

# Design an optimal storage strategy for your cloud workload

17-22 minutes

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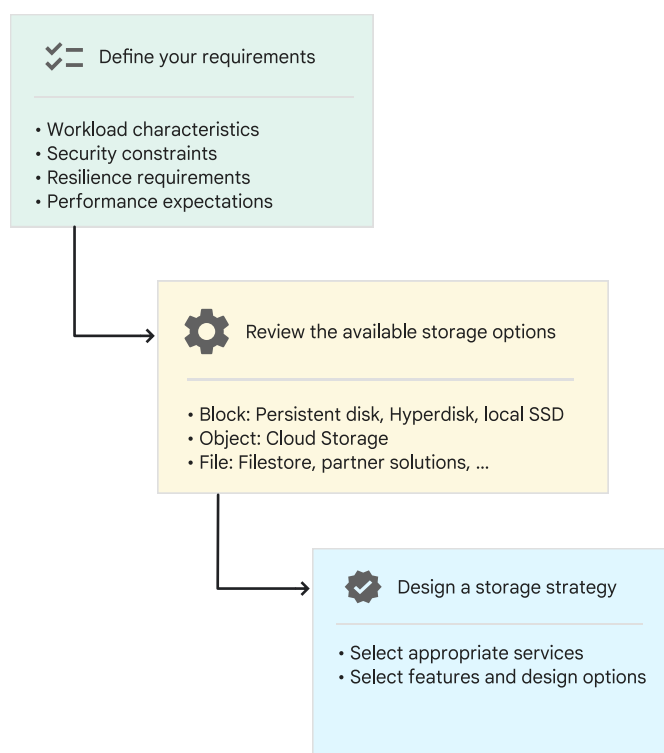
This guide helps you assess the storage requirements of your cloud workload, understand the available storage options in Google Cloud, and design a storage strategy that provides optimal business value.

For a visual summary of the main design recommendations, see the [decision tree diagram](#).

## Overview of the design process

As a cloud architect, when you plan storage for a cloud workload, you need to first consider the functional characteristics of the workload, security constraints, resilience requirements, performance expectations, and cost goals. Next, you need to review the available storage services and features in Google Cloud. Then, based on your requirements and the available options, you select the storage services and features that you need.

The following diagram shows this 3-phase design process:



## Define your requirements

Use the questionnaires in this section to define the key storage requirements of the workload that you want to deploy in Google Cloud.

### Guidelines for defining storage requirements

When answering the questionnaires, consider the following guidelines:

- **Define requirements granularly**

For example, if your application needs Network File System (NFS)-based file storage, identify the required NFS version.

- **Consider future requirements**

For example, your current deployment might serve users in countries within Asia, but you might plan to expand the business to other continents. In this case, consider any storage-related regulatory requirements of the new business territories.

- **Consider cloud-specific opportunities and requirements**

- Take advantage of cloud-specific opportunities.

For example, to optimize the storage cost for data stored in Cloud Storage, you can control the storage duration by using data retention policies and lifecycle configurations.

- Consider cloud-specific requirements.

For example, the on-premises data might exist in a single data center, and you might need to replicate the migrated data across two Google Cloud locations for redundancy.

## Questionnaires

The questionnaires that follow are not exhaustive checklists for planning. Use them as a starting point to systematically analyze all the storage requirements of the workload that you want to deploy to Google Cloud.

### Assess your workload's characteristics

- What kind of data do you need to store?

#### Examples

- Static website content
  - Backups and archives for disaster recovery
  - Audit logs for compliance
  - Large data objects that users download directly
  - Transactional data
  - Unstructured, and heterogeneous data
- How much capacity do you need? Consider your current and future requirements.
  - Should capacity scale automatically with usage?
  - What are the access requirements? For example, should the data be accessible from outside Google Cloud?
  - What are the expected read-write patterns?

