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Cloudera Enterprise Reference Architecture for Bare Metal Deployments

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Abstract

An organization’s requirements for a big-data solution are simple: acquire and combine any amount or type of data in its original fidelity, in one place, for as long as necessary, and deliver insights to all kinds of users, as quickly as possible.

Cloudera, an enterprise data management company, introduced the concept of the enterprise data hub (EDH): a central system to store and work with all data. The EDH has the flexibility to run a variety of enterprise workloads (for example, batch processing, interactive SQL, enterprise search, and advanced analytics) while meeting enterprise requirements such as integrations to existing systems, robust security, governance, data protection, and management. The EDH is the emerging center of enterprise data management. EDH builds on Cloudera Enterprise, which consists of the open source Cloudera Distribution including Apache Hadoop (CDH), a suite of management software and enterprise-class support.

As organizations embrace Hadoop-powered big data deployments, they also want enterprise-grade security, management tools, and technical support--all of which are part of Cloudera Enterprise.

Cloudera Reference Architecture documents illustrate example cluster configurations and certified partner products. The RAs are not replacements for official statements of supportability, rather they’re guides to assist with deployment and sizing options. Statements regarding supported configurations in the RA are informational and should be cross-referenced with the latest documentation.

This document is a high-level design and best-practices guide for deploying Cloudera Enterprise on bare metal.

Infrastructure

System Architecture Best Practices

This section describes Cloudera's recommendations and best practices applicable to Hadoop cluster system architecture.

Java

Cloudera Manager and CDH are certified to run on Oracle JDK. OpenJDK is also supported for Cloudera Manager and CDH 5.16 and higher 5.x releases. See Upgrading the JDK for more information.

Cloudera distributes a compatible version of the Oracle JDK through the Cloudera Manager repository. Customers are also free to install a compatible version of the Oracle JDK distributed by Oracle.

Refer to CDH and Cloudera Manager Supported JDK Versions for a list of supported JDK versions.

Right-size Server Configurations

Cloudera recommends deploying three or four machine types into production:

- **Master Node.** Runs the Hadoop master daemons: NameNode, Standby NameNode, YARN Resource Manager and History Server, the HBase Master daemon, Sentry server, and the Impala StateStore Server and Catalog Server. Master nodes are also the location where Zookeeper and JournalNodes are installed. The daemons can often share single pool of servers. Depending on the cluster size, the roles can instead each be run on a dedicated server. Kudu Master Servers should also be deployed on master nodes.
- **Worker Node.** Runs the HDFS DataNode, YARN NodeManager, HBase RegionServer, Impala impalad, Search worker daemons and Kudu Tablet Servers.
- **Utility Node.** Runs Cloudera Manager and the Cloudera Management Services. It can also host a MySQL (or another supported) database instance, which is used by Cloudera Manager, Hive, Sentry and other Hadoop-related projects.
- **Edge Node.** Contains all client-facing configurations and services, including gateway configurations for HDFS, YARN, Impala, Hive, and HBase. The edge node is also a good place for Hue, Oozie, HiveServer2, and Impala HAProxy. HiveServer2 and Impala HAProxy serve as a gateway to external applications such as Business Intelligence (BI) tools.

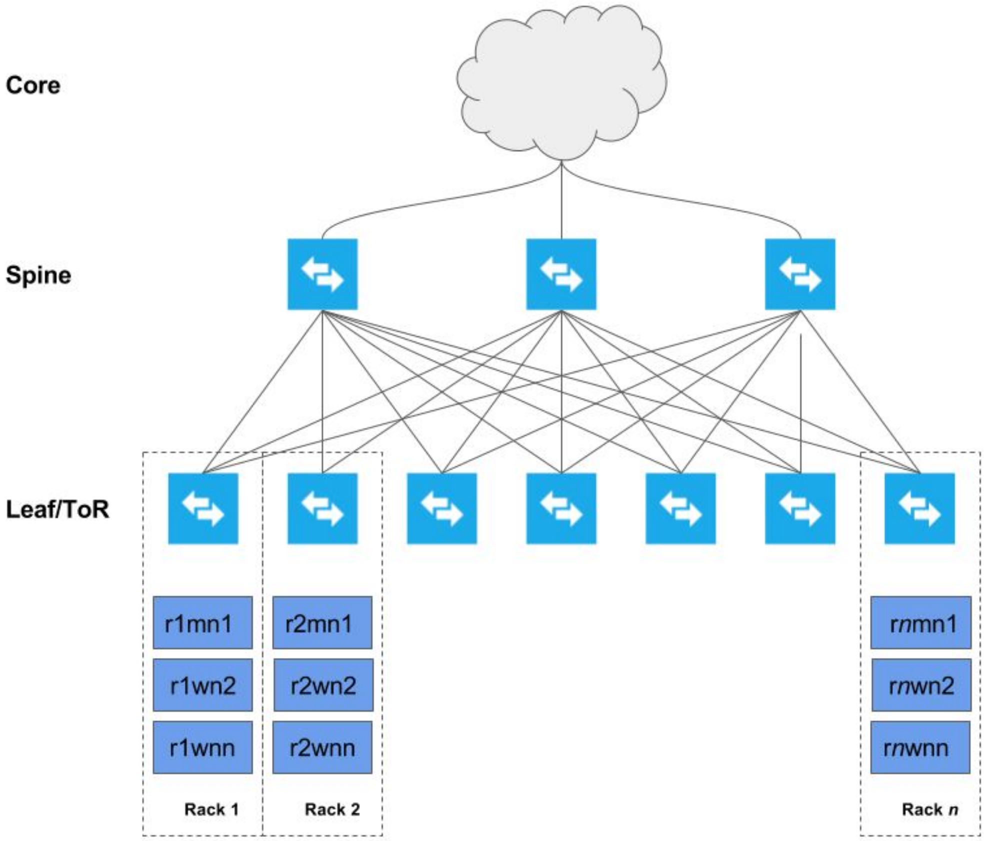
For more information refer to Recommended Cluster Hosts and Role Distribution.

Note:

The edge and utility nodes can be combined in smaller clusters.

Deployment Topology

The graphic below depicts a cluster deployed across several racks (Rack 1, Rack 2, … Rack *n*).



Each host is networked to two top-of-rack (TOR) switches which are in turn connected to a collection of spine switches which are then connected to the enterprise network. This deployment model allows each host maximum throughput, minimize of latency, while encouraging scalability. The specifics of the network topology are described in the subsequent sections.

Physical Component List

The follow table describes the physical components recommended to deploy an EDH cluster.

