Storage efficiency

ONTAP 9

NetApp
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Storage efficiency

Thin provisioning

ONTAP offers a wide range of storage efficiency technologies in addition to Snapshot copies. Key technologies include thin provisioning, deduplication, compression, and FlexClone volumes, files, and LUNs. Like Snapshot copies, all are built on ONTAP’s Write Anywhere File Layout (WAFL).

A *thin-provisioned* volume or LUN is one for which storage is not reserved in advance. Instead, storage is allocated dynamically, as it is needed. Free space is released back to the storage system when data in the volume or LUN is deleted.

Suppose that your organization needs to supply 5,000 users with storage for home directories. You estimate that the largest home directories will consume 1 GB of space.

In this situation, you could purchase 5 TB of physical storage. For each volume that stores a home directory, you would reserve enough space to satisfy the needs of the largest consumers.

As a practical matter, however, you also know that home directory capacity requirements vary greatly across your community. For every large user of storage, there are ten who consume little or no space.

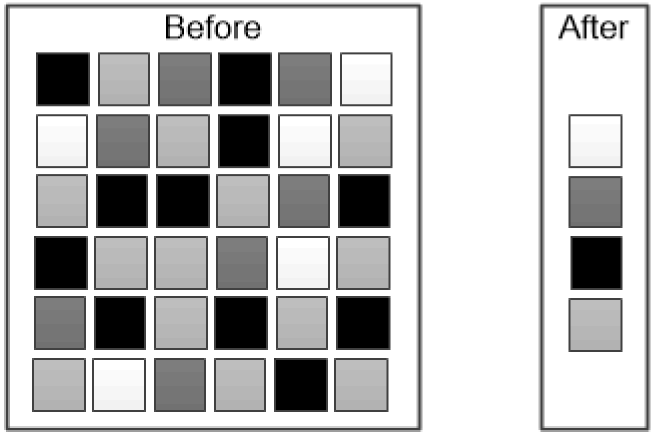
Thin provisioning allows you to satisfy the needs of the large storage consumers without having to purchase storage you might never use. Since storage space is not allocated until it is consumed, you can “overcommit” an aggregate of 2 TB by nominally assigning a size of 1 GB to each of the 5,000 volumes the aggregate contains.

As long as you are correct that there is a 10:1 ratio of light to heavy users, and as long as you take an active role in monitoring free space on the aggregate, you can be confident that volume writes won’t fail due to lack of space.

Deduplication

Deduplication reduces the amount of physical storage required for a volume (or all the volumes in an AFF aggregate) by discarding duplicate blocks and replacing them with references to a single shared block. Reads of deduplicated data typically incur no performance charge. Writes incur a negligible charge except on overloaded nodes.

As data is written during normal use, WAFL uses a batch process to create a catalog of *block signatures.* After deduplication starts, ONTAP compares the signatures in the catalog to identify duplicate blocks. If a match exists, a byte-by-byte comparison is done to verify that the candidate blocks have not changed since the catalog was created. Only if all the bytes match is the duplicate block discarded and its disk space reclaimed.



Deduplication reduces the amount of physical storage required for a volume by discarding duplicate data blocks.

Compression

Compression reduces the amount of physical storage required for a volume by combining data blocks in *compression groups,* each of which is stored as a single block. Reads of compressed data are faster than in traditional compression methods because ONTAP decompresses only the compression groups that contain the requested data, not an entire file or LUN.

You can perform inline or postprocess compression, separately or in combination:

- *Inline compression* compresses data in memory before it is written to disk, significantly reducing the amount of write I/O to a volume, but potentially degrading write performance. Performance-intensive operations are deferred until the next postprocess compression operation, if any.
- *Postprocess compression* compresses data after it is written to disk, on the same schedule as deduplication.

Inline data compaction Small files or I/O padded with zeros are stored in a 4 KB block whether or not they require 4 KB of physical storage. *Inline data compaction* combines data chunks that would ordinarily consume multiple 4 KB blocks into a single 4 KB block on disk. Compaction takes place while data is still in memory, so it is best suited to faster controllers.

Capacity measurements in System Manager

System capacity can be measured as either physical space or logical space. Beginning with ONTAP 9.7, System Manager provides measurements of both physical and logical capacity.

The differences between the two measurements are explained in the following descriptions:

- **Physical capacity**: Physical space refers to the physical blocks of storage used in the volume or local tier. The value for physical used capacity is typically smaller than the value for logical used capacity due to the reduction of data from storage efficiency features (such as deduplication and compression).

- **Logical capacity**: Logical space refers to the usable space (the logical blocks) in a volume or local tier. Logical space refers to how theoretical space can be used, without accounting for results of deduplication or compression. The value for logical space used is derived from the amount of physical space used plus the savings from storage efficiency features (such as deduplication and compression) that have been configured. This measurement often appears larger than the physical used capacity because it includes Snapshot copies, clones, and other components, and it does not reflect the data compression and other reductions in the physical space. Thus, the total logical capacity could be higher than the provisioned space.

> In System Manager, capacity representations do not account for root storage tier (aggregate) capacities.