#### Examples

- Frequent writes and reads
  - Frequent writes, but occasional reads
  - Occasional writes and reads
  - Occasional writes, but frequent reads
- Does the workload need file-based access, using NFS for example?
  - Should multiple clients be able to read or write data simultaneously?

### Identify security constraints

- What are your data-encryption requirements? For example, do you need to use keys that you control?
- Are there any data-residency requirements?

### Define data-resilience requirements

- Does your workload need low-latency caching or scratch space?
- Do you need to replicate the data in the cloud for redundancy?
- Do you need strict read-write consistency for replicated datasets?

### Set performance expectations

- What is the required I/O rate?
- What levels of read and write throughput does your application need?
- What environments do you need storage for? For a given workload, you might need high-performance storage for the production environment, but could choose a lower-performance option for the non-production environments.

## Review the storage options

Google Cloud offers storage services for all the key storage formats: block, file, and object. Review and evaluate the features, design options, and relative advantages of the services available for each storage format.

### Overview

The data that you store in block storage is divided into chunks, each stored as a separate *block* with a unique address. Applications access data by referencing the appropriate block addresses. Block storage is optimized for high-IOPS workloads, such as transaction processing. It's similar to on-premises storage area network (SAN) and directly attached storage (DAS) systems.

The block storage options in Google Cloud are a part of the Compute Engine service.

Option	Overview
Persistent Disk	Dedicated hard-disk drives (HDD) and solid-state drives (SSD) for enterprise and database applications deployed to Compute Engine VMs and Google Kubernetes Engine (GKE) clusters.
Google Cloud Hyperdisk	Fast and redundant network storage for Compute Engine VMs, with configurable performance and volumes that can be dynamically resized.
Local SSD	Ephemeral, locally attached block storage for high-performance applications.

Data is organized and represented in a hierarchy of *files* that are stored in folders, similar to on-premises network-attached storage (NAS). File systems can be mounted on clients using protocols such as NFS and Server Message Block (SMB). Applications access data using the relevant filename and directory path.

Google Cloud provides a range of fully managed and third-party solutions for file storage.

Data is stored as *objects* in a flat hierarchy of *buckets*. Each object is assigned a globally unique ID. Objects can have system-assigned and user-defined metadata, to help you organize and manage the data. Applications access data by referencing the object IDs, using REST APIs or client libraries. Object storage is similar to on-premises SAN in terms of the ability to scale, but is easier to manage and less expensive.

Cloud Storage provides low-cost, highly durable, no-limit object storage for diverse data types. The data you store in Cloud Storage can be accessed from anywhere, within and outside Google Cloud. Optional redundancy across regions provides maximum reliability. You can select a storage *class* that suits your data-retention and access-frequency requirements.

## Comparative analysis

The following table provides a comparative analysis of the key capabilities of the storage services in Google Cloud.