Component	**Configuration**	**Description**	**Quantity**
Physical servers	Two-socket, 8-14 cores per socket > 2 GHz; minimally 128 GB RAM.	Hosts that house the various cluster components.	Based on cluster design.
NICs	10 Gbps Ethernet NICs preferred.	Provide the data network services for the cluster.	At least one per server, although two NICs can be bonded

			for additional throughput.
Internal HDDs	500 GB HDD or SSD recommended for operating system and logs; HDD for data disks (size varies with data volume requirements)	These ensure continuity of service on server resets and contain the cluster data.	10-24 disks per physical server.
Ethernet ToR/leaf switches	Minimally 10 Gbps switches with sufficient port density to accommodate the cluster. These require enough ports to create a realistic spine-leaf topology providing ISL bandwidth above a 1:4 oversubscription ratio (preferably 1:1).	Although most enterprises have mature data network practices, consider building a dedicated data network for the Hadoop cluster.	At least two per rack.
Ethernet spine switches	Minimally 10 Gbps switches with sufficient port density to accommodate incoming ISL links and ensure required throughput over the spine (for inter-rack traffic).	Same considerations as for ToR switches.	Depends on the number of racks.

Network Specification

Dedicated Network Hardware

Hadoop can consume all available network bandwidth. For this reason, Cloudera recommends that Hadoop be placed in a separate physical network with its own core switch.

Switch Per Rack

Hadoop supports the concept of rack locality and takes advantage of the network topology to minimize network congestion. Ideally, nodes in one rack should connect to a single physical switch. Two top- of-rack (TOR) switches can be used for high availability. Each rack switch (i.e. TOR switch) uplinks to a core switch with a significantly bigger backplane. Cloudera recommends 10 GbE (or faster) connections between the servers and TOR switches. TOR uplink bandwidth to the core switch (two switches in a HA configuration) will often be oversubscribed to some extent.

Uplink Oversubscription

How much oversubscription is appropriate is workload dependent. Cloudera’s recommendation is that the ratio between the total access port bandwidth and uplink bandwidth be as close to 1:1 as is possible.

This is especially important for heavy ETL workloads, and MapReduce jobs that have a lot of data sent to reducers.

Oversubscription ratios up to 4:1 are generally fine for balanced workloads, but network monitoring is needed to ensure uplink bandwidth is not the bottleneck for Hadoop. The following table provides some examples as a point of reference:

Access Port Bandwidth (In Use)	Uplink Port Bandwidth (Bonded)	Ratio
48 x 1 GbE = 48 Gbit/s	4 x 10 GbE = 40 Gbit/s	1.2:1
24 x 10 GbE = 240 Gbit/s	2 x 40 Gig CFP = 80 Gbit/s	3:1
48 x 10 GbE = 480 Gbit/s	4 x 40 Gig CFP = 160 Gbit/s	3:1

Important:

Do not exceed 4:1 oversubscription ratio. For example, if a TOR has 20 x 10 GbE ports used, the uplink should be at least 50 Gbps. Different switches have dedicated uplink ports of specific bandwidth (often 40 Gbps or 100 Gbps) and therefore careful planning needs to be done in order to choose the right switch types.

Redundant Network Switches

Having redundant core switches in a full mesh configuration will allow the cluster to continue operating in the event of a core switch failure. Redundant TOR switches will prevent the loss of an entire rack of processing and storage capacity in the event of a TOR switch failure. General cluster availability can still be maintained in the event of the loss of a rack, as long as master nodes are distributed across multiple racks.

Accessibility

The accessibility of your Cloudera Enterprise cluster is defined by the network configuration and depends on the security requirements and the workload. Typically, there are edge/client nodes that have direct access to the cluster. Users go through these edge nodes via client applications to interact with the cluster and the data residing there. These edge nodes could be running a web application for real-time serving workloads, BI tools, or simply the Hadoop command-line client used to submit or interact with HDFS.

Cloudera recommends allowing access to the Cloudera Enterprise cluster via edge nodes only. You can configure this in the security groups for the hosts that you provision. The rest of this document describes the various options in detail.

Internet Connectivity

Clusters that do not require heavy data transfer between the Internet or services outside of the immediate network and HDFS still might need access to services like software repositories for updates or other low-volume outside data sources.

If you completely disconnect the cluster from the Internet, you block access for software updates which makes maintenance difficult.

Cloudera Manager

Cloudera strongly recommends installing CDH using Cloudera Manager (CM). During the CDH installation via CM there is the choice to install using parcels or native packages. A parcel is a binary distribution format. Parcels offer a number of benefits including consistency, flexible installation location, installation without sudo, reduced upgrade downtime, rolling upgrades, and easy downgrades. Cloudera recommends using parcels, though using packages is supported.

Cluster Sizing Best Practices

Each worker node typically has several physical disks dedicated to raw storage for Hadoop. This number will be used to calculate the total available storage for each cluster. Also, the calculations listed below assume 10% disk space allocated for YARN temporary storage. Cloudera recommends allocating between 10-25% of the raw disk space for temporary storage as a general guideline. This can be changed within Cloudera Manager and should be adjusted after analyzing production workloads. For example, MapReduce jobs that send little data to reducers allow for adjusting this number percentage down considerably.

The following table contains example calculations for a cluster that contains 17 worker nodes. Each server has twelve 3 TB drives available for use by Hadoop. The table below outlines the Hadoop storage available based upon the number of worker nodes:

Default Replication Factor

Raw Storage	612 TB
HDFS Storage (Configurable)	550.8 TB
HDFS Unique Storage (default replication factor)	183.6 TB
MapReduce Intermediate Storage (Configurable)	61.2 TB

Erasure Coding RS-6-3

Raw Storage	612 TB
HDFS Storage (Configurable)	550.8 TB
HDFS Unique Storage (EC RS-6-3 -- 1.5x overhead)	367.2 TB
MapReduce Intermediate Storage (Configurable)	61.2 TB

Erasure Coding RS-10-4

Raw Storage	612 TB
HDFS Storage (Configurable)	550.8 TB
HDFS Unique Storage (EC RS-10-4 -- 1.4x overhead)	393.4 TB
MapReduce Intermediate Storage (Configurable)	61.2 TB

Note:

HDFS Unique Storage will vary depending on the amount of data stored in EC directories and the RS policies chosen. The tables above are merely examples of how different policies can affect HDFS Unique Storage.

Note:

Compressing raw data can effectively increase HDFS storage capacity.

While Cloudera Manager provides tools such as Static Resource Pools, which utilize Linux Cgroups, to allow multiple components to share hardware, in high volume production clusters it can be beneficial to allocate dedicated hosts for roles such as Solr, HBase, and Kafka.

Cluster Hardware Selection Best Practices

This section will give a high level overview of how different hardware component selections will impact the performance of a Hadoop cluster.

Refer to the Hardware Requirements Guide for detailed workload-specific practices.

Number of Spindles

Traditionally Hadoop has been thought of as a large I/O platform. While there are many new types of workloads being run on Cloudera clusters that may not be as I/O bound as traditional MapReduce applications, it is still useful to consider the I/O performance when architecting a Cloudera cluster.

Unlike the number of cores in a CPU and the density of RAM, the speed at which data can be read from a spinning hard drive (spindle) has not changed much in the last 10 years[1]. In order to counter the limited performance of hard drive read/write operations, Hadoop reads and writes from many drives in parallel. Every additional spindle added per node increases the overall read/write speed of the cluster.

Additional spindles also come with the likelihood of more network traffic in the cluster. For the majority of cases, network traffic between nodes is generally limited by how fast data can be written to or read from a node. Therefore, the rule normally follows that with more spindles network speed requirements increase.

