Assimilation Overview

Published 2026-11-20

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HAMMERSPACE

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About This Documentation

The assimilation process enables Hammerspace to serve and manage data without the need to first physically relocate it. Hammerspace achieves this by separating a typical data migration into two parts:

- Assimilation
- Data Orchestration

In this document, we will discuss the basic components of an assimilation, and provide a high-level overview of what you should expect when migrating data and your clients to Hammerspace.

An assimilation is the ingest of all existing file and folder metadata that is required to serve data using the new Hammerspace global namespace. The following diagram outlines this process of metadata being imported into the Hammerspace Anvil metadata server.

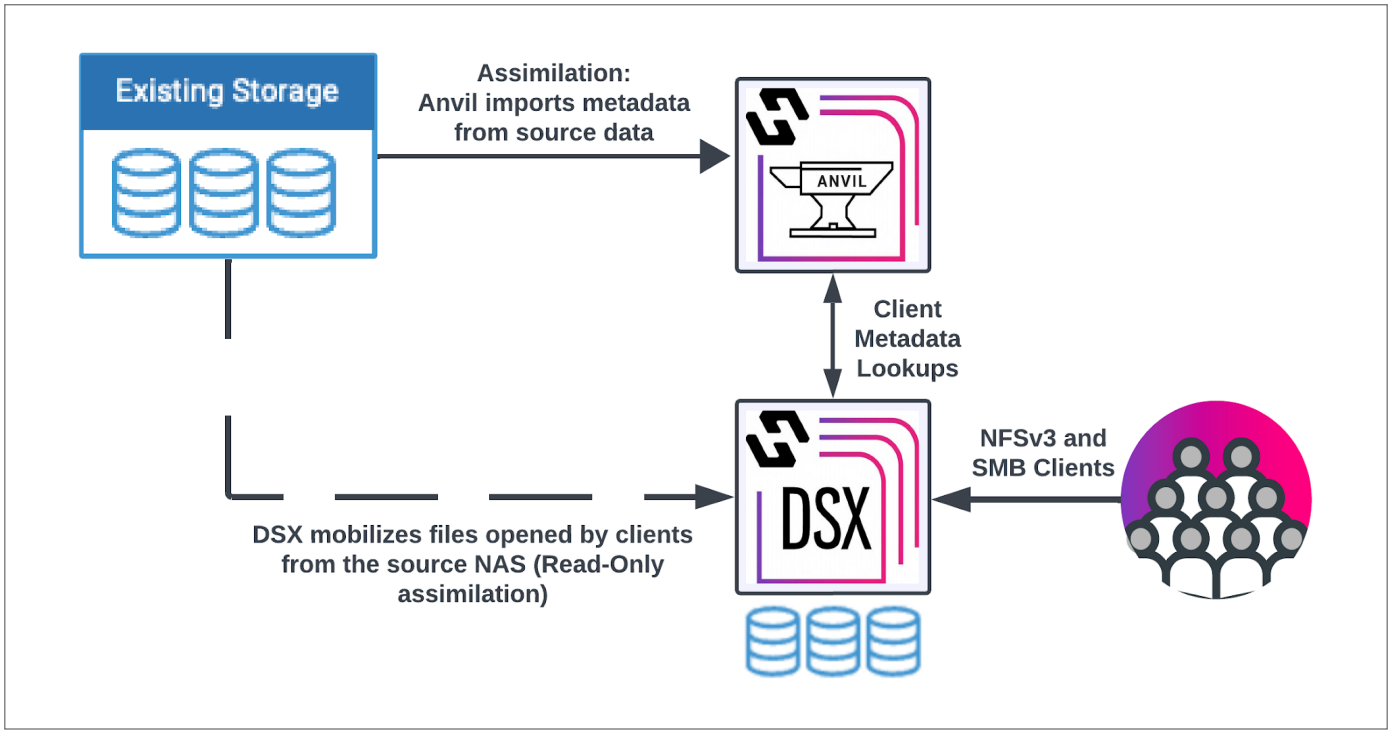


Figure 1. Metadata being imported with Hammerspace assimilation

Assimilation is on-demand and a background operation. Once the root of the source volume is assimilated, users can begin to access the data using Hammerspace. If a user happens to navigate to a file or folder that hasn't yet been assimilated, Hammerspace will assimilate that folder or file on demand and provide immediate access.

Assimilation can be used to combine many different sources (exports, volumes, different vendors) and combine them into a new namespace. The namespace is not stitched or symlinked together, but rather represented as a new share using Hammerspace. Additionally, traditional data services such as snapshots, clones, tiering, archiving and data replication are now managed using Hammerspace functionality.