	Persistent Disk	Hyperdisk	Local SSD	Filestore	Google Cloud NetApp Volumes	Cloud Storage
Capacity	10 GiB to 64 TiB per disk 257 TiB per VM	4 GiB to 64 TiB per disk 512 TiB per VM	375 GiB per disk 12 TiB per VM	1-100 TiB per Filestore instance (the minimum and maximum capacity and the scaling increments vary by <a href="#">service tier</a> )	2-500 TiB per storage pool 100 GiB to 100 TiB per volume	No lower or upper limit
Scaling	<ul style="list-style-type: none"> <li>Scale up</li> <li>Add and remove disks</li> <li>Autoscale using managed instance groups</li> </ul>	Scale performance and capacity dynamically	Not scalable	<ul style="list-style-type: none"> <li>Basic tier: scale up</li> <li>Zonal and Regional tiers: scale up and down</li> </ul>	Scale up and down	Scales automatically based on usage
Sharing	<a href="#">Limited</a> sharing <ul style="list-style-type: none"> <li>Read-only: multiple VMs</li> <li>Multi-writer: 2 VMs</li> </ul>	Not shareable	Not shareable	Mountable on multiple <a href="#">Compute Engine VMs</a> , <a href="#">remote clients</a> , and <a href="#">GKE clusters</a>	Mountable on multiple Compute Engine VMs and GKE clusters	<ul style="list-style-type: none"> <li>Read/write from anywhere</li> <li>Integrates with <a href="#">Cloud CDN</a> and third-party CDNs</li> </ul>
Encryption keys	One of: <ul style="list-style-type: none"> <li>Google-owned and Google-managed keys</li> <li>customer-managed keys</li> <li>customer-supplied keys</li> </ul>	One of: <ul style="list-style-type: none"> <li>Google-owned and Google-managed keys</li> <li>customer-managed keys</li> <li>customer-supplied keys</li> </ul>	Google-owned and Google-managed keys	<ul style="list-style-type: none"> <li>Google-owned and Google-managed keys (all service tiers)</li> <li>Customer-managed keys (Zonal and Regional tiers)</li> </ul>	One of: <ul style="list-style-type: none"> <li>Google-owned and Google-managed keys</li> <li>customer-managed keys</li> </ul>	One of: <ul style="list-style-type: none"> <li>Google-owned and Google-managed keys</li> <li>customer-managed keys</li> <li>customer-supplied <a href="#">keys</a></li> </ul>

	Persistent Disk	Hyperdisk	Local SSD	Filestore	Google Cloud NetApp Volumes	Cloud Storage
<b>Persistence</b>	Lifetime of the disk	Lifetime of the disk	Ephemeral (data lives until the VM is stopped or deleted)	Lifetime of the Filestore instance	Lifetime of the volume	Lifetime of the bucket
<b>Availability</b>	<ul style="list-style-type: none"> <li>Zonal and regional replication</li> <li>Incremental <a href="#">snapshots</a> (manual or scheduled)</li> <li><a href="#">Disk cloning</a></li> </ul>	Zonal	Zonal	<ul style="list-style-type: none"> <li>Regional availability for Regional tier instances, zonal availability for Basic and Zonal tier instances</li> <li><a href="#">Snapshots</a> for Zonal and Regional tier instances</li> <li><a href="#">Backups</a></li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Snapshots</a></li> <li><a href="#">Cross-region replication</a></li> </ul>	<ul style="list-style-type: none"> <li>Data redundant across zones</li> <li>Options for <a href="#">redundancy across regions</a></li> </ul>
<b>Performance</b>	Linearly scaling high <a href="#">performance</a> , based on disk size and CPU count	Dynamically scalable, <a href="#">high-performance</a> persistent storage	<a href="#">High-performance</a> scratch storage	<ul style="list-style-type: none"> <li>Basic tier: consistent <a href="#">performance</a></li> <li>Zonal and Regional tiers: linearly scaling <a href="#">performance</a></li> </ul>	Scalable performance  Expectations depend on the <a href="#">service level</a>	<a href="#">Autoscaling read-write rates, and dynamic load redistribution</a>
<b>Management</b>	Manually format and mount	Manually format and mount	Manually format, stripe, and mount	Fully managed	Fully managed	Fully managed
<b>Workloads</b>	<ul style="list-style-type: none"> <li>IOPS-intensive or latency-sensitive applications</li> <li>Databases</li> <li>Shared read-only storage</li> <li>Rapid, durable VM backups</li> </ul>	<ul style="list-style-type: none"> <li>Performance-intensive workloads</li> <li>Scale-out analytics</li> </ul>	<ul style="list-style-type: none"> <li>Flash-optimized databases</li> <li>Hot-caching for analytics</li> <li>Scratch disk</li> </ul>	<ul style="list-style-type: none"> <li>Lift-and-shift on-premises file systems</li> <li>Shared configuration files</li> <li>Common tooling and utilities</li> <li>Centralized logs</li> </ul>	<ul style="list-style-type: none"> <li>Lift-and-shift on-premises file systems</li> <li>Shared configuration files</li> <li>Common tooling and utilities</li> <li>Centralized logs</li> <li>Windows workloads</li> </ul>	<ul style="list-style-type: none"> <li>Streaming videos</li> <li>Media asset libraries</li> <li>High-throughput data lakes</li> <li>Backups and archives</li> <li>Long-tail content</li> </ul>

## Choose a storage option

There are two parts to selecting a storage option:

- Deciding which storage services you need.
- Choosing the required features and design options in a given service.

