Backup Solution for Epic Caché Database
With EMC® Avamar® and EMC Data Domain®

- Faster backup and recovery
- Efficient deduplication for Epic Caché Database

EMC E-Lab™ Verticals Engineering Group

Abstract

The document depicts the reference architecture for protecting Epic Caché Database with EMC backup solutions enabled by the integration of Data Domain with Avamar.

December 2014
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Reference architecture overview

Document purpose
The document describes the reference architecture of Epic Caché Database protected by EMC® DPAD solutions with EMC Avamar® and EMC Data Domain®, which was tested and validated by the EMC E-Lab™ Verticals Solutions Group.

Solution purpose
This reference architecture documents the testing and validation of the advanced backup solutions for functionality and performance. This testing environment was built by using a combination of Avamar with Data Domain.

This reference architecture validates the performance of this solution and provides guidelines to build similar solutions.

This document is not a comprehensive guide to every aspect of the solution.

Business challenge
Protecting critical data is a significant challenge for enterprises of all sizes. Specially, with the increasing stress on Electronic Medical Records (EMR) data due to explosive growth and various regulation compliance requirements, healthcare delivery organizations are looking for a better strategy to protect this important business data, including patient records. In addition, more and more healthcare solutions are transferring from traditional infrastructure to virtualization and Cloud platforms, which also call for a seamless data protection solution.

Now more than ever, to keep pace with these new requirements, the healthcare industry requires a sophisticated backup approach for the Caché Database. Several terabytes of data are required to be backed up every day with typical retention periods for Epic data of 30 days. Furthermore, the SLAs call for data recovery to occur at no less than 250 GB per hour, preferably faster. There are several new technologies available from EMC to assist in architecting this kind of solution, but the need exists to know how to best use these technologies to maximize the investment, better support service-level agreements, and minimize the TCO.

In addition to the above concerns, other challenges should also be addressed:

- Strict RTO requirement of 250 GB per hour minimum
- Zero impact on production environment when performing backup
- Ability to redirect the restore and restore single files from within the database structure
- Limited backup window, generally less than 8 hours
- Easy deployment and management

Technology solution
EMC’s next generation data protection solutions are applied to satisfy industry backup and recovery requirements, which are quite suitable for enterprise’s virtualization and Cloud environments, to enable DPaaS/BaaS (Data Protection-as-a-service/Backup-as-a-service) models. Specifically, Data Domain is integrated with Avamar to offer deduplicated backup and quick recovery.
This reference architecture is intended for EMC employees, partners, and customers with an interest in backup and recovery for Epic Caché Database. Readers should already be familiar with Epic Caché Database and EMC technologies.

Table 1 defines terms used in this document.

Table 1.  Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMR</td>
<td>Electronic medical record</td>
</tr>
<tr>
<td>RPO</td>
<td>Recovery point objective. RPO is the point in time (prior to an outage) that systems and data must be restored to</td>
</tr>
<tr>
<td>RTO</td>
<td>Recovery time objective. RTO is the period of time after an outage in which the systems and data must be restored to the predetermined RPO</td>
</tr>
<tr>
<td>OLTP</td>
<td>Online Transaction processing</td>
</tr>
<tr>
<td>TCO</td>
<td>Total Cost of Ownership</td>
</tr>
<tr>
<td>SU</td>
<td>Storage Unit in Data Domain</td>
</tr>
</tbody>
</table>
This solution describes the tests performed to validate the EMC backup and recovery methods for Epic Caché Database enabled by integrating EMC Avamar and EMC Data Domain solutions. It involves simulating 6 TB Caché database on VNX® storage and deploying an Avamar Virtual Edition (AVE) in a vSphere environment. In addition, production and proxy servers reside on Linux as physical machine and virtual machine respectively.

Figure 1 depicts the overall physical architecture of the solution.
Table 2 lists the hardware used in this solution.

**Table 2. Solution hardware**

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Quantity</th>
<th>Configuration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC VNX5400</td>
<td>1</td>
<td>DAEs configured with: 154 600GB 15k rpm SAS disks 15 3T 7.2k rpm near-line SAS disks 70 200 GB Flash drives</td>
<td>Storage used for clone Cache DB for backup</td>
</tr>
<tr>
<td>EMC Data Domain DD860</td>
<td>1</td>
<td>64 1T 7.2k SATA disks</td>
<td>Deduplication backup storage</td>
</tr>
<tr>
<td>Intel server</td>
<td>3</td>
<td>Two six-core Intel Xeon X5670/X5675 96 GB RAM 10G network adapter/8G FC</td>
<td>One for production server One for Proxy server One for virtual Avamar server</td>
</tr>
<tr>
<td>Ethernet switch</td>
<td>1</td>
<td>Cisco Nexus 5010</td>
<td>Infrastructure Ethernet switch</td>
</tr>
<tr>
<td>SAN switch</td>
<td>2</td>
<td>Brocade 6510</td>
<td>For dual FC fabric</td>
</tr>
</tbody>
</table>

Table 3 lists the software used in this solution.

