Software RAID services for local attached storage

ONTAP Select

NetApp
December 12, 2019

Table of Contents

Software RAID services for local attached storage

Software RAID is a RAID abstraction layer implemented within the ONTAP software stack. It provides the same functionality as the RAID layer within a traditional ONTAP platform such as FAS. The RAID layer performs drive parity calculations and provides protection against individual drive failures within an ONTAP Select node.

Independent of the hardware RAID configurations, ONTAP Select also provides a software RAID option. A hardware RAID controller might not be available or might be undesirable in certain environments, such as when ONTAP Select is deployed on a small form-factor commodity hardware. Software RAID expands the available deployment options to include such environments. To enable software RAID in your environment, here are some points to remember:

- It is available with a Premium or Premium XL license.
- It only supports SSD or NVMe (requires Premium XL license) drives for ONTAP root and data disks.
- It requires a separate system disk for the ONTAP Select VM boot partition.
    - Choose a separate disk, either an SSD or an NVMe drive, to create a datastore for the system disks (NVRAM, Boot/CF card, Coredump, and Mediator in a multi-node setup).

Notes

- The terms service disk and system disk are used interchangeably.
    - Service disks are the VMDKs that are used within the ONTAP Select VM to service various items such as clustering, booting, and so on.
    - Service disks are physically located on a single physical disk (collectively called the service/system physical disk) as seen from the host. That physical disk must contain a DAS datastore. ONTAP Deploy creates these service disks for the ONTAP Select VM during cluster deployment.
- It is not possible to further separate the ONTAP Select system disks across multiple datastores or across multiple physical drives.
- Hardware RAID is not deprecated.

Software RAID configuration for local attached storage

When using software RAID, the absence of a hardware RAID controller is ideal, but, if a system does have an existing RAID controller, it must adhere to the following requirements:

- The hardware RAID controller must be disabled such that disks can be presented directly to the

system (a JBOD). This change can usually be made in the RAID controller BIOS

- Or the hardware RAID controller should be in the SAS HBA mode. For example, some BIOS configurations allow an “AHCI” mode in addition to RAID, which could be chosen to enable the JBOD mode. This enables a passthrough, so that the physical drives can be seen as is on the host.

Depending on maximum number of drives supported by the controller, an additional controller may be required. With the SAS HBA mode, ensure that the IO controller (SAS HBA) is supported with a minimum of 6Gb/s speed. However, NetApp recommends a 12Gbps speed.

No other hardware RAID controller modes or configurations is supported. For example, some controllers allow a RAID 0 support that can artificially enable disks to pass-through but the implications can be undesirable. The supported size of physical disks (SSD only) is between 200GB – 16TB.

Administrators need to keep track of which drives are in use by the ONTAP Select VM and prevent inadvertent use of those drives on the host.

