WHITE PAPER

MIGRATING CRITICAL ORACLE WORKLOADS TO THE CLOUD USING VMWARE CLOUD ON AWS

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Table of Contents

Introduction to VMware Cloud on AWS

VMware Cloud on AWS is a compelling new offering from VMware and Amazon Web Services that offers an off-premises solution combining the familiar features of VMware vSphere virtualization with the reliability and ubiquity of Amazon Web Services datacenters. With VMware Cloud (VMC) on Amazon Web Services (AWS), organizations can simplify their Hybrid IT operations by using VMware Cloud foundation technologies, including vSphere, vSAN, NSX, and vCenter Server, across their on-premises data centers and on the AWS Cloud.

VMware Cloud on AWS offers:

- VMware Software Defined Datacenter (SDDC) jointly delivered by AWS and VMware
- Hybrid approach to Cloud Adoption
- Use of familiar vCenter software
- Optimized to run on elastic, dedicated, bare metal AWS Infrastructure
- Use Cases
    - Accelerate cloud migration
    - Disaster Recovery as a Service (DRaaS)
    - Capacity expansion for on-premises datacenters

First Impressions

While the preceding introduction sounds like a marketing slick, a few things were immediately apparent when we first got our hands on the environment. So, we wanted to list those right up front and encourage readers to take a closer look for themselves.

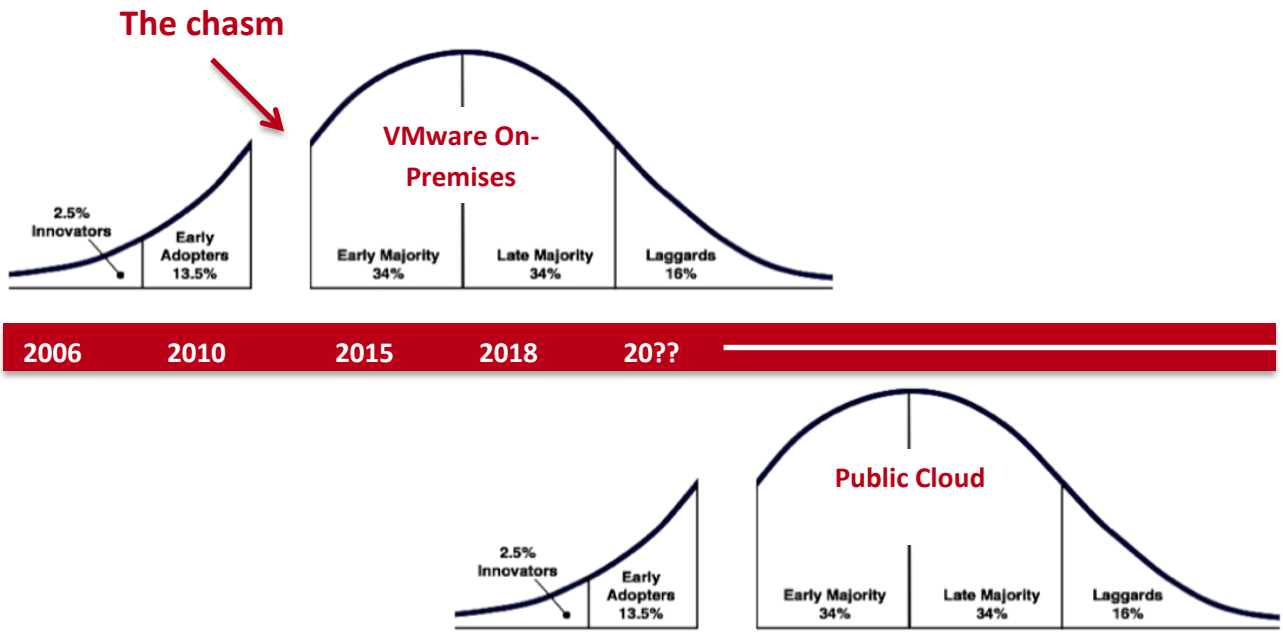
- It appeared this would be easy to adopt into our operations
- We found things immediately familiar with vCenter software front and center
- There were no surprises until we started looking a little closer – keep reading for details

Oracle on vSphere

House of Brick has been virtualizing business-critical production Oracle stacks on vSphere since 2006. House of Brick has worked with VMware Engineering for more than a decade: first to ensure that Oracle runs on VMware without issue; and second confirm that it will perform as well, or in some cases, better than it does on bare metal. The challenges are no longer technical, and rarely does anyone question whether virtualizing Oracle is a good idea or not.

By some estimates, **it is not a matter of whether a company should virtualize Oracle, but rather a question of what percentage they have already virtualized**. Below is a graphic House of Brick uses frequently that compares the adoption of virtualization to the current state and anticipated adoption of running Oracle in the cloud, based on experience and observation.

Cloud Adoption for Enterprise Workloads



There is no doubt a chasm to cross for enterprise-class workloads in the public cloud, but the technical barriers seem lower, so the adoption of cloud platforms could very well move more quickly than the adoption of on-premises virtualization platforms did. This is particularly true when considering the ease with which workloads can be migrated from vSphere on-premises to environments such as VMC on AWS.

VMC on AWS

The vSphere infrastructure is tried and true, and House of Brick has no technical concerns about running Oracle on the VMC infrastructure. Primary concerns for any enterprises contemplating using it will focus more on licensing, price vs. performance, and networking between the cloud and on-premises resources. There are also a few concerns around the features and manageability of the VMC SDDC itself. House of Brick does not predict, however, that these will be significant barriers to the large-scale Innovators and Early Adopters looking to leverage the strengths of VMC on AWS.

Adopters in the Early Majority crowd will be looking for a "complete product" with very few caveats or surprises. In particular, House of Brick anticipates that Early Majority adopters will wait until they are able to deploy, manage, and license Oracle on VMware just as they currently do in on-premises environments.

