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Optimize Data Protection for MS SQL Server 2016 on VxFlex using Dell EMC Avamar and Data Domain

Abstract

This white paper highlights the design consideration for Data protection using Dell EMC Avamar and Data Domain for MS SQL Server 2016 database running on VxFlex integrated rack.

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Executive summary

In today's enterprise database environments such as SQL 2016, organization demand un-interrupted operations with minimum downtime and SLAs. The hyperconverged infrastructure platform facilitates improved flexibility, productivity, performance, protection, and ease of infrastructure management.

The new approach is implementing Data Protection using Dell EMC Avamar and Data Domain for enterprise application such as SQL Server databases running on VxFlex integrated rack. Avamar Virtual Edition's tight integration with Data Domain uses a multi-streaming, deduplication approach – resulting in faster and more efficient backups.

This integration provides ability to directly select backup workloads to Data Domain systems, the costly need for two separately managed backup environments has disappeared.

This paper highlights in detail the specific features and architecture surrounding this integration of VxFlex integrated rack with Dell EMC Avamar Virtual Edition, and Dell EMC Data Domain system to provide enterprise-grade application protection, achieving greater process and footprint efficiency with zero performance impact to the production workloads.

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1 Introduction

This white paper outlines the design consideration of backup and recovery options for SQL Server database via Avamar Virtual Edition and Data Domain system on VxFlex integrated rack. The primary focus of this paper is to provide the reader with an understanding of Integrated Data Protection engineered for VxFlex family for Microsoft SQL Server databases.

1.1 Objective

The purpose of this white paper is to exemplify how Dell EMC data protection solution provides unique and powerful integration between Avamar and Data Domain system with VxFlex integrated rack for SQL Server databases.

1.2 Audience

This white paper is intended for SQL Server database administrators, system engineers, partners, and members of Dell EMC and partner professional service community who are looking for efficient backup and recovery procedures on SQL Server database on Dell EMC VxFlex integrated rack with ESXi hypervisor.

The reader of this document must have a working knowledge of the following technologies:

- Dell EMC VxFlex integrated rack
- Dell EMC Avamar and Data Domain systems
- VMware vSphere
- SQL Server database

In addition to working knowledge of the above technologies, the reader of this document must have basic knowledge of the following technologies:

- Storage
- Compute
- Networking

1.3 Business case

The digital economy offers incredible opportunities for businesses, but it also brings formidable challenges. Businesses are changing at an accelerating pace to cope with ever-diversifying and personalized customer needs. This trend pushes the supporting IT organizations to struggle with limited resources to maintain complex existing applications and infrastructure and invest in new and innovative solutions to better support the businesses. IT organizations want to standardize and consolidate on platforms that can deliver mission-critical, mixed-application performance, and they need to provide adequate data protection at a reasonable cost. As data volumes and the number of applications grows, data protection becomes increasingly important and difficult.

The challenges include:

- Abundant data is scattered around different and sometimes isolated environments.
- Exponential growth of data.
- Virtually no window for non-transactional activities such as backups as businesses run 24 hours a day.

1.4 Terminology

The following table defines acronyms and terms that are used throughout this document:

Term	Definition
HCI	Hyperconverged Infrastructure
AVE	Avamar Virtual Edition
RAIN	Redundant Array of Independent Nodes
DD	Data Domain
IPI	Intelligent Physical Infrastructure
vPC	Virtual Port Channel
OLTP	Online Transaction Processing
OOB	out-of-band management
SVM	Storage Virtual Machine
SDS	Storage Data Server
SDC	Storage Data Client
OLTP	Online Transaction Processing
AD	Active Directory
DNS	Domain Name System
DHCP	Dynamic Host Configuration Protocol
NTP	Network Time Protocol
VLAN	Virtual Local Area Network
TOR	Top of the Rack Switch

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2 Product overview

2.1 Dell EMC VxFlex integrated rack

The Dell EMC VxFlex integrated rack is an engineered system that provides the ultimate performance, reliability, scalability, agility, and flexibility for modern data center workloads, IaaS, and PaaS cloud infrastructure initiatives. The system is powered by Dell EMC VxFlex OS software-defined storage and based on industry-leading enterprise-class Dell EMC PowerEdge servers. It is a rack-scale hyper-converged system that comes with a proprietary intelligent physical infrastructure (IPI) cabinet, offers integrated networking and dedicated system management control plane.

Figure 1   VxFlex integrated rack benefits
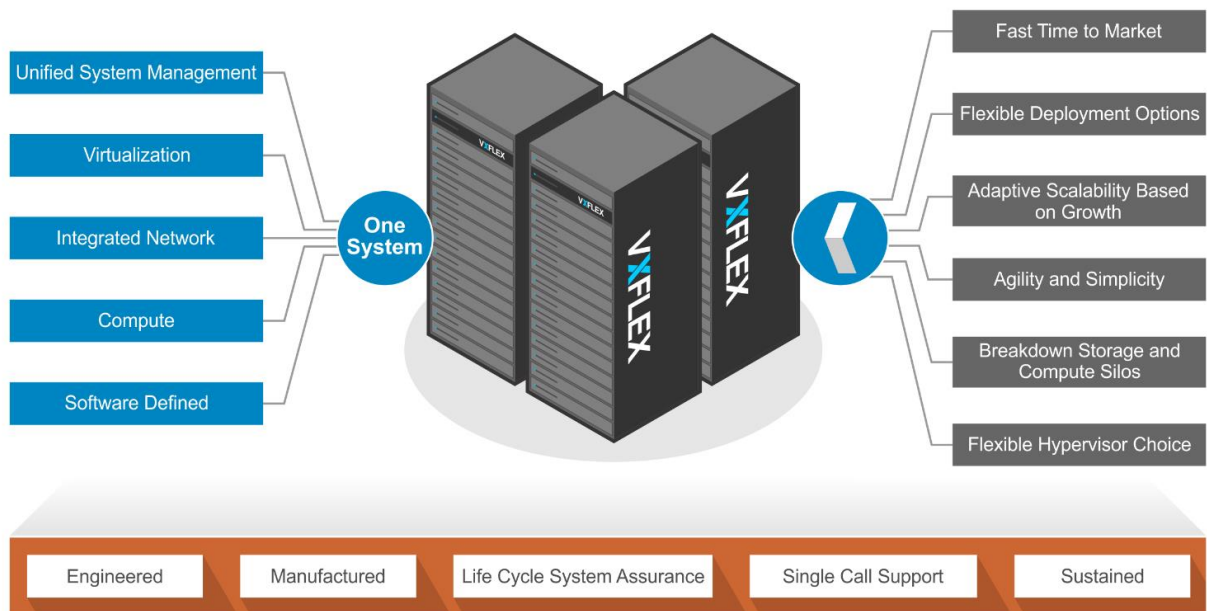
The modular design of VxFlex integrated rack enables you to add standardized units of infrastructure to the environment. With this scalable model, it is all about expanding the infrastructure in small increments, as applications require eliminating the over-provisioning that is experienced with other approaches.