Generally speaking, the more spindles a node has, the lower the cost per TB. However, the larger the quantity of data stored on one node yields a longer re-replication time if that node goes down. Hadoop clusters are designed to have many nodes. It is generally better to have more average nodes than fewer super nodes. This has a lot to do with both data protection, as well as increased parallelism for distributed computation engines such as MapReduce and Spark.

Lastly, the number of drives per node will impact the number of YARN containers configured for a node. YARN configuration and performance tuning is a complicated topic, but for I/O bound applications, the number of physical drives per host may be a limiting factor in determining the number of container slots configured per node.

Kafka clusters are often run on dedicated servers that do not run HDFS data nodes or processing components such as YARN and Impala. Because Kafka is a message-based system, fast storage and

[1] SSDs have dramatically changed the persistent storage performance landscape, but the price per GB of spinning disks is still significantly less than that of SSD storage. As SSDs come down in cost and technologies such as Intel's Optane™ enter the market, workloads may swing back towards being CPU bound. Most Cloudera customers are still deploying clusters that store data on spinning hard disks.

network I/O is critical to performance. Although Kafka does persist messages to disk, it is not generally necessary to store the entire contents of a Kafka topic log on the Kafka cluster indefinitely. Kafka brokers should be configured with dedicated spinning hard drives for the log data directories. Using SSDs instead of spinning disks has not been shown to provide a significant performance improvement for Kafka.

Kafka drives should also be configured as RAID 10 because the loss of a single drive on a Kafka broker will cause the broker to experience an outage.

Disk Layout

For Master nodes, the following layout is recommended

- 2 x Disks (capacity at least 500GB) in RAID 1 (software or hardware) for OS and logs
- 4 x Disks (>= 1TB each) in RAID 10 for Database data (see Note)
- 2 x Disks (capacity at least 1 TB) in RAID 1 (software or hardware) for NameNode metadata
- 1 x Disk JBOD/RAID 0 for ZooKeeper (>= 1TB) (see Note)
    - ZooKeeper disks must be HDD, not SSD
- 1 x Disk JBOD/RAID 0 for Quorum JournalNode (>= 1TB)

Note:

Ideally databases should be run on an external host rather than running on the master node(s).

Note:

If customer has experienced fsync delays and other I/O related issues with ZooKeeper, ZooKeeper's `dataDir` and `dataLogDir` can be configured to use separate disks. It's hard to determine ahead of time whether this will be necessary; even a small cluster can result in heavy ZooKeeper activity.

For Worker nodes, the following layout is recommended:

- 2x Disks (capacity at least 500GB) in RAID 1 (software or hardware) for OS and logs
- 15-24 SATA Disks JBOD mode (or as multiple single-drive RAID 0 arrays if using a RAID controller incapable of doing JBOD passthrough) no larger than 4 TB in capacity. If the RAID Controller has cache, use it for write caching (preferably with battery backup); disable read caching. Follow your hardware vendor's best practices where available.
- For higher performance profile, use 10K RPM SATA or faster SAS drives; these often have lower capacity but capacity considerations can be offset by adding more data nodes.

SAS drives are supported but typically do not provide significant enough performance or reliability benefits to justify the additional costs. Hadoop is designed to be fault-tolerant and therefore drive failure can easily be tolerated. In order to achieve a good price-point, SATA drives should typically be used.

RAID controllers should be configured to disable any optimization settings for the RAID 0 arrays.

Data Density Per Drive

Hard drives today come in many sizes. Popular drive sizes are 1-4 TB although larger drives are becoming more common. When picking a drive size the following points need to be considered.

- **Lower Cost Per TB** – Generally speaking, the larger the drive, the cheaper the cost per TB, which makes for lower TCO.
- **Replication Storms** – Larger drives means drive failures will produce larger re-replication storms, which can take longer and saturate the network while impacting in-flight workloads.
- **Cluster Performance** – In general, drive size has little impact on cluster performance. The exception is when drives have different read/write speeds and a use case that leverages this gain. MapReduce is designed for long sequential reads and writes, so latency timings are generally not as important. HBase can potentially benefit from faster drives, but that is dependent on a variety of factors, such as HBase access patterns and schema design; this also implies acquisition of more nodes. Impala and Cloudera Search workloads can also potentially benefit from faster drives, but for those applications the ideal architecture is to maintain as much data in memory as possible.

Cloudera does not support exceeding 100 TB per data node. You could use 12 x 8 TB spindles or 24 x 4 TB spindles. Cloudera does not support drives larger than 8 TB.[2]

Warning:

Running CDH on storage platforms other than direct-attached physical disks can provide suboptimal performance. Cloudera Enterprise and the majority of the Hadoop platform are optimized to provide high performance by distributing work across a cluster that can utilize data locality and fast local I/O. Refer to the Cloudera Enterprise Storage Device Acceptance Criteria Guide for more information about using non-local storage.

Number of Cores and Multithreading

Other than cost there is no negative for buying more and better CPUs, however the ROI on additional CPU power must be evaluated carefully. Here are some points to consider:

- **Cluster Bottleneck** – In general, CPU resources (and lack thereof) do not bottleneck MapReduce and HBase. The bottleneck will almost always be drive and/or network performance. There are certainly exceptions to this, such as inefficient Hive queries. Other compute frameworks like Impala, Spark, and Cloudera Search may be CPU-bound depending on the workload.
- **Additional Cores/Threads** – Within a given MapReduce job, a single task will typically use one thread at a time. As outlined earlier, the number of slots allocated per node may be a function of the number of drives in the node. As long as there is not a huge disparity in the number of cores (threads) and the number of drives, it does not make sense to pay for additional cores. In addition, a MapReduce task is going to be I/O bound for typical jobs, thus a given thread used by the task will have a large amount of idle time while waiting for I/O response.
- **Clock Speed** – Because Cloudera clusters often begin with a small number of use cases and associated workloads and grow over time, it makes sense to purchase the fastest CPUs available. Actual CPU usage is use case and workload dependent; for instance, computationally

[2] Larger disks offer increased capacity but not increased I/O. Clusters with larger disks can easily result in capacities exceeding 100 TB per-worker, contributing to replication storms mentioned above. Clusters with larger disks that observe the 100 TB limit end up having fewer spindles which reduces HDFS throughput.

intensive Spark jobs would benefit more from faster CPUs than I/O bound MapReduce applications.

Important:

Allocate two vCPUs for the operating system and other non-Hadoop use (although this amount may need to be higher if additional non-Hadoop applications are running on the cluster nodes, such as third-party active monitoring/alerting tools). The more services you are running, the more vCPUs will be required; you will need to use more capable hosts to accommodate these needs..

For worker nodes, a mid-range 12-14 core CPU running at 2.4-2.5 GHz would typically provide a good cost/performance tradeoff. For master nodes, a mid-range 8 core CPU with a slightly faster clock speed (e.g. 2.6 GHz) would suffice. Where available, Simultaneous Multi-Threading implementations should be enabled (for example Intel's HyperThreading). BIOS settings for CPU and memory should be set to Maximum Performance mode or equivalent.