Objectives and Design of Testing

House of Brick performed the testing exercises for this white paper with the explicit goal of validating complex Oracle setups such as we see in clients' business-critical production environments. Beyond validating that these complex configurations were possible, we had a secondary goal of validating a key operational scenario: VMotion between on-premises and cloud datacenters. The following were our objectives:

1. Build a 2-Node RAC environment within VMC on AWS
    a. Perform basic health checks
    b. Utilize SLOB to confirm that it works with Oracle RAC on VMC on AWS
    c. Document any caveats, including differences compared to an on-premise build
2. Perform a cold vMotion from VMC to on-premises
    a. Document any caveats, including differences compared to traditional linked mode vMotion
    b. Document any issues related to vMotion of RAC in general
    c. Document any issues related to vMotion of RAC from VMC to on-premises
3. Perform a cold vMotion from on-premises back to VMC on AWS
    a. Document any caveats, including differences compared to traditional linked mode vMotion
    b. Document any issues related to vMotion of RAC in general
    c. Document any issues related to vMotion of RAC from On-Prem to VMC
4. Repeat the previous tests with live migration
    a. Document any additional issues that come up.

Unfortunately, we did not complete the fourth objective, as it involved extended networking and the free NSX edge appliance that we did not have time to configure. However, it involves tried and true technology and there are plenty of case studies to validate that it works.

vSphere – On Premises vs. VMC on AWS Cloud

There are a few key differences between traditional on-premises VSphere and the VMC on AWS that VMware administrators should be aware of when evaluating VMC on AWS.

Migration of Virtual Machines

Some prerequisites exist to configure migration of virtual machines between an on-premises VCenter and the VMC on AWS environment. These are above and beyond the normal requirements for performing vMotion between local VSphere clusters. Full details can be found in this VMware KB article.

Highlights

- Must have L3VPN configured (see below)
- Must have Hybrid Linked Mode configured between on-premises and VMConnect (usually latest) version of vSphere 6 in on-premises environment
- Use of vSphere Distributed Switch v6.5

- L2 Stretch Network (vSphere NSX Overlay)
    - Required for live migration only
    - Requires NSX on-premises (alternatively, there is a free NSX Edge Appliance)
- Traditional vMotion requirements for networking

SDDC Restrictions vs. Native vCenter

DRS Rules

The DRS rules are located in their usual location within the VMC vCenter interface. However, it is very noticeable that there are only a few SDDC-defined rules available, and the controls to edit/add/remove rules are disabled. This limitation means that with the current capabilities of the VMC on AWS, DRS rules cannot be used as a means of managing sub-cluster licensing for software that is licensed on a per-server or per-processor metric.

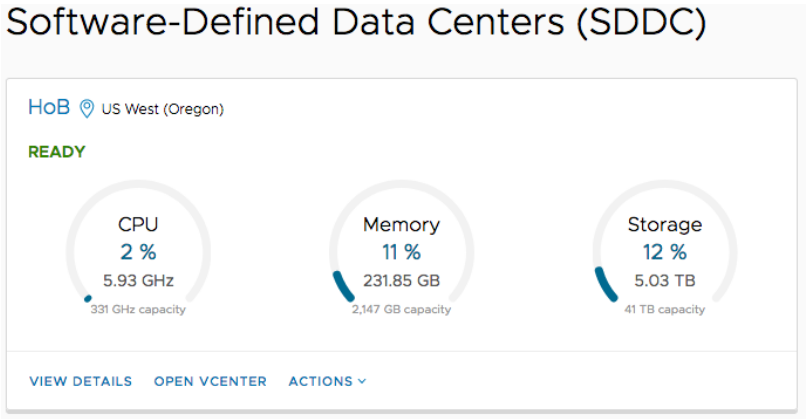
Immutable Storage Policies

VMware says this should no longer be the case, but we discovered the storage policies to be pre-assigned to the VMC datastores and immutable. For our version, this was confirmed to be the case by the assisting engineer. If these storage policy limitations had not changed, it would have presented a challenge when migrating workloads into the VMC environment as none of the predefined storage policies permit Eager-Zeroed Thick-Provisioned VMDK formats. Eager-Zeroed Thick-Provisioned VMDK format is a best practice for Oracle workloads and a hard requirement for using multi-writer VMDKs in Oracle Real Application Clusters. The storage policies do not prevent a VMDK from being created in the cloud in Eager-Zeroed Thick-Provisioned format, nor do they prevent conversion or inflation of existing VMDKs, so this is only a potential issue during VM migration.

VMC Test Setup

Start with VMware Cloud Dashboard

Start at https://vmc.vmware.com/console/sddcs, after logging in with appropriate My VMware credentials:



- 'View Details' links to the screen where one can manage SDDC Networking and Add-Ons as well as get details for other types of connections to an on-premises datacenter.
- 'Open vCenter' links to the vCenter login, which will be the familiar HTML5 interface to vSphere 6.7 (beta used during House of Brick testing).

Oracle Real Application Clusters Build

The test Real Application Clusters (RAC) build was identical to an on-premises vSphere 6.5 build exercise. The same requirements and steps apply to both. In addition there is one major caveat that applies to both in regards to the administrative interface used to perform the RAC build.

Starting in vSphere 6.5, the C# (thick/desktop/vSphere) client is no longer available. The preferred, and supported client is the vSphere Web (Flash/Flex) client. The VMC on AWS is built on vSphere 6.7, which is not yet available as of this writing. As such, in House of Brick's testing, some places still reflect a "beta" designation. With VMC and version 6.7, the default client has become the web client based on HTML5, although we do not foresee the flash client completely disappearing anytime soon.

Flash Client vs. HTML5

In its current state, vSphere 6.7 and the, now default, HTML5 client are still in transition to some extent with the HTML5 client not fully supporting all administrative actions yet in order to configure the multi-writer flag for the shared disks supporting RAC data volumes, it was necessary to switch to using the "old/fat (Flash/Flex)" client (which now refers to the Flash-based web client). It was not immediately obvious how to bring up the Flash client, but AWS support quickly pointed us to what should have been

obvious; simply replace '`/ui`' in your URL with '`/vsphere-client`'. **With the Flash client available all pre-requisites of a RAC build were met and the build proceeded just as it would have on-premises VSphere environment**.

