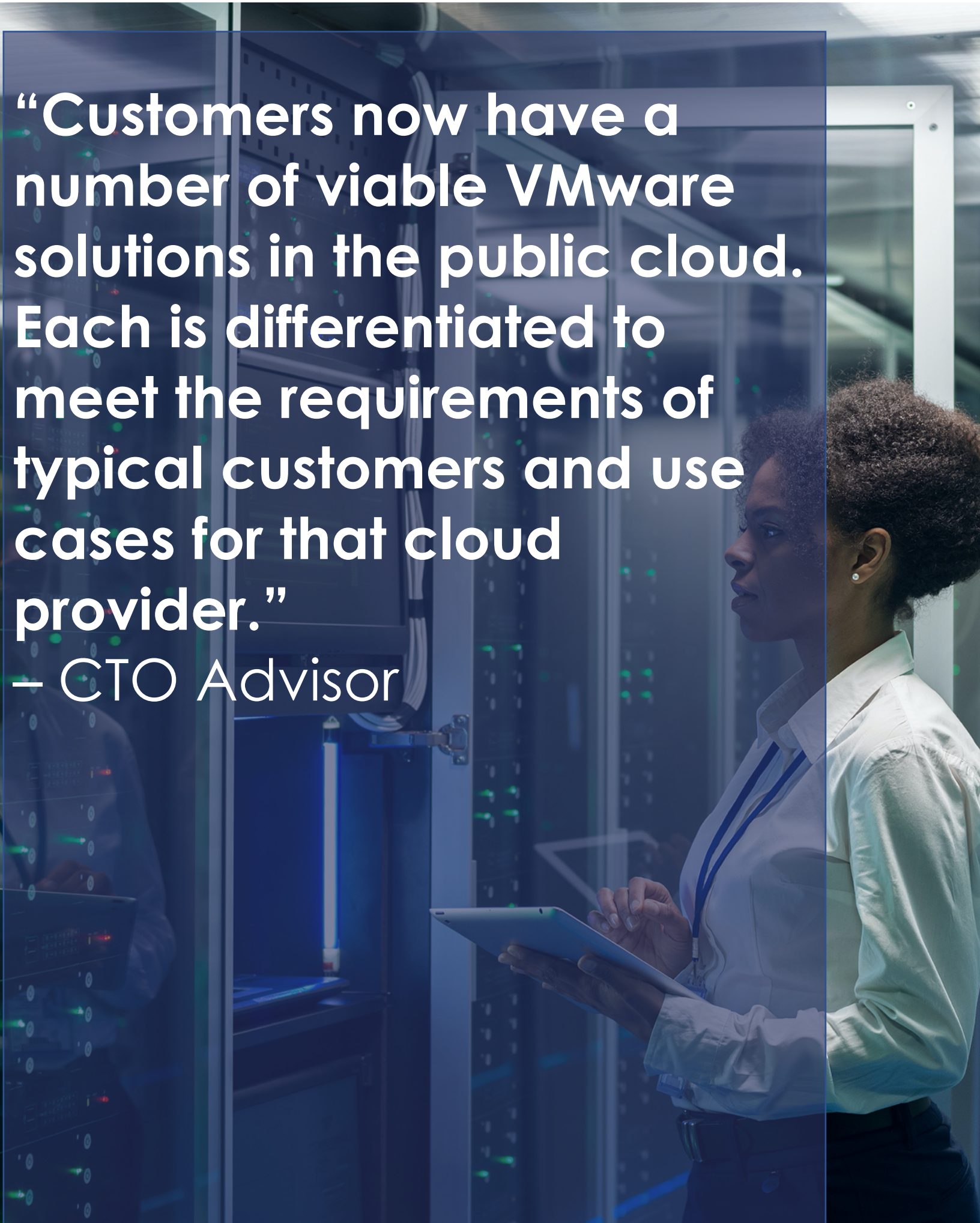
Comparison of VMware Cloud Options

Sponsored by Oracle Cloud Infrastructure

Authors:

Matt Leib – Contributing Analyst, The CTO Advisor LLC
Keith Townsend – Principal, The CTO Advisor LLC



“Customers now have a number of viable VMware solutions in the public cloud. Each is differentiated to meet the requirements of typical customers and use cases for that cloud provider.”