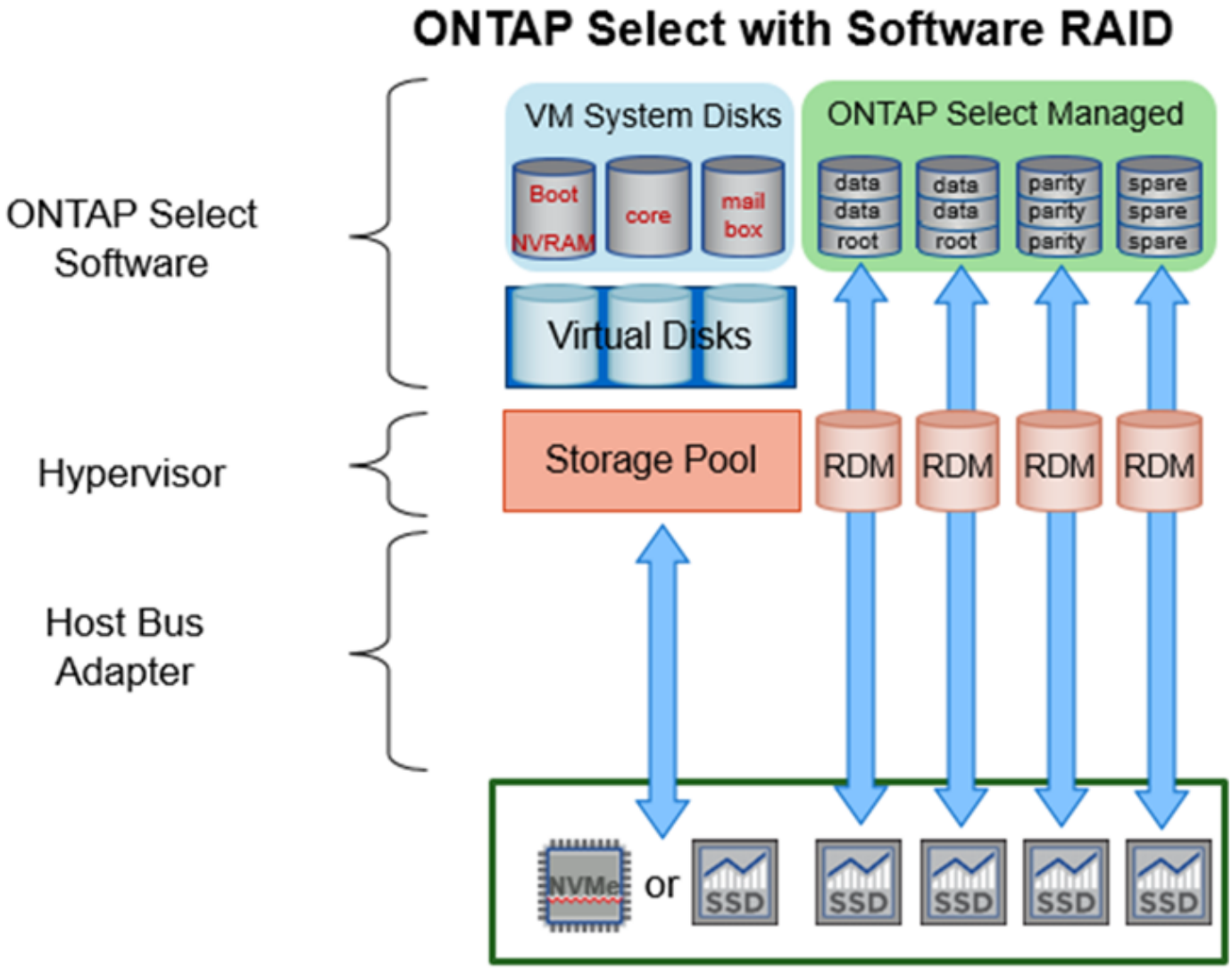
ONTAP Select virtual and physical disks

For configurations with hardware RAID controllers, physical disk redundancy is provided by the RAID controller. ONTAP Select is presented with one or more VMDKs from which the ONTAP admin can configure data aggregates. These VMDKs are striped in a RAID 0 format because using ONTAP software RAID is redundant, inefficient, and ineffective due to resiliency provided at the hardware level. Furthermore, the VMDKs used for system disks are in the same datastore as the VMDKs used to store user data.