To open a support case, use the Hammerspace Support Hub. To download Hammerspace software and licenses, use the Hammerspace Licensing and Delivery Portal.

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Do not install additional or third-party software, agents, or packages directly on Hammerspace Anvil (metadata) or DSX (data) nodes. These nodes run a managed appliance software stack; anything installed outside that stack is unsupported and is removed during a software upgrade. Such software can also interfere with node operation. If you need monitoring or integration with an external tool, contact Hammerspace Support for a supported approach.

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Chapter 1. Data Orchestration

The orchestration of assimilated data, an optional step that is directed using Hammerspace objectives, can start immediately after the assimilation has begun. The following diagram shows this orchestration underway. The data on the existing NAS has already begun to migrate even though the assimilation itself has not yet completed.

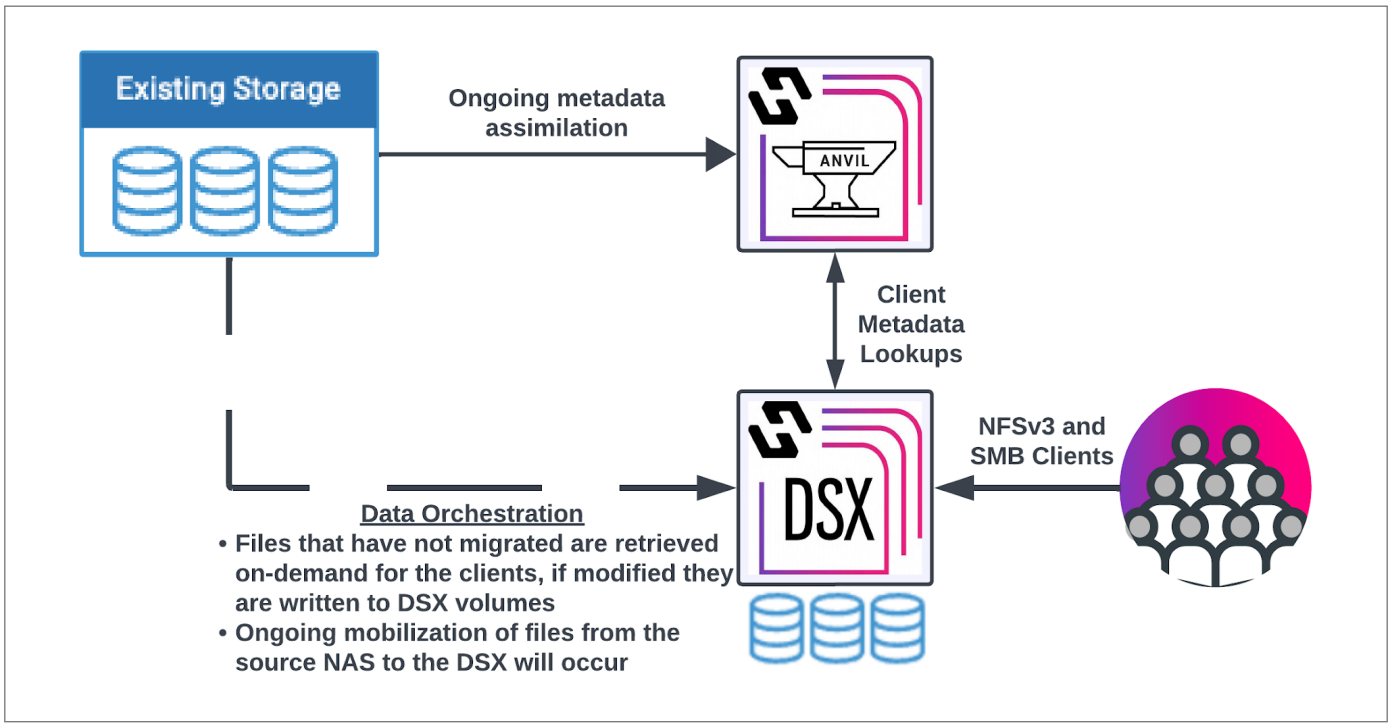


Figure 2. Data orchestration

Figure 2: Data Orchestration of Assimilated Data

The diagram above shows a basic Hammerspace implementation that is performing a read-only assimilation where the source NAS contents are not modified. All files that are changed will be written to the Hammerspace DSX node.

However, you may opt to continue using the existing storage, leverage Hammerspace DSX nodes as an additional tier, and even add external object storage as yet another tier. Hammerspace orchestration enables data to be moved between attached storage volumes without downtime, and in a manner that is invisible to the clients.

