Hewlett Packard Enterprise

Multitenancy Capabilities of NimbleOS: Use Cases

Contents

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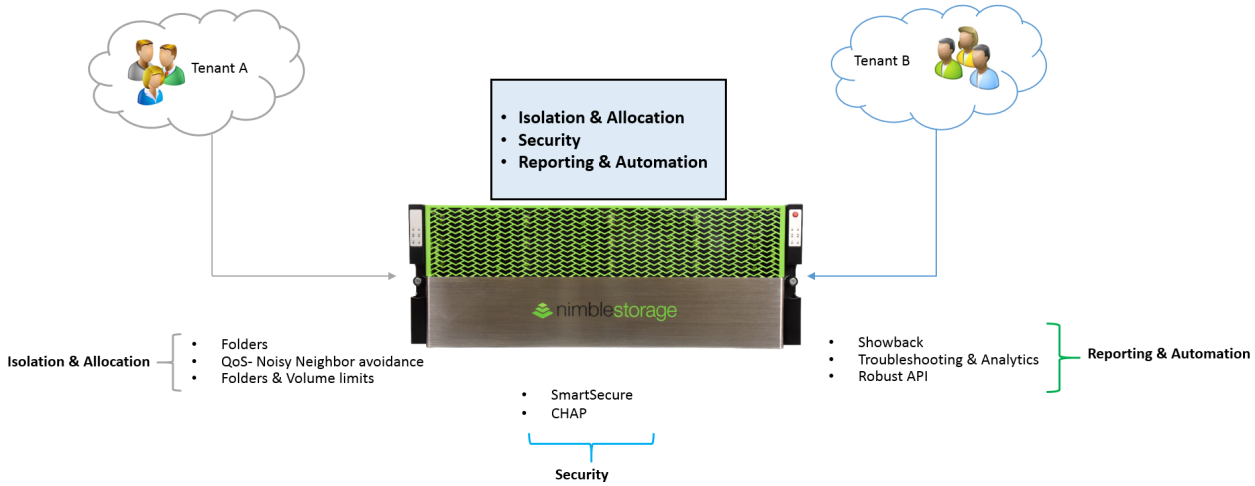
Overview

Multitenancy concepts arise from the need of service providers to carve out pools of infrastructure for multiple customers, also called *tenants*. Ideally, multitenancy design should provide the following benefits:

- Separate user experiences for service provider and tenants
- Explicit support for multiple tenants
- Assured level of performance without affecting other tenants that access the same storage resources
- Security and encryption of tenant data
- Automation of provisioning, administration, and chargeback

Figure 1: Overview of multitenancy



When service providers implement multitenant environments, they often encounter scenarios with different requirements. The multitenancy capabilities of HPE Nimble Storage arrays can fulfill the requirements of a variety of use cases to address the challenges faced by service providers and enterprises to deliver a cloud-based service that is coherent and extensible.

For more information about HPE Nimble Storage multitenancy features, see *Multitenancy Capabilities of NimbleOS*.

Scenario 1

Company A is a service provider that designs and runs IT systems and processes for businesses. It provides IaaS and SaaS to customers across various industries such as healthcare, finance, and education.

Requirements

Company A has two main multitenancy requirements:

- **Ability to configure per-tenant usage control.** The company wants to be able to limit, and ideally to reserve, the amount of resources used by each tenant.
- **Ability to enforce limits on use of resources.** The company wants to be able to prevent tenants from using more resources than expected by limiting capacity or quality of service (QoS). With limits in place, volumes should be throttled as soon as the tenants start using more than their assigned resources.

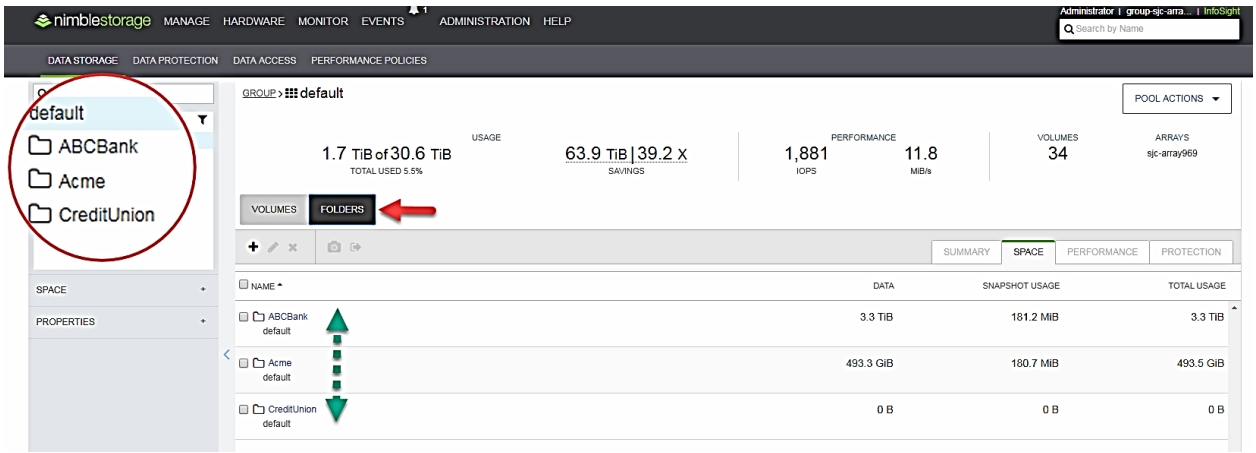
Solution

Company A can use the HPE Nimble Storage QoS feature to control resources such as IOPS, bandwidth, and capacity. The QoS feature can be applied at either the volume level or the tenant folder level.

Using Tenant Folders for Resource Management

With the release of NimbleOS 3.1, Nimble Storage introduced a new construct into the NimbleOS platform called *folders*. Folders are primarily designed to allow service providers to logically separate tenants for various use cases, such as for ease of monitoring, organizational management, grouping of individual customers, or setting limits within a storage pool.

