White Paper

VIRTUALIZED SAP HANA® ON VCE VBLOCK IN PRODUCTION — A REALITY

Benefits of Running Virtualized SAP HANA on VCE Vblock™ with Deloitte Cloud ServiceFabric™ on Hybrid Cloud

EMC Global Solutions Group

Abstract

An international team of Deloitte Consulting LLP, EMC, VMware, Cisco, and VCE functional and technical experts worked to identify the challenges of running virtualized SAP HANA on a Vblock in Production and over a hybrid cloud. Through this Proof of Concept, named Project RUBICON, that multi-company team created real-world use cases for testing Production workloads, analyzing the results, suggesting solutions for mitigating risks, and offering solutions for possible implementation of SAP's new S/4HANA in virtualized mode.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

In May 2014, SAP and VMware jointly announced support for running virtualized SAP HANA on VMware in Production and many customers including EMC IT have benefited from the more flexible and cost effective way of running productive virtualized HANA. Yet, HANA deployments in Production, whether virtual or bare metal, are not as common as traditional SAP NetWeaver so it is natural that certain customers have concerns with the maturity, system behavior, and reliability under Production-level workload, and customers are even less certain of how HANA would work in a hybrid cloud.

This white paper provides proof points and a reference architecture for customers desiring to take advantage of the efficiencies, performance and scalability of virtualized SAP HANA environments running on Vblock under Tailored Datacenter Integration (TDI) mode and in a hybrid cloud model instead of on bare metal physical appliances. This paper addresses those customer challenges and concerns by:

- Proving that virtual SAP HANA "appliances" on a VCE Vblock can easily handle Production workloads while offering long distance disaster recovery not possible with bare metal
- Demonstrating that monitoring and reporting tools can provide the required insight to ensure stability and scalability of virtualized SAP HANA on a Vblock under TDI
- Validating how to operate SAP HANA in a hybrid cloud model over long distance

Deloitte, EMC, VMware, Cisco, and VCE in conjunction with Blue Medora and Worksoft worked together to show how to monitor, measure, and take actions upon the entire computing stack of a virtualized SAP HANA Production system to achieve stability and scalability under heavy workload. This team also showed how SAP HANA can realistically be implemented in hybrid cloud mode between the Deloitte datacenter in Georgia and the EMC datacenter in North Carolina, located 550 kilometers apart.

This Proof of Concept used a workload equivalent in volume and scope to a month-end closing event, by loading inventories, creating planned orders, calculating lead times, etc., with over 2,000 concurrent SAP users logged in and multiple MRP batch jobs. Over the 2 hour test run, this massive load generated the equivalent of 784,000 dialog steps, 680,000 Updates, and 144GB of SAP HANA logs per day.

Under this large workload, the virtualized SAP HANA "appliance" running on Vblock proved to be stable and scalable according to the monitoring tools from Blue Medora Pack for SAP HANA, Cisco Intelligent Automation for SAP HANA, and EMC ViPR SRM, confirming that there is no difference in stability and performance between a traditional, bare metal infrastructure and a virtualized, converged environment based on the Vblock. The monitoring tools were even able to predict possible future failure, while providing reporting on compliance with agreed-to Service Level Agreements (SLAs).

Since long distance disaster recovery for SAP HANA is very important in Production, EMC RecoverPoint proved that it could replicate large amounts of SAP HANA logs over long distance to restart HANA at the remote site, with a more than acceptable Recovery Point Objective (RPO) at peak workload.

The POC also demonstrated that Deloitte's Cloud ServiceFabric™ (CSF) can be extended to a hybrid cloud model by implementing and controlling CSF endpoints in Durham, NC from the CSF provisioning and monitoring portal in Suwanee, GA. By relocating workloads from one datacenter to another without data loss, Cloud ServiceFabric works well in hybrid clouds for maximum optimization of resources.

The results detailed in this white paper suggest that perhaps the reference architecture proposed in this POC could be the ideal platform to implement the recently announced S/4HANA since it solves challenges pertaining to long distance BC/DR, higher availability, flexible resource allocation, comprehensive monitoring and reporting, and easy to implement workload relocation in a hybrid cloud model. The smaller memory model proposed by S/4HANA, coupled with the HANA data tiering technology, makes running S/4HANA in virtualized mode not only a reality but almost a necessity.

This white paper offers specific lessons learned for SAP customers to confidently implement virtualized SAP HANA on the Vblock in Production environments. It also proves that Deloitte's Cloud ServiceFabric can be extended into a hybrid cloud model. We also proposed a reference architecture for SAP customers to rapidly deploy S/4HANA in an on-demand, on-premise cloud which can be extended to off-premise, allowing organizations to quickly expand capacity to meet peak demand periods.

INTRODUCTION

Purpose

Provide proof points for a reference architecture including extensive test results and lessons learned that enable customers to confidently run virtualized SAP HANA "appliances" on the Vblock, the market-leading converged infrastructure, in Production.

Throughout this white paper, you will note that the word "appliance" is in double quotes whenever it is used to describe the VMware virtual machines and the associated file structure which makes up the virtualized SAP HANA environment used in all the tests of this Proof of Concept.

Put it another way, whenever the word "appliance" is used in conjunction with 'virtualized SAP HANA' as in a virtualized SAP HANA "appliance", we meant to portray the entire virtualized SAP HANA environment.

We would like to encourage the comparisons of the stability and performance of an infrastructure for virtualized SAP HANA on VMware running on a Vblock against an actual physical, bare metal SAP HANA appliance commonly used by the vast majority of customers in Production at this moment.
Demonstrate that Cloud ServiceFabric can be extended to a hybrid cloud model through remote provisioning, remote monitoring, and workload relocation

Scope

This white paper addresses the Proof of Concept scope by:

Delivering proof points that:

- Describe this Proof of Concept environment for virtualized SAP HANA on Vblock in Production with real-world use cases
- Outline architectural descriptions of critical components for testing these use cases
- Identify Key Performance Indicators (KPIs) and thresholds required to ensure performance levels and scalability
- Summarize testing results and quantify the benefits for SAP customers

Advising SAP customers with:

- Lessons learned to help ensure acceptable performance and scalability when implementing a virtualized SAP HANA environment on Vblock in Production
- Lessons learned for extending Cloud ServiceFabric to a hybrid cloud model

Audience

This White Paper is intended for customers and partners, specifically technology architects and business line decision-makers who are considering implementing virtualized SAP HANA, and who are looking for monitoring tools, technologies, and services required to provide assurances that their KPIs can be successfully met

OBJECTIVES OF THIS PROOF OF CONCEPT

Challenges & Concerns addressed by this Proof of Concept:

Through this Proof of Concept, we were able to demonstrate that deploying virtualized SAP HANA "appliances" on the VCE Vblock provides predictable performance and stability to operate in Production with the same assurances that previously could only be offered to SAP customers using bare metal physical appliances.

We also wanted to show how to overcome the challenges of long-distance Disaster Recovery for SAP HANA by proving that large amounts of logs can be replicated over long distance with minimal data loss while validating the overall performance of CPU, memory and disk I/O on these virtualized SAP environments.

This POC aimed to deliver results that meet the same KPIs typically used in SAP official certification process, the SAP Hardware Configuration Check Tool (HWCCT). In fact, before conducting the test run to gather results presented in this white paper, we proceeded to "certify" the virtualized SAP HANA "appliance" on the Vblock in Production through SAP's Hardware Configuration Check Tool (HWCCT), although this certification was not required by SAP.

This POC demonstrated flexibility and ease of implementing Deloitte's Cloud ServiceFabric into a hybrid cloud mode for instances of virtualized SAP HANA while showing how CSF can monitor off-premise infrastructure and relocate significant workloads from one datacenter to another in an orderly fashion.

Business & Technical Benefits of this Proof of Concept:

As mentioned earlier, the goal is to showcase why running virtualized SAP HANA on the Vblock not only makes sense, but it is almost a necessity. The advantages of running SAP in Production on this market leading converged infrastructure platform have been well understood. Vblock SAP customers do not want to run their HANA on physical bare metal appliances because they cannot benefit from the advantages of the Vblock such as lower Total Cost of Ownership (TCO) while optimizing performance with better availability.

Through this POC, we showed evidence that specific KPIs & SLAs are being met in order for SAP customers to confidently run virtualized SAP HANA on Vblock in Production. By utilizing market-leading monitoring tools this POC showed SAP customers how to take immediate corrective actions when KPIs are breached and take preventive actions to avoid costly down time and performance problems that can effect business.

This POC proved that large amounts of logs can be replicated over distances of 550km and we demonstrated a successful restart using EMC RecoverPoint and VMware SRM to solve the challenge of long distance disaster recovery so that customers can avoid costly down-time thanks to a viable disaster recovery methodology for virtualized SAP HANA while meeting customer SLAs.

This POC demonstrated the simplicity of an automated and orderly SAP HANA workload relocation from Suwanee, GA to Durham, NC and back over long distance in a hybrid cloud operating model without any data loss. Using Deloitte's CSF, we showed SAP customers that they can optimize their internal IT resources by using hybrid clouds to augment with external resources and address their dynamic Production workloads when needed.

This POC also provided lessons learned and a reference architecture for the possible deployment of SAP's new S/4HANA in virtualized mode and over a hybrid cloud.

ARCHITECTURAL OVERVIEW OF ENVIRONMENT BUILT FOR THIS POC

Architectural Overview & POC Landscape High-level Diagram:

The diagram below describes a high-level architectural landscape with specific components used in this POC for virtualized SAP HANA running on Vblock in the Deloitte datacenter while in the EMC datacenter, the virtualized SAP HANA is running on V+C+E infrastructure in TDI mode of operation.

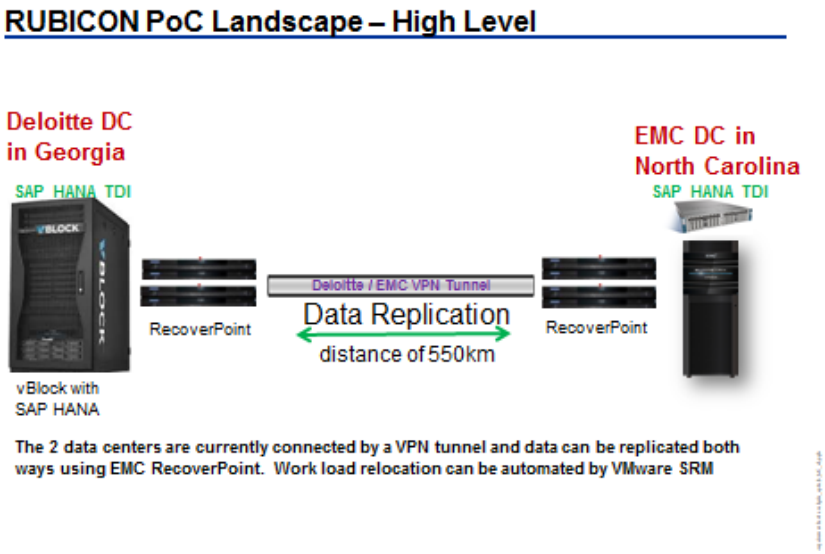


Figure 1. High level RUBICON POC Landscape

Details of the Virtualized SAP HANA Environment used in this POC

Here are the details of the configuration for the virtualized SAP HANA "appliance" running on the Vblock used for the Proof of Concept and the logs replication solution for long distance DR/BC and hybrid cloud validation:

1. Virtual machine for virtualized SAP HANA "appliance"
    a. Configured with 512GB RAM hosted by Cisco B440 M2 with 1TB RAM
    b. Configured with 32 vCPUs for the SAP HANA database and the SAP application server running ERP Suite on HANA
    c. Configured with VMDK datastore of 2.5TB in TDI mode on EMC VNX 5300
2. One pair of EMC RecoverPoint Gen5 appliances connected to a VPN linking the Deloitte datacenter in Suwanee, Georgia, and the EMC datacenter in Durham, North Carolina
3. Multiple supporting Virtual Machines hosting:
    a. VMware vCenter Server 5.5, VMware vRealize Operations Manager 6.0, VMware Site Recovery Manager 5.8, VMware vRealize Orchestrator 6.2, and VMware vRealize Automation 6.2 on Cisco R200 with 12 CPU with 96GB
    b. Blue Medora for SAP HANA sharing resources with VMware vCenter Server
    c. Cisco IA for SAP VM with 4 vCPUs, 32GB Memory, & 60GB Storage
    d. EMC ViPR SRM with 2 vCPUs, 4GB Memory, & 60GB Storage
    e. Worksoft Performance had 5 CPT VMs with 8 vCPUs, 16GB Memory, & 40GB Storage each; plus 1 Database VM and 1 Application VM

USE CASE RATIONAL & DESCRIPTIONS

Overview of Use Cases:

Specific use cases were developed by Deloitte, EMC, VMware, Cisco, and VCE to show that the stability and performance assurances of physical appliances can be provided for virtualized SAP HANA "appliances" with Production workloads, like loading and updating inventories, creating planned orders, calculating lead times with a large number of interactive users and resources intensive batch jobs.

The workload generated was equivalent in volume and scope to a planned month-end closing event that showcased the stability, scalability and performance capabilities of virtualized SAP HANA in a Production environment.

The monitoring tools utilized must not only keep track of all important KPIs to insure that alerts are raised if any preset thresholds have been breached, but the tools should be able to predict future potential problems while providing useful reporting on SLAs compliance.

Being that long distance business continuance is extremely important in any SAP Production environment, the use case needed to also prove replication of large amounts of SAP HANA logs could be done over long distance in order to restart the entire SAP landscape at the remote site should a disaster happen.

Additional use cases were developed for Deloitte's Cloud ServiceFabric (CSF) running in a hybrid cloud model to validate concepts such as remote provisioning, remote monitoring, and workload relocation over long distance by implementing the CSF endpoints in Durham, NC and remotely controlling them with the CSF portal in Suwanee, GA, a distance of 500 km apart.

By deploying this virtual machine using VMware vRealize Automation (formerly vCAC) into a VMware Site Recovery Manager (SRM) protection group for replication and automation of the SAP HANA workload relocation from Suwanee to Durham and back, we were able to prove the flexibility and ease of implementing and operating virtualized SAP HANA running on Vblock in hybrid cloud mode.

Overview of Test Scenarios:

The test plan was developed to support the use cases mentioned above:

- Monitor activity level for the computing (CPU & RAM), and networking tiers of SAP HANA with Production workloads for stability and scalability
- Monitor activity level for the storage tie and the data path for stability and scalability
- Monitor activity level for the EMC RecoverPoint appliances ability to replicate data over long distance
- Monitor disk latency for the logs volume as well as disk consumption inside logs and data volumes
- Monitor any future potential problems impacting stability and performance
- Provision and monitor remote CSF endpoints
- Execute workload relocation from on-premise to off-premise
- Validate long distance recovery capabilities by restarting SAP landscapes at the remote site in a controlled and orderly fashion

Key Metrics of Test Scenarios:

To provide proof points on the stability, scalability, and performance of a virtualized SAP HANA environment on a Vblock, key metrics or Key Performance Indicators (KPIs) must be defined to insure proper monitoring and measuring.

This POC Project Team agreed that the utilization for CPU, Network, RAM and the consumption of disk space should stay below 70% to avoid an informational warning and below 90% to avoid a critical warning:

- <70%=Green (no warning)
- <90%=Yellow (informational warning)
- >90%=Red (critical warning)

The POC Project Team also agreed that the average response time for SAP dialog activities should be under 1 second as this is the agreed-to benchmark for any SAP customer.

Measuring stability and performance:

Both stability and performance measurements can be done at the hardware, virtualization, operating system, database and application levels, while keeping in mind that all SAP dialog-based standard application benchmarks require a system response time of one second or less to be acceptable.

With a realistic Production-level SAP workload running, the project team must monitor the system components for any bottleneck or sign of instability due to badly performing components which can negatively influence the whole system that will in turn negatively impact SAP system performance.