– CTO Advisor

Executive Summary

According to this report's authors, hybrid infrastructure is an operating model, not a place. (Townsend, 2019) Regardless of the use case, enterprise IT organizations find the need to run traditional workloads alongside the modernized application stack. Decision makers are challenged with gaining the operational experience needed to deploy and manage modern applications while maintaining the traditional application landscape.

VMware's vSphere hypervisor remains the primary choice for IT teams that want to deliver high-performing and resilient infrastructure. While organizations have de-emphasized the need for privately owned data centers, the demand for vSphere-managed workloads remain consistent. According to Synergy Research Group (Synergy Research Group, 2020), private data spending has remained solid over the past 10 years. At the same time, the study shows growth in public cloud spending growing from $0 to $100B over the same time period. As a result, each of the major cloud providers have introduced a cloud-based VMware vSphere offering.

Here are the key findings of the research and testing of the CTO Advisor team:

- Each solution is representative of the individual cloud provider's approach to hybrid infrastructure and application modernization.
- The staff's learning curve to deploy and manage each solution varies widely and is highly dependent on the operations team's knowledge of the target cloud control plane.
- The bare-metal configuration for each solution varies and may dramatically impact workload cost between cloud solutions.
- The cloud provider's network design will have significant effects on the level of integration with native cloud services.
- Due to the differences in cloud control planes and vSphere implementation details, managing vSphere across more than one cloud provider via a single operations team may prove a difficult endeavor.

There's not a winner-takes-all result with these solutions. Each of the three solutions we evaluated is viable, but fall into two broad strategies. One approach is to give full control – Oracle succeeds here by most closely replicating an on-premises VMware environment, enabling full transfer of skills, tools, and experience. The second approach is a "SaaS-like" experience – AWS and Google succeed here by layering on more automation and abstracting the infrastructure. Regardless of your cloud vendor preference, you'll find this report informative in understanding the opportunities and hurdles in adopting vSphere in the public cloud.

Report Overview

As organizations tackle the challenge of modernizing their application landscape to take advantage of the public cloud, executives are challenged to provide a smooth transition. Lift and shift of the existing VMware landscape into the public cloud provides an eased transition from on-premises operations to public cloud operations.

This report focuses on hands-on operational testing of a real-world issue for many organizations: to expand their environments into the cloud with as little transformation of methodology as possible. The scenario we examine is a common one; a virtual desktop infrastructure (VDI) environment, already in place, that must be extended to the cloud and run consitently as it has been. To reduce risk, the requirement is to maintain the performance, operation, and management of the native environment as closely as possible, with as little modification as possible to expand, extend, or even enhance the operations. Our testing environment used VMware Horizon, one of the leading VDI solutions on the market today.

There are a number of approaches to running a VMware-based Horizon environment on the various public cloud architectures. The purpose of this project is to illustrate the pitfalls, the successes, the variances in approaches, and the ultimate outcome of such a project. Comparison of proven solutions takes an approach that everything will ultimately work. However, getting there and doing the work necessary to prove this out is not something all customers have the bandwidth to perform.

For the purposes of this report, The CTO Advisor staff adopts the persona and activities of an IT team tasked with performing these migrations and testing the outcomes.

> Lift and shift of the existing VMware landscape into the public cloud provides an eased transition
>
> - Keith Townsend

Vendor Landscape

VMware has long held the lion's share of the virtualization market. As of 2017, VMware captured over 80% of the hypervisor market (Chen, 2018). The concept of running true native VMware on cloud-based platforms, however, has presented a challenge. While many approaches have been tried, the concept has long been seen as the brass ring. Other approaches to stand up separate data center spaces within Azure, AWS, and Google Cloud have existed since the inception of these solutions, but operations teams have struggled to adopt a native cloud approach to running existing workloads.

