

Module 9

Storage efficiency

About this module

This module focuses on enabling you to do the following:

- Implement storage-efficiency features
- Use FlexClone software volumes

Lesson 1

Thin provisioning

Thick and thin provisioning of volumes

Thick provisioning of volumes (space-guarantee = volume)

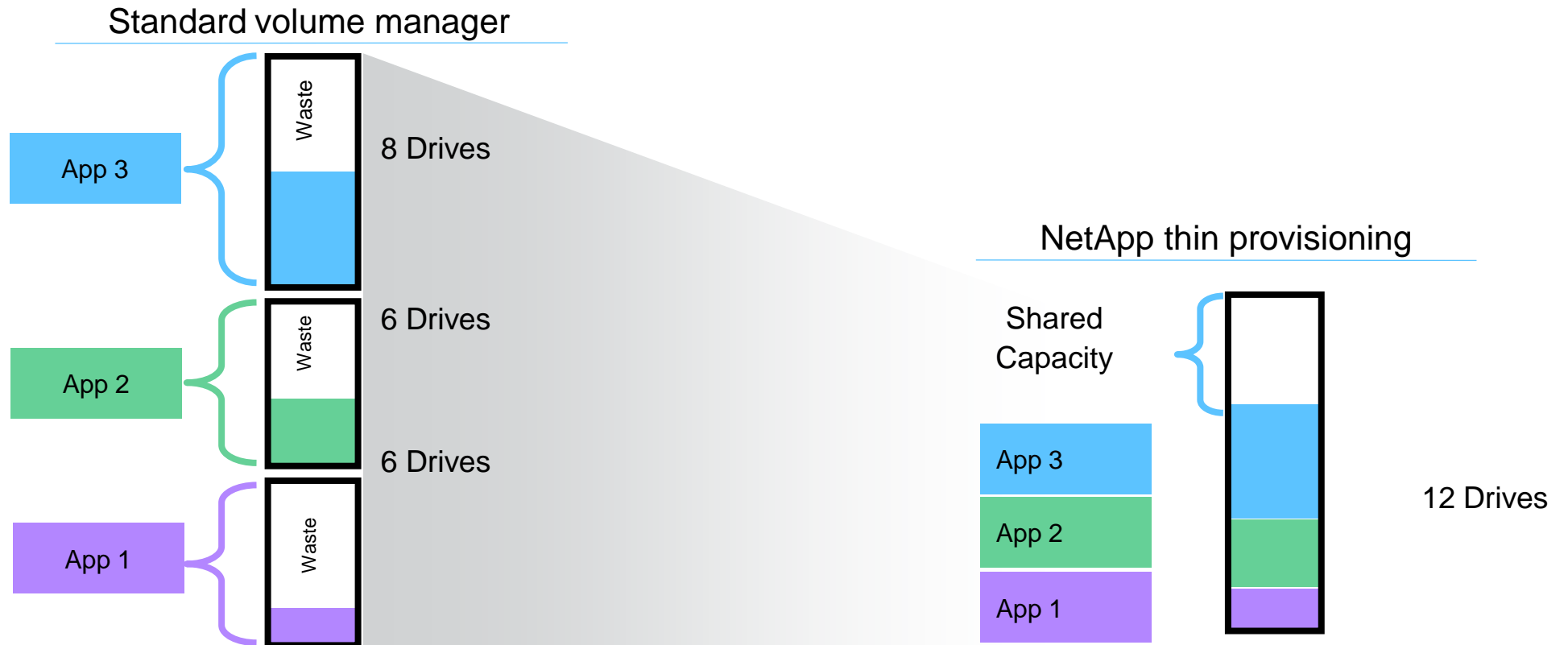
- Requires reserved space within the aggregate for volume creation
- Helps to prevent overcommitment of an aggregate
- Simplifies storage management

Thin provisioning of volumes (space-guarantee = none)

- Does not require reserved space within the aggregate for volume creation
- Enables more aggressive allocation
- Does not prevent overcommitment of an aggregate
- Requires more complex storage management

Thin provisioning

- Typical: Only 40% of provisioned storage is used.
- NetApp: More than 70% is used.
 - Buy 50% less storage.
 - Save 50% power, cooling, and space.



Enable thin provisioning

The screenshot shows the ONTAP System Manager interface. On the left is a navigation sidebar with sections: DASHBOARD, STORAGE (selected), NETWORK, EVENTS & JOBS, and PROTECTION. Under STORAGE, the 'Volumes' link is highlighted. The main area displays a table of volumes. The volume 'smb1_share_CIFS_volume' is selected. A green callout bubble points to the 'Thick Provisioned' status in the 'SPACE RESERVATION' column, with the text 'Volume space reservation setting'. An 'Edit Volume' modal is open on the right, showing the volume name and the 'Storage and Optimization' section where 'Enable thin provisioning' is checked. Below the interface, a terminal window shows the command to modify the volume's space reservation setting.

Volumes

	Name	Status	Style	Space Reservation
<input type="checkbox"/>	exp_svm3_NFS_volume			
<input checked="" type="checkbox"/>	smb1_share_CIFS_volume	Online	FlexVol	Thick Provisioned
<input type="checkbox"/>	smb2_share_CIFS_volume			
<input type="checkbox"/>	smb3_share_CIFS_volume			
<input type="checkbox"/>	svm1_root			

Edit Volume

NAME: smb1_share_CIFS_volume

Storage and Optimization

CAPACITY: 1 GB

☒ Enable thin provisioning

☐ Resize automatically

☐ Enable quota

☐ Enforce performance limits

```
::> volume modify -vserver svm4 -volume svm4_vol_002 -space-guarantee none
```



Lesson 2

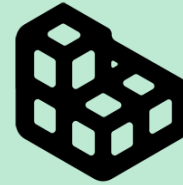
Deduplication and compression

Volume efficiency



Deduplication

- Elimination of duplicate data blocks
- Inline or postprocess options
- Inline deduplication for AFF systems and Flash Pool systems reduces the number of writes to SSDs