Measuring headroom capacity:

Measuring headroom capacity provides evidence that there is capacity for more workload, which points to the scalability of the Vblock. The alarm thresholds and related color codes are easy to understand and were agreed to by the Project Team as the Test Plan KPIs:

- **CPU & Network:** Monitor and alert on utilization
  - ≤70% = Green
  - 71% to 89% = Yellow
  - ≥90% = Red
- **Disk Latency & Throughput:** Monitor and alert on Logs & Data volume
  - Thresholds for Logs volume
    - Green: 1 Millisecond
    - Red: Over 2 Millisecond
  - Thresholds for Data volume
    - Minimum: 250 MB per second
    - Upside: over 250 MB per second
- **RAM (vRAM and not ESX host):** Measure how much RAM is consumed and alert when thresholds are breached
  - ≤70% = Green
  - 71% to 89% = Yellow
  - ≥90% = Red
- **Disk Space:** Measure disk consumption inside logs & data volumes
  - ≤70% = Green
  - 71% to 89% = Yellow
  - ≥90% = Red

Business/Technical Perspectives of Use Cases

Showing how simple it is to monitor, measure and take actions upon computing, networking, and storage tiers of a virtualized SAP HANA running Vblock in Production environments, will enable business and technical users to confidently take advantage of the unmatched stability and scalability that virtualized SAP HANA on Vblock can achieve along with providing better TCO due to lower costs for hardware, quicker implementation, simpler to execute upgrades, and easy to implement long distance disaster recovery.

These use cases even showed customers how they can use monitoring tools to predict and prevent possible failures, to provide root cause analysis of the end-to-end topology view of SAP HANA environments, to report on workload projections and to receive alerts when KPI thresholds were being exceeded or compliance with agreed-to SLAs were not being met.

Business and technical customers have also been shown how to extend Deloitte's Cloud ServiceFabric to a hybrid cloud model and how to relocate workloads from one datacenter to another datacenter over long distance without any data loss.

By combining the agility and rapid deployment of Public Clouds with the control and security of Private Clouds through the use of CSF in a hybrid cloud mode, business and technology users are now able to focus their resources on delivering better customer experiences with enhanced capabilities to their business partners, creating dramatic cost savings, process improvements, and shorter time-to-delivery.

In summary, the capabilities of virtualized SAP HANA on the Vblock shown during the POC provided evidence that it is the ideal platform for deployment of the recently announced S4/HANA since the Vblock provides better stability, scalability, resiliency, cloud awareness, and disaster tolerance than physical appliances.

OUTCOMES & RESULTS FROM USE CASES

Overview of Test Load Run

In order to provide conclusive evidence regarding the stability and performance of virtualized SAP HANA environments, we needed to show a realistic yet significant workload being put through the Vblock, in terms of the commonly understood SAP workload metrics such as number of dialog steps and number of updates to the database. We also needed to show the significant data volumes inserted and the large amount of SAP HANA logs created and replicated between the Deloitte datacenter in Suwanee, GA, and the EMC datacenter in Durham, NC.

Deloitte's SAP functional experts developed actual SAP business logic in the form of a series of SAP transactions, and Worksoft was asked to scale those business logic scripts into thousands of SAP concurrent active users over the course of this test run. That workload was further augmented by large and resource-intensive MRP batch jobs to create the equivalent of a period-end closing, in terms of data volume and SAP activities.

Object	SAP Transaction Code	Data Volumes Implications
Material Master	MM01	10,000 Material Masters
Customer Master	XD01	41,000 Customer Masters
Batch Master	MSC1n	36,000 Batches
Inventory Load	MIGO	58,000 line items
Planned Order	MD11	896 Planned Orders
Purchase Order	ME21	448 Purchase Orders
Material Master	MRP Batch Jobs: • Guarantees material availability • Monitors stocks & creates automatic procurement proposals • Calculates order quantities with stocks, on-order status, & reservations • Calculates commit dates with lead times and procurement times	These are Batch Jobs with normal run times around 4 hours on Oracle. With virtualized SAP HANA on Vblock these Batch Jobs took 14 minutes to run.
Logs directory	SAP HANA logs generated & replicated by EMC RecoverPoint	18GB=144GB/day— (Write rate of 700 IOPS & 20Mbps with 3.5 compression ratio; RPO lag between 3-to-5 seconds & 160MB at peak)

Figure 2. Summary of workload created for the Test Load Run

This test load run was managed by Deloitte in conjunction with Worksoft. Deloitte populated the Material Master file with information on all materials that a company would procure or produce, store, and sell to allow for retrieval of all material-specific data.

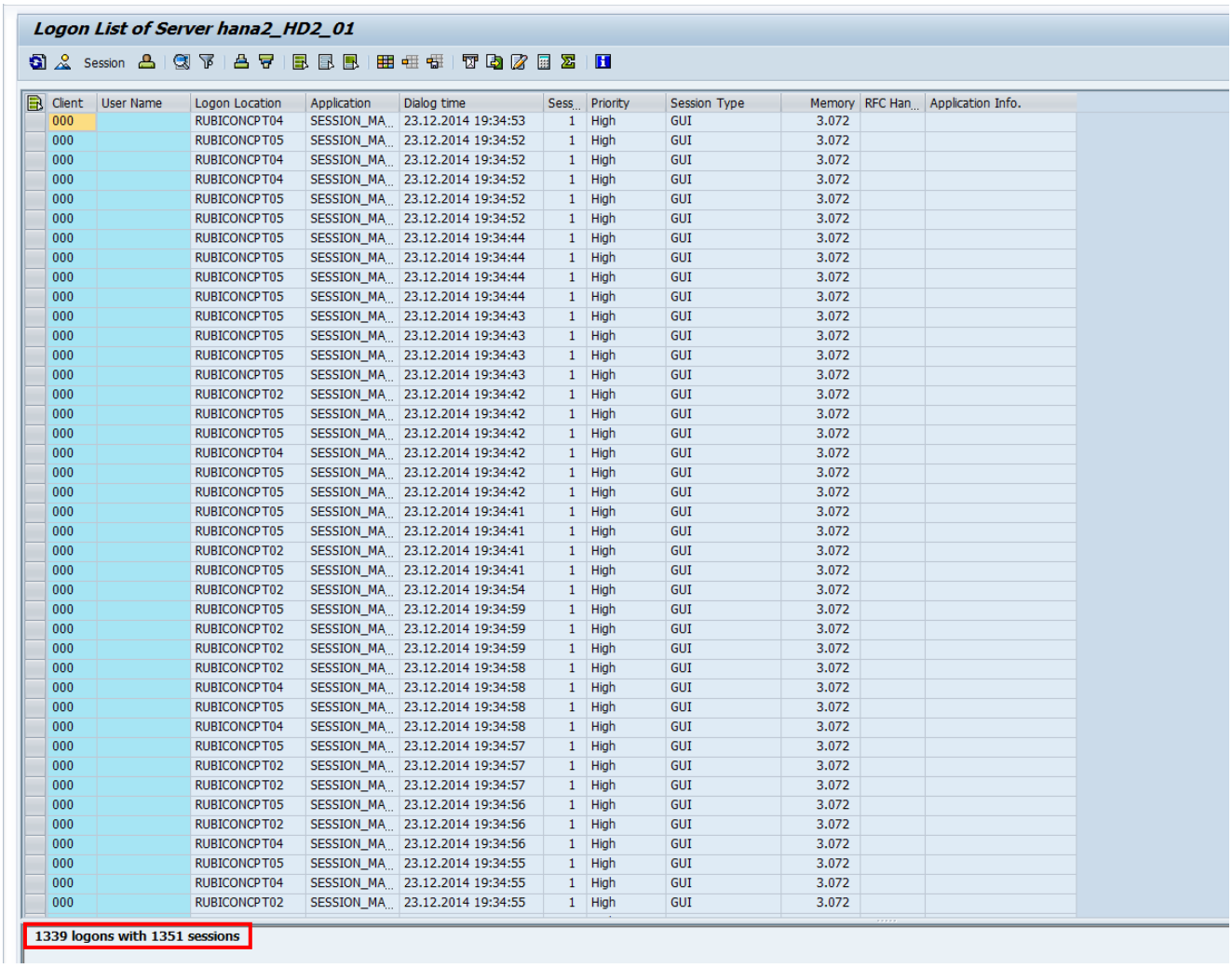
The Customer Master file, which is a record containing customer information for doing business with that customer, was then populated. Deloitte also populated the Batch Master file which contained a quantity of certain materials or products.

Worksoft scaled the business logic developed by Deloitte for Planned Order and Purchase Order by having SAP dialog user's login to the SAP GUI to execute transactions MD11 and ME21 with an aggressive think time of 5 seconds between transactions.

By way of clarification, a 5 second think time is very aggressive compared to a normal think time of 30 seconds on average in the real world. In fact, the test scenario was processing even more workload per hour than would be typical in real customer settings.

Halfway into the test iteration, Worksoft identified that the CPT Agent machines were being highly utilized (CPU), so the Deloitte Basis team doubled the CPU capacity of the Agent machines while the test was executing.

This action not only resolved the CPU utilization problem and helped alleviate the CPT errors that had appeared during the test, but resulted in an even higher actual SAP users count as reported by the SAP GUI (transaction AL08). Our goal was for at least 1,000 users to be logged into the SAP ERP on HANA system and we ended up with 2,026 users.



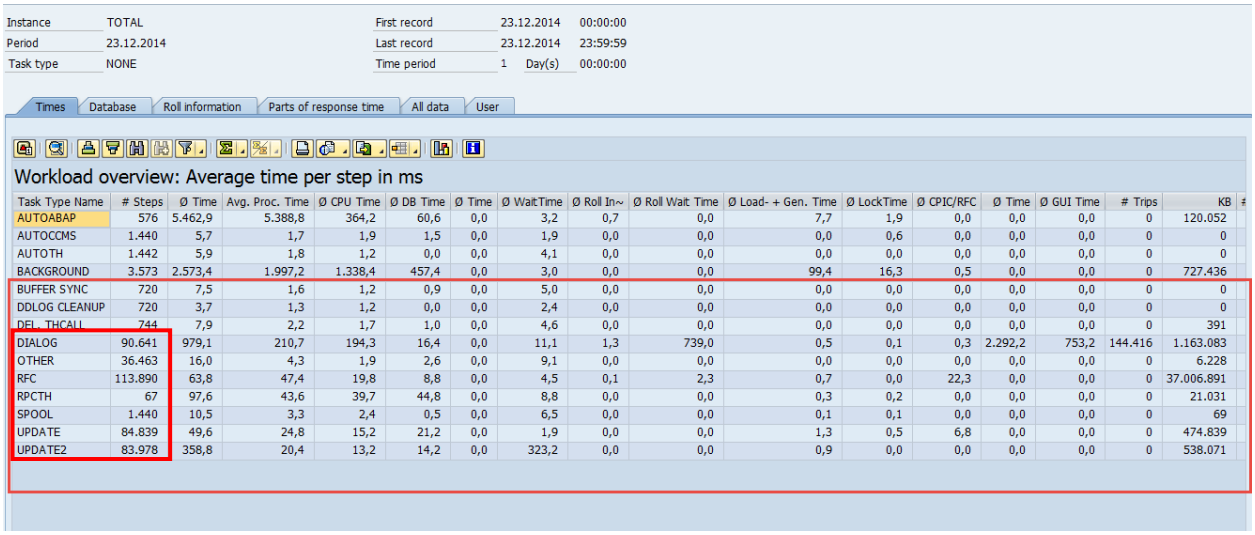
Client	User Name	Logon Location	Application	Dialog time	Sess...	Priority	Session Type	Memory	RFC Han...	Application Info.
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:53	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:52	1	High	GUI	3.072		
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:52	1	High	GUI	3.072		
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:52	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:52	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:52	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:44	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:44	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:44	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:44	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:43	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:43	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:43	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:43	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:42	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:42	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:42	1	High	GUI	3.072		
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:42	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:42	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:42	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:41	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:41	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:41	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:41	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:54	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:59	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:59	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:59	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:58	1	High	GUI	3.072		
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:58	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:58	1	High	GUI	3.072		
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:58	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:57	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:57	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:57	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:56	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:56	1	High	GUI	3.072		
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:56	1	High	GUI	3.072		
000		RUBICONCPT05	SESSION_MA...	23.12.2014 19:34:55	1	High	GUI	3.072		
000		RUBICONCPT04	SESSION_MA...	23.12.2014 19:34:55	1	High	GUI	3.072		
000		RUBICONCPT02	SESSION_MA...	23.12.2014 19:34:55	1	High	GUI	3.072		

Figure 3: High Number of Logons & User Sessions, and climbing to 2,026 users

MRP Batch jobs were then run by Deloitte to prove that these massive batch jobs which consume significant amounts of system resources can be run in Production on virtualized SAP HANA "appliances" without exceeding any KPIs established for this test environment.

To summarize, this real-world Production workload delivered:

- 2,026 concurrent dialog users
- Over 100,000 business documents created and updated
- 98,000 dialog steps over a 2 hour run, representing 784,000 dialog steps per day
- 85,000 Updates over 2 hours, representing 680,000 Updates per day
- 2 MRP jobs executed with each run lasting 14 minutes and 30 seconds
- 48,800 Planned Orders created
- 163,200 Dependent Requirements created
- Generating 18GB of SAP HANA logs over 2 hours, representing 144GB logs per day



Instance	TOTAL		First record	23.12.2014	00:00:00
Period	23.12.2014		Last record	23.12.2014	23:59:59
Task type	NONE		Time period	1 Day(s)	00:00:00

Times | Database | Roll information | Parts of response time | All data | User

Workload overview: Average time per step in ms

Task Type Name	# Steps	Ø Time	Avg. Proc. Time	Ø CPU Time	Ø DB Time	Ø Time	Ø WaitTime	Ø Roll In~	Ø Roll Wait Time	Ø Load- + Gen. Time	Ø LockTime	Ø CPIC/RFC	Ø Time	Ø GUI Time	# Trips	KB
AUTOABAP	576	5.462,9	5.388,8	364,2	60,6	0,0	3,2	0,7	0,0	7,7	1,9	0,0	0,0	0,0	0	120.052
AUTOCCMS	1.440	5,7	1,7	1,9	1,5	0,0	1,9	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0	0
AUTOTH	1.442	5,9	1,8	1,2	0,0	0,0	4,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	0
BACKGROUND	3.573	2.573,4	1.997,2	1.338,4	457,4	0,0	3,0	0,0	0,0	99,4	16,3	0,5	0,0	0,0	0	727.436
BUFFER SYNC	720	7,5	1,6	1,2	0,9	0,0	5,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	0
DDLOG CLEANUP	720	3,7	1,3	1,2	0,0	0,0	2,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	0
DEL_THCALL	744	7,9	2,2	1,7	1,0	0,0	4,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	391
DIALOG	90.641	979,1	210,7	194,3	16,4	0,0	11,1	1,3	739,0	0,5	0,1	0,3	2.292,2	753,2	144.416	1.163.083
OTHER	36.463	16,0	4,3	1,9	2,6	0,0	9,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	6.228
RFC	113.890	63,8	47,4	19,8	8,8	0,0	4,5	0,1	2,3	0,7	0,0	22,3	0,0	0,0	0	37.006.891
RPCTH	67	97,6	43,6	39,7	44,8	0,0	8,8	0,0	0,0	0,3	0,2	0,0	0,0	0,0	0	21.031
SPOOL	1.440	10,5	3,3	2,4	0,5	0,0	6,5	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0	69
UPDATE	84.839	49,6	24,8	15,2	21,2	0,0	1,9	0,0	0,0	1,3	0,5	6,8	0,0	0,0	0	474.839
UPDATE2	83.978	358,8	20,4	13,2	14,2	0,0	323,2	0,0	0,0	0,9	0,0	0,0	0,0	0,0	0	538.071

