Connection
Defining Configuration Files for Each “Ansible Host” (Server) in the Cluster
Defining Failure Domains
Setting the SSD Configuration
Confirming the Required Directory Structure

Prepare Installation Workstation (Ansible Controller)

Ansible Controller is the host running the Ansible playbook to install the LightOS cluster.

We support two ways to set up the Ansible Controller:

- Ansible and dependencies installed on the Ansible Controller.
- Using a prebuilt Ansible Docker image.

Choose one of the methods and follow these steps:

Install Ansible And Dependencies

The following tools are required to complete the LightOS cluster software installation:

- sshpass or ssh-key authentication
- Python v3.6 or higher
- Python Modules: ansible, netaddr, python_jwt, six

If you have validated the networking environment as described in the previous section, log in to your installation workstation and begin downloading and installing the required tools on your workstation.
Install sshpass or Use ssh-key Authentication

The Python tool is essential for running commands remotely on each of the servers used in the cluster. To run these commands, you must install a Secure Shell (SSH) authentication software package. There are two ways to install this package.

- Use the Linux sshpass utility.
  
  To install “sshpass”, enter the following command at the CLI:

  ```bash
  yum install -y sshpass
  ```

- Use ssh-key authentication.
  
  To use ssh-key authentication, see Using SSH-Key Authentication.

- Package required for Multi-Tenancy
  
  ```bash
  yum install -y libselinux-python3
  ```

Install the Required Python Version from CentOS Repo

The Ansible installer is a module installed with Python. Lightbits recommends that you have Python v3.x or above installed on your system.

If Linux reports that Python 3.x is not installed, use the following command:

```bash
yum install python36...
```

Complete!

Install Ansible Module Using PyPI

Check if Ansible is installed, as well as its version; for example:

```bash
ansible --version
```

Command 'ansible' not found

If not found, you can also install Ansible using pip for Python3:

```bash
pip3 install ansible
```

Verify that Ansible is installed, as well as its version, by entering:
Install Additional Python Modules

The Python netaddr module and python_jwt are also required. These modules are used to manipulate network addresses, and generate JWT tokens as part of the installation.

At your workstation CLI enter:

```bash
$ pip3 install netaddr python_jwt six
```

Use Prebuilt Ansible Docker Image

Usually it will be some machine outside the cluster that has SSH access to all cluster servers. There are also some other dependencies that the installation process requires besides Ansible. We provide a custom Ansible image to deploy the LightOS cluster image that contains all dependencies.

The only prerequisites to use this image are:

- Having Docker installed.
- Access to Lightbits public registry or a private registry to fetch the lb-ansible image.

**NOTE:** docker.lightbitslabs.com requires a Docker login. Credentials are provided in the Customer Addendum.

Copying the Ansible Environment Tarball

Lightbits Support provided you with an installation tarball along with your Installation Addendum that contains all of the configuration files that the Ansible playbook requires.

Copy the tarball file to your installation workstation and unpack the tar file using a command similar to the following:

```bash
$ tar -xvzf light-app-install-environment-v<Version>.tgz
```

For example:

```bash
$ tar -xvzf light-app-install-environment-v2.x.1.tgz
```

Unpacking this tarball creates the following Ansible directory structure, which contains the Ansible environment where the “ansible-playbook” command runs.
Creating the Inventory Structure and Adding the Ansible Hosts File

The Ansible playbook installer requires configuration files to drive it.

In Ansible terminology, each LightOS storage server is referred to as a “host”. Details about the LightOS storage servers must be entered into the Ansible “hosts” file that is stored in an “inventory” temporary directory structure.

Complete the following steps to create the inventory directory structure for the Ansible host file:

1. From the installation workstation, create the inventory directory structure. 
   
   ```bash
   $ mkdir -p /tmp/inventory
   ```

2. Copy all of the files and subdirectories in the `cluster_example` directory. An example host file is included in the Ansible subdirectory that was created when you unpacked the tarball from Lightbits that was described in the previous section.

   Enter the following command to copy the example hosts file:

   ```bash
   $ cp -r <base-dir>/ansible/inventories/cluster_example /tmp/inventory
   ```

   The source directory path depends on the location of the unpacked file from Lightbits.

   When this recursive copy command finishes, you will have the following directory structure:

   ```
   /tmp/inventory/
   |-- cluster_example
      |-- group_vars
      |   |-- all.yml
      |-- hosts
      |-- host_vars
      |   |-- client00.yml
      |   |-- server00.yml
      |   |-- server01.yml
      |   |-- server02.yml
   ```

3. Open a text editor and edit the copied `hosts` example file, now found in the new `/tmp/inventory/cluster_example` /hosts path. Replace the `ansible_host`, `ansible_ssh_pass`, and `ansible_become_user` values with your environment’s relevant values, for each server that will be in your cluster. Refer to the following example for reference. 

   ```bash
   [duros_nodes] server00 server01 server02
   
   auto_install=true cluster_identifier=ae7bdef-897e-4c5b-abef-20234abf21bf #For cluster identifier use any human readable string identifying the cluster
   
   [etcd] server00 server01 server02
   ```

2022 Lightbits Labs Proprietary And Confidential Under NDA Only
[initiators] client00 "

- You can replace the `ansible_host` flag’s value with the interface DNS name or IP address. In this example, the access network IP addresses from the cluster details table are used, not the data network IPs.
- Also in this example hosts file, there is a "local_repo_base_url" entry that includes . This information was provided to you in the Customer Addendum. You will need to enter this value here before proceeding.

### Host File Server Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Required</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>local_repo_base_url</code></td>
<td>Yes</td>
<td>Mandatory unless offline installation is used. The same value entered for the “baseurl” you configured in the Connecting to the Lightbits Software Repository section.</td>
</tr>
<tr>
<td><code>auto_install</code></td>
<td>No</td>
<td>A False value means the installation will wait for user instructions to reboot or not after installation. A True value means the installation will reboot in case of a kernel change without user instructions. Default value: False.</td>
</tr>
<tr>
<td><code>cluster_identifier</code></td>
<td>No</td>
<td>An identifier of the cluster that is used to filter the logs of a specific cluster.</td>
</tr>
</tbody>
</table>

**Note:** To use `ansible_ssh_private_key_file` instead of `ansible_ssh_pass`, see Using SSH-Key Authentication.

4. Save the new Ansible host file under the `/tmp/inventory/cluster_example` directory.

### Multi-Tenancy

LightOS v2.2.1 enforces tenant isolation on the control plane ("multi-tenancy"). With multi-tenancy, multiple tenants can share a LightOS cluster without being able to see or affect each other’s resources when accessing the LightOS API or using the LightOS command line tools.

Command line tools and all other API users must use the new v2 LightOS API. The v2 API includes provisions for authentication and authorization via standard JSON Web Tokens ("JWTs"), as well as transport security for all API operations.

The following three predefined roles are created by default:

- cluster-admin (system scope)
- admin (project scope)
- viewer (project scope)

Currently, roles cannot be added.

At installation, the user can provide their own certificate and CA to be used by the peers. If these files are not provided, the installation will generate self-signed certificates.

### Certificates Directory

By default, certificates are stored at `certificates_directory=-/lightos-certificates` on the Ansible controller machine.

`certificates_directory` can be overridden via cmd-line:
ansible-playbook playbooks/deploy-lightos.yml \
-e 'certificates_directory=/path/to/certs' ...

Or via group_vars/all:

```
yaml
certificates_directory=/path/to/certs
```

Certificate Types

Implementing multi-tenancy involves three sets of certificates:

- etcd Certificates For mTLS Peer Communication
- API Service Certificates For TLS
- System Scope Cluster Admin Certificates

**etcd Certificates for mTLS Peer Communication**

All etcd services serve client APIs only on localhost. This minimizes the exposure of etcd to outside malicious activity. Peer communication must be encrypted at all times, since etcd passes sensitive traffic between its peers.

The installation script expects the following files to be present at certificates_directory on the Ansible controller machine:

```
etcd-ca-key.pem
etcd-ca.pem
{ansible_hostname}-cert-etcd-peer-key.pem
{ansible_hostname}-cert-etcd-peer.pem
```

- **etcd-ca**: Certificate authority (CA) parameters for etcd certificates. This CA is used to sign certificates used by etcd (such as peer and server certificates).
- **{ansible_hostname}-cert-etcd-peer**: The peer certificate is used by etcd for peer communication.

These files are passed to the following etcd parameters: `--peer-cert-file` and `--peer-key-file`.

**Note**: `{ansible_hostname}` is the name we gave the etcd node in the hosts file.

**Example**

A 3-node cluster with server00-02 will result in:

```
etcd-ca-key.pem
etcd-ca.pem
server00-cert-etcd-peer-key.pem
server00-cert-etcd-peer.pem
server01-cert-etcd-peer-key.pem
server01-cert-etcd-peer.pem
server02-cert-etcd-peer-key.pem
server02-cert-etcd-peer.pem
```
Configuring Global Variables in Ansible

API Service Certificates For TLS

All API endpoints are TLS-enabled by default.