Performance

Publication of any benchmark data is explicitly forbidden by Oracle's license terms without the express permission of Oracle. Because of this limitation, House of Brick can only provide anecdotal observations on VM performance. House of Brick can confidently say that we noticed no issues during testing, and Oracle performance meets or exceeds expectations in this environment – and expectations were high going into this exercise. House of Brick can also say that when interacting with the Oracle graphical tools, both software installation and database creation were observed to be remarkably responsive. This is not especially surprising considering the high specifications of the AWS i3.metal servers that the VMC environment is built upon.

RAC and vMotion

The only limitation of RAC on VMware in all current versions of VSphere, regardless of on-premises or in the VMC, relate to the shared disk and Storage vMotion.

While vMotion by itself allows RAC nodes to seamlessly move from one vSphere host to another without interruption and provides an additional level of High Availability to RAC compared to bare metal installations, it only works when the shared storage does not move. Any vMotion that explicitly or implicitly includes a relocation of shared Virtual Machine Disks (VMDKs) will cause problems for RAC or any other clustering technology built on top of vSphere shared VMDKs. The problem is that Storage vMotion is done in the context of a single Virtual Machine (VM)and only considers that VM's visibility to the storage. Thus the first VM that is moved in conjunction with Storage vMotion will cause a relocation of the shared VMDKs without updating the other VMs as to the new location of the shared VMDKs. The existing VMs will be left looking at a different copy of the shared VMDKs. Effectively, this introduces the classic split-brain scenario where the cluster cannot determine which is the real source of truth. This can be a very challenging and perplexing issue to diagnose when it occurs.

In terms of stability and data consistency – ALL BETS ARE OFF in this split-brained condition. It is to be avoided at all costs. If it occurs, recovery will most likely require some form restoration from backup or flashback once the cluster's proper perspective of its shared disk has been restored to all nodes.

Storage vMotion Workaround

Storage VMotion by itself is not currently available in the VMC on AWS. But someday we hope that it will be. So we are including this workaround for completeness. In order to work around this shared VMDK storage-vMotion problem, and to be able to perform live Storage vMotion while retaining at least some connectivity to the database, House of Brick uses the following steps which are applicable to on-premises VSphere environments or the VMware Cloud on AWS

1. Verify required networking for both public and private interfaces exists in the new location
2. Shutdown all but one database instance

   a. Schedule this for a time when the single instance can support the application load
   b. Restart the application(s) if necessary
3. Power down the VMs associated with the terminated instances
4. Disconnect the shared disks from the powered-down VMs.
5. Perform the vMotion and/or Storage vMotion of the live node.
   a. Assuming the stretched networking is properly functioning, then client traffic will follow the node as always and without interruption.
   b. Monitor application performance – depending on network performance this operation may or may not be feasible.
   c. This can include all modes of vMotion, including cross-vCenter, cross-datacenter as well as any linked-mode and/or Hybrid Linked Mode migrations
6. Before, after, or simultaneously (depending on preference and bandwidth) cold migrate the powered-off VMs.
7. Once the live VM has been migrated, verify the multi-writer flag is set for each shared disk. Also validate that the storage policies for the target site haven't changed the Eager-Zero Thick-Provisioned nature of the disks.
8. As each powered-off VM completes migration
   a. Reattach it to the shared disks in their new location
   b. Ensure the multi-writer flag is set for all nodes attached to the shared disks
   c. Boot the node and watch it rejoin the cluster (optional)
9. If not already done, boot the remaining migrated nodes that are still powered off, verify multi-writer, and ensure they rejoin the cluster without issue.
10. Restart the application(s) if/when necessary to re-distribute the client connections.

VPN Setup to Link Environments

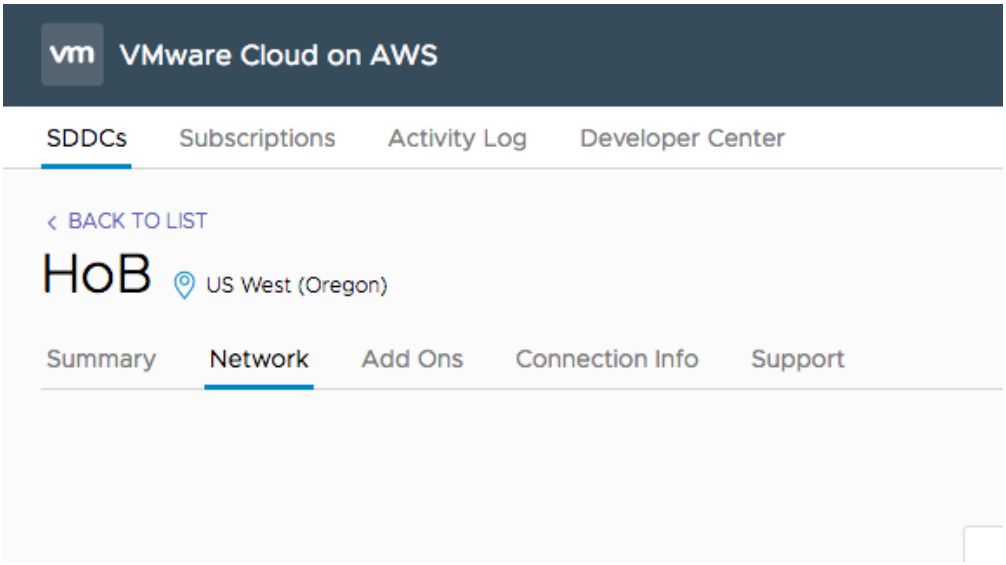
The first required configuration for testing vMotion between on-premises vSphere and the VMC is to establish an IPCSEC tunnel between sites so that encrypted traffic can be routed seamlessly.