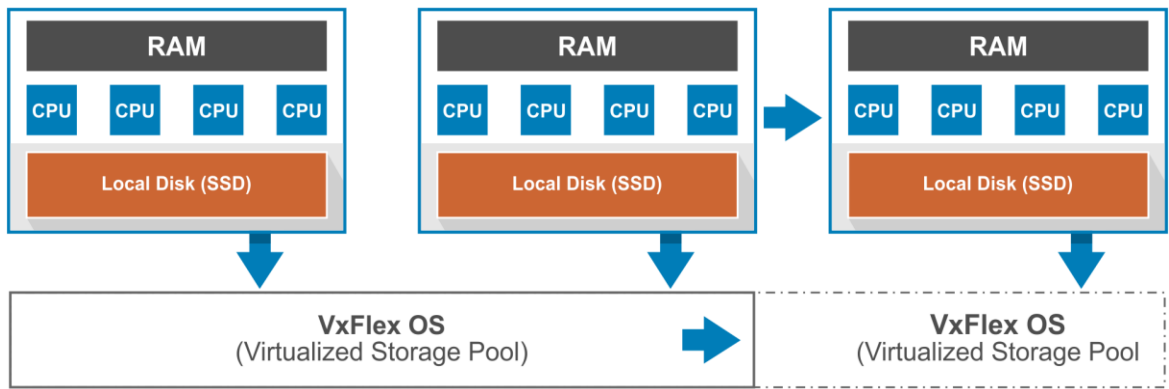The following figure shows the VxFlex integrated rack scalability.

Figure 2   VxFlex integrated rack scalability

Each cabinet is equipped with redundant access switches (Cisco 93180YC-EX). A pair of aggregation switches are installed in the first cabinet and configured in access/aggregation network topology. If more than one cabinet exists, the aggregation switches can be spread across or installed in other cabinets.

The entire system is built and configured at the Dell EMC factory according to the proven and tested best practices. In addition to the unmatched performance, scalability, and performance, customers also enjoy one-call support for all components and end to end life cycle management through a proven automated Release Certification Matrix (RCM) for all components including software and firmware.

2.2   VxFlex Manager

VxFlex Manager provides IT operations management for VxFlex. It increases efficiency by reducing time-consuming manual operations required to provision and manage VxFlex operations. Using VxFlex Manager, you can deploy and manage new and preexisting VxFlex environments.

VxFlex Manager includes the following features:

- A dashboard that provides system configuration details and communicates health status for VxFlex infrastructure elements and services
- Release Certification Matrix (RCM) compliance monitoring
- RCM remediation for nodes and switches
- Hardware monitoring and alerting through Secure Remote Services to Dell EMC Support
- Aggregated logging for troubleshooting, with the ability to send logs through Secure Remote Services to Dell EMC support

2.3   VMware vSphere

The vSphere virtualization layer decouples the application from the underlying physical resources. This decoupling enables greater flexibility in the application layer by eliminating hardware downtime for maintenance and changes to the physical system without affecting the hosted applications. In a server virtualization use case, this layer enables multiple independent virtual machines (VM) to share the same physical hardware.

vSphere is a complete and robust virtualization platform, virtualizing business-critical applications with dynamic resource pools for flexibility and reliability. It transforms physical resources of a computer by virtualizing the CPU, RAM, hard disk, and network controller. This transformation creates fully functional VMs that run isolated and encapsulated operating systems and applications.

2.4 Data protection

Data Domain deduplication storage systems and Avamar systems provide enterprise grade backup and restore capabilities.

The integration of these systems enables:

- A single point of management for backup and restore
- Avamar management of one or more Data Domain systems
- The use of Data Domain systems as a backup target for Avamar backups
- Avamar client integration with the Data Domain Boost Library so that the clients can send backups directly to Data Domain systems

2.5 Dell EMC Avamar Virtual Edition

Avamar Virtual Edition (AVE) is a single-node non-RAIN (Redundant Array of Independent Nodes) Avamar server that runs as a virtual machine in a VMware ESXi 5.5, 6.0, 6.5, or 6.7 environments. AVE integrates the latest version of Avamar software with SUSE Linux as a VMware virtual machine. AVE for VMware supports the licensed capacity configurations from minimum 0.5 TB to maximum 16 TB.

AVE generally performs better when I/O performance is higher. Change rate and utilized capacity are also lower. To maximize the capacity the AVE virtual machine can use, the daily change rate of the data AVE protects must be balanced with adequate I/O performance.

The benefits of AVE are as follows:

Hypervisor Integration: Integration with VMware and Microsoft.

Self-Service Recovery: Application owners take control of the data protection of their applications.

Simplified Administration: Wizard driven setup and management.

Simply modern management: A single interface for monitoring, management, reporting and search with integrated recovery.

Granular Level Recovery: Immediate item-level recovery with the granular level recovery of data and applications.

Data Domain integration: Optimized backup and recovery solution.

2.6 Dell EMC Data Domain

Data Domain systems are purpose-built data protection appliances that are designed to reduce the amount of disk storage that is needed to retain and protect data. A variety of backup, archive, and enterprise applications are supported by Data Domain. The list includes not only Dell EMC Avamar and Networker, but also products by SQL Server, Oracle, SAP Hana, Veritas, and others.

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Data Domain deduplication greatly reduces the data footprint before the data is backed up. Data Domain global compression technology combines an exceptionally efficient high-performance in-line deduplication technology with a local compression technique. The reduced data footprint allows data to be retained on-site for longer periods and allows transfer across the network for archival.

The benefits of Data Domain are as follows:

Scalability and Performance: Reduces storage required by 10-30x. Protects up to 150 PB of logical capacity in a single system.

