Lenovo Reference Architecture: Cloudian HyperStore

Last update: **30 November 2015**

Provides a highly scalable multi-tenant storage system

Can be used to build a public or private cloud

Supports multiple datacenters and regions.

100% compliant with Amazon S3 API

Mike Perks [Lenovo]

Phillip Tribble [Cloudian]

Table of Contents

1 Introduction

This document describes a reference architecture for Cloudian HyperStore and is a result of a collaboration between Lenovo and Cloudian.

1.1 Executive summary

With the massive growth of data from the Internet of Things (IOT) to collaboration to compliance, users are demanding low-cost, flexible, easy to scale, and simple to manage data center storage solutions. Software-defined object storage delivers on these demands by capitalizing on industry standard x86 infrastructure and storage technologies to deploy more economic and manageable storage solutions compared to legacy storage architectures.

Cloudian HyperStore is an example of the new breed of software-designed storage. Cloudian HyperStore allows companies to build their own public or private cloud storage infrastructure including enterprise IT organizations, cloud service providers, or cloud hosting providers. The decision to use cloud storage for the delivery of IT services is best made by starting with the knowledge and experience that is gained from previous work. This document gathers the essential information about a scale-out storage reference architecture and a real-world example from the Cloudian support organization that uses the Cloudian HyperStore® appliances that are powered by Lenovo hardware.

Enterprise and managed solution providers who are looking to deploy enterprise file sync and share software can use Cloudian HyperStore object storage to store and access user files from any location and any device of their choice. Cloudian HyperStore® also provides a central trusted backup and file share repository and sharing server for regional offices. Enterprises can now run Hadoop analytics directly on HyperStore software and appliances. This in-place analytics enables customers to derive meaningful business intelligence from their data quickly, efficiently, and economically.

Cloudian HyperStore provides administrators with the ability to deploy data in different data centers or geographically separated regions. HyperStore also connects different clouds with the ability to tier data to Amazon S3, Amazon Glacier, or another HyperStore deployment. With multi-tenant support, an organization can provide storage for multiple departments or groups of users without the need to deploy additional infrastructure. Cloudian HyperStore also includes necessary features such as multi-currency rating plans, billing, quality of service metrics, enforcement, and an API that allows service providers to integrate Cloudian into their own portal.

The combination of Cloudian HyperStore and Lenovo world-class hardware provides a unique 100% S3 compliant multi-device cloud storage platform with which any level of SLA can be met at the right cost with dynamic migrations from one storage tier to another. The solution meets the needs of any enterprise willing to adapt their storage cost to the value of their data as well as service providers targeting to market multi-SLA storage services for their customers.

1.2 Audience

The intended audience of this document is IT professionals, technical architects, sales engineers, and consultants to assist in planning, designing, and implementing the Cloudian HyperStore software on Lenovo hardware. This paper also assumes that the reader has basic knowledge of cloud storage infrastructure components and services.

2 Business problem and business value

This section provides a summary of the business problems that this reference architecture is intended to help address, and the additional value that this solution provides for storing large amounts of data.

2.1 Business problem

An organization's data continues to grow each year. According to analysts (such as the IDC), data is doubling in size every two years (see Figure 1). The yearly storage increase creates a need for large capacity storage. It is crucial to have a storage solution ready to scale to the needs of its users.

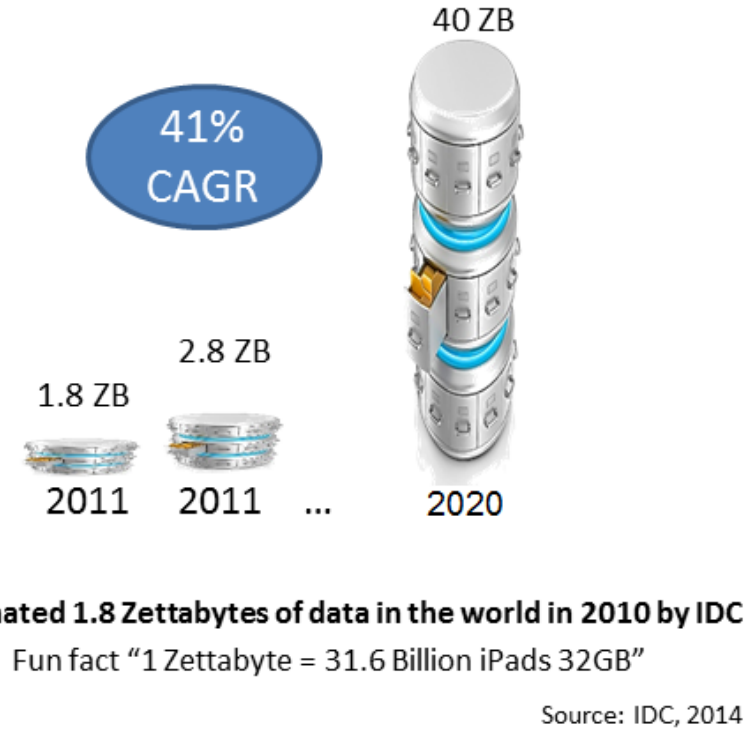

Figure 1. Predicted data growth

This solution features wide ranging applicability and is particularly strong for the following use cases:

- Backup and archival for big data

  As electronic data has exploded, backup windows have shrunk. Despite this new era of big data, IT and backup administrators are asked to use antiquated methods to manage new world demands. As a result, IT and backup administrators are spending an inordinate amount of time and budget managing onsite and offsite backups and reactively dealing with data recoveries as a fire drill. Working with backup software partners,.

- Smart data analytics

  Today's smart businesses are looking at ever increasing use of data analytics to derive business value and provide a better customer experience.

- Remote Office Backup

  Many Enterprises today are geographically dispersed and have many remote offices. These remote offices must share and collaborate on content and the data must be protected and backed up. Enterprises want to enhance sharing across these remote locations, protect and secure the business data, and do this with central IT administration and control.