In this study, we began by defining the players, specifically: AWS, Google Cloud Platform, Microsoft Azure, and Oracle Cloud Infrastructure. During evaluation, the Azure solution changed models quite dramatically, as Microsoft removed the model based on CloudSimple. By doing away with new implementations on the CloudSimple model, we determined that the Azure SDDC (Software Defined Data Center) approach would not be viable. The new model would not be ready with an out-the-door solution in the timeline required. Thus, we chose to exclude Azure from this project's testing list.

Oracle Cloud Infrastructure VMware Solution

The newest offering to be made into the extension of an on-premises data center into the cloud, Oracle's Cloud Infrastructure (OCI) performs far more like a bare-metal implementation than other solutions -- because that's what it is. Oracle gives access to the underlying hardware inclusive of the storage configuration. The model is so VMware-centric that it can be operated by a savvy engineer experienced with VMware products -- without much additional knowledge. As long as the enhanced linked mode or "FastConnect" is in place, all additional operations, regardless of locale, will operate precisely as if the administrator's environment is stretched from the primary to a secondary data center.

Oracle's VMware solution follows the methodology of the parent Oracle Cloud Infrastructure. The concept of OCI is the ability to shift existing applications as they are into the data center. For example, OCI supports Layer 2 networking within a Virtual Cloud Network (VCN). Customers can bring, without reconfiguration, an existing clustered application that leverages multicast to establish clustering. The L2 connection today is limited to VMware-to-VMware stretch clusters. This particular component appears ripe for expansion.

More valuable is the ability for Oracle to offer the solution in each of their regions, 19 regions as of this writing, with no additional infrastructure or development. Oracle claims this tight integration results in the VMware Solution looking like any other native cloud service offered by Oracle Cloud Infrastructure.

The value of this solution is that there is a minimal learning curve. It's a customer's VMware implementation on top of Oracle's hardware -- gated, secured, managed, and controlled by your existing VMware staff, yet housed on OCI's hardware. The flattened learning curve means the customer can be up and running as soon as the data pipe is in place. Wizards exist to build the SDDC implementation, the Horizon View architecture, and many other components of the required VMware solution, practically out of the box.

iSCSI and NFS Storage

The model is so emphatically different from the other cloud providers that you may actually bring in storage of your own to an Oracle data center and attach that as well to your VMware environment housed in an Oracle data center. Oracle doesn't support this feature as of this report. However, The CTO Advisor testing team set up an NFS share on a Windows machine and was able to mount it as a datastore. We'd advise customers to discuss this use case with both Oracle and VMware. Oracle allows for a cross-connection via FastConnect to be placed within the local Oracle point of presence, using that connection to mount it to OCI, then, using a replication, such as NetApp's SnapMirror, to replicate this storage from the on-premises data center to the OCVS.

VMware Cloud on Amazon Web Services (VMC on AWS)

Since its inception, Amazon Web Services (AWS), the most mature of all the major platforms, has had its own approach to the creation of virtual server platforms in the cloud. It's grown in many ways since the beginning and has been capable of creating a great deal of value for many organizations.

VMware delivers VMC on AWS as part of its VMware Cloud suite of solutions. At the surface, this may seem like a technicality. Unlike the other solutions tested, however, VMC on AWS isn't available via the product dashboard of the native cloud provider. A separate business and technical relationship is established with both VMware and AWS.

VMware Cloud on AWS opens the opportunity for a customer to extend its existing VMware infrastructure to AWS, within certain parameters. VMC on AWS is delivered similarly to a software as a service (SaaS) offering. For example, VMware places guardrails around the vSphere experience to ensure the solution can be upgraded across multiple customers without customization of each customer's experience. As such, there's no access to the underlying hardware platform via traditional vSphere tooling.