Efficient Resource Utilization: Sends only deduplicated data across the network to reduce the bandwidth required.

Reliable Access and Recovery: End-to-end data verification, fault detection, and self-healing.

Seamless Integration: Integrates with leading backup, archiving, and enterprise applications.

2.7 Microsoft SQL Server 2016

Microsoft SQL Server 2016 is a relational database platform that brings a new set of technologies, features, and services to SQL Server. SQL Server 2016 supports mission critical applications such as analytics, in-memory databases, business intelligence (BI), and online transaction processing (OLTP).

For more information about **Microsoft SQL Server 2016** and its complete list of features, see What's New in SQL Server 2016.

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3 Avamar and Data Domain architecture overview

You can use Avamar to back up and restore data in a variety of Microsoft SQL Server environments.

3.1 Avamar components for SQL Server

The Avamar software components in a SQL Server environment includes the Avamar Client for Windows, the Avamar Plug-in for SQL Server, and Avamar Administrator.

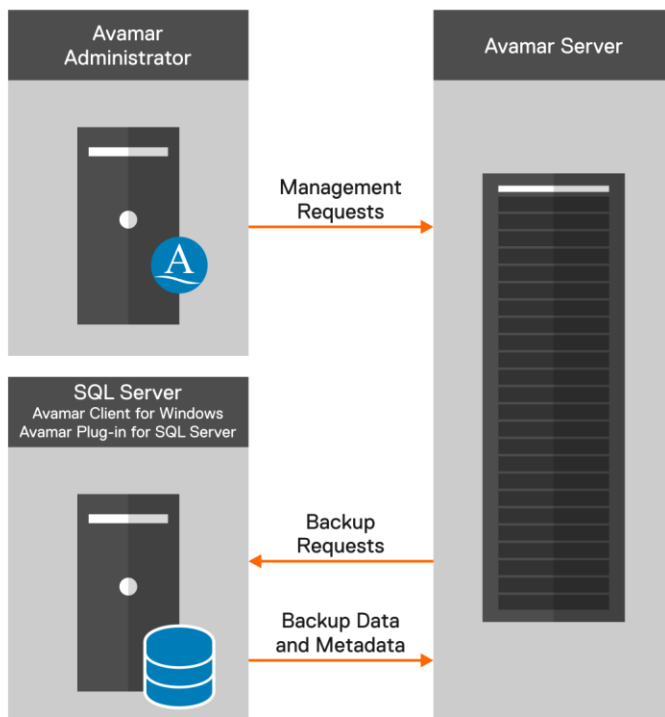The following figure provides an overview of Avamar architecture with SQL Server:

Figure 3   Avamar Architecture with SQL Server

3.2 Avamar Client for Windows

The Avamar Client for Windows installation includes the Avamar Plug-in for Windows File System and the Avamar agent, which is required for the Avamar Plug-in for SQL Server. You can use the Windows File System plug-in to back up operating system and SQL Server binary files, which are required for disaster recovery.

3.3 Avamar Plug-in for SQL Server

The SQL Server plug-in enables you to back up and restore SQL Server instances and databases.

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3.4   Avamar Administrator

Avamar Administrator is a graphical management console software application for remote administration of an Avamar system from a supported Windows or Linux client computer. You can configure, perform, monitor, and manage backups and restores using Avamar Administrator.

3.5   Avamar and Data Domain integration

Data Domain (DD) system performs deduplication through DD Operating System software. Avamar source-based deduplication to a DD system is facilitated using the DD Boost library.

Avamar uses the DD Boost library through API-based integration to access and manipulate directories, files, and so forth, contained on the Data Domain File System. The DD Boost API gives Avamar visibility into some of the properties and capabilities of the Data Domain system. This enables Avamar to control backup images stored on Data Domain systems. It also enables Avamar to manage maintenance activities and to control replication to remote Data Domain systems. DD Boost is installed on the backup clients and on the Avamar Virtual Edition.

The following figure depicts a high-level architecture overview of the combined Avamar and Data Domain solution.
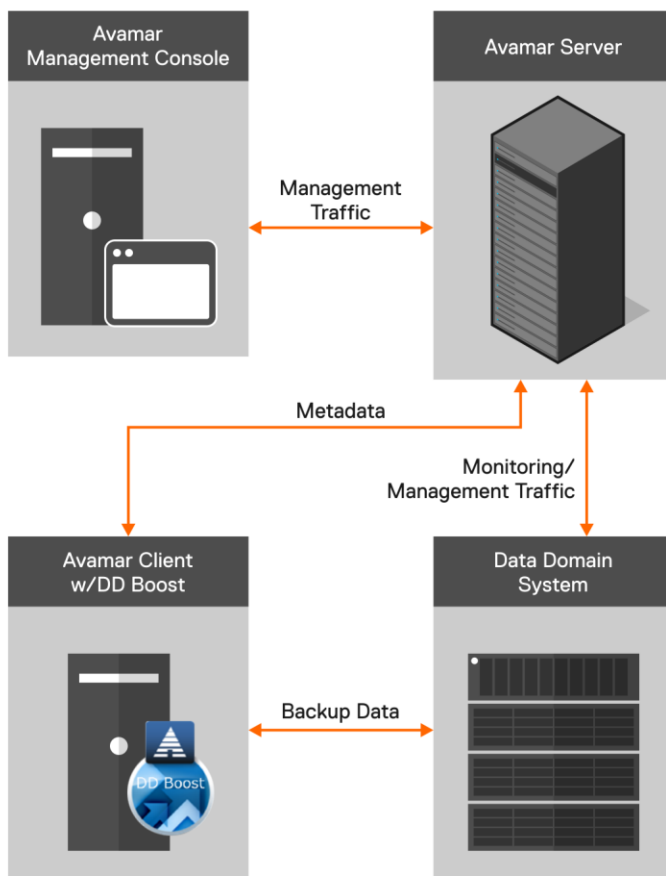

Figure 4   Avamar and Data Domain architecture

When specifying an Avamar server as the backup target, the Avamar client on each host performs deduplication segment processing. Data and metadata are stored on the Avamar server.