- Enterprise file synchronization and sharing

  With the proliferation of mobile devices and the digitization of content, there is a need for new solutions to enhance collaboration between users in Enterprises. Traditional NAS/SAN infrastructures do not support mobile devices well and do not support the distributed nature of the content.

- Private and hybrid cloud storage

  Modern Enterprises are evolving their IT organizations into service-driven IT that implement services on demand, such as the Public Cloud. Organizations are implementing S3 Private Clouds, Cloud Platforms (such as CloudStack and OpenStack) to implement this Private Cloud environments.

- Service Provider-as-a-Service

  Traditionally, service providers used storage technologies (specifically, Network Attached Storage [NAS] and Storage Area Networks [SAN]) to offer storage-as-a-service. However, these traditional storage technologies are better suited for small enterprise deployments and do not properly scale to handle large cloud deployments.

2.2 Business value

To solve this massive growth of data storage problem, organizations are looking for new approaches to storage. These modern solutions typically have the following key features:

- Scale out architecture
- Low-cost commodity hardware
- Hybrid Cloud Tiering
- S3 compatible
- Multiple data centers
- Multi-tenancy

In addition, many data center administrators need the ease of deploying a “turn-key” storage offering to scale out their storage infrastructure. For these organizations, there is value to implementing pre-certified storage appliances that take the guess work out of configuring the right server and storage combinations. Rapid deployment and risk mitigation are key benefits for these enterprises, especially because their IT staffs are stretched too thin. A turn-key system helps to speed up deployment times and mitigate the risk of application downtime or performance problems that can occur from misconfigured systems. Another benefit is that it gives the IT organization a single vendor to support the entire hardware and software stack

3 Requirements

This section describes the functional and non-functional requirements for this solution.

3.1 Functional requirements

Table 1 lists the functional requirements for an Enterprise cloud object store.

Table 1: Functional Requirements

Requirement	Description
Multi-tenancy	Provide storage for different customers, groups, or organizations
Quality of Service (QoS)	Set QoS settings for groups, tenants, user, or entire system
Multi-region and data center	Store data in geographically dispersed regions or data centers
Billing and reporting	Generate bills for users and integrate into external billing systems
Encryption	Server-side encryption of files
Monitoring	JMX and SNMP charge back reports
Access Control Lists (ACL)	Set ACL's for a bucket or object
Bucket protection	Choose different protection levels, such as replication or erasure code

3.2 Non-functional requirements

Table 2 lists the non-functional requirements for an Enterprise cloud object store.

Table 2: Non-functional Requirements

Requirement	Description
Scalability	Solution components scale for growth
Load balancing	Workload is distributed evenly across servers
Fault tolerance	Single component error does not lead to whole system unavailability
Physical footprint	Compact solution
Ease of installation	Reduced complexity for solution deployment
Ease of management/operations	Reduced complexity for solution management
Flexibility	Solution supports variable deployment methodologies
Security	Solution provides means to secure customer infrastructure
Power efficient	Uses low-power CPU's and power efficient drives with large capacities

4 Architectural overview

This section presents an architectural overview of the Cloudian HyperStore solution and compatibility with the Amazon S3 API.

4.1 Cloudian HyperStore architecture

Cloudian HyperStore® software uses a fully distributed and replicated peer-to-peer architecture with no single point of failure. It easily scales horizontally by using commodity hardware so deployments can start with a few servers in a single data center and then scale out as usage increases to thousands of servers that are distributed across multiple data centers that are managing hundreds of petabytes of data. Its distributed architecture with automatic replication and recovery services makes it highly resilient to network and node failures without data loss. Similarly, when scaling the storage cluster or performing maintenance, changes in node availability are automatically detected without service interruption. Figure 2 shows an overview of Cloudian HyperStore that uses Lenovo servers.