Measurements of used capacity

Measurements of used capacity are displayed differently depending on the version of System Manager you are using, as explained in the following table:

Version of System Manager	Term used for capacity	Type of capacity referred to
9.5 and 9.6 (Classic view)	Used	Physical space used
9.7 and 9.8	Used	Logical space used (if storage efficiency settings have been enabled)
9.9.1 and later	Logical Used	Logical space used (if storage efficiency settings have been enabled)

Capacity measurement terms

The following terms are used when describing capacity:

- **Allocated capacity**: The amount of space that has been allocated for volumes in a storage VM.
- **Available**: The amount of physical space available to store data or to provision volumes in a storage VM or on a local tier.
- **Capacity across volumes**: The sum of the used storage and available storage of all the volumes on a storage VM.
- **Client data**: The amount of space used by client data (either physical or logical).
- **Committed**: The amount of committed capacity for a local tier.
- **Data reduction**:
  - **Overall**: The ratio of all logical used space compared to physical used space.
  - **Without Snapshot copies and clones**: The ratio of logical space used only by client data compared to physical space used only by client data.
- **Logical used**: The amount of used space without considering the space saved by storage efficiency features.

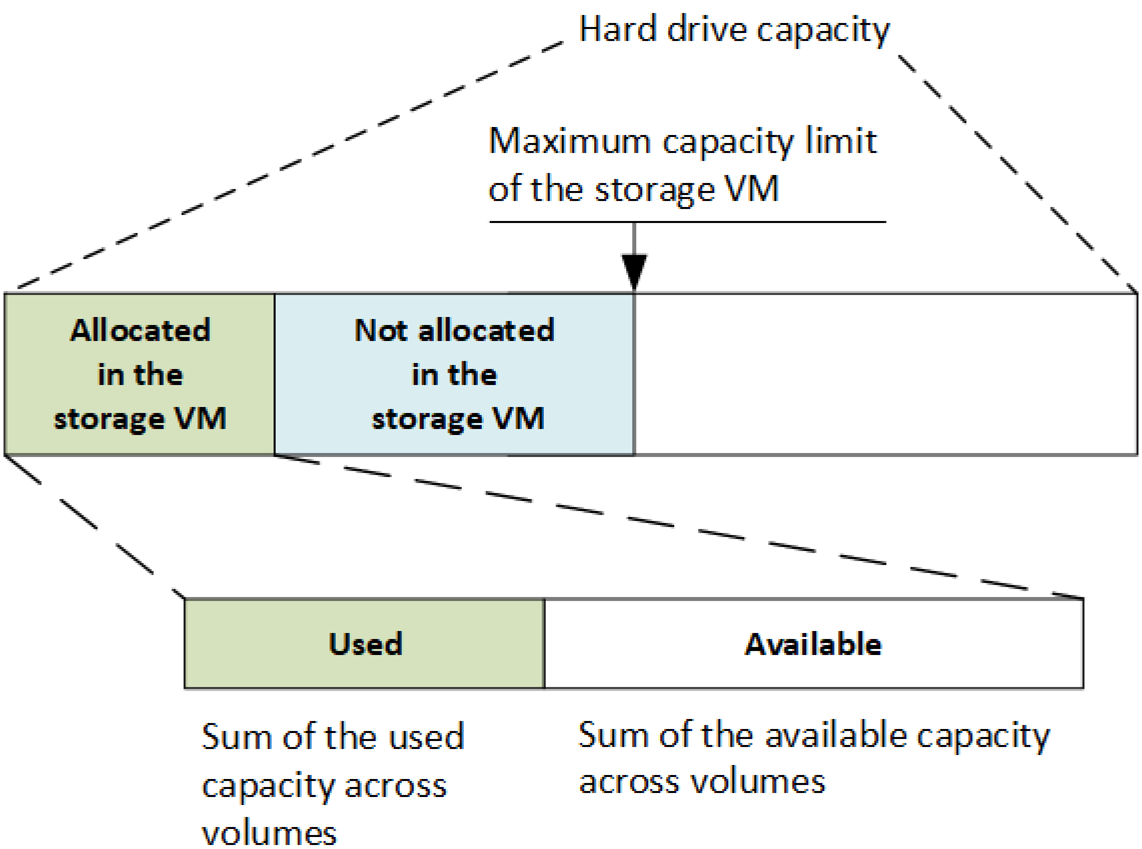
- **Logical used %**: The percentage of the current logical used capacity compared to the provisioned size, excluding Snapshot reserves. This value can be greater than 100%, because it includes efficiency savings in the volume.
- **Maximum capacity**: The maximum amount of space allocated for volumes on a storage VM.
- **Physical used**: The amount of capacity used in the physical blocks of a volume or local tier.
- **Physical used %**: The percentage of capacity used in the physical blocks of a volume compared to the provisioned size.
- **Reserved**: The amount of space reserved for already provisioned volumes in a local tier.
- **Used**: The amount of space that contains data.
- **Used and reserved**: The sum of physical used and reserved space.

Capacity of a storage VM

The maximum capacity of a storage VM is determined by the total allocated space for volumes plus the remaining unallocated space.

