



Reap the full potential of workload mobility within the cloud and data center by using consistent processor architecture

You can migrate live VMs between Intel processor-based servers but migration in a mixed CPU environment requires downtime and administrative hassle

A study commissioned by Intel Corp.

One of the greatest advantages of adopting a public, private, or hybrid cloud environment is being able to easily migrate the virtual machines that run your critical business applications—within the data center, across data centers, and between clouds. Routine hardware maintenance, data center expansion, server hardware upgrades, VM consolidation, and other events all require your IT staff to migrate VMs. For years, one powerful tool in your arsenal has been VMware vSphere® vMotion®, which can live migrate VMs from one host to another with zero downtime, provided the servers share the same underlying architecture. The EVC (Enhanced vMotion Compatibility) feature of vMotion makes it possible to live migrate virtual machines even between different generations of CPUs within a given architecture.¹

Enterprises running hybrid or multi-cloud environments require workload portability to achieve maximum business agility. Two of the key benefits of multi-cloud strategies are flexibility and choice, and the underlying architecture should support these. However, if a customer were to deploy a heterogeneous, or mixed CPU, environment, migrating virtual machines would be cumbersome.

Mixed CPU environments require virtual machines to be shut down before migrating. During this so-called cold migration, users experience some period of downtime before applications resume on the new host. The service disruption often prompts staff to schedule migrations outside of production hours.



No downtime during live migration

between legacy and current servers powered by Intel® Xeon® processors



42 seconds of downtime for a cold migration (with shared storage)

Intel processor-powered server to AMD EPYC™ processor-powered server



18 minutes of downtime for a cold migration (without shared storage)

from an Intel processor-powered server to an AMD EPYC processor-powered server

CIOs whose data centers have deployed servers powered by Intel Xeon processors and are considering deploying new servers based on the AMD EPYC™ line of processors into this environment should consider how doing so would limit their workload mobility. As AMD notes in their Virtual Machine Migration Guide, when moving VMs between EPYC processor-based servers and servers powered by Intel processors, live migration is not an option.²

	Live migration	Cold migration
Intel to Intel	✓	✓
Intel to AMD	✗	✓

In our hands-on testing, we migrated VMs in a homogeneous environment of only Intel Xeon processor-based servers and in a heterogeneous environment consisting of both Intel Xeon processor- and AMD EPYC processor-based servers. We used two new servers powered by Intel Xeon Platinum 8160 processors, one server powered by AMD EPYC 7601 processors, and one legacy server powered by Intel Xeon E5-2680 v2 processors.

We live migrated VMs among the Intel processor-based servers with zero downtime. However, to move a VM from an Intel Xeon processor-based server to one powered by AMD EPYC processors required shutting down the VM for a cold migration.

Because VMware EVC supports migration from Intel processors released as early as 2006,³ customers deploying Intel Xeon Scalable Processors (also known as Skylake processors) today can be confident that they will reap the full benefits of workload mobility.

An overview of our test approach

Imagine a data center with an installed base of servers powered by different Intel Xeon processors. The time has come to add new servers, and the team researching the purchase is debating between servers powered by Intel Xeon Scalable processors or servers powered by AMD EPYC processors. To gain insight into the migration options that would be available with each server, we set up the following:

- Two current-generation servers powered by Intel Xeon Platinum 8160 processors
- One current-generation server powered by AMD EPYC 7601 processors
- One legacy server powered by Intel Xeon E5-2680 v2 processors

About the servers and processors we tested

For our comparison, we chose servers using processors that were roughly comparable in terms of system price. (See the [science addendum](#) to this report for complete server specifications.) Each of the servers powered by Intel Xeon Platinum 8160 processors had 48 physical CPU cores and 384 GB of memory. Each of the servers powered by AMD EPYC 7601 processors had 64 physical CPU cores and 512 GB of memory. Our legacy server, powered by Intel Xeon processors E5-2680 v2, had 20 physical cores and 96 GB of memory.

About VMware vMotion

Three migration scenarios are possible with VMware vMotion:

- Move compute only (shared storage)
- Move compute and storage (non-shared storage)
- Move storage only (not tested; no processor migration)

We tested the first and second scenarios. To test moving compute only, we hosted the VM on external NFS storage presented to both hosts, so that no storage transfer was necessary. To test moving compute and storage, we hosted the VM on direct-attached local storage, so that vMotion had to move VM files from one host's storage to another. We did not test the third scenario as it did not involve migrating between processors.