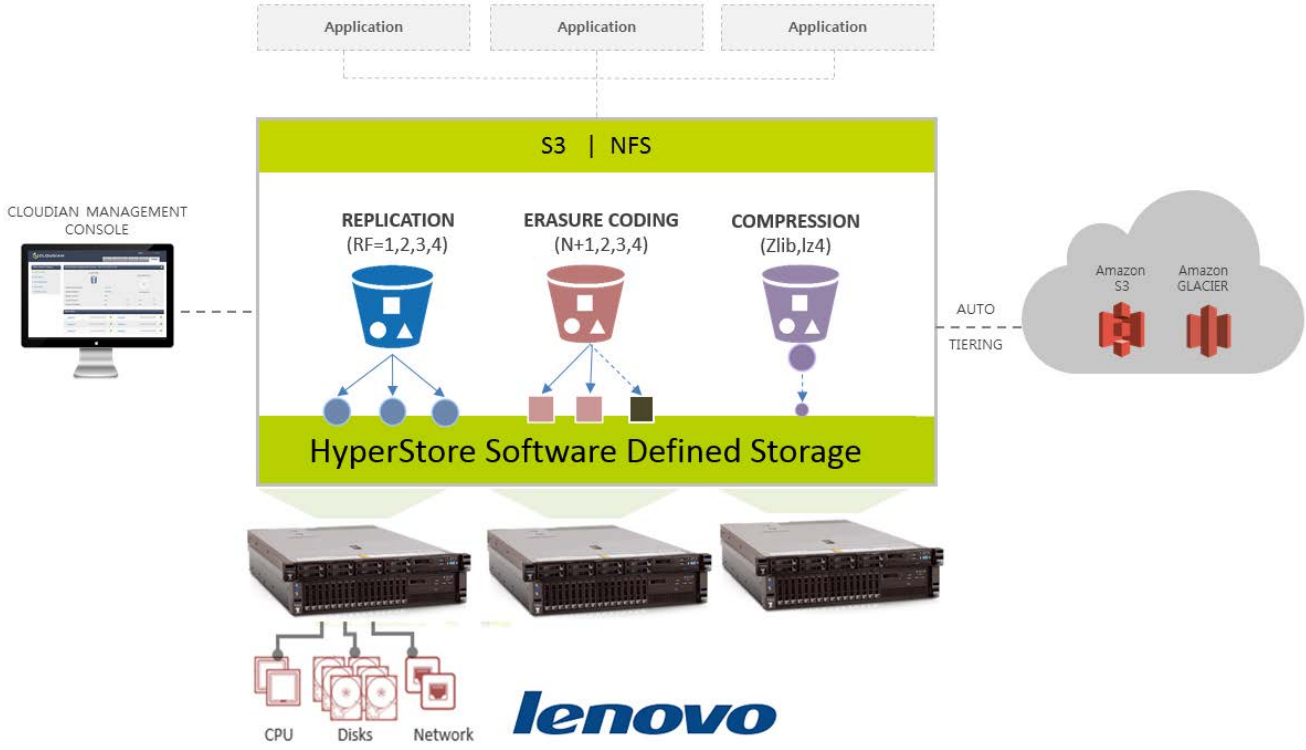

Figure 2. Cloudian HyperStore and Lenovo architecture

Cloudian HyperStore data can be stored in erasure code or a replicated format. Replication results in greater performance, but less storage capacity. Erasure code provides the most cost-effective way to store data because the data is stored in smaller chunks across the cluster. However, erasure code requires more system resources, which leads to greater latency on storage requests. Replication uses the most storage space because by default the replication factor is 3, which means that the object is copied to three different nodes.

Cloudian HyperStore supports multiple compression algorithms that compresses objects on the storage side to save space. Choosing the right storage type depends on your storage size and needs. If the media content stored on the cluster is meant for archiving and not accessed frequently, erasure code is the best choice. If the media content requires the greatest performance and replication size is not a factor, replication is the best choice.

4.2 S3 API compatibility

Amazon S3 commands twice the market share of all its closest competitors combined and it likely is the storage platform of choice for on-premise hybrid or private cloud deployments. Companies and developers that are implementing applications with the Amazon S3 API depend significantly on its compatibility from service providers to ensure that their applications remain compatible and function. With no standards enforced for claiming S3 compatibility, choosing the right storage platform can be tenuous.

The Cloudian storage platform offers 100% advanced compatibility and allows developers continued use of Amazon's S3 SDK (Software Development Kit). By supporting native S3 API calls, developers can significantly ease their workloads by not changing SDK's or API's. Also, Cloudian can automatically tier data between on-premise cloud deployments and Amazon's S3 public cloud while representing the cloud ecosystem under a single name space. With this advanced functionality, Cloudian provides a compatible storage platform for S3 on-premise and hybrid cloud deployments.

Figure 3 shows a comparison of Cloudian HyperStore and Amazon S3 object storage.

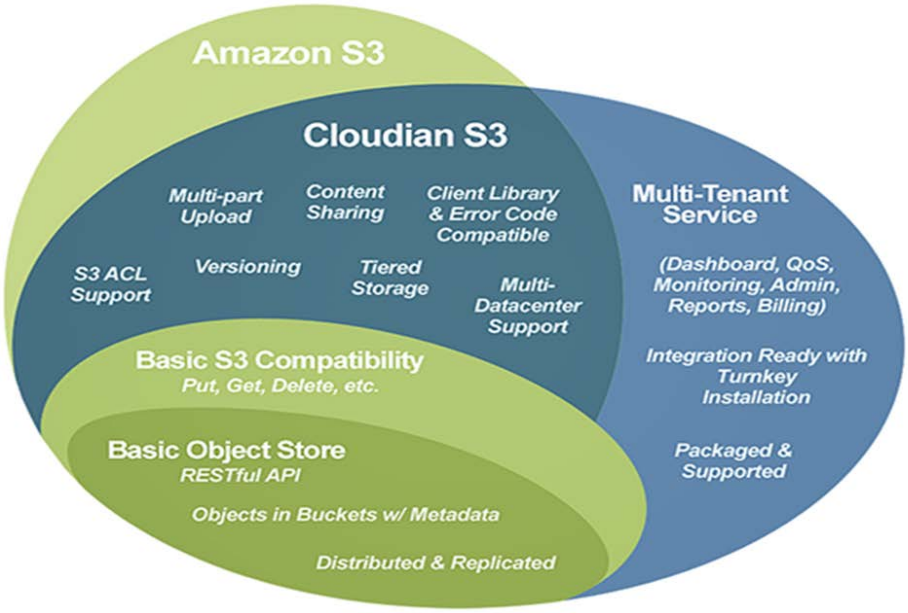

Figure 3. Cloudian HyperStore S3 environment

5 Component model

Cloudian HyperStore offers flexibility with the software installer to provide the best source of flexibility for an environment. There are standard components, such as the S3 server, HyperStore server, Cloudian Management Console, Cassandra, Redis, and Puppet that make up and define the Cloudian HyperStore architecture, as shown in Figure 4. This section describes each component that is needed for the installation and data architecture.