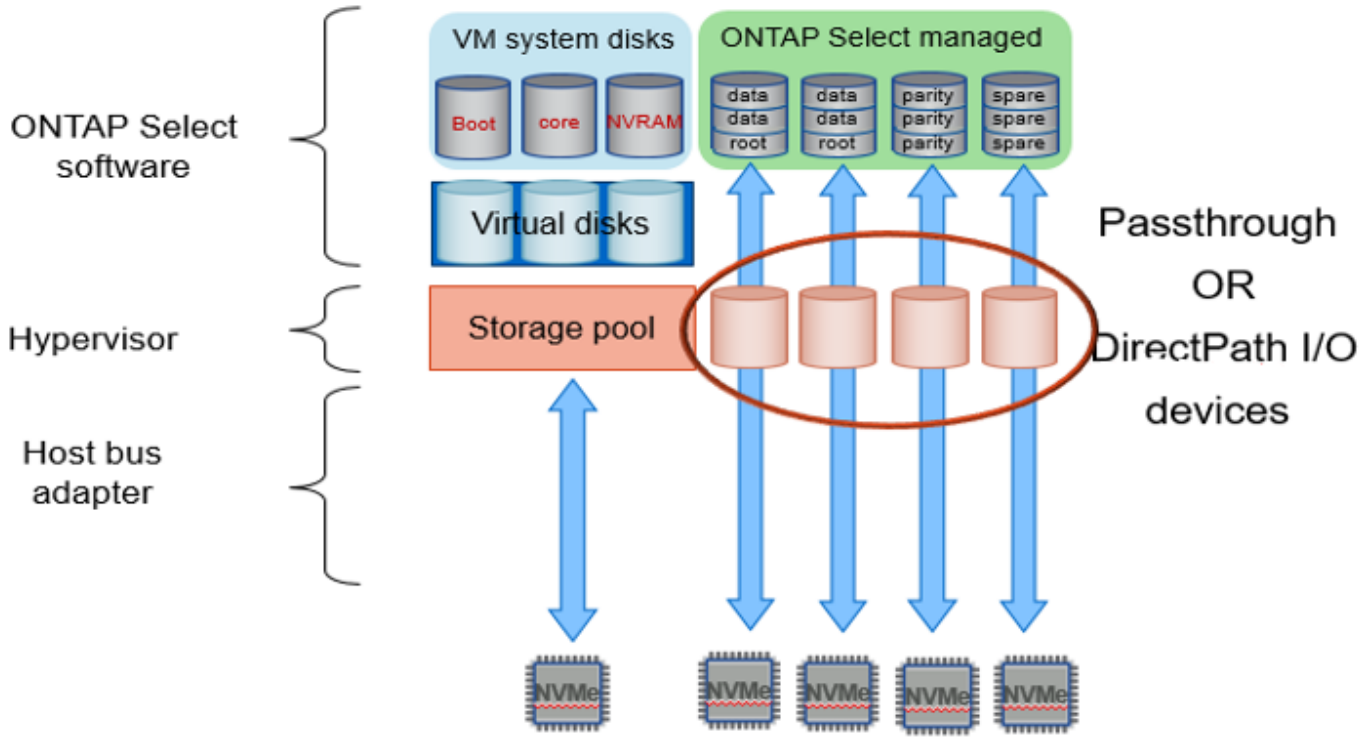
When using software RAID, ONTAP Deploy presents ONTAP Select with a set of virtual disks (VMDKs) and physical disks Raw Device Mappings [RDMs] for SSDs and passthrough or DirectPath IO devices for NVMes.

The following figures show this relationship in more detail, highlighting the difference between the virtualized disks used for the ONTAP Select VM internals and the physical disks used to store user data.

ONTAP Select software RAID: use of virtualized disks and RDMs



The system disks (VMDKs) reside in the same datastore and on the same physical disk. The virtual NVRAM disk requires a fast and durable media. Therefore, only NVMe and SSD-type datastores are supported.