With appropriate bandwidth and licensing, a customer may clone a set of servers on AWS, run them on their infrastructure and achieve satisfactory results. Most of the functionality remains the same, but there are nuances in how it works. There are limits to the granularity of control and the visibility into the hardware an administrator has over hardware, and over the performance of these hosts, thus the guests as well. VMware Cloud on AWS is a powerful step toward extending the on-premises architecture onto AWS.

Google Cloud VMware Engine (GVE)

A key differentiator on the GVE lies in the quality of its wizards. Many wizards allow for clicking on a link, which will trigger the deployment of a fully qualified, hosted VMware-based infrastructure. Unlike the other tested solutions, GVE doesn't support connecting the vCenters in Linked Mode.

The solution is more of a hybrid of the OCI and VMC on AWS solutions. As mentioned, each of these solutions tend to align with the parent solution. Google's focus is leveraging its network and Kubernetes capabilities, and GVE exhibits many of these characteristics.

Similar to VMC on AWS, the SDDC resides in a different VPC as the customer's primary Google account. This means networking is similar to AWS on VMC.

During a briefing for the product, Google representatives said that while VMware's NSX-T offers powerful capabilities, such as cloud network overlays, customers would leverage Google's native network capabilities for integration of hybrid and multi-cloud use cases. It's not apparent which features would further enable the existing VMware software-defined network.

Similar to native network capabilities, Google believes customers would leverage Google Anthos for the management of container instances in the SDDC vs. VMware's Tanzu Mission Control.

Common Use Cases

Disaster Recovery

Disaster recovery (DR) is one of the most common use cases for cloud-based vSphere deployments. By design, VMware workloads are encapsulated in a set of virtual disk images. Thus, VMware abstracts the application and data from the infrastructure. The VMware ecosystem has a long history of DR support via storage replication.

Traditional DR solutions required organizations to enact a DR site that made a substantial commitment to compute resources equal to the amount of capacity required. Today, the DR requirements both can be and are demanded to be more robust. Because of cloud-based VMware vSphere solutions, businesses enjoy shorter recovery time objectives (RTO) and near real-time recovery point objectives (RPO) while embracing a pay as you go cloud costing model.

Leveraging many of the VMware-supported file-based replication solutions enables operation teams to replicate and recover entire data centers to the public cloud without incurring the high cost or operational complexities of maintaining a hot site.

Cloud Bursting

Cloud bursting has long been the nirvana of hybrid-infrastructure design. A common use case is the ability to move or expand workloads into the public cloud as demand outstrips the capacity of the private data center.

Extending the data center into the public cloud is the ultimate goal of the project. In this case, that means extending an internal VDI environment into the chosen cloud provider's data center. Scale-up and scale-down capabilities would prove quite beneficial to a somewhat static data center build. The ability to utilize an on-demand model to add and remove architecture as needed can be compelling. On a typical depreciation schedule, 5 years of ownership of hardware that is static and potentially under-utilized or even non-utilized doesn't

Common Use Cases

make financial sense. This is not to say that `truly efficient. Appropriate research should be put into place to ensure that the financial model makes sense.

Migration

Migration may be one of the most marketed use cases for cloud-based VMware solutions. In theory, customers can simply use vMotion to move workloads to the public cloud without modification of the underlying application. Once running in vSphere in the public cloud, application teams can begin to re-platform the application. A common scenario includes taking the components of a three-tier application and moving them to native cloud services.

While re-platforming the application is often the ultimate goal, most customers start by simply moving their VMs to the public cloud. The technique is referred to as lift and shift. All of the reviewed solutions enable the lift and shift of existing workloads into the public cloud. By leveraging a high-bandwidth connection and VMware HCX, customers can simply move workloads from the private data center to any public cloud via vMotion.