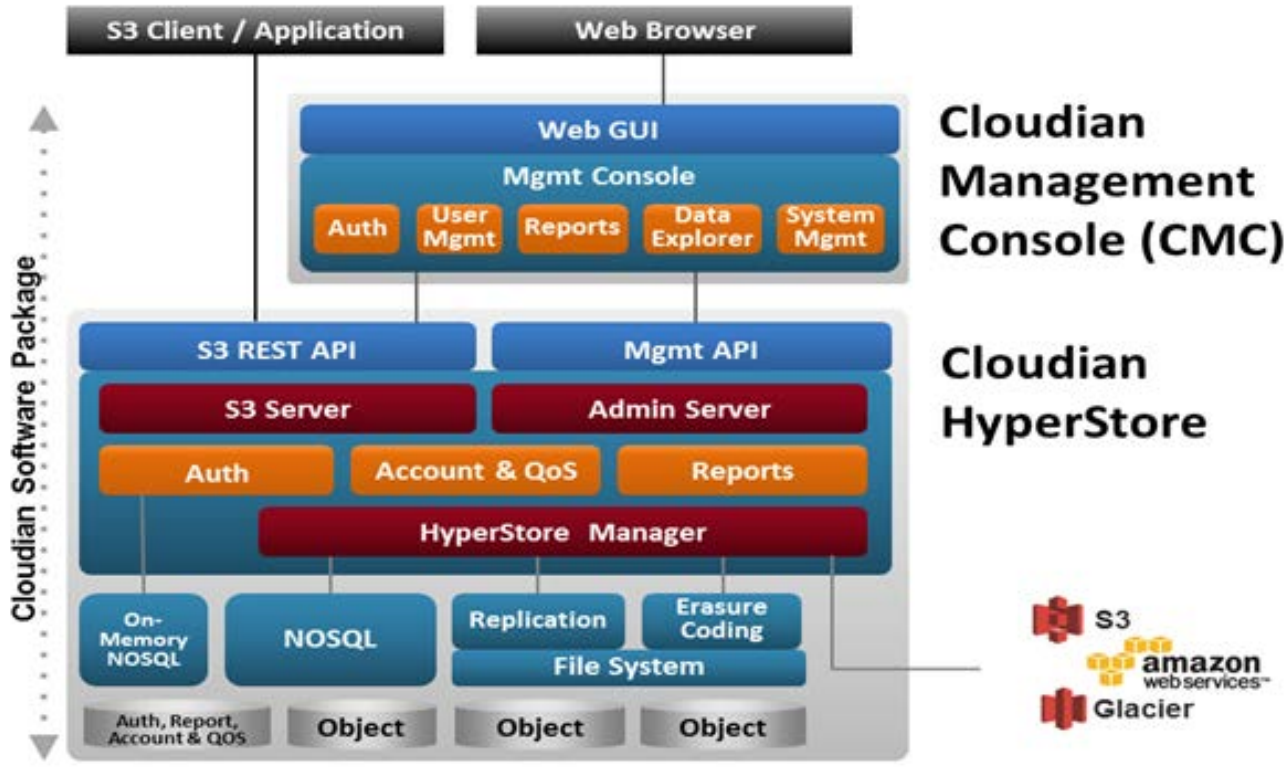

Figure 4. The Cloudian HyperStore component model

Cloudian HyperStore features the following main components:

Cloudian Management Console (CMC)	The CMC is a web-based interface for Cloudian HyperStore system administrators, group administrators, and users. From the console, administrators can manage users, generate usage reports and bills, view data that is stored on the system, and access system management functions. The system management functions allow administrators to setup log alerts and email notifications, view the storage utilization on the cluster or individually on the nodes, and view the status of the HyperStore services. In addition, node management offers the ability to add or remove a node, perform data consistency checks on the nodes, and view meta data information for objects.

S3 Service	The HyperStore system provides a high-performance S3 proxy service. The S3 Service processes S3 REST requests incoming from client. The S3 service handles the initial login request from the S3 client with the access and secret key. After logging in, Account and QoS settings are checked for each request. For example, if there is a QoS rule for a user to have a maximum of 100 MB storage and the user tries to upload 200 MB, the request is unsuccessful. The S3 daemon also contains the Admin service that extends the S3 API by allowing administrators to manage users and groups, S3 credentials, billing, and generate usage reports.
HyperStore service	As an object store, Cassandra provides a wealth of valuable built-in functionality including data partitioning, automatic replication, easy cluster expansion, quorum calculation, and so on. After the S3 service honors the request, HyperStore must access and manage the data. For example, a PUT object request comes to the S3 service and then a request is sent to HyperStore to store the data. Depending on the storage protection type, files might be stored in erasure code, Cassandra file system, or replication.
NoSQL	The HyperStore system uses the open source storage platform Cassandra to store several types of data, including object meta data, user information, and accounting information. S3 client applications do not access Cassandra databases directly; all S3 access is mediated through the S3 Service. The HyperStore Service and Admin Service also access Cassandra.
Redis	The HyperStore system uses the lightweight, open source Redis key-value data store to store various data that supports HyperStore S3 service features. The Redis Credentials DB stores user credentials and other S3 operation supporting data, such as multi-part upload session information and public URL access counters. The Redis QoS DB stores user-level and group-level Quality of Service settings that were established by system administrators. The DB is also used to keep count of user requests so that Quality of Service limits can be enforced by the system.

6 Operational model

This section describes the Cloudian HyperStore operational model that was verified with Lenovo hardware and software. It concludes with some example deployment models.

6.1 Hardware components

The Cloudian HyperStore software was validated to run on the Lenovo servers and Lenovo RackSwitch network switches.

6.1.1 Storage servers

Cloudian HyperStore can be used on Lenovo System x3650 M5 or ThinkServer 650 servers with the RHEL 6.x or CentOS 6.x operating systems.

Lenovo System x3650 M5

The Lenovo System x3650 M5 server (as shown in Figure 5) is an enterprise class 2U two-socket versatile server that incorporates outstanding reliability, availability, and serviceability (RAS), security, and high efficiency for business-critical applications and cloud deployments. It offers a flexible, scalable design and simple upgrade path to 14 3.5-inch hard disk drives (HDDs), with doubled data transfer rate via 12 Gbps serial-attached SCSI (SAS) internal storage connectivity and up to 1.5TB of TruDDR4 Memory. Its onboard Ethernet solution provides four standard embedded Gigabit Ethernet ports and two optional embedded 10 Gigabit Ethernet ports without occupying PCIe slots.

Figure 5. Lenovo x3650 M5

Combined with the Intel® Xeon® processor E5-2600 v3 product family, the Lenovo x3650 M5 server offers a high density of workloads and performance targeted to lower the total cost of ownership (TCO) per virtual machine. Its flexible, pay-as-you-grow design and great expansion capabilities solidify dependability for any kind of virtualized workload, with minimal downtime.

The Lenovo x3650 M5 server provides internal storage density of up to 84 TB (with up to 14 x 3.5-inch drives) in a 2U form factor with its impressive array of workload-optimized storage configurations. The x3650 M5 offers easy management and saves floor space and power consumption for the most demanding storage virtualization use cases by consolidating the storage and server into one system.