**Table 3. Solution software**

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC VNX5400 OE</td>
<td>05.33.000.5.038</td>
<td>Operating environment for the block</td>
</tr>
<tr>
<td>EMC DDOS</td>
<td>5.4.0.8-404909</td>
<td>Operating environment for Data Domain</td>
</tr>
<tr>
<td>InterSystems Caché</td>
<td>NA</td>
<td>Simulated Epic Database</td>
</tr>
<tr>
<td>EMC Avamar</td>
<td>V7.1</td>
<td>Avamar backup software</td>
</tr>
<tr>
<td>VMware vSphere ESXi</td>
<td>5.1.0 Build 799733</td>
<td>Server hypervisor</td>
</tr>
<tr>
<td>EMC PowerPath</td>
<td>5.7 SP3/5.6</td>
<td>Multipath software</td>
</tr>
<tr>
<td>RHEL Linux</td>
<td>5.6</td>
<td>Operating system for Production and Proxy server environment</td>
</tr>
</tbody>
</table>

Table 4 lists the virtual appliance used in this solution.

**Table 4. VM configuration**

<table>
<thead>
<tr>
<th>VM</th>
<th>Quantity</th>
<th>OS</th>
<th>vMemory</th>
<th>vCPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avamar Server</td>
<td>1</td>
<td>NA</td>
<td>16 GB</td>
<td>2</td>
</tr>
<tr>
<td>Virtual Proxy Sever</td>
<td>1</td>
<td>RHEL 5.6</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>vCenter Server</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Key components

Introduction

This section briefly describes the key components and technology used in these solutions, including:

- EMC Data Domain with DD Boost
- EMC Avamar
- EMC VNX platform
- VMware vSphere
- Epic Caché Database
- Deduplication

EMC Data Domain with DD Boost

EMC Data Domain deduplication appliances are the industry’s leading performance deduplication storage system. They provide simple and reliable disk-based data protection and disaster recovery (DR) solutions, which support various backup and archive applications and integrate seamlessly with existing infrastructures. They are designed for optimal performance, operational simplicity, and easily scale to meet all sizes of enterprise environment needs.

EMC Data Domain systems utilize a disk-based Inline deduplication method and leading-edge algorithm, which offers better performance with lower storage space requirements. EMC Data Domain systems incorporate an advanced technology to protect against data loss caused by hardware or software failures. Both of these features are enabled by:

- Stream Informed Segment Layout (SISL) scaling architecture
- Global compression technology
- Data Invulnerability Architecture (DIA) architecture

The foundation for the Data Domain system’s industry-leading performance is its SISL scaling architecture. Unlike post-processed deduplication, SISL deduplicates data inline by identifying redundant data in RAM with powerful CPU rather than disk-based processing, which minimizes disk usage and achieves better performance. It makes Data Domain a CPU-centric system, which leverages successive generations of CPU to continuously increase performance not a spindle-bound architecture like other deduplication platforms.

Data Domain use a global compression algorithm to process the incoming data streams. It combines a high-performance global deduplication with an efficient local compression technique. Data Domain uses variable-length deduplication methods to provide more efficient deduplication capabilities. The duplicate data is eliminated firstly with a block-based variable segment deduplication algorithm. Then, this unique data is compressed with a compression algorithm. The joint effort results in the required disk space being dramatically minimized.

All data stored on Data Domain systems is protected by DIA, which provides the industry’s best defense against data integrity issues and makes Data Domain ultra-safe storage for reliable recovery. It contains end-to-end data verification and continuous fault detection and self-healing mechanisms coupled with other resiliency features transparent to the application. Unlike other enterprise arrays or file systems,
continuous fault detection and self-healing features protect data throughout its lifecycle on all Data Domain systems.

Taken together, all these techniques allow more backups to complete faster while putting less pressure on limited backup windows, making it a good candidate for backup cases such as database, email, and unstructured data.

![EMC Data Domain example](image)

**Figure 2. EMC Data Domain example**

EMC Data Domain Boost is a software option available for all Data Domain systems, which significantly increases backup performance and reliability, simplifies operational and disaster recovery, and allows better leverage of current infrastructure investments.

DD Boost is made up of two components:

- A DD Boost library (plug-in) that runs on the backup server or client
- A DD Boost server component that runs on the Data Domain system

This innovative technology offloads part of the deduplication process (ID segment and compression) to the backup server or client. This allows the Data Domain to focus on determining what data is unique and only writing that data to the disk, which improves performance. Furthermore, since only unique data is sent to the Data Domain system, this enables more efficient use of the existing LAN or SAN.
EMC Avamar deduplication software and systems are a complete data protection solution, equipped with integrated data deduplication technology to dramatically reduce daily backup data at the client side before it is transferred across the LAN or WAN and stored to disk. With Avamar, enterprise organizations can improve backup performance, dramatically reduce storage and network costs, and enjoy fast single-step recovery with existing networks and infrastructure.

These technologies allow Avamar to provide fast, efficient and reliable backup, recovery and disaster recovery for all size of enterprises:

- Scalable grid architecture
- Global, client-side deduplication technology
- Redundant Array of Independent Nodes (RAIN)
- Fast, single-step recovery

Grid architecture offers a number of significant benefits including flexibility and scalable performance and capacity. It enables every Avamar client to connect to every storage node in an Avamar Grid Server for both backup and restore, which eliminates potential performance bottlenecks. Avamar uses a distributed indexing architecture, to automatically load balance data across all available storage nodes to streamline access to data. Linear performance increases and more capacity are achieved by simply adding nodes.