Figure 2: Managing resources with tenant folders



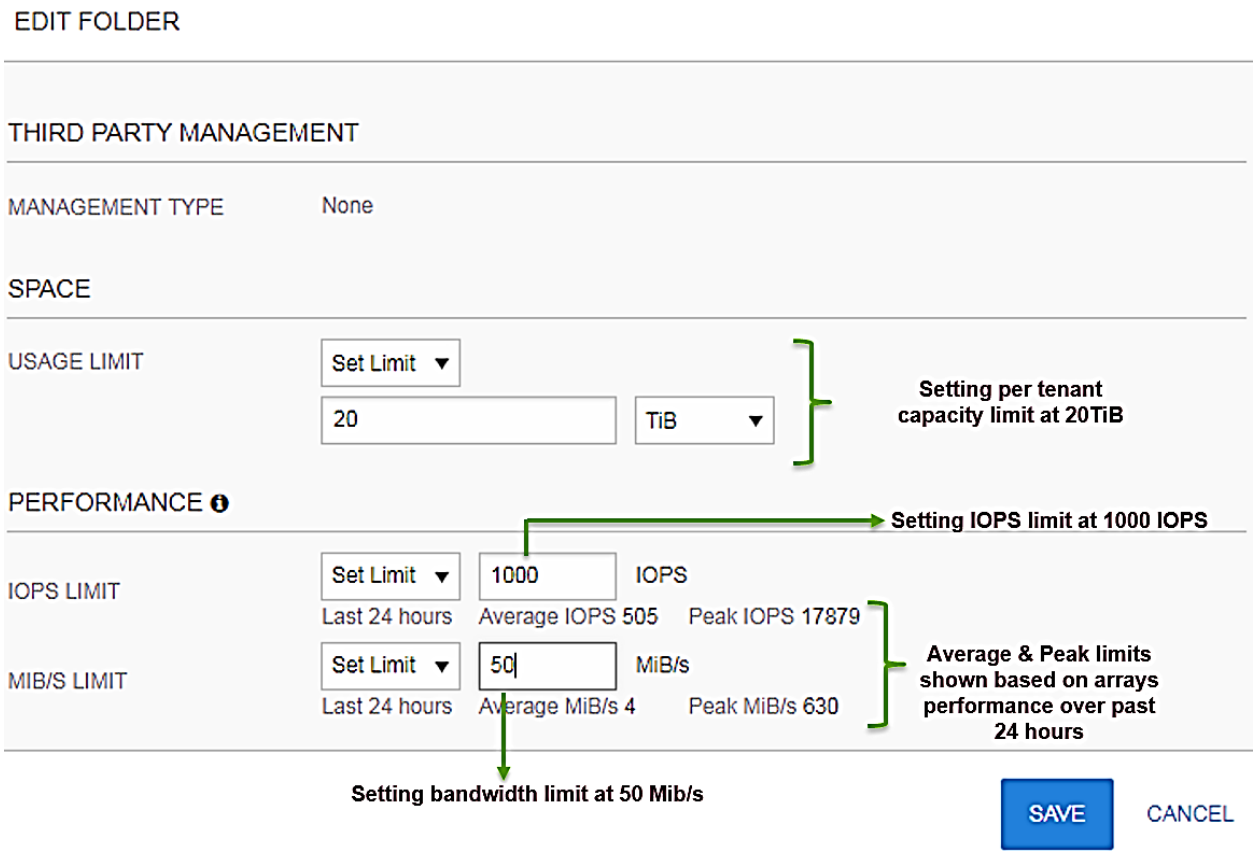
For ease of management, the volumes from a particular tenant can be grouped in a folder for that tenant. Tenant folders also help set operational limits (QoS limits) on space usage (capacity) and performance level (IOPS and bandwidth) for each tenant. Through the use of tenant folders, each tenant can be restricted to or guaranteed certain limits for space and for performance. By default, the upper values for space and performance are unlimited, but service providers can customize them for each tenant.

Using Tenant Folders to Limit IOPS, Bandwidth, and Usage

Tenant folders, which contain all of a tenant's volumes, can be edited individually, with options for limiting capacity and performance per tenant. An added advantage for the service provider is that the NimbleOS GUI provides guidance on limits over the last 24 hours.

In the following figure, Company A, a service provider, has set a space limit of 20 TiB for a particular tenant. It has also restricted performance by setting a limit of 1000 IOPS and a bandwidth of 50 MiB/s. The tenant's volumes will be throttled to keep IOPS and bandwidth within these limits.

Figure 3: Setting QoS limits for tenant folders



The creation of this folder can be automated with the HPE Nimble Storage REST API. The following calls create a folder for tenant BetaCorp. This tenant has a usage capacity of 2000 MiB, an IOPS limit of 1000, and a throughput limit of 50 MiB/s.

Figure 4: Automating folder creation with the REST API

```
client> # Get the pool ID from the pool resource
client> curl -k -H "X-Auth-Token:a9328be12d86dc20b2044fa1fef4f2b4“  -X 'GET'
https://10.18.163.160:5392/v1/pools/detail?fields=name,id
{ "data": [{ "name": "default"
            "id": "0a00000000000004d3000000000000000000000001",
      }]}
client> # Use the pool ID when creating a folder
client> curl -k -H "X-Auth-Token:a9328be12d86dc20b2044fa1fef4f2b4“ -d '{"data":{"name":"Tenant-
BetaCorp","limit_bytes":"2097152000","pool_id":
"2f00000000000004d3000000000000000000000001","limit_iops":"1000","limit_mbps":”50”}}' -X 'POST'
https://192.168.0.101:5392/v1/folders
{"data": { "name": "Tenant-BetaCorp",
         “id": "2f00000000000004d3000000000000000000000003",
         "last_modified": 1505166024,
         “creation_time": 1505166024,
         "limit_iops": 1000
         "limit_mbps": 50,
         "capacity_bytes": 2097152000,
         "pool_id": "0a00000000000004d3000000000000000000000001",
         "pool_name": "default",
         "usage_bytes": 0,
         "usage_valid": true,
         "volume_list": null
   …
}}
```

For more information about using these settings, see *Multitenancy Capabilities of NimbleOS*.

Conclusion

Company A was able to configure per-tenant usage control and set QoS and capacity limits with the help of the HPE Nimble Storage QoS and folder options.

Scenario 2

Company B is a small-to-medium-sized service provider that offers aggregation, integration, deployment, and management of multiple cloud-based applications to deliver a fully managed enterprise application solution. Its chargeback model is based on the amount of storage resources provisioned to each tenant monthly.