When specifying a Data Domain system as the backup target, backup data is transferred to the Data Domain system. The related metadata generated by the Avamar client software is simultaneously sent to the Avamar server for storage. The metadata enables the Avamar management system to perform restore operations directly from the Data Domain system without first going through the Avamar server. The Avamar Plug-in for SQL Server supports backups to and restore from Data Domain systems. You can back up SQL Server data to a Data Domain system by using Avamar Administrator. The Avamar Plug-in for SQL Server stores the metadata for the backup on the Avamar server.

Before you can store backups on a Data Domain system, you must add the Data Domain system to the Avamar configuration by using Avamar Administrator. After you configure the Data Domain system, you can back up SQL Server database files to the Data Domain system by selecting the appropriate plug-in option from Avamar Administrator. You can also specify a Data Domain system when you create a dataset for a scheduled backup.

Avamar Administrator dashboard

The Avamar Administrator dashboard provides an at-a-glance view of Avamar system status, as well as access to all functionality through menus and launcher link.

The **System Information** panel on the Avamar Administrator dashboard provides an overview of important system statistics such as capacity information or DD system state.
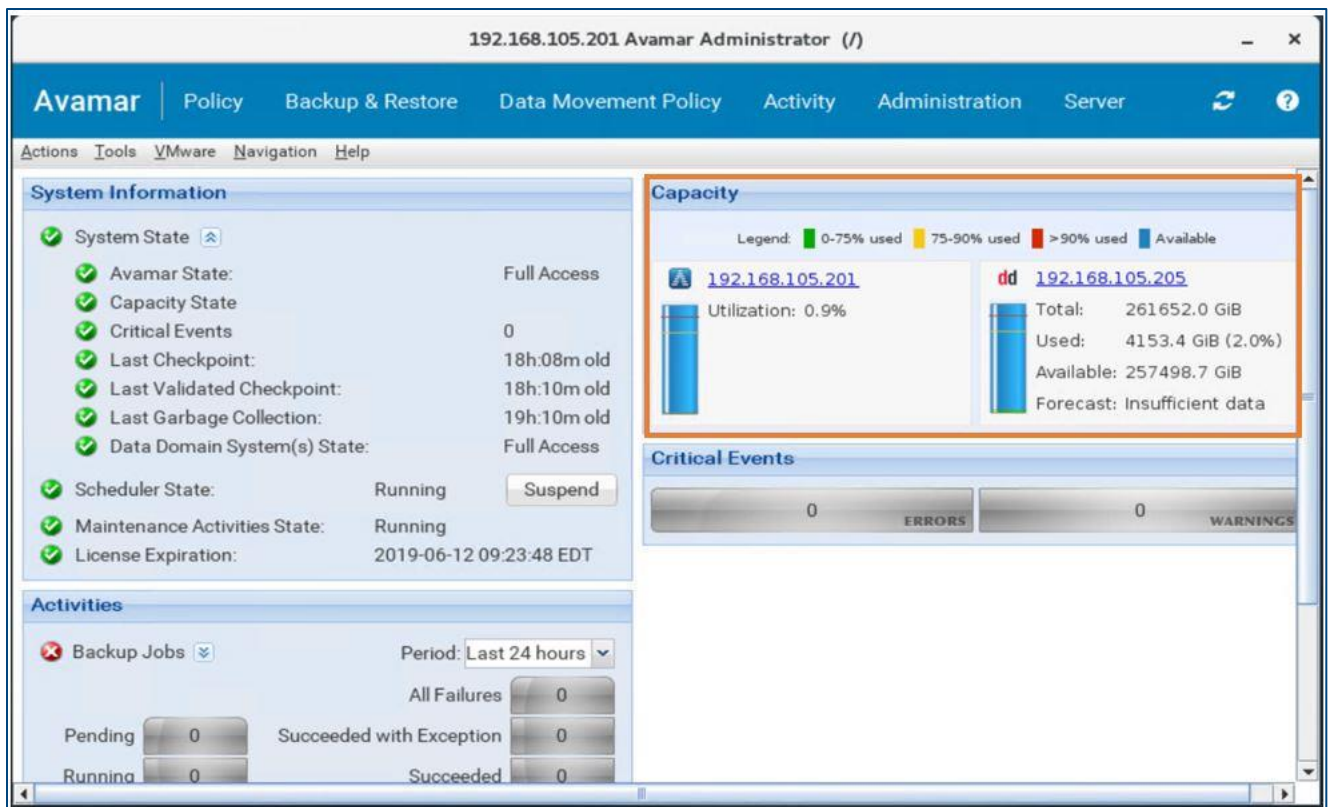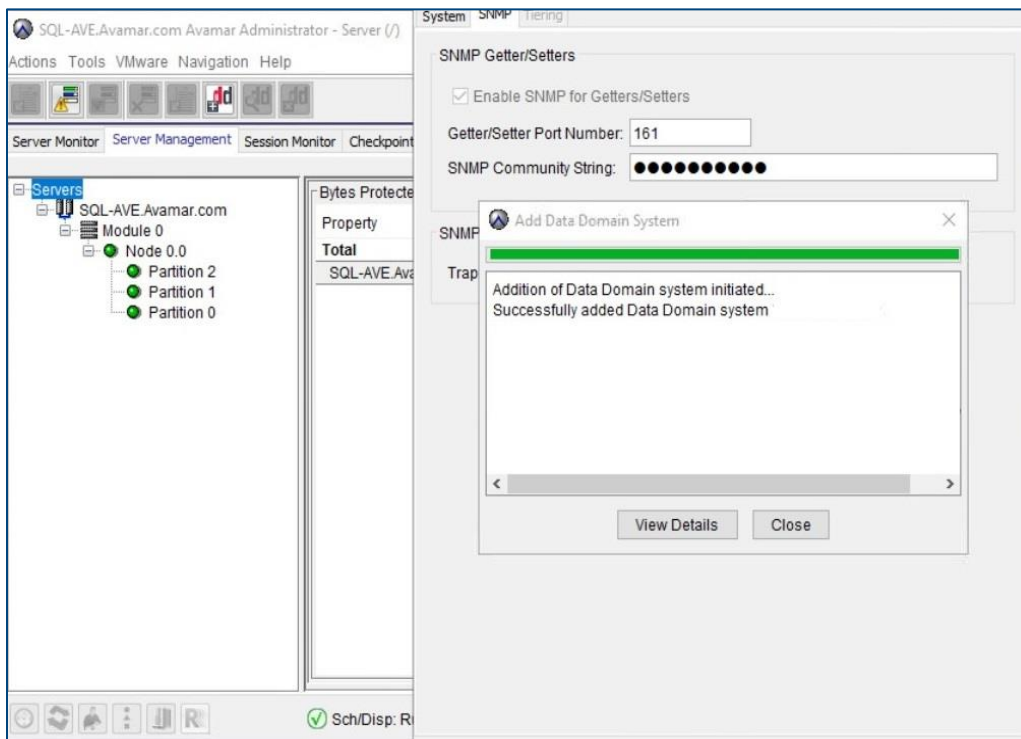

Figure 5   Avamar Administrator dashboard

For more information about AVE and DD appliance integration, see **Adding a Data Domain system** section in Dell EMC Avamar Administration Guide.