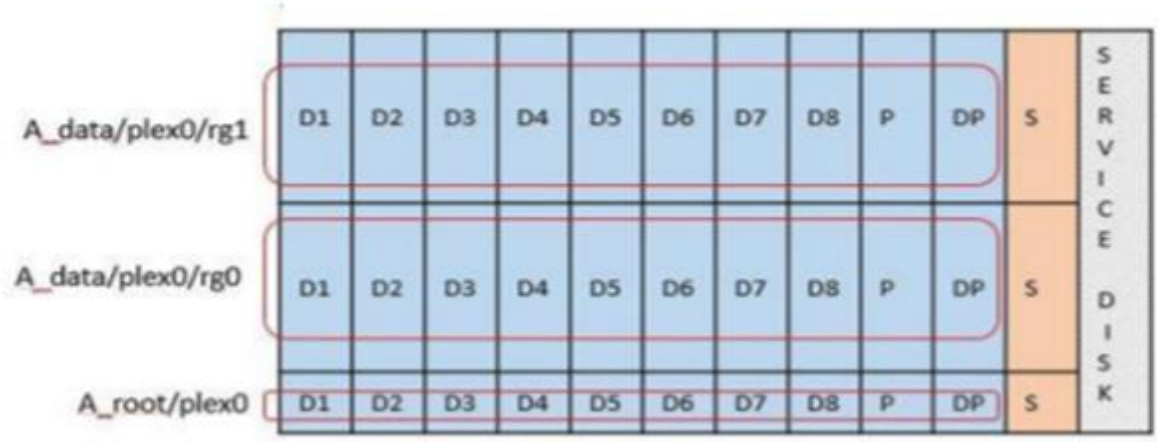
The system disks (VMDKs) reside in the same datastore and on the same physical disk. The virtual NVRAM disk requires a fast and durable media. Therefore, only NVMe and SSD-type datastores are supported. When using NVMe drives for data, the system disk should also be an NVMe device for performance reasons. A good candidate for the system disk in an all NVMe configuration is an INTEL Optane card.

With the current release, it is not possible to further separate the ONTAP Select system disks across multiple datastores or multiple physical drives.

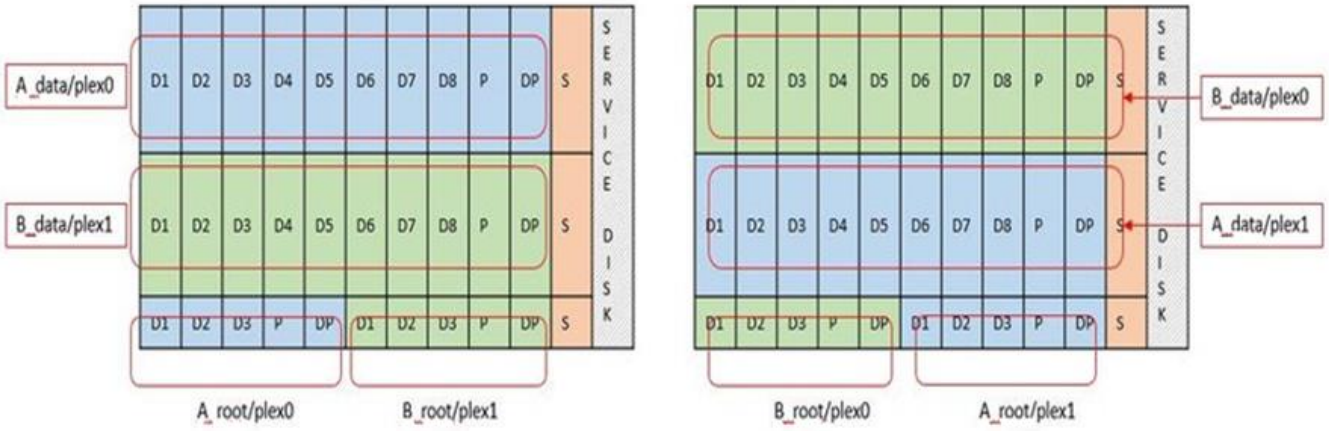
Each data disk is divided into three parts: a small root partition (stripe) and two equal-sized partitions to create two data disks seen within the ONTAP Select VM. Partitions use the Root Data Data (RD2) schema as shown in the following figures for a single node cluster and for a node in an HA pair.

P denotes a parity drive. DP denotes a dual parity drive and S denotes a spare drive.