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Chapter 2. Assimilation - Under the Hood

When Hammerspace assimilates data, all existing file metadata is extracted and stored in the Anvil metadata database including all file details, timestamps, and any other values you may know. Hammerspace also extends the metadata to include new values to support Hammerspace data orchestration.

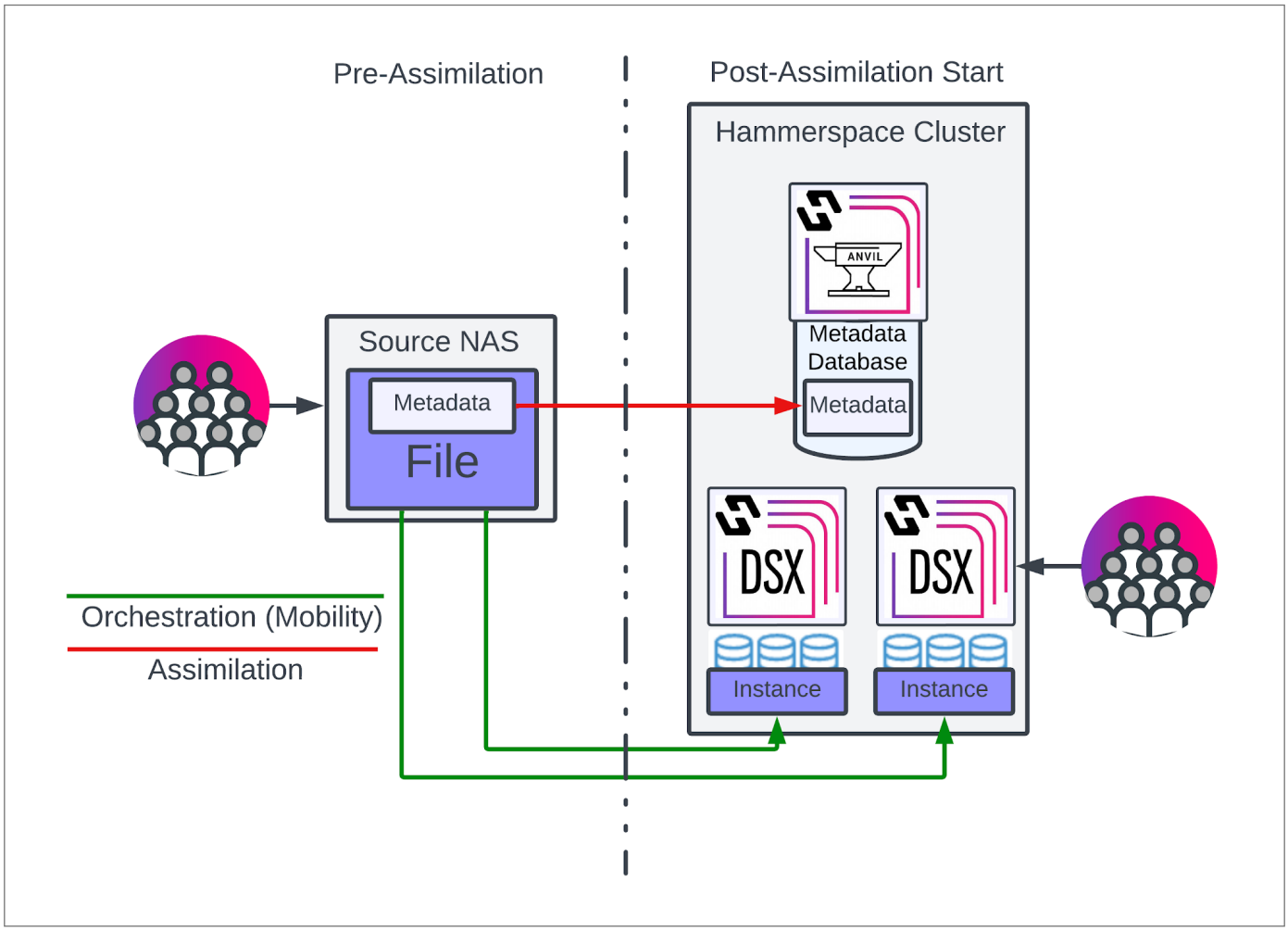


Figure 3. Assimilation - under the hood

Figure 3: Hammerspace Assimilation

In the diagram above, we see a typical NAS environment on the left, including the file with its metadata. While functional, this architecture makes interacting with the file metadata inefficient as any metadata operation will compete with file IO operations. If you attempt to layer data orchestration on top of this legacy architecture, the chances that it would impact file IO performance would only increase.