Avamar employs a patented redundant array of independent nodes (RAIN) technology and daily system integrity checks to obtain a higher level of availability and reliability. Similar to RAID-5, RAIN enables parity data to be striped across the active data nodes, which ensures data stored on any node can be reconstructed from the other nodes when a server node fails or becomes unavailable while daily internal checkpoints verification is designed to verify data recoverability. In addition, Avamar Replicator provides the ability to replicate data to and recover from an off-site location in the event of a disaster scenario. These features ensure data is recoverable and accessible throughout its lifecycle.

Avamar utilizes a patented global data deduplication algorithm to identify repeated sub-file data segments at the source, this is done globally to ensure unique variable length objects are stored only once across the enterprise. During backups, Avamar client examine existing records on Avamar grid to determine if the data has been backed up previously. Data never has to be re-sent over the network if already stored, which significantly minimizes LAN/WAN traffic and greatly enhances storage efficiency.

Avamar stores all backups as virtual full images, which can be immediately recovered to any system running the Avamar agent, eliminating incremental backups and enabling simple one-step restore.

Depending on the specific use case and recovery requirements, Avamar provides flexible deployment options for physical and virtual environments. Avamar Virtual Edition (AVE) enables an Avamar server to be quickly and easily deployed as a virtual appliance for reduced cost and complexity, which optimizes resources. Each virtual appliance supports up to 4 TB of deduplicated backup capacity and can leverage the existing infrastructure to further lower costs and simplify management.
All these industry leading techniques make Avamar a good solution for protecting file systems, NAS systems, virtual environments, desktop/laptop systems and ROBO, low-change-rate databases, and enterprise critical applications over the LAN/WAN.

**EMC VNX platform**
- The EMC VNX family delivers industry-leading innovation and enterprise capabilities for file, block, and object storage in a scalable, easy-to-use solution. The VNX family includes the VNEXe series, purpose-built for the IT manager in entry-level environments, and the VNX series, designed to meet the high-performance, high-scalability requirements of all size of enterprises.

**VMware vSphere**
- VMware vSphere is the market-leading virtualization platform used across thousands of IT environments around the world for building cloud infrastructures. It is a trusted virtualization platform offering the highest levels of availability and responsiveness. VMware and EMC work together to build solutions that enable healthcare providers to dramatically reduce capital and operating costs and complexity, which maximizes IT efficiency while giving healthcare organization agility to the new business needs.

**Simulated Caché database**
- An Epic environment contains multiple databases: Caché and Clarity. Caché is a high-performance post-relational database and is utilized as an OLTP database. This document focuses on the Caché databases.

For testing purposes, EMC utilized a simulated Caché database created with eight file systems and a separate file system for the journal files. The database was created through the use of a test IO utility created by Epic known as GenerateIO. The data files were created; then a simulated workload was designed to change 10% of the data on a daily basis, similar to what would be expected in a production Epic environment.

Everything in the Epic environment is tightly integrated with Caché. It’s typically large averaging over 2TB and daily full backup is required. In this test the simulated Caché database was used as a backup workload. The total size was about 6 TB and was evenly distributed. Figure 3 shows an example of a simulated Cache database.

![Simulated Caché Database sample](image)

**Figure 3.** Simulated Caché Database sample

**Note:** Clarity acts as Reporting database that uses Oracle or MS SQL to provide reporting and queries services.
Deduplication makes satisfying current and future backup needs difficult using traditional methods. Additionally, keeping costs relatively low on data protection with desired performance is a difficulty confronting all enterprises.

Deduplication is one of the most attractive technologies to address such an issue. It’s a data compression technique for eliminating redundant copies of repeating data. It offers fast, reliable, and cost-effective backup and recovery by shrinking storage requirements and improving bandwidth efficiency. EMC’s advanced deduplication method enables enterprises to maximize efficiency while minimize TCO.

Deduplication ratio is one of the most important indicators when measuring overall efficiency of reduction in storage space. Besides different algorithms and work models, the key factors contributing to the ratio include backup candidate data type and backup policy.

Depending on the characteristics of the data, those with low change rate containing redundancy and a small number of large files, will benefit most from deduplication. It means that user data like text files, presentations, spreadsheets, documents, most database types, source code, and Exchange are dedup-friendly. For pre-compressed data types, the first full backup may provide a high ratio but following backups will generally deduplicate well. Examples include audio, video streams, and scanned images.

The applied backup policy also plays an important role when considering deduplication ratio. Specifically, different frequency of full backups and retention periods yield various results. Typically, longer data retention periods and more frequent full backups result in better commonality with the greater chance that identical data exists and better deduplication ratios are achievable.