Using VMware vSphere 6.7, we created a virtual machine running Microsoft Windows Server 2016 Datacenter on each server. We installed Microsoft SQL Server 2016 onto the VM and tested availability with a Microsoft SQL Server database workload, which is used by many customers working in data centers.⁴

We then performed the following migration scenarios:

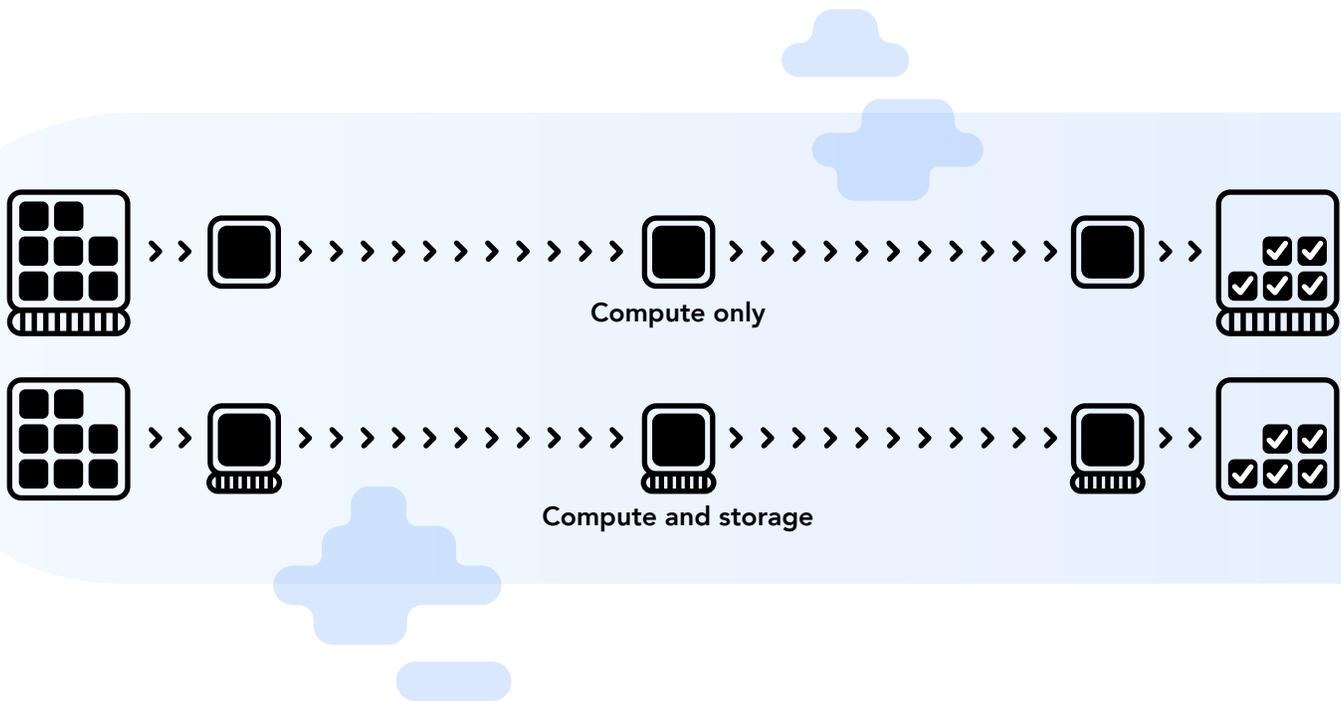
1. Using VMware vMotion live migration to move an active VM between two current-generation servers powered by Intel Xeon Platinum 8160 processors
2. Using VMware vMotion live migration to move an active VM from a legacy server powered by Intel Xeon E5-2680 v2 processors to a current-generation server powered by Intel Xeon Platinum 8160 processors
3. Using VMware vMotion to move a VM from a server powered by Intel Xeon Platinum 8160 processors to a server powered by AMD EPYC 7601 processors

We used a 60GB VM to represent a typical database VM size. In the scenario without shared storage, the migration time depends on the time required to copy to the virtual disk to the new storage location. The migration time would increase for VMs larger than 60GB, and decrease for VMs smaller than 60GB.

Scenario 1: Migrating an active VM between two servers powered by Intel Xeon Platinum 8160 processors

In this phase of our testing, we migrated an active virtual machine from one of the Intel Xeon Platinum 8160 processor-powered servers to the other under two configurations: with and without shared storage. In both cases, the VM was running a database application serving requests to an external client.

Because live migration is supported between Intel Xeon processors, the database connection stayed up and continued servicing requests throughout the migration period. This was the case with both shared and non-shared storage. An end user accessing this database would experience no interruption, and could work through the migration with no indication that the server hosting the database had changed.



Scenario 2: Migrating an active VM from a legacy server powered by Intel Xeon E5-2680 v2 processors to a current-generation server powered by Intel Xeon Platinum 8160 processors using VMware Enhanced vMotion Compatibility (EVC)

In this phase of our testing, we migrated an active virtual machine running a database application from a legacy Intel Xeon E5-2680 v2 processor-powered server to a current-generation Intel Xeon Platinum 8160 processor-powered server. As in the scenario above, we used an external client machine to send database requests to our active VM and tested one configuration with shared storage and one without shared storage.