Data compression

- Compression of data within a file
- Inline or postprocess options
- Two compression methods:
 - **Secondary:** 32KB compression groups
 - **Adaptive:** 8KB compression groups, which improve read performance

Enable deduplication

ONTAP System Manager

Volumes

- + Add
- Delete
- Protect
- More

Name
exp_svm3_NFS_volume
<input checked="" type="checkbox"/> smb1_share_CIFS_volume
smb2_share_CIFS_volume
smb3_share_CIFS_volume
svm1_root

Overview

STATUS
Online

STYLE
FlexVol

STORAGE EFFICIENCY
Disabled

EXPORT POLICY

Edit Volume

NAME
smb1_share_CIFS_volume

Storage Efficiency

- ☒ Enable background deduplication

STORAGE EFFICIENCY POLICY
Default

- ☐ Enable background compression
Deduplication has to be enabled to activate background compression. Do not enable background compression for performance-critical applications.
- ☐ Enable inline compression
Enabling inline compression automatically enables background compression.

Deduplication and compression setting

```
::> volume efficiency on -vserver svm4 -volume svm4_vol_002
```

Characteristics of data compression

Inline compression

- Data is compressed in memory before being written to the drives.
- Storage consumption and write operations are reduced.
- Throughput increases because of fewer I/O operations.

Postprocess compression

- Uncompressed data is compressed during idle time.
- Only previously uncompressed blocks are compressed.
- Compression occurs before deduplication.
- ONTAP software can detect incompressible data before wasting effort.

For more information, see the *ONTAP 9 Logical Storage Management Guide*.

Configuring data compression

The screenshot shows the ONTAP System Manager interface. On the left is a navigation sidebar with sections: DASHBOARD, STORAGE (expanded), and NETWORK. Under STORAGE, there are links for Overview, Applications, Volumes (selected), Shares, Qtrees, Quotas, Storage VMs, and Tiers. The main area displays a 'Volumes' table with columns for selection and Name. The table lists several volumes, with 'smb1_share_CIFS_volume' selected. An 'Edit Volume' modal is open, showing the 'Storage Efficiency' tab. In this tab, three checkboxes are checked: 'Enable background deduplication', 'Enable background compression', and 'Enable inline compression'. Below these, a dropdown menu for 'STORAGE EFFICIENCY POLICY' is set to 'Default'. A note states: 'Deduplication has to be enabled to activate background compression. Do not enable background compression for performance-critical applications.' Another note states: 'Enabling inline compression automatically enables background compression.'

```
::> volume efficiency modify -vserver svm4 -volume svm4_vol002  
-compression true -inline-compression true
```



Lesson 3

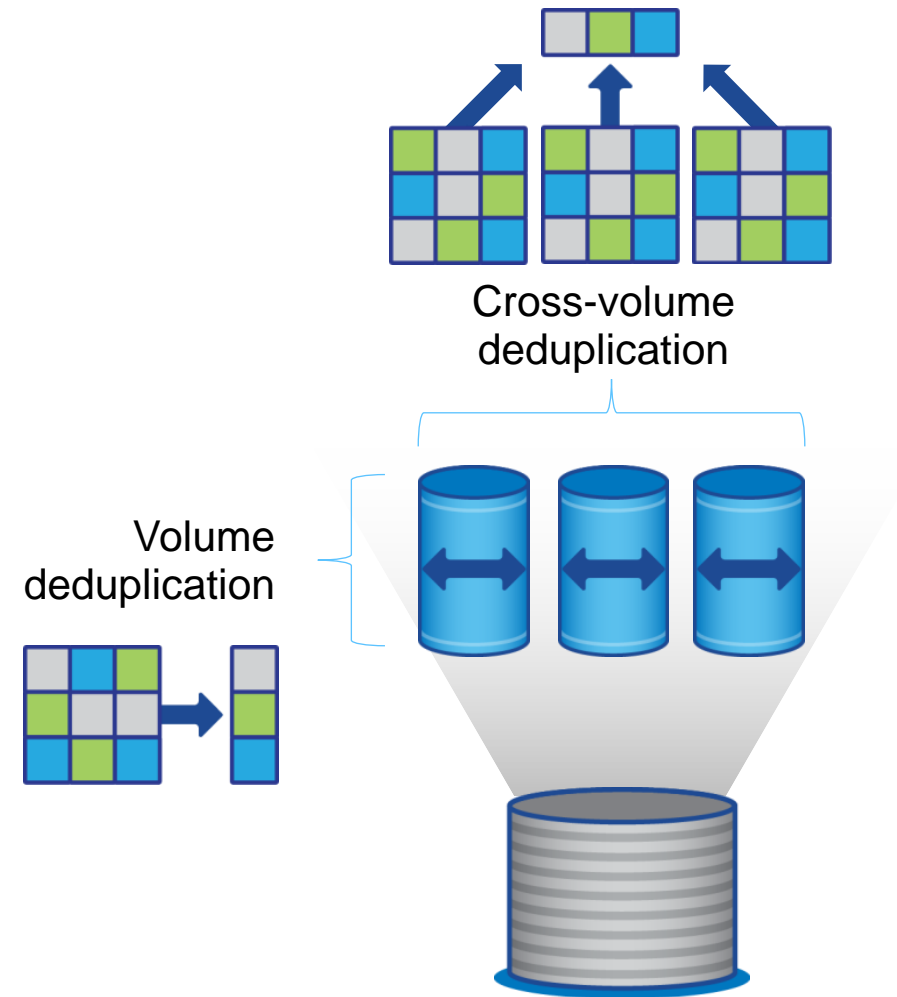
Flash efficiency

Aggregate inline deduplication

Overview

Aggregate inline deduplication enables block sharing across multiple volumes within an aggregate:

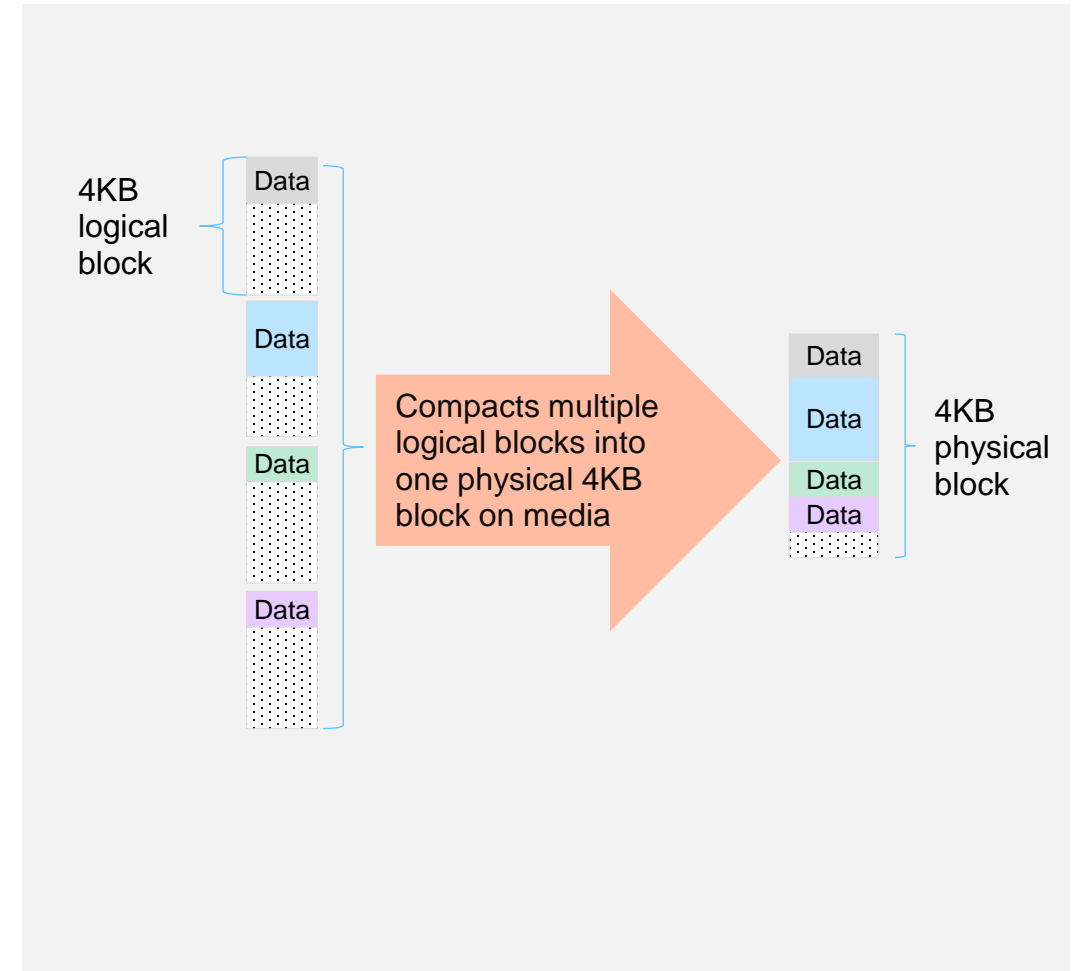
- Is available on only AFF and All SAN Array (ASA) systems
- Uses the volume efficiency parameter:
`-cross-volume-inline-dedupe`