- The allocated space for volumes is the sum of the used capacity and the sum of available capacity of FlexVol volumes, FlexGroup volumes, and FlexCache volumes.
- The capacity of volumes is included in the sums, even when they are restricted, offline, or in the recovery queue after deletion.
- If volumes are configured with auto-grow, the maximum autosize value of the volume is used in the sums. Without auto-grow, the actual capacity of the volume is used in the sums.

The following chart explains how the measurement of the capacity across volumes relates to the maximum capacity limit.



Beginning with ONTAP 9.13.1, cluster administrators can enable a maximum capacity limit for a storage VM. However, storage limits cannot be set for a storage VM that contains volumes that are for data protection, in a SnapMirror relationship, or in a MetroCluster configuration. Also, quotas cannot be configured to exceed the maximum capacity of a storage VM.

After the maximum capacity limit is set, it cannot be changed to a size that is less than the currently allocated capacity.

When a storage VM reaches its maximum capacity limit, certain operations cannot be performed. System Manager provides suggestions for next steps in **Insights** .

Capacity measurement units

System Manager calculates storage capacity based on binary units of 1024 (2^{10}) bytes. In ONTAP 9.10.0 and earlier, these units were displayed in System Manager as KB, MB, GB, TB, and PB. Beginning with ONTAP 9.10.1, they are displayed in System Manager as KiB, MiB, GiB, TiB, and PiB.

> The units used in System Manager for throughput continue to be KB/s, MB/s, GB/s, TB/s, and PB/s for all releases of ONTAP.

Capacity unit displayed in System Manager for ONTAP 9.10.0 and earlier	Capacity unit displayed in System Manager for ONTAP 9.10.1 and later	Calculation	Value in bytes

KB	KiB	1024	1024 bytes
MB	MiB	1024 * 1024	1,048,576 bytes
GB	GiB	1024 * 1024 * 1024	1,073,741,824 bytes
TB	TiB	1024 * 1024 * 1024 * 1024	1,099,511,627,776 bytes
PB	PiB	1024 * 1024 * 1024 * 1024 * 1024	1,125,899,906,842,624 bytes

Related information

Monitor capacity in System Manager

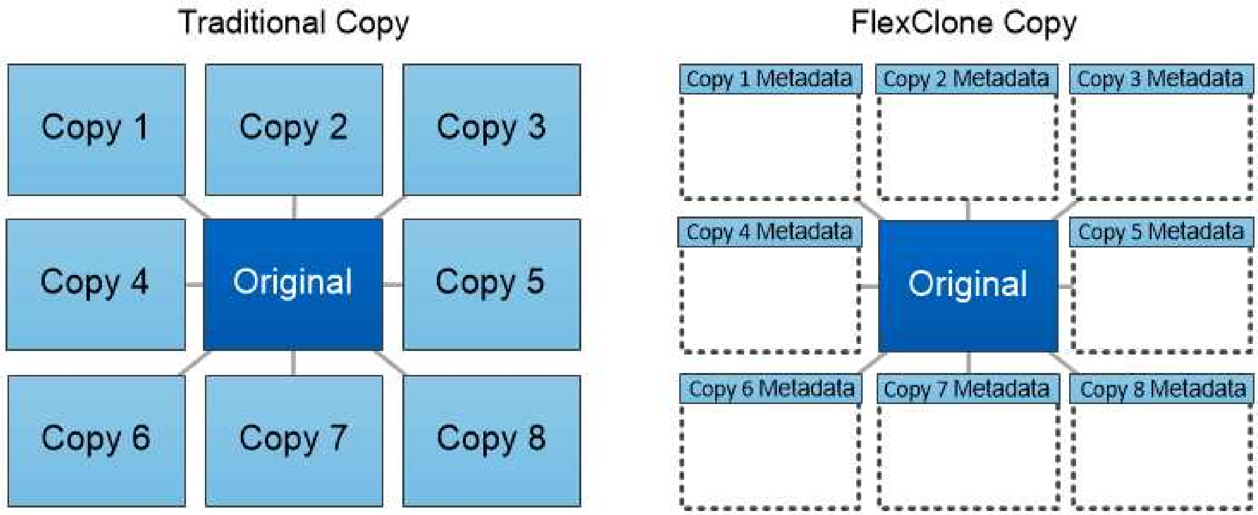
Logical space reporting and enforcement for volumes

FlexClone volumes, files, and LUNs

FlexClone technology references Snapshot metadata to create writable, point-in-time copies of a volume. Copies share data blocks with their parents, consuming no storage except what is required for metadata until changes are written to the copy. FlexClone files and FlexClone LUNs use identical technology, except that a backing Snapshot copy is not required.

Where traditional copies can take minutes or even hours to create, FlexClone software lets you copy even the largest datasets almost instantaneously. That makes it ideal for situations in which you need multiple copies of identical datasets (a virtual desktop deployment, for example) or temporary copies of a dataset (testing an application against a production dataset).

You can clone an existing FlexClone volume, clone a volume containing LUN clones, or clone mirror and vault data. You can *split* a FlexClone volume from its parent, in which case the copy is allocated its own storage.



FlexClone copies share data blocks with their parents, consuming no storage except what is required for metadata.