Migration without the HCX functionality into a cloud space becomes a case of cloning the existing infrastructure to that of the particular cloud provider. This must be done while the application or data is in a static state, meaning the application is not writing actively to the database at that moment. Images may simply be copied.

Testing & Results Summary

Use Case

The CTO Advisor discussed the challenges presented by the Covid-19 pandemic to enabling remote workers (Townsend, YouTube, 2020). The solution presented by the CTO Advisor In a typical enterprise, pre-pandemic systems may have had the capacity for a few hundred concurrent remote workers. During the pandemic, an enterprise may require thousands of concurrent connections. It was precisely this scenario on which we based our ideal test case.

The pandemic created a mini-DR scenario, in which organizations needed to increase capacity virtually overnight. Procuring and implementing that capacity within the timeframes dictated by the pandemic may have proven too much for many enterprises. Now, months on, we are still seeing the problem of addressing this issue and hope we have provided some food for thought for organizations who've struggled with these decisions.

The CTO Advisor's data center operations team is representative of an enterprise IT department that may encounter the need for instantaneous increased capacity. The existing solution is a 4-year-old VMware vSphere cluster nearing the end of its lifecycle. Via a cloud broker, the team has access to a 10Gbps connection to public cloud providers.

By leveraging an all-VMware solution, The CTO Advisor team will take advantage of existing operations and tools to extend its virtual desktop infrastructure into a public cloud provider. The hope is that the minimization of the risk associated with cloud bursting via a consistent operating model that mimics in as close a manner as possible those the representative organization has used previously.

Note: Cloud providers weren't immune to the challenges of manufacturing and shipping delays and limited personnel. At least one of the major cloud providers placed limits on the ability of customers to add capacity to existing environments for roughly 5-8 weeks while the provider increased its own capacity.

Testing & Results Summary

Test Use Case - VDI Cloud Bursting

The testing performed assumes the business and technical decision to move forward with one of VMware's cloud partners has already been made. Our testing takes a proof-of-concept approach that would be appropriate prior to full implementation. Success criteria are listed in the Appendix under "Areas Tested."

The team tested Oracle Cloud VMware Solution, VMware Cloud on AWS (VMW on AWS), and Google Cloud VMware Engine (GVE).

The design requirements include a stretched vCenter and Horizon View environment. The VMware environment can be managed from within the on-premises VMware infrastructure.

Key to the rationale for the utilization of the cloud for these functions were the following objectives:

- Elasticity of a cloud-based infrastructure; resolving the lack of ability to scale the current solution
- Ability to connect from the management interface to either the on-premises or the cloud-based infrastructure
- Capability to increase capacity without shifting technical operations or training end users on a new remote access solution.

VMware Cloud Study – Summary of Key Test Results

The following sections summarize the key findings of the operational testing of 3 major VMware vSphere solutions offered by major cloud providers.

"Horses for Courses" market landscape

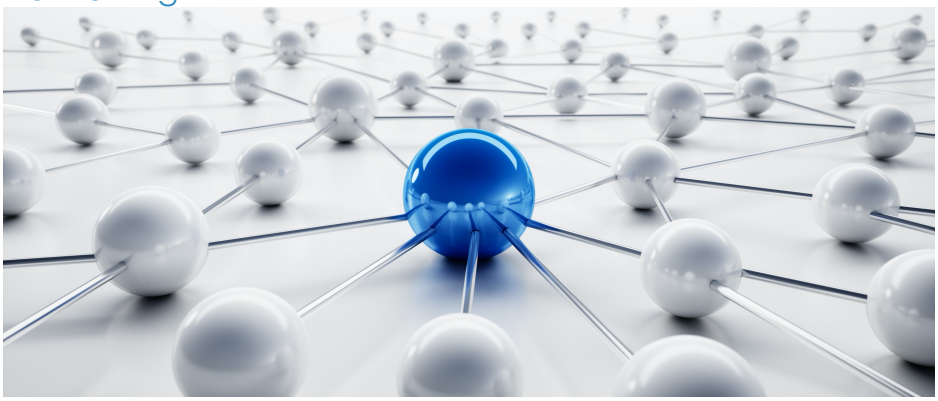
There is no clear-cut, technically superior solution. The solutions are designed to meet the requirements of typical customers and use cases appropriate for the overall offering of each cloud provider. For example, Oracle Cloud Infrastructure highlights its ability to support existing enterprise applications and operations. Oracle Cloud VMware Solution carries this theme throughout the technical solution by providing bare-metal access to the user. We like to call it "Expert VMware Mode" in the public cloud, because it allows experts to access all platform features.