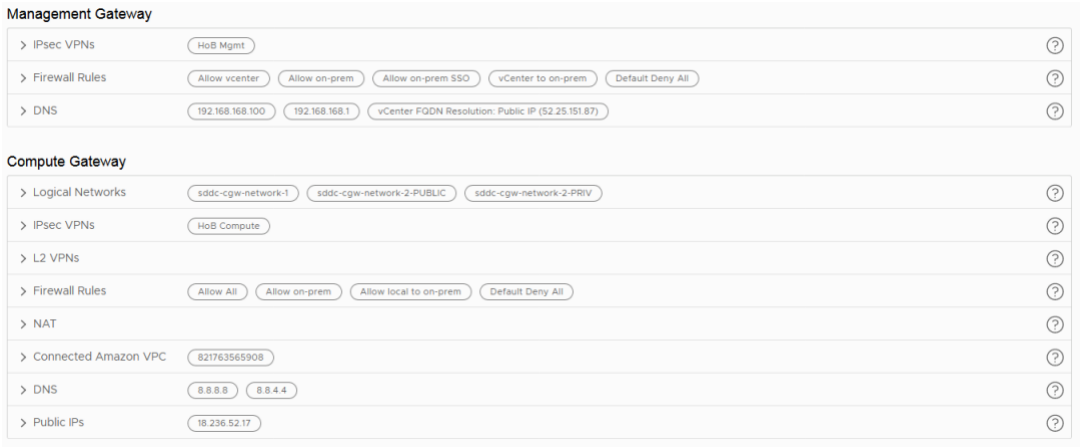
House of Brick used the following reference:

https://docs.vmware.com/en/VMware-Cloud-on-AWS/services/com.vmware.vmc-aws.getting-started/GUID-30BED7B3-D312-4DF3-BD7A-66F8D1C619DC.html#GUID-30BED7B3-D312-4DF3-BD7A-66F8D1C619DC

The general steps were:

1. Configure a directory service (OpenLDAP)
2. Configure L3VPN Tunnel (SDDC Networking)





3. Ensure firewall rules allow traffic to flow in both directions at both sites

Hybrid Linked Mode

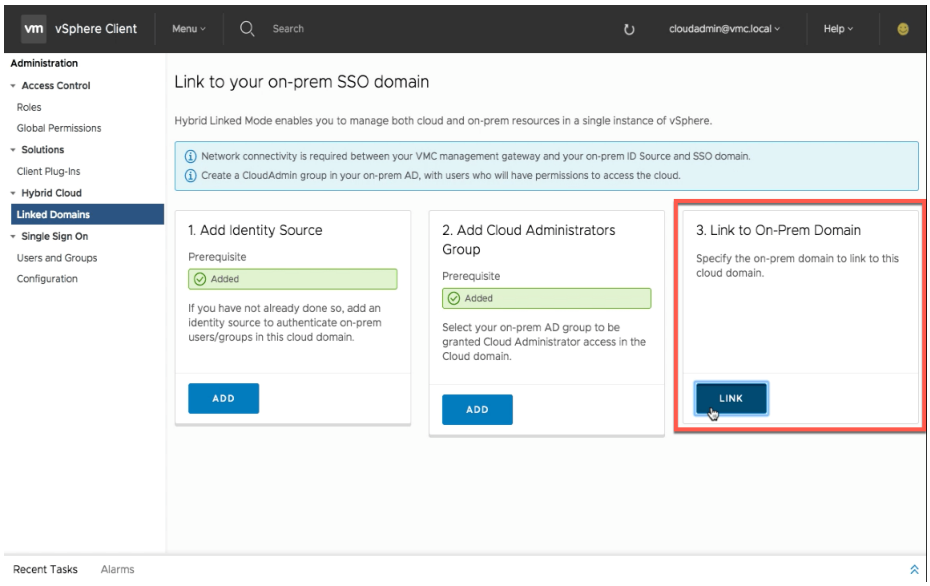
This is the mode that extends the VMC on AWS vCenter to include an on-premises vCenter server(s). Note that for customers using vSphere 5.x, the Hybrid Cloud Extension (HCX) is the preferred means of managing mixed on-premises and cloud resources. For this test, as House of Brick utilized vSphere 6.5 in our on-premises lab environment, we utilized Hybrid Linked Mode. Once Hybrid Linked Mode setup is completed, the on-premises resources appear like those from any other linked datacenter.

House of Brick used the following references when configuring this:
https://docs.vmware.com/en/VMware-Cloud-on-AWS/services/com.vmware.vmc-aws.getting-started/GUID-91C57891-4D61-4F4C-B580-74F3000B831D.html#GUID-91C57891-4D61-4F4C-B580-74F3000B831D

http://emadyounis.com/vmware-cloud-on-aws/configuring-hybrid-linked-mode-hlm-for-vmware-cloud-on-aws/

Configuration Steps:

1. Connect SDDC w/on-premises vCenter(s) in Hybrid Linked Mode
    a. Add on-premises Identity Service (OpenLDAP or AD) to SDDC
    b. Select on-premises security group to be added to SDDC cloud administrators
    c. Link to the on-premises vCenter



2. Log in to SDDC with on-premises security credentials
    a. Ensure L3VPN tunnels are active
    b. To aid troubleshooting, House of Brick changed the on-premises Identity Source to the default

    Please note that if the VPN tunnel is not fully established, then the on-premises datacenter may not appear, and there is currently no indication of the problem. In House of Brick's testing, when this happened, simply disconnecting and reconnecting to vCenter seemed to solve the problem.