Figure 4: High Number of Dialog Steps & Updates, and still increasing

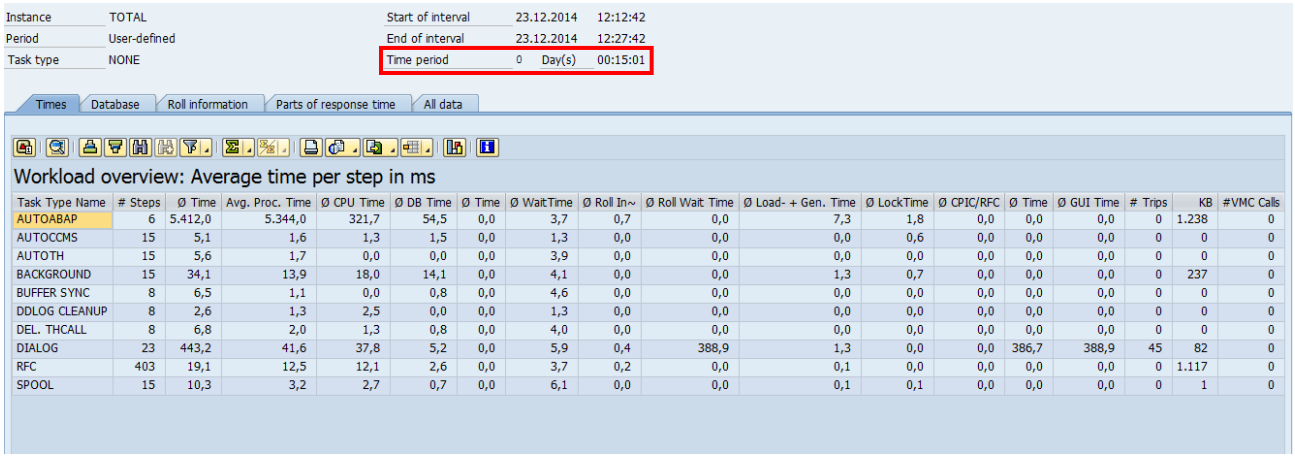
These dramatic results from this test load run further proved that we can be confident about the stability and scalability of running SAP HANA on Vblock in Production by showing:

- The delta between physical and virtual appliances remained constant throughout the entire 2 hour test
- Activity level for the computing (CPU & RAM) and networking tiers in the SAP Solution Manager and SAP HANA with real-world Production workloads ran at 60% of its capacity during peak workload
- Activity level for the storage and SAN networking tiers and the ability of EMC RecoverPoint appliances to replicate data over long distance operated with an RPO lag time between 3-to-5 seconds and 160MB/sec at peak
- Disk latency for the logs volume as well as on throughput for data volumes never exceeded any of the established KPI thresholds
- Disk consumption inside data volumes during peak loads triggered a red alert in EMC ViPR SRM because datastore RUBICON_ERP_HDB_DATA was 93% full thus exceeding the predefined red KPI threshold of 90% - the admin team quickly took corrective action and avoided any problems
- Disk consumption inside the logs datastore during peak loads triggered a red alert in EMC ViPR SRM because the datastore RUBICON_ERP_HDB_LOG was 98% full thus exceeding the predefined red KPI threshold of 90% - the admin team again corrected the situation and avoided any problems

- Database latency by measuring log writing capabilities while there is load generated against the system never exceeded any of the established KPI thresholds
- Log writing capabilities and if queuing slows down SAP HANA log writing while executing SQL commands, all remained constant throughout testing

- Monitoring tools were smart enough to enable system admins and business line managers to predict potential future problems. In fact, we were able to predict with 95% probability when we would run out of trace disk space if no corrective action was taken.

Stability & Scalability Proof Point: Note that during the entire test run, the SAP System response time was under 1 second as mandated by SAP.



Instance	TOTAL		Start of interval	23.12.2014	12:12:42
Period	User-defined		End of interval	23.12.2014	12:27:42
Task type	NONE		Time period	0 Day(s)	00:15:01

Times | Database | Roll information | Parts of response time | All data

Workload overview: Average time per step in ms

Task Type Name	# Steps	Ø Time	Avg. Proc. Time	Ø CPU Time	Ø DB Time	Ø Time	Ø WaitTime	Ø Roll In~	Ø Roll Wait Time	Ø Load- + Gen. Time	Ø LockTime	Ø CPIC/RFC	Ø Time	Ø GUI Time	# Trips	KB	#VMC Calls
AUTOABAP	6	5.412,0	5.344,0	321,7	54,5	0,0	3,7	0,7	0,0	7,3	1,8	0,0	0,0	0,0	0	1.238	0
AUTOCCMS	15	5,1	1,6	1,3	1,5	0,0	1,3	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0	0	0
AUTOTH	15	5,6	1,7	0,0	0,0	0,0	3,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	0	0
BACKGROUND	15	34,1	13,9	18,0	14,1	0,0	4,1	0,0	0,0	1,3	0,7	0,0	0,0	0,0	0	237	0
BUFFER SYNC	8	6,5	1,1	0,0	0,8	0,0	4,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	0	0
DDLOG CLEANUP	8	2,6	1,3	2,5	0,0	0,0	1,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	0	0
DEL. THCALL	8	6,8	2,0	1,3	0,8	0,0	4,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0	0	0
DIALOG	23	443,2	41,6	37,8	5,2	0,0	5,9	0,4	388,9	1,3	0,0	0,0	386,7	388,9	45	82	0
RFC	403	19,1	12,5	12,1	2,6	0,0	3,7	0,2	0,0	0,1	0,0	0,0	0,0	0,0	0	1.117	0
SPOOL	15	10,3	3,2	2,7	0,7	0,0	6,1	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0	1	0

Figure 5. SAP System Response Time was under 1 second as mandated by SAP

Benefits of running the virtualized SAP HANA "appliance" on VCE Vblock

In this white paper, we provided evidence that virtualized SAP HANA running on the Vblock can take on a Production-level workload while showing the same level of stability and performance of a HANA physical appliance while adding scalability, additional flexibility for resources utilization, and long distance disaster recovery – these additional features are either not possible or quite difficult to implement on bare metal physical appliances.

For Project RUBICON, the contribution of the Vblock is significant to the success of the project, and the table below shows the key reasons why it is the ideal platform to run virtualized SAP HANA in Production:

Attribute	RUBICON validation	Technology or tools involved	Importance to SAP customer
Optimize system utilization for lower TCO & IT complexity	Virtualized SAP HANA was one of several VMs & applications running on the Vblock	VMware vCloud Suite, VCE Release Certification Matrix (RCM)	Very high
Stability of the SAP HANA environment	1. Delta between physical & virtual constant under load 2. No alert on compute & network tiers 3. Prompt alert on space utilization 4. Tools able to predict future failure	1. Blue Medora 2. Cisco IA for SAP 3. EMC ViPR SRM 4. VCE architecture of multiple redundant components	Very high
Performance & scalability of the SAP HANA environment	1. CPU consumption never passed 60% 2. Computing resources (vCPU & vRAM) can be added without downtime	1. Blue Medora 2. VMware vCloud Suite virtualization 3. VCE architecture 4. Cisco IA for SAP	Very high
Increased uptime & availability	1.Ability to resist hardware failure 2. Ability to move workload to other servers	1. VMware HA 2. VMware vMotion	Very high
Better manageability	1. Every critical aspect monitored & alerted on 2. Ease of operation across the entire stack 3. Simple deployment of VM through cloning	1. Blue Medora 2. Cisco IA for SAP 3. EMC ViPR SRM 4. VMware vCenter & vRealize Operations 5. VCE Vision Intelligent Operations	High
Long distance disaster recovery	1. Simple to execute long distance DR of virtualized HANA 2. Effortless replication of large amount of HANA logs	1. VMware Site Recovery Manager (SRM) 2. EMC RecoverPoint 3. VMware vCenter & vCloud Suite	Very high
Cloud readiness, to allow SAP customer to easily move SAP HANA workload from on-premise to off-premise and back	1.Ability to provision & monitor remote CSF endpoints 2. Simplified & orderly relocation of HANA workload from one site to another	1. VMware vCloud Suite & vRealize 2. VMware SRM 3. EMC RecoverPoint	High

Figure 6. Key Reasons Vblock is the platform for virtualized SAP Hana in Production

This POC reaffirmed that SAP customers should run their virtualized SAP HANA on a VCE Vblock, which incorporates best-of-breed compute, network and storage components from Cisco and EMC. Think of it as a complete datacenter in a rack so the SAP customers can experience reduced downtime because every component has been thoroughly tested and integrated at the factory. Vblock customers deal with a single point of contact for all platform issues, no matter if they turn out to be compute, storage, or network-related.

It is important to note that any SAP customer running virtualized SAP HANA (as opposed to on a bare metal appliance) does so under TDI mode – TDI is the acronym for SAP's Tailored Datacenter Integration program that allows HANA customers to leverage existing infrastructure components for their HANA environment. Therefore, any customer running virtualized SAP HANA in Production on a Vblock will need to do so in TDI mode.

Being that it is considered a datacenter on a rack, the Vblock is not often dedicated to running a single application, as would be the case of a SAP HANA bare metal appliance. On the Vblock, customers can use VMware's virtualization solutions to divide resources to service multiple applications thereby reducing the total cost of ownership and IT complexity while increasing availability and scalability.

The entire virtualized SAP HANA landscape (Production, Dev, QA, UAT, etc.) easily works alongside the numerous enterprise applications on a Vblock – this fact is in stark contrast to the common situation in which customers running a productive HANA database never want to run other applications next to it in order to optimize system utilization, due to performance concerns. It is simple and practical to add more resources should one HANA database need more computing power than can be provided by a single server and numerous VMware technologies such as VMware HA and vMotion allow for the reduction of planned and unplanned downtime, such as in the case of server maintenance.

Finally, cloud readiness means that SAP customers are in command of their entire SAP resources pool working with their hosting providers. It is much easier to move workload running on a virtual machine from one cloud to the other than starting to install the operating system and the application on top of it from scratch, and then having to do backup/restore for the database. Virtual machines can be migrated from the customer's on-premise to their cloud service provider off-premise datacenter and back, easily and simply with a simple push of a button.

ROLE OF TOOLS IN VALIDATING STABILITY & PERFORMANCE

Blue Medora vCenter Operations Management Pack for SAP HANA

Blue Medora's vCenter Operations Management Pack for SAP, in conjunction with VMware vRealize Operations, confirmed the Production-level SAP HANA "appliance" was stable and scalable on this virtual infrastructure.

VMware vRealize Suite is the VMware flagship management solution for software defined datacenter (SDDC) and hybrid clouds. For this Proof of Concept, vRealize Operations was used with Blue Medora's vCenter Operations Management Pack for SAP to provide end-to-end monitoring capabilities during the actual test run on 12/23/14, to anticipate future bottlenecks through pre-warning alerts and reporting capabilities.

During this POC testing, the Blue Medora vCenter Operations Management Pack for SAP and the Deloitte Admin team were able to proactively address the following:

- **Stability Proof Point:** Capturing the fact that the delta between the physical layer and the virtualized layer of both CPU and memory remained constant under heavy workload (both physical and virtual CPU utilization stayed below 60%)
- **Scalability Proof Point:** Determining that the significant headroom would provide system administrators and business line managers with an opportunity to discuss right sizing and consolidation, on par with physical bare metal appliances
- **Stability Proof Point:** Providing an accurate prediction of a failure in trace disk space while providing useful reports validating that KPIs and SLAs are being met
- **Stability & Scalability Proof Point:** High trace disk utilization showed that once the backup issue was resolved, this system can run a long time without any further work needed. It also can take a lot more load on that disk, which addresses both scalability and capacity
- **Stability & Scalability Proof Point:** Traffic could be increased by 70% without user impact. When an SAP customer has spare capacity, they can either leave that free to scale up their system or use that capacity to add an instance from a different system. The key here is that Blue Medora enables them to know and to make informed decisions

Stability Proof Point: By showing that the delta was constant between physical and virtual CPU utilization throughout our testing, Figure 7 demonstrates the stability of virtualized SAP HANA on Vblock even under extreme workloads. Figure 8 shows that the delta for memory utilization between physical and virtual was also constant under heavy load.

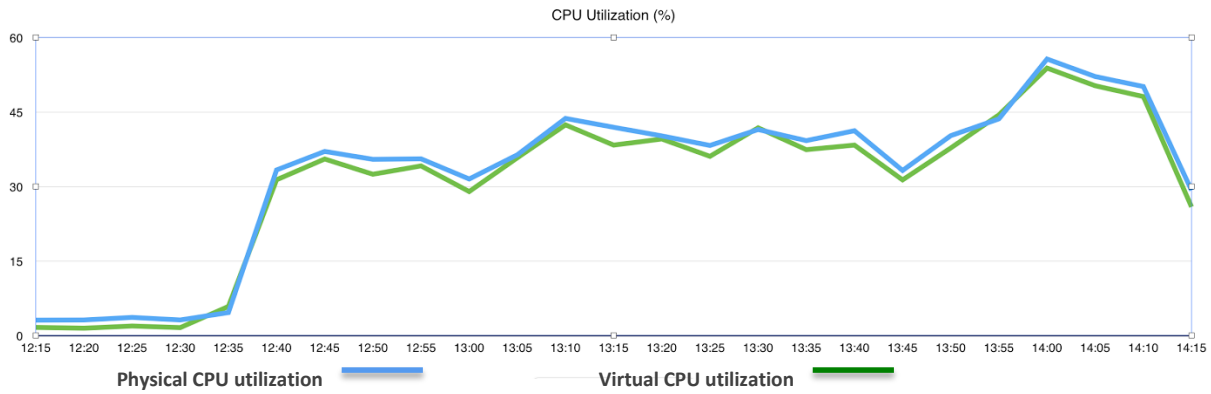


Figure 7. Blue Medora shows constant delta in CPU utilization under heavy load

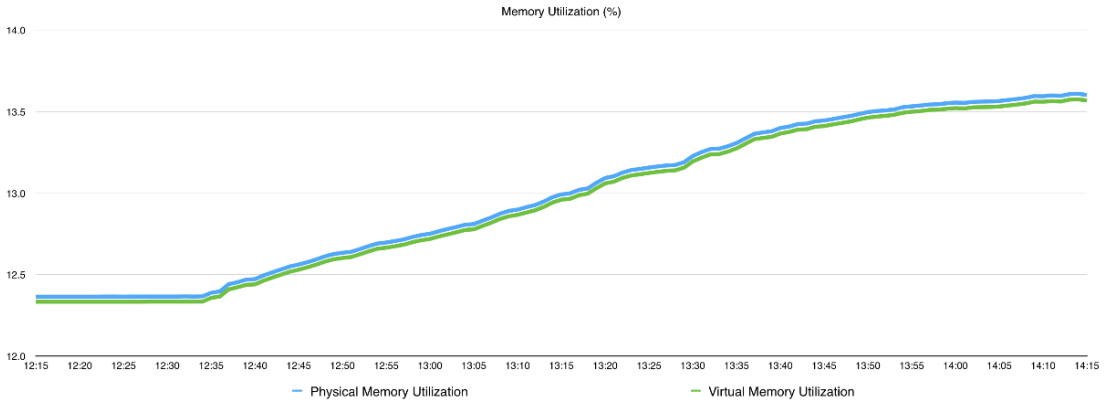


Figure 8. Blue Medora shows constant delta in Memory Utilization under heavy load

Performance & Scalability Proof Point: Figure 7 also shows the significant amount of head room (60% CPU utilization at peak) could allow system admins and business line decision makers to have the OPPORTUNITY to discuss right sizing and consolidation, and it is another proof point that such flexibility and scalability are difficult to achieve with bare metal physical system deployments. Since the SAP HANA environment is virtualized, it is simple to make the kind of changes to the virtual machines that would maximize flexibility and scalability without impacting Production.

Prediction of potential future problems: Preventing a major issue or possible failure is something that every customer wishes they could do. For this POC, Blue Medora used its capable forecasting ability to measure key potential problem areas such as trace disk utilization for backup jobs. Even though the POC test environment proved stable under heavy workload during the entire test run, Blue Medora was able to determine that the backup directory /dev/sdb1 was being filled up to 77% usage, as shown in Figure 9.

Filesystem	Size	Used	Available	Use %	Mounted on
/dev/sda2	196G	54G	132G	29%	/
udev	253G	112G	253G	1%	/dev
temfs	379G	940G	379G	1%	/dev/shm
/dev/sdb1	**504G**	**368G**	**112G**	**77%**	**/hana/shared**
/dev/sdc1	1.0T	128G	896G	13%	/hana/data
/dev/sdd1	504G	20G	459G	5%	/hana/log

Figure 9. Showing /dev/sdb1 backup directory at the 77% usage threshold

Through its forecasting capability, Blue Medora and VMware vRealize Operations successfully predicted that the backup directory /dev/sdb1 would be full in the not too distant future as shown in Figure 8 and could cause a serious problem if not addressed. When Blue Medora notified Deloitte of the potential to run out of disk space, Deloitte was able to take corrective action by adding more storage capacity which avoided any potential problems with system stability during this testing.