Refer to the Hardware Requirements Guide for detailed workload-specific practices.

RAM

More memory is always good and it is recommended to purchase as much as the budget allows. Applications such as Impala and Cloudera Search are often configured to use large amounts of heap, and a mixed workload cluster supporting both services should have sufficient RAM to allow all required services.

Refer to the Hardware Requirements Guide for detailed workload-specific practices.

Important:

Allocate at least 4 GB memory for the operating system and other non-Hadoop use (although this amount may need to be higher if additional non-Hadoop applications are running on the cluster nodes, such as third-party active monitoring/alerting tools). The more services you are running, the more memory will be required; you will need to use more capable hosts to accommodate these needs.

It is critical to performance that the total memory allocated to all Hadoop-related processes (including processes such as HBase) is less than the total memory on the node, taking into account the operating system and non-Hadoop processes. Oversubscribing the memory on a system can lead to the Linux kernel's out-of-memory process killer being invoked and important processes being terminated. It can also be harmful to performance to unnecessarily over-allocate memory to a Hadoop process as this can lead to long Java garbage collection pauses.

For optimum performance, one should aim to populate all of the memory channels available on the given CPUs. This may mean a greater number of smaller DIMMS, but this means that both memory and CPU are operating at their best performance. Confer with your hardware vendor for defining optimal memory configuration layout.

Whilst 128 GB RAM can be accommodated, this typically constrains the amount of memory allocated to services such as YARN and Impala, therefore reducing the query capacity of the cluster. A value of 256 GB would typically be recommended with higher values also possible.

Power Supplies

Hadoop software is designed around the expectation that nodes will fail. Redundant hot-swap power supplies are not necessary for worker nodes, but should be used for master, utility, and edge nodes.

Operating System Best Practices

Cloudera currently supports running the EDH platform on several Linux distributions. To receive support from Cloudera, a supported version of the operating system must be in use. The Requirements and Supported Versions guide lists the supported operating systems for each version of Cloudera Manager and CDH.

Hostname Naming Convention

Cloudera recommends using a hostname convention that allows for easy recognition of roles and/or physical connectivity. This is especially important for easily configuring rack awareness within Cloudera Manager. Using a project name identifier, followed by the rack ID, the machine class, and a machine ID is an easy way to encode useful information about the cluster. For example:

```
acme-test-r01m01
```

This hostname would represent the ACME customer's test project, rack #1, master node #1.

Hostname Resolution

Cloudera recommends using DNS for hostname resolution. The usage of `/etc/hosts` becomes cumbersome quickly, and routinely is the source of hard to diagnose problems. `/etc/hosts` should only contain an entry for 127.0.0.1, and `localhost` should be the only name that resolves to it. The machine name must not resolve to the 127.0.0.1 address. All hosts in the cluster must have forward and reverse lookups be the inverse of each other for Hadoop to function properly. An easy test to perform on the hosts to ensure proper DNS resolution is to execute:

```
dig <hostname>
dig -x <ip_address_returned_from_hostname_lookup)
```

For example:

```
dig themis.apache.org
themis.apache.org.   1758  IN   A    140.211.11.105

dig -x 140.211.11.105
105.11.211.140.in-addr.arpa. 3513 IN      PTR   themis.apache.org.
```

This is the behavior we should see for every host in the cluster.

Functional Accounts

Cloudera Manager and CDH make use of dedicated functional accounts for the associated daemon processes. By default these accounts are created as local accounts on every machine in the cluster that needs them if they do not already exist (locally or from a directory service, such as LDAP). The Requirements and Supported Versions guide includes a table showing the UNIX user and group associated with each service.

> **Note:**
>
> Kerberos deployment models (including identity integration with Active Directory) are covered in detail within the Authentication documentation.

As of Cloudera Manager 5.3, it is also possible to install the cluster in single user mode where all services share a single service account. This feature is provided for customers who have policy requirements that prevent the use of multiple service accounts. Cloudera does not recommend the use of this feature unless the customer has this requirement, as CDH uses separate accounts to achieve proper security isolation and therefore removing this feature will reduce the overall security of the installation. Additional information about single user mode can be found in the Cloudera Installation and Upgrade manual: Configuring Single User Mode.

Time

All machines in the cluster need to have the same time and date settings, including time zones. Use of the Network Time Protocol (NTP) is highly recommended. Many cluster services are sensitive to time (e.g. HBase, Kudu, ZooKeeper) and troubleshooting will be greatly eased if time is consistent across all hosts. Doing the following will enable the NTP daemon:

(RHEL/CentOS 6)

```
service ntpd start
chkconfig ntpd on
```

(RHEL/CentOS 7)

```
systemctl start ntpd.service
systemctl enable ntpd.service
```

> **Note:**
>
> Chrony may be preferred on newer operating systems.

Name Service Caching

It is recommended that name service caching be enabled, particularly for clusters that use non-local Hadoop functional accounts, such as the `hdfs` and `yarn` users. This becomes critical in the case where the latter is combined with using Kerberos. Many difficult-to-diagnose problems can arise when name service lookups time out or fail during heavy cluster utilization. Doing the following will enable the Name Service Cache Daemon (nscd):

(RHEL/CentOS 6)

```
service nscd start
chkconfig nscd on
```

(RHEL/CentOS 7)

```
systemctl start nscd.service
systemctl enable nscd.service
```

If you are running Red Hat SSSD you will need to modify the nscd configuration to not cache passwd, group, or netgroup information.

SELinux

Cloudera Enterprise (without Cloudera Navigator) is supported on platforms with Security-Enhanced Linux (SELinux) enabled, however we recommend SELinux be disabled on all machines in the Hadoop cluster until you get your cluster up and running.

The Linux command `getenforce` returns the status of SELinux.

SELinux can be disabled on RHEL/CentOS by editing `/etc/sysconfig/selinux` (RHEL/CentOS 6) Or `/etc/selinux/config` (RHEL/CentOS 7) and setting `SELINUX=disabled`. This change must be done as root (or with proper sudo access), and requires a reboot.

IPv6

Hadoop does not support IPv6. IPv6 configurations should be removed, and IPv6-related services should be stopped.

iptables

Cloudera recommends disabling host based firewalls on the cluster, at least until you get your cluster up and running. Many problems that are difficult to diagnose result from incorrect/conflicting iptables entries that interfere with normal cluster communication. Doing the following will disable iptables for both IPv4 and IPv6:

(RHEL/CentOS 6)

```
service iptables stop
service ip6tables stop
chkconfig iptables off
chkconfig ip6tables off
```

(RHEL/CentOS 7)

```
systemctl stop firewalld.service
systemctl disable firewalld.service
```

For those who must restrict access using host-based firewalls, refer to the list of ports used by Cloudera Manager, Cloudera Navigator, and CDH 5.