The user can provide their own SSL certificates, or the installation process will generate a self-signed certificate.

These are the files used by **api-service** to set up TLS communication.

```
cert-lb-api-service-key.pem
cert-lb-api-service.pem
```

System Scope Cluster Admin Certificates

These files will be stored in etcd and used to authenticate a system-scope project.

These are the files used to generate system scope credentials:

```
cert-lb-admin-key.pem
cert-lb-admin.pem
```

Generating Self-Signed Certificates

The LightOS installation playbook checks for **certificates_directory** existence. If it does not exist, a folder will be created and populated with self-signed certificates. If it exists, the playbook will verify that all expected certificates files are present. In case one is missing the installation will fail.

**Notes:**
- Certificate file names are hard-coded in the installation script. Only the source directory can change.
- These are pairs and go together.

File name format:

- `\<name>.pem`: Certificate.
- `\<name>-key.pem`: RSA private key that matches the certificate.

- In case we want to regenerate the self-signed certificates, we should delete the **certificates_directory** and all of its content.

Bring Your Own Certificates

The user can provide their own certificates for each of the components.

The user can override part or all of the files before running the **install-lightos.yaml** playbook.

Configuring Global Variables in Ansible

To configure global variables in Ansible, you can use a special **all.yml** file that is normally located in the following location:

`...`
If all the machines in the cluster have nvdimm, the **persistent_memory** flag must be set as follows:

```yaml
persistent_memory: true
```

If there are machines in the cluster that do not have nvdimm, set this flag to **false**.

**Note:** Since the persistent_memory flag is a global property for all of the clusters, it is important to declare this flag only once under the all.yml file and not in host_vars files with different values.

IP ACL allows support for restricted/non-restricted access to a cluster. This feature must be enabled during installation, by setting the **enable_iptables** flag; otherwise it cannot be used.

When the **enable_iptables** flag is set to **true**, access to the cluster nodes is allowed only from client IPs that are defined per volume using the **ip_acl** setting of each volume. By default, it is set to **false**. In order to use this mode, add the following to **all.yml**:

```yaml
enable_iptables: true
```

**Verifying Hosts Connection**

Use the ping command to verify that all machines in the cluster respond. Enter the following Ansible shell command:

```bash
$ cd light-app/ansible
ansible -i /tmp/inventory/cluster_example/hosts all -m ping
```

A successful response from this Ansible ping is as follows:

```
server02 | SUCCESS => {
  "ansible_facts": {
    "discovered_interpreter_python": "/usr/bin/python"
  },
  "changed": false,
  "ping": "pong"
}
Server00 | SUCCESS => {
  "ansible_facts": {
    "discovered_interpreter_python": "/usr/bin/python"
  },
  "changed": false,
  "ping": "pong"
}
server01 | SUCCESS => {
  "ansible_facts": {
    "discovered_interpreter_python": "/usr/bin/python"
  },
  "changed": false,
  "ping": "pong"
}
```
Defining Configuration Files for Each “Ansible Host” (Server) in the Cluster

Return to the `/tmp/inventory/cluster_example` directory you created in Creating the Inventory Structure and Adding the Ansible Host File.

From this path we will edit each of the yml files found in the `/tmp/inventory/cluster_example/host_vars` subdirectory. In our example cluster, we have three LightOS storage nodes that are defined by the files:

- server00.yml
- server01.yml
- server02.yml

1. In each of the host variable files, update the following required variables:

   **Required Variables for the Host Variable File**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>The cluster server’s name.</td>
</tr>
<tr>
<td>datapath_config</td>
<td>The path is the customer profile directory information provided by Lightbits.</td>
</tr>
<tr>
<td>instances</td>
<td>The configuration parameters for the logical node in this server. Currently, LightOS supports up to two logical nodes per server.</td>
</tr>
<tr>
<td>ec_enabled</td>
<td>(per logical node) Enables Erasure Coding (EC) protects against SSD failure within the storage server by preventing IO interruption. Normal operation continues during reconstruction when a drive is removed.</td>
</tr>
<tr>
<td>failure domains)</td>
<td>(per logical node) The servers sharing a network, power supply, or physical location that are negatively affected together when network, power, cooling, or other critical service experiences problems. Different copies of the data are stored in different FDs to keep data protected from various failures. To specify the servers in the FD, you must add the server names. For further information, see Defining Failure Domains.</td>
</tr>
<tr>
<td>data_ip</td>
<td>(per logical node) The data/etcd IP used to connect to other servers.</td>
</tr>
<tr>
<td>storageDeviceLayout</td>
<td>(per logical node) Sets the SSD configuration for a node. This includes the number of initial SSD devices, the maximum number of SSDs allowed, allowance for NUMA across devices, and memory partitioning and total capacity. For further information, see Setting the SSD Configuration.</td>
</tr>
</tbody>
</table>
Defining Configuration Files for Each “Ansible Host” (Server) in the Cluster

Installation Planning Table Sample

Note: The following is an example for three LightOS servers in a cluster with a single client.

<table>
<thead>
<tr>
<th>Server Name</th>
<th>Role</th>
<th>Access Network IP</th>
<th>Data NIC Interface Name</th>
<th>Data NIC IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>server00</td>
<td>LightOS Storage Server 1</td>
<td>192.168.16.22</td>
<td>ens1</td>
<td>10.10.10.100</td>
</tr>
<tr>
<td>server01</td>
<td>LightOS Storage Server 2</td>
<td>192.168.16.92</td>
<td>ens1</td>
<td>10.10.10.101</td>
</tr>
<tr>
<td>server02</td>
<td>LightOS Storage Server 3</td>
<td>192.168.16.32</td>
<td>ens1</td>
<td>10.10.10.102</td>
</tr>
<tr>
<td>client00</td>
<td>client</td>
<td>192.168.16.45</td>
<td>ens1</td>
<td>10.10.10.103</td>
</tr>
</tbody>
</table>

Examples for the three host variable files follow.

server00.yml

name: server00
nodes:
- instanceID: 0
  data_ip: 10.10.10.100
  failure_domains:
    - server00
  ec_enabled: true
  storageDeviceLayout:
    initialDeviceCount: 4
    maxDeviceCount: 12
  allowCrossNumaDevices: false
  deviceMatchers:
    # - model =~ ".*"
    - partition == false
    - size >= gib(300)
    # - name =~ "nvme0n1"

server01.yml

name: server01
nodes:
- instanceID: 0
  data_ip: 10.10.10.101
  failure_domains:
    - server01
  instanceID: 0
  ec_enabled: true
  storageDeviceLayout:
    initialDeviceCount: 4
    maxDeviceCount: 12
  allowCrossNumaDevices: false
  deviceMatchers:
    # - model =~ ".*"
    - partition == false
    - size >= gib(300)
    # - name =~ "nvme0n1"

server02.yml
Defining Failure Domains

A Failure Domain (FD) encompasses a section of a network, power supply, or physical location negatively affected when network, power, cooling, or other critical service experiences problems. Different copies of the data are stored in different FDs to keep data protected from various failures.

To specify the servers in the FD, you must enter the server names to the host configuration file as follows:

```
name: server00
data_ifaces:
  - bootproto: static
    conn_name: ens1
    ifname: ens1
    ip4: 10.16.205.14/27

name: server02
nodes:
  - instanceID: 0
    data_ip: 10.10.10.102
    failure_domains:
      - server02
    ec_enabled: true
    storageDeviceLayout:
      initialDeviceCount: 4
      maxDeviceCount: 12
      allowCrossNumaDevices: false
    deviceMatchers:
      - model =~ ".*"
      - partition == false
      - size >= gib(300)
      - name =~ "nvme0n1"
```

**Notes:** * See Host Configuration File Variables for the entire list of variables available for the host variable files. * You can also reference additional host configuration file examples. * If you want the Ansible playbook to configure the data NIC IP, you must add a section Data_ifaces with the data interface name. For further information see, Configuring the Data Network. * If you need to create a separate partition for etcd data on the boot device, see etcd Partitioning. * Based on the placement of SSDs in the server, check if you need to make a change in the client profile to permit cross-NUMA devices.
Setting the SSD Configuration

To allow for future storage expansion, you will need to set the Maximum Device Count to the total number of drive slots physically available in the LightOS node during the initial LightOS configuration process.

Setting the Maximum Device Count to the maximum number of drive slots allows you to start the LightOS node with empty drive slots in the server chassis. This is because you only need a small amount of storage and plan to add more SSDs into the empty drive slots as demand increases.

For example, your storage server chassis has 12 SSD slots, but initially, you only want to configure LightOS to use eight drives. So in this case, you need to:

- Set your Maximum Device Count to 12.
- Physically install only eight drives.
- Leave four drive slots empty for later use.