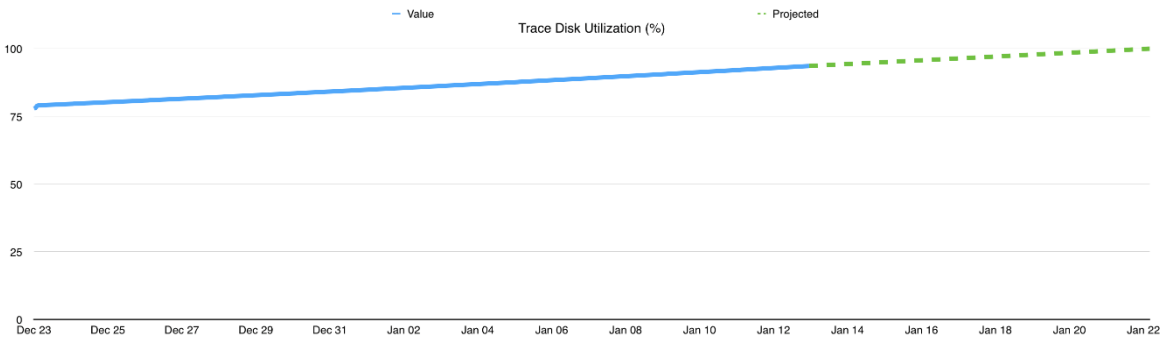


Figure 10. Predicting Trace Disk Utilization directory will be at 100% full

In Figure 10 above, the blue sloped line represents the percent of disk that was full. The green dotted line represents the date that Blue Medora and vCenter Operations Manager predicted the disk to be completely full, hypothetically on January 22.

By identifying this potential problem with backups before it became an issue, the Deloitte Admin team was able to correct it without incident.

For more on the capabilities of Blue Medora, please refer to page 43 of Appendix 5.

Cisco IA for SAP

Cisco Intelligent Automation for SAP (IA for SAP and also known as SAP IT Process Automation by Cisco) is the software platform on which to standardize, unify, and automate best practices for IT processes in complex, heterogeneous environments. Cisco's IA for SAP helps companies shift from a siloed, manual management process to process automation through its outstanding operational performance analysis across datacenters.

During the Dry Run on 12/17/2014, and with some additional contributions during the Test Run on 12/23/2014, the following actions were taken with Cisco's IA for SAP:

- **Enabled adjustments** when bottlenecks were discovered with SAP Basis layer
- **Suggested remedial actions** when SAP issues or errors were discovered
- **Provided useful reports** to validate that KPIs & SLAs were being met

For this POC, Cisco's IA for SAP was configured to monitor the ECC application, the HANA database, as well as the Suse Linux Operating System and automatically alert system administrators if any of their Key Performance Indicator (KPI) thresholds were exceeded.

Stability & Scalability Proof Point: During the performance test to tune the ERP on HANA system, IA for SAP was the first system to identify pending issues when the app server hit the maximum allowed number of concurrent users. At that point, the Basis administrator was alerted to adjust the configuration parameters allowing for a higher concurrent user count.

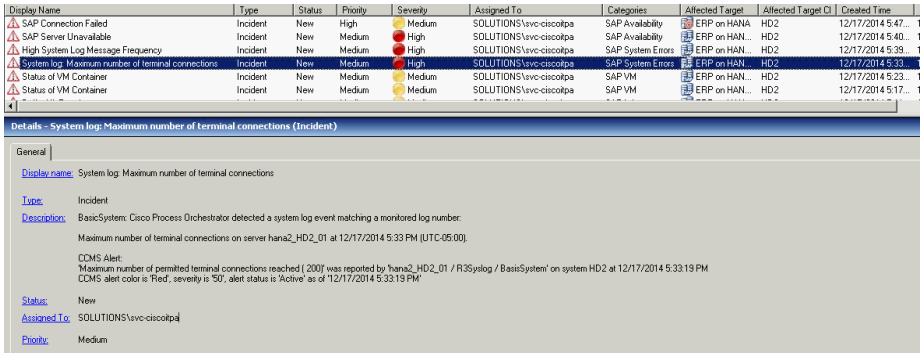


Figure 11. System Log for maximum number of terminal connections

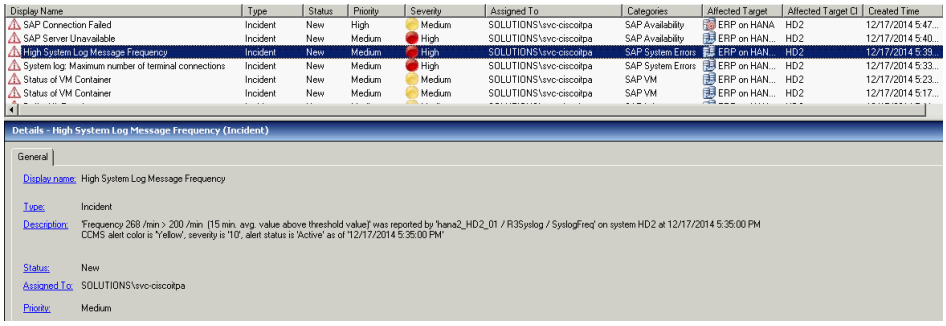


Figure 12. High System Log Message Frequency during Dry Run

During the Dry Run on December 17th, the alert above indicated high syslog message rates. Investigating these syslog messages identified the need to tune memory parameters on the virtualized SAP HANA application server running ECC. Having early warnings such as this, allowed the Deloitte Basis team to implement corrective actions to prevent issues that could potentially cause system outages.

During the 2 hour duration of the load testing, none of the other KPI's identified were exceeded and no alerts were generated which further proved that virtualized SAP HANA running ECC can handle these workloads.

Beyond simple database statistical monitoring, IA for SAP can perform complex analysis to help determine why an SAP system is not performing as well as expected. Below is a screenshot showing some of the complex database analysis that is available through Cisco's IA for SAP.

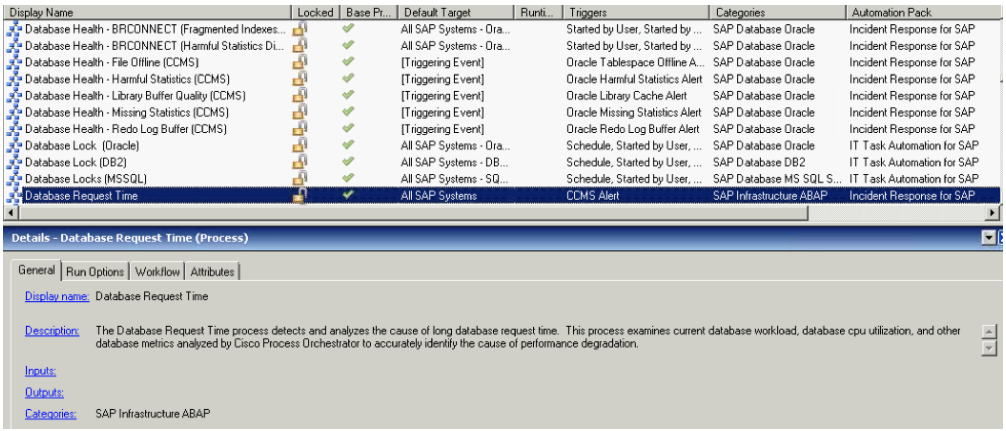


Figure 13. Complex Database Analysis available with IA for SAP

Stability Proof Point: During the final test run on 12/23/2014 and near peak user load, IA for SAP alerted that the SAP HANA response time exceeded the warning threshold. The cause was identified as VM live migrations going on in the background to balance the load on the VMware servers. The other warnings in this screenshot were for the IA for SAP system itself. Based on these early warnings from IA for SAP, the Deloitte Basis team was able to take corrective action by balancing the load and avoiding any major thresholds from being exceeded.

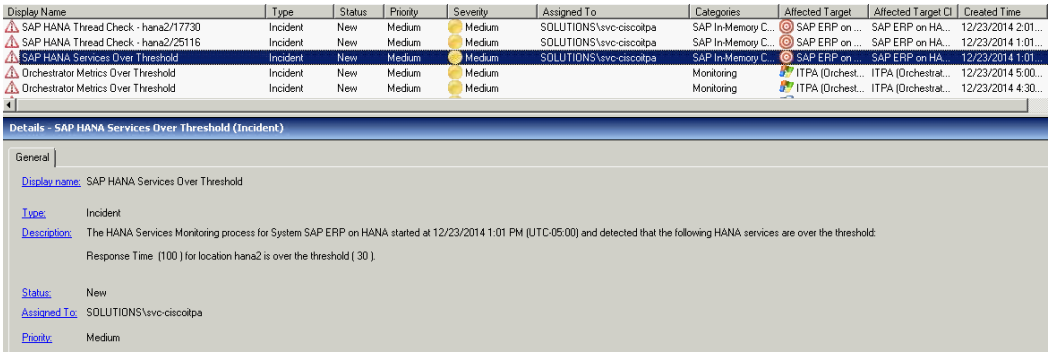


Figure 14. Alert of SAP HANA Response Time Warning threshold exceeded

Cisco IA for SAP can not only catch a problem and manually suggest a remedial course of action, but if set up in advance by the system administrator, IA for SAP can automatically implement a remedial course of action while notifying the system admin of those actions.

While automated remediation was not implemented as part of this testing, IA for SAP can be configured to automatically resolve common issues. Uncommon issues or issues where manual intervention is desired or required can trigger a Knowledge Base article to be referenced in the alert to guide the system administrator in resolving that issue.

For more on the capabilities of Cisco IA for SAP, please refer to the Appendix 5, page 44.

EMC ViPR SRM

Consistently meeting the availability, performance, and data protection requirements of a mission-critical application like SAP HANA means IT must implement a solution to proactively identify issues that could impact service levels. EMC ViPR SRM is a comprehensive monitoring and reporting solution that enables storage teams to visualize, analyze, and optimize storage resources for SAP applications in physical and virtual environments. EMC ViPR SRM offers detailed end-to-end visualization of data path dependencies while simplifying monitoring, trouble-shooting, and analysis of the performance, health, configuration, and capacity of storage infrastructures for virtualized SAP HANA "appliances" on Vblock.

EMC ViPR SRM also offers health, capacity, and performance monitoring and reporting for EMC RecoverPoint. Key Performance Indicators that can be tracked include time lag and write lag by consistency group, application traffic, compression ratios and much more. Analyzing these KPIs helps storage teams assess if recover point objectives are being met and if the infrastructure has sufficient capacity to meet current and future requirements.

During this POC, EMC ViPR SRM delivered complete monitoring of the storage infrastructure including detailed reporting on CPU, memory, and disk performance that validated the environment's stability and scalability. This included:

- **Infrastructure Performance monitoring of LUN response time, server port latency, and port IOPS across the data path** enabling storage and infrastructure management to quickly spot bottlenecks
- **Path Level Performance on host response times, throughput, and IOPS** analyzing the performance of every transaction and reporting on response times, throughput, and IOPS to ensure service levels are being met even for short bursts that occur during peak demand periods. It also included monitoring the health of each data path to identify failed data paths
- **SAN Port traffic and utilization** proactively monitoring the health and utilization of the SAN switch environment to identify saturated ports to proactively detect potential bottlenecks
- **Storage array processor utilization, queue length, service time, & cache dirty pages** offering detailed array performance metrics to identify issues from front-end port utilization to queue lengths to cache dirty pages
- **Workload distribution for virtual guests with highest CPU workloads** allowing infrastructure teams to identify competing workloads to more effectively balance that load across the storage infrastructure
- **Virtual Host Reporting** by analyzing storage performance from a virtual or physical host perspective, storage admins can quickly assess the impact of storage at the host level and drill down into the data path to troubleshoot performance and availability

Stability Proof Point: By using the full capabilities of EMC ViPR SRM, this team was able to show that none of the preset alert thresholds listed above had been exceeded during the 2 hour testing of this virtualized SAP HANA appliance (including LUN response time, server port latency, and port IOPS).

EMC ViPR SRM provides the tools that storage and infrastructure management teams can use to monitor and report on their storage infrastructure. In this role, ViPR SRM can determine how storage is performing from the host perspective and enables the user to drill down and identify issues throughout the data path. It can also monitor a virtual, shared storage infrastructure and identify impacted applications to avoid SLAs being missed. These monitoring capabilities are critical to recognizing the stability of virtualized SAP HANA running on Vblock while reinforcing its outstanding performance and scalability.

EMC ViPR SRM can also collect data from PowerPath's position in the data path to analyze every transaction and report on maximum host device latency (as an SLA measurement) and maximum write IOPs and throughput (as a measurement of workload). By analyzing these maximum values, EMC ViPR SRM was able to identify the worst case performance sustained during peak workloads.

Example of Stability & Performance: Deloitte simulated a typical SAP workload with 2026 concurrent SAP users. The system response times had an RPO lag of 3-to-5 seconds and 160MB/sec at peak with a compression ratio of 3.5 and that is how a real-world scenario would most likely look. However, that storage load did not even come close to creating a bottleneck.

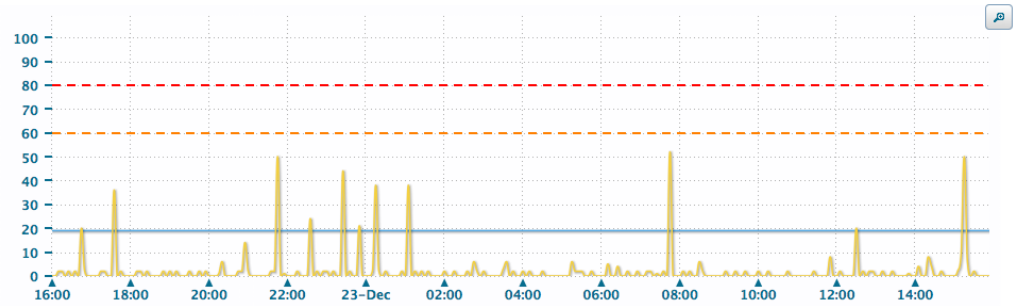


Figure 15. SAN Switch CPUs shown with two warning thresholds

Scalability Proof Point: With the SAN Switch CPUs shown in Figure 15, two thresholds have been set with a "warning" threshold (orange) and a "critical" threshold (red). And this graphic shows that neither threshold was ever reached.

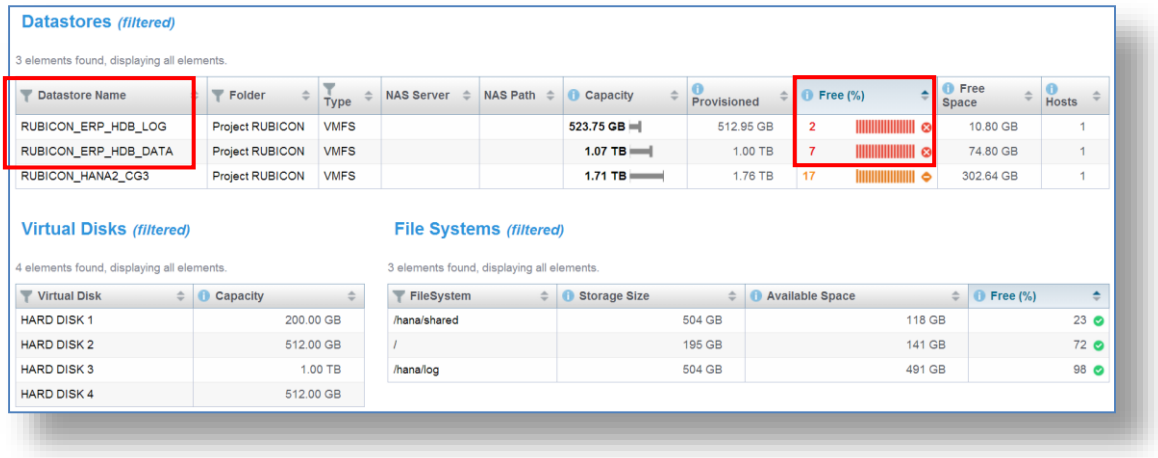


Figure 16. RUBICON_ERP_HDB_LOG datastore showing 2% free space

Stability Proof Point: Figure 16 shows 2% free space alert on the datastore for RUBICON_ERP_HDB_LOG and also shows 7% free space alert on the datastore for RUBICON_ERP_HDB_DATA which identified two potential problems that were avoided. These are important KPIs that EMC ViPR SRM caught when thresholds exceeded 90%.