Requirements

Company B has the following multitenancy requirements:

- **Reporting and showback.** The company needs to be able to generate reports on used or provisioned capacity and on performance for each of its tenants.
- **Per-tenant resource usage.** The company needs to monitor per-tenant usage (IOPS, MiB/s, and latency).
- **Analytics.** The company wants to be able to predict capacity consumption to ensure that enough resources are available for all tenants.

Solution

HPE InfoSight, the HPE Nimble Storage predictive analytics tool, provides the capabilites that Company B needs to meet its varied information requirements of reporting for showback, per-tenant usage tracking, and analytics.

Reporting and Showback

HPE Nimble Storage arrays provide valuable showback data analysis from which chargeback costs for each department or tenant can be derived. The robust built-in reporting capabilities of HPE InfoSight help enterprises and service providers to analyze resource utilization and create accurate models for charging business units and tenants for the resources that they consume.

Company B can leverage HPE InfoSight capacity reports to track the amount of capacity that each tenant has used and how much capacity remains available. Capacity reports provide in-depth information about capacity utilization across multiple data structures:

- Pools
- Volumes
- Folders
- Applications

This capability helps the service provider to analyze space utilization across various tenants and to monitor capacity requirements across the arrays that provide service.

Figure 5: Capacity report dashboard across all pools

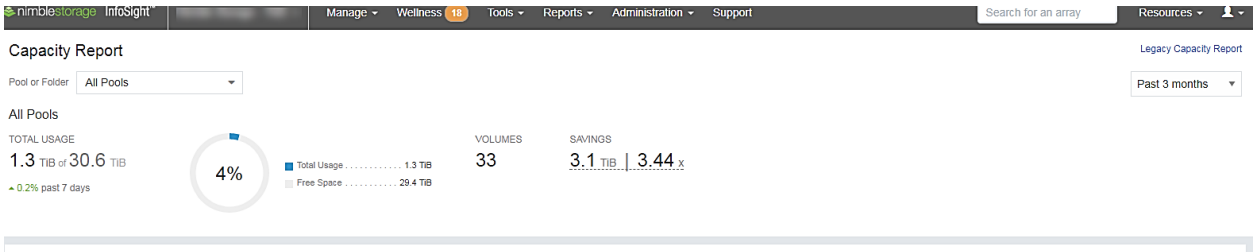


Figure 6: Capacity usage by folder

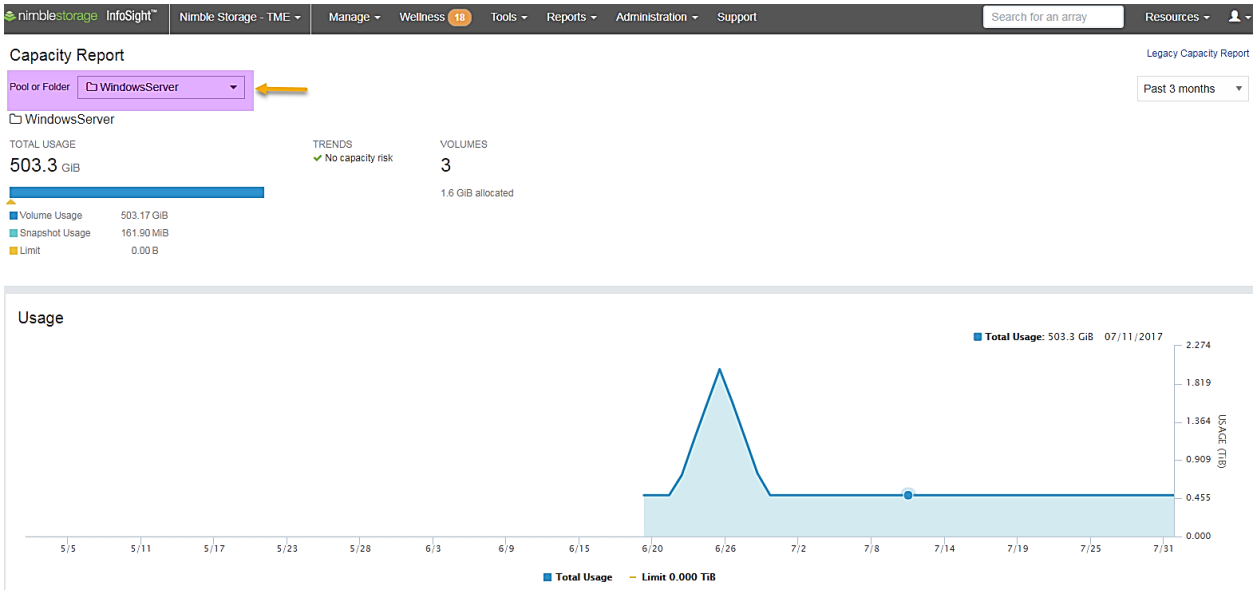
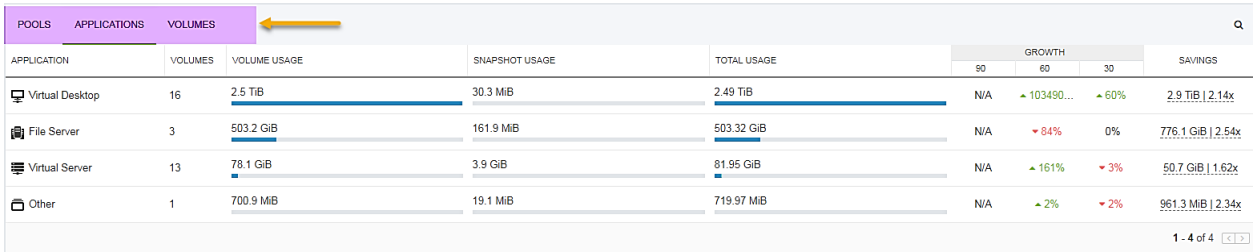


Figure 7: Capacity report based on application type



POOLS | APPLICATIONS | VOLUMES

APPLICATION	VOLUMES	VOLUME USAGE	SNAPSHOT USAGE	TOTAL USAGE	GROWTH 90	GROWTH 60	GROWTH 30	SAVINGS
Virtual Desktop	16	2.5 TiB	30.3 MiB	2.49 TiB	N/A	103490...	60%	2.9 TiB | 2.14x
File Server	3	503.2 GiB	161.9 MiB	503.32 GiB	N/A	84%	0%	776.1 GiB | 2.54x
Virtual Server	13	78.1 GiB	3.9 GiB	81.95 GiB	N/A	161%	3%	50.7 GiB | 1.62x
Other	1	700.9 MiB	19.1 MiB	719.97 MiB	N/A	2%	2%	961.3 MiB | 2.34x

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The capacity report also provides the ability to look back a year for reporting purposes.