After performing the integration, the **Server Management** tab in Avamar Administrator displays the success message.

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4 Solution overview

This solution uses Dell EMC Data Domain and Dell EMC Avamar data protection solutions to provide enterprise-grade application protection, achieving process and footprint efficiency with zero performance impact to the production workloads. This paper focuses on Microsoft SQL Server database backup and restore operations.

4.1 Solution architecture

The solution is deployed as a hyperconverged deployment with VxFlex integrated rack, AVE, and Data Domain systems. The VxFlex integrated rack HCI is running with ESXi hypervisor for compute and network and VxFlex OS for software-defined storage.

The solution is built with the following configurations in each server:

- Four PowerEdge R640 servers
- Two Intel Xeon Skylake 14-core processors
- 384 GB RAM
- Ten 1.92 TB SSDs

Each VxFlex integrated rack node has Dell EMC Storage Virtual Machine (SVM) running on it, providing both storage clustering and storage services.

The following figure provides an overview of the logical network components in the VxFlex HCI network architecture:

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Figure 6   Solution Architecture
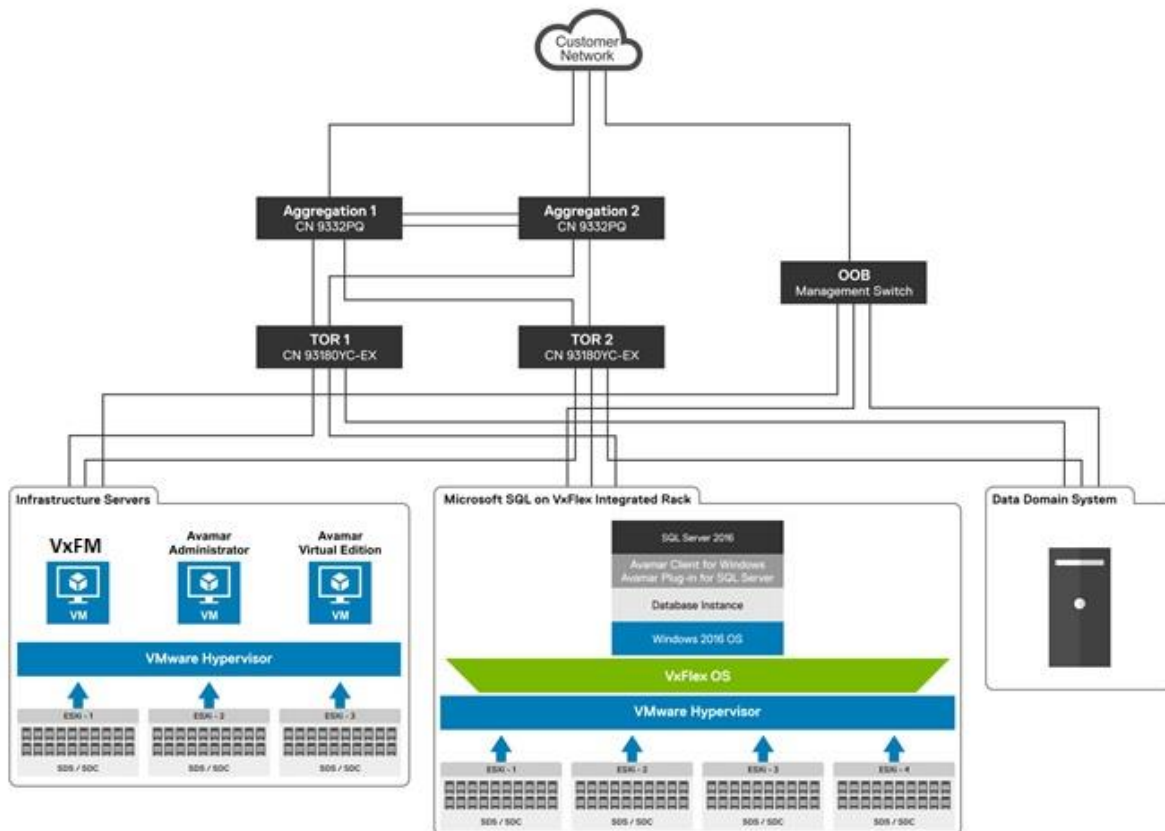
 Hyperconverged infrastructure configuration has four SDS and SDC role configured on each node in the cluster. SDC provides the compute capabilities while SDS provides backend storage.
The Storage Data Server (SDS) aggregates the serves raw local storage in a node and serves it up as VxFlex OS cluster. A single protection domain is carved out of the SSD on these four SDSs. A single storage pool is configured, and multiple volumes were carved out to meet the SQL Server database requirements. These volumes are mapped to the ESXi cluster and added as a datastore and later mapped as disks drive to SQL Server virtual machine using VMware Paravirtual SCSI (PVSCSI) adapters.

SQL Server 2016 Virtual Machine:
Microsoft SQL Server was deployed as virtual machines on a vSphere cluster. The SQL Server virtual machine consists of 16 virtual CPUs, 128 GB RAM and thick provisioned disks on VxFlex backend storage.

After the drives are provisioned, the SQL Server data and log drives were formatted with a 64 KB NTFS cluster size. This size optimizes I/O performance with no overhead and offers a good balance between flexibility, performance, and ease of use. The following table lists the details of the SQL layout.

Table 1. SQL layout

Disk size (GB)	Drive	Disk purpose
80	C	Windows OS disk
104	D	Database disk 1
104	E	Database disk 2
104	F	Database disk 3
150	G	Database log disk 1
120	H	Database log disk 2

Avamar Client for Windows and the Avamar SQL plug-in is installed on the SQL Server virtual machine. The agent is registered with the AVE server. The SQL Server plug-in enables you to back up and restore SQL Server databases.

