White Paper

EMC CLOUD-ENABLED INFRASTRUCTURE FOR SAP—BUSINESS CONTINUITY SERIES: DATA PROTECTION BUNDLE—VNX

EMC Next-Generation VNX, EMC Data Domain, EMC Avamar, and EMC Data Protection Advisor

- Comprehensive backup and recovery for Cloud-enabled Infrastructure for SAP
- Efficient protection of backups and images using native replication and deduplication technology
- Comprehensive service-level and chargeback reporting for data protection

EMC Solutions

Abstract

This white paper focuses on backup and recovery management of the Cloud-enabled Infrastructure for SAP. This solution is delivered as an add-on bundle designed to fully integrate with the Cloud-enabled Infrastructure foundation. The solution is powered by EMC® next-generation VNX® storage systems, EMC Data Domain®, EMC Avamar®, and Data Protection Advisor to provide a total solution to efficiently back up and recover every component of the whole environment.

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Part Number H12635

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Executive summary

Business case

With the exponential growth of cloud environments, backup and recovery have always created consistent challenges for an IT administrator. From a business perspective, all backup administrators know that a backup can only be as good as its recoverability. However, as the recovery time objective (RTO) and recovery point objective (RPO) requirements grow, so do the challenges in efficiency, such as:

- Exponential data growth leaves the backup window times insufficient to fulfill service level agreements (SLAs)
- A high network bandwidth requirement for simultaneous backups in a cloud environment
- Difficult charging backup services to customers in tenant-based cloud environments
- Compliance with information security standards , such as International Standardization Organization (ISO) and Information Technology Infrastructure Library (ITIL), which require retention of backups for specific periods and securing backup copies in offsite locations

Recoverability is an absolute must, but it comes at a cost:

- Daily full backups using traditional approaches require intensive server resource consumption and large storage footprint
- Incremental backups conserve disk space but typically have more complex restore procedures
- Sending offsite backups over a wide area network (WAN) can consume a lot of bandwidth
- Sophisticated solutions can solve these but are difficult to manage and can be costly

With today's SAP virtual infrastructures housing hundreds of virtual machines, customers should strike a balance between each virtual machine's backup window, network utilization, and client resources.

Solution overview

This solution enables you to perform comprehensive and highly reliable backups, reduce your restore downtime, dramatically minimize backup footprint, and keep overhead to a minimum. To achieve this, we[1] use the following technologies:

- EMC® Data Domain® Systems serve as the high-speed, deduplication storage system and offsite replication medium for all backups
- EMC Avamar® serves as the central management software, enables backup, recovery, and offsite replication all in a single management console and directly integrates with Data Domain systems
- EMC Data Protection Advisor (DPA) serves as the central monitoring and chargeback reporting tool for backup and restore activities

[1] In this white paper, "we" refers to the EMC Solutions engineering team that validated the solution.

Key benefits

This solution achieves highly effective and efficient data protection by providing:

- Comprehensive backup and recovery strategies, simple deployment, and full integration with SAP databases, VMware, and EMC Data Domain systems that use easy-to-use interfaces
- Reduced backup and recovery times
- Reduced the backup footprint and the network resources using deduplication technology
- Replication to another site for remote backup protection and long-term retention
- Instant image access for image backups
- Backup-as-a-service (BaaS) solution that is suitable for cloud environments - accurate tenancy-based chargeback to services and actual resource consumption

Introduction

Purpose

This white paper introduces the data protection bundle—a backup and recovery enhancement, and one of several integral parts of an EMC Cloud-enabled Infrastructure for SAP. This white paper aims to:

- Introduce the technical components needed to implement and operate this solution
- Test and validate the functionalities presented
- Evaluate the technical and business value of the solution in the context of an SAP virtual cloud environment

Scope

This white paper focuses mainly on its integration with a standalone foundation bundle on a next-generation VNX platform. However, the solution is highly compatible with any other Cloud-enabled Infrastructure enhancement implementations that may have already been in place, such as a high availability bundle or a disaster recovery bundle.

Audience

This white paper is intended for SAP operations managers, administrators (SAP/server/network/storage), IT architects, and technical managers responsible for architecting, deploying, and managing mission-critical SAP landscapes. SAP administrators are expected to understand SAP database backup and recovery procedures prior to reading this white paper. Knowledge of basic deduplication concepts, Avamar and Data Domain architectures is helpful but not required to fully understand the rest of the solution.

Terminology

Table 1 defines the terms used in this document.

Table 1. Terminology

Term	Definition
BR*Tools	A toolset provided by SAP for Oracle database administrator tasks.
CBT	Changed Block Tracking, a feature that keeps track of the storage blocks of virtual machines as they change over time. The VMkernel keeps track of block changes on virtual machines, which enhances the backup process for applications that have been developed to take advantage of VMware's new vStorage Application Program Interfaces (APIs).
Datastore	A storage location for virtual machine files
Deduplication	Deduplication is a method to optimize storage consumption by eliminating redundant data. Only one unique data instance of the data is retained on storage media. Redundant data is replaced with a pointer to the unique data copy.
Multistreaming	A feature that enables a single backup or restore to use multiple threads (data streams) to Data Domain system.

Term	Definition
OvDC	Organization Virtual Data Center. A vDC abstraction, which is partitioned from a PvDC that maps resources to an organization
PiT	Point in-Time recovery
Resource pool	A logical abstraction used for flexible management of CPU and memory resources
Retention policies	The rules that are used to determine how long data is maintained on the system and available for recovery
vApp	Virtual application. A virtual system that contains one or more individual virtual machines and system parameters that define operational details
VADP	VMware vStorage APIs for Data Protection (VADP) enable backup software to perform centralized virtual machines, which enhances the backup process for applications that have been developed to take advantages of VMware's new vSphere APIs.

Technology overview

Introduction

This section introduces the concept of the Cloud-enabled Infrastructure as a whole and how its key components are integrated. This section also details the hardware and software components used in this solution.

The Cloud-enabled Infrastructure for the SAP solution is a result of the preferred 3-way partnership between EMC, SAP, and VMware. The infrastructure is divided into several different functionalities, which are delivered as separate add-on bundles, as illustrated in Figure 1. The EMC Cloud-enabled Infrastructure for the SAP solution is designed to offer flexibility so that customers can choose the required cloud functionalities (referred to as add-on bundles), which they can enable without losing sight of their end goal—an efficient and reliable private cloud.

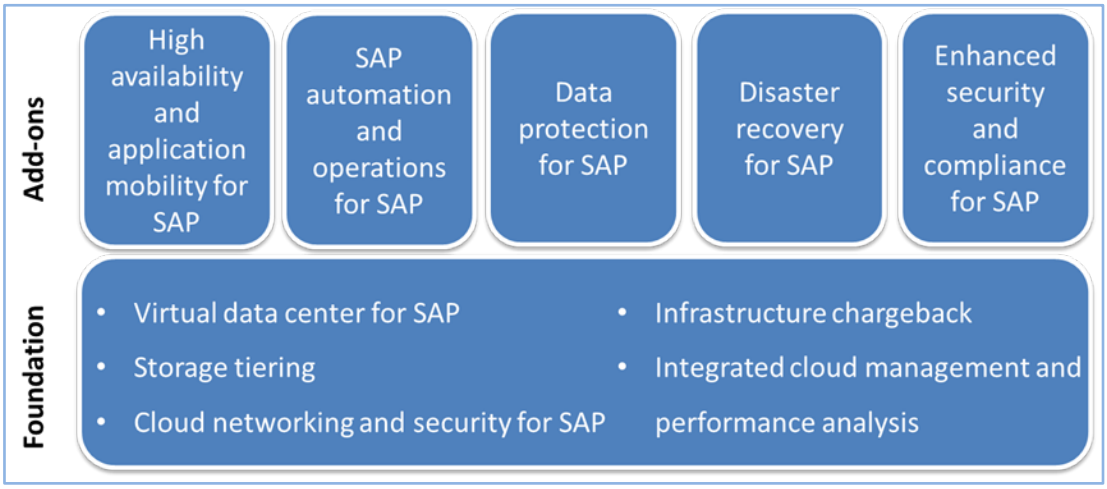

Figure 1. Cloud-enabled Infrastructure for SAP

A journey to the private cloud starts with the Foundation bundle, which is described in *EMC Cloud-Enabled Infrastructure for SAP Foundation Bundle White Paper*.

The Cloud-enabled Infrastructure for the SAP foundation bundle is a mandatory component and it is the base for all add-on bundles. Table 2 outlines the functions and benefits of the EMC Cloud-enabled Infrastructure foundation bundle.

Table 2. EMC virtual IT stacks: Foundation bundle

Function	Benefits	Technology
Virtual datacenter for SAP	• Autonomy of business units and application operations • Service catalogs • Service level agreements (SLAs) • Management of vCloud tenants • Resource pooling	• VMware vCloud Suite Enterprise

Function	Benefits	Technology
Infrastructure chargeback	Cost measurement, analysis, and reporting of the use of compute, network, storage, and backup resources (in combination with data protection add-on bundle)	VMware vCenter Chargeback
Integrated cloud management and performance analysis	• Manage availability, capacity, performance, and health in the SAP landscape	• VMware vCenter Operations Manager • EMC Storage Resource Management • EMC Storage Analytics (ESA) • EMC Virtual Storage Integrator (VSI)
Storage tiering	• Automatically get the right data to the right place at the right time	• EMC VNX • ENC FAST™ Suite
Cloud networking and security for SAP	• Cloud-enabled Infrastructure security framework • Authorization concepts • Compliance and non-compliance tracking	VMware vCloud networking and security

For more information about the foundation bundle, refer to the *EMC Cloud-enabled Infrastructure for SAP White Paper*.

This foundation bundle is the base for all other add-on bundles, including the data protection bundle. You can then strategize your roadmap on what to build next.

Table 3 describes the five add-on bundles that enable cloud functionalities and data center enhancements.

Table 3. EMC Cloud-enabled Infrastructure for SAP: Add-on bundles

IT strategy	Bundle	Benefits	Technology
Business continuity	High Availability (HA) and Application Mobility for SAP	• High availability within one datacenter and across two datacenters with application awareness for the complete SAP landscape • Non-disruptive movement of applications from one datacenter to another datacenter • Improved resource utilization across datacenters • Minimize downtime for infrastructure maintenance	• EMC VPLEX Metro • vSphere HA • vSphere DRS • Symantec ApplicationHA

IT strategy	Bundle	Benefits	Technology
	Disaster Recovery (DR) for SAP	Provide disaster recovery protection for cloud management applications and SAP systems	• VMware vCenter Site Recovery Manager • EMC RecoverPoint®
	Data Protection (DP) for SAP	• Provide data protection to cover the cloud management applications and SAP systems • Backup and recovery at all datacenters with remote replication of backup sets for offsite protection	• EMC Avamar • EMC Data Domain • EMC Data Protection Advisor
Service support/ Provisioning	Automation and operations for SAP	• SAP application virtualization enables any service any time on any server • Provision SAP systems on demand with automated end-to-end process • Reduce downtime window during maintenance leveraging mass operations	SAP NetWeaver Landscape Virtualization Management
Enhanced security	Enhanced security and compliance for SAP	• Efficient, collaborative enterprise governance, risk and compliance (eGRC) program across IT, finance, operations, and legal domains • Data loss prevention • Secure user to network authentication	• RSA Archer eGRC • RSA Data Loss Prevention • RSA SecurID

Physical architecture

From an infrastructure point-of-view, the data protection bundle consists of two pairs of Avamar servers and Data Domain systems, with each pair situated on geographically separated sites. Figure 2 shows the physical architecture of the data protection bundle.

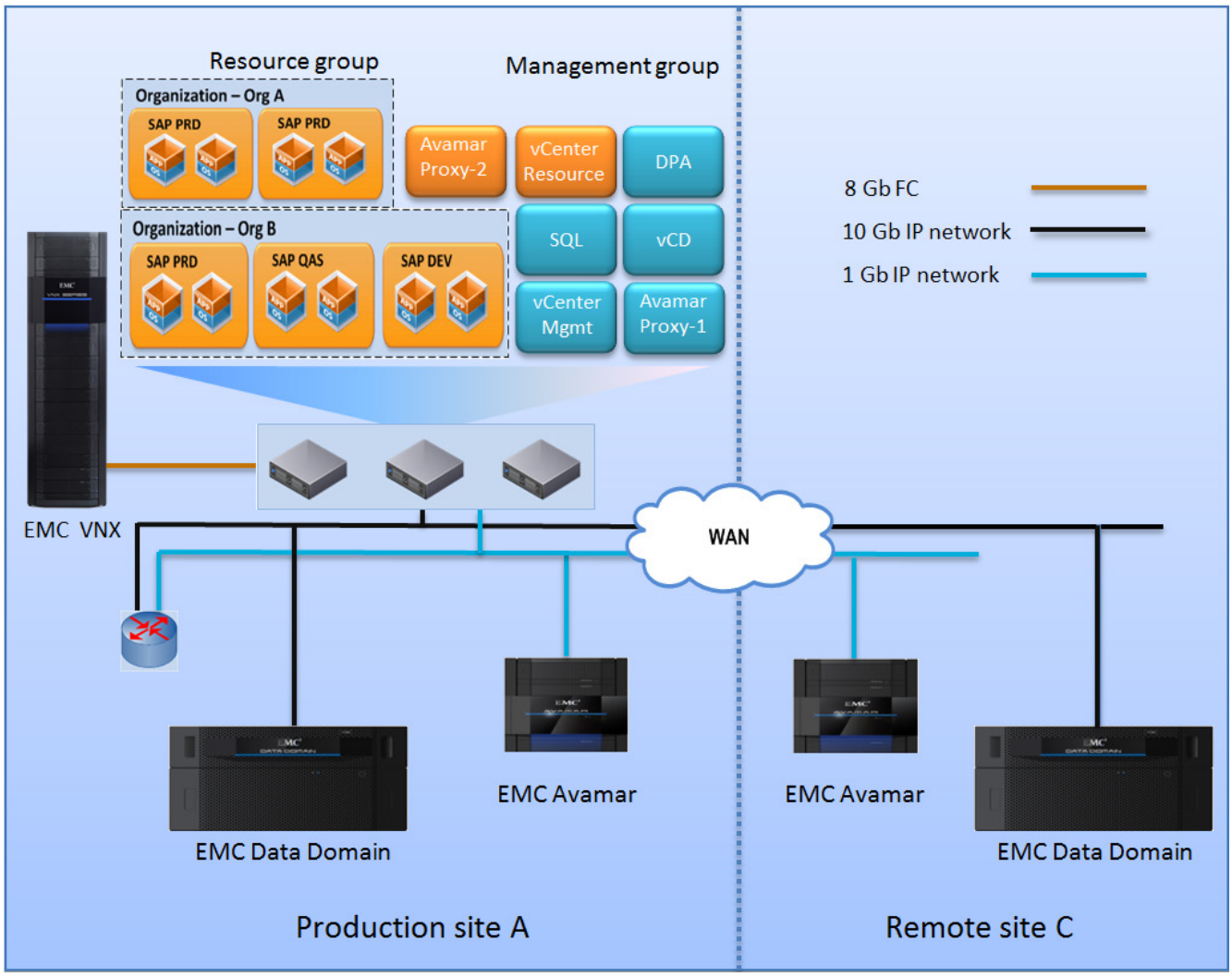

Figure 2. Physical architecture of the data protection bundle

Hardware resources

Table 4 lists the hardware resources used in this solution.

Table 4. Hardware resources

Hardware	Quantity	Product configuration
Storage	1	EMC VNX8000
VMware ESXi servers for the management cluster	2	2 four-core CPUs, 128 GB RAM
VMware ESXi servers for the resource cluster	2	2 eight-core CPUs, 256 GB RAM
Avamar	2	Gen 4S - 3.9 TB capacity
Data Domain	2	EMC Data Domain DD670
Network switching and routing system	4	10 gigabit Ethernet (GbE) fabric switch
	2	SAN fabric switch

Software resources Table 5 lists the hardware components used in this solution.

Table 5. Software components

Software	Version	Description
EMC Avamar	7.0	Deduplication backup software and system
EMC Data Domain	5.3.0.6	Operating system
EMC Data Protection Advisor	6.0.0	EMC reporting and analytics platform
Active Directory	Windows 2008	Central hostname and user management
EMC PowerPath®/VE	5.8	Multipathing software
EMC Enginuity	5876	Operating environment for Symmetrix VMAX
EMC Solution Enabler	7.5	Symmetrix command line interface
EMC Unisphere	1.1.0.5	VMAX management software
SAP ERP	6.0 EHP 4/NW 7.01 SP 10	IDES/Unicode
Oracle Database	11.2.0.3	Used by SAP system
Microsoft SQL Server	2012	Used by SAP system
VMware vSphere	5.1	Hypervisor hosting all virtual machines
Microsoft SQL Server	2008 R2	Used by VMware vCenter Chargeback Manager and vCloud Director
VMware vCenter Server	5.1	Managing resource and management clusters
VMware vCloud Director	5.1.0	Multitenancy software component of the VMware vCloud suite
VMware vCloud Networking and Security	5.1.0	Security
SUSE Linux Enterprise	11 SP2	Operating system for SAP
Avamar SAP plug-in with Oracle	7.0	Used for deduplicated backup and recovery for SAP Oracle data
Avamar plug-in for SQL Server	7.0	Used for deduplicated backup and recovery for SQL Server environment
Avamar client for Linux Avamar client for Windows	7.0	Includes Avamar plug-ins for Windows/Linux file systems and the Avamar agent
Avamar plug-in for VMware	7.0	Used for VMware image backup and restore
Avamar plug-in for vSphere Web Client	7.0	Interface used for backing up, monitoring, and restoring VMware image-level backups

Note: Other operating system and database combinations that are supported by the EMC Solutions Support Matrix (SSM) can also be used.