Figure 8: Reporting back on capacity and usage

```
client> curl -k -H "X-Auth-Token:a9328be12d86dc20b2044fa1fef4f2b4“ -X 'GET'
https://10.18.163.160:5392/v1/folders/detail?fields=name,capacity_bytes,free_space_bytes,usage_bytes,usage_valid,id
{ "data": [
    { "name": "Tenant-FunCorp",
      "id": "2f00000000000004d3000000000000000000000001",
      "capacity_bytes": 3145728000,
      "free_space_bytes": 3145728000,
      "usage_bytes": 0,
      "usage_valid": true
    }]}
```

The same usage information can be retrieved through the REST API. A folder may be created with a usage limit. The REST API reports back the limit as a capacity. The folders resource also reports back the used and free space in bytes. The usage bytes are the consumed blocks in all the volumes in the folder. The usage and free space are valid only when the usage_valid parameter is set to true.

The REST API can be used to retrieve all the folders in one REST call, or individual calls can be used to retrieve each tenant folder individually. If a service provider wants showback information on provisioned usage

instead of consumed usage, the REST API can be used to get the size of all the volumes in the folder. The provisioned size would be the sum of the size of each volume returned.

Figure 9: Retrieving usage through the REST API

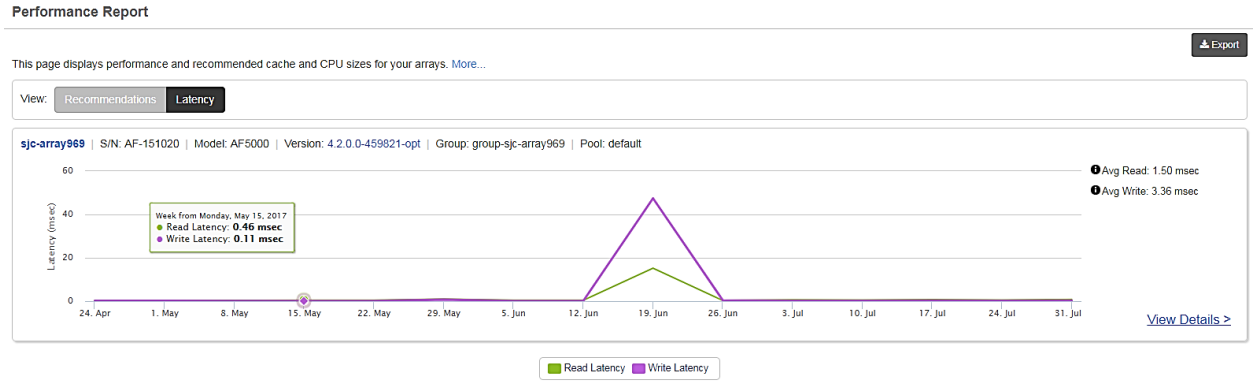
```
client> curl -k -H "X-Auth-Token:a9328be12d86dc20b2044fa1fef4f2b4" -X 'GET'
https://10.18.163.160:5392/v1/volumes/detail?folder_id=2f00000000000004d3000000000000000000000001\&fields=name,size,id
{ "data": [
    { "id": "0600000000000004d3000000000000000000000002",
      "name": "vol2",
      "size": 2000
    },
    { "id": "0600000000000004d3000000000000000000000004",
      "name": "vol3",
      "size": 3000
    },
    { "id": "0600000000000004d3000000000000000000000003",
      "name": "vol1",
      "size": 1000
    }
  ]}
```

Per-Tenant Resource Usage

Company B can also leverage the performance reports that are available on HPE InfoSight to gain insights into the performance of individual folders and volumes so that it can comply with the SLA that its has guaranteed its tenants.

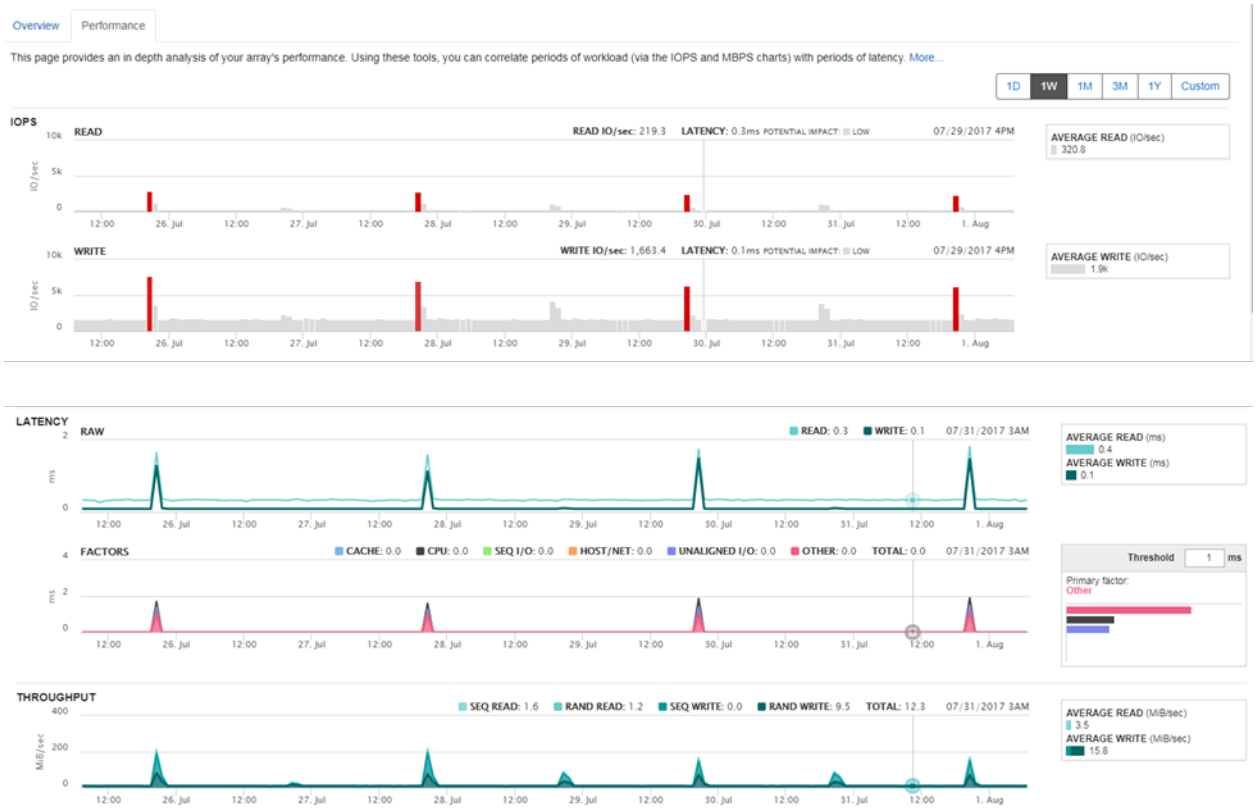
Performance reports display performance information and provide recommended cache and CPU sizes for all arrays. They also offer views into latency across various timeframes. These insights into latency provide a valuable indication of how the array is performing for various workloads.