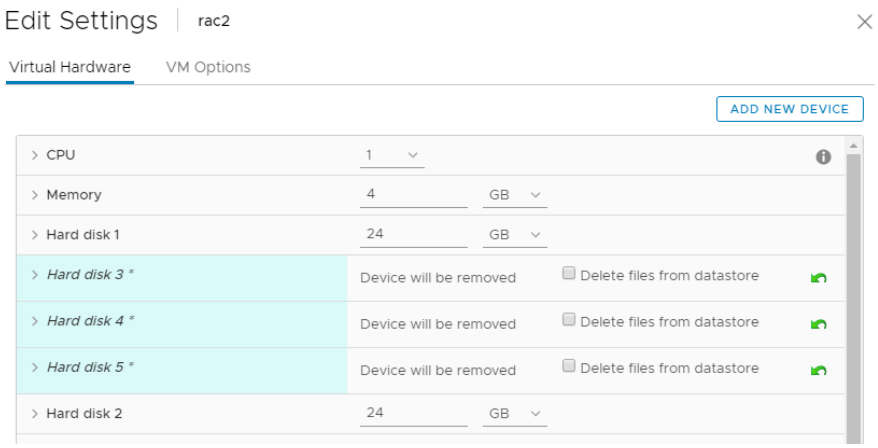
NOTES

a. Hybrid Linked Mode requires shared Identity Management Source, either AD or LDAP. House of Brick used OpenLDAP in the on-premises lab for the test environment.
b. Although invisible, there is an AWS/SDDC feature that is installed for use in VMC and which allows for navigation of on-premises datacenters. It is the key to using Hybrid Linked Mode but we did not see any indication when it was not working properly (the on-premises datacenters simply did not show up).
c. Both sites are only visible in one direction - from the VMC vCenter, via Hybrid Linked Mode.

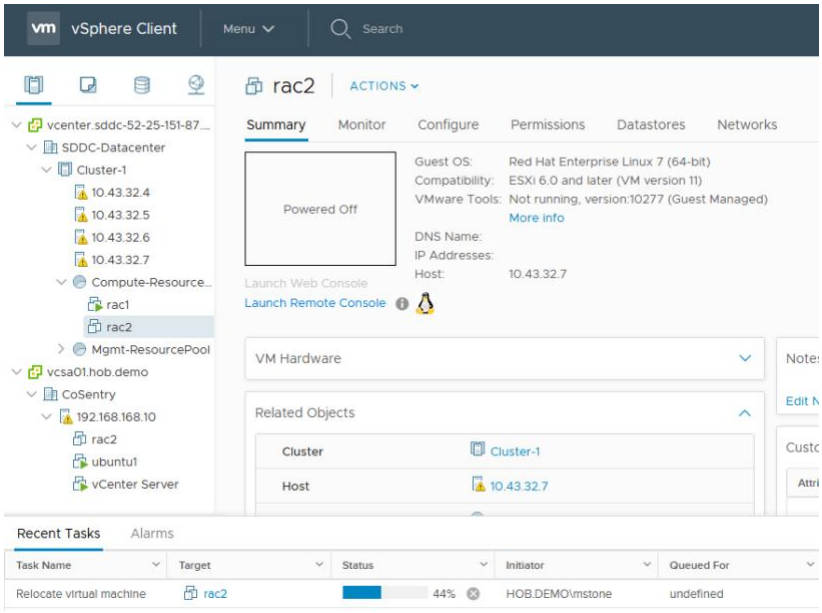
vMotion Testing To/From the Cloud

In order to fully exercise vMotion House of Brick performed the following test steps to test a vMotion of the RAC platform we had provisioned in the VMC on AWS environment.

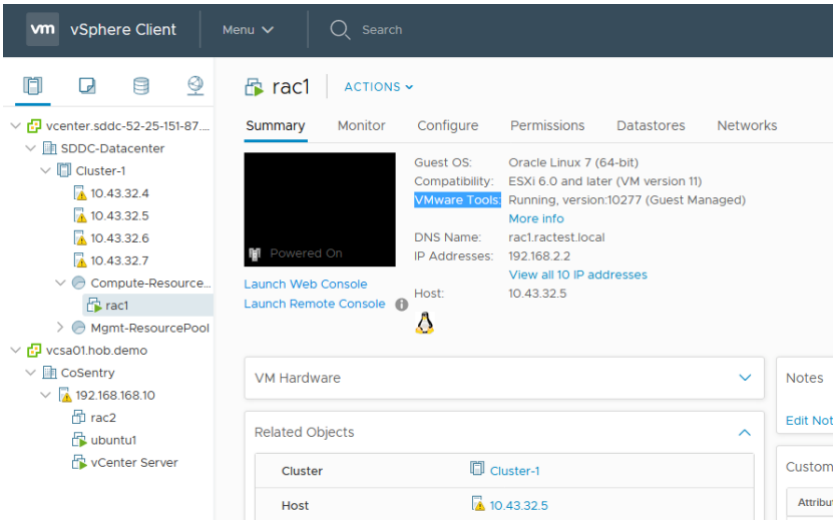
1. Cold migrate all but primary node
    a. Shutdown the cluster node being migrated (apps should be configured to failover gracefully to an active node)
    b. Disconnect any local devices (CDROM, etc.)
    c. Disconnect from shared disk devices