Epic Caché Database is a good candidate for deduplication with its file-based structure and full backup requirement. In addition, the individual file systems consist of a single large file and numerous smaller files making deduplication more efficient.
Test scenario and methodology

Scenario

Several scenarios with different parallelism stream settings were applied for the testing, as shown in Table 5:

Table 5. Test cases

<table>
<thead>
<tr>
<th>No</th>
<th>Operation</th>
<th>Streams</th>
<th>Platform</th>
<th>Test Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backup</td>
<td>8/4/2/1</td>
<td>Physical</td>
<td>5/5/5/5</td>
</tr>
<tr>
<td>2</td>
<td>Restore</td>
<td>8/4/2/1</td>
<td>Physical</td>
<td>1/1/1/1</td>
</tr>
<tr>
<td>3</td>
<td>Backup</td>
<td>8</td>
<td>Virtual</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Restore</td>
<td>8</td>
<td>Virtual</td>
<td>1</td>
</tr>
</tbody>
</table>

Methodology

For the testing, Epic provided a test suite for Caché database simulation while the EMC E-Lab Verticals team conducted all the tests and captured the performance metrics.

- The number of **Test Cycles** for each backup scenario is designed as 5 rounds to reflect a full business week and allow a representative deduplication period. The focus of the virtualization test cycle was to verify the functionality and determine sizing for the proxy server.

- **Backup Workload** is generated by the scripts and is large enough at ~ 6 TB to be representative. In order to simulate a real world case, initial backup together with subsequent 4 days full backup with a 10% daily change rate (approximately 600 GBs) was based upon the last backup database size as the source data. In an actual customer deployment, a daily clone (or clones) is created and presented for backup. For testing purposes, the initial Caché DB and following data for Day1 to Day5 were created on the Source LUN via production server. It was then synchronized to the Clone LUN. Lastly, it was cloned to the Backup LUN for a backup test via a proxy server. Figure 4 shows an example of this process.

- $D_1$ – Initial DB data generated on the production server
- $D_1$ to $D_5$ – DB data with 10% change for each single day
- Note: The DB size for each day is the same about 6 TB

Figure 4. Backup workload process
• **Environmental Reset** is required before starting another sub scenario. It ensures the test bed is clean and has all the tests start from the same point. **Figure 5** shows an example of an environmental reset.

![Figure 5. Environment reset](image)

- **R1** – Erase backed-up data/metadata on Avamar server and start Garbage Collection. Also remove Data Domain from Avamar.
- **R2** – Delete logical storage unit (LSU) on Data Domain
- **R3** – Start cleaning job on Data Domain
- **R4** – Reconnect Data Domain with Avamar server

• The **Testing Process** is basically the same for each cycle of every stream settings. **Figure 6** shows an example.

![Figure 6. Testing process](image)

- **P1** – Create 10% database change rate through application processes
- **P2** – Mount the clone LUN onto the proxy server
- **P3** – Conduct test on proxy server
- **Note:** 5 test cycles for each scenario

• The **Observation Method** relies mainly on the log or operation reports from Avamar and Data Domain. Backup duration, RTO, and Deduplication/Compression ratio were measured during the test.
Configuration

Backup data flow
A dedicated Proxy server is used to mount the Epic production clone. This ensured that no other Epic-specific processes or services were impacted while performing routine backups. The backup data was transferred from VNX array through Proxy server to Data Domain while the metadata was sent from proxy server to Avamar server. This metadata allows Avamar to direct the client in performing restore operations directly from Data Domain without first going through the Avamar.

Figure 7 shows an example of backup data flow.

![Backup data flow example](image)

Restoring data flow
The solution allows your site to offer safe, user-driven, single-file restore operations. During recovery to an Avamar client, the Data Domain system converts the stored data to its original non-deduplicated state. When a restore operation is required, data is retrieved from Data Domain storage, decompressed, verified for consistency, and transferred to the backup servers using Ethernet.

Multiple processes can access a Data Domain system simultaneously.
Backup Solutions for Epic Caché Database with EMC Avamar and EMC Data Domain

Figure 8 shows an example of restoring data flow.

![Data Flow Diagram](image)

This section describes the storage LUN layout used in the VNX storage array for the backup process, but only focuses on the backup LUN. To avoid impacting production performance, a dedicated server and LUNs are applied when backing up simulated Epic Caché DB.

Generally, Epic Caché DB consists of multiple separate LUNs. To achieve performance, Fibre Channel SAS disk and RAID 5 was applied to the backup LUN, which often requires higher sequential throughput. Figure 9 shows an example of the backup LUN layout.

![Backup LUN Diagram](image)

Figure 9. Backup LUN layout example
This section describes the network layouts used in this scenario. Specifically, a 10GE card and link was used on Proxy Server, Production Server, and Data Domain for better performance compared with using 1GE link aggregation. A dedicated VLAN was used to isolate traffic. 1GE can be used on Avamar Server for the small amount of metadata and log files. This does not require high bandwidth. It is recommended to use jumbo frames in a backup environment. (Make sure all components in the data path are capable of handling jumbo frames. Increase the MTU to 9 KB.)

