DR4000
Architecture Overview
Introduction

Backup is an overlooked, but required component to data integrity and recovery. While the last couple of decades have seen tremendous progress in primary storage technologies, these technological advantages are still not adequate to replace a good backup and restore strategy.

Data generated by organizations of all sizes has grown exponentially, increasing demand for systems that meet backup and restoration requirements in better and more innovative ways. Traditionally, tape has been the most prominent medium for data backup. However, tape solutions do not meet the performance, reliability and ease of management required for today's information infrastructures. Systems that support backup-to-disk, with features such as deduplication and compression, have emerged as the backup technology of choice.

The Dell™ DR4000 Disk Backup System is a high performance, disk-based backup and recovery appliance that delivers innovative features such as inline deduplication and compression, advanced data protection, and replication. Additionally, the management features, ease of deployment, and an architecture that enables core backup data to remain on disk and online longer will help organizations to reduce the complexity associated with backup. These features, when combined with an all-inclusive licensing model, deliver unsurpassed Total Cost of Ownership (TCO).

Deduplication and Compression Overview

The DR4000 implements advanced deduplication and compression technologies that enable organizations to reduce their storage footprint significantly.

Duplicate data exists in the form of duplicate virtual machine image files, attachments to e-mails, duplicate copies of files, etc., all of which increase the storage footprint. Deduplication technologies seek to identify and eliminate duplicate copies of data at the file or block level.

Similarly, data can also be compressed to achieve space efficiency. The DR4000 performs Inline compression and decompression using either the Fast or Best compression algorithms, which can be selected in the DR4000 administrator console.

The Fast algorithm compresses data in memory or read and provides faster compression, but at a cost of the amount of compression achieved. The Best algorithm, developed by Dell, provides for a much higher compression of data, but performs slower.
The Dell DR4000 Solution – An Overview

The DR4000 is a high-performance, disk-based backup and recovery appliance that is simple to deploy and manage. The appliance is available in 2.7TB, 5.4TB, and 9TB storage capacities and is ideal for deployment in small enterprise and remote office environments. The DR4000 boasts an impressive feature set, which includes:

- Inline deduplication and compression
- Deduplicated replication
- Advanced data protection
- Replication licenses
- Non-disruptive deployment
- NFS, CIFS, and future OST protocol support
- Simplified management

DR4000 Building Blocks

The DR4000 firmware implements an inline, content-aware deduplication and compression engine. The software architecture consists of the following building blocks:

- Front end protocol layer: This layer implements protocol support for incoming I/O. The supported protocols are NFS and CIFS. (OST and NDMP will be supported in future releases.)

- Dedupe/compression engine: This is the key component of the architecture. The dedupe engine implements advanced chunking and deduplication algorithms to achieve space savings.

- Ingest buffers: The DR4000 implements inline deduplication and compression. Ingest buffers, which reside in high-speed NVRAM, receive incoming data flows, and the dedupe engine works on the data in the ingest buffers.

- Disk storage structures: Several key data structures are stored on disk, which enable efficient dedupe and compression operations. These data structures include:

  - **Dictionary**: The firmware maintains a list of references to all unique data chunks that have been encountered while processing the incoming user data. The dictionary is a dynamic list of the all unique patterns and forms the basis for deduplication.

  - **Data Suitcase**: This is the list of actual unique data chunks. The dictionary contains references to the unique data chunks in the data suitcase.

  - **Blockmap/Objectmap Suitcase**: This is a mapping file that maintains the mapping of user data to chunks in the suitcase. During the processing of user data, if a chunk matches a reference in the suitcase, reference counts to those chunks in the data suitcase are incremented, rather than storing a duplicate copy of the data.
Data Deduplication Workflow

The following diagram details the lifecycle of data and I/O within the DR4000 firmware. Each I/O is taken through the following steps.

1. Incoming data flows into the ingest buffers in the high-speed NVRAM cache.

2. The firmware implements a Rabin Fingerprinting algorithm for isolating chunks. (This algorithm has produced significantly better deduplication results when compared to fixed-size chunking.)

3. The chunk determined in step 2 is compared with patterns in the data dictionary for a match.
   a) If a match is not found, the chunk data is saved.
   b) If a match is found, the block/object map is updated and the reference counts are updated. The incoming chunk is discarded.
Data Integrity Features

Backups are typically used when all available means to recover data on the production systems have failed or are not feasible. Backups are not verified by users on a daily basis, so it is essential that backup systems treat data protection as the most important task.

DR4000 has several hardware and software features that together deliver unsurpassed levels of data protection. These features are:

- **Software**
  - **Continuous data verification**: Existing data is read back periodically and checksums compared to verify data integrity.

- **Hardware**
  - **NVRAM**: Ensures data is protected in case of power loss.
  - **Surface Scans**: These are triggered in the event of hardware faults to report and/or correct data inconsistencies.
  - **RAID6**: All data on the DR4000 is protected by RAID6 with a hot spare. This RAID level protects data against as many as two simultaneous drive failures.

Continuous data verification and surface scans are performed in the background so as to not disrupt core backup and deduplication activities.

Hardware

The DR4000 solution uses the following industry-standard hardware:

- 2U rack-mountable, Intel®-based server
- Hot-swappable 300-GB, 600-GB, or 1-TB 6-Gpbs SAS drives (12 drives)
- Four 1Gb Ethernet or two 10Gb Ethernet Base-T
- Redundant power supplies and fans
Replication

The DR4000 can replicate from one node to another. Replication is configured on a per container basis, meaning that you can replicate some containers or all of the containers on the system. Replication can be configured to run from either the source or target DR4000 and runs in two modes based on specific flags and criteria within the DR4000:

- **Resync replication** occurs when replication is enabled on a container with existing data when the replication is configured. Replication is done by snapping and crawling the source namespace volume. A Resync replication cycle also runs after a maintenance mode repair has deleted some files, as well as when the replication log file becomes full or corrupted. When resync replication is active, the log automatically starts logging all changes to the source data volume after the snap was taken.

- **Log-based replication** occurs if a container does not have any existing data when replication is configured, or when a resync replication cycle has processed all of the existing data stored in the volume. The log is located in the source container, and it is maintained even if the target container is not reachable. Log size is not limited, but is bound by physical disk size.

Network Architecture (local)

The DR4000 appliance sits in the network infrastructure behind any backup system that can connect via a CIFS or NFS share. The DR4000 connects to the network using four 1-GB ports or two 10-GB ports. These ports are bonded and can be set up as automated load balancing (ALB) or as an 802.3ad bond. For best performance, Dell recommends bonding the ports as an 802.3ad aggregated link.
**Network Architecture (remote)**

The DR4000 appliance sits in the network infrastructure behind any backup system that can connect via a CIFS or NFS share. The disaster recovery node can be located in any remote location that the primary DR4000 can connect to the CIFS or NFS share for replication.