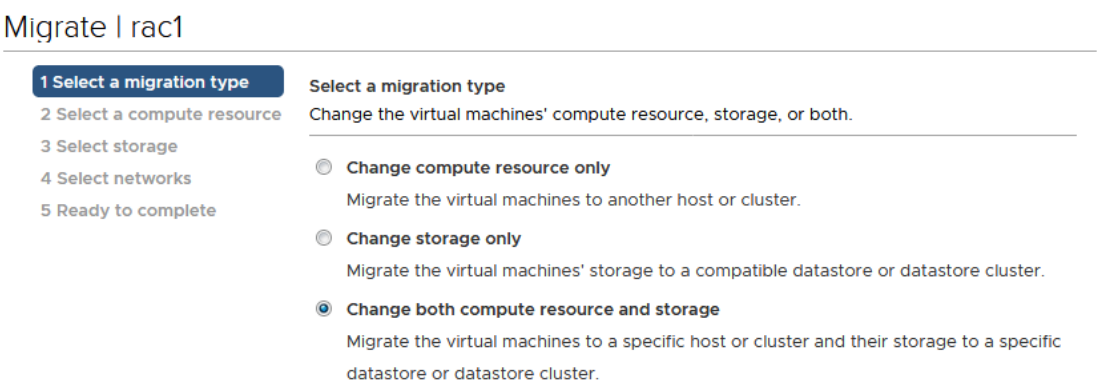


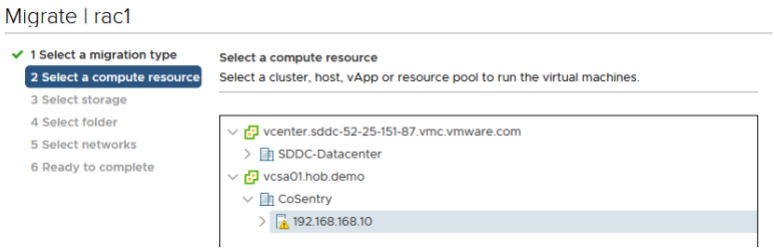
d. Migrate both compute and storage

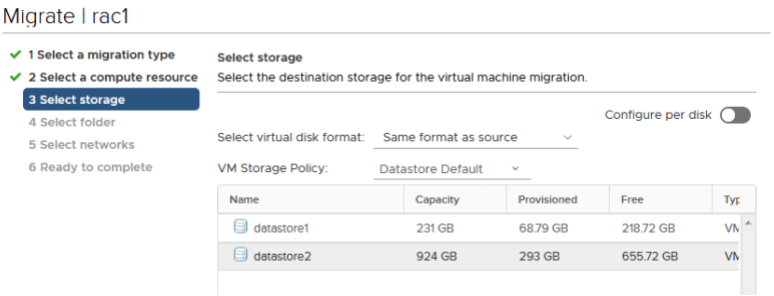


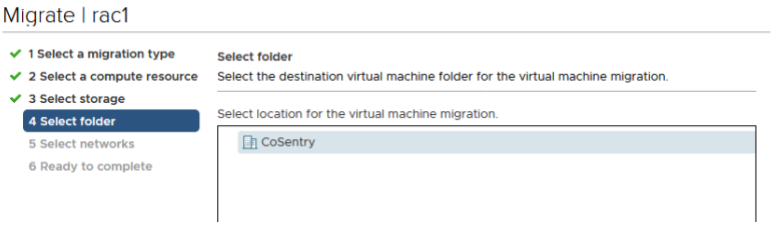
2. Live (if NSX) or cold migrate the primary node
   a. Leave shared disks attached so they get moved as well





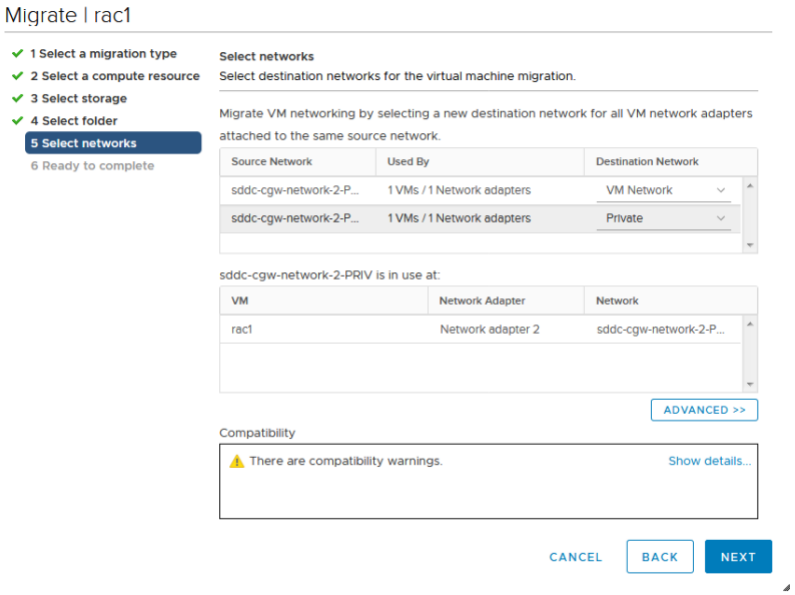


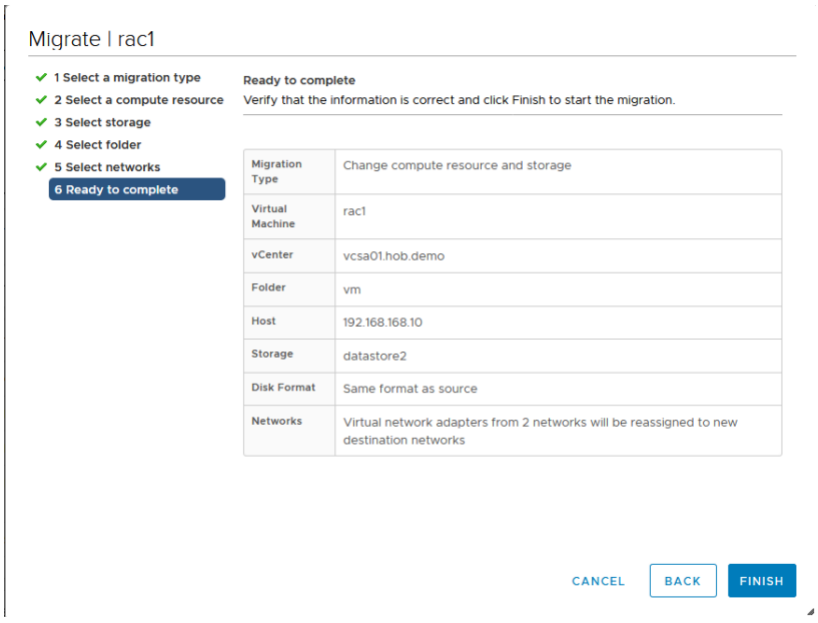




Validate any compatibility warnings and press 'Next'. Without NSX at both sites, network warnings are likely, but usually safe to ignore. With NSX (required for live migration) there should not be warnings because the network device mapping will already be established for the stretched network(s).

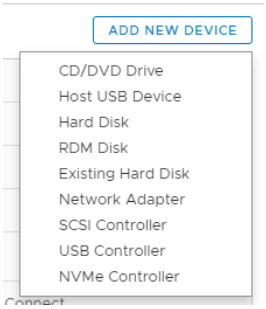
NOTE: A free NSX edge appliance can be deployed offering a minimal NSX capability on-premises for this purpose. A link to download / deploy the appliance will be provided upon request once your service is established.