More info in Addendum

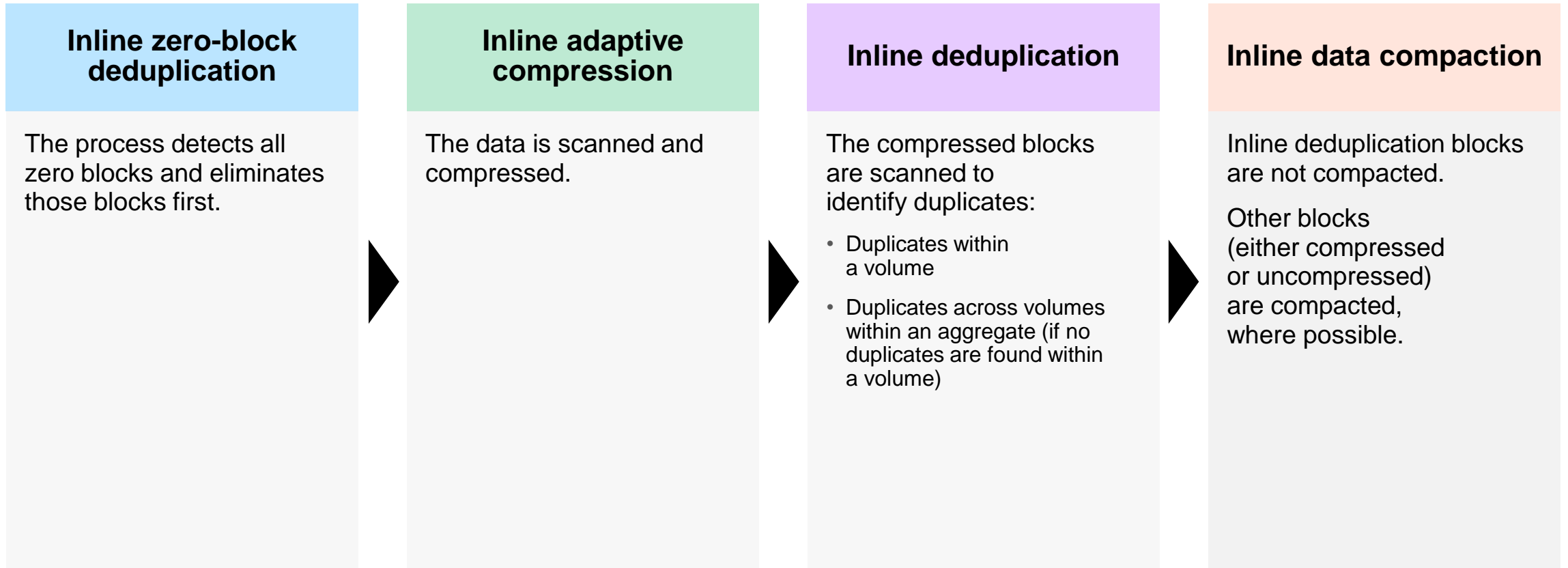
Inline data compaction

- Writes multiple logical data blocks in the same volume to one 4KB block on storage:
 - Compaction occurs during the consistency point (CP) operation just before the write to media.
 - Compaction occurs after inline adaptive compression and inline deduplication.
- Provides additional space savings with highly compressible data
- Is enabled by default for new AFF systems but is disabled on FAS systems:
 - Optional policy for Flash Pool aggregates
 - Optional policy for hard disk-only aggregates