Startup Services

As with any production server, unused services should be removed and/or disabled. Some example services that are on by default that are not needed by CDH are:

- bluetooth
- cups
- iptables
- ip6tables
- postfix[3]

This list is by no means exhaustive. To view the list of services that are configured to start during system startup, execute the following command:

(RHEL/CentOS 6)

```
chkconfig -list | grep on
```

(RHEL/CentOS 7)

```
systemctl list-unit-files --type service | grep enabled
```

Process Memory

The memory on each node is allocated out to the various Hadoop processes. This predictability reduces the chance of Hadoop processes inadvertently running out of memory and so paging to disk, which in turn leads to severe degradation in performance. See the section on Kernel and OS Tuning for further information.

A minimum of 4 GB of memory should be reserved on all nodes for operating system and other non-Hadoop use. This amount may need to be higher if additional non-Hadoop applications are running on the cluster nodes, such as third party active monitoring/alerting tools.

Memory requirements and allocation for Hadoop components are discussed in further detail in other sections of this document.

Kernel and OS Tuning

The Cloudera EDH platform depends on a properly tuned underlying host operating system for optimal performance. Cloudera strongly suggests setting the vm.swappiness and transparent hugepage compaction kernel parameters. The Cloudera Administration manual has additional background information and suggested settings: Optimizing Performance in CDH.

Entropy

Cryptographic operations require entropy to ensure randomness. The Cloudera Security guide explains how to check available entropy and how to ensure sufficient entropy is available: Entropy Requirements.

[3] While not needed by CDH, postfix (or other MTA) may be required by other services to deliver generated notices/alerts from the system.

Networking Parameters

The following parameters are to be added to `/etc/sysctl.conf` to optimize various network behaviors.

Disable TCP timestamps to improve CPU utilization (this is an optional parameter and will depend on your NIC vendor):

```
net.ipv4.tcp_timestamps=0
```

Enable TCP sacks to improve throughput:

```
net.ipv4.tcp_sack=1
```

Increase the maximum length of processor input queues:

```
net.core.netdev_max_backlog=250000
```

Increase the TCP max and default buffer sizes using `setsockopt()`:

```
net.core.rmem_max=4194304
net.core.wmem_max=4194304
net.core.rmem_default=4194304
net.core_wmem_default=4194304
net.core.optmem_max=4194304
```

Increase memory thresholds to prevent packet dropping:

```
net.ipv4.tcp_rmem="4096 87380 4194304"
net.ipv4.tcp_wmem="4096 65536 4194304"
```

Enable low latency mode for TCP:

```
net.ipv4.tcp_low_latency=1
```

Set the socket buffer to be divided evenly between TCP window size and application buffer:

```
net.ipv4.tcp_adv_win_scale=1
```

Filesystems

In Linux there are several choices for formatting and organizing drives. That being said, only a few choices are optimal for Hadoop.

In RHEL/CentOS, the Logical Volume Manager (LVM) should never be used for data drives. It is not optimal and can lead to combining multiple drives into one logical disk, which is in complete contrast to how Hadoop manages fault tolerance across HDFS. It can be beneficial to keep LVM enabled on the OS drives. Any performance impact that may occur is countered by the improvement to manageability of the system. Using LVM on the OS drives enables the admin to avoid over-allocating space on partitions. Space needs can change over time and the ability to dynamically grow a file system is better than having to rebuild a system. Do not use LVM to stripe or span logical volumes across multiple physical volumes to mimic RAID.

Cloudera recommends using an extent-based file system. This includes `ext3`, `ext4`, and `xfs`. Most new Hadoop clusters use the `ext4` filesystem by default. Red Hat Enterprise Linux 7 uses `xfs` as its default filesystem.

Important:

If utilizing Kudu be sure to ensure that filesystem hole punching is a capability of the filesystem. Hole Punching is the use of the `fallocate()` system call with the `FALLOC_FL_PUNCH_HOLE` option set. Newer versions of ext4 and xfs support Hole Punching. ext3 does not support Hole Punching and unpatched RHEL prior to 6.4 does not support this facility. Older versions of ext4 and xfs that do not support Hole Punching cause Kudu to fail to start as Kudu provides a pre-start test for this facility. Without Hole Punching support the block manager is unsafe to use as claimed blocks will never be released and ever more disk space will be consumed.

Filesystem Creation Options

When creating ext4 filesystems for use with Hadoop **data volumes**, we recommend reducing the superuser block reservation from 5% to 1% for root (using the `-m1` option) as well as setting the following options:

- use one inode per 1 MB (largefile)
- minimize the number of super block backups (sparse_super)
- enable journaling (has_journal)
- use b-tree indexes for directory trees (dir_index)
- use extent-based allocations (extent)

Creating such an ext4 filesystem might look like this:

```
mkfs -t ext4 -m 1 -O -T largefile \
  sparse_super,dir_index,extent,has_journal /dev/sdb1
```

Creating an xfs filesystem might look like this:

```
mkfs -t xfs /dev/sdb1
```

Note:

When creating xfs filesystems, no special options are required.

Disk Mount Options

HDFS by design is a fault tolerant file system. As such, all drives used by DataNode machines for data need to be mounted without the use of RAID. Furthermore, drives should be mounted in `/etc/fstab` using the `noatime` option (which also implies `nodiratime`). In case of SSD or flash also turn on TRIM by specifying the `discard` option when mounting.

In /etc/fstab ensure that the appropriate filesystems have the noatime mount option specified:

```
/dev/sda1   /            ext4    noatime                 0 0
```

In order to enable TRIM, edit /etc/fstab and set mount option discard as well.

```
/dev/sdb1   /data       ext4    noatime,discard        0 0
```

Disk Mount Naming Convention

For ease of administration, it is recommended to mount all of the disks on the DataNode machines with a naming pattern, for example:

```
/data1
/data2
/data3
/data4
/data5
/data6
```

Cluster Configuration

This section contains information about how the cluster is configured, including Cloudera recommendations specific to the customer hardware being used, and some best practices and general recommendations for each Cloudera EDH service. This section is not an exhaustive description of every configuration, but rather a focus on important configurations and those that have been changed from the default setting.

Teragen and Terasort Performance Baseline

The `teragen` and `terasort` benchmarking tools are part of the standard Apache Hadoop distribution and are included with the Cloudera distribution. In the course of a cluster installation or certification, Cloudera recommends running several `teragen` and `terasort` jobs to obtain a performance baseline for the cluster. The intention is not to demonstrate the maximum performance possible for the hardware or to compare with externally published results, as tuning the cluster for this may be at odds with actual customer operational workloads. Rather the intention is to run a real workload through YARN to functionally test the cluster as well as obtain baseline numbers that can be used for future comparison, such as in evaluating the performance overhead of enabling encryption features or in evaluating whether operational workloads are performance limited by the I/O hardware. Running benchmarks provides an indication of cluster performance and may also identify and help diagnose hardware or software configuration problems by isolating hardware components, such as disks and network, and subjecting them to a higher than normal load.

The `teragen` job will generate an arbitrary amount of data, formatted as 100-byte records of random data, and store the result in HDFS. Each record has a random key and value. The `terasort` job will sort the data generated by `teragen` and write the output to HDFS.