For more information, see the following websites:

- System x3650 M5 – Overview
- System x3650 M5 Product Guide

Lenovo ThinkServer RD650

The Lenovo® ThinkServer® RD650 (as shown in Figure 6) is a 2U, two-socket storage-rich server that provides up to 74 TB of storage capacity. It features a Lenovo AnyBay® design that allows a unique hybrid option with nine 3.5-inch and six 2.5-inch front-access drive bays in the front and two 2.5-inch drive bays in the back and the standard 3.5-inch and 2.5-inch HDD chassis, which is ideal for creating a tiered storage environment. The RD650 provides Lenovo AnyRAID® technology, which is a mid-plane RAID adapter design that connects directly to the drive backplane without the use of a PCIe slot. SD card options are available to enable flexible boot-drive choices.

Figure 6. Lenovo ThinkServer RD650

For more information, see the Lenovo ThinkServer RD650 Product Guide.

6.1.2 Network switches

Cloudian HyperStore can be used with the Lenovo RackSwitch network switches that are described in this section.

Lenovo RackSwitch G8124E

The Lenovo RackSwitch G8124E (as shown in Figure 7) delivers exceptional performance that is lossless and low-latency. It also provides high availability and reliability with redundant power supplies and fans as standard. In addition, RackSwitch G8124E delivers excellent cost savings and a feature-rich design redgarding virtualization, Converged Enhanced Ethernet (CEE)/Fibre Channel over Ethernet (FCoE), Internet Small Computer System Interface (iSCSI), and enterprise-class Layer 2 and Layer 3 functionality.

With support for 10 Gb, this 24-port switch is designed for clients who are using 10 Gb Ethernet or plan to do so. The G8124E is designed to support Lenovo Virtual Fabric, which provides the ability to dynamically allocate bandwidth per virtual network interface card (vNIC) in increments of 100 MB, while adjusting over time without downtime.

Figure 7. Lenovo RackSwitch G8124E

For more information, see the RackSwitch G8124E Product Guide.

Lenovo RackSwitch G8264

Designed with top performance in mind, Lenovo RackSwitch G8264 (as shown in Figure 8) is ideal for today's

big data, cloud, and optimized workloads. The G8264 switch offers up to 64 10 Gb SFP+ ports in a 1U form factor and allows for future expansion with four 40 Gb QSFP+ ports. It is an enterprise-class and full-featured data center switch that delivers line-rate, high-bandwidth switching, filtering, and traffic queuing without delaying data. Large data center grade buffers keep traffic moving. Redundant power and fans and numerous high-availability features equip the switches for business-sensitive traffic.

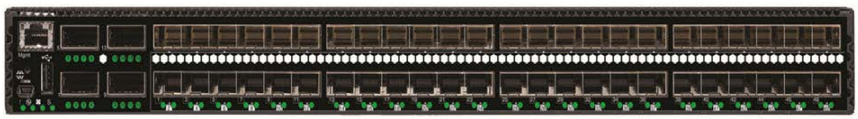

Figure 8. Lenovo RackSwitch G8264

The G8264 switch is ideal for latency-sensitive applications, such as client virtualization. It supports Virtual Fabric to help clients reduce the number of I/O adapters to a single dual-port 10 Gb adapter, which helps reduce cost and complexity. The G8264 switch supports the newest protocols, including Data Center Bridging/Converged Enhanced Ethernet (DCB/CEE) for support of FCoE, iSCSI, and NAS.

For more information, see the RackSwitch G8264 Product Guide.

Lenovo RackSwitch G7028

The Lenovo RackSwitch G7028 (as shown in Figure 9) is a 1 Gb top-of-rack switch that delivers line-rate Layer 2 performance at an attractive price. G7028 has 24 10/100/1000BASE-T RJ45 ports and four 10 Gb Ethernet SFP+ ports. It typically uses only 45 W of power, which improves energy efficiency.

Figure 9. Lenovo RackSwitch G7028

For more information, see the RackSwitch G7028 Product Guide.

Lenovo RackSwitch G8052

The Lenovo System Networking RackSwitch G8052 (as shown in Figure 10) is an Ethernet switch that is designed for the data center and provides a virtualized, cooler, and simpler network solution. The Lenovo RackSwitch G8052 offers up to 48 1 GbE ports and up to four 10 GbE ports in a 1U footprint.

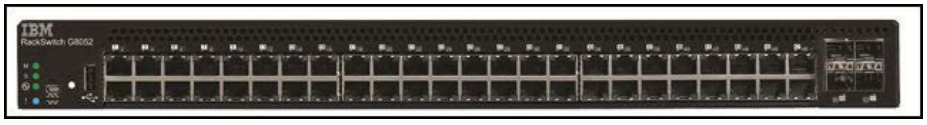

Figure 10. Lenovo RackSwitch G8052

For more information, see the RackSwitch G8052 Product Guide.

6.2 Storage servers

This section describes the hardware configuration and capacity planning examples for a typical HyperStore deployment on Lenovo servers. Table 3 lists the default configuration for the storage servers.

Table 3: Default Hardware Configuration for Lenovo ThinkServer RD650 and System x3650 servers

	ThinkServer RD650	**System x3650 M5**
Drives	12 x 4 TB or 12 x 6 TB	12 x 4 TB or 12 x 6 TB
Storage Capacity	48 TB or 72 TB	48 TB or 72 TB
Flash Optimized	Yes. 2 x 300 GB SSD	Yes. 2 x 400 GB SSD
Data Protection	Replication and erasure coding	
Protocol Support	S3, NFS	
Network Interface	10 GbE dual port NIC	10 GbE dual port NIC
Form Factor	2U	2U
CPU	Intel Xeon E5-2600 v3 Series	Intel Xeon E5-2600 v3 Series
Memory	64 GB	64 GB
Monitoring/Management	CLI, GUI, API, IPMI, JMX	

6.2.1 Storage server capacity planning

Cloudian HyperStore supports data replication and erasure coding, which have their optimal use cases. It is important to choose optimal protection approach for your data. The most important trade-off is the capacity efficiency that is given by data replication versus the reduced I/O latency that is given by erasure coding.