Key components

Overview

This solution includes the following technology components:

- EMC next-generation VNX
- EMC Data Domain
- EMC Avamar
- EMC Data Protection Advisor

EMC next-generation VNX

The EMC VNX flash-optimized unified storage platform delivers innovation and enterprise capabilities for file, block, and object storage in a single, scalable, and easy-to-use solution. Ideal for mixed workloads in physical or virtual environments, VNX combines powerful and flexible hardware with advanced efficiency, management, and protection software to meet the demanding needs of virtualized application environments.

VNX includes many features and enhancements designed and built on the success of the first generation. From a performance and scalability perspective, these features and enhancements include the following:

- More capacity with optimized multicore optimization (MCx), including Multicore Cache, Multicore RAID, and Multicore FAST Cache
- Greater efficiency with a flash-optimized hybrid array

EMC Data Domain

EMC Data Domain is a deduplication storage system for backup and recovery. Scalable Data Domain systems feature high-speed, inline deduplication, and network-efficient replication.

Data Domain deduplication storage systems reduce the amount of data to process by only backing up data that have not previously been processed, which skips all unnecessary duplicates in the process.

Data Domain reduces backup storage requirements by up to 30 times, and it protects up to 28.5 petabytes of logical capacity.

EMC Data Domain Boost is a software option available for all Data Domain systems, and a requirement of Cloud enabled infrastructure. DD Boost is made up of two components—a DD Boost plug-in that runs on the backup server or client and a DD Boost component that runs on the Data Domain system. DD Boost includes three main features.

- Distributed segment processing, which distributes parts of the deduplication process from the Data Domain system to the backup sever or client, increasing backup application performance by up to 50 percent.
- Managed file replication, which allows backup applications to manage Data Domain replication with full catalog awareness.

- Advanced load balancing and link failover, providing link aggregation for load balancing and link failover, which eliminates the need for network layer aggregation.

EMC Avamar

EMC Avamar is a deduplication backup software and system that provides centralized scheduling, faster backups, reduced network traffic, and simpler single-step recovery. It is optimized for VMware backup and recovery. Avamar enables different backup strategies to protect the data in the cloud, such as database-level, image level, and file-level backups.

The Avamar plug-in for SAP with Oracle client software uses the BR*Tools Backint interface to back up and restore the database from the virtual machine to guarantee application and data consistency. Avamar enables a cloud administrator to use powerful image-level virtual machine backups within vApps.

EMC Data Protection Advisor

DPA provides a single view of the entire cloud infrastructure through data discovery, analysis, and reporting. DPA interfaces with different backup solutions, replication technologies, virtual environments, tape/VTL storage, SAN and NAS systems, and the business applications protected by the infrastructure for a holistic analysis.

DPA enables IT departments to offer data protection bundle as a service. DPA can generate tenant-specific chargeback reports related to backup and recovery operations, and bill these to each tenant. Your customers can see exactly the service level, operational status, and charges they are paying.

Key capabilities

Overview

This section details the capabilities provided by the data protection bundle.

High efficiency

The solution ensures efficiency in multiple aspects of the Could-enabled Infrastructure:

- **Easy integration**—Data Domain systems are qualified with many leading enterprise backup and archiving applications, and integrate easily into existing storage infrastructures. This solution centralizes its management using the Avamar Administrator console, but you can also use plug-ins to backup and restore from existing GUIs, such as SAP GUI and vSphere Web Client.
- **High-speed deduplication**—With the Data Domain system's throughput of up to 31 TB per hour, administrators can complete backups faster while putting less pressure on limited backup windows.
- **Multistreaming**—The solution enables you to specify the number of backup or restore sessions (data streams) to run concurrently for an operation. Multistreaming improves backup and restore performance.
- **Centralized management**—Avamar makes it easy for cloud administrators to protect hundreds of SAP and non-SAP systems using a common single interface, regardless of operating system or database. Centralized scheduling enables administrators to orchestrate backup operations to maximize resources and optimize backup performance.
- **Changed Block Tracking** —The solution fully uses the VMware Changed Block Tracking feature, which minimizes the network traffic and reduces the backup or restore time, thereby improving the RTO and reducing the total cost of ownership (TCO).
- **Instant access**— Instant access enables a backup administrator to boot up a virtual machine nearly instantaneously from the backup image in a Data Domain system. This feature can be used to quickly restore a mission-critical virtual machine, reducing downtime.
- **Network-efficient replication**—The solution sends only deduplicated and compressed data across the network, requiring a fraction of the bandwidth, time, and cost of traditional replication methods.
- **End-to-end data integrity**—The data protection bundle provides safe and reliable continuous recovery verification, fault detection, and healing.

Full integration

This solution was designed to ensure seamless integration within its own components and with Cloud-enabled Infrastructure for a smooth, hassle-free operation.

- **Integration with databases**—The data protection bundle supports backup and recovery of SAP systems hosted on various databases. EMC Avamar offers database protection support for Oracle, Microsoft SQL Server, IBM DB2, and Sybase to ensure database consistency. The Avamar Administrator console is used to orchestrate and manage the backup and restore operations.

  Integration with SAP on an Oracle database—The Avamar plug-in for SAP with Oracle enables backup and recovery of SAP systems using the same SAP BR*Tools command line interface used in DB13. This allows more integrated control and automation of the backup through SAP.

- **Integration with VMware**—The data protection bundle supports all major modes of guest-level backup to ensure consistency of any applications that are deployed on VMware environments. This bundle also integrates with VMware vStorage APIs for Data Protection (VADP) to perform online image-level backups. This image-level strategy offloads the backup processing overhead from the client to the virtual machine proxy server.

  Avamar preserves the hierarchy relationships of individual clients to their original VMware folder, resource, vApp or host. This means that you can now back up and restore a set of virtual machines in the same VMware folder or resource pool at the same time. This makes post-recovery procedures much more organized especially on cloud environments with a large number of virtual machines.

- **Integration with Data Domain**—A Data Domain system is typically implemented to complete critical high-speed backups of large databases with a high change rate, such as SAP applications. Data Domain replication and DD Boost software are controlled through the Avamar server. Avamar and Data Domain systems are monitored using a single user interface, the Avamar Administrator console.

  Avamar supports all file-level, guest-level, and image-level backups and their corresponding replication with one or more Data Domain systems as targets. While Avamar manages the backup process, the backup data itself is sent directly from the client to the Data Domain system using DD Boost software. This can significantly decrease the network bandwidth during the backup.

Backup-as-a-service

The data protection bundle combines several technologies into a single backup-as-a-service solution suitable for on-premises cloud environments:

- Integration between Avamar and Data Domain provides the scalability and backup performance of Data Domain systems, while keeping the simplicity and efficiency of Avamar's backup policy engine.
- DPA, when integrated with the same Avamar engine, generates performance and chargeback reports for each tenant in the cloud environment, enabling IT departments to bill any business unit that uses these resources.

Security

The data protection bundle strictly limits backup and recovery of a tenant within its own data to ensure security in the cloud environment.

To provide enhanced security during client and server data transfers, data protection bundle encrypts all data sent between clients and the server "in flight." Each Avamar server can also be configured to encrypt data that is stored on the server "at rest."

For detailed information, refer to *EMC Avamar 7.0 Product Security Guide*.

Replication

The solution supports data replication between a local site and a remote site. This replication only sends unique data over the network, which significantly reduces the network bandwidth requirement. Deduplicated replication enables you to have more redundant backups while keeping longer retention periods with much lower capacity consumption, effectively reducing your TCO. In addition, this eliminates the need to physically transfer tape backups to a remote site for safekeeping.

Data protection for Cloud-enabled Infrastructure

Overview

The data protection bundle of the Cloud-enabled Infrastructure solution delivers backup and recovery solution that is most suitable for SAP cloud environments.

Workflow and functionality

Figure 3 shows the workflow of the data protection bundle:

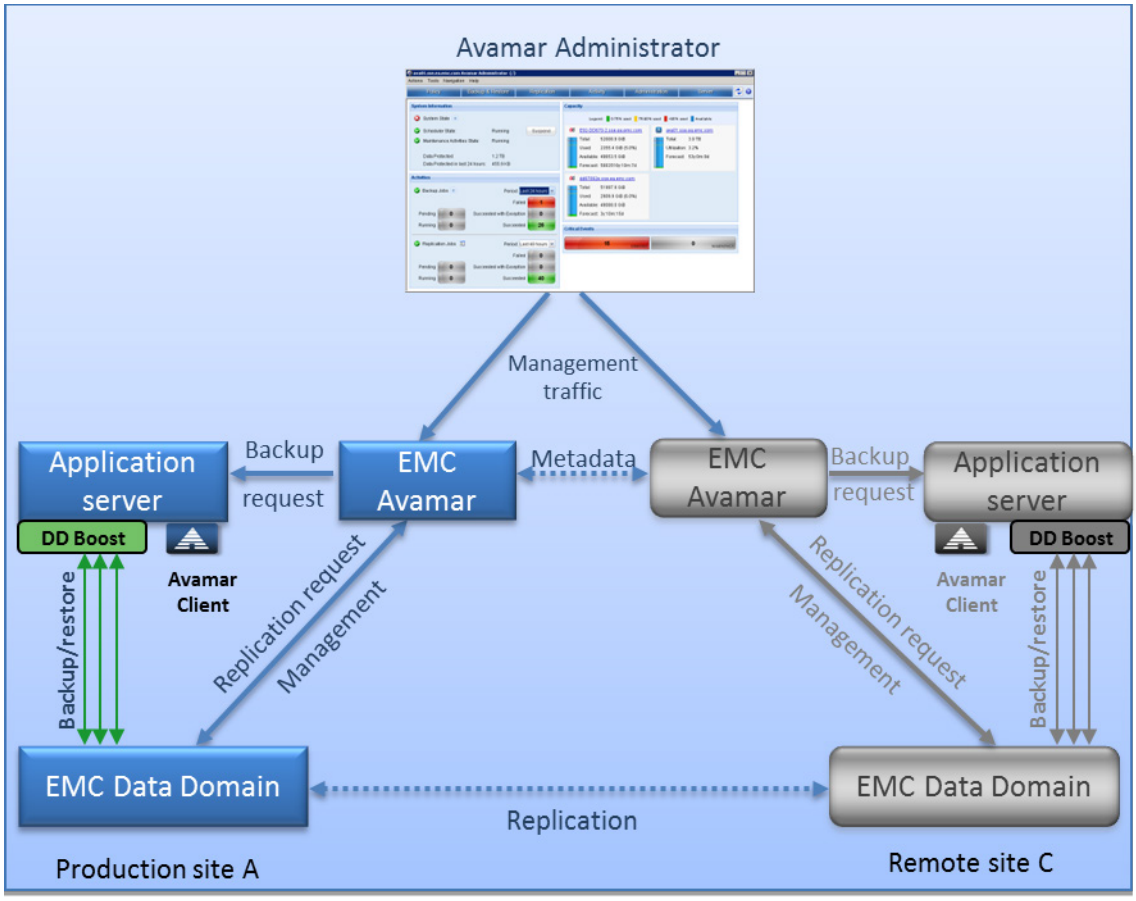

Figure 3. Data protection bundle workflow

Using this data protection bundle, the following online and offline backup and restore functionalities are possible:

- Centralized backup of SAP database and/or archive logs from Avamar Administrator console or directly from SAP transaction code DB13 (Oracle only)
- Image backup of SAP and non-SAP applications
- Backup of SAP application servers and VMware management software, such as vCenter, vCloud Director, and so on
- File-level backup to Data Domain
- Replication of backups to the remote site
- Database point-in-time (PiT) recovery
- Image restore

- File-level restore
- Instant-access restore

Initial configuration

When the foundation bundle is already in place, setting up the data protection bundle requires the following steps, as shown in Figure 2 on page 13:

1. Install and configure one Data Domain system each on the primary and secondary sites.
2. Install and configure one Avamar server each on the primary and secondary sites.
3. Add Data Domain systems to the Avamar server configuration in Avamar Administrator console.
4. Create domains in Avamar according to your OvDC setup in vCloud Director and assign user accounts and respective roles.
5. Implement an isolated network connection between the two Data Domain systems.
6. Configure replication.

For detailed steps, refer to *EMC Avamar 7.0 and Data Domain System Integration Guide* and *Avamar 7.0 Administration Guide*.

This builds the initial backup environment for your data protection bundle. You need to perform additional steps depending on how you want to back up your virtual machines. These additional configurations will be discussed in later sections.

Backup

This section covers the following backup options:

- Database-level backup for SAP systems
- Image-level backup for SAP and Non-SAP applications
- File-level backup

Database-level backup for SAP systems

EMC recommends a database-level backup for all SAP ABAP/J2EE database instances. A database level backup ensures business data consistency and maintenance support from SAP should technical issues occur after a restore operation.

Traditional incremental and delta backups to tape are usually not encouraged due to environmental risks suffered from:

- Tape media
- Prolonged restore time
- A higher risk of recovery failure, especially when using delta backups

When you select a Data Domain system as the backup target, only deduplicated and compressed data is directly transferred to the Data Domain system through DD Boost. The related metadata generated by the Avamar Client is simultaneously sent to the

Avamar server for storage. This mechanism provides increased speed of backup operations by transferring only the delta change in parallel during backup, while providing the consistency of a full database backup. In addition to this, the network penalty during replication is dramatically reduced because of the small size of the resulting backup.

For those users who are implementing SAP on Microsoft SQL Server, IBM DB2, or Sybase, the data protection bundle offers database protection support with Avamar plug-ins for each database technology. All these plug-ins offer the capability to specify different backup types (hot, cold, full, incremental, and so on) and handle a full-feature database log.

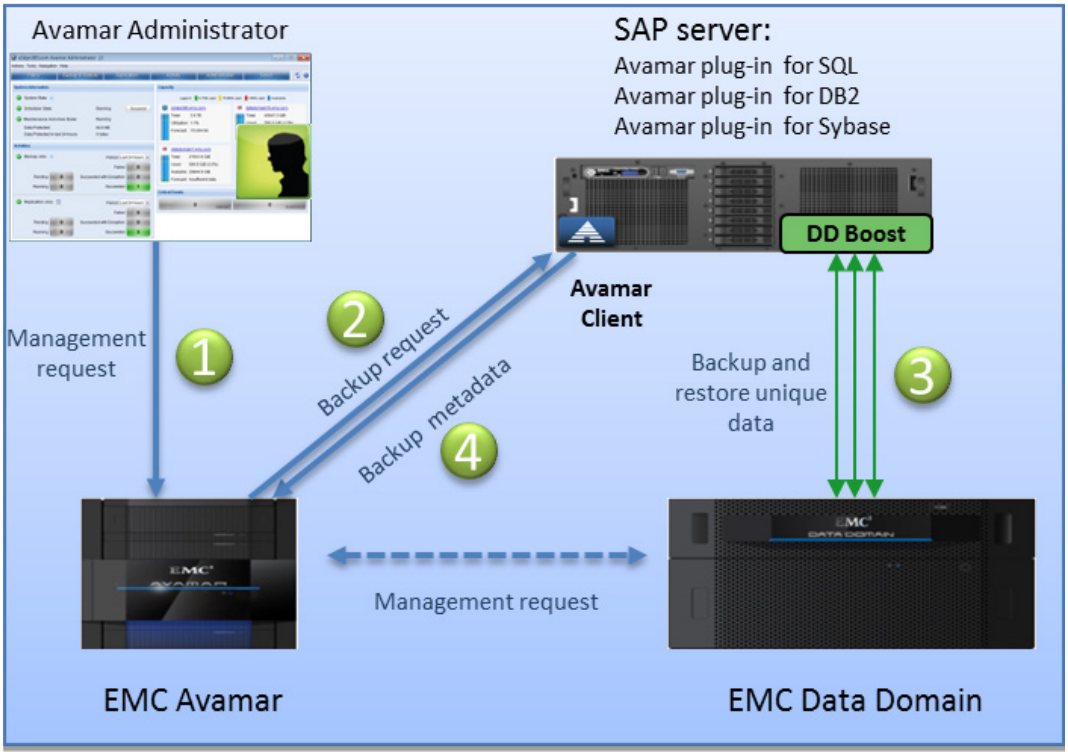

Figure 4. Non-Oracle SAP backup and restore workflow

Figure 4 shows the backup and restore workflow for non-Oracle SAP systems, which is:

1. A backup administrator sends a request to the Avamar server from Avamar Administrator console.
2. Avamar sends the backup request to the SAP server with appropriate plug-in installed.
3. The Avamar plug-in triggers one or more processes (avtar) to start a multistreamed backup to the Data Domain system using DD Boost.
4. Avamar plug-in sends the backup metadata and backup progress updates to the Avamar server.

To implement this workflow, you must perform the following steps:

1. Install the appropriate Avamar plug-in on each SAP database instance.
2. Register the SAP system in Avamar and assign it under one of the OvDC domains that you have configured as shown in Figure 5.