We placed both servers in a VMware EVC Cluster and used EVC mode, which allows the servers to match processor features across hosts in the cluster so that VMs can be migrated back and forth smoothly. In our testing, the VM stayed online and achieved a true live migration with zero downtime and no interruption to service.



What the findings of Scenarios 1 and 2 could mean for your company

If your company selected new servers powered by Intel Xeon Scalable processors, you would be able to migrate VMs seamlessly—not only among the new servers but also between legacy servers and new servers. Without live migration, admins would have to schedule downtime for periods that would cause the least disruption for users. For mission-critical VMs, this can quickly turn into a large project requiring resources from technical, managerial, and executive departments, and requiring after-hours work. Instead, that staff can focus their energies on activities that bring value to the company.

Scenario 3: Migrating a VM from a server powered by Intel Xeon Platinum 8160 processors to a server powered by AMD EPYC 7601 processors

In the third phase of our testing, we tried to migrate a virtual machine from an Intel Xeon Platinum 8160 processor-powered server to an AMD EPYC 7601 processor-powered server, both with and without shared storage. We could not perform live migration, unlike in the previous two test scenarios. (Note: VMware Enhanced vMotion Compatibility, which we used in the second phase of testing, is available only for servers powered by processors with the same underlying architecture.⁵)

Because live migration is not an option when migrating between a server powered by Intel Xeon processors and one powered by AMD EPYC processors, we had to shut down the active VM running on the Intel Xeon Platinum 8160 processor-powered server before we could migrate it. This is commonly known as a cold migration. In an enterprise environment, this would require users to pause during the migration period. To mitigate the burden this would place on users, IT would likely try to schedule the migration for the time when usage is lowest.

About Intel Xeon Scalable processors

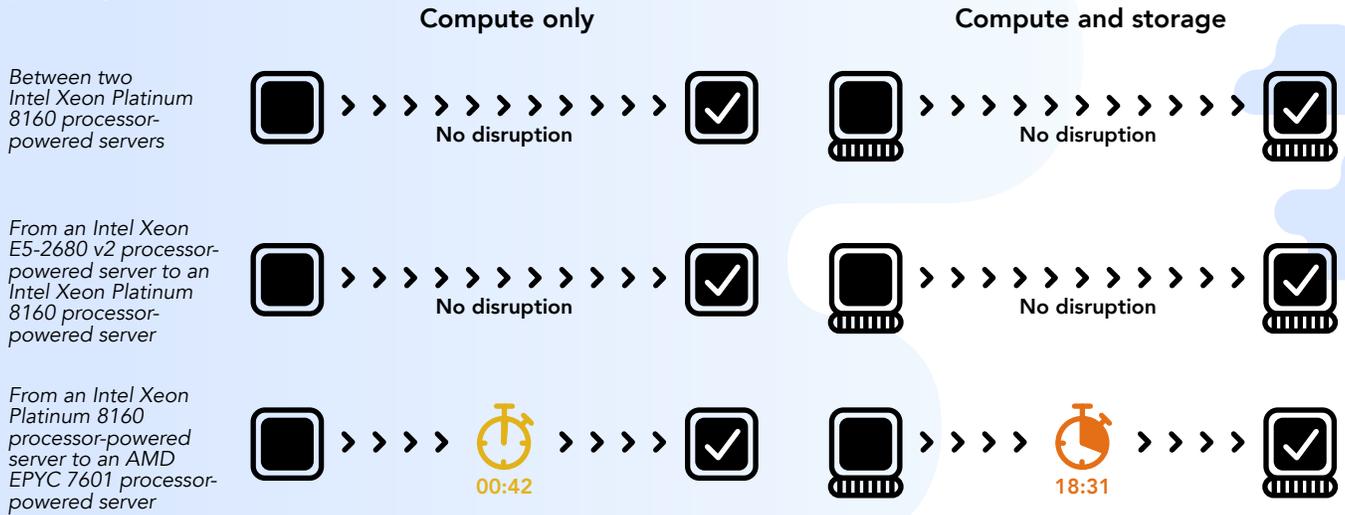
The Intel Xeon Scalable processor series includes many upgrades over previous-generation Intel processors. They have as many as 28 cores (which can enable greater performance and scalability), six memory channels, and up to 1.5 TB of memory per socket.⁶

The series includes four feature configurations: Platinum, Gold, Silver, and Bronze. The Intel Xeon Platinum 8160 processors in the servers we tested each had a 33MB L3 cache, 24 cores, 48 threads, and 3.70 GHz max turbo frequency.