For data replication, the minimum number of servers is three. To estimate how much usable data is available in the cluster when replication is used, take the total raw capacity of the disks in the HyperStore cluster and divide by three.

Table 4 lists the number of servers that are required, assuming 12 x 6TB drives in each server.

Table 4: HyperStore Replication sizing

Usable Data	72TB	144 TB	216 TB	360 TB
Servers Required	3	6	9	12

For erasure coding, the default number of server is six: four servers for data fragments and two servers for redundant data fragments. To estimate the total usable space for erasure code, take the total raw capacity of the disks in the HyperStore cluster and divide by the sum of the data and redundant fragments that is specified in the erasure code configuration. Table 5 lists the number of servers required assuming 12 x 6TB drives in each server.

Table 5: HyperStore Erasure coding sizing

Usable Data	72TB	144 TB	216 TB	360 TB
Servers Required	6	6	6	10

6.3 Networking

This section describes the networking topology and includes design guidance to correctly configure the network environment for redundancy and failover.

This reference architecture uses two 24-port ultra low-latency, high-performance Lenovo RackSwitch G8124 10 GbE network switches to provide primary data communication services. If more ports are required, the 64-port Lenovo RackSwitch G8264 switch can be used. The management interface on the compute nodes can also be connected to one of the two switches or the management interface can connect to an extra 1 GbE switch, such as the Lenovo RackSwitch G7028.

High availability and failover in the network architecture is achieved by using Inter-Switch Link (ISL), Link Aggregation Control Protocol (LACP), and Virtual Link Aggregation Groups (vLAGs). The recommended vLAG/LACP configuration is shown in Figure 11.

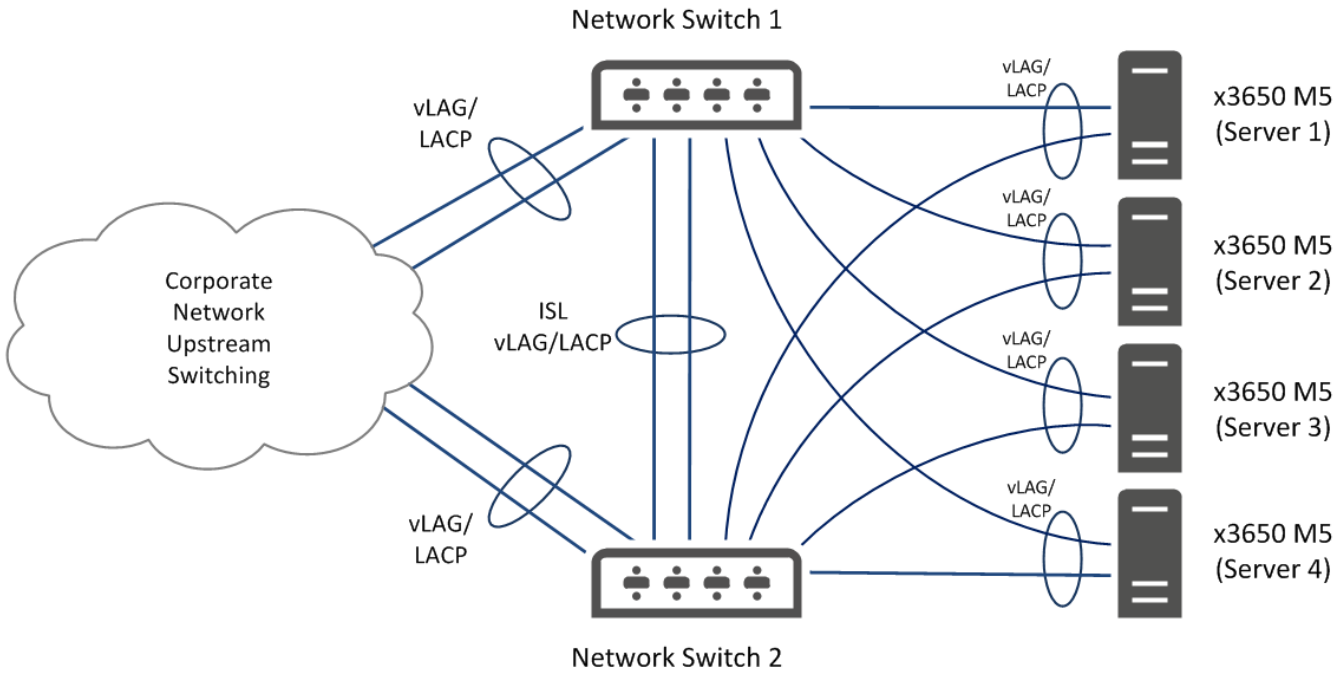

Figure 11. LACP/vLAG recommended network design

An ISL is a physical network connection from a physical network port on one switch to a physical network port on another switch that enables communication between the two switches. This reference architecture uses two physical connections between the two networking switches, which are link aggregated.

Link Aggregation Control Protocol (LACP) is an IEEE 802.3ad standard for grouping several physical ports into one logical port (which is known as a *dynamic trunk group*). If a link in a LACP trunk group fails, traffic is reassigned dynamically to the remaining links of the dynamic trunk group.

LACP teams are formed on the ISLs between the switches and on the host connections to the switches, which provides for host connection redundancy. To maintain maximum bandwidth over the multiple connections, vLAGs also are configured on the LACP teams. Disabling Spanning Tree on the LACP teams helps avoid the wasted bandwidth that is associated with links that are blocked by spanning trees.

By using VLAGs, the redundant uplinks remain active and use all available bandwidth. To maintain maximum bandwidth over the multiple connections, vLAG is enabled on the LACP teams in this reference architecture.

At the operating system level, the NIC ports are bonded together to provide high availability and failover for the Cloudian HyperStore.