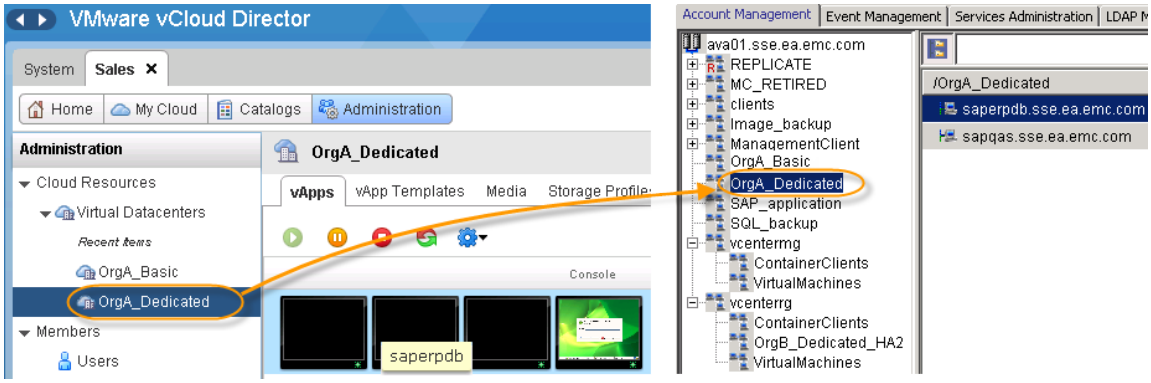

Figure 5. Register the SAP client in Avamar Administrator console

3. Select one or more instances or databases to back up.
4. Specify the backup options. Figure 6 shows advanced options and settings for the SAP systems on SQL server.

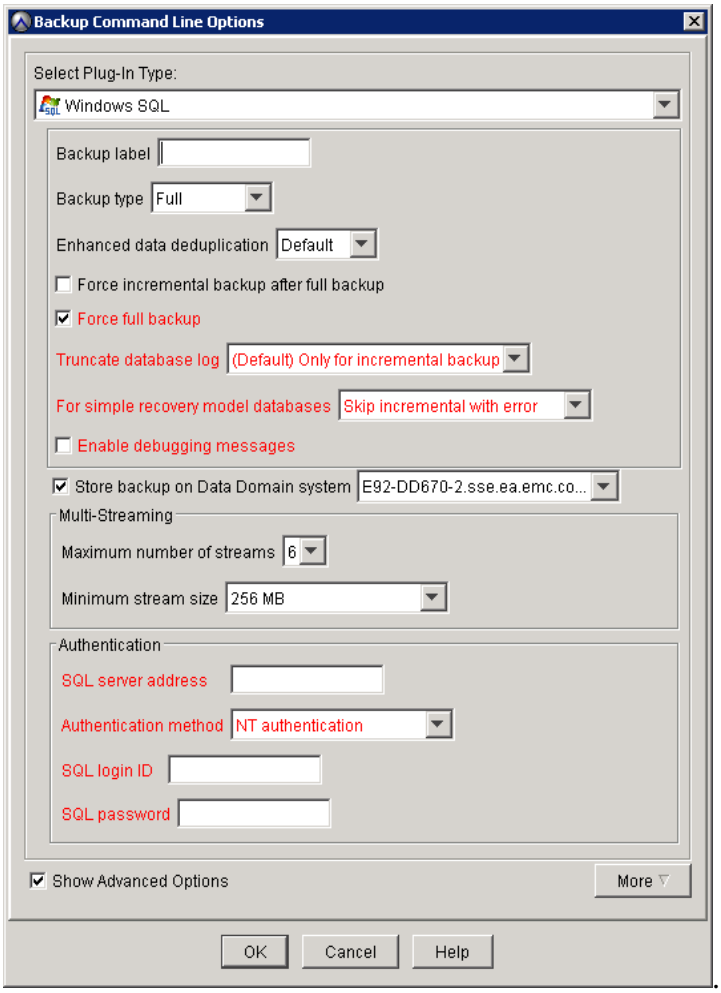

Figure 6. Advanced options and settings for the SAP systems on SQL server

For more detailed steps, refer to the following user guides:

- *EMC Avamar 7.0 for SQL Server User Guide*
- *EMC Avamar 7.0 for Sybase ASE User Guide*
- *EMC Avamar 7.0 for IBM DB2 User Guide*

EMC Avamar plug-in for SAP with Oracle enables the backup administrator to perform database backups directly using the conventional BR*Tools, or through the SAP transaction code DB13. This means that typical backup options such as online consistent, tablespace backups, and redo log backups, which are supported by BR*Tools are also supported by Avamar. Thus, SAP backup administrators can also easily schedule and monitor on-demand backups directly from SAP without having to log on to the Avamar Administrator console.

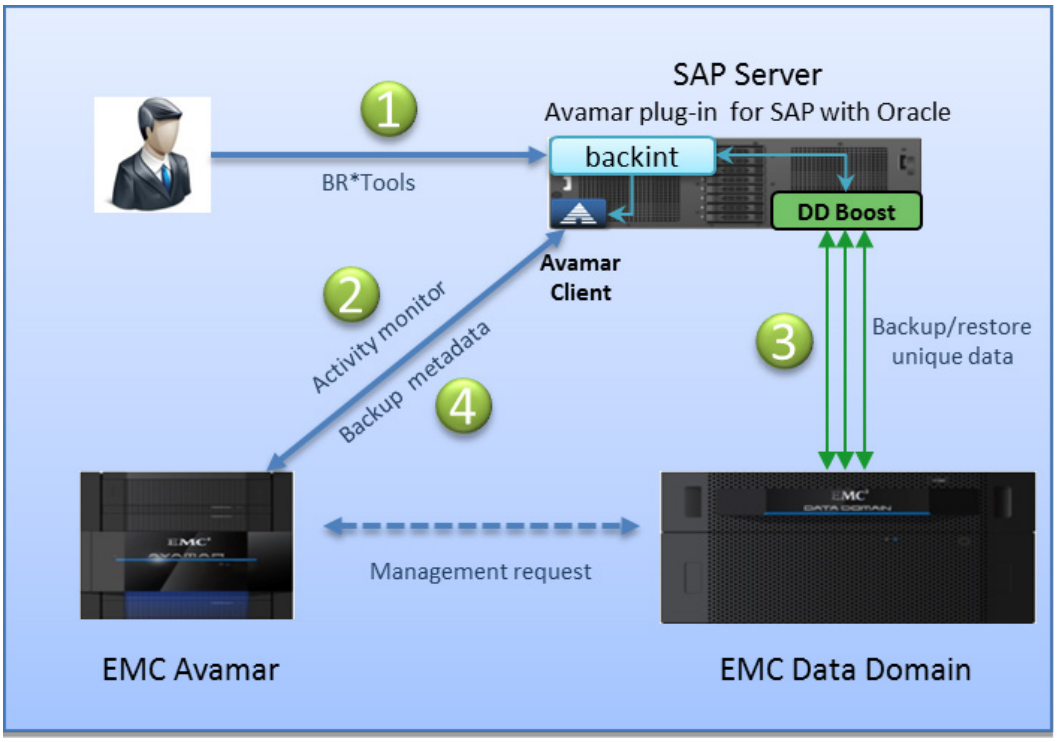

Figure 7. SAP with Oracle client backup and restore workflow

Figure 7 shows the backup and restore workflow for SAP with Oracle.

1. A backup administrator sends a request to the SAP system using DB13 to invoke Oracle BR*Tools (**brbackup** or **brarchive**).
2. **Backint** process uses the Avamar plug-in for SAP with Oracle to start activity monitoring in the Avamar server.
3. **Backint** triggers one or more Avamar plug-in processes (avtar) to start a multistreamed backup to the Data Domain system using DD Boost.
4. **Backint** process uses the Avamar plug-in to send the backup metadata and backup progress updates to the Avamar server.

To implement this workflow, you must perform the following steps:

1. Install an Avamar plug-in for SAP with Oracle for each SAP database instance.
2. Register the SAP system in Avamar and assign it under one of the OvDC domains that you have configured as shown in Figure 5 on page 23.
3. Link the SAP plug-in **backint** program with BR*Tools.
4. Configure the file **init‹SID›.sap.**
5. Create the utility file **init‹SID›.utl** that contains Avamar and Data Domain-specific configurations.

For more detailed steps, refer to the *EMC Avamar 7.0 for SAP with Oracle User Guide*.

Note: If you are setting up the DB13 backup of an SAP database in a distributed environment (that is, the application and the database are on separate virtual machines) for the first time, make sure that a working rsh connection is established between the SAP application and the database.

The progress can be monitored on both Avamar Administrator console (as shown in Figure 8) and DB13 (as shown in Figure 9).

Session

Status	Error Code	Start Time (CST)	Elapsed	End Time (CST)	Type	Server	Progress Bytes	New Bytes
Running		2013-09-01 17:04	01h:52m:45s	2013-09-02 17:04	On-Demand Backup	DD - E92-DD670-2.sse.ea.emc.com	271.3 GB	100%
Completed		2013-08-31 14:06	00h:00m:00s	2013-08-31 14:06	Replication Source	Avamar	33.4 MB	99.5%
Completed		2013-08-31 14:06	00h:00m:00s	2013-08-31 14:06	Replication Source	Avamar	0	0%
Completed		2013-08-31 14:06	00h:00m:00s	2013-08-31 14:06	Replication Source	Avamar	0	0%

Figure 8. Backup activity on Avamar Administrator console

Display Details of Action

Action Description

Action	Whole database online + redo log backup	1 / 1
Planned Start	02.09.2013	11:38:16
Status	Finished successfully	
Action Started	02.09.2013	11:38:17
Action Finished	02.09.2013	13:31:32

Action Parameters | Job Log | Action Log

Date	Time	Message
02.09.2013	13:31:33	BR0280I BRBACKUP time stamp: 2013-09-02 13.28.37
02.09.2013	13:31:33	BR0340I Switching to next online redolog file fordatabase instance EP1 ...
02.09.2013	13:31:33	BR0321I Switch to next online redolog file for database instance EP1 successful
02.09.2013	13:31:33	
02.09.2013	13:31:33	BR0280I BRBACKUP time stamp: 2013-09-02 13.28.45
02.09.2013	13:31:33	BR0229I Calling backup utility with function 'backup'...
02.09.2013	13:31:33	BR0278I Command output of '/usr/local/avamar/bin/backint -u EP1 -f backup -i /oracle/EP1/sapbac
02.09.2013	13:31:33	avtar Info <5008>: Logging to /usr/local/avamar/var/clientlogs/COD-1378099725363#1-1030-SAPS
02.09.2013	13:31:33	avtar Info <5008>: Logging to /usr/local/avamar/var/clientlogs/COD-1378099725363#3-1030-SAPS
02.09.2013	13:31:33	avtar Info <5008>: Logging to /usr/local/avamar/var/clientlogs/COD-1378099725363#2-1030-SAPS

Figure 9. DB13 backup log

Image-level backup for SAP and non-SAP applications

EMC recommends using image-level backups for virtual machines that do not have underlying databases or highly volatile data. This is best suited for distributed primary and additional SAP application servers, and cloud management instances with a separate database instance, such as vCloud Director, vCenter, vShield Manager, vChargeback, and so on. This is primarily used to provide crash-consistent protection for application kernels and operating systems.

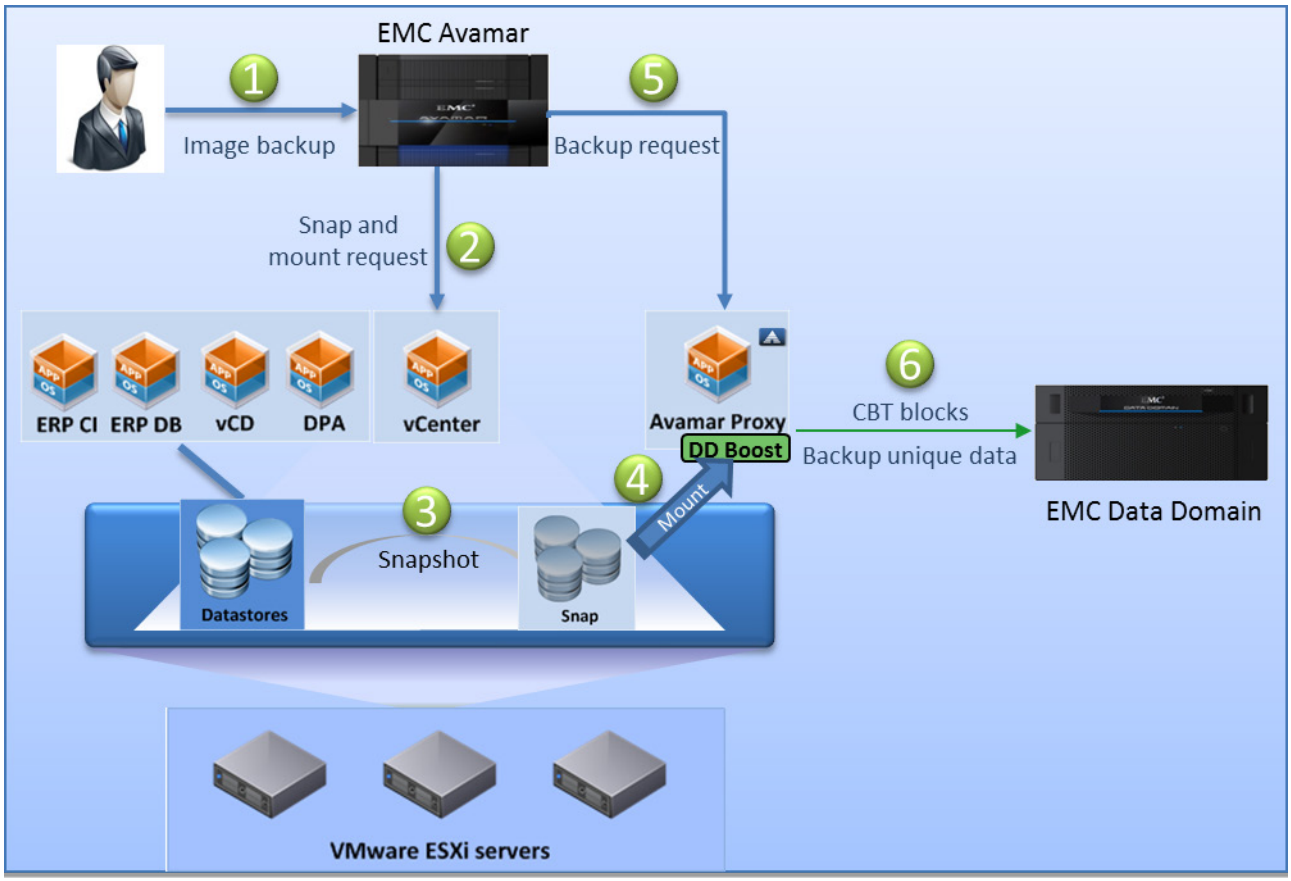

Figure 10. Image backup workflow

An image-level backup relies on an Avamar proxy server, deployed as a virtual appliance. Figure 10 shows how the image-level backups work, which is:

1. A backup administrator triggers or schedules an image backup in Avamar Administrator.
2. Avamar sends a snap and mount request to vCenter.
3. vCenter takes a snapshot of the source virtual machine.
4. vCenter mounts the snapshot to the Avamar proxy server.
5. Avamar sends a backup request to the Avamar proxy server
6. The proxy server starts the backup to the Data Domain system.

To implement this workflow, perform the following steps:

1. Configure vCenter-to-Avamar authentication.
2. Add vCenter Client in Avamar Administrator.
3. Deploy two Avamar proxy appliances in vCenter: one for the Resource group and another for the Management group as shown in Figure 2 on page 13.
4. Register and activate the proxy server with the Avamar server.
5. Configure the proxy settings in Avamar Administrator.

For more detailed steps, refer to the *EMC Avamar 7.0 for VMware User Guide*.

Changed Block Tracking is a VMware feature that tracks which specific file system blocks on a virtual machine have changed between backups. The data protection bundle fully uses the VMware CBT feature, backing up or restoring only the blocks that were changed since the last backup. As shown in Figure 11, you can set the CBT option prior to the backup.

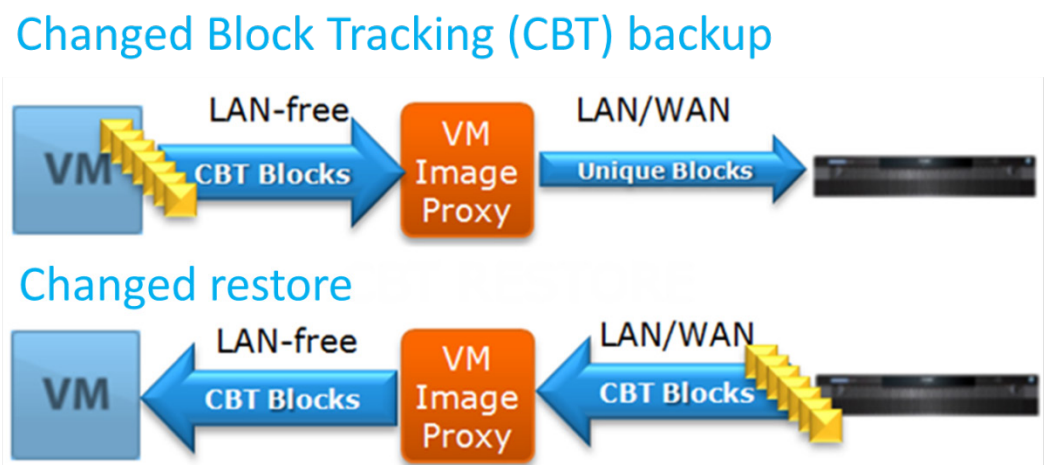

Figure 11. Changed Block Tracking backup

The data protection bundle also supports backup protection for entire containers such as VMware folders, resource pools, and vApps. As long as the vApp exists or has not been corrupted, the virtual machine can be restored directly into the vApp. Figure 12 shows how to back up virtual machines under one resource pool.