On the right, we see how the file and its metadata have been separated so that the metadata is hosted within a dedicated database on Hammerspace Anvil nodes. Interacting with the metadata has no direct impact on the file IO data managed by Hammerspace DSX nodes. The file instances are placed in one or more writable volumes as directed by Hammerspace objectives, filed away into a customized comb structure that simplifies the process of storing and locating them.

Even with this re-architecture of how file metadata is stored and how file instances are managed, the client

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interacts with the file system just as they did before. They see the same file and folder structure, permissions, and file metadata, but the underlying storage can now orchestrate data invisibly based on whatever requirements the organization requires.



In the example above, two instances of the file were created using Hammerspace objectives. Refer to the Objectives Guide for more details on how Hammerspace objectives are designed and implemented.

2.1. File Instances and the Comb Structure

Clients do not interact with the stored files directly. They instead connect to a virtual portal that uses the Hammerspace Anvil metadata database to present a view of the filesystem. On disk, the files are renamed and placed into an optimized comb structure of folders.

In the following example, we used the Hammerspace Toolkit to query the file metadata and list where the actual file instances reside.

```
$ hs eval -e this telemetry.txt | grep -e VOLUME -e PATH
VOLUME = STORAGE_VOLUME('hs-dsx-2.catalyst.local::/hsvol1'),
PATH = "/PrimaryData/Instances/1/0/3240/v65-f1-8000000000008ca6",
VOLUME = STORAGE_VOLUME('S3-Bucket-East'),
PATH = "000245/5D/0002455D3FD88C6E4DA03440A35CD744238D9CD21DFEAEDBC15D4E93349535F3F3BA0000000000000245",
VOLUME = STORAGE_VOLUME('S3-Bucket-West'),
PATH = "000245/5D/0002455D3FD88C6E4DA03440A35CD744238D9CD21DFEAEDBC15D4E93349535F3F3BA0000000000000245",
```

As you can see, there are 3 instances of the `telemetry.txt` file available. One is located on a Hammerspace DSX node (`hs-dsx-2.catalyst.local`) while the other two are located on object storage volumes (`S3-Bucket-East` and `S3-Bucket-West`). Note that the instances do not reuse the actual file name or path that the end user sees. Only the metadata database holds those values.

The naming of the instance files and folders in the comb structure is done to optimize the performance of the metadata database, as well as the interaction with the file instances.



- All files placed in offline object storage volumes are deduplicated; those larger than 4MB are chunked beforehand.
- Files placed on online DSX storage nodes or NFS volumes are written as is, but still renamed according to the comb structure rules.

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Chapter 3. Assimilation Types

Hammerspace offers two types of assimilations:

- **Read-Write** - This option should be selected when the existing NAS platform will continue to be used, but Hammerspace will take over the responsibility of serving the NAS namespace (including hosting the file metadata), extending the namespace to other Hammerspace sites, performing any needed data orchestration or providing data services like snapshots, versioning, etc.
  - Note that just because the existing NAS platform will be used, the option of using additional writeable storage, including Hammerspace DSX nodes, other NAS devices, or even object storage volumes is still available.
  - If the source volume is writable, Hammerspace will create a comb structure (if objectives instruct it to) and place modified files within. The existing folder structure will not be modified.
- **Read-Only** - Used when migrating off of existing NAS sources, the source volume is left untouched even after the data migration has been completed.



You must have at least one writable storage volume available (such as a Hammerspace DSX node) before performing a read-only assimilation.

Once the assimilation has completed, objectives enable data to be orchestrated wherever you prefer without any further disruption to the clients.

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Chapter 4. Assimilation Phases

The following diagram shows the three high-level phases of an assimilation. Note that the assimilation and data migration phases can overlap.