**Note:** If Erasure Coding is enabled (**ec_enabled: true**), you must have a minimum of eight SSDs installed.

To specify the SSD configuration for a node, you must enter a value for the total drive slots available for your LightOS node to the host configuration file as follows:

```yaml
name: server00
Data_ifaces:
  - bootproto: static
    conn_name: ens1
    ifname: ens1
    ip4: 10.10.10.100/27

nodes:
  - instanceID: 0
    failure_domains:
      - server00
    ec_enabled: true
    data_ip: 10.10.10.100
    storageDeviceLayout:
      initialDeviceCount: 4
      maxDeviceCount: 12
      allowCrossNumaDevices: false
    deviceMatchers:
      # - model =~ ".*"
      - partition == false
      - size >= gib(300)
      # - name =~ "nvme0n1"
```

**Notes:**
- If you are using a LightField accelerator card the allowCrossNumaDevices field must be set to False.
- See the Host Configuration File Variables for the entire list of variables available for the host variable files.

Confirming the Required Directory Structure

Before proceeding, confirm that a directory structure similar to the following example exists on your system for the inventory directories and host variable files.
Running the Ansible Installation Playbook to Install LightOS Cluster Software

LightOS Cluster Installation Process

<table>
<thead>
<tr>
<th>#</th>
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<td>1</td>
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</tr>
<tr>
<td>6</td>
<td>Provisioning storage, connecting clients, and performing IO tests</td>
</tr>
</tbody>
</table>

Running the Ansible Controller

To install the cluster software and configure the cluster, enter the following command to run the playbook:

```bash
$ cd light-app/ansible
ansible-playbook -i /tmp/inventory/cluster_example/hosts playbooks/deploy-lightos.yml -vv
```

Running Using the lb-ansible Docker Image

To save the LightOS certificates at `/opt/lightos-certificates`, or to provide a certificate directory that already exists, place it under `/opt/lightos-certificates`.

```bash
mkdir -p /opt/lightos-certificates
cd light-app
docker run -it --rm --net=host \
  -v /opt/lightos-certificates:/lightos-certificates \
  -v `pwd`:/ansible \
  -w /ansible \
  docker.lightbitslabs.com/lightos-2-<Minor Ver>-x-ga/lb-ansible:4.2.0 \
sh -c 'ansible-playbook \
  -e ANSIBLE_LOG_PATH=/ansible/ansible.log \
  -e system_jwt_path=/ansible/lightos_jwt \
  -e lightos_default_admin_jwt=/ansible/lightos_default_admin_jwt \
  -e certificates_directory=/lightos-certificates \
  -i inventories/cluster_example/hosts \
  playbooks/deploy-lightos.yml -vvv'
```
Command breakdown:

- Mount `/opt/lightos-certificates` to `/lightos-certificates` to store generated certificates on the host.
- Mount `light-app/ansible` to `/ansible` inside the container to have access to the playbook and roles.
- Set the `WORKDIR` to `/ansible` inside the container.
- Configure `Ansible` to write logs to `/ansible/ansible.log`
- Run the playbook with specified hosts from an inventory folder in `/ansible/inventories/cluster_example`
- Set `system_jwt_path` to be placed at `$PWD/ansible/lightos_jwt` after the container is closed.
- Set `lightos_default_admin_jwt` to be placed at `$PWD/ansible/lightos_default_admin_jwt` after the container is closed.

Custom Inventory Folder

If the inventory folder is placed in a different location, such as: `/path/to/inventory`, you can mount this path as well and use it:

```bash
mkdir -p /opt/lightos-certificates
cd light-app
docker run -it --rm --net=host \
  -v /opt/lightos-certificates:/lightos-certificates \
  -v `pwd`:/ansible \
  -v /path/to/inventory:/inventory \
  -w /ansible \
  docker.lightbitslabs.com/lightos-2-<Minor Ver>-x-ga/lb-ansible:4.2.0 \
  sh -c 'ansible-playbook \
    -e ANSIBLE_LOG_PATH=/ansible/ansible.log \
    -e system_jwt_path=/ansible/lightos_jwt \
    -e lightos_default_admin_jwt=/ansible/lightos_default_admin_jwt \
    -i inventories/cluster_example/hosts \
    playbooks/deploy-lightos.yml -vvv'
```

Using SSH-Keys Present On Ansible-Controller Host

If you use SSH-Keys present on your `ansible-controller` machine and you copied these keys to the `authorized_keys` on target hosts you will want to use this key inside the container. The following example shows how to mount the `~/.ssh` folder so that Ansible running inside the container will use it.

```bash
cd light-app
mkdir -p /opt/lightos-certificates
docker run -it --rm --net=host \
  -v /opt/lightos-certificates:/lightos-certificates \
  -v `pwd`:/ansible \
  -v ${HOME}/.ssh:${HOME}/.ssh \
  -w /ansible \
  docker.lightbitslabs.com/lightos-2-<Minor Ver>-x-ga/lb-ansible:4.2.0 \
  sh -c 'ansible-playbook \
    -e ANSIBLE_LOG_PATH=/ansible/ansible.log \
    -e system_jwt_path=/ansible/lightos_jwt \
    -e lightos_default_admin_jwt=/ansible/lightos_default_admin_jwt \
    -i inventories/cluster_example/hosts \
    playbooks/deploy-lightos.yml -vvv'
```

**Note:** This operation can take several minutes. The output will report the status of all the tasks that succeeded/-failed on the nodes.
Verify Successful Installation

When the installation completes with no errors, you will see an output similar to the following:

```
PLAY RECAP*************************************************************************
server00 :ok=68 changed=19 unreachable=0 failed=0 skipped=34 rescued=0 ignored=0
server01 :ok=67 changed=18 unreachable=0 failed=0 skipped=33 rescued=0 ignored=0
server02 :ok=67 changed=18 unreachable=0 failed=0 skipped=33 rescued=0 ignored=0
```

Notes: - The “failed=0” indicates that the installation finished without errors.  
- If the installation process failed, see Recovering from Cluster Installation Failure.

Each logical node in the cluster is assigned a unique UUID that is generated from the SEED (node-name, instance-id). This ensures that each (node, instance) pair has a unique repeatable UUID.

Steps 1 through 4 of the installation flow is now complete, and you can move on to the client configuration sections of the Installation Guide.

System-Scope JWT

Once the installation process is done, the system is bootstrapped with a system-scope project. 

To act as `cluster-admin` you will need a JWT. The installation process will create a JWT and should be placed at:

```
yaml
system_jwt_path: "{{ '~/lightos-system-jwt' | expanduser }}"
```

This path can be overwritten at the command-line, or via a variable in the `group_vars/all`

Note: This JWT gives admin access to the cluster. Make sure to delete this file once it’s complete or secure, and do not share the file with unauthorized users.

Linux Cluster Client Software Installation

To connect to the LightOS Storage Server, the cluster client software requires the appropriate NVMe over TCP kernel module and application support. Therefore, you must install the same base kernel on your clients that you installed on the LightOS Storage Server.

Connecting to the Cluster Client DEB Repository

To start the installation process, you must verify that you have the TOKEN for the Lightbits NVME-Client-DEBs.

Note: The Linux Repo File Customer TOKEN section in your LightOS Installation-Customer Addendum has the TOKEN that is required to install the Lightbits NVME-Client-RPMs.

1. Run the following commands:
   ```bash
   apt-get install -y debian-keyring apt-get install -y debian-archive-keyring apt-get install -y apt-transport-https apt-get install curl
   ```
2. Add the apt key: `bash curl -1sLf 'https://dl.lightbitslabs.com/lightos-2-x-ga/cfg/gpg/gpg.key' | apt-key add -`

   
   **Note:** GPG KEY and Token should be provided via the customer addendum.


   **Note:** Token should be provided via the customer addendum.

   In case you want to bypass the GPG verification - edit the `/etc/apt/sources.list.d/lightbits-lightos-2-x-ga.list` file and add `[trusted=yes]` after the deb:

   ```
cat /etc/apt/sources.list.d/lightbits-lightos-2-<Minor Ver>-x-ga.list
# Source: Lightbits
# Repository: Lightbits / lightos-2-<Minor Ver>-x-ga
# Description: A certifiably-awesome private package repository curated by Lightbits, hosted by Cloudsmith.

deb [trusted=yes] https://dl.lightbitslabs.com/<TOKEN>/lightos-2-<Minor Ver>-x-ga/deb/ubuntu xenial main
deb-src [trusted=yes] https://dl.lightbitslabs.com/<TOKEN>/lightos-2-<Minor Ver>-x-ga/deb/ubuntu xenial main
```

4. Run the apt-update command:

   ```
   apt-get update
   ```

---

**Connecting to the Cluster Client RPM Repository**

To start the installation process, you must verify that you have the TOKEN for the Lightbits NVME-Client-RPMs.