Below Figure 17 shows Storage Server Processor utilization during POC testing.

Figure 17. Storage Server Processor Utilization

Scalability Proof Point: Figure 17 shows that Storage Processor utilization does not impose a bottleneck onto this system. Note that there are two warning thresholds, yellow for major and red for critical and neither warning threshold was reached during testing.

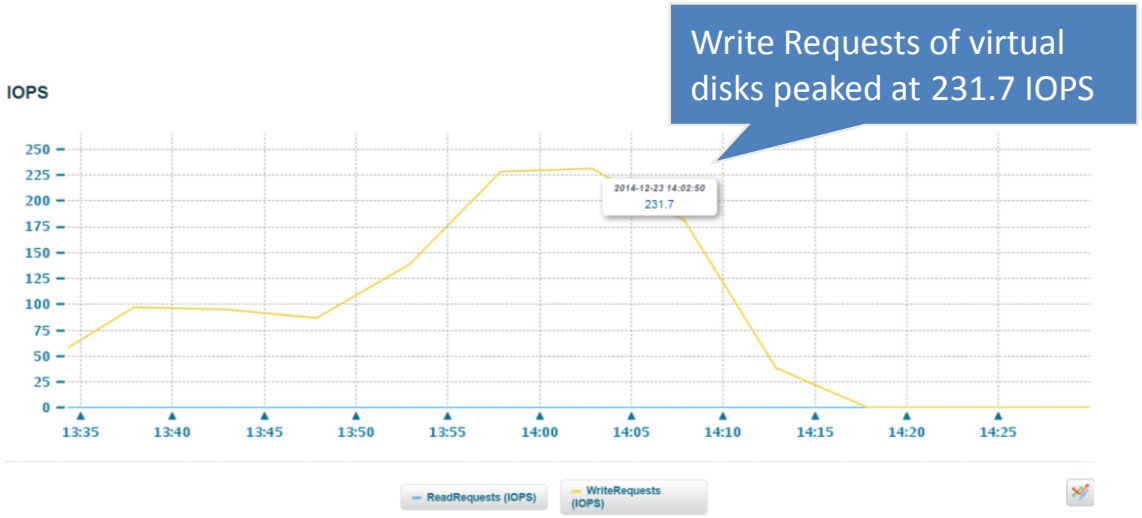


Figure 18. Monitoring the Host System for KPI thresholds

Figure 18 shows that the host system responsible for writing the data logs for the virtualized SAP HANA environment was monitored during the POC testing and the workload reached a maximum of 231.7 IOPS.

Stability Proof Point: The test ran from 12pm until 2pm EST on December 23 and proved overall system reliability. Figure 18 above also reflects those results in the amount of I/O per second shown, significantly below the capacity of the VNX array in this Vblock. In addition, Figure 19 shows that during this period, the write latency as measured from the host perspective never exceeded 5.04 milliseconds.

Figure 19. Write Requests & Write Latency results from SLA Reporting

EMC ViPR SRM provides monitoring across the data path from storage over to the SAN switches and up into VMware. This POC proved that SAP customers can monitor their entire platform with ViPR SRM, so that storage administrators can better understand their performance metrics and measure fulfillment of SLAs. These capabilities also help to identify performance bottlenecks and SAN related issues.

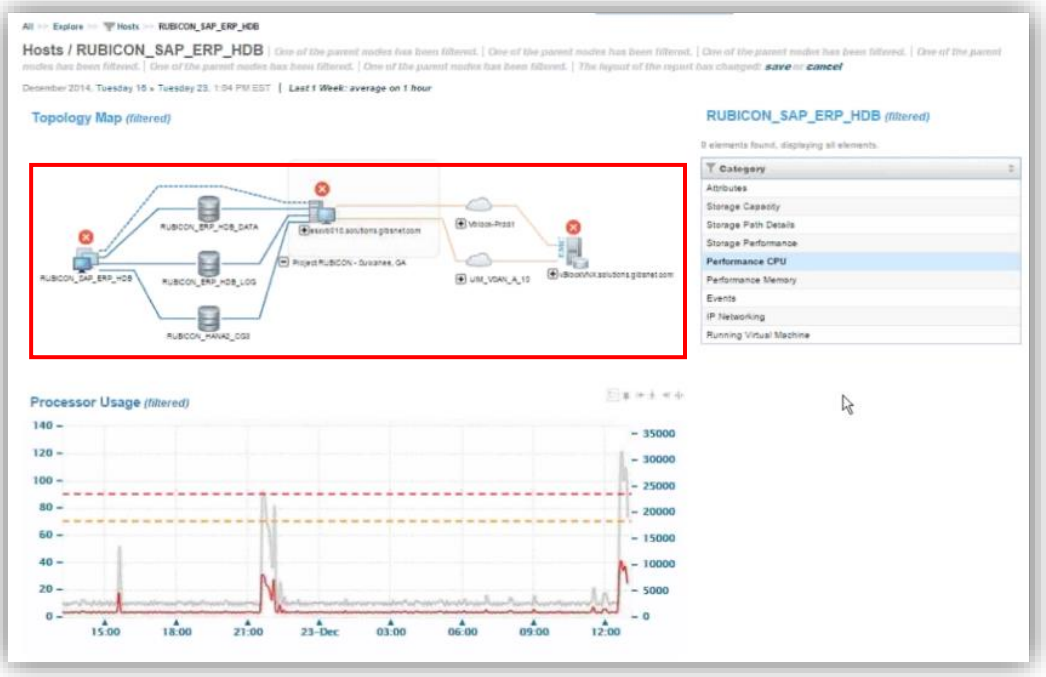


Figure 20. Relationship & Topology views from EMC ViPR SRM

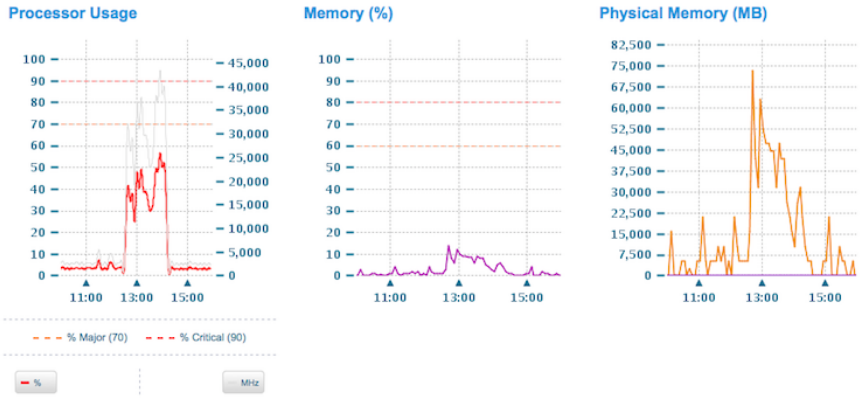


Figure 21. Utilization Results for Processor & Memory

The graphic above demonstrates that EMC ViPR SRM can help storage teams quickly analyze Key Performance Indicators to identify bottlenecks in the whole system from virtual host through to the storage array and across the replication infrastructure. Users can easily set custom thresholds to receive alerts when those thresholds are exceeded. EMC ViPR SRM keeps tabs on every aspect of the storage layer and the data path to predict problems which further enables system stability.

For more on the capabilities of EMC ViPR SRM, please refer to page 46 of Appendix 5.

Summary of Contributions of the Tools in Project RUBICON

The market leading monitoring tools from Blue Medora, Cisco, and EMC played critical roles in proving that the virtualized SAP HANA "appliance" on the VCE Vblock provides predictable performance and stability to operate in Production with the same assurances that previously could only be offered to customers using bare metal physical appliances.

The table below provides an overview of the contribution of the tools, Blue Medora vCenter Operations Management Pack for SAP HANA (Blue Medora for short), Cisco Intelligent Automation for SAP (Cisco IA for SAP for short) and EMC ViPR SRM.

This summary shows only the features of the tools which were ACTUALLY used in this POC, because these tools offer much more functionality and capability than listed in this table below.

For the full details on what each tool is capable of, please consult the Appendix or contact each of these tool vendors directly.

Functionality used in this POC	Blue Medora	Cisco IA for SAP	EMC ViPR SRM
Able to monitor SAP HANA specific activity, through purpose-built HANA extensions	✓	✓	
Able to monitor VMware virtual environment resources consumption	✓	✓	✓ As related to the storage tier
Able to monitor overall performance of VMware environment including headroom	✓	✓	✓ As related to the storage tier
Able to monitor level of physical resources consumption by VMware environment	✓	✓	✓ As related to the storage tier
Able to trigger alerts on monitored component based on specified thresholds	✓	✓	✓
Able to monitor storage tier at the VMDK datastore level	✓	✓	✓
Able to monitor all aspects of the storage tier including all data paths			✓
Able to monitor the performance of the EMC RecoverPoint appliances for remote replication			✓
Able to analyze activity patterns to predict possible future problems or failure	✓	✓	✓
Able to analyze SAP Basis problems and make suggested remedial steps		✓	
Able to analyze SAP Basis problems and take predefined & authorized remedial steps		✓	
Able to interface directly with the SAP Solution Manager		✓	
Able to provide robust reporting to document compliance to SLAs and KPIs	✓	✓	✓

Table 22: Summary of Features of the Tools ACTUALLY USED in Project RUBICON

Worksoft Certify Performance Test

Worksoft Certify Performance Test™ provides users with the ability to automatically execute virtual SAP user load tests to validate capacity and response times for the SAPGUI and Web portal. This consists of an SAP workload utility that is used to record actions (transactions) for the load test (as well as Web application transactions) containing an organized collection of test assets for stress and load testing, a Certify Performance Test (CPT) Agent Manager used to launch agents that execute SAP transactions, and Performance Database that is used as a repository for all the test assets.

For this POC, the goal was for Worksoft to help the POC team to demonstrate the following proof points:

- **Stability Proof Point: Initiated at least 1000 virtual users** logging into SAPGUI and performing activity, with a minimum of those 500 users running transaction MD11 (creating planned orders) and another 500 users running ME21 (creating purchase orders)
- **Stability Proof Point: Ran this test for 2 hours** with 5 CPT Agent machines being used for the test iteration. Each Agent machine had 4 SAPGUI users with CPT Agent processes running and each process handled 50 virtual users to scale up the business logic developed by Deloitte for the POC testing
- **Stability & Scalability Proof Point: Created 896 Planned Orders** (MD11) using the business logic developed by Deloitte to show how well virtualized SAP HANA performed during this testing
- **Stability & Scalability: Executed 448 Purchase Orders** (ME21) again using heavy workloads consistent with a Production environment to show true performance metrics and reinforce the stability and scalability of this virtualized SAP HANA infrastructure

Users logged into SAP at the rate of 1 user every 2 seconds and after each test iteration, users would log out of SAP and then back in again for the next iteration.

Think time between SAP Dialog Steps for the CPT virtual users was established at 5 seconds, which is very aggressive compared to normal think time of 30 seconds, so in effect, this points to the fact that even more work could be done under a more typical think time of 30 seconds or more.

Halfway into the test iteration, Worksoft identified that the CPT Agent machines were being highly utilized (CPU), so the Deloitte Basis team doubled the CPU capacity of the CPT Agent virtual machines while the test was executing. This action not only resolved the CPU utilization problem and helped alleviate the CPT errors that had appeared during the test but resulted in an even higher actual SAP users count as reported by the SAP GUI (transaction AL08). The goal was to have at least 1,000 users logged into the SAP ERP on HANA system to work and we ended up with 2,206 users.

Name	CPU Count	Memory Size
RUBICON_CPT_01	8	16384 MB
RUBICON_CPT_02	8	16384 MB
RUBICON_CPT_03	8	16384 MB
RUBICON_CPT_04	8	16384 MB
RUBICON_CPT_05	8	16384 MB
RUBICON_CPT_APP	4	16384 MB
RUBICON_CPT_DB	8	32768 MB
RUBICON_CPT_TPHC	2	4096 MB

Figure 23. Details of the Worksoft environment for scaling the workload

Without Worksoft, these real-world load tests could not have been performed with this level of activity volume to validate the stability and scalability of virtualized SAP HANA running on Vblock and should give customers the confidence to run their SAP HANA solutions on virtualized "appliances".

For more on the capabilities of Worksoft, refer to Appendix 5 on page 48.

Deloitte's Cloud ServiceFabric running in Hybrid Cloud Mode

Project RUBICON showcases how virtualized SAP HANA can work with Deloitte's Cloud ServiceFabric (CSF) in a hybrid cloud model by demonstrating how SAP customers can remotely provision CSF endpoints and initiate planned relocation workloads.

This POC documents the ease of deploying virtualized SAP HANA instances on-premise at the Deloitte datacenter in Suwanee, Georgia, as well as off-premise at the EMC datacenter in Durham, North Carolina, acting as a Cloud Service Provider.

VMware's Site Recovery Manager 5.8 was integrated directly with EMC RecoverPoint and existing Deloitte service management lifecycle workflows to show how SAP customers can quickly spin up an SAP HANA project and relocate to a remote location when they do not have the available resources to handle the workload. Then when physical resources are available on-premise, they can quickly move the SAP HANA application back without losing any data.

This approach also applies to impending natural disasters when organizations must quickly move their SAP applications from one datacenter in the path of a hurricane and then move it back after the storm. Using these technologies, Deloitte can also advise its clients on how to implement Disaster Recovery-as-a-service.

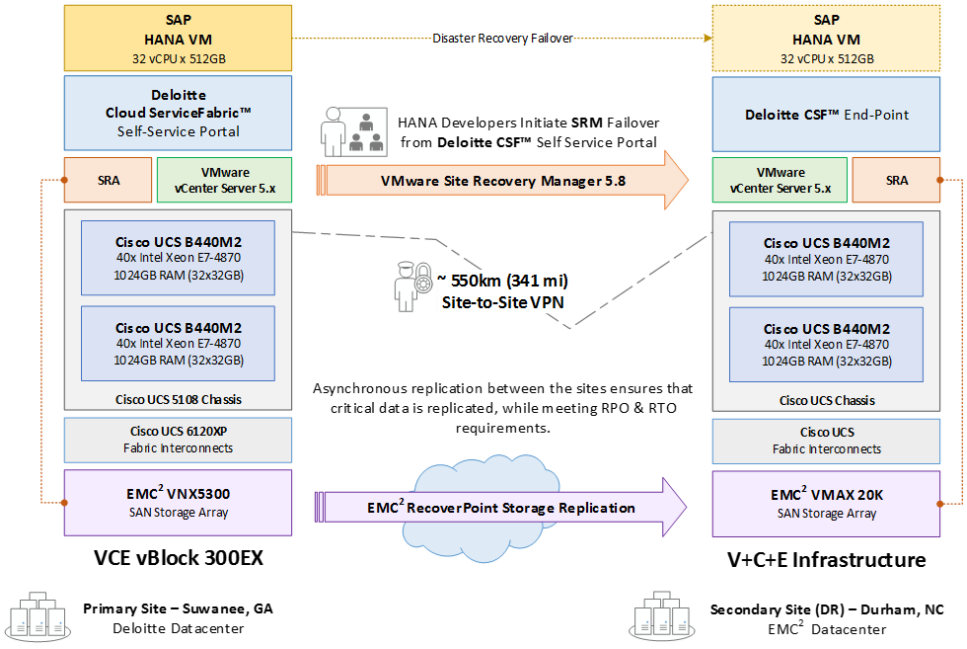
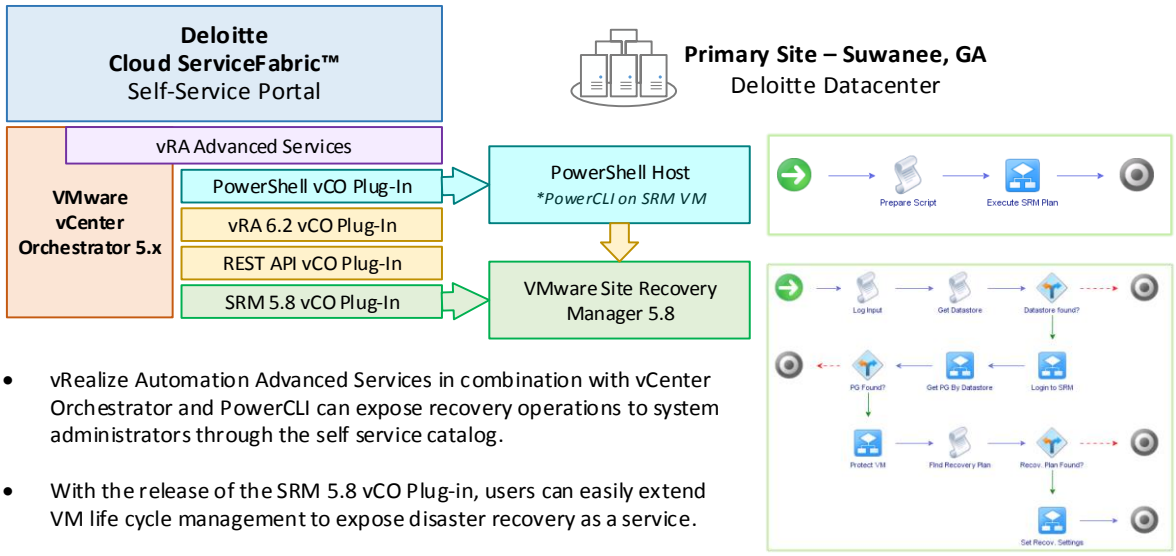


Figure 24. POC Architecture for extending Cloud ServiceFabric to Hybrid Cloud

This Figure 24 illustrates the POC Architecture for extending Deloitte's Cloud ServiceFabric to a hybrid cloud mode between Deloitte's datacenter in Suwanee to EMC's datacenter in Durham which enables automation of the workload relocation over long distance between both on-premise and off-premise locations without any data loss.