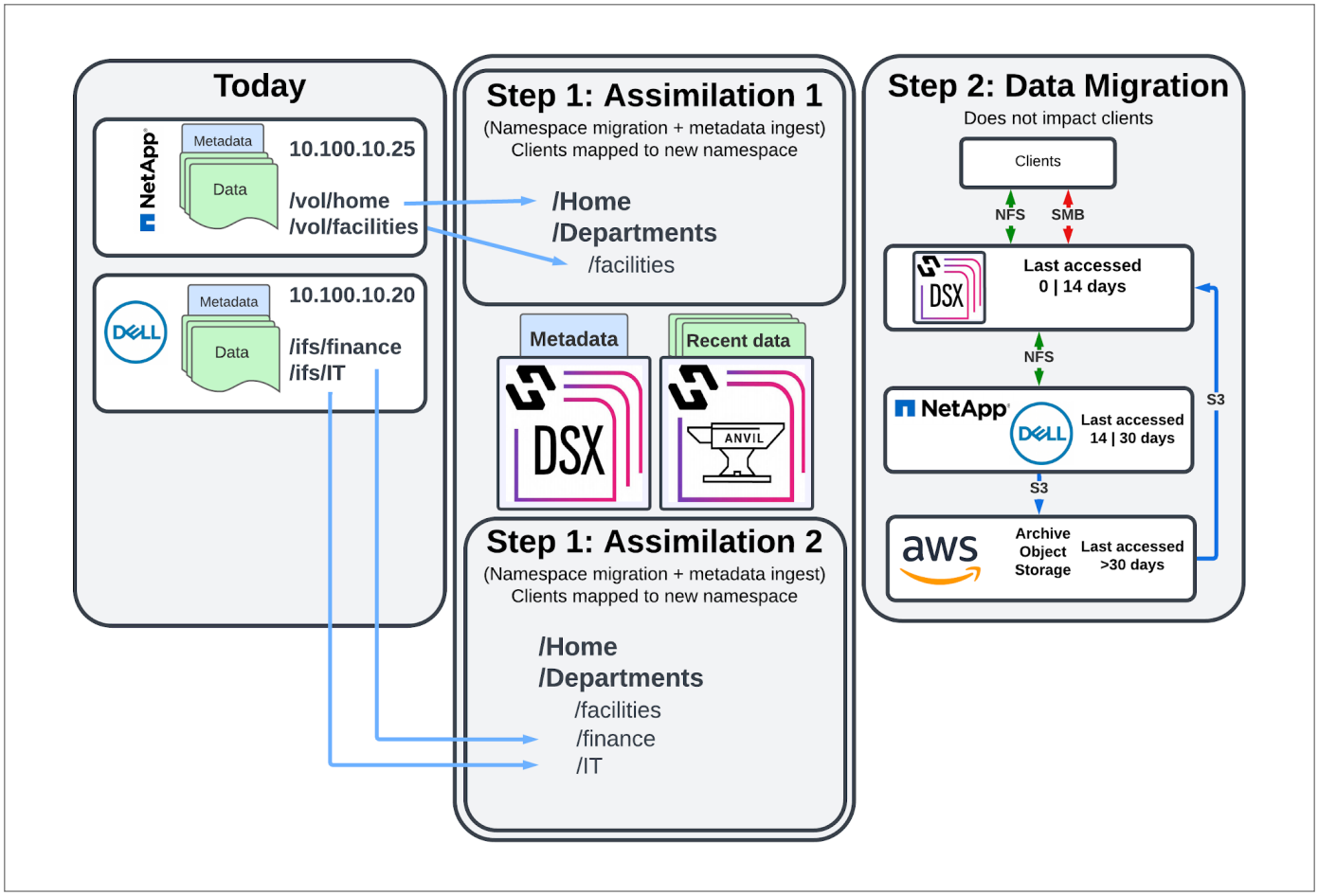


Figure 4. Assimilation phases

Figure 4: Hammerspace Assimilation Phases

- **Pre-Assimilation Phase** - In this phase, no changes have been made and clients are still connected to the original NAS source(s). Typical activities during the phase include planning how the migration to Hammerspace will proceed, designing the new namespace, assessing the source data (file counts and capacity), and verifying client compatibility (with Hammerspace) and connectivity requirements.
- **Assimilation Phase** - The assimilation process is where the existing namespace (the file/folder metadata) is migrated to Hammerspace on a per share/export basis, and clients are then connected to Hammerspace to access that data.
  - It is also possible to replicate the namespace to another Hammerspace site at this time.
  - Immediately prior to an assimilation, clients are typically disconnected from the shares/exports that are being assimilated.
  - Shortly after the assimilation begins, clients are connected to the new share/export now hosted by Hammerspace.

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- ***Data Orchestration Phase (Optional)*** - In this phase, Hammerspace data orchestration begins to move data based on the share objective configuration.
  - This process has no impact on client access to data, and can include the mobilizing of data to additional Hammerspace sites in a global file system.

These phases are described in greater detail in the following sections.

4.1. Pre-Assimilation Phase

Hammerspace recommends breaking down assimilation planning into a series of dependent tasks. In this section, we will review the most common tasks that are critical to ensuring a supported, successful assimilation.

4.1.1. Verify Sources Support Assimilation

The first step in the pre-assimilation phase is to confirm that the assimilation source is supported. While it is possible to migrate data manually using third party tools, none of those are able to minimize downtime and overall effort required like an assimilation.