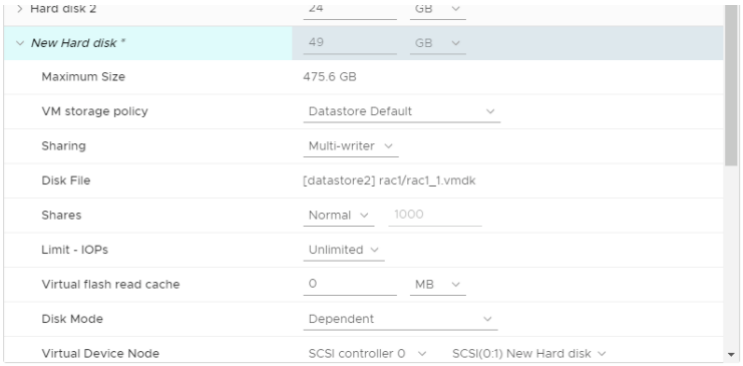




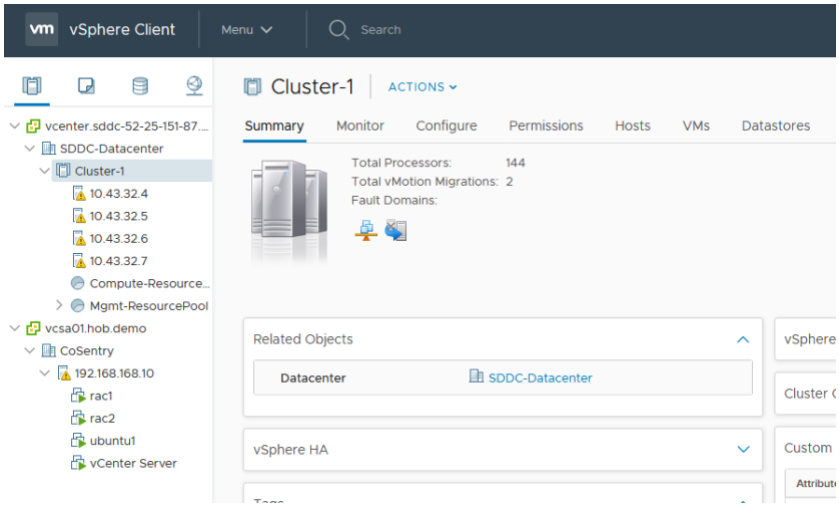
3. If necessary reconfigure client networking
4. Boot primary node (if not migrated live)
    a. Start applications
5. Reestablish the inactive Cluster nodes

a. Reconnect shared disks





b. Boot inactive cluster nodes



c. Check client load balancing

NOTES

1. The consolidated view of vCenter is only available from the SDDC side via the Hybrid Link Mode feature. The on-premises vCenter does not show the SDDC resources.
2. The objectClass, and other properties, are not well defined for on-premises identity service, but it seems to be fairly flexible (see Appendix A for sample LDAP).

We encountered a new caveat related to the Storage vMotion issue and RAC shared disks, as identified above. During the migration of the storage from on-premises to our VMC environment, the default storage policy reconfigured our disks to thin provisioned. So, in order to reestablish them as valid shared disks for RAC (with the multi-write flag enabled), we had to first expand them to be thick provisioned again.

Cold Migration

Other than the previous note about thin vs. thick provisioned storage, the migration worked like any other linked-mode migration.

Live (Hot) Migration

Configuring and testing the NSX layer that would have facilitated live migration is outside the scope of this white paper. However, nothing encountered would lead House of Brick to believe that there would be any additional issues beyond what was experienced with the cold migration.

Disk Expansion

In order to expand a disk from thin-provisioned to thick-provisioned under a running VM, House of Brick made use of the Storage vMotion capability and changed the provisioning at the same time as relocating the shared disks to a common folder. After the migration, the disks will typically be located in the same folder as the other VM disk files. Once the disks are expanded and the multi-write flag is set, then the remaining nodes can be configured to add the existing shared disks and then booted as described previously.

Additional Considerations

Oracle Licensing Options

Because VMC on AWS uses bare-metal, it is easy to identify the actual hardware supporting your environment and license it using traditional (hardware-based) metrics.

For very large deployments, this might make sense. However, at the present time (due to several restrictions), the entire SDDC must be licensed. The primary factor preventing sub-cluster licensing is the lack of tools for managing where VMs can/should run, although House of Brick has been told that may be changing. Specifically, the lack of user-editable DRS rules prevents the creation and management of [anti-] affinity rules (including “Must” rules) that would normally be used to restrict VMs to licensed hosts. Although there are other mechanisms that can be applied on-premises, none of them are available yet for VMC on AWS. An exception to this licensing restriction, however, is if there is a

single virtual machine running Oracle in the SDDC. Whenever this single VM moves, it could be considered an uninstall operation, and a subsequent re-install on the target host. In this case, only one host would ever have Oracle installed and/or running on it, and only one host would need to be licensed. Two VMs would have to license two hosts, and so on.

For now, the minimal licensable hardware consists of four, 36-core hosts, for a total of 144 cores. After applying Oracle's 0.5 core factor for x86, that is 72 processor licenses, or a minimum of 1,800 named users. The only option at that scale is, of course, Oracle Enterprise Edition. List prices for Database[1] are shown in the following table:

Oracle Database Edition	List	25% Discount	Annual Support
Enterprise Edition – Processor Perpetual	$3.42M	$2.56M	$560K
RAC Option – Processor Perpetual	$1.44M	$1.08M	$237K
Enterprise Edition – Named User Plus Perpetual (Minimum 1,800 Users)	$1.71M	$1.28M	$282K
RAC Option – Named User Plus Perpetual (Minimum 1,800 Users)	$720K	$540K	$118K

Oracle's Cloud Licensing Policy

Oracle has published a policy document called Licensing Oracle Software in the Cloud Computing Environment (Oracle cloud policy). This policy provides a means for customers to license Oracle software by the number of vCPUs that are in use, rather than by physical processor core. For most Oracle database and middleware products **except for RAC** (see below), this policy may be used to license Oracle environments deployed using VMC on AWS. House of Brick Technologies (HoB) has previously commented that the policy may impose a price/performance penalty of 2x to 4x compared to traditional metrics. But given the other benefits, it may be well worth considering. Below is an excerpt from the recent blog, Licensing Oracle on AWS: Opening a Window Wide to the Cloud, by House of Brick CEO, Nathan Biggs.