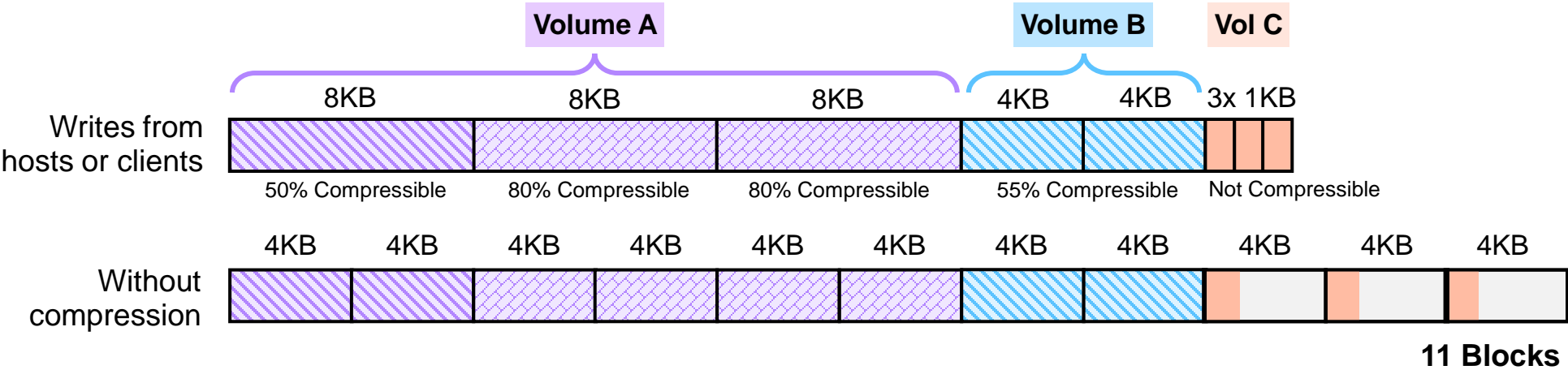
AFF inline storage efficiency

ONTAP workflow



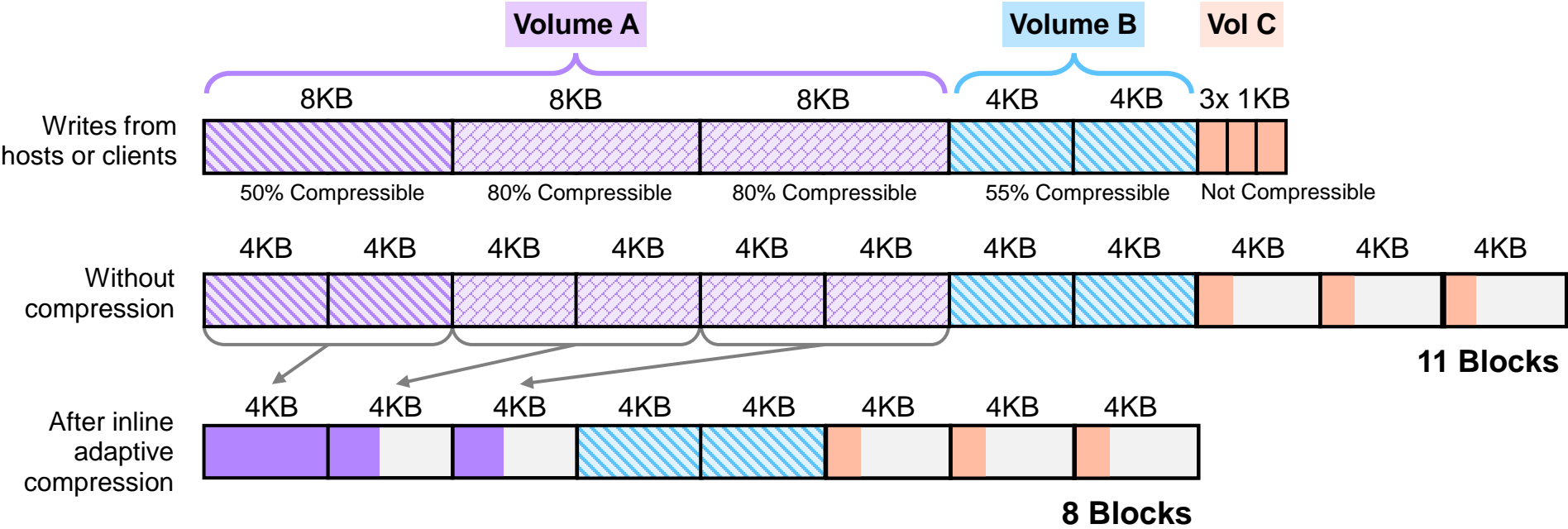
Storage consumption

No inline storage efficiency



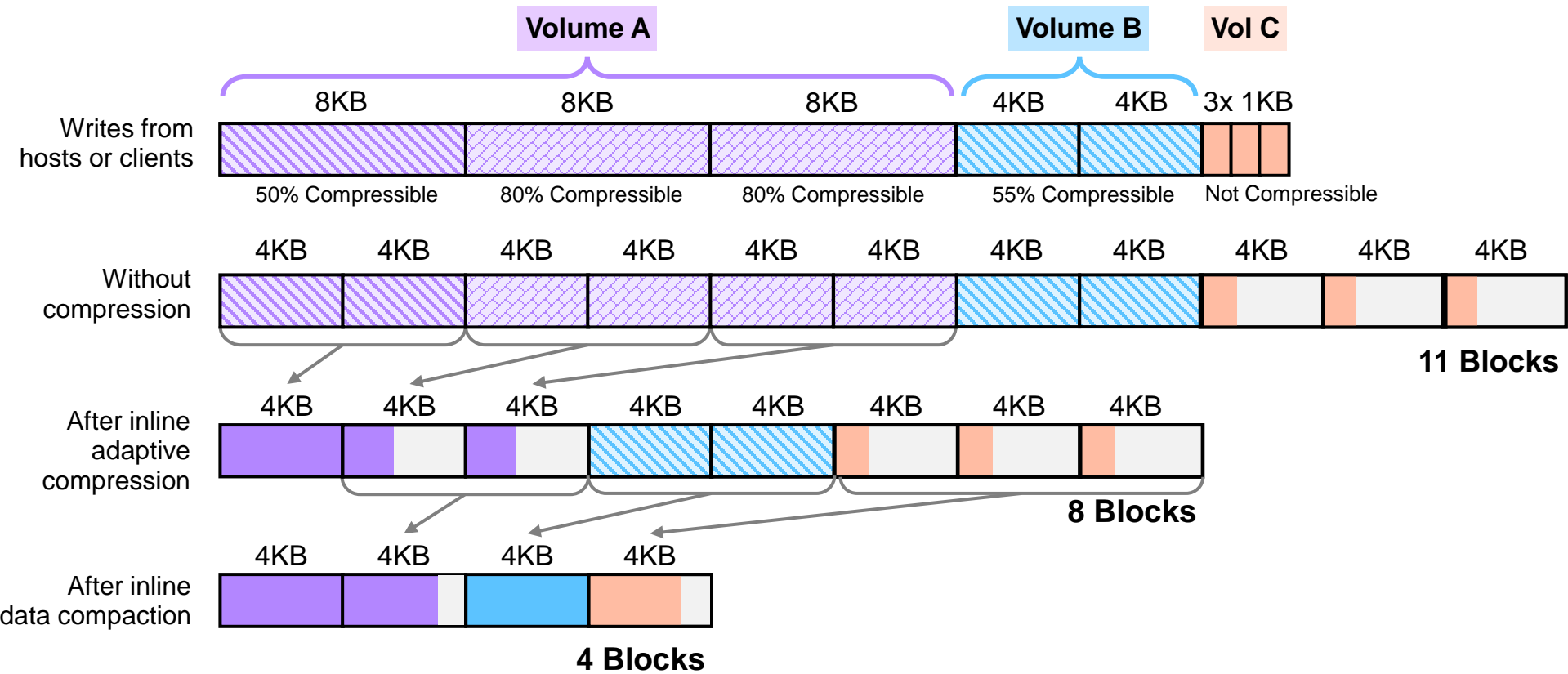
Storage consumption

Inline adaptive compression



Storage consumption

Inline adaptive compression and inline data compaction



Default storage efficiency settings

Storage efficiency feature	AFF	FAS
Inline compression	Enabled	Disabled
Background compression	Not supported	Disabled
Inline volume deduplication	Enabled	Flash Pool only
Background volume deduplication	Enabled*	Disabled
Inline aggregate deduplication	Enabled	Not supported
Background aggregate deduplication	Enabled*	Not supported
Inline compaction	Enabled	Disabled

* - Background deduplication operations are disabled when the `-inline-only` storage efficiency policy is applied to a volume.