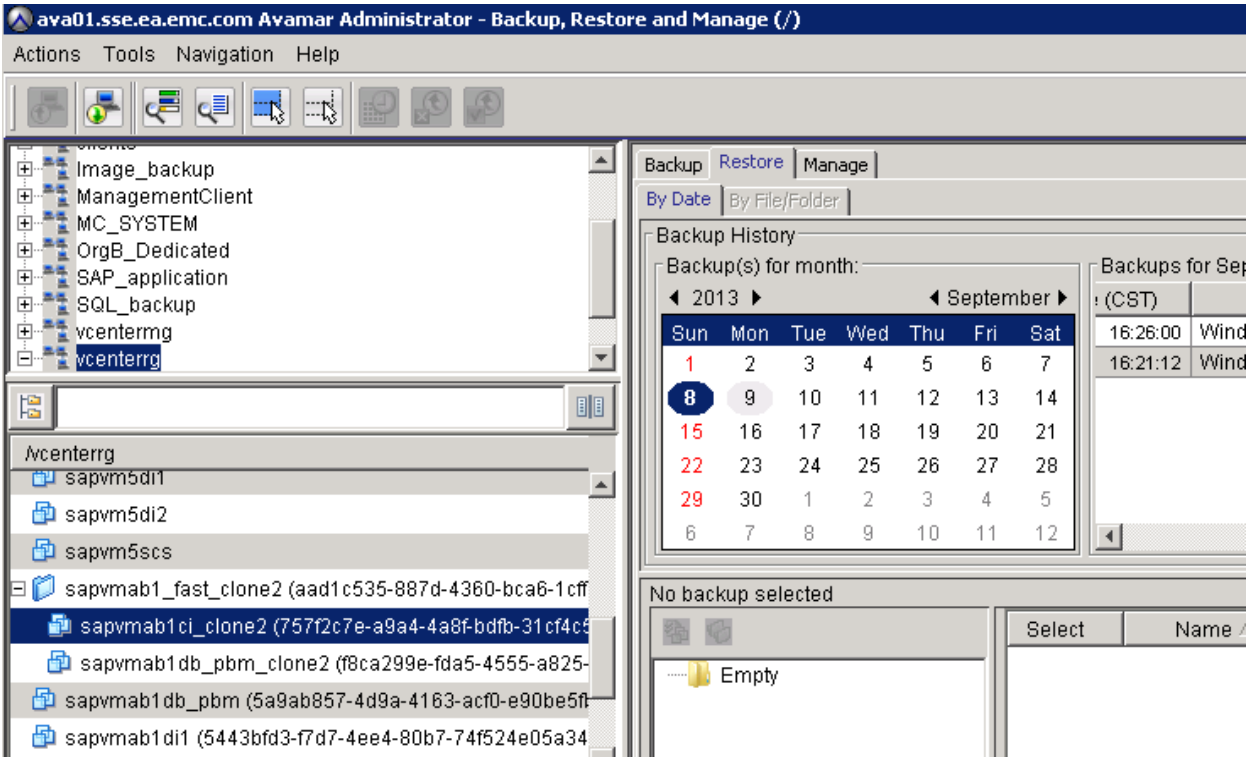

Figure 12. Back up virtual machines under one VMware folder

File-level backup

The data protection bundle supports file-level backup to Data Domain. This type of backup is suitable for backing up virtual machines that function as file repositories, such as those used in SAP Business Objects (BOs) filestores. You need to back up an SAP BO database and its filestore at the same time to ensure consistency upon restore.

Backing up through Avamar is very simple. If the Avamar agent is already installed, select a registered virtual machine, navigate to the desired folder, and back up the contents. Restoring is just as easy.

With Avamar 7.0, individual files can be selectively restored from an image backup without restoring the entire image. This is discussed further in the *EMC Avamar 7.0 for VMware User Guide*.

Restore

This section covers the following recovery options:

- Database-level restore for SAP systems
- Image-level restore for SAP and Non-SAP applications
- File-level restore

Database-level restore for SAP systems

Figure 4 on page 22 also shows the restore workflow for non-Oracle SAP systems, which is:

1. A backup administrator sends a request to the Avamar server from Avamar Administrator console.
2. Avamar sends the restore request to the SAP server with appropriate plug-in installed.
3. The SQL server plug-in triggers one or more plug-in processes (avtar) to start a multistreamed restore from the Data Domain system.
4. Avamar plug-in sends restore progress updates to the Avamar server.

For SAP systems with Oracle database, you can do a full database restore or PiT recovery (restore database and apply redo logs) easily using the same BR*Tools interactive GUI as you restore any backup from tape or other media. Prior to initiating a restore, make sure that the database kernel is fully operational and that the restore destination can connect to the Avamar server's fully qualified domain name (FQDN).

You can specify the utility file **init‹SID›.utl** to restore without further prompting.

Figure 7 on page 25 also shows the restore workflow for SAP systems on Oracle databases, which is:

1. A backup administrator sends a request invokes Oracle BR*Tools (**brrestore** or **brrecover**).
2. **Backint** process uses the Avamar plug-in for SAP to start activity monitoring in the Avamar server.
3. **Backint** triggers one or more SAP plug-in processes to start a multistreamed database restore directly from the Data Domain system. After the database restore, redo logs backed up in the Data Domain system are reapplied directly as needed.
4. **Backint** process uses the Avamar plug-in for SAP to communicate the success or failure of the restore to BR*Tools. The database can now be opened for access.

Image-level restore for SAP and non-SAP applications

You can trigger image-level recovery from the Avamar Administrator console with a few mouse clicks. The data protection bundle is capable of performing CBT and a full image restore, and automatically runs the more efficient option, depending on the case.

Avamar 7.0 supports VMware Instant Access, a special type of full image restore that boots up a virtual machine almost instantly from an image backup stored on a Data

Domain system. You can select the Instant Access option prior to a restore, as shown in Figure 13.

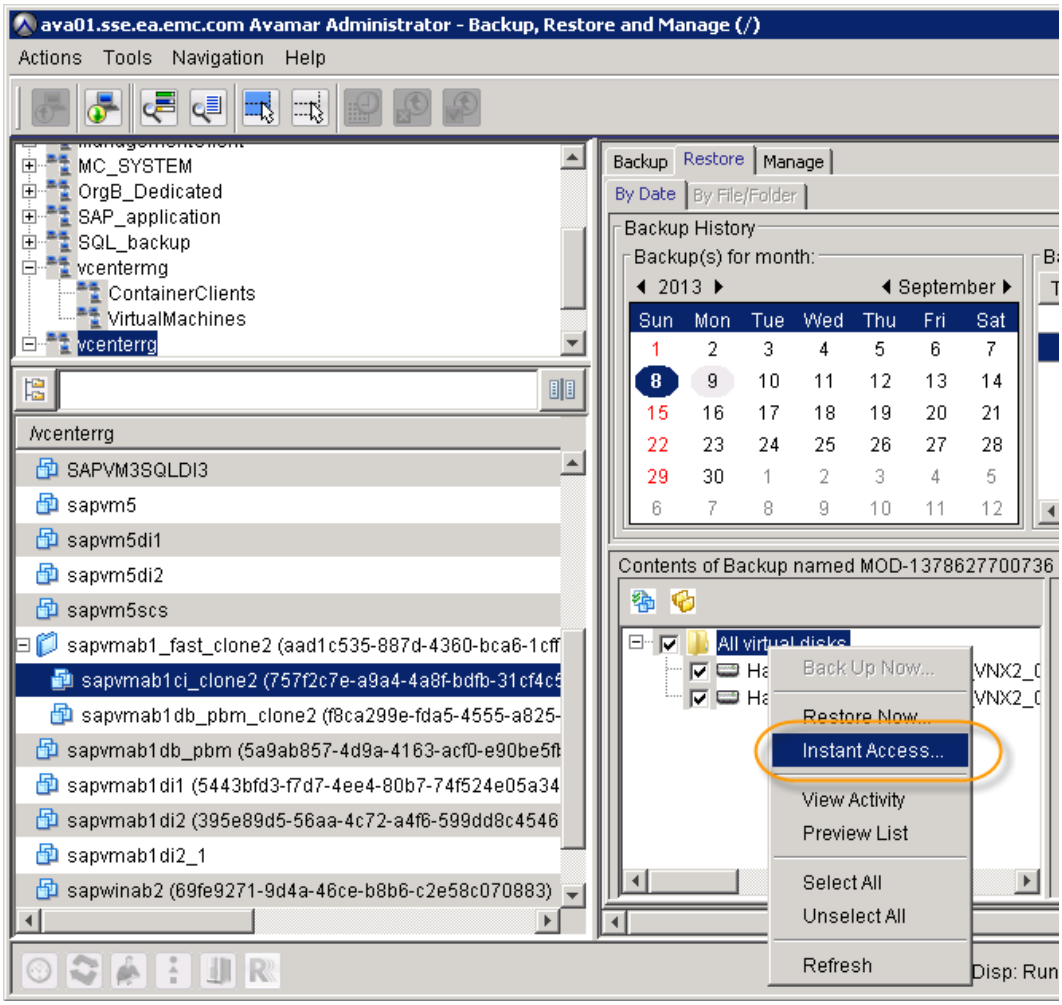

Figure 13. Instant Access feature in Avamar 7.0

Instant Access is most suitable to quickly recover servers running critical processes and whose data is not accessed frequently, such as an SAP Central Services Instance, or a network gateway server. Both do not contain heavy data but are integral for data access. VMware Instant Access works as follows:

1. A virtual machine image backup is staged to a temporary location on the Data Domain system.
2. The virtual machine is exported to a temporary location as a secure Network File System (NFS) share.
3. The share is mounted as an NFS datastore on an ESX/ESXi host.

Note: You must perform a Storage vMotion to return this restored image to its intended storage pool for performance reasons. This is detailed in the Considerations and best practices section.

File-level restore

The data protection bundle supports restore using a file-level backup, or an image-level backup from the Data Domain system. When using a backup image as source, the files can be selectively chosen without the need of restoring the entire image.

This type of restore is suitable for restoring damaged or accidentally deleted files.

Restoring is as simple as its backup. Select a registered virtual machine, navigate to the desired folder, and click Restore.

Replication

With replication, you can secure backups offsite, which not only protects your data center from completely losing recoverability to a site disaster, but also enables you to keep longer retention periods.

Restoring from a remote site can be used as an on-demand business continuity measure when there is no disaster recovery bundle deployed in the Cloud-enabled Infrastructure.

All types of backups are replicated in the same way. Replication requires a pair of Avamar and Data Domain systems on the remote site.

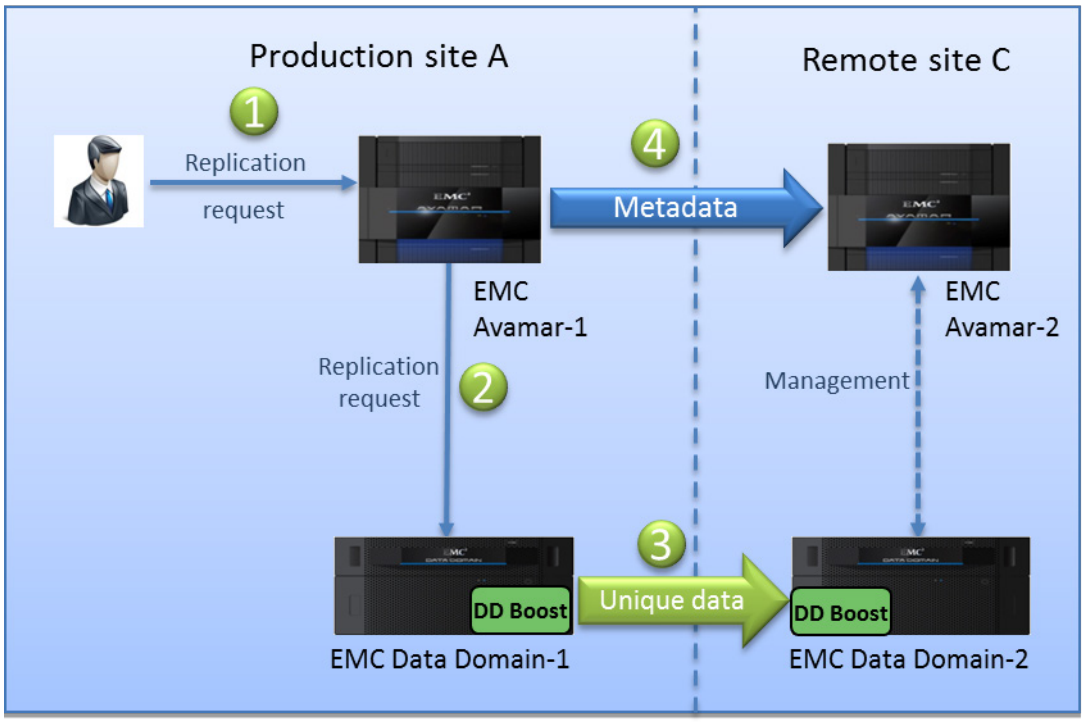

Figure 14. Replication workflow

Figure 14 shows the Avamar replication workflow, which is:

1. A backup administrator applies a replication schedule through Avamar Administrator.
2. Avamar sends the replication request to the local Data Domain system.

3. The local Data Domain system uses Data Domain Replicator to send the unique data directly to the remote site.
4. The local Avamar server sends the backup metadata to the remote Avamar system.

You can restore replicated backups in the following ways:

- Replicate the remote backup and restore locally.
- Restore directly from the remote backup onto the local production system or a disaster recovery site (if both the local Data Domain system and Avamar are not operational).

We tested two recovery scenarios in our lab environment. The results are presented in Use case 4: Backup replication.

Monitoring and chargeback

DPA provides trending reports on performance and capacity for further analysis. With DPA, you have visibility over the data protection infrastructure, such as:

- SLA compliance for each tenant
- Chargeback reporting
- Resource utilization during backup and restore
- Failed backups
- Capacity management

Figure 15 shows an example of setting different SLA policies in the form of recovery and protection rules, such as RTO and RPO.

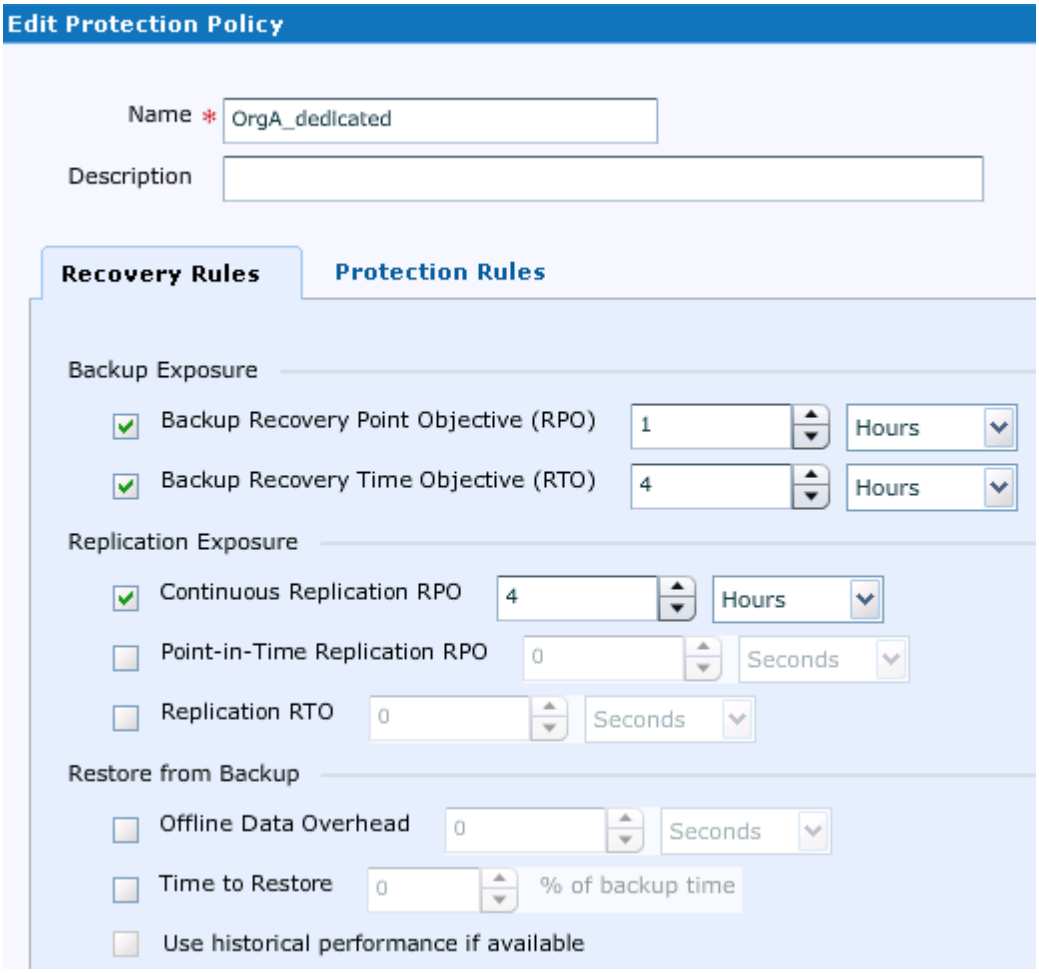

Figure 15. Setting protection policies in DPA

Figure 16 below shows an example of configuring the chargeback policies in DPA. The costs are calculated based on several factors such as backup size, frequency, and retention period.