Testing & Results Summary

On the other end of the spectrum is VMware Cloud for AWS (VMC on AWS). VMware Cloud on AWS implements guardrails that reduce the risk of organizations misconfiguring the system and creating performance and availability problems. However, it also limits the ability of customers to leverage existing tools and operations.

Data protection and recovery highlighted this difference in approach. Both VMC on AWS and GVE provide data protection for the configuration state of the VMware vCenter Server Appliance (VCSA), which holds the configuration state of the vSphere implementation. Both providers leverage proprietary methods for backing up the configuration state of the SDDC. Contrast that to Oracle Cloud VMware Solution, which allowed the CTO Advisor team to back up the VM using our on-premises installation of Veeam Backup and Replication.

Networking



Networking may be the most substantial area of difference between the solutions. Each solution leans into the strengths and, therefore, weaknesses of the platform.

Two areas highlight this strength in networking. The first was connecting the CTO Advisor data center to Oracle Cloud Infrastructure via cloud broker Megaport. OCI, which has a reputation for robust network design and performance, allows dynamic reconfiguration of the port speed to enable the scaling of the connection based on demand. A connection to VMC on AWS via Megaport required a complete teardown of the Direct Connect to adjust the bandwidth. Google enabled the changing of bandwidth in predefined increments from 50Mbps up to 10Gbps.

Combining the flexibility of OCI FastConnect with Megaport's API enables customers to dynamically scale bandwidth as replication needs

Testing & Results Summary

to expand and contract without tearing down the connection as required by AWS.

A second example is that, unlike the other cloud providers, Oracle allows direct Layer 3 traffic between the customer's virtual cloud network (VCN) and SDDC. The architecture simplifies the management of traffic between the SDDC and the VCN. For example, we were able to leverage a single security policy administered at the VCN layer via the OCI control panel. Thus, setting up a connection between a VM existing in the SDDC and an OCI service, such as a DBaaS, results in a collapsed architecture.

In comparison, VMC on AWS exists in a VMware-owned virtual private cloud (VPC). It creates both management complexity and the inability to offer support for multicast, the SDDC, and VPC. Both Google and VMC on AWS require an NSX-T overlay to communicate between a VM in the SDDC and a native cloud service.

Security and Compliance

Google and Oracle have similar approaches to delivering the VMware infrastructure. Each provider provisions and manages the physical underlay of the solution. For each of these providers, there is a single point of contact for an audit of security and compliance. The VMware SDDC for each solution inherits the parent cloud's physical and logical controls. In addition, the Oracle solution allows full administrative access and control to the bare metal servers, the SDDC infrastructure software, and the vCenter management server. Operational, security and lifecycle processes in Oracle Cloud can remain the same as in on-premises infrastructure.

Unlike the other solutions, VMware manages VMC on AWS, while AWS provides the underlay. The VMC on AWS model creates a dual set of vendors to collaborate with when auditing the SDDC and native cloud solution.