> "Because of the unequivocal statement that VMC on AWS is "Amazon EC2" and Oracle's requirement for cloud authorization is EC2, **House of Brick is now prepared to endorse that our customers consider the cloud policy as a valid option for licensing Oracle in all AWS deployment configurations (including VMC on AWS)**."

One large caveat to considering whether to use Oracle's cloud licensing policy in the VMC on AWS is that **Oracle Real Application Clusters (RAC) is not included on the list of products authorized by Oracle to**

[1] Prices listed as of May 1, 2018 and are subject to change at any time.

use this policy. Thus RAC workloads, such as the one tested by House of Brick for this whitepaper, must be licensed by actual physical processor cores.

Of course, any decisions on licensing Oracle products, including the use of the cloud policy from Oracle, should first be validated with your legal advisors. Special attention should be paid to contractual terms, and those policies promoted by Oracle that are not contractually-based.

Conclusions

The Good

At the end of the day, the migration worked pretty much as expected. As experienced vSphere administrators, familiar with linked-mode, House of Brick did not encounter any significant surprises.

a. Everything works as advertised
b. Performance met, or exceeded, expectations
c. Process did not feel overly complicated
d. Free NSX Edge appliance is available for shops not already using NSX
e. Migration from the cloud to on-premises was seamless
f. Oracle Cloud Licensing Policy can be applied for smaller workloads (but not for RAC)

The Bad

The environment we used indicated a 6.7 version number that had not yet been released as GA, and in several places indicated "beta". Our experience with the offering at House of Brick left us feeling that it still needs more maturity. Hopefully in future releases, obvious flaws like needing to change the default identity source and the lack of an indicator in the Hybrid Linked Mode vSphere feature when something is wrong with the Hybrid Link Mode are obvious flaws. Another key concern is that some things that experienced, vSphere administrators are used to being able to tweak (storage policies, and [anti-] affinity rules in particular) are off limits. Additionally House of Brick found several quirks such as UI inconsistencies and the fact that migrating shared disks to the cloud required a workaround due to storage policies not allowing VMDKs to keep Eager-Zero Thick-Provisioning. Note: VMware has told House of Brick that they are fully committed to addressing these issues in upcoming releases.

In general, House of Brick found the environment (including the interface and availability of specific settings) is still suffering a little from lack of maturity compared to on-premises vSphere capabilities, but we did not encounter any deal-breaking issues.

The (not so) Ugly

House of Brick did not encounter anything in the environment itself that could be considered truly ugly. In fact, quite the opposite is true. "Not fully mature" is about as strong a criticism as we could offer. However, licensing Oracle with traditional core-based metrics in VMC may still be prohibitive when considering the needs of the actual workload and the number of cores requiring a license in a VMC cluster. Because of the current lack of means to limit licensed cores in a VMC on AWS cluster, If an

organization does not have the need for 144 cores (72 processor licenses, or 1,800 named users), then they may be limited by the licensing considerations discussed previously.

NOTE: DRS rules and other vSphere mechanisms to restrict where specific software is installed and/or running are currently unavailable – so for now, licensing must account for a minimum of 144 processor cores distributed across the four nodes, for software such as Oracle that is licensed on a processor core metric.

Recommendation

Running RAC on VMC on AWS is sufficient for many workloads and, due to the ease of migration, moving non-critical workloads would be a great way to get started while the offering continues to mature. Overall, House of Brick's experience was very encouraging and there is much to be excited about with this technology. The VMC on AWS is particularly attractive as a DR target, or as a solution to expand capacity, for organizations already leveraging vSphere . It offers an almost frictionless ability to leverage cloud resources without needing to retrain personnel on a new platform or tackling a costly migration project.

References

White Paper: Deploying Database-as-a-Service with Pure Storage and VMware
Product Information: vRealize Orchestrator

Additional Resources

DBaaS Blogs:
DBaaS Overview
5 Things a Business Person Should Think About When Considering DBaaS

Oracle Licensing Blogs:
Licensing Oracle on AWS: Opening a Window Wide to the Cloud
Soft Partitioning on VMware is Your Contractual Right
Managing Oracle Licensing in a Shared Storage Environment

Appendix A – LDAP

Shell script used to establish basic LDAP schema for use with AWS / Hybrid-Linked mode (replace the highlighted values with your own organizational values):

IMPORTANT NOTE: Your LDAP server and SDDC should use a common time source to ensure successful authentication.

```
#!/bin/bash

ldapadd -x -c -D cn=admin,dc=hob,dc=demo -W <<EOLDIF
dn: ou=People,dc=hob,dc=demo
objectClass: organizationalUnit
ou: People

dn: ou=Groups,dc=hob,dc=demo
objectClass: organizationalUnit
ou: Groups

dn: cn=awsadmin,ou=Groups,dc=hob,dc=demo
objectClass: groupOfUniqueNames
objectClass: top
cn: awsadmin
description: AWS Administrators
uniqueMember: uid={uid attribute},ou=People,dc=hob,dc=demo

dn: uid={uid attribute},ou=People,dc=hob,dc=demo
objectClass: inetOrgPerson
objectClass: posixAccount
objectClass: shadowAccount
uid: {uid attribute; example 'mstone'}
sn: {last name}
givenName: {first name}
cn: {first name} {last name}
displayName: {first name} {last name}
gecos: {first name} {last name}
uidNumber: 10000
gidNumber: 5000
userPassword: {plain text password}
loginShell: /bin/bash
homeDirectory: /home/{uid attribute}
EOLDIF

ldapsearch -x -LLL -b dc=hob,dc=demo 'uid={uid attribute}' cn gidNumber
ldapsearch -x -LLL -b dc=hob,dc=demo 'cn=awsadmin' cn uniqueMember
```