**Note:** The Linux Repo File Customer TOKEN section in your LightOS Installation-Customer Addendum has the TOKEN that is required to install the Lightbits NVME-Client-RPMs.

1. In your preferred text editor, create the following new file: `bash /etc/yum.repos.d/lightos.repo`

2. Copy the following template into the file. `bash # LightOS-Client-RPM-repository - Lightbits repository
   [lightbits-lightos-2-<Minor Ver>-x-ga] name=lightbits-lightos-2-<Minor Ver>-x-ga baseurl
   =https://dl.lightbitslabs.com/<YOUR_TOKEN>/lightos-2-<Minor Ver>-x-ga/rpm/el/7/$basearch
   repo_gpgcheck=0 enabled=1 gpgcheck=0 autorefresh=1 type=rpm-md`

3. Enter the Lightbits TOKEN that was included in your copy of the LightOS Installation-Customer Addendum.

4. Save the `lightos.repo` file.

5. Verify your system’s connectivity to the repository by entering the `yum repolist` command. This command displays the enabled software repositories. For example: `bash $ yum repolist lightbits-lightos-2-<Minor Ver>-x-ga`

**Note:** An optional Ansible playbook is available to you that performs the following:
- Installs kernel v5.x, which includes the nvme-tcp upstream driver.
- Creates a small 4GB volume with a replication factor of 2.
- Runs the nvme connect command to connect the client machine to the cluster volume.
- Runs an fio read/write workload for 30 seconds.
- Performs a cleanup that disconnects the nvme client and removes the volume.
Installing the New Kernel on CentOS

Notes: * Before proceeding with the installation, you must have the GNU Wget software installed. You can download the software at https://www.gnu.org/software/wget/ * You can use any kernel version v5.3.5 or above, which is written in the following instructions.

To install the Client on CentOS:
1. Go to https://elrepo.org/linux/kernel/el7/x86_64/RPMS/ and search for any kernel-ml-5.3.x, or above, kernel file.
2. Use Wget to download the following kernel:
   ```
   https://elrepo.org/linux/kernel/el7/x86_64/RPMS/kernel-ml-5.X.Y-1.el7.elrepo.x86_64.rpm
   ```
   #where X,Y is the latest version
3. To install the kernel, run the yum install command as follows:
   ```
   $ yum install -y kernel-ml-5.X.*
   ```

Configuring the Client to Boot from the New Kernel

You must configure the client to boot from the new kernel that you just installed. 1. Find the Lightbits kernel grub entry with the following command. bash $ grubby --info=ALL
2. Identify the Lightbits kernel index in the output list. In the following example, the Lightbits kernel has an index value of 0 because it is at the top of the list of available kernels. bash index=0
   ```
   kernel=/boot/kernel/ml-5.4.11-1.el7.elrepo.x86_64 args="ro crashkernel=auto rd.lvm.lv=CentOS_rack05-server67/root rd.lvm.lv=CentOS_rack05-server67/swap rhgb quiet LANG=en_US.UTF-8" root=/dev/mapper/ CentOS_rack05--server67/root initrd=/boot/initramfs-kernel-ml-5.4.11-1.el7.elrepo.x86_64.img title=CentOS Linux(kernel-ml-5.4.11-1.el7.elrepo.x86_64) 7 (Core) index=1
   ```
   ```
   kernel=/boot/vmlinuz-3.10.0-957.el7.x86_64 args="ro crashkernel=auto rd.lvm.lv=CentOS_rack05-server67/root rd.lvm.lv=CentOS_rack05-server67/swap rhgb quiet LANG=en_US.UTF-8" root=/dev/mapper/ CentOS_rack05-server67/root initrd=/boot/initramfs-3.10.0-957.el7.x86_64.img title=CentOS Linux(3.10.0-957.el7.x86_64) 7 (Core) index=2
   ```
   ```
   kernel=/boot/vmlinuz-0-rescue-9758554168974f5dbe0d6dac5a6ac621 initrd=/boot/initramfs-0-rescue-9758554168974f5dbe0d6dac5a6ac621.img title=CentOS Linux (0-rescue-9758554168974f5dbe0d6dac5a6ac621) 7 (Core) index=3
   ```
   non linux entry
3. Use the following command to set the default kernel index value.
   ```
   bash $ grubby --set-default-index 0
   ```
4. Verify the correct kernel version is set.
   ```
   $ grubby --default-kernel
   /boot/kernel/ml-5.4.11-1.el7.elrepo.x86_64
   ```

5. Reboot the system to load the Lightbits kernel. bash $ shutdown -r now
6. After the client reboots, you must log in and verify that the client is now running from the new kernel using the Linux command `uname -r`.

For more information about using this optional playbook, see Automated Client Connectivity Verification.
For example: `bash $ uname -r kernel-ml-5.3.6-1.el7.elrepo.x86_64` Installing the Lightbits NVMe Command Line Interface

The NVMe command line interface (CLI) is a standard command line interface to run NVMe over fabrics commands from the client. Lightbits provides a customized NVMe CLI for LightOS that will be available in future versions of the public/upstream NVMe CLI version.

**Note:** These instructions will work on any Lightbits client’s side deb that you want to install on your client.

1. (Optional) If a public NVMe CLI version is installed on your system, you can replace it with the NVMe CLI version supplied by Lightbits. Before installing the supplied NVMe CLI from the Lightbits repository, you’ll need to remove the public NVMe CLI from your system.

   To check if you have an NVMe CLI package installed, enter the following in the system’s command shell: `bash $ rpm -qa | grep nvme-cli
cvm-cli-1.9-2.3.4-1.x86_64``

2. (Optional) If the command returns this value, you need to delete the NVMe CLI package from your system with the following command: `bash $ rpm -e nvme-cli`

3. With the public NVMe CLI version deleted from the system, you can install the NVMe CLI from the Lightbits RPM repository by entering the following in the system’s command shell: `bash $ yum install -y nvme-cli
cvm-cli-1.9-2.3.4-1.x86_64`

4. Enter the following command to verify that the NVMe CLI version is v1.9-2.2.1-1. `bash $ rpm -qa | grep nvme
   nvme-cli-1.9-2.3.4-1.x86_64` The output for this command can include additional package names with the nvme string.

**Installing the Lightbits NVMe Command Line Interface (Ubuntu)**

The NVMe command line interface (CLI) is a standard command line interface to run NVMe over fabrics commands from the client. Lightbits provides a customized NVMe CLI for LightOS that will be available in future versions of the public/upstream NVMe CLI version.

**Note:** These instructions will work on any Lightbits client’s side deb that you want to install on your client.

1. (Optional) If a public NVMe CLI version is installed on your system, you can replace it with the NVMe CLI version supplied by Lightbits. Before installing the supplied NVMe CLI from the Lightbits repository you’ll need to remove the public NVMe cli from your system.

   To check if you have an NVMe CLI package installed, enter the following in the system’s command shell: `bash $ apt list --installed | grep nvme-cli
   WARNING: apt does not have a stable CLI interface. Use with caution in scripts.
cvm-cli/bionic-updates,now 1.5-1ubuntu1 amd64 [installed]
```

2. (Optional) If the command returns this value, you need to delete the NVMe CLI package from your system with the following command: `bash $ apt-get remove nvme-cli`

3. With the public NVMe CLI version deleted from the system, you can install the NVMe CLI from the Lightbits RPM repository by entering the following in the system’s command shell: `bash $ apt-get install nvme-cli
   WARNING: apt does not have a stable CLI interface. Use with caution in scripts.
cvm-cli/xenial,now 1.9-2.3.4-1.bionic amd64 [installed]
```

4. Enter the following command to verify that the NVMe CLI version is v1.9-1. `bash $ apt list --installed | grep nvme
   WARNING: apt does not have a stable CLI interface. Use with caution in scripts.
cvm-cli/xenial,now 1.9-2.3.4-1.bionic amd64 [installed]
```

**The output for this command can include additional package names with the nvme string.**
Loading the NVMe/TCP Host Software

To use NVMe/TCP, you must load the NVMe host models by entering the following command in the system’s command shell.