During the first iteration of the `teragen` job, the goal is to obtain a performance baseline on the disk I/O subsystem. The HDFS replication factor should be overridden from the default value 3 and set to 1 so that the data generated by `teragen` is not replicated to additional data nodes. Replicating the data over the network would obscure the raw disk performance with potential network bandwidth constraints.

Once the first `teragen` job has been run, a second iteration should be run with the HDFS replication factor set to the default value. This will apply a high load to the network, and deltas between the first run and second run can provide an indication of network bottlenecks in the cluster.

While the `teragen` application can generate any amount of data, 1 TB is standard. For larger clusters, it may be useful to also run 10 TB or even 100 TB, as the time to write 1 TB may be negligible compared to the startup overhead of the YARN job. Another `teragen` job should be run to generate a dataset that is 3 times the RAM size of the entire cluster. This will ensure we are not seeing page cache effects and are truly exercising the disk I/O subsystem.

The number of mappers for the `teragen` and `terasort` jobs should be set to the maximum number of disks in the cluster. This will likely be less than the total number of YARN `vcores` available, so it is advisable to temporarily lower the vcores available per YARN worker node to the number of disk spindles to ensure an even distribution of the workload. An additional `vcore` will be needed for the YARN ApplicationMaster.

The `terasort` job should also be run with the HDFS replication factor set to 1 as well as with the default replication factor. The `terasort` job hardcodes a DFS replication factor of 1, but it can be overridden or set explicitly by specifying the *mapreduce.terasort.output.replication* parameter as shown below.

Teragen and Terasort Command Examples

Teragen Command to Generate 1 TB of Data With HDFS Replication Set to 1

```
EXAMPLES_PATH=/opt/cloudera/parcels/CDH/lib/hadoop-mapreduce

yarn jar ${EXAMPLES_PATH}/hadoop-mapreduce-examples.jar \
  teragen -Ddfs.replication=1 -Dmapreduce.job.maps=360 \
  10000000000 TS_input1
```

The above command generates 1 TB of data with an HDFS replication factor of 1, using 360 mappers. This command would be appropriate for a cluster with 360 disks.

Teragen Command to Generate 1 TB of Data With HDFS Default Replication

```
EXAMPLES_PATH=/opt/cloudera/parcels/CDH/lib/hadoop-mapreduce

yarn jar ${EXAMPLES_PATH}/hadoop-mapreduce-examples.jar \
  teragen -Dmapreduce.job.maps=360 \
  10000000000 TS_input2
```

The above command generates 1 TB of data with the default HDFS replication factor (usually 3), using 360 mappers. This command would be appropriate for a cluster with 360 disks.

Terasort Command to Sort Data With HDFS Replication Set to 1

```
EXAMPLES_PATH=/opt/cloudera/parcels/CDH/lib/hadoop-mapreduce

yarn jar ${EXAMPLES_PATH}/hadoop-mapreduce-examples.jar \
  terasort -Ddfs.replication=1 \
  -Dmapreduce.job.maps=360 \
  TS_input1 TS_output1
```

The above command sorts the data generated by `terasort` using 360 mappers and writes the sorted output to HDFS with a replication factor of 1. This would be appropriate for a cluster with 360 disks.

Terasort Command to Sort Data With HDFS Replication Set to 3

```
EXAMPLES_PATH=/opt/cloudera/parcels/CDH/lib/hadoop-mapreduce

yarn jar ${EXAMPLES_PATH}/hadoop-mapreduce-examples.jar \
  terasort -Dmapreduce.job.maps=360 -Ddfs.replication=3 \
  TS_input2 TS_output2
```

The above command sorts the data generated by `terasort` using 360 mappers and writes the sorted output to HDFS with a replication factor of 3 (a typical default). This would be appropriate for a cluster with 360 disks.

Teragen and Terasort Results

Command	HDFS Replication	Number of Mappers	Run Time
Teragen for 1 TB data set	1		
Teragen for 3x cluster RAM data set	1		
Terasort for 1 TB data set	1		
Terasort for 3x cluster RAM data set	1		
Teragen for 1 TB data set	3		
Teragen for 3x cluster RAM data set	3		
Terasort for 1 TB data set	3		
Terasort for 3x cluster RAM data set	3		

Cluster Configuration Best Practices

ZooKeeper

ZooKeeper is extremely sensitive to disk latency. While it only uses a modest amount of resources, having ZooKeeper swap out or wait for a disk operation can result in that ZooKeeper node being considered 'dead' by its quorum peers. For this reason, Cloudera recommends against deploying ZooKeeper on worker nodes where loads are unpredictable and are prone to spikes. It is acceptable to deploy Zookeeper on master nodes where load is more uniform and predictable (or generally, on any node where it can be have unimpeded access to disk).

HDFS

Java Heap Sizes

NameNode memory should be increased over time as HDFS has more files and blocks stored. Cloudera Manager can monitor and alert on memory usage. A rough estimate is that the NameNode needs 1 GB of memory for every 1 million files. Setting the heap size too large when it is not needed leads to inefficient Java garbage collection, which can lead to erratic behavior that is hard to diagnose. NameNode and Standby NameNode heap sizes must always be the same, and thus must be adjusted together.

NameNode Metadata Locations

When a quorum-based high availability HDFS configuration is used, JournalNodes handle the storage of metadata writes. The NameNode daemons require a local location to store metadata as well. Cloudera recommends that only a single directory be used if the underlying disks are configured as RAID, or two directories on different disks if the disks are mounted as JBOD.

Block Size

HDFS stores files in blocks that are distributed over the cluster. A block is typically stored contiguously on disk to provide high read throughput. The choice of block size will influence how long these high throughput reads will run for, and over how many nodes a file is distributed. When reading the many blocks of a single file, a too low block size will spend more overall time in slow disk seek, and a too high block size will have reduced parallelism. Data processing that is I/O heavy will benefit from larger block sizes, and data processing that is CPU heavy will benefit from smaller block sizes.

The default provided by Cloudera Manager is 128MB. The block size can also be specified by an HDFS client on a per-file basis.

Replication

Bottlenecks can occur on a small number of nodes when only small subsets of files on HDFS are being heavily accessed. Increasing the replication factor of the files so that their blocks are replicated over more nodes can alleviate this. This is done at the expense of storage capacity on the cluster. This can be set on individual files, or recursively on directories with the -R parameter, by using the Hadoop shell command `hadoop fs -setrep`. By default, the replication factor is three (3).

Erasure Coding

Erasure Coding (EC) is an alternative to the 3x replication scheme. Refer to Data Durability for details on how EC works.

EC reconstruction is nearly free computationally with the Intel ISA-L codec. Performance improvements can be obtained by speeding up the computations through the use of the following instruction sets: AES-NI, SSE, AVX, AVX2, and AVX 512. To determine whether a node has ISA-L instruction sets available, check to see if any of the following CPU flags are present.

```
$ grep flags /proc/cpuinfo
aes
sse
avx
avx2
avx512f
avx512cd
```

It is important that edge nodes and client gateways have codec support so that they can do the calculations.