And Figure 25 below shows how the Deloitte CSF Self-Service Portal can be used to quickly provision a remote endpoint, as was the case with the EMC datacenter in Durham during this use case.



- vRealize Automation Advanced Services in combination with vCenter Orchestrator and PowerCLI can expose recovery operations to system administrators through the self service catalog.
- With the release of the SRM 5.8 vCO Plug-in, users can easily extend VM life cycle management to expose disaster recovery as a service.

Figure 25. Standard Provisioning Portal to standup remote endpoint

This POC also demonstrated that system administrators can use the same self-service portal to provision a remote CSF endpoint. This service catalog, depicted in Figure 26 below, can be configured for a variety of services and platforms. In this graphic, we have presented SAP HANA virtual machine through SAP as a Service or SAPaaS catalog.

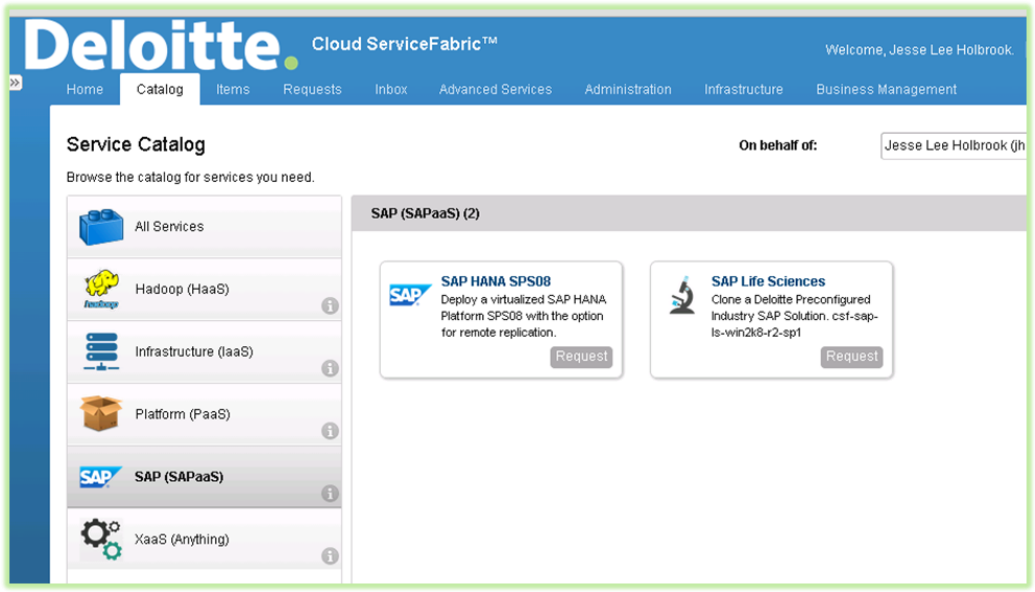


Figure 26. SAP As a Service Offering, including SAP virtualized HANA

All virtual machine requests require basic information about the VM configuration such as the VM(s), CPU, memory, and storage allocation. In this case, a custom set of blueprint properties or associations has been defined for each portion of the service management lifecycle, so the required properties can be applied to the build profile shown in Figure 27.

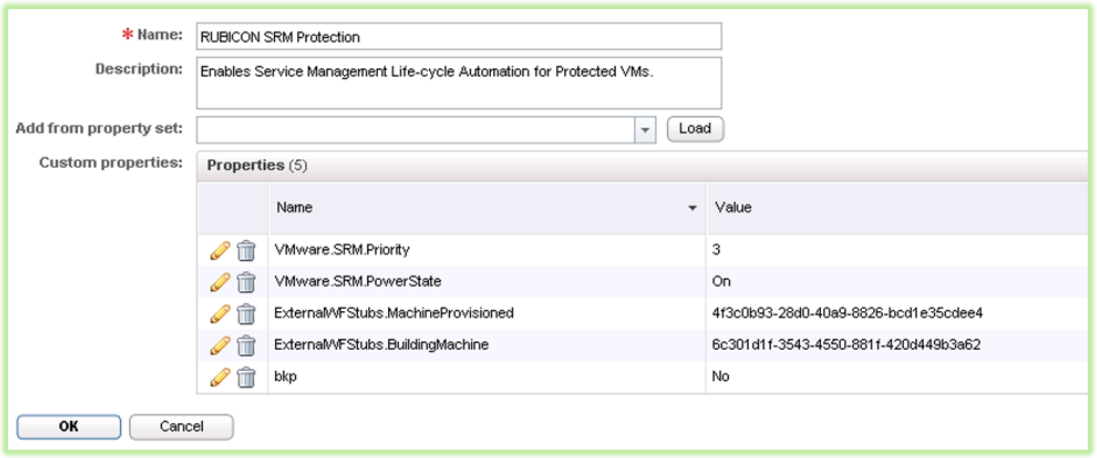


Figure 27. Build Profile associated with HANA Deployments

Once the proper information has been entered, users can simply press submit to request that the work will be performed by Deloitte's Cloud ServiceFabric.

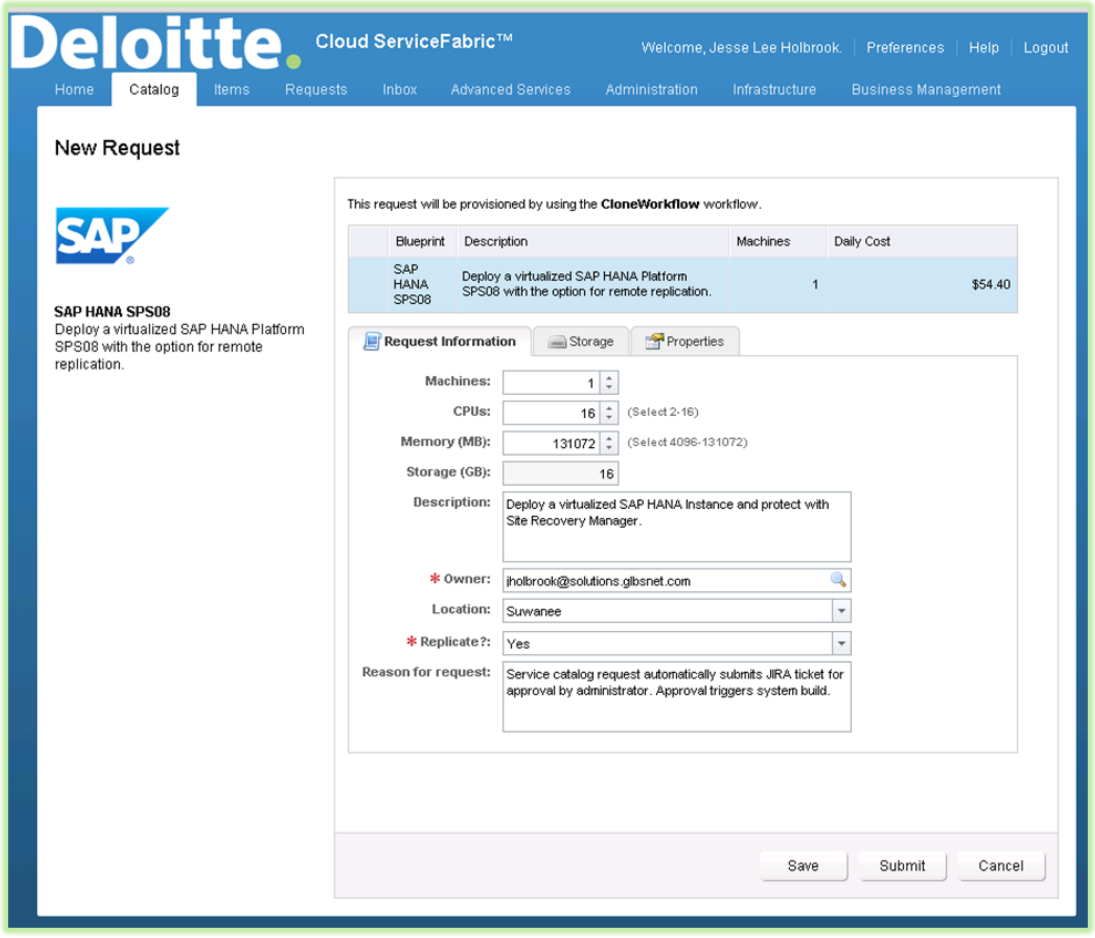


Figure 28. Catalog Request for HANA Virtual Machine

Users can view the status of each request submitted on the request tab. The submitted request then enters the service management lifecycle, where a corresponding VMware vRealize Orchestrator (formerly vCenter Orchestrator or vCO) workflow is called for every step in that lifecycle. Properties of requested virtual machines are automatically populated in the request to ensure the approver has the required pertinent information.

Then the workflow continues with deployment of the requested catalog items and provisioning of the virtual machine within the defined compute resource. When the virtual machine is successfully deployed, vRealize Orchestrator advances to the next step in the service management lifecycle and at the remote site in Durham, NC, and a copy of the VM configuration is deployed to the placeholder datastores.

The remote (or off-premise) site is now ready for:

1. A failover of one or more SAP HANA landscapes from Suwanee to Durham in the event of a disaster, a business continuance & disaster recovery use case
2. Or the planned move of SAP HANA workloads (in the form of one or more VMware VMs) from Suwanee to Durham, a workload relocation use case

In either use case, the underlying technologies of the VMware vCloud Suite and EMC RecoverPoint are called upon to perform two distinctly different tasks, but utilizing the same technical solutions for the orderly restart of the virtual machines at the remote site.

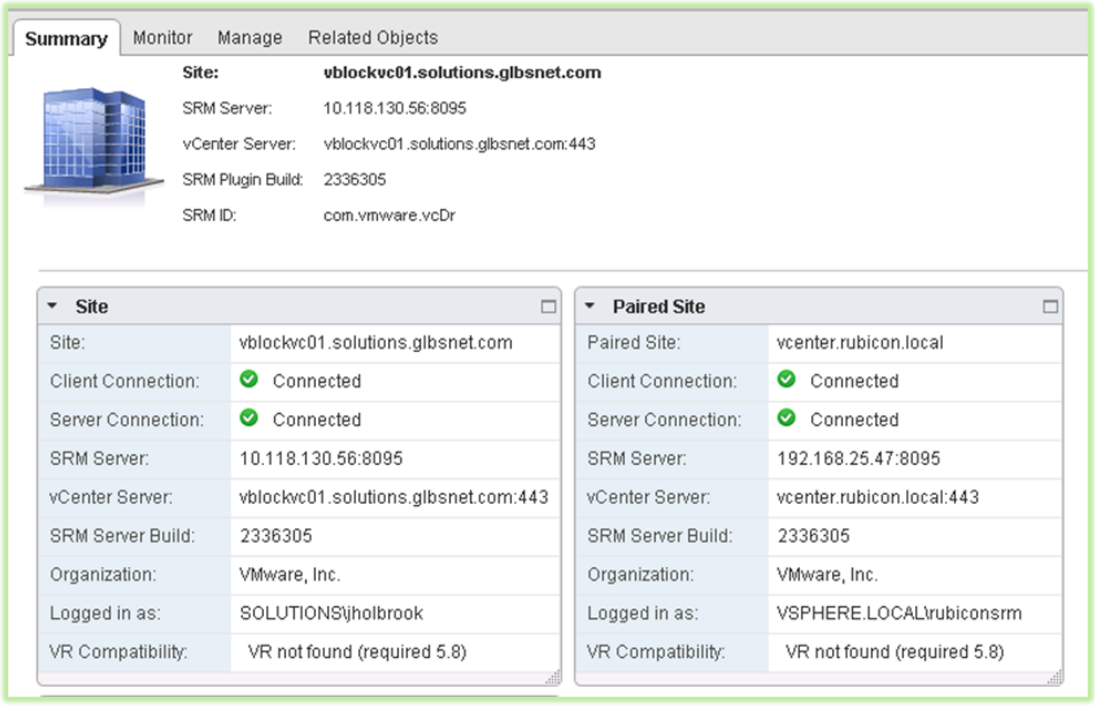


Figure 29. On-Premise & Off-Premise Paired Site Connection Status

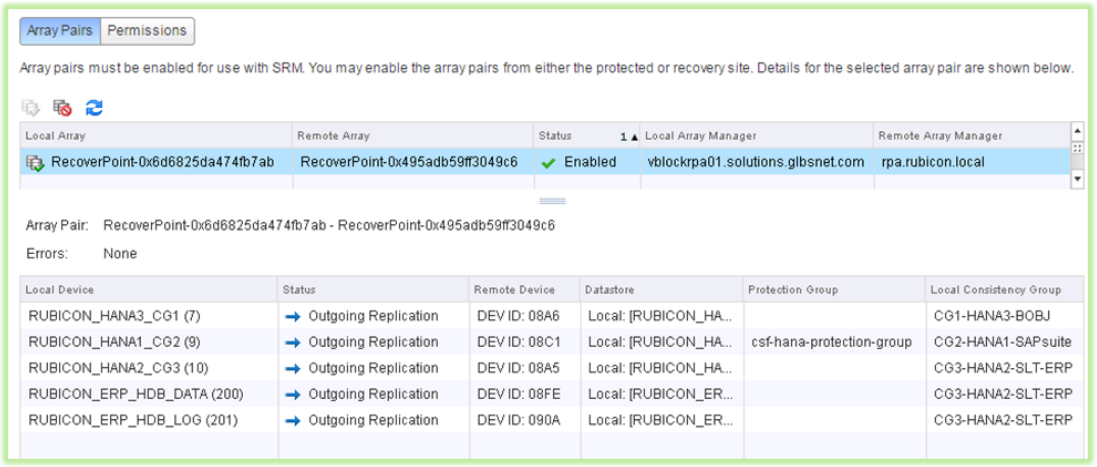


Figure 30. Array pairs enabled for use with VMware SRM

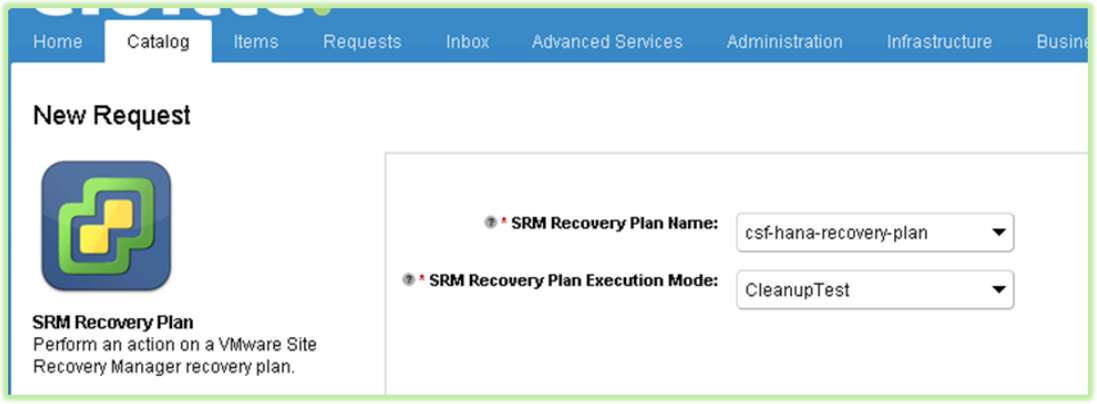


Figure 31. Writable Storage Snapshot automatically mounted by VMware SRM

Figure 31 above shows that on the remote VMware vRealize server (formerly vCenter), a writeable storage snapshot of the replicated volume is mounted automatically by Site Recovery Manager from which to recover the VM. This also shows the recovered VM running on the remote site following the SRM test, and then could return to the CSF service catalog to clean up the recovery test.