Figure 10: Performance report



The View Details link in performance reports gives access to the HPE InfoSight page that shows a detailed analysis of the array's performance. On this page, service providers can correlate periods of workload activity (by looking at the IOPS and throughput graphs) with periods of latency.

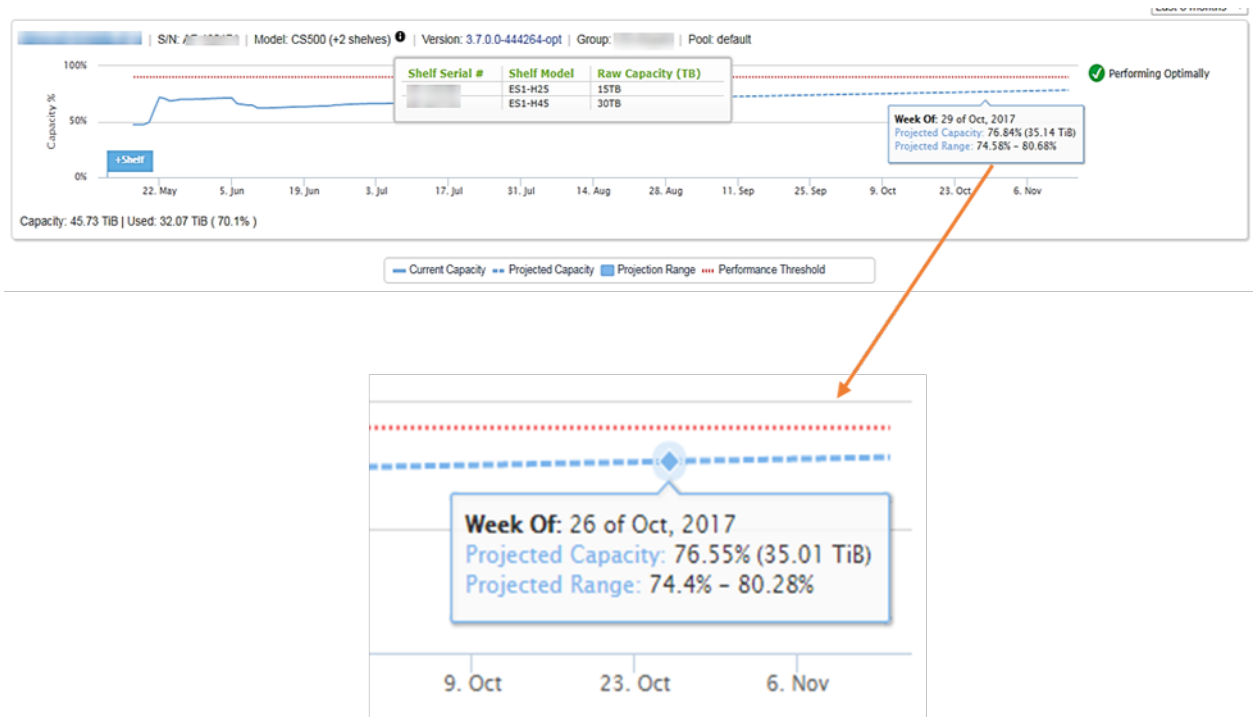
Figure 11: Detailed performance analysis



Analytics

Company B also has a requirement for analytics so that it can predict capacity utilization across the array to ensure that enough resources are present for all of the tenants. With HPE InfoSight, Company B can forecast what the overall capacity utilization will be for a future date. This is all done through the award-winning analytics of HPE Infosight.

Figure 12: Predicting future capacity utilization



Conclusion

Company B can leverage HPE InfoSight to create performance and resources utilization reports to help it administer accounts and charge its tenants as required. With these reports, Company B can stay on top of resource utilization and ensure that it delivers the promised QoS to its tenants.

Scenario 3

Company C has an on-premises private cloud, and it distributes resources to individual departments. Its tenants are in-house developers who create and manage applications and who must comply with various regulatory requirements.

Requirements

Company C has a hard requirement to keep its tenants separated. Separation is necessary because the company's developers of infrastructure services work on applications that require them to comply with numerous regulations.

The company has two specific multitenancy requirements:

- **Per-tenant access control and isolation.** The company needs to configure per-tenant data access controls to prevent tenants from seeing each other’s data.
- **Per-tenant data encryption and shredding.** The company needs to enable data encryption and shredding on a tenant-by-tenant basis.

Solution

HPE Nimble Storage arrays give Company C the ability to control and restrict volume access and to encrypt and shred data on a tenant-by-tenant basis.