```
$ modprobe nvme-tcp; lsmod | grep nvme
```

The output is similar to the following example:

```
nvme_tcp    24576  0
nvme_fabrics 20480 1 nvme_tcp
nvme_core    49152 4 nvme_fabrics,nvme_tcp
```

Provisioning Storage and Connecting the Cluster Client to LightOS

LightOS Cluster Installation Process

<table>
<thead>
<tr>
<th>#</th>
<th>Installation Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connecting your installation workstation to Lightbits’ software repository</td>
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</tr>
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<td>6</td>
<td><strong>Provisioning storage</strong>, connecting clients, and performing IO tests</td>
</tr>
</tbody>
</table>

With the LightOS software installed and the LightOS management service running, you can create a volume and connect that volume to your application clients.

This section includes:

- Creating a Volume on the LightOS Storage Server
- Connecting the Cluster Client to LightOS

Creating a Volume on the LightOS Storage Server

To create a volume on the cluster, log into any of the LightOS cluster servers and enter the lbcli create volume command.

**Sample Command**

```
$ lbcli -J $LIGHTOS_JWT create volume --size="2 GiB" --name=vol1 --acl="acl3" --replica-count=2 --project-name=default
```

**Sample Output**

```
Name   UUID                      State  Size  Replicas  ACL
vol1   76c3eaee8-7ade-4394-82e5-056d05a92b5e Creating 2.0 GiB 2 values:"acl3"
```
This example command creates a volume with 2GB of capacity, an Access Control List (ACL) string “acl3”, and a replication factor of 2.

**Connecting the Cluster Client to LightOS**

After creating a volume on the LightOS storage server, log in to one or more of your application clients and use the Lightbits nvme CLI utility to make a connection to the LightOS cluster.

Before you begin, enter a Linux ping command to check the TCP/IP connectivity between your application client and the LightOS storage servers. In the below example `rack02-server70` is an application client and the IP address of the data NIC on one of the LightOS storage server nodes is `10.10.10.100`.

**Sample Command**

```bash
$ ping -c 1 10.10.10.100
```

**Sample Output**

```
PING 10.10.10.100 (10.10.10.100) 56(84) bytes of data.
64 bytes from 10.10.10.100: icmp_seq=1 ttl=255 time=0.032 ms
--- 10.20.20.10 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.032/0.032/0.032/0.000 ms
```

This output indicates that this application client has a connection to the data NIC IP address on the LightOS storage server where volumes were created.

Repeat this ping check for the other LightOS cluster servers.

After you have checked the TCP/IP connectivity between your application client and the LightOS storage servers, use the nvme CLI utility to connect the application client via NVMe/TCP to the LightOS storage server.

To use the nvme CLI utility on your application client, you will need the following details.

**Required LightOS Storage Cluster Connection Details**

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Description</th>
<th>Connect Command Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>LightOS Data NIC IP address</td>
<td>The data NIC IP address of each LightOS cluster node. These values can be retrieved from the LightOS management server using the <code>lbcli list nodes</code> command.</td>
<td>-a</td>
</tr>
<tr>
<td>ACL string</td>
<td>You used this ACL string when you created the volume on the LightOS storage server node.</td>
<td>-q</td>
</tr>
<tr>
<td>Subsystem NQN</td>
<td>The LightOS cluster subsystem NQN value can be retrieved from the LightOS management server using the <code>lbcli get cluster</code> command.</td>
<td>-n</td>
</tr>
<tr>
<td>TCP port</td>
<td>The data TCP port for each of the LightOS cluster nodes can be retrieved from the LightOS management server using the <code>lbcli list nodes</code> command.</td>
<td>-s</td>
</tr>
</tbody>
</table>

Enter the `lbcli get cluster` command on the LightOS storage server to identify the subsytem NQN.
Connecting the Cluster Client to LightOS

PROVISIONING STORAGE AND CONNECTING THE CLUSTER CLIENT TO LIGHTOS

Sample Command

$ lbcli get cluster

Sample Output

<table>
<thead>
<tr>
<th>UUID: 95a251b6-0885-4f5b-a0eb-90e90a2009a3</th>
<th>currentMaxReplicas: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistics:</td>
<td></td>
</tr>
<tr>
<td>effectivePhysicalStorage: &quot;42638469827787&quot;</td>
<td></td>
</tr>
<tr>
<td>estimatedFreeLogicalStorage: &quot;42638469827787&quot;</td>
<td></td>
</tr>
<tr>
<td>freePhysicalStorage: &quot;42638469827787&quot;</td>
<td></td>
</tr>
<tr>
<td>installedPhysicalStorage: &quot;75014889578496&quot;</td>
<td></td>
</tr>
<tr>
<td>logicalStorage: &quot;4294967296&quot;</td>
<td></td>
</tr>
<tr>
<td>logicalUsedStorage: &quot;0&quot;</td>
<td></td>
</tr>
<tr>
<td>managedPhysicalStorage: &quot;56011126800384&quot;</td>
<td></td>
</tr>
<tr>
<td>physicalUsedStorage: &quot;0&quot;</td>
<td></td>
</tr>
<tr>
<td>physicalUsedStorageIncludingParity: &quot;0&quot;</td>
<td></td>
</tr>
<tr>
<td>subsystemNQN: nqn.2014-08.org.nvmexpress:NVMf:uuid:b5fe744a-b919-465a-953a-a8a0df7b9d31</td>
<td></td>
</tr>
<tr>
<td>supportedMaxReplicas: 3</td>
<td></td>
</tr>
</tbody>
</table>

Enter the `lbcli list nodes` command to identify the NIC IP address and TCP port.

Sample Command

$ lbcli list nodes

Sample Output

<table>
<thead>
<tr>
<th>Name</th>
<th>UUID</th>
<th>State</th>
<th>NVMe endpoint</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>server00-0</td>
<td>08fd2b3bd-925a-5e73-adde-8daf881969d3</td>
<td>Active</td>
<td>10.10.10.100:4420</td>
<td>[server00]</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>server01-0</td>
<td>112a555f-8168-5f07-a4e0-bf8f5b59c740</td>
<td>Active</td>
<td>10.10.10.101:4420</td>
<td>[server01]</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>server02-0</td>
<td>bc759c13-356e-5521-9ba2-752259abf8f0</td>
<td>Active</td>
<td>10.10.10.102:4420</td>
<td>[server02]</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With the IP, port, subsystem NQN and ACL values for the volume, you can execute the `nvme connect` command to connect to all of the nodes in the cluster.

Sample NVMe Connect Commands
Confirming the Cluster Client Connection to LightOS

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</tr>
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</table>

After you have entered the `nvme connect` command, you can confirm the client’s connection to LightOS by entering the `nvme list-subsys` command.

Sample Command

```
$ nvme list-subsys
```

Sample Output

```
nvme-subsys0 - NQN=nqn.2014-08.org.nvmexpress:NVMf:uuid:b5fe744a-b919-465a-953a-a8a0df7b9d31
  \+- nvme0 tcp traddr=10.10.10.100 trsvcid=4420 live
  \+- nvme1 tcp traddr=10.10.10.101 trsvcid=4420 live
  \+- nvme2 tcp traddr=10.10.10.102 trsvcid=4420 live
```
Next, review your connected block devices to see the newly connected NVMe/TCP block device using the Linux `lsblk` command.

**Sample Command**

```
$ lsblk
```

**Sample Output**

```
 NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
nvme0n1 259:1 0 2G 0 disk
sdb 8:16 0 223.6G 0 disk
| |-sdb2 8:18 0 222.6G 0 part
| | |-CentOS00-swap 253:1 0 22.4G 0 lvm [SWAP]
| | |-CentOS00-home 253:2 0 150.2G 0 lvm /home
| | |-CentOS00-root 253:0 0 50G 0 lvm /
| |-sdb1 8:17 0 1G 0 part /boot
sda 8:0 0 111.8G 0 disk
```

A new `nvme0n1` block device with 2GB of storage is identified and available.

To determine which node in the cluster is the primary and which is secondary for this block device, enter the `nvme list-subsys` command with the block device name.

**Sample Command**

```
$ nvme list-subsys /dev/nvme0n1
```

**Sample Output**

```
nvme-subsys0 - NQN=nqn.2014-08.org.nvmexpress:NVMe:uuid:b5fe744a-b919-465a-953a-a8a0df7b9d31\nnvme0 tcp traddr=10.10.10.100 trsvcid=4420 live optimized
nvme1 tcp traddr=10.10.10.101 trsvcid=4420 live inaccessible
nvme2 tcp traddr=10.10.10.102 trsvcid=4420 live
```

In the output, the optimized status identifies the primary node, and an inaccessible status for the secondary node.
Troubleshooting

Ansible Role Errors

Confirm that the duroslight ports are synchronized in the Ansible default yml file, which can be overridden in inventory ymls, and the node-manager configuration Ansible default yml:

/ansible/roles/install-lightos.defaults/main.yml

SSH Strict Key Errors When Using sshpass

If you use the sshpass utility method in your hosts file, you can receive an error related to SSH keys in the Known Hosts file, such as:

```
$ ansible -i hosts all -m ping
node02 | FAILED! => {
  "msg": "Using a SSH password instead of a key is not possible because Host Key checking is enabled and sshpass does not support this. Please add this host's fingerprint to your known_hosts file to manage this host."
}
```

To avoid this error, you need to disable StrictHostKeyChecking in the /etc/ssh/ssh_config, or log into each node from your installation workstation at least once.

By default, StrictHostKeyChecking is enabled in the file /etc/ssh/ssh_config. You can disable this by un-remarking it in ssh_config and setting it to:

```
StrictHostKeyChecking no
```

Or, you can leave StrictHostKeyChecking enabled and log into each node from the installation workstation and “answer yes” to permanently add the host to the Known Hosts files.

The first time you SSH from one server to another the following SSH exchange occurs:

```
$ ssh root@192.168.16.22
The authenticity of host '192.168.16.22 (192.168.16.22)' can't be established.
ECDSA key fingerprint is SHA256:zouTZEZF2oUXfIGpnyWtTrDR4/fBnd5ARqXNj0iqD0.
Are you sure you want to continue connecting (yes/no)? Yes
Warning: Permanently added '192.168.16.22' (ECDSA) to the list of known hosts.
root@192.168.16.22's password:
Last login: Wed Nov 13 19:06:13 2019 from cluster-manager
[root@node00 ~]#
```

So, by logging into all the servers at least once from your installation workstation before you run the Ansible playbook, there will be no issues using the sshpass method.

Free Space in Linux OS for etcd Logical Volume Manager Use

If your Linux operating system has volume groups that were created for the home, root, and swap file systems and are utilizing 100% of the storage, you must reduce one of these volume groups. The LightOS installer requires at least 10GB of space to create an LVM for use with etcd.
For example, review the Linux OS logical volumes. The Linux Virtual Server (LVS) software is used in this example.

```
$ lvs
LV VG Attr LSize Pool Origin Data% Meta% Move Log Cpy%Sync Convert
home CentOS_lightos-c3 -wi-ao---- <64.24g
root CentOS_lightos-c3 -wi-ao---- 50.00g
swap CentOS_lightos-c3 -wi-ao---- 4.00g
$ lvs
LV VG Attr LSize Pool Origin Data% Meta% Move Log Cpy%Sync Convert
home CentOS_lightos-c3 -wi-ao---- <64.24g
root CentOS_lightos-c3 -wi-ao---- 50.00g
swap CentOS_lightos-c3 -wi-ao---- 4.00g
```

**Note:** If the Linux Virtual Server (LVS) software reports anything but “CentOS” for the Volume Group name used for the LinuxOS file system, you will need to specify the exact name in the /tmp/inventory/host_vars file for that node. For more information, see the `etcd_vg_name` variable description in the Host Configuration File Variables list.

In this example, the LinuxOS was installed onto a 118 GB drive and the entire amount is allocated. You can resize the home LVM by 20 GB to free up some space.

To resize this file system, you need to:

1. Move any files you have in the `/home` file system to a safe location.
2. Unmount, resize, and recreate the file system.
3. Remount the file system.

To identify how much space is available to free up, use `lsblk` as follows:

```
$ lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
sda 8:0 0 119.2G 0 disk
├─sda1 8:1 0 1G 0 part /boot
├─CentOS-root 253:0 0 50G 0 lvm /
├─CentOS-swap 253:1 0 4G 0 lvm [SWAP]
├─CentOS-home 253:2 0 64.2G 0 lvm /home
```

In this example, the LinuxOS is installed on device “sda” and on partition sda1 with 119.2 GB of space available. It is possible to take 20 GB away from home to free up some space and still have over 44 GB remaining.

1. Mount and record the current mount path for home.

```
$ mount
/dev/mapper/CentOS_lightos--c3-home on /home type xfs (rw,relatime,attr2,inode64,
noquota)
```

2. Unmount home and then resize it.

```
$ umount /home
$ lvresize -L -20G CentOS_lightos-c3/home
```
3. Remake the home file system.

```
$ mkfs.xfs -f /dev/mapper/CentOS_lightos--c3-home
```

4. Remount home.

```
$ mount /dev/mapper/CentOS_lightos--c3-home /home
```

## Recovering from Cluster Installation Failure

At times during deployment, errors occur and the configuration step must be retried. To do that, a playbook is provided to stop all services and delete the data-plane and control-plane data and configuration.

Cleanup command:

```
ansible-playbook -i /tmp/inventory/hosts playbooks/cleanup-lightos-playbook.yml --tags=cleanup
```

Reconfigure command:

```
ansible-playbook -i /tmp/inventory/hosts playbooks/configure-lightos-playbook.yml
```

Log Artifacts Collection

In addition to the td-agent facility, use a more basic or fundamental Ansible tool to collect logs artifacts like journal files, system health, and CLI outputs by entering the following Ansible command:

```
$ ansible-playbook -i <hosts file> playbooks/logs.yml
```

Sample Output

```
logs-2019-11-24-17:05:41
|-- server00
 |  |-- tmp
 |   |-- lb-cluster-logs
 |   |  |-- lvm.txt
 |   |  |-- pip.txt
 |   |-- lb-support
 |   |  |-- lb-support_rack02-server68_20191124-170544.tgz
|-- server01
 |  |-- tmp
 |   |-- lb-cluster-logs
 |   |  |-- lvm.txt
 |   |  |-- pip.txt
 |   |-- lb-support
 |   |  |-- lb-support_rack08-server93_20191124-170544.tgz
```

See the following default file for further customizations:
Appendixes

The following sections provide additional information to help you complete the LightOS installation.

This section includes:

- Performing an Offline Installation
- Configuring the Data Network
- etcd Partitioning
- Using SSH-Key Authentication
- Network Time Protocol Configuration
- Fluent Bit Logging Configuration
- Log Artifacts Collection
- Automated Client Connectivity Verification
- Dashboard Installation
- Open TCP Ports and Verify

Host Configuration File Variables

Each host configuration file includes some basic configuration variables.

See Host Configuration File Examples for instances of how these variables are used in a host configuration file.