By combining this self-service portal with vRealize Automation and vRealize Orchestrator to create an extensible orchestration engine, this POC validated that Deloitte's Cloud ServiceFabric works well in hybrid cloud mode along with integrating directly into Deloitte's service management lifecycle for DR-as-a-Service.

Proof Point: Extending the capabilities of Deloitte's Cloud ServiceFabric to a hybrid cloud mode for orderly relocation from on-premise to off-premise and back without any data loss. This provides SAP customers with greater flexibility, resource utilization, and cost effectiveness around where they locate their SAP applications.

Proof Point: Confirming the use of DR-as-a-Service as a viable offering with CSF in hybrid cloud mode since a viable BC/DR solution is a critical part of any SAP implementation in Production.

Benefits of running Cloud ServiceFabric in Hybrid Cloud Mode

By proving that Deloitte's Cloud ServiceFabric can run in hybrid cloud mode, we provided the foundation for an evolving Cloud Architecture by combining the agility and rapid deployment of Public Clouds with the control and security of Private Clouds. The lessons learned from this POC will enable IT organizations to increase their business agility, rapidly deploy any SAP applications including HANA based, mobile or big data projects, and reduce IT operating costs while still retaining deep management and governance oversight of their current infrastructure.

Using Deloitte's Cloud ServiceFabric in hybrid cloud mode, customers can:

- Simplify the provisioning of SAP HANA environments
- Reduce implementation and operating costs
- Optimize internal IT resources

As a result, IT organizations are now able to focus their resources on delivering a better user experience and enhanced capabilities to their business partners, creating dramatic cost savings, process improvements, and better time-to-value for users.

CONCLUSIONS OF RESULTS AND ANALYSIS FROM THESE OUTCOMES

The goals of this POC were to validate the stability and performance of a reference architecture for a virtualized SAP HANA environment running on a Vblock simulating a large Production workload, and to demonstrate that Deloitte's Cloud ServiceFabric can be run in hybrid cloud mode. This table summarizes those proof points and shows Project RUBICON Reference Architecture as the ideal platform to deploy SAP's new S/4HANA environment requiring high availability, flexibility, and performance with long distance disaster recovery.

Proof Points	What actually happened	Conclusion
Stability of virtualized SAP HANA "appliance" on Vblock	1. Delta between the physical & virtual CPU & memory consumption remained constant under heavy workload 2. Lots of alerts were set for CPU, memory, networking & storage tiers, however no major alarms were triggered except on storage tier even under heavy workload 3.EMC ViPR SRM triggered alerts that allowed for quick corrective actions to be taken when disk consumption inside data volumes and inside datastore logs exceeded predefined red thresholds	Virtualized SAP HANA "appliance" on Vblock capable of handling Production-level workload
Scalability of virtualized SAP HANA "appliance" on Vblock	CPU consumption did not exceed 60% at peak load with 2,026 SAP users connected and the equivalent of 784,000 dialog steps & 680,000 Updates per day	There is ample head room for the virtual SAP HANA "appliance" to scale, and with virtualization, additional compute resources can be dynamically added
Large volume SAP HANA logs can be captured & replicated over long distance	1. The 2 hour Test Run produced 18GB of logs, the equivalent of 144GB of SAP HANA logs per day 2. At peak, the RecoverPoint replication showed a RPO lag of 3-to-5 seconds	The storage and data replication of the virtualized SAP HANA "appliance" on the Vblock can more than handle this very heavy workload, including the capability to offer long distance BC/DR of virtualized SAP HANA environments
The monitoring and reporting tools used provide comprehensive analysis to proactively identify problems to ensure stability and consistent performance	1. The tools provided compelling evidence of stability 2. The tools provided evidence of performance & scalability 3. The tools were successful in detecting future problems 4. The tools provided a framework for analyzing & troubleshooting problems when they arise	With the proposed tools in place, infrastructure management teams can confidently deploy and manage a virtual SAP HANA "appliance" in Production complete with reporting on compliance to SLAs and KPIs
Deloitte's Cloud ServiceFabric (CSF) can run in hybrid cloud mode	1. CSF endpoints were provisioned & monitored remotely 2. Workload relocation from on-premise to off-premise was done in an orderly fashion	There is no issue in running SAP HANA instances under CSF in hybrid cloud mode
The Project RUBICON Reference Architecture is the ideal platform to deploy SAP S/4HANA	1. Virtualized SAP HANA is rock-solid on the Vblock 2. Virtualized SAP HANA works well in a hybrid cloud model	Customers wanting to deploy SAP's new S/4HANA in a highly available, scalable and robust environment with long distance BC/DR capabilities can immediately benefit from Project RUBICON lessons learned

Figure 32. Conclusions showing Results & Analysis from POC Testing

LESSONS LEARNED & RECOMMENDATIONS

Customer Issues Addressed

Through this Proof of Concept, we are able to demonstrate that the following customer issues or concerns were addressed:

Customer Issues or Concerns	Addressed	Solution
Maximum flexibility & agility	YES	Running virtualized SAP HANA on the Vblock
Lowest cost of ownership	YES	Running virtualized SAP HANA on the Vblock with other SAP and non-SAP workloads
Stability of virtualized SAP HANA	YES	Applying heavy load to the virtualized SAP HANA "appliance" on the Vblock and analyze behavior for stability
Scalability of virtualized SAP HANA	YES	Applying heavy load to the virtualized SAP HANA "appliance" on the Vblock and analyze behavior for scalability
Early warning of potential problems	YES	Deploy market leading monitoring tools
Robust reporting on SLA compliance	YES	Deploy market leading monitoring tools
Long distance disaster recovery of SAP HANA landscapes	YES	Deploy EMC RecoverPoint with VMware SRM to replicate HANA logs over long distance
Ability to leverage hybrid cloud for peak usage needs	YES	Showcase remote provisioning and remote monitoring of CSF endpoints and ease of workload relocation
Finding ideal platform to deploy the new S/4HANA	YES	Running virtualized SAP HANA on the Vblock in hybrid cloud mode for maximum resiliency, disaster tolerance, stability, performance, and lowest TCO

Figure 33. Customer Issues Addressed by this POC

Technical Lessons Learned

The table below summarizes the Technical Lessons Learned from this Proof of Concept:

Technical Point	How Addressed	Importance
Valid & certified virtualized SAP HANA "appliance" configuration	Run SAP's HWCCT to "certify" for Production use	High
Prove stability of virtualized SAP HANA on the vBlock	Show that the delta between CPU and memory consumption was constant between the physical and virtual environments	Very high
Prove scalability of virtualized SAP HANA on the vBlock	Show that there is ample headroom for taking on additional workload if necessary	Very high
Prove that potential problems in the virtualized SAP HANA environment on the Vblock can be detected early	Show that the monitoring tools have the ability to analyze data and predict potential issues	Very high
Prove that long distance disaster recovery of SAP HANA is possible and easy to implement	Show that EMC RecoverPoint can replicate large amount of HANA logs over long distance and that the restart of the SAP HANA landscape at the remote site can be done in an orderly fashion	Very high
Prove that virtualized SAP HANA under Deloitte CSF can work well in a hybrid cloud	Show that it is possible to provision and monitor remote endpoints with the ease of workload relocation	High

Figure 34. Technical Lessons Learned from this POC

Business Lessons Learned

The table below summarizes the Business Lessons Learned from this Proof of Concepts:

Business Issue	Implication	Importance
Valid & certified virtualized SAP HANA "appliance" configuration	Insure SAP support and solid performance to support the business needs	High
Prove stability of virtualized SAP HANA on the vBlock	Insure that the virtualized SAP HANA environment can properly support the business needs and mission	Very high
Prove scalability of virtualized SAP HANA on the vBlock	Insure that the virtualized SAP HANA environment can properly support the business needs and mission	Very high
Prove that potential problems in the virtualized SAP HANA environment on the Vblock can be detected early	Insure that no potential problem could bring down the virtualized SAP HANA environment	Very high
Prove that long distance disaster recovery of SAP HANA is possible and easy to implement	Insure that the critical SAP HANA landscape can be restart at the remote site quickly and in an orderly fashion	Very high
Prove that virtualized SAP HANA under Deloitte CSF can work well in a hybrid cloud	Provide maximum flexibility for the business to fully utilize all available resources to support its mission at the lowest TCO possible	High

Figure 35. Business Lessons Learned from this POC

APPENDICES

This section contains pointers to diagrams and screenshots that reinforce our key proof points as well as reference information on VCE Vblock and the market-leading tools that have been used in this Proof of Concept testing.

APPENDIX 1: Diagrams & Charts:

APPENDIX 2: Inventory of Components used in this Proof of Concept:

In order to prove that customers can run virtualized SAP HANA on a Vblock with agreed-to KPIs for stability and scalability, this cross-functional team from Deloitte, EMC, VMware, Cisco, and VCE has architected a real-world SAP HANA environment on Vblock to certify, measure, analyze, and report on the computing, networking, and storage tiers at datacenters in Suwanee, Georgia and Durham, North Carolina.

The architectural components of this POC environment includes:

- One (1) Cisco UCS B440 M2 High Performance Blade Servers with 1TB RAM to match the specs of the Cisco blades on the Vblock in Suwanee, GA
- Two (2) Cisco UCS B230 M2 Blade Servers with 512GB RAM to match the specs of the Cisco blades on the Vblock in Suwanee, GA
- VMware vSphere ESXi 5.5 on all servers to match what is on the Vblock in Suwanee, GA
- EMC VMAX 20K with 4 engines as the TDI storage component & with FAST VP support – with total usable disk capacity of 87TB
- EMC RecoverPoint Appliances (2X) with software for replication of the SAP HANA data and log files
- EMC ViPR SRM
- Cisco Nexus 5548 & MDS 9148 SAN Switches
- Cisco Intelligent Automation for SAP
- VCE Vblock (with 32 VCPU for database and application servers)
- VMware vRealize Operations Suite
- VMware vRealize Server & vRealize Orchestrator
- VMware Site Recovery Manager (VMware SRM)
- Blue Medora's vCenter Operations Management Pack for SAP
- Worksoft Certify Performance Test

APPENDIX 3: Descriptions of Architectural Components for Proof of Concept:

VMware vSphere ESXi 5.5 (formerly VMware Infrastructure) is VMware's cloud computing virtualization operating system.

VMware vRealize Operations Suite is a cloud management platform purpose-built for the hybrid cloud that provides a comprehensive management stack for IT services on vSphere and other hypervisors, physical infrastructure and external clouds, all with a unified management experience

VMware vRealize Server provides centralized visibility, proactive management and extensibility for VMware vSphere—all from a single console.

Cisco UCS B440 M2 is a High-Performance Blade Server extending the Cisco Unified Computing System to new levels of performance, scalability, and reliability. With the Intel® Xeon® processor E7-4800, this 4-socket Cisco Blade Server platform is ideal for mission-critical workloads like SAP HANA.

Cisco UCS B230 M2 is a 2-socket Blade Server delivering high performance and density in a compact, half-width form factor where the management software ran for this POC.

Cisco Nexus 5548 switches are modular network switches designed for data centers. Nexus switches provide high speed, low latency network based upon 10 and 40 GB Ethernet. Nexus switches also support the concept of a Unified Fabric where IP and storage traffic (via FCoE) are carried over a single network for lower TCO and faster ROI.

Cisco MDS 9148 SAN Series helps build highly available, scalable storage networks with advanced security and unified management while combining robust, flexible hardware architecture with multiple layers of network and storage-management intelligence.

EMC VMAX Storage delivers smart storage solutions for data centers using purpose–built software with high-availability, security and tiering, while reducing TCO in hybrid cloud environments, and with the highest levels of consolidation, performance, and scalability.

EMC RecoverPoint provides continuous data protection with multiple recovery points to restore applications instantly to a specific point in time.

EMC ViPR SRM is monitoring and reporting software that enables storage and infrastructure management teams to ensure service levels across multivendor, highly virtualized storage environments. With EMC ViPR SRM, customers can visualize application to storage dependencies, analyze performance, capacity, configurations and health, and optimize their infrastructure to improve return on investment.

VMware Site Recovery Manager (VMware SRM) is a disaster recovery management product that ensures the reliable disaster protection for all virtualized applications.

Blue Medora's vCenter Operations Management Pack for SAP provides comprehensive visibility and customizable dashboards for SAP HANA DBAs and System Administrators that shows the health, performance, and capacity metrics of SAP HANA workloads while simplifying trouble-shooting and SAP HANA infrastructure management complexity.

Cisco Intelligent Automation for SAP (IA for SAP and also known as SAP IT Process Automation by Cisco) helps standardize, unify, and automate best practices, remediation and performance monitoring for IT processes in complex, heterogeneous software environments so customers can view and manage their SAP applications in the context of end-to-end IT processes that span the datacenter.

Worksoft Certify Performance Test is a combination of Worksoft business process validation (BPV) technology and consulting services that allows users to validate the behavior, capacity, and user response time of SAP enterprise applications under real world workload scenarios.

APPENDIX 4: Overview of the VCE Vblock

The Virtual Computing Environment Company (VCE) offers Vblock® systems that seamlessly integrate the leading compute, network, and storage technologies by providing an optimized converged infrastructure solution that ensures secure and predictable performance through pre-engineered, modular infrastructure. Vblock systems deliver the highest levels of virtualization and application performance in the industry today.

Vblock systems have been proven to dramatically reduce the cost of IT by simplifying deployment, management and ongoing operations. Vblock has consistently addressed the challenges of how to:

- Maximize performance of SAP applications and HANA databases
- Provision servers and storage for capacity
- Help IT to be more efficient and proactive
- Recover all layers of application stack quickly and efficiently

Vblock systems have also addressed some limitations of SAP HANA on physical appliances:

- Shortens time required for overall SAP projects across the entire infrastructure
- Optimizes performance, scalability and design, offering non-disruptive expansion
- Lowers TCO with reduced hardware, implementation, and upgrade costs
- Improves integration capabilities with interoperability testing and update validation

Using Vblock, customers can now manage their complex business processes in real-time to better cope with the increasing rates of change while minimizing their risks and optimizing their time-to-value by enabling their mission-critical solutions to scale from design and testing to full production in significantly less time.