6.4 Data architecture

Each HyperStore software implementation starts with three or more distributed nodes and then objects are replicated or erasure coded across the available nodes for data durability and availability. Administrators can configure the number of replicas or erasure code strategy required to meet SLA and cost objectives, including the option to replicate copies to other data centers for geo redundancy. Reads and writes are always performed at the local data center with remote replication performed in the background to avoid latency of remote writes.

Figure 12 shows an example of a Cloudian cluster that is distributed and elastic across Geos.

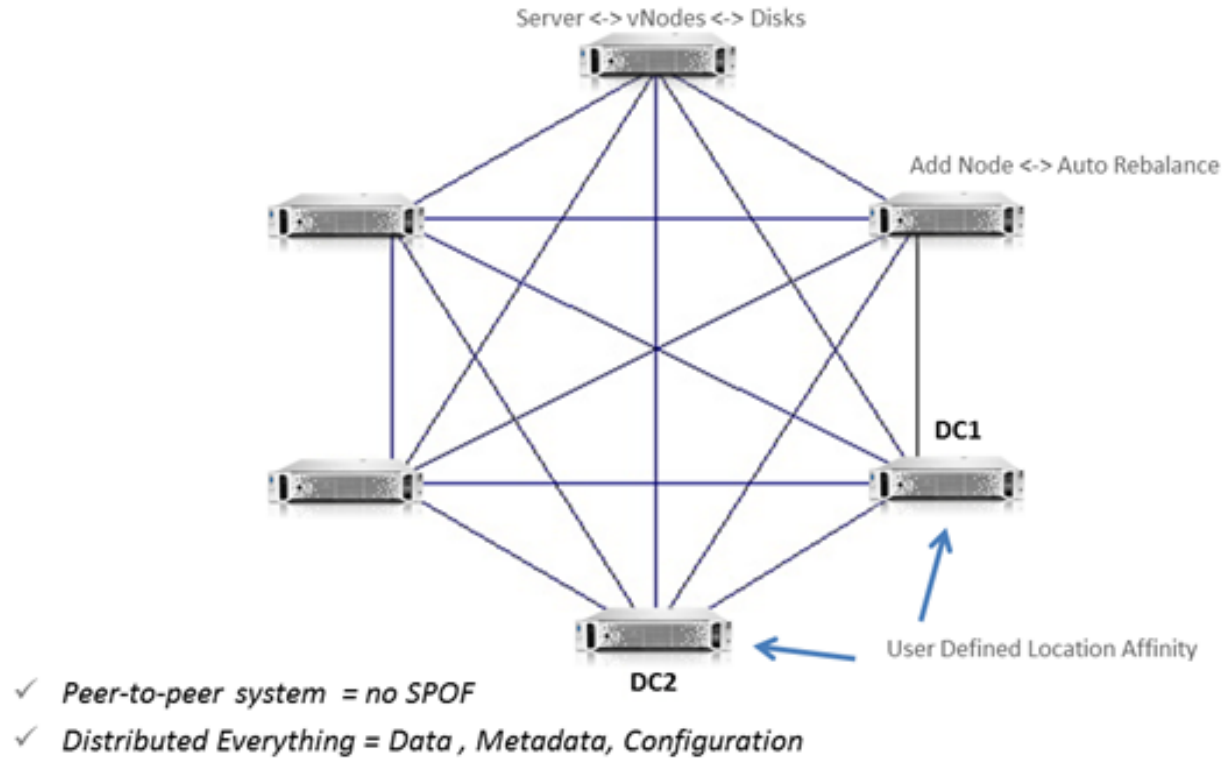

Figure 12. HyperStore data architecture

7 Deployment considerations

This section describes several considerations, such as high availability, Server/CMC nodes, load balancers, and backup, and tiering to different cloud infrastructures.

7.1 High availability

The Lenovo solution with Cloudian HyperStore contains high availability attributes. By default, every node includes the core services installed and running, such as Cassandra, Redis, HyperStore, S3, and the Cloudian Management Console. Redis services are installed in a master and slave and can fail over to another node if a failure is detected. For example, a deployment of six nodes can tolerate up to two node failures if the default read and write consistency level of quorum is met.

7.2 Cloudian Management Console

The Cloudian Management Console (CMC) can be installed independently on a separate node in the cluster that is running core services, such as Cassandra, S3, HyperStore, and Redis. The CMC also can work in a load balancer configuration for high-availability and to scale performance. Alternatively, the CMC can be run on a less powerful server separate from the data nodes.

7.3 Load balancers

The Cloudian HyperStore software works with most load balancers that are available on the market. Services that are available for load balancing are: S3, Admin, and the CMC.

7.4 Backup

By using third-party applications, data that is stored in Cloudian HyperStore can be backed up to other storage mechanisms, such as tape, another Cloudian HyperStore deployment, or other cloud storage providers.

7.5 Tiering

Cloudian HyperStore allows users to transition objects on a per-bucket level basis to Amazon S3, Amazon Glacier, or another Cloudian HyperStore cluster.

7.6 Multi-tenancy

Multi-tenant support enables service providers to offer storage to multiple customers. System administrators can isolate different customers or departments of an organization into separate groups on a single HyperStore cluster. Each tenant can have group administrators to manage administration tasks such as adding or removing authorized users, maintaining and implementing quality of service settings, and creating usage reports.

8 Appendix: Bill of Materials

This appendix contains the Bill of Materials (BOMs) for different configurations of hardware for Cloudian HyperStore deployments. There are sections for storage servers and networking.

8.1 BOM for storage servers

Below is the bill of materials for a single Lenovo System x3650 M5 storage server.