```yaml
data_ifaces:
  bootproto:
  ifname:
  ip4:
instances:
  instanceID:
  data_ip:
  failure_domains:
  ec_enabled:
  storageDeviceLayout:
  initialDeviceCount:
  maxDeviceCount:
allowCrossNumaDevices:
  deviceMatchers:
    - model =
    - partition ==
    - size >=
    - path =
    - name =
use_lvm_for_etcd:
  etcd_lv_name:
  etcd_settings_user:
  etcd_lv_size:
  etcd_vg_name:
auto_reboot:
  datapath_config:
listen-client-urls:
```

Host Configuration File Variable Notes
<table>
<thead>
<tr>
<th>Variable</th>
<th>Required</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data_ifaces</td>
<td>No</td>
<td>If provided, the Ansible playbook configures the interface. The configuration is permanent, and results in a new <code>ifcfg-&lt;iface-name&gt;</code> file. If this variable is not provided, no action is taken, the playbook assumes that the interfaces are valid, and the link is up and configured. If data-ifaces is used, you must also use the bootproto, conn_name, ifname, and ip4 variables.</td>
</tr>
<tr>
<td>bootproto</td>
<td>No</td>
<td>IP allocation type (dynamic or static). Only static is supported in LightOS 2. Default value: Static.</td>
</tr>
<tr>
<td>ifname</td>
<td>No</td>
<td>The interface name, such as eth0 or enp0s2, that the data path in the ip4 variable is dedicated to.</td>
</tr>
<tr>
<td>ip4</td>
<td>No</td>
<td>The data path IP address.</td>
</tr>
<tr>
<td>data_ip</td>
<td>Yes</td>
<td>The data/etcd IP used to connect to other nodes.</td>
</tr>
<tr>
<td>instances</td>
<td>Yes</td>
<td>A list of instance IDs, one for each logical data-path instance.</td>
</tr>
<tr>
<td>failure_domains</td>
<td>No</td>
<td>The servers sharing a network, power supply, or physical location that are negatively affected together when network, power, cooling, or other critical service experiences problems. For more information, see the Defining Failure Domains procedure. Default value: Empty list.</td>
</tr>
<tr>
<td>instanceID</td>
<td>Yes</td>
<td>A unique number assigned to this logical node. Only one logical node per server is supported in LightOS 2. This means that the value is “0”.</td>
</tr>
<tr>
<td>storageDeviceLayout</td>
<td>Yes</td>
<td>The storageDeviceLayout key, under the node-specific settings, groups the information required to detect the initial storage configuration of the node.</td>
</tr>
<tr>
<td>initialDeviceCount</td>
<td>No</td>
<td>An optional setting specifying the initial count of physical drive the system will start with on the first startup.</td>
</tr>
<tr>
<td>maxDeviceCount</td>
<td>Yes</td>
<td>The pre-determined, maximum number of physical nvme drives that this node can contain.</td>
</tr>
<tr>
<td>allowCrossNumaDevices</td>
<td>No</td>
<td>An optional setting, specifying whether block devices can be used by system-nodes that are affiliated with a different Numa ID than the block device is attached to. Default: false. Note: Do not allow devices attached on different numas to be used by this node.</td>
</tr>
<tr>
<td>Variable</td>
<td>Required</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>deviceMatchers</td>
<td>No</td>
<td>This section contains a list of matching conditions for locating the wanted physical drives to be used by the system.</td>
</tr>
<tr>
<td>partition</td>
<td>No</td>
<td>Whether or not a device is a partition (true/false).</td>
</tr>
<tr>
<td>model</td>
<td>No</td>
<td>The vendor/model of the device. For example: name =~ &quot;nvme5n.*&quot; or name == &quot;nvme1n1&quot;.</td>
</tr>
<tr>
<td>name</td>
<td>No</td>
<td>The file name of the device.</td>
</tr>
<tr>
<td>path</td>
<td>No</td>
<td>The full path of the device.</td>
</tr>
<tr>
<td>size</td>
<td>No</td>
<td>The capacity of the physical device. size &gt;= mib(1000), size == gib(20), size &lt;= tib(50).</td>
</tr>
<tr>
<td>ec_enabled</td>
<td>Yes</td>
<td>Enables Erasure Coding (EC) for protecting against SSD failure within the storage server. Normal operation continues during reconstruction when a drive is removed.</td>
</tr>
<tr>
<td>name</td>
<td>Yes</td>
<td>A unique, user-friendly name for the node.</td>
</tr>
<tr>
<td>use_lvm_for_etcd</td>
<td>No</td>
<td>Use the Linux Volume Manager (LVM) partition for etcd data. Default value: false. <strong>Note:</strong> If this variable is not used in the host configuration file, the system uses the default fault value. The following etcd variables are only relevant if the use_lvm_for_etcd variable value is true.</td>
</tr>
<tr>
<td>etcd_lv_name</td>
<td>No</td>
<td>Logical volume name for etcd data local volume management.</td>
</tr>
<tr>
<td>etcd_settings_user</td>
<td>No</td>
<td>Key-value map for overriding the etcd service settings.</td>
</tr>
<tr>
<td>etcd_lv_size</td>
<td>No</td>
<td>Logical volume size for etcd data local volume management.</td>
</tr>
<tr>
<td>etcd_vg_name</td>
<td>No</td>
<td>Volume group name for etcd data local volume management. Mandatory if use_lvm_for_etcd is used.</td>
</tr>
<tr>
<td>datapath_config</td>
<td>Yes</td>
<td>The path to the system-profile yml file.</td>
</tr>
<tr>
<td>etcd_settings_user</td>
<td>No</td>
<td>User etcd settings.</td>
</tr>
<tr>
<td>listen-client-urls</td>
<td>No</td>
<td><a href="http://127.0.0.1:2379">http://127.0.0.1:2379</a></td>
</tr>
<tr>
<td>profile_generator_overrides_dir</td>
<td>No</td>
<td>Directory path containing &lt;system-profile&gt;.yaml file to override the profile-generator generated one.</td>
</tr>
<tr>
<td>auto_reboot</td>
<td>No</td>
<td>If set to false the system will not automatically reboot after installation.</td>
</tr>
</tbody>
</table>
Notes - By default, the etcd is installed on a dedicated logical volume and the default value for the `use_lvm_for_etcd` variable is set to false.
- The user must provide the etcd volume group name in the `etcd_vg_name` variable, and confirm that there is enough server space to create a new logical volume. The default logical volume name (`etcd_lv_name`) is “etcd” and the default volume size (`etcd_lv_size`) is 10GB.
- If there is not enough space in the server, the user must reduce the other logical volume sizes before the cluster software installation to allocate the required space. For more details, see https://www.rootusers.com/lvm-resize-how-to-decrease-an-lvm-partition.

Host Configuration File Examples

Example 1: Data Network Interface Manually Configured

Host configuration with no data interfaces provided. The user configured the interfaces prior to running the playbook.

```yaml
---
nodes:
  - instanceID: 0
data_ip: 10.10.10.10
failure_domains:
  - server00
ec_enabled: true
storageDeviceLayout:
  - initialDeviceCount: 4
  - maxDeviceCount: 12
  - allowCrossNumaDevices: false
deviceMatchers:
  # - model =~ ".*"
  - partition == false
  - size >= gib(300)
  # - name =~ "nvme0n1"
```

Example 2: Data Network Interface Automatically Configured

Host configuration with a single data interface. The playbook configured the interface.
Example 3: Override the LightOS Configurations

Host configuration with LightOS override. The provided value overrides the key `listen-client-urls`.

Example 4: Provide Custom Datapath Configuration

Host configuration with custom datapath configuration provided.

By default, the playbook inspects the remote machine and determines the directory containing the specific configuration for duroselight and backend services (datapath configuration). The excluding node-manager configuration uses the following logic:
Example 5: Use the Linux Volume Manager (LVM) Partition for etcd Data

Host configuration with custom lvm partition for etcd data.

```yaml
---
nodes:
- instanceID: 0
data_ip: 10.10.10.10
failure_domains:
- server00
ec_enabled: true
storageDeviceLayout:
  initialDeviceCount: 4
  maxDeviceCount: 12
  allowCrossNumaDevices: false
deviceMatchers:
#  - model =~ ".*"
  - partition == false
  - size >= gib(300)
#  - name =~ "nvme0n1"
datapath_config: custom-datapath-config

use_lvm_for_etcd: true
etcd_lv_name: etcd
#etcd_settings_user:
etcd_lv_size: 15GiB
etcd_vg_name: centos
```

Example #6: Profile-Generator Overrides

Enable humans to override profile-generator output and provide for each server a custom file that will be taken by profile-generator as the system-profile.

Each host may be different so each host can specify its own override file.
In case the cluster is homogeneous and we want to apply the same override to all nodes we can provide a single setting in the `groups/all.yml` file or via the cmd with:

```yaml
ansible-playbook -i ... playbooks/deploy-lightos.yml -e profile_generator_overrides_dir=/tmp/overrides.d
```

In the above example, we specify `profile_generator_overrides_dir` which is a directory on the Ansible Controller that will be copied to the target machine.

## Performing an Offline Installation

The offline installation scenario is used when there is no internet access to download the required LightOS RPMs and their dependencies. In such a case, the machine being used for installation should include the LightOS cluster software RPM files and their dependencies.

During the offline installation, the software packages are copied to the target machine and installed locally.

To complete the offline installation:

1. Copy the packages to the installation server.
2. Enter the following commands on the installation machine under hosts. See section Creating the Inventory Structure and Adding the Ansible Hosts File.

```bash
source_type=offline
source_etcd_binary=<path to etcd binary zip>
source_rpms_dir=<path to rpms>
source_dependencies_rpms_dir=<path to dependencies rpms>
dest_dir=<path>
```

For example:
[duros_nodes:vars]
source_type=offline
source_etcd_binary="/root/lightos_release/deps/etcd-v3.3.13-linux-amd64.tar.gz"
source_rpms_dir="/root/lightos_release/target_rpms"
source_dependencies_rpms_dir="/root/lightos_release/deps"
dest_dir="/tmp/rpms"

Offline Ansible Controller Installation and Self-Signed Certificates

The LightOS cluster installation requires SSL certificates. You can provide these certificates, or the playbook will automatically generate self-signed certificates. To create these certificates Ansible downloads some binaries from the internet at runtime.

In case of an offline Ansible controller, the installation script requires that certificates_directory will be present and contain all needed certificates before running the playbook.

This directory and its content can come from two sources:

- If you bring your own organization certificates.
- Use the self-signed certificates generated by the initial cluster installation process.

You will need to copy the folder credentials_directory to the Ansible Controller machine, before running the installation script.

Configuring the Data Network

Nodes in the LightOS server clusters communicate via a high-speed data network interface.

All nodes in the cluster must be configured with an IP address from the same accessible network before running the Ansible playbook.

You can configure the network using an automatic (recommended) or manual method.

Automatic Data Network Configuration (Recommended)

The Ansible playbook can help you automatically set the data interface IP when some optional network host variables are transferred.

This means that to make deployment easier the playbook configures the data network interface persistently for you by specifying for each host the list variable. For example:

```
data_ifaces:
  - bootproto: static
    conn_name: ens1
    ifname: ens1
    ip4: 10.20.20.10/27
    Netmask: 255.255.255.240
```

In this example, we have set the playbook to permanently configure interface ens1 with static IP 10.20.20.10 and netmask 255.255.255.240.

Manual Data Network Configuration

In this method, you assign the data IPs on the data interfaces for each node on the cluster.

To set the data IPs:

1. Log into the machine with the following command:
etcd Partitioning

Based on your boot device’s write latency performance, you might need to create a separate partition for etcd data on the boot device. If you have questions about the need to use etcd partitioning, contact Lightbits.

To use etcd partitioning:

1. Confirm that a partition pre-allocated for etcd exists on the node and has at least 10 GB of space.
2. If it does not already exist on the node, configure an LVM group.
3. Enter the LVM group name for the `etcd_vg_name` variable in the host configuration file.
Using SSH-Key Authentication

To use key authentication, you must provide the SSH key file used in all the cluster servers.

To use SSH-key authentication instead of a plain text password, see the knowledge base article How To Configure SSH Key-Based Authentication on a Linux Server.

After you have configured the SSH key for authentication, you can connect from the installation server to the target with the `ansible_ssh_private_key_file` instead of `ansible_ssh_pass` in the following format:

```bash
ansible_ssh_private_key_file=<private RSA key file path>
```

For example:

```bash
ansible_ssh_private_key_file=/root/mykey.txt
```

Network Time Protocol Configuration

The Network Time Protocol (NTP) must be installed and configured on the cluster nodes to keep the cluster nodes in sync with each other.

You can use one of the following methods to install the required NTP packages.

**Method 1**

The latest RPMs are retrieved from the CentOS repository and installed on the cluster nodes.

**Method 2**

The specific NTP version required by the customer is installed on the cluster nodes. To use this method:

1. Create a new `group_vars` directory under your inventory directory. For more, see Creating the Inventory File (Hosts).
2. Under the new `group_vars` directory, create a new `all.yml` file.
3. Add the following section to the new `all.yml` file using the specific version that you want to install. For example:

```yaml
ntp_version: ntp-4.2.6p5-29.el7.CentOS.x86_64
```

**Method 3**

The NTP is installed using an offline method.

1. Create a new `group_vars` directory under your inventory directory. For more, see Creating the Inventory File (Hosts).
2. Under the new `group_vars` directory, create a new `all.yml` file.
3. Add the following section to the new `all.yml` file with the desired packages to install. This section’s order first lists the prerequisites and then the desired package. For example:

```yaml
ntp_packages:
  - "autogen-libopts*.rpm"
  - "ntpd*.rpm"
  - "ntp*.rpm"
```

4. The desired NTP packages must be copied to the `dest_dir`. For more, see Performing an Offline Installation.
Configuring the NTP Server

After you have installed NTP on all of the cluster nodes, you must configure the NTP service to sync with a global NTP server that is inside or outside the enterprise.

The default NTP configuration is implemented during the cluster software installation and configuration process run by the Ansible tool, which uses the defaults provided in the NTP package (Global Server Pool).

To overwrite the defaults provided in the NTP package and provide these overrides to other NTP servers, complete the following steps:

1. Under the inventory directory (/tmp/inventory) described in Creating the Inventory File (Hosts), create a new directory named `group_vars`.

2. Under the new `group_vars` directory, create a new `all.yml` file. You can skip this step if the `all.yml` file was created in a previous step.

3. Add to the `all.yml` file the following section, using the relevant NTP servers for your system.

```yaml
ntp_enabled: true
ntp_manage_config: true
ntp_servers:
  - "0{{ '.' + ntp_area if ntp_area else '' }}.pool.ntp.org iburst"
  - "1{{ '.' + ntp_area if ntp_area else '' }}.pool.ntp.org iburst"
  - "2{{ '.' + ntp_area if ntp_area else '' }}.pool.ntp.org iburst"
  - "3{{ '.' + ntp_area if ntp_area else '' }}.pool.ntp.org iburst"
```

Additional Note

In order to ensure NTP client consistency and synchronization with the NTP servers, it is highly recommended to eliminate the NetworkManager from updating `/etc/resolv.conf`. Incorrect configuration of the file could cause the NTP client to communicate with the NTP server, and therefore create time drifting between the cluster nodes.

This can be done by:

As the root user, create the `/etc/NetworkManager/conf.d/90-dns-none.conf` file with the following content - by using a text editor:

```ini
[main]
dns=none

# systemct1 reload NetworkManager
Note: After you reload the service, NetworkManager no longer updates the /etc/resolv.conf file. However, the last contents of the file are preserved.

Optionally, remove the Generated by NetworkManager comment from /etc/resolv.conf to avoid confusion.
```

Fluent Bit Logging Configuration

For storage nodes using Fluent Bit td-agent-bit to emit logging data to a centralized logging server location like EFK, use the following configuration parameters to configure and enable the td-agent-bit.

```yaml
log_server_enable=<"true"|"false">
log_server_ip=<Log server IP>
```
Note: If the log_server_enable parameter does not exist, the default value is false.

For example:

```yaml
[duros_nodes:vars]
log_server_enable=true
log_server_ip=192.168.16.51
```

See the following template file for additional customizations:

```bash
light-app/ansible/roles/fluent-bit/templates/td-agent-bit.conf.j2
```

## Automated Client Connectivity Verification

After you finish installing LightOS and configuring the nodes for a cluster, you can use an optional Ansible playbook that verifies the success of the cluster installation and runs basic I/O operations to verify the client connectivity.

To use this optional Ansible playbook, the following must be configured:

1. In the host files, the Ansible host file must have the "initiators section to declare another client server. For more, see [Creating the Inventory Structure and Adding the Ansible Host File](/lightos-cluster-software-installation/configuring-the-ansible-environment/creating-the-inventory-structure.html).

2. If you want the Ansible script to configure the IP, you must add the host variables file that includes the `data_ifaces` section. For more, see [Configuring the Data Network](/appendixes/configuring-the-data-network/_index.html).

   > **Note:**
   
   It is important that the inventory folder is shared with the cluster inventory folder so that you can fetch all cluster IPs.

Enter the following command to start the Ansible playbook:

```bash
$ ansible-playbook -i <hosts file> playbooks/deploy-nvme-tcp-initiator.yml
```

### Dashboard Installation

#### Configuring Prometheus and Grafana

**Prerequisite**

- docker-ce

**Installing Monitoring Packages**

```bash
sudo yum install lightos-monitoring-images lightos-monitoring-clustering
```
**Usage**

After lightos monitor rpms (lightos-monitoring-clustering, lightos-monitoring-images), run the following:

```
/var/lib/monitoring-images/deploy.sh deploy-clustering
```

Edit the following file: `/var/lib/monitoring-clustering/configure_grafana/configure_grafana.yml`

In the Clusters section, change the instance names for your cluster hosts (remove the extra lines in case of a single cluster).

```
clusters:
  cluster_1:
    - rack01-server01
    - rack02-server02
    - rack03-server03
  cluster_2:
    - rack04-server04
    - rack05-server05
```

Then run:

```
/var/lib/monitoring-images/deploy.sh configure-monitor
```

**Outcome**

Running the following:

```
docker ps
```

- We should see two Dockers running Prometheus and Grafana.
- They are running on port `http://localhost:9090` (prometheus) and `http://localhost:3000` (grafana).
- The Grafana user/password is:
  - user: admin
  - password: foobar
- Inside Grafana we should have two dashboards:
  - cluster_tab - showing information about the cluster.
  - nodes_tab - showing information per node.

**Open TCP Ports and Verify**

TCP ports in CentOS 7 for example can be blocked either using the IPTABLES service or using the firewall service. The following is an example of how to use the IPTABLES service to open a TCP port and then test it using the netcat utility.

1. Check if a port is blocked.
   In this example, we can check if port 80 is accepting traffic by entering the `iptables` command with grep:

   ```
   $ iptables -nL | grep 80
   ```
If the `iptables` command returns no data, the port needs to be opened.

2. To open TCP Port 80, enter the `iptables` command as follows:

   ```bash
   $ iptables -I INPUT -p tcp --dport 80 -j ACCEPT
   ```

3. Re-enter the `iptables -nL` command to see if the port is now open.

   ```bash
   $ iptables -nL | grep 80
   ACCEPT tcp -- 0.0.0.0/0 0.0.0.0/0 tcp dpt:80
   ```

4. Install the netcat utility.

   ```bash
   $ yum install nc
   ```

5. Run netcat as a server listing on port 80.

   ```bash
   $ nc -l -p 80
   ```

6. From another server, install the netcat utility.

   ```bash
   $ yum install nc
   ```

7. Run netcat to the server you are running iperf3 to verify that port 80 is accepting commands.

   ```bash
   $ nc -z -v 192.168.16.7 80
   Ncat: Version 7.50 ( https://nmap.org/ncat )
   Ncat: Connected to 192.168.16.7:80.
   Ncat: 0 bytes sent, 0 bytes received in 0.01 seconds.
   ```
About - Legal

Lightbits™ Labs, founded in 2016, is a software-defined storage company that brings hyperscale efficiency and flexibility to everyone. Lightbits’ solution delivers composable, disaggregated storage that performs like local flash. The company pioneered NVMe/TCP so the solution is easy to deploy at scale while delivering performance that from applications’ perspective is indistinguishable from local SSDs. Lightbits Labs is backed by strategic investors including Dell Technologies Capital, Cisco Investments and Micron, as well as top investors and VCs including Avigdor Willenz, Lip-Bu Tan, Marius Nacht, SquarePeg Capital, and Walden International.

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