The combination of Avamar and Data Domain offers a great data protection solution benefiting from Data Domain systems’ scale and performance as well as the simplicity of Avamar. It allows quick and easy direction of enterprise-wide backups to either Avamar or Data Domain based on data types and characteristics, which enables faster backups, greater resource utilization and reduced bandwidth demand. It also simplifies management and reduces overall complexity and IT costs by providing a centralized single interface to eliminate the need for separately managed environments.

Specifically, Data Domain Systems are typically applied to complete critical high-speed backups of large high-change rate databases while Avamar is typically implemented to complete secure and efficient backup of file systems, VMware, low-change-rate databases, desktops, laptops, and remote offices over the WAN.

This feature is enabled by Data Domain Boost. Prior to DD Boost, Avamar clients could only send data to an Avamar Data Store or Avamar Virtual Edition. Now, Avamar easily integrates with Data Domain via Data Domain Boost and the Avamar client can send unique data segments directly to the Data Domain system. Furthermore, DD Boost significantly increases performance by distributing parts of the deduplication process to the Avamar client. The client leverages DD Boost to redirect this data directly to Data Domain Systems, so there is no Avamar deduplication and no client cache files to tune if using Data Domain as the backup target.
The following sections introduce the key steps when integrating Avamar with Data Domain enabled by DD Boost. There are five phases, each further discussed in this section:

- Prerequisites
- Data Domain settings
- Avamar settings
- Proxy Server settings
- Backup Profile settings

## Prerequisites

Before integration, prerequisites and limitations of this solution should be understand and noted as shown below:

<table>
<thead>
<tr>
<th>Prerequisites</th>
<th>Feature not supported</th>
</tr>
</thead>
</table>
| Versions      | • DD OS 5.3.x or later
                • Avamar 7.0 or later
                Avamar client-side encryption and compression is not supported
| Licenses      | • Data Domain Boot License
                • Standard Avamar License
| Servers       | • DNS server or local host file
                • NTP server
| Other         | Satisfy firewall requirements

Notes:
- Make sure the DD OS and Avamar versions meet the minimum requirements as shown in the above prerequisites. Beginning with Avamar 6.0, Avamar and Data Domain systems are integrated through a single user interface; prior to Avamar 7.0 it supports file system backups and restores from the Data Domain system for 64-bit operating systems.
- Obtain all the required licenses. Data Domain Boost license applied on Data Domain system and a Standard Avamar license on Avamar server. This example used Avamar Virtual Edition 2TB license.
- A DNS server or local host file to ensure Data Domain, Proxy server (backup Client), and Avamar sever can consistently resolve their hostnames in the network from multiple locations in both directions. NTP server is required to provide reliable timing service for all the components in the environment.
• Ensure the entire physical link is configured as shown in the Network configuration section and is functioning correctly. Additionally, firewall should be enabled on a couple of specific ports to allow communication between the Data Domain and Avamar servers. For details, refer to EMC Avamar Product Security Guide. For this case, all the components were put into a VLAN.

**Data Domain settings**

Ensure Data Domain has been properly initialized and required licenses have been applied. Then, log in to Data Domain system as administrative user and run the CLI, as shown in the following steps.

1. Enable NFS service.

   ```
   --nfs enable
   ```

   You need to enable NFS services on the Data Domain system, even if no users or shares are configured. If NFS is not enabled, Boost will not be active.

2. Add and enable a ddboost account.

   ```
   --user add username
   --ddboost set user-name username
   ```

   This step will create a ddboost account which will be used by Avamar server.

3. Enable ddboost.

   ```
   --ddboost enable
   ```

   This step will enable ddboost so Avamar server can access Data Domain ddboost device.

4. Enable and configure SNMP traps.

   ```
   --snmp add ro-community communityname
   --snmp enable
   --snmp add trap-host hostname[:port]
   ```

   This step will allow Avamar server to capture Data Domain statistics.

5. Enable distributed segment processing (DSP).

   ```
   --ddboost option set distributed-segment-processing enabled
   ```
DD boost DSP feature allows Data Domain to offload part of the deduplication work to the Avamar client and only send the unique data to the Data Domain device.

6. Choose local compression type as Lempel-Ziv (LZ) via Data Domain GUI, this provides good balance between compression ratio and required backup duration.

**Note:** In current Data Domain system using DDOS 5.4, only one DD Boost user has access to the Data Domain system at a time.

**Avamar settings**

In this test environment, an Avamar Virtual Edition (AVE) has been deployed on a physical server. Launch Avamar Administrator GUI to integrate Avamar with Data Domain by completing the following steps:

1. Add a new Data Domain System via DD Boost
2. Configure SNMP settings.

3. Check if created device can be found in Data Domain and Avamar GUI. By default, the wizard creates 1 SU (Storage Unit) per Avamar server.

Notes:
- One or more Data Domain systems can be managed by Avamar.
- Make sure set the appropriate number of streams for “Max used by Avamar” to assure that the Avamar backup streams do not oversubscribe Data Domain Systems if other backup jobs are being targeted to it within the same backup window.
Avamar does not have a native multi-stream capability to efficiently backup a file structure as used by the Caché database. In order to create a multi-stream approach using Avamar, the following steps are required to set up and enable this capability. These steps outline how to create, configure the multiple streams, and attach datasets.