Infrastructure cluster:
VxFlex system consists of three controller nodes that are clustered together to run various infrastructure management services like Active Directory, DNS, DHCP and NTP for VxFlex system. These nodes run VMware ESXi. The infrastructure cluster hosts Avamar Virtual Edition and Avamar Administration virtual machine.

Avamar Administrator is the user interface for configuring and managing the Avamar system. Backup Administrators can backup, restore, and monitor the progress. Avamar Administrator enables administrators to define backup and restore policies, manage users and clients and perform system maintenance activities. Avamar virtual edition integrated with Data Domain Appliance gives administrator a single centralized administration and management console for the backup environment.

4.2 Network architecture

The following figure provides an overview of the network architecture and design of VxFlex integrated rack for SQL Server with Data Protection using Avamar and Data Domain system.
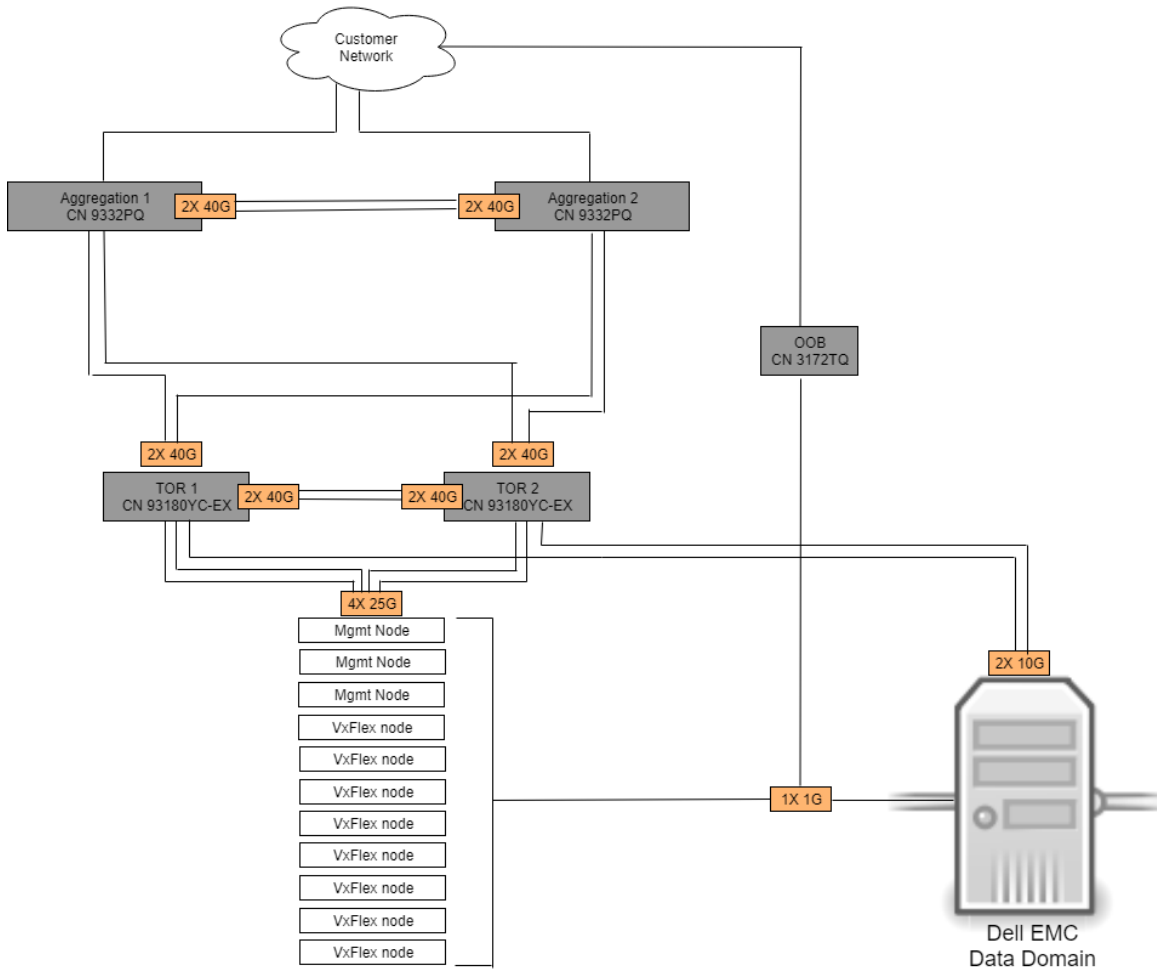

Figure 7   Network architecture

Components	Description
Cisco Nexus 93180YC-EX	10 & 25 Gbps TOR switches
Cisco Nexus 9332PQ	40 Gbps Aggregation switches
Cisco Nexus 3172TQ	1 & 10 Gbps Management switches
Data Domain Appliance	2 x 10 Gbps links
Application Traffic	2 x 25 Gbps links
VxFlex Storage traffic	2 x 25 Gbps links

Architecture flow:

- VxFlex integrated rack uses a pair of Cisco Nexus 93180YC-EX as TOR switches.
- VxFlex integrated rack uses a pair of Cisco Nexus 9332PQ as Aggregation switches.
- Cisco virtual port channel is configured between the TOR and Aggregation switches.
- Cisco Nexus 3172TQ switch is used for OOB traffic with 1GbE dedicated network.
- Both TOR (Cisco Nexus 93180YC-EX) switch have uplinks to aggregation (Cisco Nexus 9332PQ) switches for redundancy and network bandwidth aggregation.
- Each node comprises of four 25 GbE ports, two ports connected to each TOR (Cisco Nexus 93180YC-EX) switch.
- For network isolation between different traffics, multiple VLAN have been used.

VLAN Configuration:

The following table lists the VLAN configuration for different traffic types.

Table 2. VLAN IDs on Cisco Nexus 93180YC-EX

Traffic type	VLAN ID
SQL Server data network	171
Management network	105
Backup and Recovery network	115
VxFlex OS Management network	150
vMotion network	106

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5 Backup and Restore validation

The SQL Server database administrator can choose from the following data protection options:

- **On-demand backup:** An on-demand backup is a user-initiated backup of SQL Server instances or databases. You can perform an on-demand backup for the first backup of the client immediately after you install the Avamar client software. You should also perform an on-demand backup before system maintenance, software installations, or software upgrades.