APPENDIX 5: Overview of Tools Used in this POC

Blue Medora Management Pack for SAP

With Blue Medora's vCenter Operations Management Pack for SAP (vCOps), customers are able to gain comprehensive visibility and insights into the performance, capacity and health of their SAP HANA workloads running on VMware as well as SAP HANA instances running on virtualized "appliances" or in the cloud. Advantages of Blue Medora's vCenter Operations Management Pack for SAP are to:

- Leverage existing investments in vCenter Operations Manager
- Increase cost savings associated with VMware virtualization (including integrating SAP HANA as well as the applications leveraging SAP HANA into a single console)
- Reduce trouble-shooting time
- Simplify security, compliance and infrastructure management complexity
- Deliver performance and capacity metrics on storage volumes, transactions and workloads

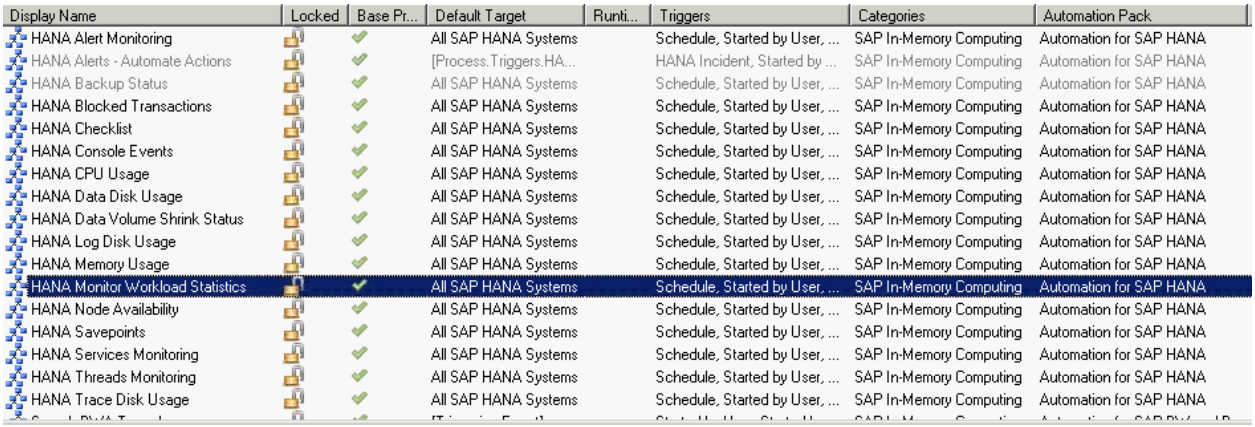
Blue Medora's vCOps empirically determines SAP customer requirements based on continuous performance and configuration monitoring to eliminate any guessing about proper sizing of SAP systems. Once correct sizing has been identified, virtualized SAP HANA can be easily scaled up or down as needed. Based on intelligent vCOps forecasting, SAP customers know when they will need to scale up in the future, so they can more accurately plan future system requirements, putting CPU, RAM, and other critical resources where they will have the most value.

Cisco IA for SAP

Cisco's Automation Packs for SAP are powerful software content additions to the Cisco Intelligent Automation platform. These automation packs interface with SAP environments and include preconfigured SAP content, enabling users to automate incident response activities and orchestrate complex operational processes, such as "system copy" for SAP applications.

While the Cisco Intelligent Automation platform provides users with enterprise context for IT process automation, these SAP automation packs are specifically designed to integrate with SAP Solution Manager and CCMS to automate SAP functions around performance monitoring, incident response, task management, corrective actions and system copy activities.

The base Cisco IA for SAP product plus the SAP and SAP HANA automation packs provides a total of 400 items to monitor SAP applications.



Display Name	Locked	Base Pr...	Default Target	Runti...	Triggers	Categories	Automation Pack
HANA Alert Monitoring			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Alerts - Automate Actions			[Process.Triggers.HA...		HANA Incident, Started by ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Backup Status			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Blocked Transactions			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Checklist			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Console Events			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA CPU Usage			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Data Disk Usage			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Data Volume Shrink Status			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Log Disk Usage			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Memory Usage			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Monitor Workload Statistics			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Node Availability			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Savepoints			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Services Monitoring			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Threads Monitoring			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA
HANA Trace Disk Usage			All SAP HANA Systems		Schedule, Started by User, ...	SAP In-Memory Computing	Automation for SAP HANA

Figure 36. Cisco IA for SAP HANA application monitoring

Beyond simple database statistic monitoring, Cisco IA for SAP can perform complex analysis to help determine why an SAP system is not performing as well as expected. Below is a screen shot showing some of the complex database analysis available through Cisco IA for SAP.

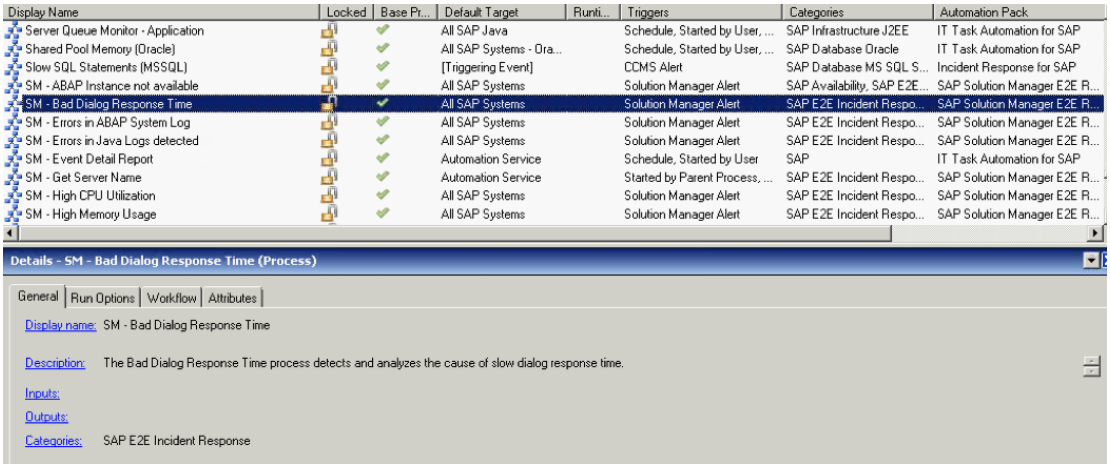


Figure 37. Cisco IA for SAP example of System Performance Analysis

Cisco's IA for SAP comes with predefined detection and incident-response process flows and, of course, you can customize or add to this list of predefined processes. For example, the software can send out automatic alerts if the service performance falls below acceptable levels. These alerts then trigger SAP best-practice based corrective actions that will resolve the issue.

Troubleshooting functionality within IA for SAP provides you with fast, automated incident response. The application then provides a visual process flow to take you by stages through how recommendations were made and how a resolution was reached. This process flow contains the same steps your Basis team would use. In many cases, the process can be automated and the corrective action is made automatically rather than waiting for the Basis team to manually execute the series of steps.

IA for SAP also produces an XML based incident analysis report showing analysis steps performed and actions taken. The incident report also includes useful historical information such as job logs for the offending task.

With a range of sophisticated reporting options, IA for SAP helps improve process visibility and traceability across different functional teams. In addition to preconfigured process flow templates, detailed reports can be setup and aligned with existing policies, service levels, and auditing procedures. This helps ensure compliance with regulatory reporting requirements under legislation such as the Health Insurance Portability and Accountability Act and the Sarbanes-Oxley Act.

Workflows are based on Information Technology Infrastructure Library (ITIL) best practices to help ensure optimum IT service management. Authorization functionality within IA for SAP allows IT personnel the access they need to achieve specific tasks but no more, helping to comply with security protocols. By providing a central repository where details of all procedures are stored, customers establish a fully auditable record of events.

EMC ViPR SRM

EMC ViPR SRM is monitoring and reporting software that enables storage and infrastructure management teams to increase visibility and control through multivendor performance, capacity, health, configuration, and data protection analysis for both traditional and software-defined storage environments.

As organizations deploy more highly virtualized infrastructures to drive efficiencies and agility, comprehensive monitoring and reporting becomes an essential component in ensuring SLAs for mission critical applications like SAP HANA. In these highly virtualized environments, applications frequently compete for resources and bottlenecks can spring up anywhere across the data path. In addition, infrastructure management teams must continuously monitor the health and configuration of the environment to proactively identify issues that could impact service levels.

Understanding relationships between applications and the underlying physical infrastructure is an important first step in understanding the impact storage has on the application. The ability to consistently report on SLA status from a performance, health, configuration and data protection perspective provides the insight necessary to ensure the resiliency of a virtualized SAP HANA environment.

EMC ViPR SRM enables storage infrastructure management teams to **visualize** applications to storage dependencies, **analyze** health, configurations and capacity growth, and **optimize** their environment to improve return on investment.

Visualize
EMC ViPR SRM provides detailed relationship and topology views from virtual or physical host down through the storage infrastructure to identify application to storage dependencies. It not only provides visibility across server environments, but also virtual storage technologies like EMC ViPR, VPLEX and IBM SVC. Users can also view performance trends across the data path to help troubleshoot problems and really understand the impact storage has on applications.

Analyze
Customers can quickly spot SLA problems through custom dashboards and reports that meet the needs of a wide range of users and roles. EMC ViPR SRM can analyze storage consumption trends with built in views that identify who is using capacity, how much they're using, and when more will be required. Customers can continuously track changes and validate compliance with design best practices and the EMC Support Matrix to ensure their environments are always configured right to meet SLAs. Integrations with RecoverPoint and EMC Data Protection Advisor help to identify compliance with data protection policies. It allows users to proactively identify health, performance, configuration, and capacity issues across their multivendor storage infrastructure through ViPR SRM's comprehensive alert console.

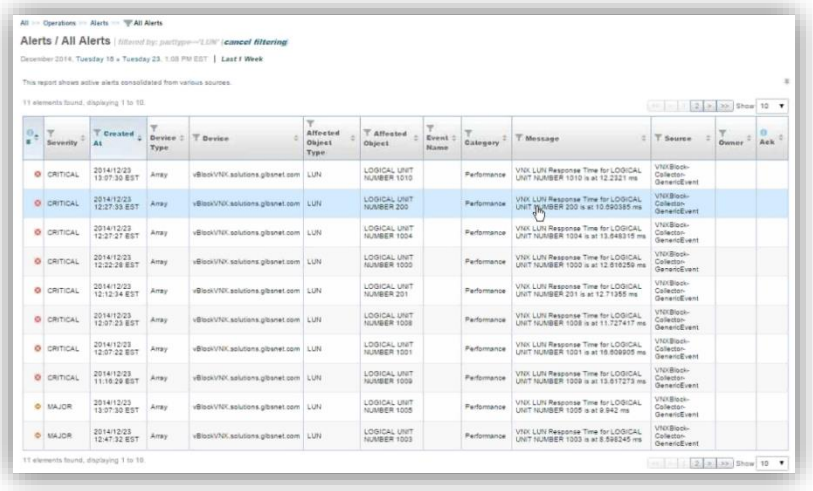


Figure 38. EMC ViPR SRM alert console

Optimize

EMC ViPR SRM has tight integration with EMC industry leading storage platforms like ViPR, VMAX, VNX, XtremIO, Isilon, and Data Domain and multivendor storage to help improve utilization and storage tiering to lower storage costs. Customers can track consumption of thin pools and identify when more capacity will be required to proactively plan new capacity purchases and reduce costs. EMC ViPR SRM analyzes capacity use by service-level and tracks historical workloads and response times to help determine if you have selected the right service level for your application. It also allows for the creation of show back or chargeback reports to align application requirements with costs. Tight integration with ViPR Controller leverages ViPR's ability to abstract pool and automate storage resources to further reduce costs.

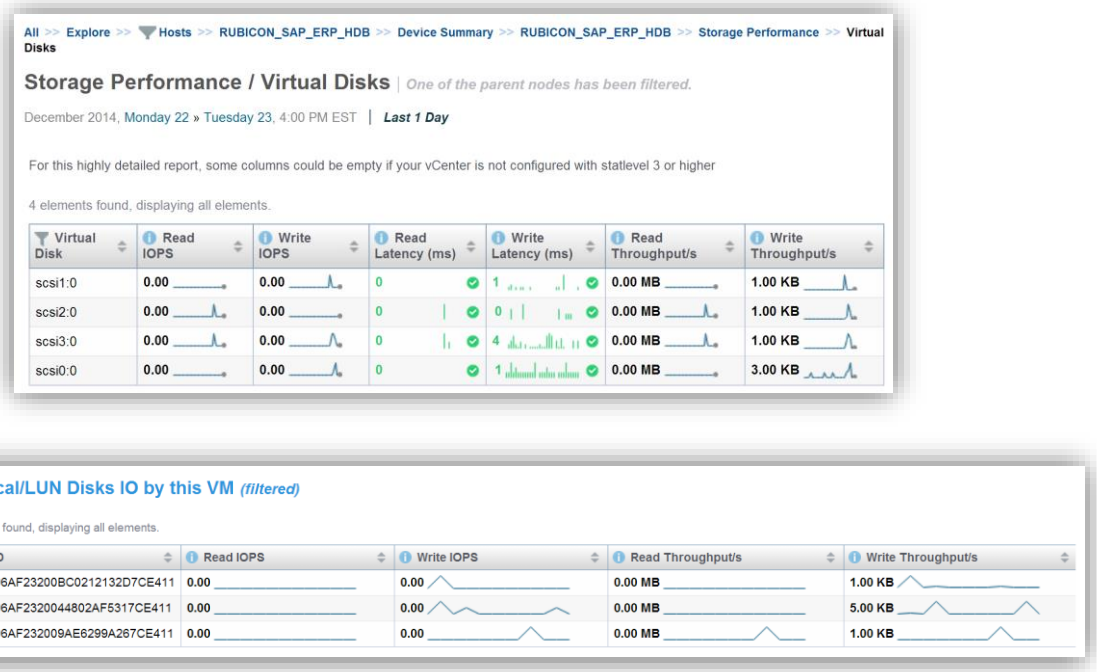


Figure 39. Virtual disk & Physical LUN Performance trends in ViPR SRM

Worksoft Certify Performance Test

Worksoft Certify Performance Test is a combination of Worksoft business process validation technology and consulting services which allow users to validate the behavior, capacity and user response time of an application under real world workload scenarios. Determining the behavior of an application under load and using the actual test results to provision system capacity appropriately is a critical activity before the application goes live. Worksoft Performance enables customers to get the answers they need quickly, with little upfront configuration and little-to-no training because this solution is bundled with expert services.

Worksoft Performance provides:

- Comprehensive performance and load testing with reporting on performance readiness or issues, and diagnostic help.
- Technology and services bundled together in three configurations depending on an organization's needs. No surprises, no extras, just confidence in price and delivery for performance analysis and reporting.
- Reports, results, and analysis using metrics captured by SAP via CCMS. Reported information includes infrastructure metrics along with key internal SAP data points such as response time, dialogs, and queues.
- Efficiency, cost savings, and greater budget predictability by reducing the resources needed to produce load test results. Customers can test faster and have the option of testing more often. Best of all, load tests will more accurately reflect true business process performance for more realistic results.

Directory	Components
Certify Performance Web	Folder contains the following: • CertPerfWebServer.exe (installs test web app) • Database Folder
Certify Performance Web Capture	Folder contains CertPerfWebCapture.exe application that installs the Web Capture utility (on each client machine that will be used to record tests)
Certify Agent Manager	Folder contains the CertifyPerfAgentManager.exe application that installs the Certify Performance Agent Manager (on each agent machine used to replay tests, and does not need to be installed on the Certify Performance Test server)
Documents	Folder contains the following user documents: • Certify Performance Test Installation Guide • Certify Performance Test User Guide

Figure 40. Worksoft Certify Performance Test package Directories & Components

Worksoft Certify Performance 9 has the following system requirements for:

- Servers:
  - Microsoft® SQL Server 2003 or later versions or MySQL® Enterprise Server v5.1 and later with Java™ Database Access (JDBC) driver
  - Windows® Server 2003 or later versions
  - Java™ Runtime Environment v6 or later versions
  - Microsoft® .NET Framework v4 or later versions
  - SAP® JCo v3.x Connector for SAP RFC access
  - Adobe® Reader® for Windows®

- Test Web Application:
  - Mozilla Firefox® v3.5 or later versions
  - Mozilla Firefox Add-on Tool—Firebug v1.5 or later versions
- Test Web Capture:
  - Microsoft® Internet Explorer® v6.0 or later versions
  - Microsoft .NET Framework v4 or later versions
  - Recommended minimum screen resolution of 1280 X 800 pixels
- Agents:
  - Java Runtime Environment v6 or later versions
  - Microsoft .NET Framework v4 or later versions
  - SAP® GUI for Windows v6.20 or later versions

Worksoft Certify Performance 9 has the following hardware requirements in order to achieve 750 virtual users:

Item	CPU	Memory	Storage
Database Server	8-core processor	8 GB	500 GB
Web Application Server	Quad-core Processor	8 GB	100 GB

Figure 41. Worksoft Certify Hardware Specifications