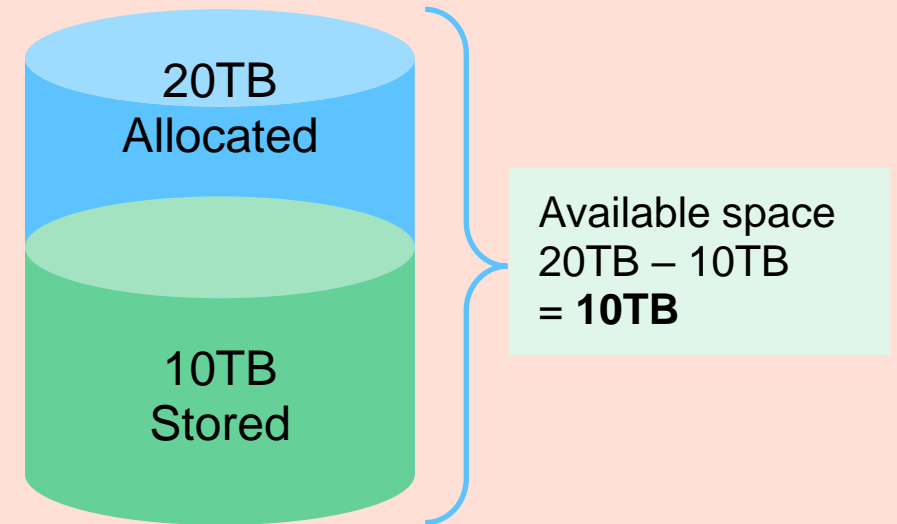
Lesson 4

Logical space reporting

The storage service provider conflict

Charge for data stored

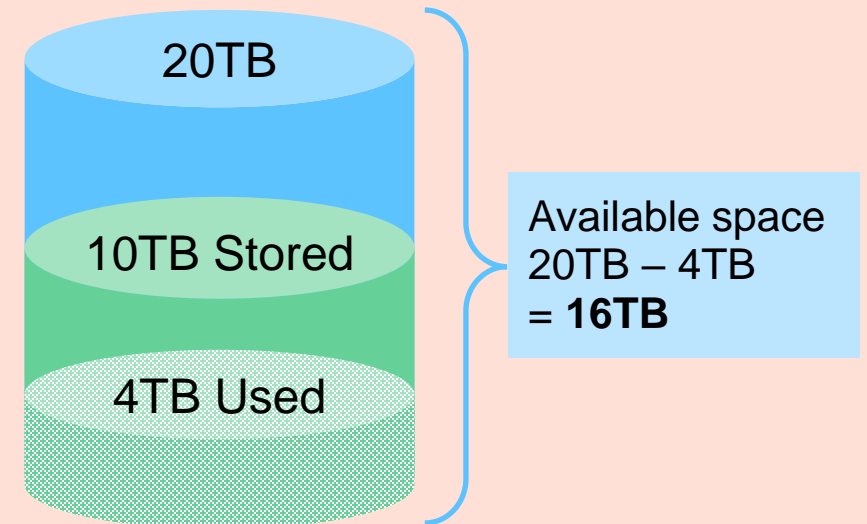
- Storage service providers want to charge customers for data space that they reserve.
- Customers want to pay for only the data that they store.



The storage service provider conflict

Storage efficiencies provide more space

- Storage efficiencies give customers more storage space than they pay for.
- Before ONTAP 9.4 software, ONTAP software provided reporting only for consumed physical storage. Storage service providers could charge only for the space consumed, not for the data that was stored.



Logical space reporting

Volume option

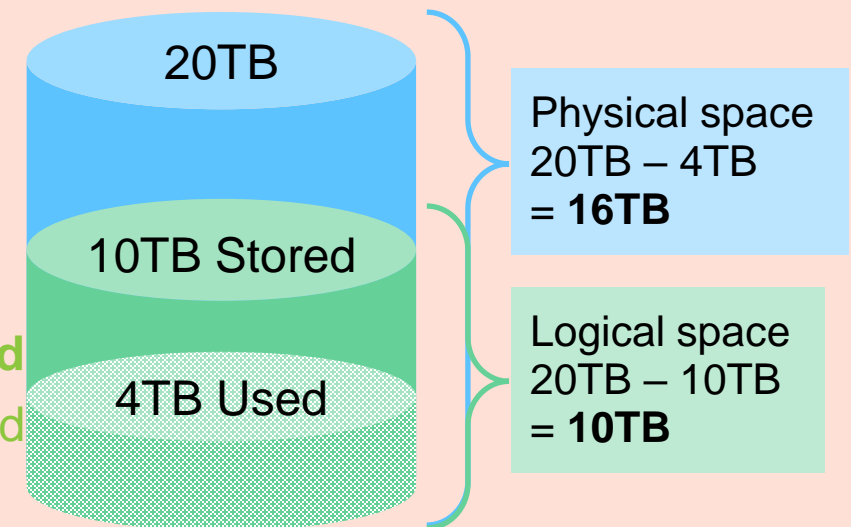
`-is-space-reporting-logical` [true | false]

shows customers the consumed logical space,
rather than the consumed physical space.

With logical space accounting: 10TB used

Without logical space accounting: 4TB used

```
volume modify -vserver SVM-name -volume volume-name  
-is-space-reporting-logical true
```

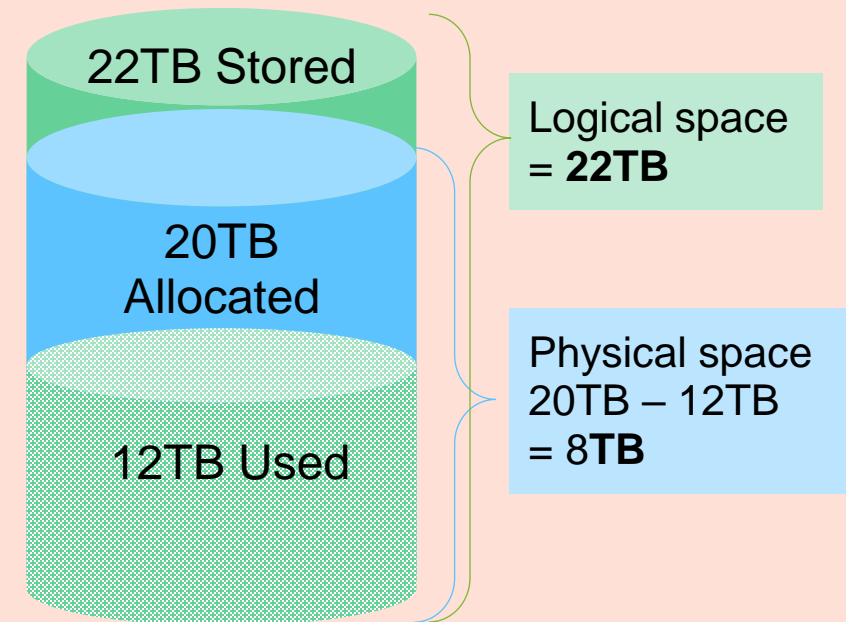


Logical space enforcement

- Storage efficiencies enable customers to store more data than space was allocated for.
- Volume option
`-is-space-enforcement-logical` [true | false]
ensures that customers cannot store more than the logical space that is allocated, regardless of the physical space that is consumed.