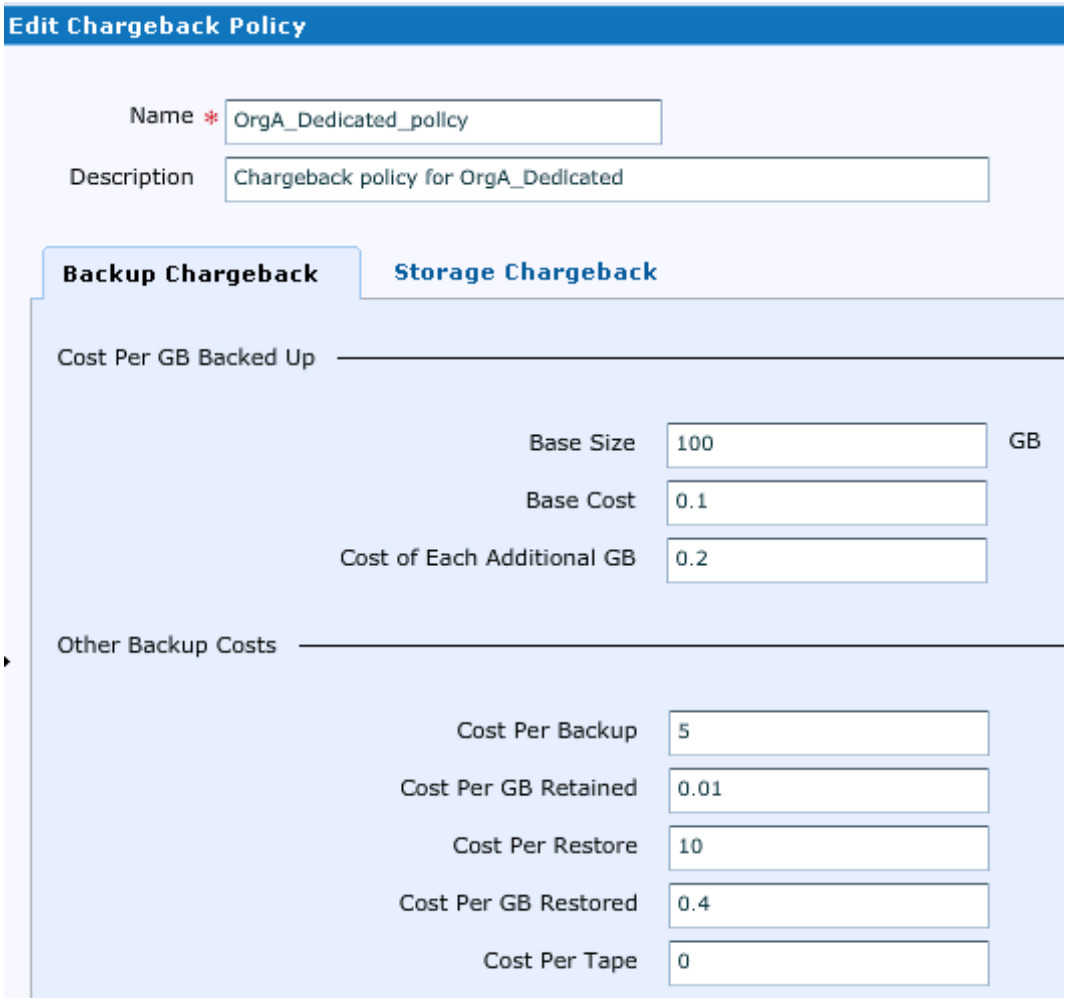

Figure 16. Setting SLA protection and backup chargeback policies in DPA

All performance data throughout the test results in this white paper were taken from DPA, and chargeback reports were continuously taken for the duration of testing. For more details, refer to Use case 5: Chargeback and reporting.

Considerations and best practices

Site considerations for different bundle implementations

The practical considerations that must be taken into account as to how the Data Protection bundle is deployed for different implementations of a Cloud enabled Infrastructure:

- Different systems are protected differently: some will be protected by high availability, disaster recovery and backup, while some might only be protected by disaster recovery and backup but without high availability. In a disaster situation, the recovery sequence may vary per system.
- Some implementations may or may not involve the high availability and disaster recovery bundles. Therefore, a 3-datacenter environment may or may not be present.
- In a 2-datacenter high availability environment, administrators may opt to balance resource usage by distributing the non-critical systems (that is, test systems that do not need high availability or disaster recovery) across the two sites instead of concentrating them all in just one datacenter.
- Some systems may not be protected by high availability or disaster recovery, but all systems must be protected by data protection.

To maximize the protection available for each system in the Cloud-enabled Infrastructure, we recommend the configurations as described in the table below. This section details each appliance's preferred location.

Table 6. Data protection bundle guidelines for different implementation scenarios

Bundle combination	Site A primary production	Site B secondary production (high availability)	Site C disaster recovery
Foundation + data protection	• Avamar-1 • Data Domain-1	N/A	• Avamar-2 • Data Domain -2
Foundation + data protection + disaster recovery	• Avamar-1 • Data Domain-1 • RecoverPoint-1	N/A	• Avamar-2 • Data Domain -2 • RecoverPoint-2
Foundation + data protection + high availability	• Avamar-1 • Data Domain -1 • VPLEX-1	• Avamar-2 • Data Domain -2 • VPLEX-2	N/A
Foundation + data protection + disaster recovery + high availability	• VPLEX-1 • RecoverPoint-1	• Avamar-1 • Data Domain -1 • VPLEX-2 • RecoverPoint-2	• Avamar-2 • Data Domain -2 • RecoverPoint-3

Every application in the Cloud-enabled Infrastructure is protected by the data protection bundle and can be backed up using the strategies discussed in the

Workflow and functionality section. Table 7 outlines recommended backup and recovery strategies based on consistency and criticality.

Table 7. Recommended backup and recovery strategies

Type of application	Recommended backup strategy	Recommended recovery strategy
SAP system on Oracle database	Online consistent database backup using DB13 or Avamar Administrator	PiT restore using BR*Tools
SAP system on other databases, such as SQL, DB2, and Sybase	Online consistent database backup using Avamar Administrator	Avamar Administrator
SAP Central Services Instance	Image backup	Image restore, Instant Access
SAP application instances	Image backup	Image restore
• vCloud Director • vCenter Server • vChargeback Manager • VMware vCenter Site Recovery Manager	Image backup for application and guest backup for database	Image restore, Instant Access for application and database restore using Avamar Administrator
• Active Directory • DNS server • Network Gateway server	Image backup	Image restore, Instant Access
Servers with: • Solution Enabler • vCenter Operations Manager • DPA • EMC Storage Resource Management Suite	Image backup	Image restore

Network bandwidth

Before you add a Data Domain system to an Avamar configuration, ensure that the infrastructure provides adequate network bandwidth for backups and Avamar maintenance activities.

Network bandwidth in an Avamar configuration has the most impact on Avamar client backups to a Data Domain system and Avamar server maintenance activities. The process that sends Avamar client metadata to the Avamar server has less impact on the network bandwidth.

To measure the network bandwidth between the Avamar server and the Data Domain system, use the **iperf** utility. The **iperf** utility is available on the Avamar server, on the Data Domain system, and from the Internet:

- On an Avamar server, the Linux operating system includes the **iperf** utility in **/usr/local/avamar/bin**.
- On a Data Domain system, the Data Domain operating system (DD OS) includes the **iperf** utility.
- For Avamar clients, download the **iperf** utility from the Internet.

Multistreaming

The Avamar plug-in always tries to use the specified number of data streams for backups and restores. In our test environment, we backed up a 1.95 TB SAP database with different multistreaming settings. Figure 17 shows that the backup time has decreased using multistreaming.

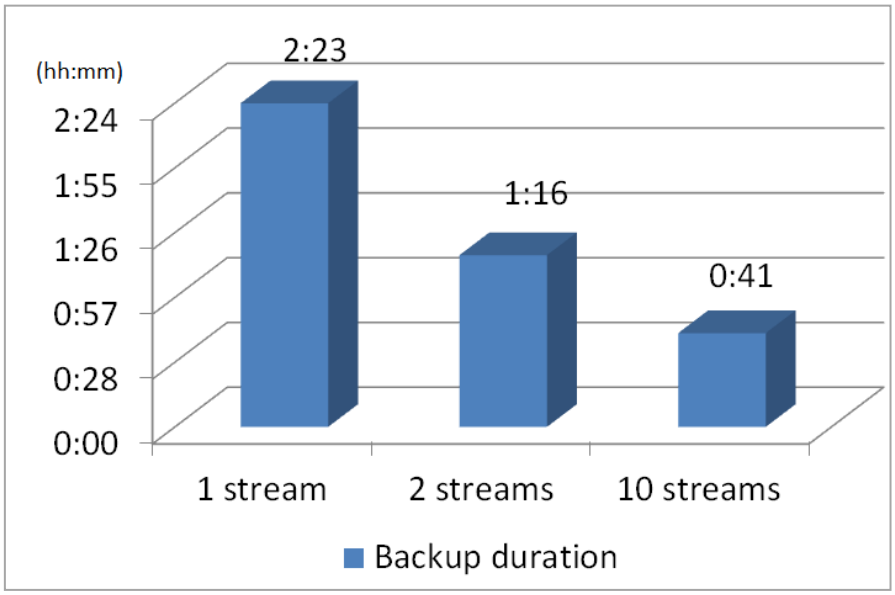

Figure 17. Backup duration in different multistreaming settings

The recommended number of streams is 8 as per *Avamar 7.0 Operational Best Practices*. This value can be set either in Avamar Administrator, or the parameter ***max-streams*** in the SAP plug-in parameter file **init‹SID›.utl.**

Multitenancy support

EMC recommends that a cloud administrator creates domains in Avamar Administrator according to the OvDC in vCloud Director to keep consistency across the cloud environment, which enables generating chargeback report in DPA for each tenant. To ensure multitenant security, create user accounts and assign different roles in each domain, as shown in Figure 18.

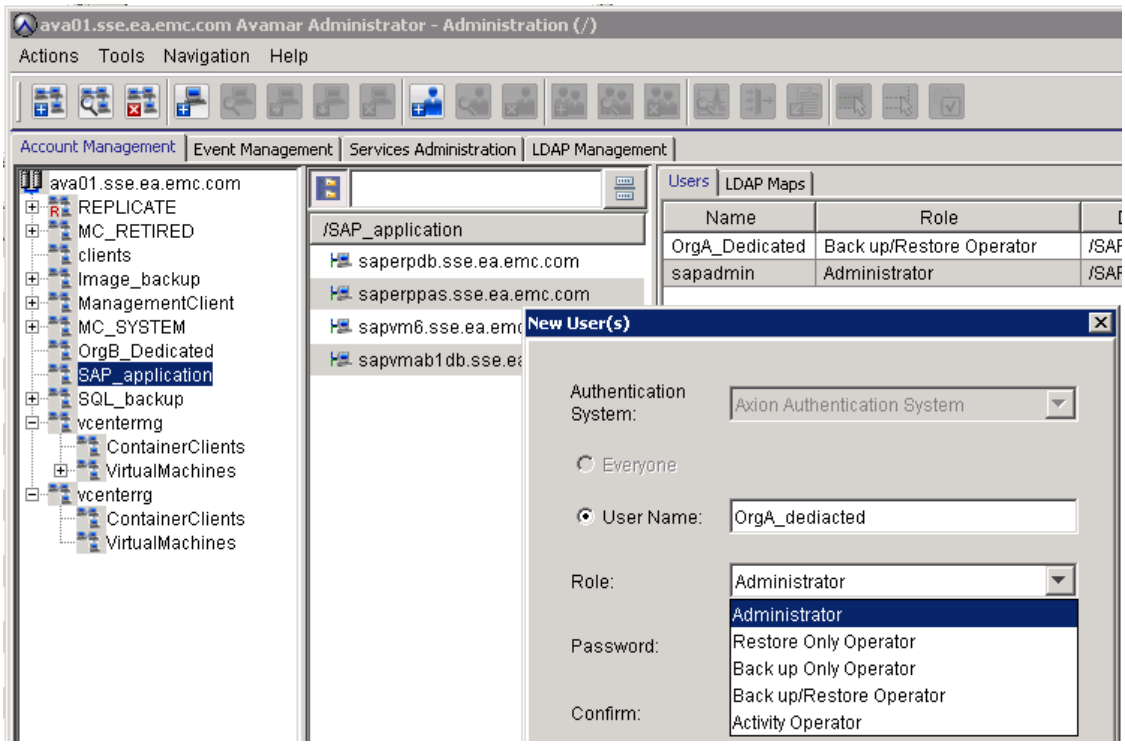

Figure 18. Domain and user creation in Avamar Administrator

These user accounts restrict a tenant's access only within the tenant's own domain. Roles on the other hand enable the tenants to perform activities (such as backup, restore, monitor, and so on) in their domain depending on which roles are assigned to them.

Instant access best practices

In order to minimize operational impact to the Data Domain system, only one instant access is permitted at a time. Therefore, it is important to migrate the instant access virtual machine from the Data Domain system to the VMware production environment using VMware Storage vMotion, then fully clean up and unmount the NFS share after each instant access so that subsequent instant accesses are not impacted.

For detailed information, refer to the *EMC Avamar for VMware User Guide*.

Support for SAP system on different database

The data protection bundle supports different databases used by SAP. Avamar provides database-specific plug-ins for Oracle, SQL Server, DB2 and Sybase. These databases can be backed up directly using the Avamar Administrator console. Table 8 shows the recommended Avamar Client plug-ins for each target database type.

Table 8. Recommended Avamar plug-ins for databases in SAP

SAP underlying database	Recommended EMC Avamar Client plug-in
Oracle	EMC Avamar plug-in for SAP with Oracle
SQL	EMC Avamar plug-in for SQL
DB2	EMC Avamar plug-in for DB2
Sybase	EMC Avamar plug-in for Sybase

Centralizing backup management

All scheduled and on-demand backup operations in the cloud environment can be controlled and managed either centrally by you using Avamar Administrator, or independently by each tenant. The latter option offloads some responsibilities from you while at the same time enabling tenants to trigger additional backups themselves, if needed. These activities are reflected in the DPA SLA and chargeback reports, regardless of who triggered these backups.

Testing and validation

Overview

The engineering team built the data protection bundle and integrated it with an existing Cloud-enabled Infrastructure Foundation bundle according to the Key capabilities section of this paper as follows:

- Local Protection of the SAP database
- Local Protection of SAP and VMware applications
- Local protection of the cloud environment
- Backup replication
- Chargeback and reporting

For testing purposes, we have arbitrarily set RTO to four hours and the RPO to one hour.

We backed up and restored every aspect of the environment and evaluated the operational efficiency and resource consumption.

The performance and consumption for every backup or recovery operation was closely monitored through DPA. All performance and chargeback-related screenshots were taken from DPA unless otherwise specified.

Benchmark results

Benchmark results are highly dependent upon workload, specific application requirements, and system design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, this workload should not be used as a substitute for a specific customer application benchmark when critical capacity planning and/or product evaluation decisions are contemplated.

All performance data that is contained in this report was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly.

EMC Corporation does not warrant or represent that a user can or will achieve similar transactions per minute.

Use case 1: Local protection of the SAP database

SAP database backup

Test scenario

We performed online backups to simulate a typical scenario in productive environments, with plans for a PiT recovery later on. This test was done on the following two distributed SAP systems:

- 1.95 TB Microsoft SQL database on Windows 2008 R2
- 2 TB Oracle database on SLES 11 SP2

Objective

The objectives of this use case were as follows:

- Assess the effectiveness of deduplication and multistreaming on the performance and storage footprint of the backup compared with a standard backup
- Assess manageability

Procedure

We performed the following steps:

1. We triggered an online consistent backup from the Avamar Administrator.
2. After the backup, we generated business data in the database to simulate a delta change and scheduled the daily backup. This cycle was repeated six more times to simulate a week of daily backups.
3. We compared the first conventional backup with subsequent full deduplicated backups.
4. We used DPA to observe the performance and recorded down the results.

Results

We performed backup testing for SAP systems on both Oracle and SQL databases, but for brevity, we are only presenting results for the SAP system on the SQL database for this use case.

Figure 19 shows the net daily backup size, network throughput, and duration for each backup.

All Jobs

11/26/13 00:00 - 12/12/13 11:59

ava01.sse.ea.emc.com:Avamar:/SAP_application:sapvmab1db.sse....

Client	Started 1 ▲	Size (GB)	Level	Throughput (MB/sec)	Duration (hour)
sapvmab1db.sse.ea.emc.com	11/30/13 4:50 PM	505.893	Full	95.914	1 hour 30 minutes
sapvmab1db.sse.ea.emc.com	12/1/13 11:49 PM	28.869	Full	10.373	0 hours 47 minutes
sapvmab1db.sse.ea.emc.com	12/2/13 12:36 AM	27.153	Full	5.526	0 hours 42 minutes
sapvmab1db.sse.ea.emc.com	12/3/13 2:49 PM	25.071	Full	9.893	0 hours 43 minutes
sapvmab1db.sse.ea.emc.com	12/4/13 5:51 PM	10.731	Full	4.389	0 hours 41 minutes
sapvmab1db.sse.ea.emc.com	12/5/13 12:51 PM	22.063	Full	8.64	0 hours 43 minutes
sapvmab1db.sse.ea.emc.com	12/6/13 10:11 AM	10.24	Full	4.096	0 hours 42 minutes

Figure 19. Daily backup job report from DPA

Figure 20 shows the backup size, aggregated average daily change, and the deduplication rates for each backup.