The following are the core requirements in order to be able to use the assimilation process:

- NFSv3 is required for assimilation, even if no NFSv3 clients access the data today.
  - If NFSv3 is not supported, then data must be migrated to Hammerspace manually using tools such as robocopy or rsync.
- If the SMB ACLs (referred to as AD Metadata in the Hammerspace GUI) must also be assimilated, the source NAS should:
  - Support simultaneous NFSv3 and SMB access. If it does not, then the SMB ACLs cannot be assimilated and the Hammerspace share root folder ACLs will be applied to the assimilated files.

While copying SMB ACLs is not required in order to assimilate data, all custom ACLs will be lost and replaced with the new share defaults if Hammerspace is unable to assimilate the AD Metadata.



Some source NAS devices, such as NetApp, may have unique volume configurations that impact the ability of Hammerspace to accurately assimilate AD metadata. Consult Hammerspace support for any NAS-specific assimilation requirements or recommendations.

4.1.2. Review Share multi-Protocol Requirements

The next step in the pre-assimilation phase is to assess any multi-protocol access requirements on a per-share/export basis. Hammerspace supports RFC2307/RFC2307bis to enable consistent ID mapping across Windows and Linux environments. As such, any customer that has multi-protocol shares will need to take steps to ensure that there are no interruptions in access post-migration to Hammerspace.

The steps required to implement RFC2307/RFC2307bis will be unique to each customer, and in many cases require guidance outside the scope of this document. Hammerspace will provide general guidance where possible, but the customer is ultimately responsible for making the changes needed to support RFC2307/RFC2307bis.

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The following is a high-level outline of common tasks often required for customers who are new to RFC2307 and Hammerspace:

- Any NAS-based manual user mapping will need to be migrated to Active Directory (uid/gid attributes for RFC2307, uid/gid/member attributes for RFC2307bis).
- Any many to one or one to many Unix to AD mappings should be converted to globally unique, one to one mappings to ensure a predictable experience.
- UID and GID values must be unique throughout the Active Directory forest.

4.1.3. Designing Your Global Namespace

Planning for the unification of all namespaces is a key part of ensuring that the assimilation process proceeds without any unexpected complications. When assimilating from more than one source NAS, or from a source NAS that is using some sort of multi-tenancy functionality, an examination of the existing namespaces should be performed with confirmation of the following:

- Are there any duplicate share/export names among all the assimilation sources?
  - If duplicates exist, only one can keep the original name.
  - This includes duplicates that are present in separate tenants such as Isilon zones or NetApp SVMs (discussed next).
- Does the source NAS utilize any multi-tenancy capabilities such as Isilon zones or NetAPP SVMs? If so, please note:
  - A Hammerspace cluster can be placed on multiple networks, though each will see all available shares unless a feature like access-based enumeration (enabled using objectives) is used.
  - As mentioned previously, share names must be unique across the entire global namespace.
- Does the structure of the source share/exports impact the migration plan? For example:
  - If the entire share/export cannot be assimilated in a single session from the root folder, how will you manage the transition?
  - If the share/export contains aliases that provide access to subfolders, have you documented those so that they can be created after the assimilation has started?

Where possible, Hammerspace recommends obtaining a combined list of all NAS sources and all current share/export names to utilize during planning of the new namespace design. While Hammerspace will prevent you from creating shares with duplicate names, it is much easier to identify this ahead of time and plan for how to mitigate it then after the fact.

4.2. Assimilation Phase

This document will refer only to assimilation tasks that involve Hammerspace, as it is assumed that the reader is familiar with what is required to migrate clients, applications, and so on to a new location. This includes identifying data owners, verifying any unique requirements, identifying post-cutover test criteria and who will perform the tests, and determining what defines a successful cutover and migration.

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4.2.1. Prepare for the Assimilation Start

Prior to performing the assimilation, you should prepare the destination Hammerspace share. The following tasks are most commonly performed during or after the share creation process:

- Apply any needed objectives
- Configure the NFS export rules
- Configure the SMB share (not folder) permissions
- Configure the share root folder permissions if AD Metadata will not be assimilated

4.2.2. Start the Assimilation

Once the destination Hammerspace share has been created, you are ready to begin the assimilation process.

An assimilation typically proceeds in the following order:

1. Stop any applications that are actively writing to the assimilation source share/export to ensure that the data on disk is application consistent.
2. Modify the NFS export rules so that only Hammerspace cluster IPs can access the export (**NFS outage begins at this time**).
3. If assimilating SMB ACLs, modify the share permissions (not folder) so only the Hammerspace AD service account has access to the share (**SMB outage begins at this time**).
4. Start the assimilation process and monitor the progress using the task-list command. Once the root folder of the source has been assimilated, clients can be connected to the share/export on Hammerspace (**NFS/SMB access to share/export root is restored**).
5. Recreate any SMB aliases as needed; note that you should access the alias target folders prior to creating the alias to ensure that they have been assimilated. Once the aliases have been created, SMB clients can be connected to them on Hammerspace (**SMB access to share aliases is restored**).