Per-Tenant Access Control and Isolation

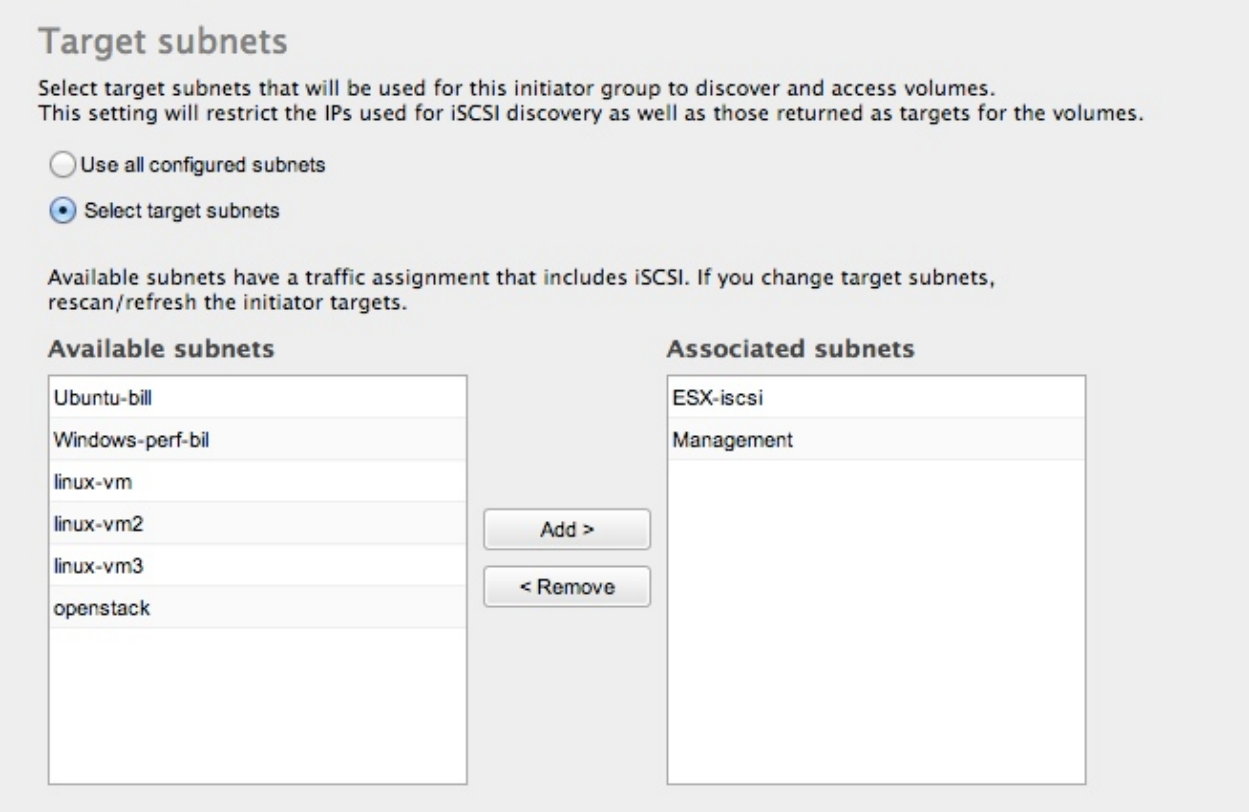
When multiple developer teams access the same resources, it is important to segregate their access. Per-tenant data access control can be achieved through iSCSI initiator groups and the Challenge Handshake Authentication Protocol (CHAP) access methodology.

Network isolation for tenants can be achieved by configuring initiator groups to allow volume discovery only on selected subnets. In the following figure, the initiator group has been configured with two subnets:

- ESX-iscsi
- Management

Therefore, when a host with the assigned iSCSI qualified name (IQN) issues a volume discovery, the HPE Nimble Storage array responds either on the management IP address or on the IP address configured for the ESX-iscsi subnet.

Figure 13: Selecting target subnets

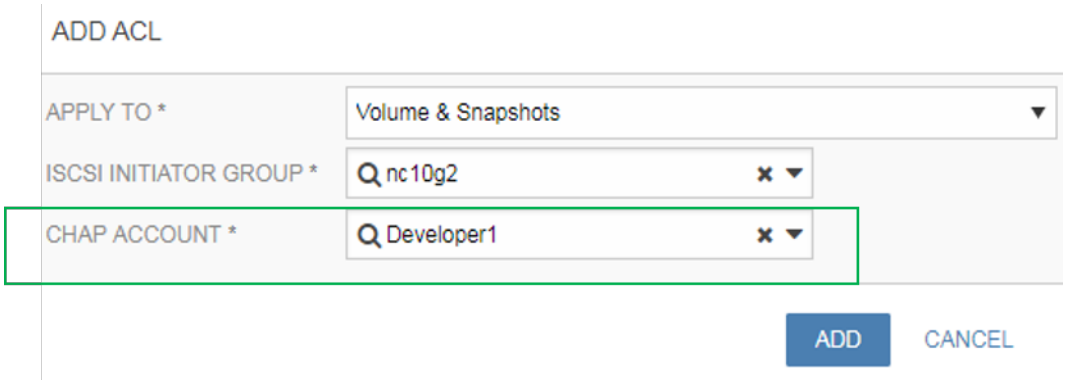


Another way to limit access to iSCSI volumes is through the use of CHAP. CHAP users share a designated secret: a word, a phrase, or a series of characters that both the array and the initiator know. The array allows access only to those iSCSI initiators that respond with the correct secret.

Company C can create CHAP accounts for individual developer groups and then associate the iSCSI initiator groups for the developer group with their respective CHAP accounts.

Figure 14: Creating a CHAP account

Figure 15: Associating an initiator group with a CHAP account



Company C can restrict access to the volumes associated with a certain initiator group to only the servers on which the CHAP user and secret have been configured. With distinct CHAP users and secrets for each department, the company can ensure that the data is segregated by department so that each department sees only the volume and data that were created for it.