**Proxy Server settings**

1. **Install Avamar agent on Proxy server.**
   
   Avamar has different agent for different OS. So choose the appropriate agent for the Proxy server.

2. **Increase the size of TCP send/receive buffers.**

   Add the following parameters to the `/etc/sysctl.conf` file and then run the `/sbin/sysctl -p` command.

   ```
   net.core.rmem_default = 262144
   net.core.wmem_default = 262144
   net.core.rmem_max = 16777216
   net.core.wmem_max = 16777216
   net.ipv4.tcp_rmem = 3192 524288 16777216
   net.ipv4.tcp_wmem = 3192 524288 16777216
   sunrpc.tcp_slot_table_entries = 64
   ```

   This step provides the capability to handle larger TCP packets, resulting in more data carried per TCP packet. More data is transmitted with less block fragmentation, further reducing I/O overhead.

**Notes:**

- The tuning is only for the backup environment via NFS/CIFS and IP protocol.
- These settings are dependent on the operating system and proxy server. Other OS with different hardware configurations will have different tuning settings.
- Some of the values may differ when dealing with 1GE data path.
- Make sure all the systems have such same settings in your environment.
Backup Profile settings

The following steps describe how to manually add/register multi-instance on the proxy server and configure backup dataset in Avamar with the given table.

<table>
<thead>
<tr>
<th>Proxy Server</th>
<th>Backed up Dataset</th>
<th>Avamar Client Instance</th>
<th>Avamar Client Filesystem</th>
<th>Avamar Client Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>/epica/aprd</td>
<td>/usr/local/avamar</td>
<td>epicaprd01</td>
<td>/usr/local/avamar_epicaprd01</td>
<td>28011</td>
</tr>
<tr>
<td>/epica/aprd01</td>
<td></td>
<td>epicaprd02</td>
<td>/usr/local/avamar_epicaprd02</td>
<td>28012</td>
</tr>
<tr>
<td>/epica/aprd02</td>
<td></td>
<td>epicaprd03</td>
<td>/usr/local/avamar_epicaprd03</td>
<td>28013</td>
</tr>
<tr>
<td>/epica/aprd03</td>
<td></td>
<td>epicaprd04</td>
<td>/usr/local/avamar_epicaprd04</td>
<td>28014</td>
</tr>
<tr>
<td>/epica/aprd04</td>
<td></td>
<td>epicaprd05</td>
<td>/usr/local/avamar_epicaprd05</td>
<td>28015</td>
</tr>
<tr>
<td>/epica/aprd05</td>
<td></td>
<td>epicaprd06</td>
<td>/usr/local/avamar_epicaprd06</td>
<td>28016</td>
</tr>
<tr>
<td>/epica/aprd06</td>
<td></td>
<td>epicaprd07</td>
<td>/usr/local/avamar_epicaprd07</td>
<td>28017</td>
</tr>
<tr>
<td>/epica/aprd07</td>
<td></td>
<td>epicaprd08</td>
<td>/usr/local/avamar_epicaprd08</td>
<td>28018</td>
</tr>
<tr>
<td></td>
<td>ver093068</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Copy /usr/local/avamar and /var/avamar for each Avamar client instance.

2. Replace the default symbolic link with the new directory just created for each Avamar client instance. That is, for instance epicaprd01, run the following commands:

   ```
   cd /usr/local/avamar_epicaprd01
   rm -r /usr/local/avamar_epicaprd01/var
   ln -s /var/avamar_epicaprd01 /usr/local/avamar_epicaprd01/var
   ```
3. Edit file "/usr/local/avamar__<instance_name>/etc/avagent.d" and "/usr/local/avamar__<instance_name>/bin/avregister" to modify the line "BASEDIR=" to specify the base directory for the each Avamar client instance. For example, for instance epicaprd01, it looks like the following.

```
VERSION=11
AVAGENT=avagent_bin
BASEDIR=/usr/local/avamar__epicaprd01
LD_LIBRARY_PATH="$BASEDIR/lib:$LD_LIBRARY_PATH"
SHLIB_PATH=$LD_LIBRARY_PATH
LIBPATH="$BASEDIR/lib":$LIBPATH"
# LD_LIBRARY_PATH for Solaris, SHLIB_PATH for HP-UX, LIBPATH for AIX
export LD_LIBRARY_PATH
export SHLIB_PATH
export LIBPATH
```

```
echo "### Client Registration and Activation"
echo "This script will register and activate the client with the administrator server."
echo "Find Avamar client installation"
BASEDIR=/usr/local/avamar__epicaprd01
if [ "$AVAGENT_CLUSTER_CLIENT" = "true" ]; then
  if [ "$AVAGENT_HOSTNAME" = "" ]; then
```

4. Create a file "/usr/local/avamar__<instance_name>/var/.avagent" and add two lines for each Avamar client instance. For example, for instance epicaprd01, it looks like the following:

```
--hostname=epicaprd01
--listenport=28011
```

5. Register each client instance to the Avamar by typing below comments. For example, for instance epicaprd01.

```
--- cd /usr/local/avamar_epicaprd01/bin
--- ./avregister
```

You will then be asked to provide Avamar server name and the Avamar server domain if you have created. If not, you can use the default domain 'client'. In this example, a domain named 'Epic' was created.