### Examples of service-specific features and design options

- Deployment region and zone
- Regional replication
- Disk type, size, and IOPS (for Extreme Persistent Disk)
- Encryption keys: Google-owned and Google-managed, customer-managed, or customer-supplied
- Snapshot schedule
- Deployment zone
- Disk type, size, and IOPS
- Encryption keys: Google-owned and Google-managed, customer-managed, or customer-supplied
- Snapshot schedule

- Deployment region and zone
- Instance tier
- Capacity
- IP range: auto-allocated or custom
- Access control
- Deployment region
- Service level for the storage pool
- Pool and volume capacity
- Volume protocol
- Volume export rules
- Location: multi-region, dual-region, single region
- Storage class: Standard, Nearline, Coldline, Archive
- Access control: uniform or fine-grained
- Encryption keys: Google-owned and Google-managed, customer-managed, or customer-supplied
- Retention policy

## Storage recommendations

Use the following recommendations as a starting point to choose the storage services and features that meet your requirements. These recommendations are also presented as a [decision tree](#) later in this document.

- For applications that need **file-based access**, choose a suitable file storage service based on your requirements for access protocol, availability, and performance.

Access protocol	Recommendation
NFSv3	<ul style="list-style-type: none"> <li>◦ If you need regional availability, use Filestore Regional.</li> <li>◦ If zonal availability is sufficient but you need high performance, use Filestore Zonal.</li> <li>◦ Otherwise, use either Filestore Basic or <a href="#">NetApp Volumes</a>.</li> </ul> <p>For more information about the differences between the Filestore service tiers, see <a href="#">Service tiers</a>.</p>
SMB or NFSv4.1	Use NetApp Volumes.

- For workloads that need primary storage with **high performance**, use local SSDs, Persistent Disks, or Hyperdisks depending on your requirements.

Requirement	Recommendation
Fast scratch disk or cache	Use local SSD disks (ephemeral).
Sequential IOPS	Use Persistent Disks with the pd-standard disk type.
IOPS-intensive workload	Use Persistent Disks with the pd-extreme or pd-ssd disk type.
Balance between performance and cost	Use Persistent Disks with the pd-balanced disk type.
Scalable performance and capacity dynamically	<p>Use Hyperdisk.</p> <p>Choose a suitable Hyperdisk type:</p> <ul style="list-style-type: none"> <li>◦ Hyperdisk Throughput is recommended for scale-out analytics, data drives for cost-sensitive apps, and for cold storage.</li> <li>◦ Hyperdisk Extreme is recommended for workloads that need high I/O, such as high-performance databases.</li> </ul>

- Depending on your redundancy requirements, choose between zonal and regional disks.

Requirement	Recommendation
Redundancy within a single zone in a region	Use zonal Persistent Disks or Hyperdisks.
Redundancy across multiple zones within a region	Use regional Persistent Disks.

For a detailed comparative analysis, see [Persistent Disk options](#).

- For **unlimited-scale and globally available** storage, use Cloud Storage.

Depending on the data-access frequency and the storage duration, choose a suitable Cloud Storage class.

Requirement	Recommendation
Access frequency varies, or the data-retention period is unknown or not predictable.	Use the <a href="#">Autoclass</a> feature to automatically transition objects in a bucket to appropriate storage classes based on each object's



- Learn about the [differences between object, block, and file storage in Google Cloud](#) (video).
- Learn when to use [parallel file systems like Lustre](#) for HPC workloads.

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