- **Scheduled backup:** Scheduled backups run automatically to ensure that backups of the SQL Server data occur on an ongoing basis.

- **Restore:** You can use the Avamar Plug-in for SQL Server to restore a backup of a database to its original instance, but with a new name that creates a database in the instance.

    When you restore to a new database in the original instance, you can perform a tail-log backup and recovery to recover transactions that were not in the backup. You also can specify the path for the database and log files. If the database uses the full recovery model, then you can restore to either a specific date and time or to a named mark in the transaction log.

5.1 Testing scenario

The Dell EMC data protection components Avamar and Data Domain system demonstrates that the validated configuration is compatible with SQL Server database on VxFlex integrated rack.

To show the capabilities of this solution, we simulated a real-world, workload environment composed of SQL Server application. We ran concurrently database users throughout the backup activity. **HammerDB** tool was used to configure and generate the random workload with 70:30 read/write IO operations.

Table 3. SQL Server production database configuration and workload profile

Characteristics	Description
Database type	OLTP
Database size	300 GB
Number of test users	10 users
Workload profile	70:30

5.2 Testing validation

This section describes the SQL Server database backup was triggered while concurrent database transactions were running.

The following procedure was used to validate on-demand backup and restore of SQL Server database:

1. Login to SQL Server Management console.
2. Invoke the HammerDB console from the client machine.
3. Create the virtual users on the HammerDB Tool. See, Table 3.
4. Start the OLTP workload with virtual users on the SQL Server database.
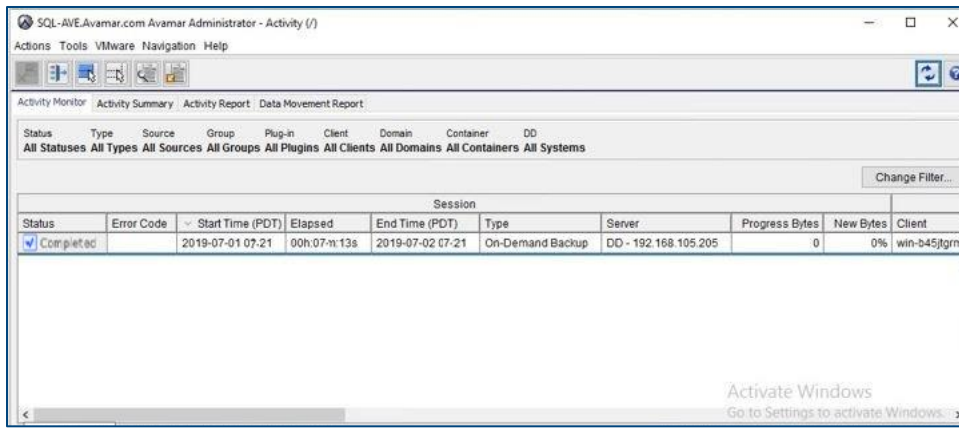
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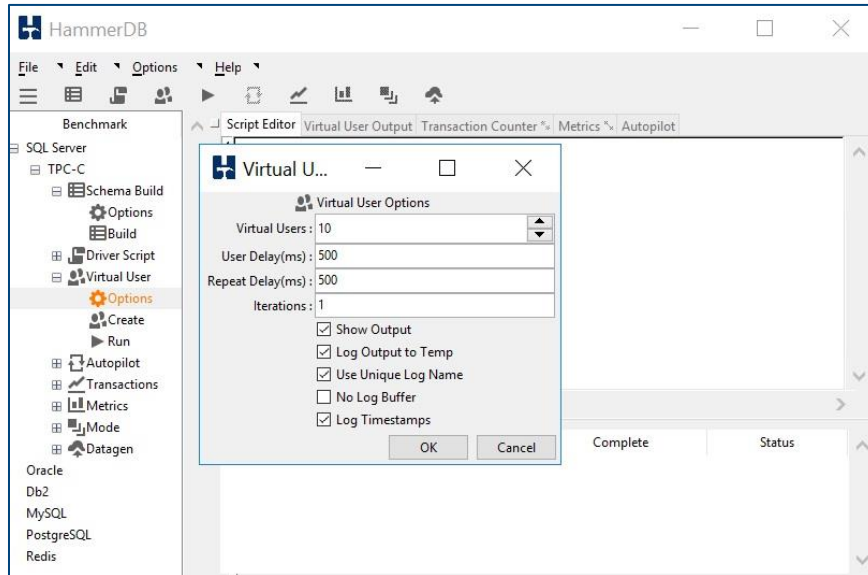
5. Start the **On Demand** backup and monitor the backup process to finish.
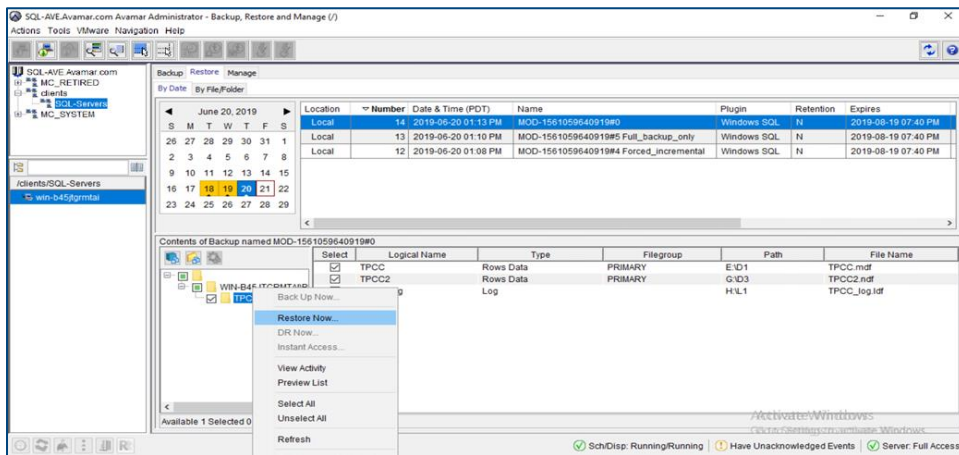
    The **Activity Monitor** tab in the Avamar Administrator shows SQL Server database backup running during the OLTP workload.
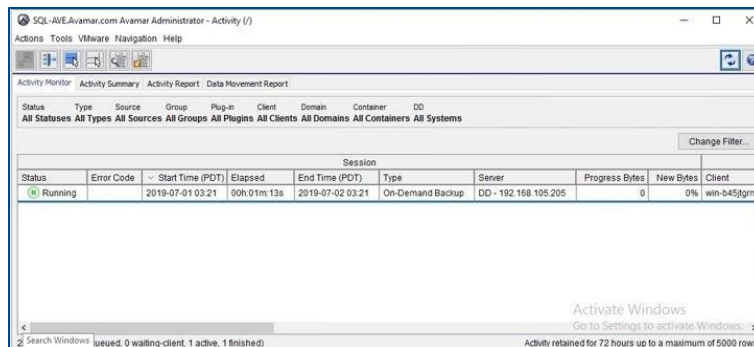

6. Monitor the progress of the Avamar backup to complete. For more information about on-demand backup, see Performing on-demand backup section in Dell EMC Avamar for SQL User Guide.