Backup Client De-Dupe Ratios

11/28/13 00:00 - 12/11/13 11:59

ava01.sse.ea.emc.com:Avamar:/SAP_application:sapvmab1db.sse...

Client	Protected (TB)	Avg Daily Change (GB)	De-Dupe Rate (%)
sapvmab1db.sse.ea.emc.com	1.953	505.893	74.096
sapvmab1db.sse.ea.emc.com	1.953	267.381	86.309
sapvmab1db.sse.ea.emc.com	1.953	187.305	90.409
sapvmab1db.sse.ea.emc.com	1.953	146.747	92.486
sapvmab1db.sse.ea.emc.com	1.953	119.543	93.879
sapvmab1db.sse.ea.emc.com	1.953	103.297	94.711
sapvmab1db.sse.ea.emc.com	1.953	90.003	95.392

Figure 20. Backup client deduplication ratio report from DPA

Analysis

The test results demonstrate the following:

- **Backup storage requirement:** The total size for seven full backups without compression or deduplication would have been 13.65 TB (1.95 TB x 7) as shown Figure 20. Due to compression and a deduplication rate of about 74-up to 95 percent, the resulting total size (similar to the full backup sizes in Figure 19) was only 630 GB—a total decrease of 13 TB in just seven days.
- **Network throughput:** The initial backup throughput represented that of a conventional backup. A six-day average of 20.69 GB backup size consumed an average throughput of 7.15 MB/s.
- **Duration:** A 1.95 TB database took an average of 45 minutes to do a subsequent backup.

Findings

The use case demonstrates the following:

- In seven days, the data protection bundle effectively protected 13.65 TB of full backups, but only used 5 percent of the estimated storage capacity, as shown in Figure 21. Data Domain is a global deduplication system, so all systems, such as DEV, QAS, and PRD systems, which are to be backed up to the same Data Domain system, can benefit from the deduplicated data.

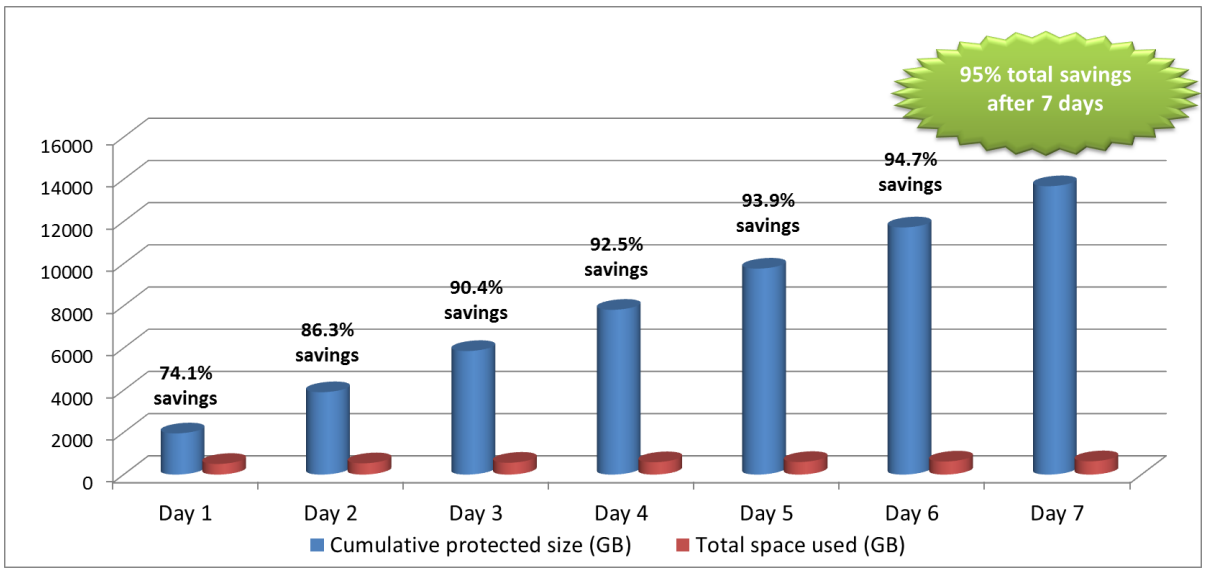

Figure 21. Cumulative space reduction

- The solution was able to save the cost of backup storage. In this test environment, backing up a 1.95 TB database (with a constant 20.69 GB average daily backup size and 28-day retention period) originally required 55 TB of backup space, only required 579.32 GB. Therefore, the space reserved for 28 days can now last for nearly 8 years.
- The bandwidth consumed was reduced by 95.83 percent from 95.9 MB/s to 7.2 MB/s, increasing the network efficiency by around 13 times, as shown in Figure 22. The solution is not only efficient, but also practical for a cloud environment: conserving network utilization to such a low rate enables backup of multiple virtual machines in parallel avoiding network bottleneck risks. In a case where there is a network bottleneck, DD Boost helps reduce the contention, resulting to a shorter backup time.

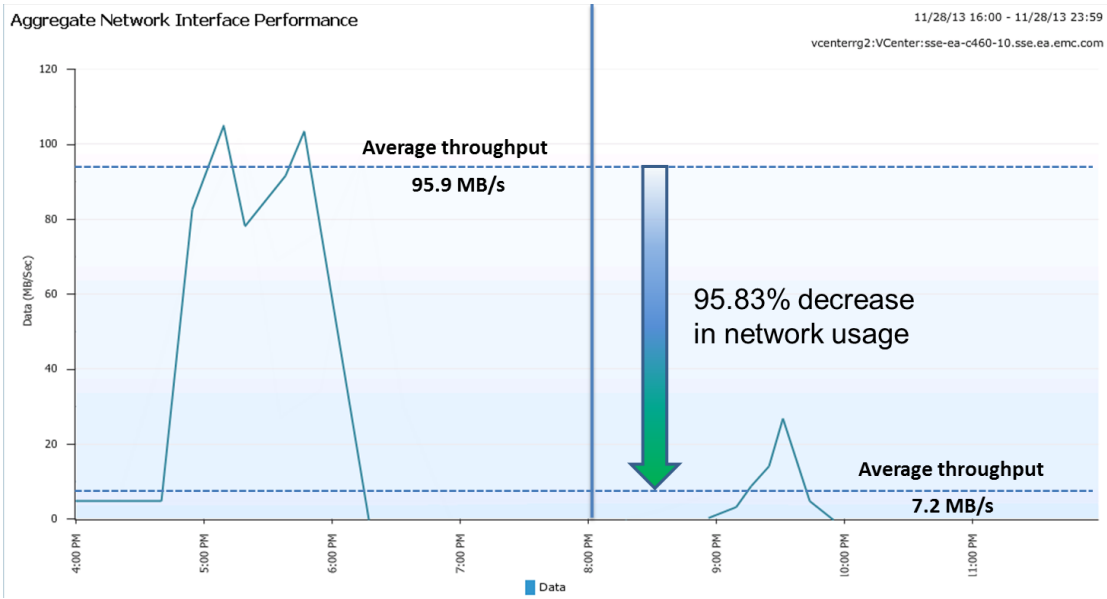

Figure 22. Aggregate network performance comparison between initial and deduplicated backups

- An administrator can centralize backup scheduling through Avamar Administrator, or through the SAP system if using Oracle as the database.

SAP database restore

Test scenario

We restored the full backups taken from the preceding test several times, each with varying multistreaming settings. We measured the duration of each restore and the corresponding network bandwidth consumed. This test was done on the following two distributed SAP systems:

- 1.95 TB Microsoft SQL database on Windows 2008 R2
- 2 TB Oracle database on SLES 11 SP2

Objective

The objective of this use case was as follows:

- Assess the ease of restores
- Perform a PiT recovery and restore a consistent and fully operational database within the RTO
- Assess the effects of multistreaming to the restore operation

Procedure

We performed the following steps:

1. Restored the SAP system on a SQL database by using Avamar Administrator to an arbitrary point in time.
2. Restored the SAP system on Oracle database by using BR*Tools to an arbitrary point in time.
3. Measured the restore time from the time we triggered the restore until we were able to log on and transact in SAP to verify service.
4. Changed the multistreaming settings and repeated the restore of the same backup five more times.

Results

We performed restore testing for SAP systems on both Oracle and SQL databases, but for brevity, we only present results for the SAP system on a SQL database in this use case.

Figure 23 shows the duration of the restore and the network bandwidth consumed when using different multistream settings.

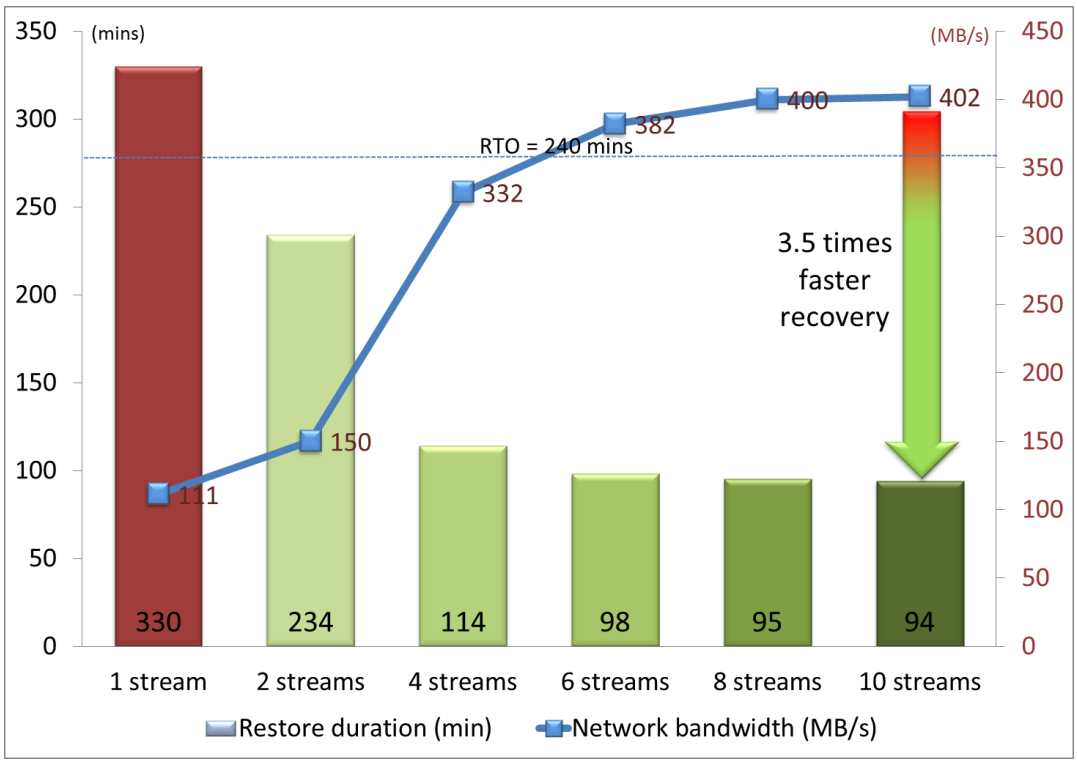

Figure 23. Restore duration and network bandwidth in different multistream settings

Analysis

The test results demonstrate the following:

- **Duration**—Based on the same chart, when multistreaming is not used, the RTO of four hours (240 mins) was breached by 90 minutes.
- **Multistreaming**—The restore duration shortened as the number of streams increased. Adding just one additional stream has already reduced the restore time by 96 minutes, reducing it to well within the RTO.
- **Network bandwidth**—The network utilization was increased from 111 MB/s to 402 MB/s or around 3.5 times network bandwidth as the number of streams was also increased.
- **One-step restore**—A full database backup streamlines the recovery process. Assembling the restored database by using a sequence of full and incremental backups was no longer necessary.

Findings

One-step restore dramatically improves the recovery process, making the data protection bundle very efficient.

The data protection bundle enables you to maximize network resources to ensure the fastest recovery possible. When the maximum number of streams (10 streams) was used, the network utilization improved more than 3.5 times and the recovery time was decreased by almost 72 percent.

Use case 2: Local protection of SAP and VMware applications

Image backup

Test scenario

We performed image backup operations on the following types of virtual machines:

- Virtual machine applications, online image backup
- SAP application instances, online image backup
- 2.7 TB SAP central system (database, SCS, and application instance in one virtual machine backed up offline)

For demonstration purposes, we only present the results of the SAP central system, which is the largest.

Objective

The objectives of this use case were to:

- Assess ease of restore
- Verify the effect of CBT in the duration and network resources

Procedure

We performed the following steps:

1. Logged on to Avamar Administrator and took image backups of the virtual machines listed above. The initial image represents an ordinary non-deduplicated backup.
2. Used DPA to gather statistics and repeated the test using vSphere Web Client to observe the effects of deduplication. We compared the results.

Results

Figure 24 shows how we triggered the image backup from the Avamar Administrator.

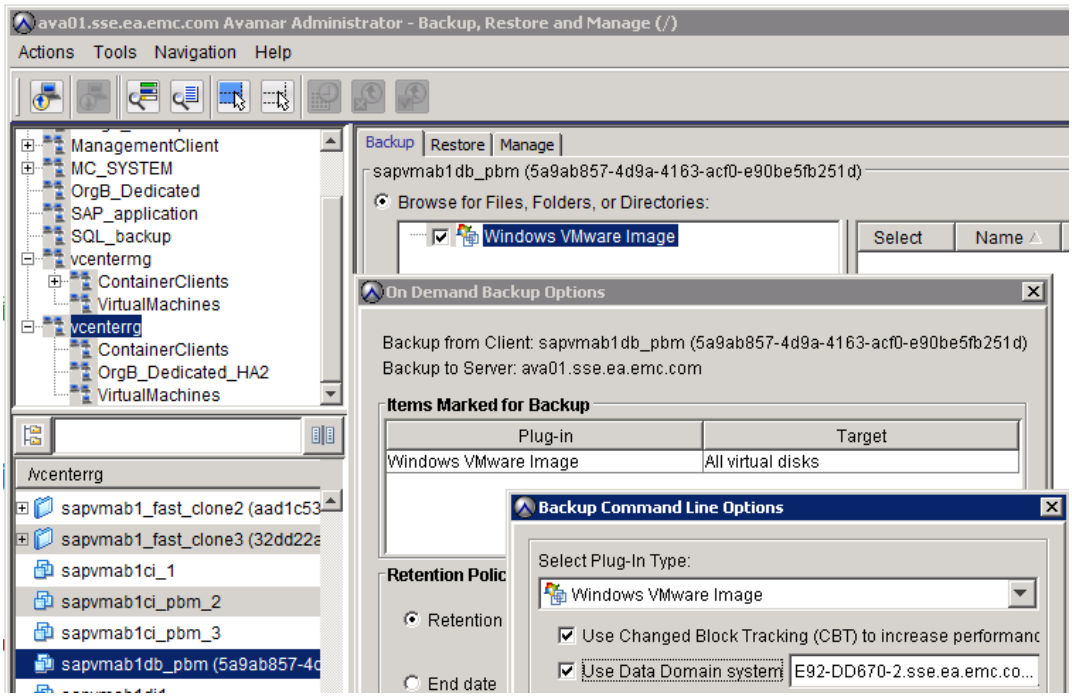

Figure 24. Image backup from Avamar Administrator

Figure 25 shows the backup and restore interface from the vSphere Web Client.

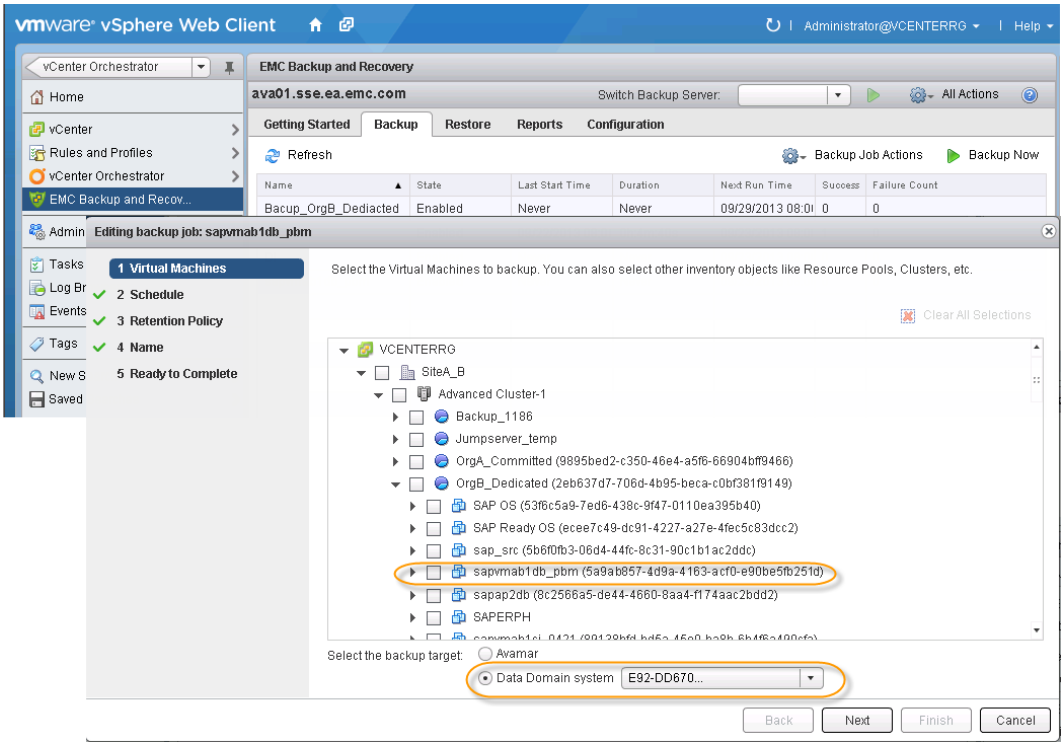

Figure 25. Backup and restore interface of the vSphere Web Client

Figure 26 shows the information on the initial and deduplicated image backups, respectively, in DPA.