RDD disk partitioning for single-node clusters



RDD disk partitioning for multinode clusters (HA pairs)



ONTAP software RAID supports the following RAID types: RAID 4, RAID-DP, and RAID-TEC. These are the same RAID constructs used by FAS and AFF platforms. For root provisioning ONTAP Select supports only RAID 4 and RAID-DP. When using RAID-TEC for the data aggregate, the overall protection is RAID-DP. ONTAP Select HA uses a shared-nothing architecture that replicates each node's configuration to the other node. That means each node must store its root partition and a copy of the its peer's root partition. Since a data disk has a single root partition, that the minimum number of data disks will vary depending on whether the ONTAP Select node is part of an HA pair or not.

For single node clusters, all data partitions are used to store local (active) data. For nodes that are part of an HA pair, one data partition is used to store local (active) data for that node and the second data partition is used to mirror active data from the HA peer.

Passthrough (DirectPath IO) devices vs. Raw Device Maps (RDMs)

VMware ESX does not currently support NVMe disks as Raw Device Maps. For ONTAP Select to take

direct control of NVMe disks, the NVMe drives must be configured in ESX as passthrough devices. Please note that configuring an NVMe device as a passthrough devices requires support from the server BIOS and it is a disruptive process, requiring an ESX host reboot. Furthermore, the maximum number of passthrough devices per ESX host is 16. However, ONTAP Deploy limits this to 14. This limit of 14 NVMe devices per ONTAP Select node means that an all NVMe configuration will provide a very high IOPs density (IOPs/TB) at the expense of total capacity. Alternatively, if a high performance configuration with larger storage capacity is desired, the recommended configuration is a large ONTAP Select VM size, an INTEL Optane card for the system disk, and a nominal number of SSD drives for data storage.

To take full advantage of NVMe performance, consider the large ONTAP Select VM size.

There is an additional difference between passthrough devices and RDMs. RDMs can be mapped to a running VM. Passthrough devices require a VM reboot. This means that any NVMe drive replacement or capacity expansion (drive addition) procedure will require an ONTAP Select VM reboot. The drive replacement and capacity expansion (drive addition) operation is driven by a workflow in ONTAP Deploy. ONTAP Deploy manages the ONTAP Select reboot for single node clusters and failover / failback for HA pairs. However it is important to note the difference between working with SSD data drives (no ONTAP Select reboot / failovers are required) and working with NVMe data drives (ONTAP Select reboot / failover is required).

Physical and virtual disk provisioning

To provide a more streamlined user experience, ONTAP Deploy automatically provisions the system (virtual) disks from the specified datastore (physical system disk) and attaches them to the ONTAP Select VM. This operation occurs automatically during the initial setup so that the ONTAP Select VM can boot. The RDMs are partitioned and the root aggregate is automatically built. If the ONTAP Select node is part of an HA pair, the data partitions are automatically assigned to a local storage pool and a mirror storage pool. This assignment occurs automatically during both cluster-creation operations and storage-add operations.

Because the data disks on the ONTAP Select VM are associated with the underlying physical disks, there are performance implications for creating configurations with a larger number of physical disks.

The root aggregate's RAID group type depends on the number of disks available. ONTAP Deploy picks the appropriate RAID group type. If it has sufficient disks allocated to the node, it uses RAID-DP, otherwise it creates a RAID-4 root aggregate.

When adding capacity to an ONTAP Select VM using software RAID, the administrator must consider the physical drive size and the number of drives required. For details, see the section Increasing storage capacity.