6. Do not forget to add them into Linux startup and shutdown script so they can be launched and terminated automatically when rebooting the server, for example, for instance epicaprd01.
7. As a final check, log on the Avamar Administrator console and check if all the client instances have been registered successfully.

The following steps show how to create and attach datasets to the client instance using GUI:

1. Build a dataset group, name it ‘Epic’ and create 8 dataset containers under it.
2. Modify each dataset container. Add backup dataset, select plug-in type, and set Data Domain as target storage accordingly.

3. Edit each client instance and attach the corresponding dataset container to them.
Note the above configuring steps are for 8 multi-instances with only 1 separate dataset for each (8 streams). Fewer instances with more datasets, for example 2 multi-instances containing 4 datasets for each (2 streams), could be used. We varied the stream count using this approach, as shown in the Test section.

After successfully launching the backup in the Avamar, you can find similar information in Avamar Activity Monitor tab and in proxy server:

We understand there is no Avamar deduplication and no client cache files to tune when integrated with Data Domain but we still wanted to determine how much CPU and RAM would be needed for this type of Epic Caché backup. In this testing the physical proxy server was converted to a virtual machine. The CPU and RAM configuration was adjusted in the test to figure out the appropriate settings when sizing the proxy server.

The Avamar provides backup and recovery of VMware virtual clients by using traditional method (guest-Level) or integrates the vStorage APIs for Data Protection (image-Level) to centrally protect virtual machines.

Specifically, guest-based method involves installing the Avamar client within each virtual machine, then registering and activating each client with Avamar server. There are no additional configuration requirements. Backup and recovery operations are essentially the same as backing up and recovering a physical machine, which is already well-known by administrators.

Image-based backup and recovery requires separate backup proxy host and the workload is offloaded to it. Besides, Image-based backup can leverage the Changed Block Tracking (CBT) technique to keep track of disk sectors that have changed in the virtualization layer. It improves backup performance and optimization for file systems with large quantities of small files.

Figure 11 shows an example of a backup method for a VMware environment.
There are load and resources considerations on the backup client virtual machines when using guest-level backup. When using image-level backup, additional hardware and infrastructure must be considered as well, and it is more complex. Generally, the former is the preferred strategy for protecting those critical application servers and the latter is a better choice for other non-application intensive VMs. In this test, we applied guest-level backup for Epic Caché database. Table 6 compares guest-level to image-level backup.

![Backup method for VMware environment](image)

**Table 6. Guest Level vs Image Level**

<table>
<thead>
<tr>
<th>Item</th>
<th>Guest level</th>
<th>Image level</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMDK level backup</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Individual file backup</td>
<td>Yes</td>
<td>For Windows guest OS only</td>
</tr>
<tr>
<td>File level backup</td>
<td>Yes</td>
<td>For Windows guest OS only</td>
</tr>
<tr>
<td>Deduplication supported</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Deduplication efficient</td>
<td>Higher</td>
<td>High</td>
</tr>
<tr>
<td>Consistent type</td>
<td>Application consistent</td>
<td>Crash consistent</td>
</tr>
<tr>
<td>Impact on virtual machine</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Impact on ESX server</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Additional hardware requirements</td>
<td>No</td>
<td>VM or Physical server</td>
</tr>
</tbody>
</table>
Test results

Backup statistics

This section provides detailed information regarding test results and observations. During the test there was no other activity on either SAN or LAN.

Important: These tests were intended for comparison purposes only and are lab-based results. Actual durations for backup and restore activities depend on multiple variables both within the data itself and the customer's environment.

The following figure and table show the tracking of backup time in Hours:Minutes:Seconds for the five backups of each stream settings:

<table>
<thead>
<tr>
<th>Item</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Stream</td>
<td>12h:42m:24s</td>
<td>6h:40m:35s</td>
<td>6h:18m:19s</td>
<td>6h:08m:21s</td>
<td>6h:42m:45s</td>
</tr>
<tr>
<td>2 Streams</td>
<td>6h:43m:59s</td>
<td>3h:21m:14s</td>
<td>3h:11m:50s</td>
<td>3h:09m:22s</td>
<td>3h:21m:00s</td>
</tr>
<tr>
<td>4 Streams</td>
<td>4h:56m:14s</td>
<td>1h:47m:34s</td>
<td>1h:44m:31s</td>
<td>1h:39m:49s</td>
<td>1h:44m:21s</td>
</tr>
<tr>
<td>8 Streams</td>
<td>3h:12m:38s</td>
<td>1h:16m:06s</td>
<td>1h:07m:42s</td>
<td>1h:04m:56s</td>
<td>1h:17m:50s</td>
</tr>
</tbody>
</table>

Observations

Based on E-Lab testing, the following observations were made:

- The initial backup requires additional time since all data is unique to Data Domain. In this case, all the data was moved to Data Domain after compression.
- The initial backup duration with 8 streams was significantly better compared to that of the single stream backup.
- Multiple streams are optimal for Avamar backups.
Figure 12 illustrates the deduplication effect over the 5 day test cycle.