Per-Tenant Data Encryption and Shredding

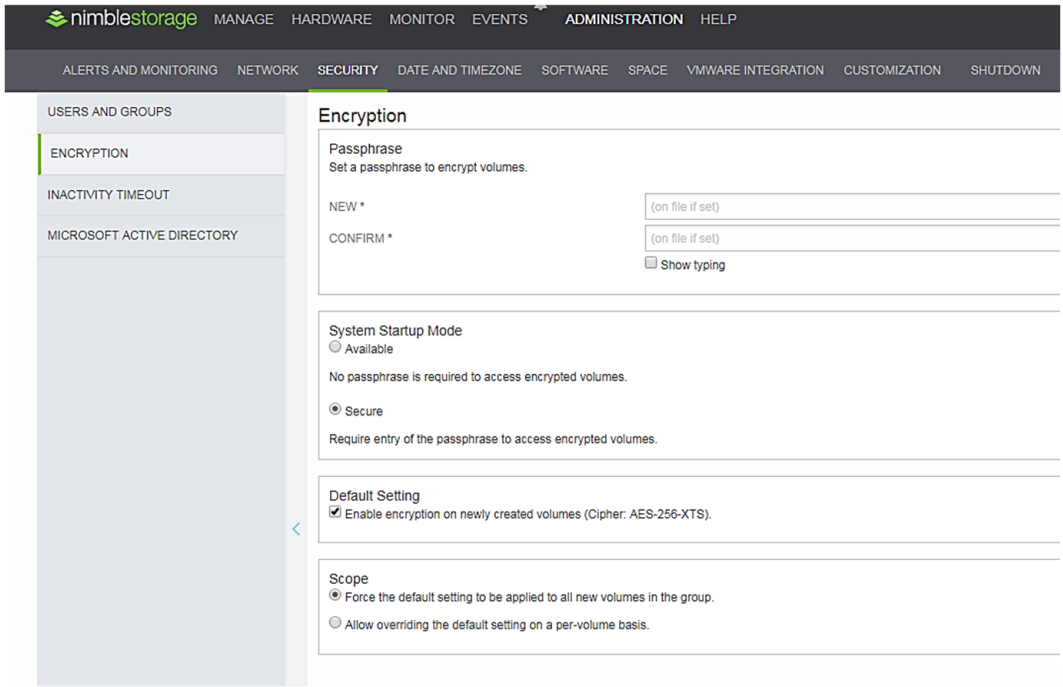
Because of the importance of securing data, encryption at rest is highly developed in HPE Nimble Storage arrays, making it one of the pillars of HPE multitenancy values. The HPE Nimble Storage SmartSecure encryption feature maintains management simplicity, at no additional licensing cost, with zero impact to performance, and with the ability to add extra security and certificates, if necessary.

HPE Nimble Storage SmartSecure allows the creation of one encryption key per volume, as opposed to one key per disk, to provide per-volume choice. This capability also enables per-volume or per-tenant shredding. Simply deleting a volume removes access to the key that is associated with that volume.

Encryption is accomplished by using AES-256 in XTS cipher mode, which is the cipher mode designed specifically for storage. Both algorithms (AES-256 and XTS) are validated by the FIPS 140-2 standard. Data encryption keys are stored locally in an encrypted table that can be decrypted only by using a master key, which is in turn encrypted with a passphrase that the user creates when initializing encryption for the first time.

For Company C to be able to provide Export Administration Regulations (EAR) services, the encryption service must be initialized, or set up. The setup involves generating the master key that is used to encrypt all volume keys. The master key is then encrypted by a passphrase. The service provider must keep the passphrase secure. The passphrase is required for setting a new passphrase and for changing the operation mode of encryption at rest.

Figure 16: Setting the master passphrase



Conclusion

Company C is able to provide restricted access for individual developer groups and also to encrypt each volume that is associated with a developer group.

Scenario 4

Company D manufactures touchscreen monitors, computers, and signage. It has an on-premises environment that supports all of its engineering and QA teams.

Requirements

In Company D, multiple engineering and QA teams want to administer and provision their own resources. The company plans to build custom dashboards and provision access based on the roles that are required for each group.

For example, Company D wants to provide access for the engineering group to create and delete their own volumes. It also wants to enable the QA team to maintain their own snapshots for each of the volumes that they own.

Solution

HPE Nimble Storage arrays provide a REST API that can help Company D to set up and maintain a custom dashboard. The dashboard can then provide access to various HPE Nimble Storage array features.

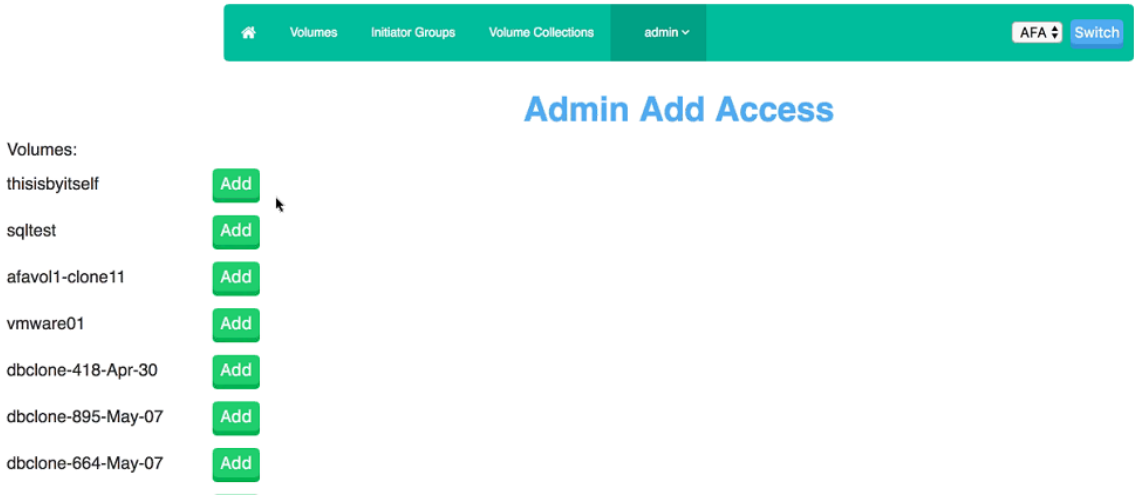
The following list contains some of the object sets that Company D can use to create a custom dashboard:

- `access_control_records`
- `active_directory_memberships`
- `alarms`
- `application_categories`
- `application_servers`
- `arrays`
- `audit_log`
- `chap_users`
- `disks`
- `events`
- `fibre_channel_configs`
- `fibre_channel_initiator_aliases`
- `fibre_channel_interfaces`
- `fibre_channel_ports`
- `fibre_channel_sessions`
- `folders`
- `groups`
- `initiator_groups`
- `initiators`
- `jobs`
- `snapshot_collections`
- `snapshots`
- `software_versions`
- `space_domains`
- `subnets`
- `tokens`
- `user_groups`

- `users`
- `versions`
- `volume_collections`
- `volumes`

The following figures show examples of custom dashboards that were created by using the HPE Nimble Storage REST API. In the first case, a specific user is given access to a set of volumes.