You can also choose to assimilate from a NAS snapshot, though you should still plan to stop client access to the live source volume prior to beginning the assimilation. Reason being if you are assimilating from a snapshot and clients are still connected to the live share/export, any changes they make will not be captured during the assimilation.



Snapshots are primarily recommended for performing a test assimilation, as you should not attempt to assimilate from a volume where clients are actively writing data.

4.3. Data Orchestration Phase

Almost all Hammerspace implementations will include some sort of data orchestration, even if the orchestration is to occur later. Here are the most common scenarios where orchestration is used:

- Move data from the source NAS to a new location.
- Move data that has not been used for some time to an object storage volume.

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- Move data to one or more storage tiers based on when it was last used, or some other determining factor.

It is important to note that many Hammerspace implementations include all three of the previous orchestration examples. For more examples of how Hammerspace objectives are used to orchestrate data, refer to the Objectives Guide.

When leveraging Hammerspace to migrate data from an existing NAS, the process typically happens in the following order:

1. Assimilate the source volume.
2. Migrate data using Hammerspace objectives.
3. Decommission the data source volume to formally end the data migration.

In the following section, we will provide more detail about the tasks related to data orchestration and migration.

4.3.1. Data Orchestration - Configuration

In most cases, data orchestration will be explicitly controlled using Hammerspace objectives. The following collection of objectives shows a three-tier configuration where files are moved to ("placed on") one of three tiers based on when they were last used:

Objective	Condition
place-on-NFS-NVMe-Tier1	LAST_USE_AGE < 14*DAYS
place-on-NFS-SSD-Tier2	LAST_USE_AGE >= 14*DAYS AND LAST_USE_AGE ⇐ 45*DAYS
place-on-S3-Tier3	LAST_USE_AGE > 45*DAYS

Default Orchestration Behaviors

Some data orchestration will occur due to the default share objectives. While the details regarding when and why these orchestrations might occur is outside the scope of this document, some common examples include:

- Data being moved to object storage if the current NAS volume reaches a certain threshold.
- Newly created files being written to DSX volumes, rather than the attached legacy NAS volumes.
- Two copies of a file being created for resiliency purposes.

In most cases, you will configure your own objectives that place data based on your requirements.

4.3.2. Migrating Data Using Hammerspace

When migrating from an existing storage platform to Hammerspace, you will typically initiate a data migration using two methods:

- Implement Hammerspace objectives that relocate the data to the desired location(s); this can be at any point after the assimilation has begun.

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- Decommission the source NAS storage volume once the assimilation is complete; this will cause the cluster to move any files that have not yet migrated using the highest priority mobility type.



The decommission process is always the last step in a data migration, even if the files were relocated using the share objective. Once the decommission process completes, the source volume will be removed from the Hammerspace cluster to signal that it is no longer required.

4.3.3. Observing Orchestration Activity

The Hammerspace GUI provides both a list-based and graphical representation of the data orchestration activities, which the cluster refers to as mobilities.

The following image shows an example of the Hammerspace mobility chord diagram that depicts files moving from several volumes to several different volumes.

- The dark end of the bar represents where the files are moving to.
- The light side represents where they are moving from.

This diagram is typical of a migration that is moving files from a large number of volumes to another group of volumes.