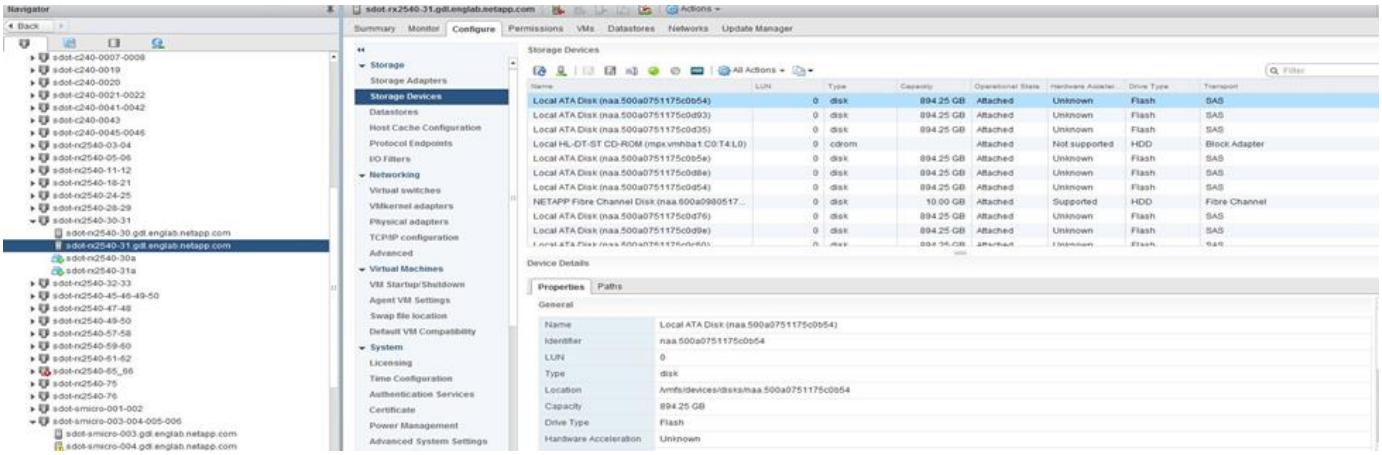
Similar to FAS and AFF systems, only drives with equal or larger capacities can be added to an existing RAID group. Larger capacity drives are right sized. If you are creating new RAID groups, the new RAID

group size should match the existing RAID group size to make sure that the overall aggregate performance does not deteriorate.

Matching an ONTAP Select disk to the corresponding ESX disk

ONTAP Select disks are usually labeled NET x.y. You can use the following ONTAP command to obtain the disk UUID:

```
<system name>::> disk show NET-1.1
Disk: NET-1.1
Model: Micron_5100_MTFD
Serial Number: 1723175C0B5E
UID:
*500A0751:175C0B5E*:00000000:00000000:00000000:00000000:00000000:00000000:00000000:000000
00
BPS: 512
Physical Size: 894.3GB
Position: shared
Checksum Compatibility: advanced_zoned
Aggregate: -
Plex: -This UID can be matched with the device UID displayed in the ‘storage devices’ tab
for the ESX host
```



In the ESXi shell, you can enter the following command to blink the LED for a given physical disk (identified by its naa.unique-id).

```
esxcli storage core device set -d <naa_id> -l=locator -L=<seconds>
```

Multiple drive failures when using software RAID

It is possible for a system to encounter a situation in which multiple drives are in a failed state at the same time. The behavior of the system depends on the aggregate RAID protection and the number of failed drives.

A RAID4 aggregate can survive one disk failure, a RAID-DP aggregate can survive two disk failures, and a RAID-TEC aggregate can survive three disks failures.

If the number of failed disks is less than the maximum number of failures that RAID type supports, and if a spare disk is available, the reconstruction process starts automatically. If spare disks are not available, the aggregate serves data in a degraded state until spare disks are added.

If the number of failed disks is more than the maximum number of failures that the RAID type supports, then the local plex is marked as failed, and the aggregate state is degraded. Data is served from the second plex residing on the HA partner. This means that any I/O requests for node 1 are sent through cluster interconnect port e0e (iSCSI) to the disks physically located on node 2. If the second plex also fails, then the aggregate is marked as failed and data is unavailable.