Figure 17: Adding access to volumes



After access is granted, the user can manage the clones and the snapshots of those volumes.

Figure 18: Managing volumes

Conclusion

By using the HPE Nimble Storage REST API, Company D can create custom dashboards that will enable its engineering and QA teams to provision and administer their own resources.

Scenario 5

Company E provides disaster recovery (DR) as a service for its customers.

Requirements

Company E has multiple customers who back up their production data from their on-premises HPE Nimble Storage arrays to Company E's multitenant HPE Nimble Storage arrays. Company E must ensure that these customers can leverage its multitenant HPE Nimble Storage arrays to also replicate the data in their on-premises arrays.

Solution

Company E can leverage HPE Nimble Storage replication and HPE InfoSight reporting capabilities to address the requirement.

HPE Nimble Storage arrays provide both scheduled backup and scheduled replication with retention policies, using the native HPE Nimble Storage SmartSnap, SmartReplicate, and SmartCopy technologies. It is possible to bring environments up on the DR site for testing without the need to break replication as well as to recover VMs, files, and full volumes.

Company E can use the HPE Nimble Storage array in its data center as the downstream array to provide DR services. The upstream arrays are in the tenant's data center, where the tenant stores primary data on HPE Nimble Storage arrays. The replication must be coordinated and set up on both the upstream and the downstream arrays. The schedules must be configured on the upstream arrays.

Before replication can be set up, the networking between the tenant and Company E's data center must be configured to allow communication between the data IP addresses and the management IP address of the two HPE Nimble Storage arrays. Replication uses ports 4213 and 4214.

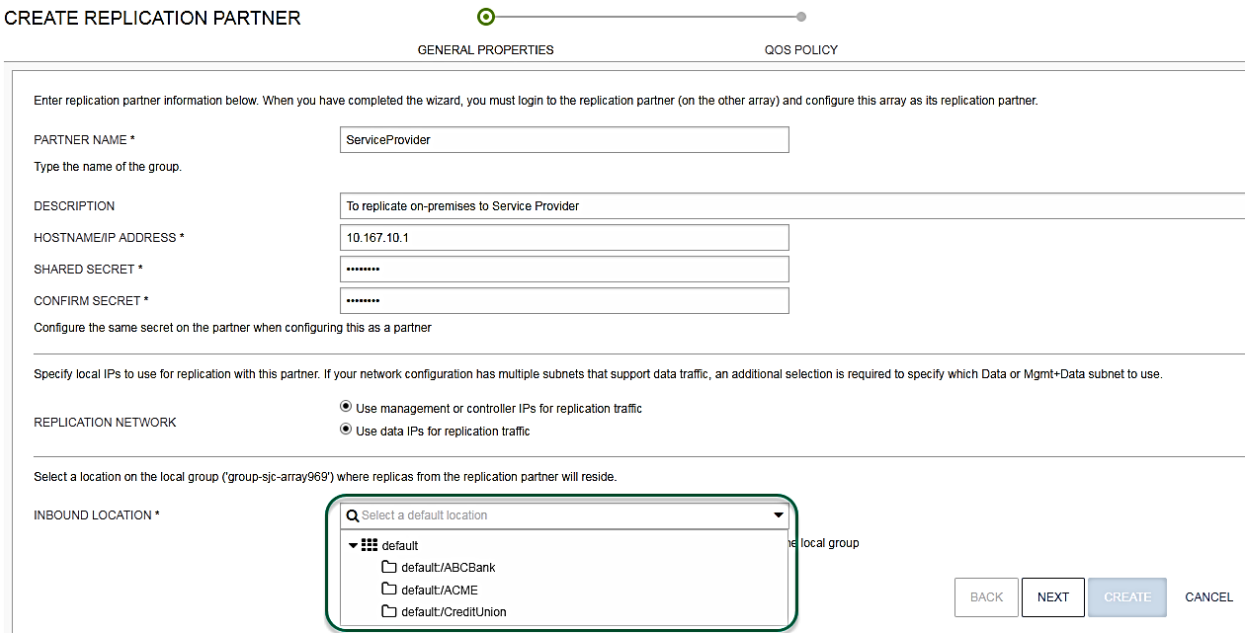
In addition, the names of the two groups must be exchanged by the service provider and the tenant, and a shared secret must be communicated to the tenant. The secret must be between 8 and 255 characters long.

With the group names and the secret known, replication partners can be created both on the upstream array in the tenant's data center and on the downstream array in Company E's data center. The arrays use the secret to ensure that replication partnership is established with the correct group (the security does not rely solely on the name of the group). If the networking is set up correctly, and the group name and the secret are correct, the partners will communicate with each other and show up as online in the NimbleOS GUI.

Company E can host up to 50 tenants on the same array, and it should create a unique secret for each tenant and replication relationship. Company E should also create a default folder for the replication partner so that all volumes that are replicated will be created in that folder. Then reporting and monitoring can be done in relation to the volumes in that folder. Company E can set a usage limit on the folder to make it easier to track and find tenants that exceed the expected or purchased usage.

The following example shows how Company E might set up replication to accept replication from a tenant.

Figure 19: Creating a replication partner



Creating replication partners enables two arrays to replicate volume collections that are based on a defined schedule. The tenant can create a volume collection and use the partner that points to the service provider's group. Any volumes that are associated with the volume collection are automatically created in the service provider's group within the tenant folder that is specified by the service provider.

In a DR situation, the volumes in the service provider's data center can be cloned and served to local servers in the service provider's data center, which can then bring up the tenants' applications. Another option to recover from a DR situation would be to perform a handover and switch the direction of replication (potentially to a separate HPE Nimble Storage array) to send the data back to the tenant's data center.

Conclusion

Company E can easily leverage the replication benefits of HPE Nimble Storage arrays to ensure that its tenants have a safe and easy way to back up their data elsewhere.

About the Author

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Bharath Ram specializes in virtualization technologies for servers and desktops and in storage solutions for data centers. He has extensive experience with the VMware and Citrix product portfolios, and he has worked on numerous projects to integrate these products with HPE Nimble Storage offerings. Before joining HPE, Bharath was a solution architect for other storage companies where he implemented virtual desktop and application solutions for the healthcare and insurance domains.

Version History

Version	Release Date	Description
1.0	October 2017	Initial release