8/7/13 01:00 - 8/12/13 10:00

10.110.87.160:Avamar

Client	Media Server	Started	Size (GB)	Throughput (MB/sec)	Duration (hour)	Level	Plugin Name
sapvmab1db_pbm (5a9ab857-4d9a-4163-acf0-e90be5fb251d)	e92-dd670-2.sse.ea.emc.com	8/7/13 5:10 PM	673.491	22.431	8 hours 32 minutes	Full	Windows VMware Image
sapvmab1db_pbm (5a9ab857-4d9a-4163-acf0-e90be5fb251d)	e92-dd670-2.sse.ea.emc.com	8/8/13 11:35 AM	0.047	0.34	0 hours 2 minutes	Full	Windows VMware Image

Figure 26. Image backup report from DPA

Note: The database size is 2.7 TB, and the sizes shown here are the resulting backup sizes after compression and deduplication.

Analysis

Under the situation of very low volume of delta change:

- Backup window of a 2.7 TB virtual machine was reduced from 8.5 hours to only two minutes, or by 99.6 percent compared with the initial backup,
- Backup bandwidth consumption was reduced from 22.4 MB/s to 0.34 MB/s, or by 98.5 percent compared with the initial backup.

Findings

- A backup administrator can choose to back up images directly from Avamar Administrator or vSphere Web Client.
- The data protection bundle is very efficient for image backups, especially when the change rate is very small, such as SAP application instances or cloud management systems.
- Image backups provide protection against SAP kernel or operating system (OS) corruption.

Image restore

Test scenario

We restored the latest backup taken from the preceding test, using different methods:

- Full-image restore
- Instant-access restore
- File-level restore – we deleted system folders to simulate file corruption, to see if an image backup can be used to selectively retrieve the folders without overwriting the whole virtual machine.

Objective

The objective of this use case was to restore a virtual machine using full-image and instant-access restore.

Procedure

To verify the flexible restore capabilities using an image backup, we performed the following steps:

1. Logged on to the Avamar Administrator and triggered a full-image restore. After completing the restore, we brought the system online and verified the service. We noted down the total recovery time and the effects on performance.
2. Triggered an instant-access restore using the same backup and noted the recovery time and the effects to performance.
3. Deleted an arbitrary folder and restored it using the same image backup.

Results and analysis

As shown in Figure 27, a full-image restore of a 60 GB virtual machine was completed in 12m 33s. Instant-access restore of the same 60 GB virtual machine was accessed in 1 minute.

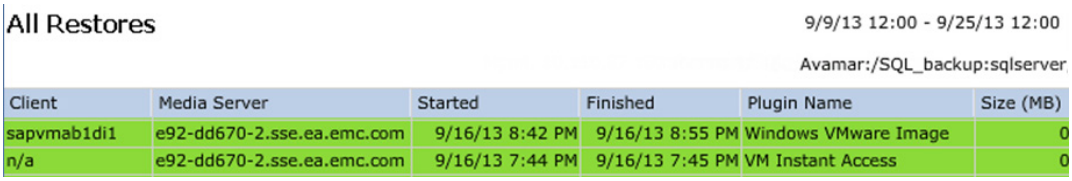

Figure 27. Full image restore and instant-access restore status in DPA

Figure 28 below shows the selected folders to be extracted from the image backup and restored to the original virtual machine.

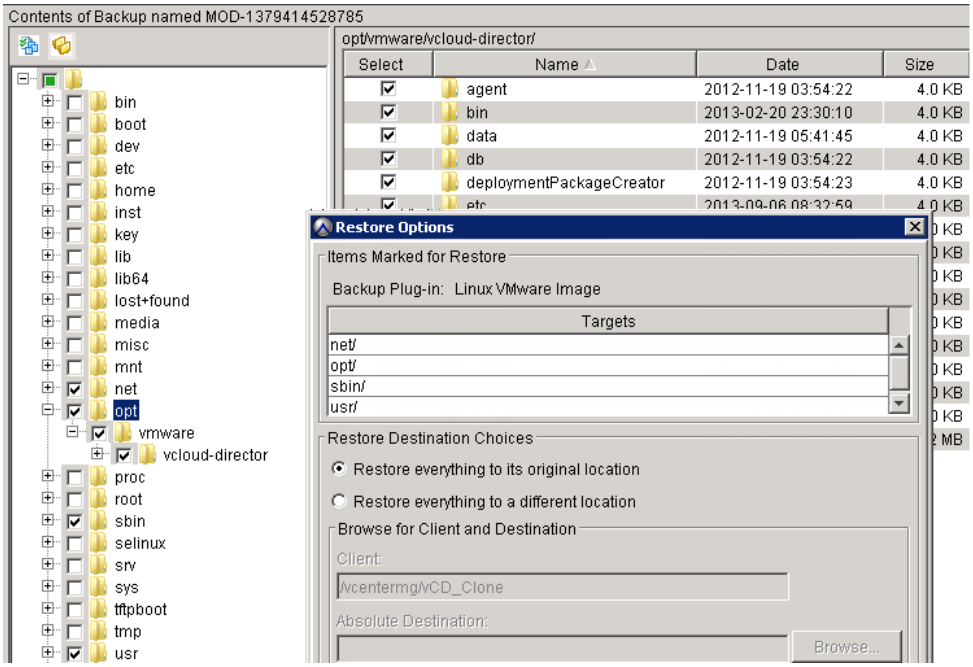

Figure 28. File-level restore using an image backup in Avamar Administrator

Findings

The use case demonstrates the following findings:

- An image backup can be restored either using a full-image restore or using an instant access plus Storage vMotion.
- Instant access minimizes downtime by enabling a virtual machine to be accessed in a very short period. This is most ideal for recovery of SAP central services in a distributed system, or critical cloud management applications. Refer to Recommended backup and recovery strategies for details.
- Individual files can be directly extracted from an image backup without restoring the whole image.

Use case 3: Local protection of the cloud environment

Cloud environment protection

Corruption of the vCloud Director will not impact on SAP production systems that are currently running. However, this will prevent cloud management operations such as powering on virtual machines. Because of this, we have set a stricter RTO or one hour.

The vCloud Director is comprised of an application and a database layer. For our test environment, we used MS-SQL. We will show how this is backed up directly from the Avamar Administrator console. The vCloud Director has the following specifications:

- 1 GB MS-SQL database
- 100 GB vCloud Director application

Test scenario

We restored the vCloud Director database and its virtual machine using a database restore, and a full-image and Instant access respectively. We measured the duration of each restore and the corresponding network bandwidth consumed using DPA.

Objective

The objective was to back up and restore the vCloud Director system within the RTO.

Procedure

1. Installed a SQL plugin and backed up vCloud Director's SQL database directly from Avamar Administrator.
2. Performed an image backup on the vCloud Director application.
3. Deleted the vCloud Director virtual machine and its database to simulate a system crash.
4. Restored the database using the Avamar Administrator.
5. Restored the image of the vCloud Director application using both full-image and instant-access restore, and verified the service.

Results

Figure 29 below shows the backup information for image back up vCloud director application and its database using VMware SQL plug-in from DPA:

Successful Jobs 9/9/13 00:00 - 9/18/13 00:00

10.110.87.160:Avamar:/SQL_backup:sqlserver, 10.110.87.160:Av...

Client	Started	Duration (minute)	Throughput (MB/sec)	Size (GB)	Plugin Name	Level
sqlserver	9/14/13 11:27 PM	0 minutes 45 seconds	0.644	0.028	Windows SQL	Full
vcd	9/14/13 11:10 PM	7 minutes 29 seconds	0.584	0.256	Linux VMware Image	Full

Figure 29. vCloud Director image and database backups

Figure 30 below shows the restore information for a full-image restore of the vCloud Director application and its database using VMware SQL plugin from DPA:

All Restores 9/9/13 12:00 - 9/25/13 12:00

Mgmt, 10.110.87.160:Avamar:/SQL_backup:sqlserver, 10.110.87....

Client	Media Server	Started	Finished	Plugin Name	Size (MB)
sqlserver	e92-dd670-2.sse.ea.emc.com	9/15/13 2:21 PM	9/15/13 2:22 PM	Windows SQL	5
vcd	e92-dd670-2.sse.ea.emc.com	9/15/13 2:11 PM	9/15/13 2:24 PM	Linux VMware Image	0
n/a	e92-dd670-2.sse.ea.emc.com	9/16/13 7:44 PM	9/16/13 7:45 PM	VM Instant Access	0

Figure 30. vCloud Director image and database restore logs

The whole vCloud system was completely restored in two minutes using instant access.

Analysis

The test results show that the vCloud Director was recovered in 14 minutes using a Full image+database restore, and two minutes using instant access and database restore.

Findings

While we demonstrated how the data protection bundle was able to back up and recover vCloud Director, the same or similar strategy is applicable to other key components in the cloud environment, such as vCenter, vShield Manager, and vChargeback.

Use case 4: Backup replication

Restore SAP data from a remote site

The engineering team established replication, measured the network consumption using DPA, and compared the backup size with the data that was shipped out.

We consider a use case where an administrator needs to restore an SAP database. The required backup has already reached its retention limit and has been purged in the local system. He finds a replicated copy of the backup in the remote site, and decides to use that instead.

Test scenario

An administrator may do either of these options depending on the following cases:

- Case 1: Replicate back the surviving backup copy and perform a local restore.

  In this scenario, the two sites are too far from each other to guarantee network stability. The administrator decides to copy back the backup first and restore it locally.

- Case 2: Restore directly from the remote backup onto the local production system.

  In this use case, the local Avamar and Data Domain systems are inaccessible and there is no choice but to restore remotely.

We used the data protection bundle's replication feature to address these scenarios.

Objectives

This use case aimed to validate the following functionalities:

- Show that an administrator can manually select clients to be replicated
- Extend the retention period of the replicated backups
- Verify backup replication and measure the network performance
- Restore the replicated backup by:
  - Case 1: Replicating back from the remote Data Domain system to the local Data Domain system, and restore the local image
  - Case 2: Restoring the backup to the local production system directly using the Avamar server and Data Domain system in the remote site
- Monitor the network bandwidth in DPA during replication

Procedure

We performed the following steps:

1. Established replication from the production site to the remote site, and vice versa.
2. Defined a replication group and selected which clients will be replicated.
3. Changed the retention policy of the replication group.
4. Backed up an SAP system, ensured that it was replicated to the remote site, and deleted the local backup copy. This will simulate the scenario narrated above, where the needed backup is only available on the recovery site.

Figure 31 shows that we deleted the sapvm6 database backup with name **belxmstad1ced864**.

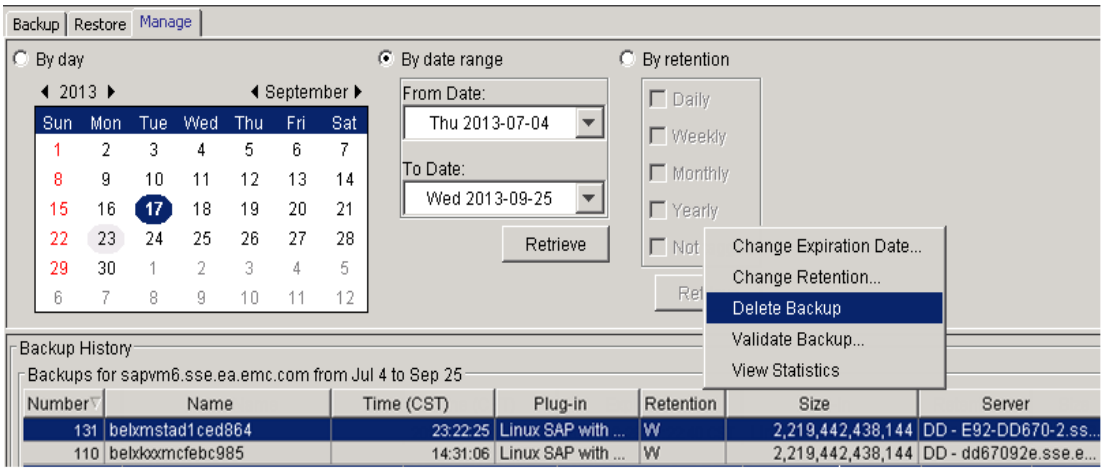

Figure 31. Delete the backup from Avamar Administrator console

5. To simulate case 1: we logged on to the remote Avamar using PuTTy, and issued the following command to replicate back the remote copy to the production site.

   ```
   root@ave-sse-ea:~/#: replicate --dstaddr[2]=ava01 --
   hfsaddr[3]=ave-sse-ea --dstid=repluser -- dstpassword=9RttoTriz
   --restore --include[4]=sapvm6 --srcpath[5] =
   /REPLICATE/ava01.sse.ea.emc.com/SAP_application --
   dstpath[6]=/SAP_application
   ```

   After replication, we triggered the restore locally.

6. To simulate case 2: we redirected the SAP system's Oracle configuration files towards the remote Avamar hostname and Data Domain system according to the user guide, and triggered the restore remotely.

```
sapvm6:oravm6 104> more initVM6_remote.utl
--bindir=/usr/local/avamar/bin
--sysdir=/usr/local/avamar/etc
--vardir=/usr/local/avamar/var
--id=MCUser
--password=59bdd4c5e956185f8bcbf58c41c24418d3eb84a75d8c12f8ed67de628ffa33b145f38225
d75d429a
--account=/REPLICATE/ava01/SAP_application/sapvm6.sse.ea.emc.com
--server=ave-sse-ea.sse.ea.emc.com

--max-streams=10
--encrypt-strength=high
--ddr=true
--ddr-index=1
--expires=120
```

Figure 32. Change the utility file

[2] Destination Avamar hostname
[3] Source Avamar hostname
[4] Hostname of the virtual machine to be replicated
[5] Path to source backup (site C)
[6] Path (site A) to restore destination

7. We used DPA to monitor the duration and bandwidth during replication.

Results

As seen in Figure 33, the Avamar Administrator console enables you to select the clients that are to be replicated.

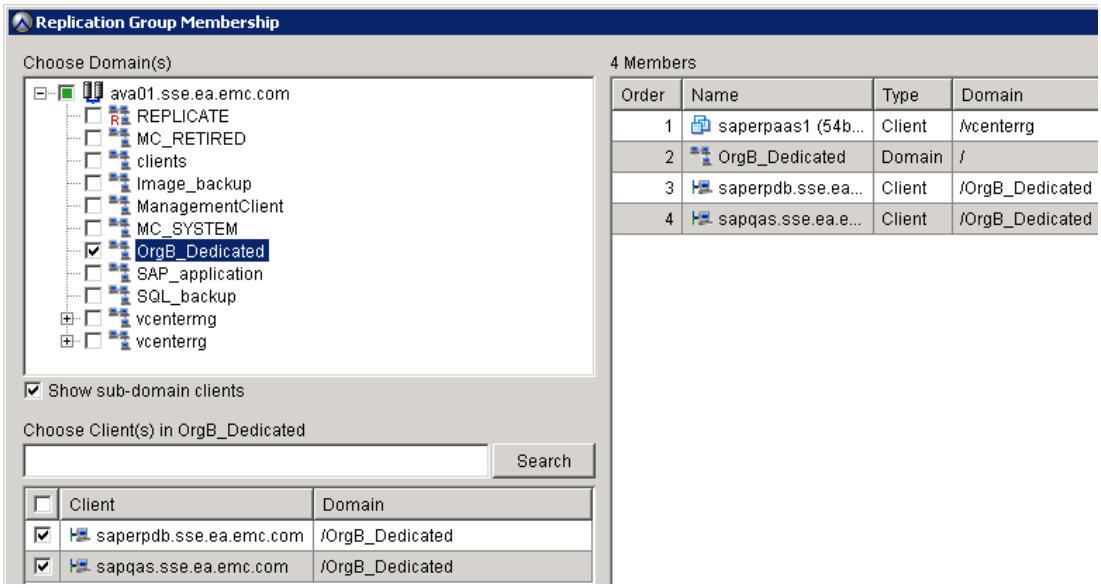

Figure 33. Choose the client to be replicated in Avamar Administrator

Figure 34 shows that a different retention policy can be configured for replicated backups under the same replication group.