The use of Erasure Coding levies additional demands on the number of nodes or racks requires to achieve fault tolerance:

- **node-level**: number of DataNodes needs to equal or exceed the data stripe width
- **rack-level**: number of racks needs to equal or exceed the data stripe width

For example, in order for a RS-10-4 policy to be rack-failure tolerant you need at least 14 racks (10 for data blocks, 4 for parity blocks); for host-failure tolerance you'd need at least 14 nodes.

Erasure Coding will observe rack topology, but the resulting block placement policy (BPP) differs from replication. With EC, the BPP tries to place all blocks as evenly on all racks as possible. Cloudera recommends racks have a consistent number of nodes. Racks with fewer DataNodes will be busier and fill faster than racks with more DataNodes.

Warning:

Impala and HBase queries will fail if they attempt to access Erasure Coded data. For more information, consult Data Durability.

Rack Awareness

Hadoop can optimize performance and redundancy when rack awareness is configured for clusters that span across multiple racks, and Cloudera recommends doing so. Rack assignments for nodes can be configured within Cloudera Manager.

When setting up a multi-rack environment, place each master node on a different rack. In the event of a rack failure, the cluster can continue to operate using the remaining master(s).

DataNode Failed Volumes Tolerated

By default, Cloudera Manager sets the HDFS datanode failed volume threshold to half of the data drives in a datanode. In other words, if each datanode has eight drives dedicated to data storage, this threshold would be set to four, meaning that HDFS will mark the datanode dead on the fifth drive failure. This number may need to be adjusted up or down depending on internal policies regarding hard drive replacements, or because of evaluating what behavior is actually seen on the cluster under normal operating conditions. Setting the value too high will end up having a negative impact on the Hadoop cluster. Specifically for YARN, the number of total containers available on the node with many drive failures will still be the same as nodes without drive failures, meaning data locality is less likely on the former, leading to more network traffic and slower performance.

Important:

Multiple drive failures in a short amount of time might be indicative of a larger problem with the machine, such as a failed disk controller.

DataNode Xciever Count

Xcievers are handlers in the datanode process that take care of sending and receiving block data. Some services, such as HBase, tend to use a lot of Xcievers. Cloudera Manager typically configures a sufficient xciever count, but it is possible that some workloads or storage policies like Erasure Coding may require a higher setting.

Balancing

HDFS will try to spread data evenly across the cluster in order to optimize read access, MapReduce performance, and node utilization. Over time it is possible that the cluster can become out of balance due to a variety of reasons. Hadoop can help mitigate this by rebalancing data across the cluster using the balancer tool. Running the balancer is a manual process that can be executed from within Cloudera Manager as well as from the command line. By default, Cloudera Manager configures the balancer to rebalance a datanode when its utilization is 10% more or less from the average utilization across the cluster. Individual datanode utilization can be viewed from within Cloudera Manager.

By default the maximum bandwidth a datanode will use for rebalancing is set to 10 MB/second (80 Mbit/second). This can be increased but network bandwidth used by rebalancing could potentially impact production cluster application performance. Changing the balancer bandwidth setting within Cloudera Manager requires a restart of the HDFS service, however this setting can also be made instantly across all nodes without a configuration change by running the command:

```
hdfs dfsadmin -setBalancerBandwidth <bytes_per_second>
```

This command must be run as an HDFS superuser. This is a convenient way to change the setting without restarting the cluster, but since it is a dynamic change, it does not persist if the cluster is restarted.

> **Important:**
>
> Cloudera generally does not recommend running the balancer on an HBase cluster as it affects data locality for the RegionServers, which can reduce performance. Unfortunately, when HBase and YARN services are collocated and heavy usage is expected on both, there is not a good way to ensure the cluster is optimally balanced.

You can configure HDFS to distribute writes on each DataNode in a manner that balances out available storage among that DataNode's disk volumes.

By default a DataNode writes new block replicas to disk volumes solely on a round-robin basis. You can configure a volume-choosing policy that causes the DataNode to take into account how much space is available on each volume when deciding where to place a new replica.

For more information refer to Configuring Storage Balancing for DataNodes.

YARN

The YARN service manages MapReduce and Spark tasks. Applications run in YARN containers, which use Linux Cgroups for resource management and process isolation. The Cloudera Installation and Upgrade manual has a section on YARN tuning guidance.

Impala

The Impala service is a distributed, MPP database engine for interactive performance SQL queries over large data sets. Impala performs best when it can operate on data in memory; as a result, Impala is often configured with a very large heap size.

Impala daemon processes must be collocated with HDFS data nodes to use HDFS local reads, which also improve performance.

Impala does not provide any built-in load balancing, so a production Impala deployment should sit behind a load balancer for performance and high availability. The Cloudera Impala product documentation contains detailed information on configuring Impala with a load balancer: Using Impala through a Proxy for High Availability.

The Cloudera Impala product documentation also contains a section on Impala performance tuning that should be reviewed prior to a production deployment: Tuning Impala for Performance.

Spark

Cloudera supports Spark on YARN-managed deployments for a more flexible and consistent resource management approach. When running under Spark, the number of executors (YARN containers) can be specified when submitting the job. As of CDH 5.5, dynamic allocation is enabled by default but can be disabled either by setting `spark.dynamicAllocation.enabled=false`. If `--num-executors` is specified in the job, dynamic allocation is disabled implicitly. Additional information on Spark configuration and management is available in the Cloudera Administration manual: Managing Spark.

Spark standalone mode is not supported.

HBase

Automatic Major Compaction

By default major compactions happen every 7 days. The next major compaction happens 7 days after the last one has finished. This means that the actual time that major compaction happens can impact production processes, which is not ideal if it is desired to run compactions at a specific known off-peak hour (e.g., 3 AM). Cloudera strongly recommends disabling automatic major compaction by setting the interval to zero (hbase.hregion.major.compaction = 0). Major compactions should then be run via cron calling the HBase admin tool.

Search

Cloudera Search, based on Apache Solr, provides a distributed search engine service. Search engines are often expected to provide fast, interactive performance so it is important to allocate sufficient RAM to the search service.

If other resource intensive applications, such as Impala, are deployed on the same cluster, it’s important to use the resource management facilities in Cloudera Manager. In some cases, it may also be preferable to avoid collocating the search service with other services.

Oozie

Writing Oozie XML configuration files can be tedious and error-prone. Cloudera recommends using the Oozie editor provided by Hue for workflow creation, scheduling, and execution.

Kafka

Kafka’s default configuration with Cloudera Manager is suited to being able to start development quickly but several settings should be changed from the defaults before deploying a Cloudera Kafka cluster in production.

The default ZooKeeper Kafka root is `/`, however Cloudera recommends changing this to `/kafka`. This is the location within ZooKeeper where the znodes for the Kafka cluster are stored. As long as a single

Kafka cluster is using the ZooKeeper service, using `/kafka` is advised. If multiple Kafka clusters (eg. dev, test, qa) are sharing a ZooKeeper service, each Kafka instance should have a unique ZooKeeper root (eg. `/kafka-dev`, `/kafka-test`, `/kafka-qa`).