A failed plex must be deleted and recreated for the proper mirroring of data to resume. Note that a multi-disk failure resulting in a data aggregate being degraded also results in a root aggregate being degraded. ONTAP Select uses the root-data-data (RDD) partitioning schema to split each physical drive into a root partition and two data partitions. Therefore, losing one or more disks might impact multiple aggregates, including the local root or the copy of the remote root aggregate, as well as the local data aggregate and the copy of the remote data aggregate.

```
C3111E67::> storage aggregate plex delete -aggregate aggr1 -plex plex1
Warning: Deleting plex "plex1" of mirrored aggregate "aggr1" in a non-shared HA
configuration will disable its synchronous mirror protection and disable
         negotiated takeover of node "sti-rx2540-335a" when aggregate "aggr1" is online.
Do you want to continue? {y|n}: y
[Job 78] Job succeeded: DONE

C3111E67::> storage aggregate mirror -aggregate aggr1
Info: Disks would be added to aggregate "aggr1" on node "sti-rx2540-335a" in the
following manner:
      Second Plex
        RAID Group rg0, 5 disks (advanced_zoned checksum, raid_dp)
                                                            Usable Physical
          Position   Disk                      Type           Size     Size
          ---------- ------------------------- ---------- -------- --------
          shared     NET-3.2                   SSD               -        -
          shared     NET-3.3                   SSD               -        -
          shared     NET-3.4                   SSD         208.4GB  208.4GB
          shared     NET-3.5                   SSD         208.4GB  208.4GB
          shared     NET-3.12                  SSD         208.4GB  208.4GB
```

```
      Aggregate capacity available for volume use would be 526.1GB.
      625.2GB would be used from capacity license.
Do you want to continue? {y|n}: y

C3111E67::> storage aggregate show-status -aggregate aggr1
Owner Node: sti-rx2540-335a
 Aggregate: aggr1 (online, raid_dp, mirrored) (advanced_zoned checksums)
  Plex: /aggr1/plex0 (online, normal, active, pool0)
   RAID Group /aggr1/plex0/rg0 (normal, advanced_zoned checksums)
                                                            Usable Physical
     Position Disk                      Pool Type     RPM     Size     Size Status
     -------- ------------------------- ---- ----- ------ -------- -------- ----------
     shared   NET-1.1                     0   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-1.2                     0   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-1.3                     0   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-1.10                    0   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-1.11                    0   SSD        -  205.1GB  447.1GB (normal)
  Plex: /aggr1/plex3 (online, normal, active, pool1)
   RAID Group /aggr1/plex3/rg0 (normal, advanced_zoned checksums)
                                                            Usable Physical
     Position Disk                      Pool Type     RPM     Size     Size Status
     -------- ------------------------- ---- ----- ------ -------- -------- ----------
     shared   NET-3.2                     1   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-3.3                     1   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-3.4                     1   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-3.5                     1   SSD        -  205.1GB  447.1GB (normal)
     shared   NET-3.12                    1   SSD        -  205.1GB  447.1GB (normal)
10 entries were displayed..
```

In order to test or simulate one or multiple drive failures, use the `storage disk fail -disk NET-x.y -immediate` command. If there is a spare in the system, the aggregate will begin to reconstruct. You can check the status of the reconstruction using the command `storage aggregate show`. You can remove the simulated failed drive using ONTAP Deploy. Note that ONTAP has marked the drive as `Broken`. The drive is not actually broken and can be added back using ONTAP Deploy. In order to erase the Broken label, enter the following commands in the ONTAP Select CLI:

```
set advanced
disk unfail -disk NET-x.y -spare true
disk show -broken
```

The output for the last command should be empty.

Virtualized NVRAM

NetApp FAS systems are traditionally fitted with a physical NVRAM PCI card. This card is a high-performing card containing nonvolatile flash memory that provides a significant boost in write performance. It does this by granting ONTAP the ability to immediately acknowledge incoming writes back to the client. It can also schedule the movement of modified data blocks back to slower storage media in a process known as destaging.

Commodity systems are not typically fitted with this type of equipment. Therefore, the functionality of the NVRAM card has been virtualized and placed into a partition on the ONTAP Select system boot disk. It is for this reason that placement of the system virtual disk of the instance is extremely important.