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7. Restore the database to original client using Avamar Administrator and verify that restore starts and completes. For more information about restore, see **Restoring system databases automatically to the original location** section in [Dell EMC Avamar for SQL User Guide](#).

8. Monitor the restore process to finish. The **Activity Monitor** tab in Avamar Administrator shows restore of SQL Server database completed successfully.
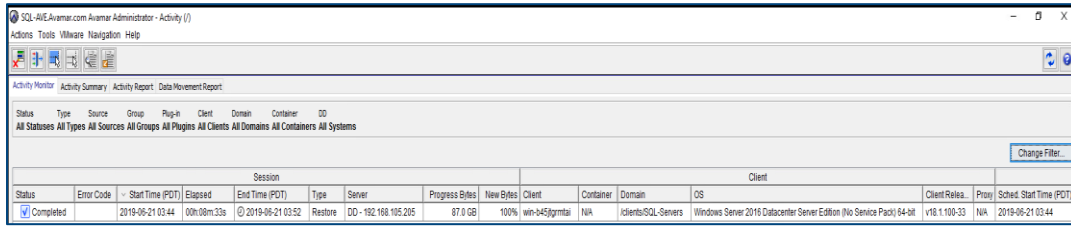
Based on this test, we validated that the database backup has been successful and restored back to the same location.

5.3 Test summary

We initiated the Avamar on-demand backup and simultaneously we ran HammerDB tool to generate the OLTP workload transaction on the SQL Server Databases. There was a slight increase in the SQL Server VM CPU utilization when the on-demand backup was initiated, but later the CPU utilization was consistent during the backup process. Backup operation did not have any significant impact on the SQL Server database during the backup process. The SQL Server continued to provide 726750 tpm throughout the backup operation. We did not observer any user disconnects or drop in transaction throughout the backup operation.
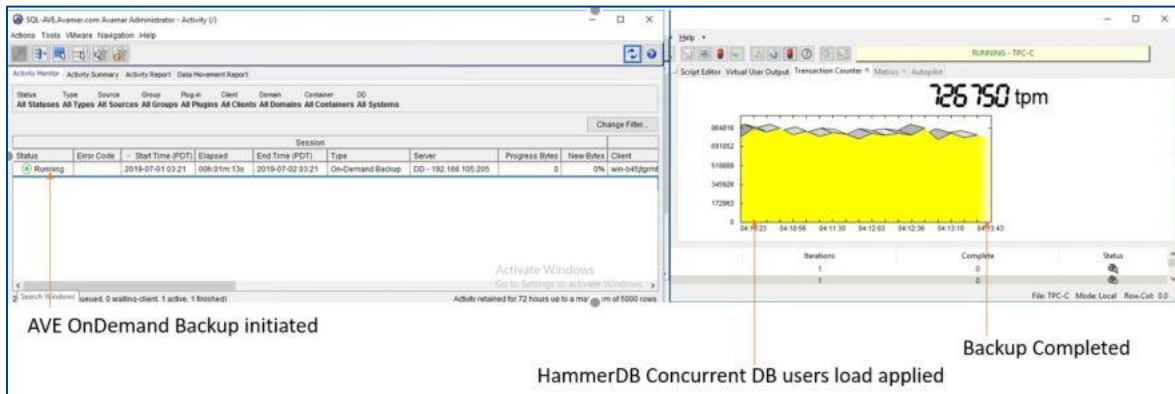

Figure 8   Validation results

A Technical support and resources

Dell.com/support is focused on meeting customer needs with proven services and support.

Storage technical documents and videos provide expertise that helps to ensure customer success on Dell EMC storage platforms.

A.1 Hardware and software components

Component	Definition
VxFlex integrated rack	**4 x VxFlex Nodes (R640 servers)** • VxFlex OS version: R2_6.1 • ESXi version: 6.5 • CPU: 2 x 14 core Intel(R) Xeon(R) Gold 6132 (2.60 GHz) • Memory: 384-GB RAM (12 x 32-GB DIMMs) • Storage: 10 x 1.92 TB SSDs (12 Gbps)
Network	2 NIC cards, each having 2 ports 25 GbE connection
Avamar Virtual Edition	• AVE Version: 18.1.0.33 • Guest OS: SUSE Linux Enterprise 11 (64-bit) • vCPU: 2 • Memory: 6 GB • Size: 500 GB
Avamar Administrator	• Guest OS: CentOS 7 (64-bit) • vCPU: 2 • Memory: 4 GB
Data Domain details	• Model: DD6800 • OS: 6.0.2.9-579709 • Size: 255.5 TiB
Guest VM configuration	**SQL Server 2016 Enterprise Edition** • Operating system version: Windows Server 2016 • vCPU: 16 • Memory: 128 GB
SVM configuration	**4 x Linux VMs** • Operating system version : SUSE Linux Enterprise 12 • VM version : 11 • vCPU : 8 • Memory : 10 GB

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Component	Definition
Database software	Microsoft SQL Server 2016 Enterprise Edition
VxFM	Version: 2.6.1.1
iDrac	Version: 3.2.1.2.1
OS	Version: Windows server 2016 Data Center Edition
Cisco Nexus 93180YC-EX Switch	Nexus OS
Cisco Nexus CN 9332PQ	Nexus OS

A.2   Related resources

Dell EMC Avamar for SQL Server User Guide

Del EMC Avamar Virtual Edition Data Sheet

Dell EMC Avamar Data Domain System Integration Guide

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