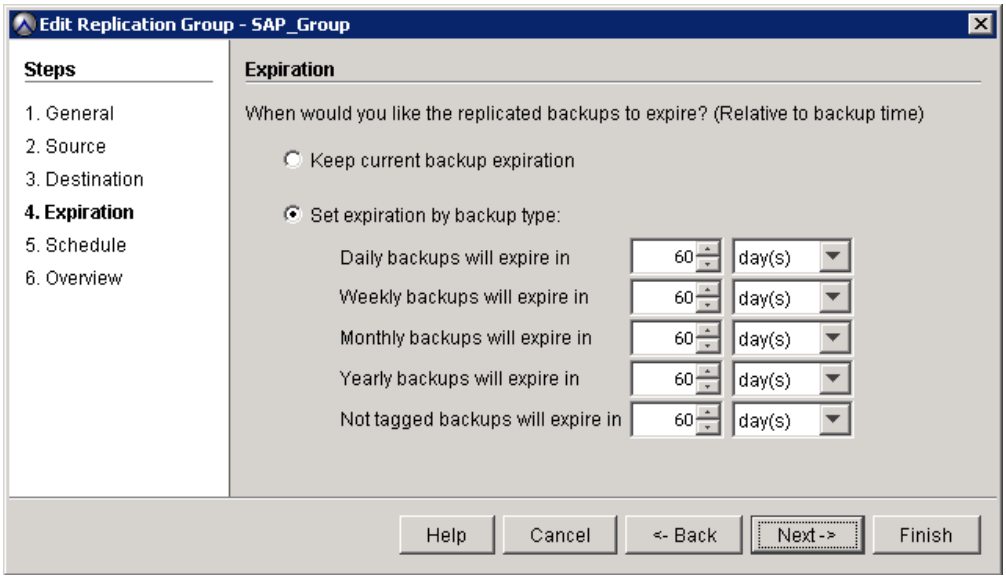

Figure 34. Change the retention policy

Figure 35 shows the bandwidth consumption during replication.

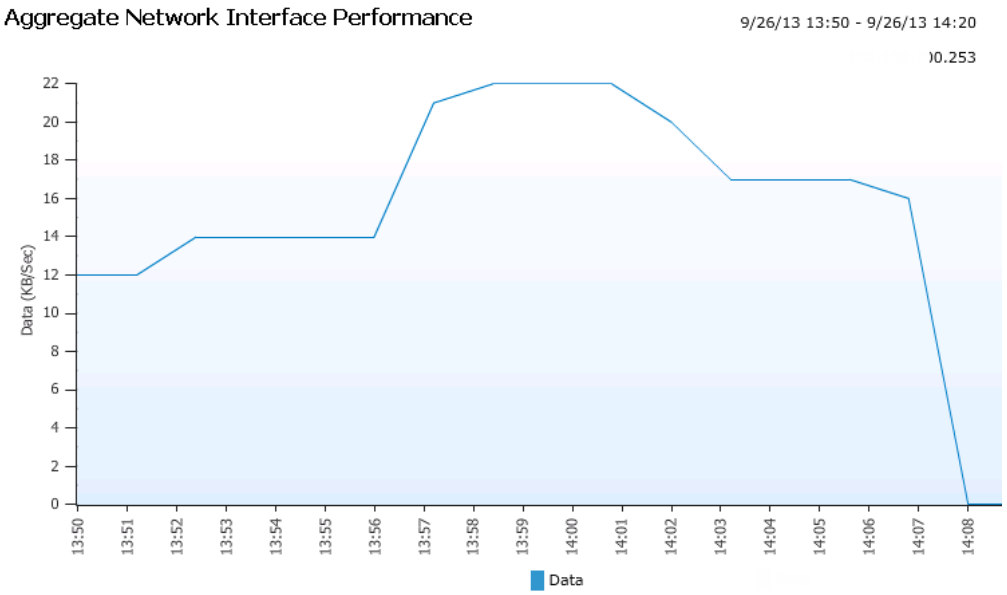

Figure 35. Network bandwidth during replication from DPA

As shown in Figure 36 , the restore operation of a 257.8 GB database backup was completed in 4.06 minutes.

Status	Start Time (CST)	Elapsed	End Time (CST)	Type	Progress Bytes	New Bytes	Client	Domain
Completed	2013-09-26 14:01	00h:04m:07s	2013-09-26 14:05	Replication Source	258.7 GB	100%	saperpdb.sse.ea.emc.com	/OrgB_Dedicat

```
2013-09-26 14:01:11 avtar Info <6653>: Backup 89 is already on target server, but not for this account
2013-09-26 14:01:11 avtar Info <6654>: Replicating backup 89, Label "bembwpka491a3293", 258.7 GB
2013-09-26 14:01:11 avtar Info <10534>: Initializing session on Data Domain: 2, mode:REPLICATE, boost:ENABLED, ma
2013-09-26 14:01:11 avtar Info <10535>: - DDR naming options: Filenames: UNIQUE, ClientID:CID, BackupID:HEX-TIME,
2013-09-26 14:04:50 avtar Info <18789>: Backup Replication Stats: original backup size: 277,797,252,400 (258.7 GB
2013-09-26 14:05:14 avtar Info <0000>: ReplicateTo: File: /STAGING/82fa8f7d40b1884867a0984bd5b560fad6a24d62/BACKU
2013-09-26 14:05:14 avtar Info <5673>: Backup #12 timestamp 2013-09-14 01:41:45 CST created
2013-09-26 14:05:14 avtar Info <5675>: Replicated 1 of 11 backups (0 errors) for client "saperpdb.sse.ea.emc.com"
2013-09-26 14:05:14 avtar Info <7925>: Restored 258.7 GB from selection(s) with 258.7 GB in 2 files
2013-09-26 14:05:14 avtar Info <6090>: Restored 258.7 GB in 4.06 minutes: 3,819 GB/hour (30 files/hour)
2013-09-26 14:05:14 avtar Info <7883>: Finished at 2013-09-26 14:05:14 CST, Elapsed time: 0000h:04m:03s
2013-09-26 14:05:14 avtar Info <8468>: Sending wrapup message to parent
2013-09-26 14:05:14 avtar Info <5314>: Command completed (1 warning, exit code 0: success)
```

Figure 36. Replication Activity in Avamar Administrator console

Findings

The use case demonstrates the following findings:

- The data protection bundle enables you to choose which clients to replicate based on tenant requirements. At the same time, cloud administrators can efficiently utilize network bandwidth and backup storage.
- SAP backup administrators can flexibly change the retention periods of source and replicated backups. They can choose to set shorter retention periods on the local site, but set an extended period on the remote site, according to audit requirements.

- The data protection bundle is suitable for replicating backups over WAN. Its deduplicated replication feature minimizes bandwidth consumption across long distances, eliminating the need to physically transfer tapes to an offsite location.

Use case 5: Chargeback and reporting

Test scenario

We prepared the data protection bundle environment according to the multitenancy model of an existing Cloud-enabled Infrastructure foundation bundle. During the entire testing cycle, the bundle continuously monitored all backup and restore activities. Since the previous use cases have already demonstrated how DPA can monitor performance for each component, we focused on how the bundle was able to measure resource consumption in a multitenancy environment, and provide accurate chargeback reporting.

Objectives

The objectives of this use case were to validate the following capabilities:

- Report the total resource consumption of a tenant
- Identify breaches in the SLA
- Use a chargeback model to translate the consumption into a concrete billing cost and generate the report

Procedure

We performed the following steps:

1. Established discovery of the ESXi hosts, Data Domain, and Avamar to DPA to enable monitoring during the use case testing.
2. Created groups based on the existing vCloud Director's OvDC configuration.
3. Defined SLA and chargeback policies as shown in Figure 15and Figure 16. We then assigned these policies to the groups.
4. We performed actual use case testing and simulated backup failure.
5. After completing all tests, we generated the reports that can be e-mailed to the tenants.

Results

Figure 37 shows the most recent backup and restore statistics as viewed from the Avamar Administrator console. You can easily view the current status of both the Avamar server and the connected Data Domain system using a single interface.

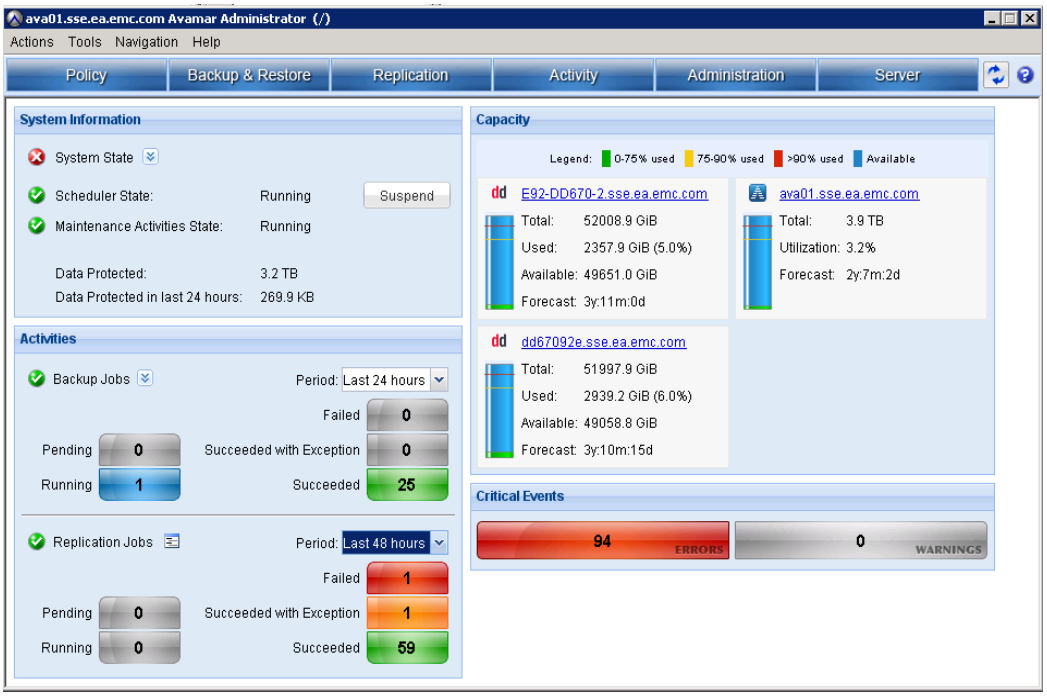

Figure 37. Avamar Administrator console

Figure 38 shows the itemized and total costs incurred by tenant **OrgA_Dedicated**. The total cost was computed based on the chargeback policies defined in Figure 16 on page 35.

Chargeback Details

8/1/13 00:00 - 9/4/13 00:00

OrgA_Dedicated

Client	Num. Backups	Backup Size (GB)	Backup Cost	Num. Restores	Restore Size (TB)	Restore Cost	Total Cost
saperpaas1 (54b826c0-e788-45bb-bb55-bc16bd942dde)	2	3	$10.30	0	0		$10.30
saperpascs (e87d241f-32e3-4ef2-8167-bc9d7e6306d9)	2	0	$10.00	0	0		$10.00
saperpdb (080304fb-1378-4542-ad40-243bde18e955)	3	49	$19.90	0	0		$19.90
saperpdb.sse.ea.emc.com	29	659	$266.80	6	4.037	$1,713.60	$1,980.40

Figure 38. Chargeback report for OrgA_Dedicated from DPA

Figure 39 shows the current RTO and RPO settings for the OrgA_dedicated:

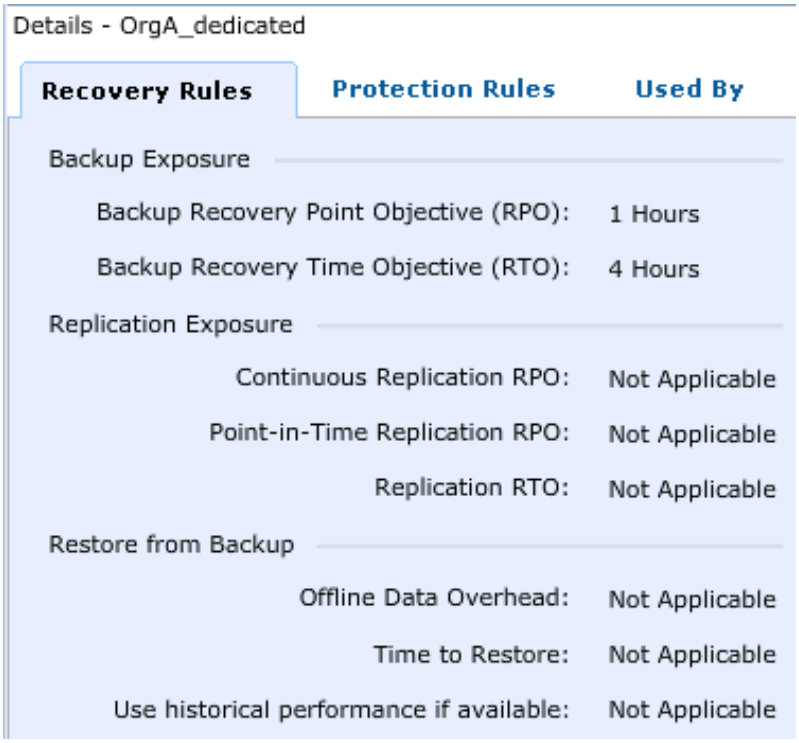

Figure 39. SLA settings used in the test environment

Figure 40 shows an SLA report, highlighting systems that breached the SLA according to the policies set in Figure 39. All entries in green indicate 100 percent compliance with the SLA. Entries in orange and red indicate failed jobs.

SLA Summary

8/1/13 00:00 - 9/6/13 23:59

10.110.

Client	Jobs	Successful	Within SLA	% Successful (%)	% Within SLA (%)
sapvmab1db_pbm (5a9ab857-4d9a-4163-acf0-e90be5fb251d)	4	3	3	75	75
saperpdb (080304fb-1378-4542-ad40-243bde18e955)	3	3	3	100	100
sqlserver	9	9	9	100	100
sapvm3sqldi3	1	0	0	0	0
sapvmab1di1 (5443bfd3-f7d7-4ee4-80b7-74f524e05a34)	4	4	4	100	100
saperpdb.sse.ea.emc.com	29	24	24	82.759	82.759
vclouddirector	5	2	2	40	40
vc_management_group	3	1	1	33.333	33.333
sapvm6.sse.ea.emc.com	12	9	9	75	75

Figure 40. SLA report from DPA

Findings

This use case demonstrates the following:

- The data protection bundle improves compliance and lowers risk through better visibility and assurance that critical data is protected. It reduces complexity using simple interfaces to provide an integrated, automated view.
- In addition, the solution is capable of multitenancy and has an independent chargeback mechanism. Performance data and resource consumption are well segregated according to domain (business unit) to provide accurate reports and billing. This enables an IT business unit to bill other tenants for data protection services and retention costs.

Conclusion

Summary

This white paper highlights the EMC data protection bundle and how its unique architecture provides an effective, affordable, and efficient backup and recovery protection for critical business functions in a Cloud-enabled Infrastructure for SAP.

The foundation of this solution is predicated not only on technologies that achieve tighter RTOs and RPOs, but on strategies that simplify management and reduce the TCO of the entire cloud environment.

The data protection bundle achieves the perfect balance of speed, resources, manageability and cost of backup by integrating the solution and BaaS into the on-premises SAP cloud infrastructure. This seamless integration significantly improves business agility and scales out for common SAP production system and test system needs, providing:

- Secure, comprehensive, and reliable backups for cloud environments but at a considerably smaller footprint
- Swift database and image recovery using familiar and easy-to-use interfaces
- Robust replication strategies that minimize network requirements and prolong retention periods
- Comprehensive overview and monitoring of the backup infrastructure
- Accurate tenancy-based chargeback so that business units only pay for the service and the storage that they actually consume
- Centralized interface for simpler management

Findings

This solution demonstrates the following:

- Reducing backup storage and network resources, combined with its multi-tenancy functionalities, prove that this solution is more than ready to protect enterprise landscapes typically found in enterprise SAP and cloud environments. Backup infrastructure and operations that used to be a cost overhead can now be turned to a profitable backup-as-a-service strategy for on-premises cloud architectures.
- Replication protects the backups that in turn protect your environment. Not only does this eliminate the need to secure tapes offsite, this also enables you to keep backup data for much longer retention periods.

References

Reference architecture

For additional information, see the *EMC Transforms IT On-Premise Private Cloud Infrastructure for SAP–Reference Architecture.*

Product documentation

For additional information, see the following product documents.

- *EMC Avamar 7.0 for SAP with Oracle User Guide*
- *EMC Avamar 7.0 for VMware User Guide*
- *EMC Avamar 7.0 and Data Domain System Integration Guide*
- *Avamar 7.0 Administration Guide*
- *EMC Avamar Compatibility and Interoperability Matrix*
- *EMC Data Protection Advisor 6.0 - Applied Technology*
- *Backup and Recovery for SAP Environments using EMC Avamar 7: A Detailed Review*
- *Avamar plug-in for vSphere Web Client Administration Guide*
- *EMC DD OS 5.3 Initial Configuration Guide*
- *EMC DD OS 5.3 Administration Guide*
- *EMC Avamar 7.0 for SQL Server User Guide*
- *EMC Avamar 7.0 for Sybase ASE User Guide*
- *EMC Avamar 7.0 for IBM DB2 User Guide*
- *EMC Avamar 7.0 Product Security Guide*
- *Avamar-7.0 Operational Best Practices Guide*

Other documentation

For additional information, see the following documents

- *vCloud Director Administrator's Guide vCloud Director 5.1*
- *VMware vCloud Design Best Practices vCloud Director 1.5*
- *Installation and Configuration Guide for Windows and Linux -vCenter Operations Manager 5.6*
- *VMware vCenter Operations Enterprise Automated Operations Management for Your Enterprise—VMware Technical Paper SAP Note 1122388 - Linux: VMware vSphere configuration guidelines*
- *Setup rsh server from scratch Admin Page*
- *SAP Note 10403 - Starting external programs*
- *SAP Note 446172 - SXPG_COMMAND_EXECUTE (program_start_error) in DB13*
- *SAP Help Portal - Setting Up Access Control Lists (ACL)*
- *SAP Help Portal - Security Parameters*