Maturity of Solution

The Google and Oracle solutions have only recently been made generally available to customers. Although SDDC functionality was similar on all the platforms, our engineers experienced many of the early pains associated with newly available solutions, especially where the SDDC cluster interacted with the public cloud functionality. There were few, if any, tasks that could not be completed on each platform. The primary difference is the ability to ramp up. Learning the GCP and

Testing & Results Summary

> While the VMware vSphere experience remained consistent, the integration of the native cloud infrastructure raised the complexity of managing vSphere across multiple cloud providers. There's no true single pane of glass across all 3 providers. For example, there are 3 ways to implement connectivity to your on-premises solution and 3 ways to expose a public IP in your SDDC.

the AWS interfaces, as well as migrating to the newly deployed SDDC model within each platform creates that ramp up.

A simple example, each solution takes a different approach to exposing a VM to the public internet. OCI uses an OCI provided load balancer. VMC on AWS has a wizard that assigns a public IP in the VMware managed VPC. Operationalizing this simple task also shows the complexity of managing multiple clouds. Operations teams must educate themselves in the nuances of each cloud control panel to implement the same feature across cloud providers.

The ecosystem around community support for VMC on AWS has a head start over the ecosystem for OCI VMware Solution. Our engineers were able to find many quick-start guides to simple tasks for VMC on AWS.

In our testing, support teams at Google and Oracle were able to quickly issue installation notes for first-time tasks.

Ease of Use

While ease of use can be determined in a number of ways, the method The CTO Advisor most emphasized was the one that answered the question: If I am a VMware administrator, which would most likely be the solution that featured the smallest learning curve, required the least effort in standing up, and provided the smoothest migration.

Ease of use may be one of the most qualitative measures of this study and subjective to each organization's staff. Collectively, the CTO Advisor team has well over 40 years of experience designing, building and administering VMware vSphere.

The Oracle Cloud VMware solution is the most consistent experience with on-premises vSphere. We found the team's inexperience with the larger OCI solution the primary barrier to adoption. While our testing team was able to perform native vSphere tasks quickest in Oracle Cloud, tasks requiring integration with the OCI environment took the most time to perform the first time because the steps needed to accomplish those needed to be learned. For example, exposing the Horizon web interface to a public IP required our team to come up to speed with Oracle Cloud networking.

Testing & Results Summary

VMC on AWS and GVE both had the additional challenge of slightly different implementations of VMware vSphere from on-premises vSphere and the learning curve of adapting native cloud services such as public IP access. As explained above, the AWS and GVE implementations required the nesting of the ESXi hosts such that the hosts themselves are virtual machines, while standing up ESXi within Oracle's Cloud Infrastructure actually places ESXi onto bare-metal hosts. This differentiation alone, makes the whole picture more robust. In addition, the ability to leverage NSX, Horizon View, and other components of the VMware portfolio as native products make the OCI implementation more specifically like that of the on-premises installation.

Speed of Deployment

We determined that "Day 0" speed of deployment fell lower in priority on our scenario's list of requirements. However, it is interesting to note the differences between cloud platforms. On Oracle's Cloud Infrastructure, for example, the deployment from clicking on the wizard to a full SDDC-based platform took roughly 2.5 hours. The same procedure on VMC on AWS took 2 hours. Google VMware Cloud Engine deployed the SDDC within 35 minutes.

The process of adding and removing hosts on each platform was fairly straightforward and presented no material operational difference.

Support Experience

The support experience when engaging with Oracle on OCI and Google with GVE was a fairly consistent "White Glove Experience" that offered quick responsiveness and high visibility, often escalating up to the product managers responsible for the VMware Cloud Platform. The Amazon VMC on AWS support experience was typically initiated via chat, which would result in a response within 5 minutes, day or night.

Overall, the experience for these mature or brand-new offerings provided a comfortable enterprise feel, enabling any operations team the comfort to know that they will be heard and responded to whether in Day 0 setup or Day 2 and beyond production operations.

Conclusion

Horses for Courses

Customers now have a number of viable VMware solutions in the public cloud. Each is differentiated to meet the requirements of typical customers and use cases for that cloud provider

Which platform is the right choice for your VMware applications? It depends on your strategy for leveraging the public cloud.

Each platform confidently implements the known strengths of VMware. Customers should consider the following factors when deciding between the platforms.