![Deduplication Factor](image)

**Figure 12. Deduplication factor**

Figure 13 presents overall deduplication ratio with 4 streams from Day 1 to Day 5.

![Deduplication Ratio](image)

**Figure 13. Deduplication ratio**

**Observations**

- The deduplication ratio does not change since the same backup data sets are used regardless of stream count setting.
• The deduplication ratio for initial backup is low since deduplication algorithm is not applicable. The initial day results are derived from Data Domain local compression technology.

• The largest increase in deduplication factor is from the initial to the second full backup. This period has the most redundant data that has not previously been through the deduplication algorithms.

• The rate of change for the deduplication ratios from the second to the fifth test run is reduced since the amount of redundant data is tied to the 10% growth factor. The deduplication ratio will continue to grow for the following backup cycles, but at a slower rate.

**Restore statistics**  
RTO is a key indicator of performance in a data protection environment, the restore time also was measured during the testing.  
*Figure 14* shows the time for recovering the data from Data Domain to the proxy server.

![Restore Time Diagram](image)

**Figure 14.** Restore time

**Observations**

• The restore time for 8 streams was much faster than a single stream for 6 TB of simulated Cache data.

• More streams means faster recovery when using Avamar.
In order to determine the CPU and RAM resource required for Epic Caché database, we executed several tests with different combinations of CPU and RAM settings. Some of the results are shown below. Resource usage and backup duration was observed via OS internal monitor tool and vSphere embedded monitor tool. Throughput on Data Domain/Backup status on Avamar during backup duration was also monitored to determine whether backup performance had a negative impact under such CPU and RAM settings.

Figure 15 shows the CPU and RAM is OK to handle the work for the 1st backup cycle when using 6vCPU plus 16G RAM.

Figure 15. Backup with sufficient CPU and RAM

It was noted that the throughput on Data Domain and backup duration was good.
Figure 16 shows the CPU resource is **not** enough to handle the work for the second backup cycle when using 6vCPU plus 16G RAM.

---

**Backup with insufficient CPU**

1. CPU usage was a little high.
2. RAM resource was enough.
3. One avtar session was suspended/slow due to insufficient CPU resource.

----

1. 7 avtar sessions got enough resource to run.
2. 1 avtar session did **NOT** get enough CPU resource to proceed.

---

1. The sustain CPU usage was about 100%
2. Declined when 7 sessions done
3. The slowest 1 avtar session got enough CPU resource.
It was noted the throughput on Data Domain is little low and backup duration was extended.

**Figure 17** shows the Memory resource is **not** enough to handle the work for the 1\textsuperscript{st} backup cycle when using 12vCPU plus 8G RAM.

**Observations**

- In our test environment using at least 8vCPU plus 16G RAM was enough to provide good results for 8 Avamar avatar streams.

- Each avatar stream together with DD Boost uses about 830 MB of physical RAM this equates to \( \sim 1\text{TB} \) virtual RAM.

- For required CPU resource for each cycle: initial cycle need less CPU while the following backup cycles need more CPU resource to process deduplication.
- For required RAM resource for each cycle: It does not change with the backup cycles.
- When Avamar client on Linux and running the backup the majority of RAM will be used as cache.
- The backup duration will be longer if backup client does not have sufficient CPU or RAM resources. In that case some avtar streams are suspended and proceed very slowly until resource released when other avtar streams completed. Lack of RAM will negatively impact the performance.
Conclusion

Summary
The integration of Avamar and Data Domain is a more efficient data protection solution, which speeding up backups and recovery with less storage space consumption and simplifying daily operations. Our testing proves it to be a good solution for protecting Epic Caché Database.

Specifically, Data Domain helps enterprises reduce the amount of data to backup and dramatically reduces the amount of disk storage needed to retain and protect data, while Avamar provides a common management interface and backup workflow to simplify the whole process. This solution is also suited to diverse enterprise environments with various data types and workloads. For example, database backup goes to Data Domain while desktop/laptop systems backup goes to Avamar.

Findings
Based on our testing:

- We achieved greater than 250 GB/hour throughput required for both backup and restore.
- We found that making the stream count equivalent to the number of Cache file systems (in our case, 8) was the optimum setting if enough proxy server resource is available.
- EMC recommends considering at least 2G RAM for each stream. Always refer to the Avamar Best Practices for the latest sizing guidelines.
- EMC recommends considering 1vCPU for each stream.
- May need more CPU and RAM resources when considering 70 percent rule.
- Restoring needs less proxy server resource compared with backup.

Important: All backup and restore performance levels are subject to a multitude of factors. Under the specific laboratory conditions used in this testing, we were able to achieve performance levels. Performance numbers will vary depending on environment size and specifications.
References

Documents

The following documents, located on the EMC online support website at https://support.emc.com, provide additional and relevant information. Access to these documents depends on your login credentials. If you do not have access to a document, contact your EMC representative.

- Avamar 7.0 and Data Domain System Integration Guide
- Avamar 7.0 Administration Guide
- Avamar 7.0 Backup Clients User Guide
- Avamar Configuration for Epic Caché Database Backups
- Avamar 7.1 for VMware User Guide