Cloudera Manager enables Kafka topic auto-creation by default. This means that any data written to a topic will cause the creation of that topic if it does not already exist. While this may be convenient in prototyping and development, it should not be used in production as it leads to cases where arbitrary topics can be created and data may be written to the wrong topic in the case of an improper application configuration without leading to an error.

Cloudera Manager sets the default minimum number of in sync replicas (ISR) to 1. This should generally be increased to a minimum of 2 in a production cluster to prevent data loss.

The Kafka Maximum Process File Descriptors setting may need to be increased in some cases in production deployments. This value can be monitored in Cloudera Manager and increased if usage requires a larger value than the default 64k ulimit.

The default data retention time for Kafka is often acceptable for production but should be reviewed for use case suitability.

Flume

For Flume agents, use memory channel, file channel, or a Kafka channel. Flume's memory channel offers increased performance at the cost of no data durability guarantees. File channels offer a higher level of durability guarantee because the data is persisted on disk in the form of files. Kafka channels allow you to write to Hadoop directly from Kafka without using a source, to write to Kafka directly from Flume sources without additional buffering, or as a reliable and highly available channel for any source/sink combination

Kudu

Limitations

Current versions of Kudu come with a number of usage limitations:

- Kudu does not currently include any built-in features for backup and restore. Users are encouraged to use tools such as Spark or Impala to export or import tables as necessary.
- Kudu does not currently support rack awareness or rolling restarts.
- Kudu does not currently support multi-row transactions. Operations that affect multiple rows will not roll back if the operation fails part way through. This should be mitigated by exploiting the primary key uniqueness constraint to make operations idempotent

Impala Compatibility

Lower versions of CDH (< 5.10) and Cloudera Manager used an experimental fork of Impala which is referred to as IMPALA_KUDU. If you have previously installed the IMPALA_KUDU service, make sure you remove it from your cluster before you proceed. Install Kudu 1.2.x (or later) using either Cloudera Manager or the command-line.

Partitioning Guidelines

Kudu supports partitioning tables by RANGE and HASH partitions. Note that RANGE and HASH partitions can be combined to create more effective partitioning strategies. It is also possible to utilize non-covering RANGE partitions.

For large tables, such as fact tables, aim for as many tablets as you have cores in the cluster.

For small tables, such as dimension tables, aim for a large enough number of tablets that each tablet is at least 1 GB in size.

Further details can be found in the Apache Kudu Guide.

Note:

In general, be mindful of the number of tablets limits the parallelism of reads, in the current implementation. Increasing the number of tablets significantly beyond the number of cores is likely to have diminishing returns.

Security Integration

The Cloudera Security guide is intended for system administrators who want to secure a cluster using data encryption, user authentication, and authorization techniques.

It provides conceptual overviews and how-to information about setting up various Hadoop components for optimal security, including how to setup a gateway to restrict access. The guide assumes that you have basic knowledge of Linux and systems administration practices, in general.

Common Questions

Multiple Data Centers

Cloudera EDH deployments are restricted to data centers within a geographic region. Single clusters spanning large geographic regions are not supported. Refer to Appendix A: Spanning Multiple Data Centers for more information.

Operating Systems

A list of supported operating systems for CDH and Cloudera Manager can be found here.

Storage Options and Configuration

The HDFS data directories should use local storage, which provides all the benefits of keeping compute resources close to the storage and not reading remotely over the network.

The root device size for Cloudera Enterprise clusters should be at least 500 GB to allow parcels and logs to be stored.

To guard against data center failures, you can set up a scheduled distcp operation to persist data to AWS S3 (see the examples in the distcp documentation) or leverage Cloudera Manager's Backup and Data Recovery (BDR) features to backup data to another running cluster.

Relational Databases

Cloudera Enterprise deployments require relational databases for the following components: Cloudera Manager, Cloudera Navigator, Hive metastore, Hue, Sentry, Oozie, and others. The database credentials are required during Cloudera Enterprise installation.

Refer to Cloudera Manager and Managed Service Datastores for more information.

Important:

The embedded PostgreSQL database is not supported for use in production systems.

Appendix A: Spanning Multiple Data Centers

Spanning a CDH cluster across multiple data centers can provide highly available services and further protect data against host, rack, and data center failures.

We recommend the following deployment methodology when spanning a CDH cluster across multiple data centers.

Networking Requirements

Deploying across multiple data centers can introduce new challenges. Network throughput -- all but guaranteed on local networks -- becomes a more limited and often more expensive commodity. Similarly, cross-site links are subject to higher and variable latency as network traffic travels greater distances.

Consult the Network Specification earlier in this document. The deployment topology remains the same, except that the network core will span numerous data centers and be connected by WAN links. We recommend 10 Gbps switches with sufficient port density to accommodate cross-site links. Redundant links connecting each site are highly recommended.

Network throughput between sites will depend on how many nodes you have at each data center. Oversubscription ratios up to 4:1 are generally fine for balanced workloads, but network monitoring is needed to ensure uplink bandwidth is not the bottleneck for Hadoop.

Network latency between sites should not exceed 10ms.

Provisioning

Provision hosts within different data centers, each data center with a dedicated subnet. In this way the entire cluster can exist within a handful of subnets and cross-site security ACLs can be more easily managed to permit traffic to and from each data center.

Deploy across three (3) data centers within a single geographical region. This might not be possible within your preferred region due to availability or network requirements.

Note: Network latency tends to be higher and less predictable across geographic regions. We do not recommend or support spanning clusters across geographic regions.

CDH Deployment

Deploy HDFS NameNode in High Availability mode with Quorum Journal nodes, with each master placed in a different data center. For example, if you've deployed the primary NameNode to a datacenter in Virginia you might deploy your standby NameNode to a data center in Maryland or Pennsylvania. You should place a QJN in each data center.

Although HDFS currently supports only two NameNodes, the cluster can continue to operate if any one host, rack, or data center fails:

- lose active NameNode, standby NameNode takes over

- lose standby NameNode, active is still active; promote 3rd data center master to be new standby NameNode
- lose data center without any NameNode, still have two viable NameNodes

Deploy YARN ResourceManager nodes in a similar fashion.

Deploy a three node ZooKeeper quorum, one located in each data center.

Deploy edge nodes to all three data centers and configure client application access to all three.

Configure rack awareness, one rack per data center. For example, your rack IDs might look like this:

- /va-ashburn
- /va-herndon
- /va-sterling

If you are using Erasure Coding, you must have a consistent number of DataNodes in each data center. The requirements for rack-level tolerance also apply, meaning you need to have a number of data centers equal to or exceeding data width of the RS policy.

Considerations

There may be data transfer costs associated with host network data sent between data centers, not limited to setup fees, monthly charges, ongoing costs for personnel and maintenance, and hardware refresh.

DFS throughput will be less than if cluster nodes were provisioned within a single data center.

Network throughput and latency can vary based on WAN link. Network throughput and latency ought to be verified for suitability before deploying to production and routinely throughout the life of the project.

References

Cloudera Enterprise

Product Documentation

- Hardware Requirements Guide
- Requirements and Supported Versions
- Security Guide

Cloudera Services & Support

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