Error messages are generated when stored data reaches 95%, 98%, and 100% of logical space limits.

```
volume modify -vserver SVM-name -volume volume-name  
-is-space-enforcement-logical true
```



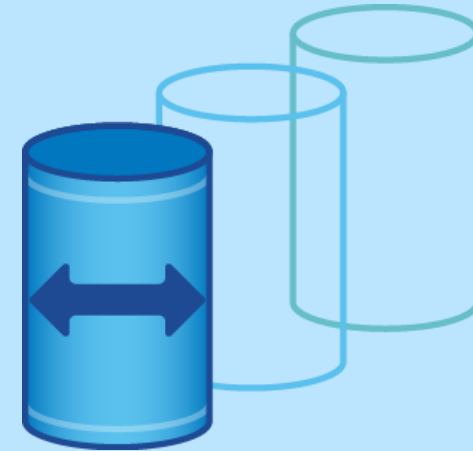


Lesson 5

Volume and file clones

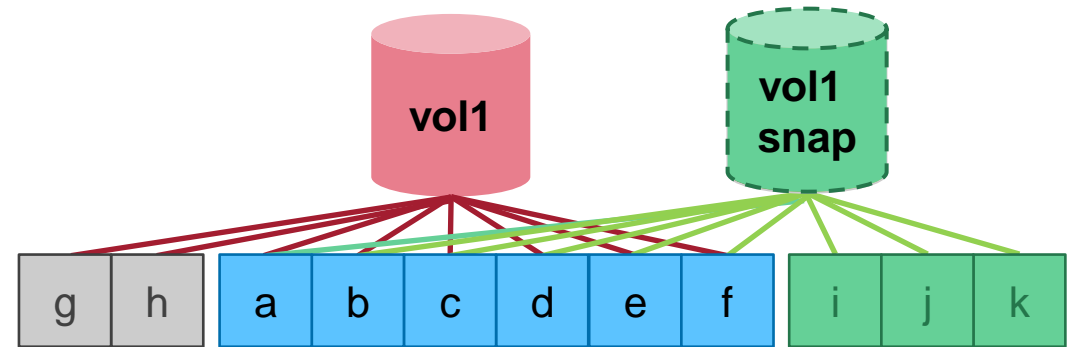
FlexClone technology

- FlexClone software uses block pointers to enable you to create multiple, instant dataset clones (files, LUNs, or entire volumes) with no storage overhead.
- FlexClone technology provides dramatic improvement for application testing and development environments:
 - Create an instantaneous replica of a file or LUN (such as an entire database).
 - Provision thousands of virtual machines (VMs) in seconds by cloning *golden images*.
- Clones can be split from the source, but then make copies of all shared blocks.



How cloning works

- Make a Snapshot copy of the volume.
- Create a clone by adding another pointer to the blocks in the Snapshot copy (blocks A–H):
 - Modifications to the original volume are separate from modifications to the cloned volume (blocks G and H).
 - Modifications to the clone are separate from the original volume (blocks I – K). These blocks are the only drive space that is consumed by the clone.



Clone a volume

The screenshot shows the ONTAP System Manager interface. On the left is a navigation sidebar with sections: DASHBOARD, STORAGE (expanded), and NETWORK. The 'STORAGE' section includes links for Overview, Applications, Volumes (selected), LUNs, Shares, Qtrees, Quotas, Storage VMs, and Tiers. The main panel displays the 'Volumes' page with a table of storage volumes. A context menu is open for the volume 'smb1_share_CIFS_volume', with the 'Clone' option highlighted. A 'Clone Volume' dialog box is open on the right, showing the name 'smb1_share_CIFS_volume_clone', 'Enable thin provisioning' checked, and 'Add a Snapshot copy' selected under 'CLONE PARENT SNAPSHOT COPY'.

	Name	Storage VM	Status	Capacity (available total)
<input type="checkbox"/>	exp_svm3_NFS_volume	svm3	Online	972 MB 1 GB
<input checked="" type="checkbox"/>	smb1_share_CIFS_volume	svm1	Online	972 MB 1 GB
<input type="checkbox"/>	smb2	svm2	Online	972 MB 1 GB
<input type="checkbox"/>	smb3	svm3	Online	972 MB 1 GB
<input type="checkbox"/>	svm1	svm1	Online	17.6 MB 20 MB
<input type="checkbox"/>	svm2	svm2	Online	17.8 MB 20 MB
<input type="checkbox"/>	svm3	svm3	Online	17.5 MB 20 MB
<input type="checkbox"/>	svm4	svm4	Online	18.4 MB 20 MB

Clone Volume

NAME
smb1_share_CIFS_volume_clone

☒ Enable thin provisioning

CLONE PARENT SNAPSHOT COPY

☒ Add a Snapshot copy

☐ Use an existing Snapshot copy

Cancel Clone

```
::> volume clone create -vserver svm3 -parent-volume exp_svm3_NFS_volume  
-flexclone exp_svm3_NFS_volume_clone
```

Split a cloned volume

ONTAP System Manager

Search actions, objects, and pages

?

<>

DASHBOARD

STORAGE

Overview

Applications

Volumes

LUNs

Shares

Qtrees

Quotas

Storage VMs

Tiers

NETWORK

EVENTS & JOBS

PROTECTION

Volumes

+ Add

Delete

Protect

More

	Name	Stor...	Status	Capacity (available total)
<input type="checkbox"/>	exp_svm3_NFS_volume	svm3	Online	972 MB
<input type="checkbox"/>	smb1_share_CIFS_volume	svm1	Online	972 MB
<input checked="" type="checkbox"/>	smb1_share_CIFS_volume_clone	svm1	Online	972 MB
<input type="checkbox"/>	smb2_share_CIFS_volume	svm2	Online	972 MB
<input type="checkbox"/>	smb3_share_CIFS_volume	svm3	Online	972 MB
<input type="checkbox"/>	svm1_root	svm1	Online	17.8 MB
<input type="checkbox"/>	svm2_root	svm2	Online	17.7 MB
<input type="checkbox"/>	svm3_root	svm3	Online	17.5 MB

Edit

Delete

Split Clone

Clone

Take Offline

Enable Quota

Split Clone

Splits the clone from its parent volume and deletes all the Snapshot copies created on the clone. This operation might take several minutes to complete for large volumes.