- Staff familiarity with the target cloud platform
- Technical network requirements for lift and shift of application migrations
- The integration of SDDC life cycle with existing and future change management and service management requirements
- Total cost of ownership including egress networking cost
- Ability to meet organizational compliance, security, and audit requirements
- Availability of services in the desired geographic region
- Integration with native cloud services

Appendix

Areas Tested

- Monitoring
  - Integration into a single console (vROP)
  - Parallel deployment of vROP
  - Requires new solution
- Data Protection
  - Integration of existing solution
  - Parallel deployment of Veeam
  - VM Level Restore
  - File Level Backup
  - File Level Restore
  - vCenter (or equal) Settings Backup
  - vCenter (or equal) Settings Restore
- Migration
  - vMotion on-prem to Cloud
  - Establish Network Connection
  - Stretch Layer 2 for vMotion (HCX)
  - Configure VM-Networks
  - Cold move from on-prem to Cloud
- Management
  - Perform manual vMotion
  - Perform manual Storage vMotion
  - Create Affinity Rule
  - Configure DRS
  - New Host Provisioning
  - HCX installation and configuration
  - vCenter Link Mode
  - Failure mode testing
  - Clone & Deploy Local VM
- Authentication
  - vCenter AD Integration
  - Login to vCenter
  - Delegate vCenter role
- VDI Experience/Functionality
  - Deploy desktop instances
  - Network traffic path
  - Instant Clone
- Cloud Services
  - Cloud-Hosted Database or Storage Service (Out of Scope)

Test Methodology

Key design decisions:

- Data protection: An on-premises version of Veeam Backup and Replication for all backup and data recovery.
- VMware Horizon/View will be extended out to each public cloud provider
- Where available, VMware Link Mode will be leveraged
- On-premises Active Directory for authentication with a connection via two-way trust to the dedicated AD environment within each cloud provider.
- Established vCenter Linked Mode for single pane of glass administration
- Leverage 10Gbps Megaport connection to establish "Direct Connection" to each cloud provider

CTO Advisor Hybrid Infrastructure

On-Premises: CTOADC – QTS Chicago Data Center
Hardware: (3) Dell R730XC/128GB RAM/16-Core Xeon processors
VSAN: hybrid array
Hypervisor: vSphere 6.7u3
VDI: VMware Horizon v.7.9

Oracle Cloud Infrastructure:
Region: US East (Ashburn)
Hardware: (3) Oracle Server X7-2L/768 GB RAM/52-Core Xeon processors
VSAN: NVMe all-flash
Hypervisor: vSphere 6.7u3
VDI: VMware Horizon v.7.9

VMware Cloud on AWS
Region: US-East-2 (Ohio)
Hardware: (2) AWS i3/512 GB RAM/36-Core Xeon processors
VSAN: all-flash
Hypervisor: vSphere Cloud (base off of 7.0)
VDI: VMware Horizon v.7.9

Google Cloud VMware Engine
Region: US-East-4 (Ashburn)
Hardware: (3) ve1-standard-72/768 GB RAM/36-Core Xeon processors
VSAN: NVMe all-flash
Hypervisor: vSphere 6.7u3
VDI: VMware Horizon v.7.9

Works Cited

Chen, G. (2018, December 01). *vmware.com*. Retrieved 8 25, 2020, from https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/products/vmware-idc-virtual-machine-market-shares-2017.pdf

Synergy Research Group. (2020, 1 6). *srgresearch.com*. Retrieved 8 25, 2020, from https://www.srgresearch.com/articles/the-decades-megatrends-in-numbers-part-1

Townsend, K. (2019, 3 7). *thectoadvisor.com*. Retrieved from https://www.thectoadvisor.com/blog/2019/3/7/hybrid-isnt-a-place-its-an-operating-model

PO Box 515
Tinley Park, IL 60477

sales@thectoadvisor.com

www.thectoadvisor.com