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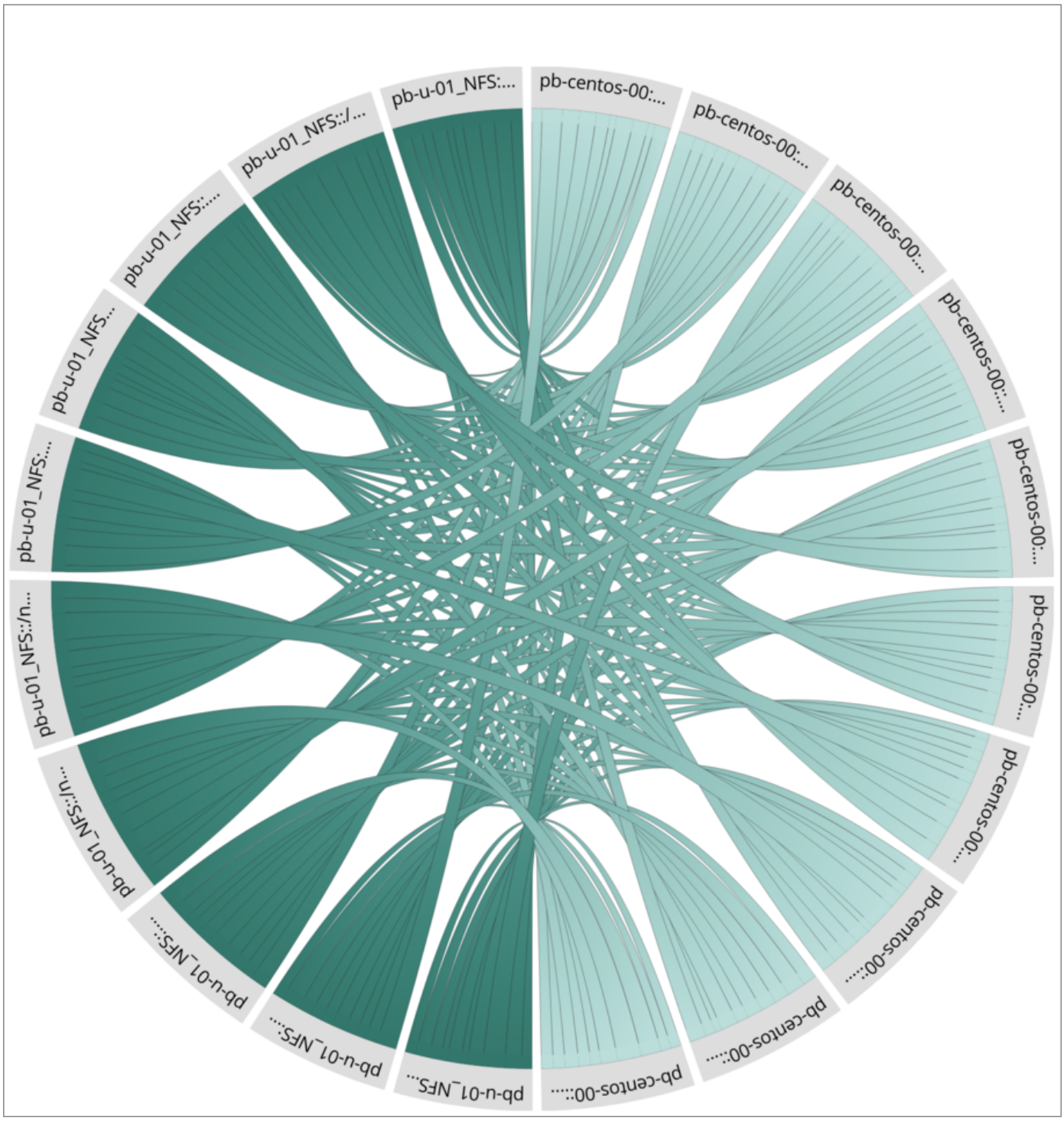


Figure 5. Observing orchestration activity

Figure 5: Hammerspace Mobility Chord Diagram

The throughput at which these mobilities occur is largely dependent on two general factors:

- How many items currently await mobilization
- How many concurrent mobilities the cluster can support

Hammerspace support can adjust the number of concurrent mobilities the cluster will attempt to increase the

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throughput, though an analysis of any possible infrastructure limitations (such as source NAS throughput capabilities) is recommended before they make any changes to the default settings.

Common Mobility Types

Following an assimilation of a read-only volume, the most common assimilation, you will typically see three different mobility types:

- **On-demand** - This occurs when a client has opened a file that has not yet migrated. Note that in some cases, how the file was opened impacts whether or not it needs to be mobilized first.
- **Location** - Indicates that an objective directed the file be placed somewhere else.
- **Contention** - Indicates that the file was mobilized for some higher priority reason, such as the volume it is currently on is being decommissioned.

While there are more types of mobilities, these three are the most common ones you will see when performing assimilations and the subsequent migration of data.

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Chapter 5. Conclusion

Once Hammerspace owns the NAS namespace, data can be freely orchestrated in a manner that is invisible to the clients. Examples include tiering cold data to the cloud, migrating to new data storage locations, or implementing highly customized tiering that precisely places data on the most appropriate storage class.

The Hammerspace assimilation process enables customers to migrate their existing NAS namespace with minimal downtime and effort. By decoupling the file metadata migration from the physical file migration, Hammerspace is able to greatly reduce the pain commonly associated with current and future data migrations.

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Appendices

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Appendix A: Additional Resources

- Objectives Guide

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