SELECTED CLONE VOLUME

smb1_share_CIFS_volume_clone

PARENT VOLUME

smb1_share_CIFS_volume

☒ Delete Snapshot copies and split the clone

Cancel

Split

```
::> volume clone split start -vserver svm3 -flexclone svm3_vol_002_clone
```

Clone a file or LUN

ONTAP System Manager

Search actions, c

DASHBOARD

STORAGE

Overview

Applications

Volumes

LUNs

Shares

Qtrees

Quotas

Storage VMs

Tiers

NETWORK

LUNs

+ Add

	Name	Storage VM	V
<input type="checkbox"/>	QA_mongoDB_1	svm_iSCSI	Q
<input type="checkbox"/>	QA	svm_iSCSI	Q
<input type="checkbox"/>	QA	svm_iSCSI	Q

Edit

Delete

Clone

Move

Protect

Add Related LUNs

Clone LUN

NAME

QA_mongoDB_1_clone

Host Information

HOST OPERATING SYSTEM

Windows

HOST MAPPING

☒ Existing initiator group

☒ QA_mongoDB_7Apr21_tuw7_igroup

☐ New initiator group

```
::> volume file clone create -vserver svm5 -volume svm5_vol_002
-source-path file1 -destination-path file1_clone
```

An abstract graphic in the top right corner consisting of a grid of teal-colored cubes. The cubes are arranged in a way that creates a sense of depth and perspective, with some cubes appearing to be in front of others, creating a 3D effect. The overall color is a light teal, matching the background.

Knowledge check

Module 9: Storage efficiency

Knowledge check

Which types of data compression are available in ONTAP software?

- a. inline and external
- b. inline and preprocess
- c. inline and postprocess
- d. inline and reclaimable

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Knowledge check

Data can be written to a FlexClone volume.

- a. true
- b. false

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Knowledge check

A FlexClone volume, by definition, shares no data blocks with the parent volume.

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- b. false

Knowledge check

A FlexClone volume, by definition, shares no data blocks with the parent volume.

- a. true
- b. false

References

- NetApp Hardware Universe: <http://hwu.netapp.com>



- ONTAP 9 Documentation Center:
<http://docs.netapp.com/ontap-9/index.jsp>
 - *Cluster Management Using OnCommand System Manager*
 - *Logical Storage Management Guide*



- TR-4476: NetApp Deduplication, Compression, and Compaction



- Storage Efficiency Video: How NetApp FlexClone Works (YouTube)
https://www.youtube.com/watch?v=c8VI_L5K8VM

Module summary

This module focused on enabling you to do the following:

- Implement storage-efficiency features
- Use FlexClone software volumes



Complete an exercise

Module 9
Storage efficiencies

Managing storage efficiency

Managing FlexClone volumes

Bonus: Creating a FlexGroup volume

- Access your lab equipment.
- Open your Exercise Guide, Module 9.
- Complete Exercises 1 and 2.
- Share your results.

This exercise requires approximately
30 minutes.



Share your experiences

Roundtable discussion

- Were you able to observe storage-efficiency benefits in your exercise environment?
- What are some popular uses for FlexClone volumes?

Addendum

Inline deduplication status

Aggregate inline deduplication

Status

Volume status

```
::> volume efficiency show -vserver svm4 -volume svm4_vol003
      -fields cross-volume-inline-dedupe
vserver   volume           cross-volume-inline-dedupe
-----
svm4      svm4_vol003      true
```

Aggregate status

```
::> aggregate efficiency show -aggregate n1_data_003
                                Aggregate: n1_data_003
                                Node: cluster1-01
Cross Volume Background Deduplication: false
Cross Volume Inline Deduplication: true
Has Cross Volume Deduplication Savings: true
Has Auto Adaptive Compression Savings: false
```

Aggregate inline deduplication

Savings

Aggregate Savings

```
::> aggr show-efficiency -details
```

```
Aggregate: cluster1_ssd_001
```

```
Node: cluster1-01
```

```
Total Storage Efficiency Ratio: 25.22:1
```

```
Total Data Reduction Ratio: 2.57:1
```

```
Aggregate level Storage Efficiency
```

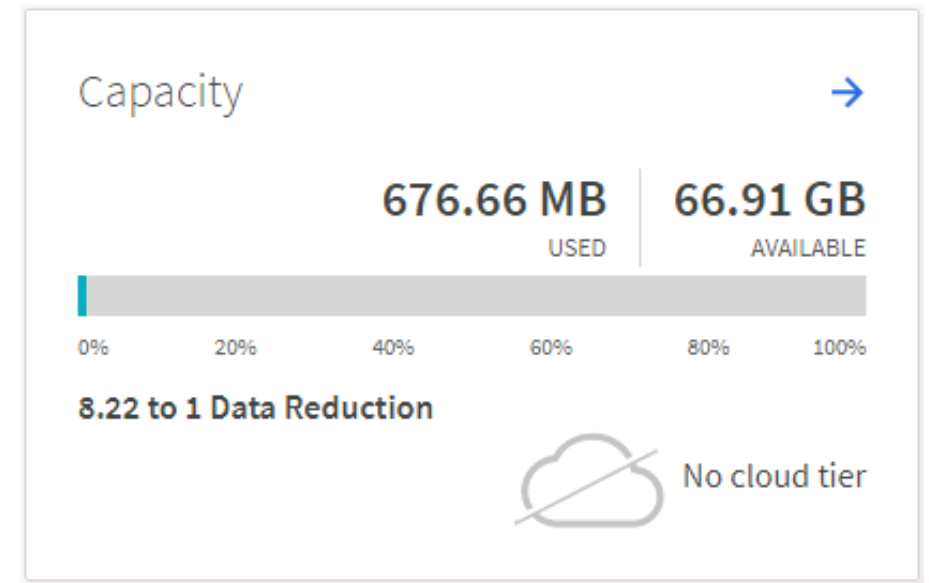
```
(Aggr Dedupe and Data Compaction): 1.33:1
```

```
Volume Dedupe Efficiency: 1.40:1
```

```
Compression Efficiency: 1.29:1
```

```
Snapshot Volume Storage Efficiency: 27.14:1
```

```
FlexClone Volume Storage Efficiency: -
```



The data-reduction ratio includes aggregate inline deduplication savings.