Part #	Description	Quantity
5462D4x	Lenovo System x3650 M5, Xeon 8C E5-2630v3 85W 2.4GHz/1866MHz/20MB, 1x16GB, O/Bay HS 3.5in SATA/SAS, SR M5210, 750W p/s, Rack	1
00FK643	Intel Xeon Processor E5-2630 v3 8C 2.4GHz 20MB Cache 1866MHz 85W	1
46W0796	16 GB TruDDR4 Memory (2Rx4, 1.2V) PC3-17000 CL152133MHz LP RDIMM	3
00FN173	6TB 7.2K 6Gbps NL SATA 3.5in G2HS 512e HDD	12
00FK658	System x3650 M5 Rear 2x 2.5in HDD Kit	1
46C9114	ServeRAID M1215 SAS/SATA Controller	1
00YC325	S3710 400GB Enterprise Performance SATA G3HS 2.5in SSD	2
00KA498	System x3650 M5 PCIe Riser (2 x8 FH/FL + 1 x8 FH/HL Slots)	1
00JY820	Emulex VFA5 2x10 GbE SFP+ PCIe Adapter	1
90Y9430	3m Passive DAC SFP+ Cable	2
00FK932	System x 750W High Efficiency Platinum AC Power Supply	1
90Y3901	Integrated Management Module Advanced Upgrade	1
00FK622	System x Enterprise 2U Cable Management Arm (CMA)	1

Below is the bill of materials for a single Lenovo ThinkServer RD650 storage server.

Part #	Description	Quantity
70D00025UX	ThinkServer RD650: 2U Rack Server - 1 x Intel Xeon E5-2630 v3 2.40 GHz – 1X8 GB memory, 12Gb/s SAS 720ix AnyRAID controller, 1100W p/s	1
4X20F28577	ThinkServer Gen 5 1100W Platinum Hot Swap Power Supply	1
4XG0F28818	ThinkServer RD650 Intel Xeon E5-2630 v3 (8C, 85W, 2.4GHz) Processor	1
4X70F28589	ThinkServer 8GB DDR4-2133MHz (1Rx4) RDIMM	7
4XB0G88731	ThinkServer Gen 5 3.5" 4TB 7.2K Enterprise SAS 12Gbps HS HDD	12
4XC0F28742	Intel X520-DA2 AnyFabric 10Gb 2 Port SFP+ Ethernet Adapter	1
4XB0G45738	ThinkServer Gen 5 2.5" 300GB Value Read-Optimized SATA 6Gbps HS SSD	2
4XF0G45877	ThinkServer Gen 5 2.5" 2-Drive Rear Backplane Kit (Business Partner only)	1

8.2 BOM for networking

Below is the bill of materials for a single 1 GbE network switch.

Part #	Description	Quantity
7159BAX	Lenovo RackSwitch G7028 (Rear to Front)	1
39Y7938	2.8m, 10A/100-250V, C13 to IEC 320-C20 Rack Power Cable	2

Below is the bill of materials for a single 10 GbE network switch.

Part #	Description	Quantity
7159BR6	Lenovo RackSwitch G8124E (Rear to Front)	2
39Y7938	2.8m, 10A/100-250V, C13 to IEC 320-C20 Rack Power Cable	4
90Y9427	1m Passive DAC SFP+ Cable	2

Resources

For more information, see the following resources:

- Cloudian HyperStore resources:

  cloudian.com/resources

- Cloudian HyperStore Technical Review white paper:

  cloudian.com/cloudian-docs/white-papers/Cloudian-HyperStore-Technical-Review.pdf

- S3 API: What it takes to build 100% Compatible Object:

  info.cloudian.com/S3API-wp-lp-0515.html

- Using Cloudian HyperStore with Hortonworks:

  cloudian.com/cloudian-docs/Cloudian-Hortonworks-Solutions-Brief.pdf

Trademarks and special notices

References in this document to Lenovo products or services do not imply that Lenovo intends to make them available in every country.

Lenovo, the Lenovo logo, ThinkCentre, ThinkVision, ThinkVantage, ThinkPlus and Rescue and Recovery are trademarks of Lenovo.

Cloudian, the Cloudian logo, and HyperStore® are registered trademarks or trademarks of Cloudian, Inc. All other trademarks are property of their respective holders.

IBM, the IBM logo, and ibm.com are trademarks or registered trademarks of International Business Machines Corporation in the United States, other countries, or both.

Microsoft, Windows, Windows NT, and the Windows logo are trademarks of Microsoft Corporation in the United States, other countries, or both.

Intel, Intel Inside (logos), MMX, and Pentium are trademarks of Intel Corporation in the United States, other countries, or both.

Other company, product, or service names may be trademarks or service marks of others.

Information is provided "AS IS" without warranty of any kind.

All customer examples described are presented as illustrations of how those customers have used Lenovo products and the results they may have achieved. Actual environmental costs and performance characteristics may vary by customer.

Information concerning non-Lenovo products was obtained from a supplier of these products, published announcement material, or other publicly available sources and does not constitute an endorsement of such products by Lenovo. Sources for non-Lenovo list prices and performance numbers are taken from publicly available information, including vendor announcements and vendor worldwide homepages. Lenovo has not tested these products and cannot confirm the accuracy of performance, capability, or any other claims related to non-Lenovo products. Questions on the capability of non-Lenovo products should be addressed to the supplier of those products.

All statements regarding Lenovo future direction and intent are subject to change or withdrawal without notice, and represent goals and objectives only. Contact your local Lenovo office or Lenovo authorized reseller for the full text of the specific Statement of Direction.

Some information addresses anticipated future capabilities. Such information is not intended as a definitive statement of a commitment to specific levels of performance, function or delivery schedules with respect to any future products. Such commitments are only made in Lenovo product announcements. The information is presented here to communicate Lenovo’s current investment and development activities as a good faith effort to help with our customers' future planning.

Performance is based on measurements and projections using standard Lenovo benchmarks in a controlled environment. The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput or performance improvements equivalent to the ratios stated here.

Photographs shown are of engineering prototypes. Changes may be incorporated in production models.

Any references in this information to non-Lenovo websites are provided for convenience only and do not in any manner serve as an endorsement of those websites. The materials at those websites are not part of the materials for this Lenovo product and use of those websites is at your own risk.