Learn more about Intel Xeon Scalable processors at <https://www.intel.com/content/www/us/en/processors/xeon/scalable/xeon-scalable-platform.html>

We measured how long it took for VMware vMotion to migrate the virtual machine, both with and without shared storage. With shared storage, from the time we shut down the VM, the database application took 42 seconds to resume servicing requests. This time was dramatically longer without shared storage: 18 minutes, 31 seconds.⁷

Time to migrate a 60GB VM running Microsoft SQL Server 2016 (min:sec)



Any length of downtime requires a plan to avoid problems such as losing data from unsaved work or losing customers due to unresponsive services. To avoid these problems, a migration window requires people from multiple teams to work together, often during off-hours, to make sure the downtime does not negatively affect business. The additional time required from team members can quickly become expensive, especially for planning mission-critical VM migrations.

What the findings of Scenario 3 could mean for your company

If your company selected servers powered by the AMD EPYC processor, you would not be able to carry out live migrations between existing servers powered by Intel processors and the AMD processor-based servers. The data center would, in effect, have two separate pools of servers and the mobility of VMs would remain limited for the life of those servers. To avoid service interruptions when migrating VMs, your company would have two choices: (1) performing cold migrations during scheduled downtime, which creates extra managerial overhead and after-hours work, or (2) incurring the extra costs of implementing a highly-available solution.”

Conclusion

For years, technologies such as VMware vMotion have made it easy to move virtual machines from one host to another—provided those hosts have the same processor architecture. When you can take advantage of the live migration capabilities of vMotion, your applications stay up and your users stay connected during the migration period. This eliminates downtime and makes scheduling migrations for periods of low usage unnecessary.

As cloud adoption for small and large enterprises has grown, and as companies are increasingly taking advantage of both private and public clouds, planning for workload portability is key. Movement across data centers and clouds is inevitable for modern IT environments and IT experts rely on VMware live migration technology to power their multi-cloud and hybrid cloud strategies.

However, live migration works only between servers with the same processor architecture. We performed migrations with and without shared storage between two current-generation servers powered by Intel Xeon Platinum 8160 processors, from a legacy server powered by Intel Xeon E5-2680 v2 processors to an Intel Xeon Platinum 8160 processor-powered server, and from an Intel Xeon Platinum 8160 processor-powered server to a server powered by AMD EPYC 7601 processors, and confirmed that live migration was an option only in the environment with servers powered by processors from the same vendor.

Between the current and legacy Intel processor-powered servers, the database application running in the virtual machine remained available throughout the migration period and no downtime occurred. When we tried to migrate a VM from an Intel processor-based server to the AMD EPYC 7601 processor-powered server, however, live migration was not possible. Furthermore, the elapsed time until the database connection resumed for our 60GB VM was 42 seconds in the shared storage configuration and 18 minutes, 31 seconds in the direct-attached storage configuration. This downtime can be expensive for businesses to plan around; thus, companies should factor this added expense into their calculations when selecting servers to expand their datacenters on premises or in the cloud.

- 1 EVC and CPU Compatibility FAQ, accessed January 10, 2019, [https://kb.vmware.com/s/article/1005764?lang=en_US#q=EVC%20and%20CPU%20Compatibility%20FAQ%20\(1005764\)](https://kb.vmware.com/s/article/1005764?lang=en_US#q=EVC%20and%20CPU%20Compatibility%20FAQ%20(1005764))
- 2 AMD Virtual Migration guide, accessed January 10, 2018, <https://developer.amd.com/wp-content/resources/VM%20Migration%20Guide.pdf>
- 3 Enhanced vMotion Compatibility (EVC) processor support (1003212), accessed January 10, 2018, <https://kb.vmware.com/s/article/1003212>
- 4 The benchmark we used in our testing was DVD Store version 2.1, available from <https://github.com/dvdstore/ds21>. We downloaded it on December 3, 2018.
- 5 VMware Knowledge Base EVC and CPU Compatibility FAQ (1005764), accessed December 19, 2018, <https://kb.vmware.com/s/article/1005764#Does%20EVC%20allow%20AMD%20and%20Intel%20CPUs%20to%20be%20vMotion%20compatible>.
- 6 Intel Xeon Scalable processors, accessed December 18, 2018, <https://www.intel.com/content/www/us/en/processors/xeon/scalable/xeon-scalable-platform.html>.
- 7 We performed three runs to confirm repeatability. The time to resume servicing requests with shared storage ranged from 41 seconds to 45 seconds, with a median time of 42 seconds. The time to resume servicing requests without shared storage ranged from 18 minutes, 20 seconds to 18 minutes, 50 seconds, with a median time of 18 minutes, 31 seconds.

Read the science behind this report at <http://facts.pt/op42zx8> ►



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This project was commissioned by Intel Corp.

Disclaimer:

The content on the following pages includes appendices and methodologies from our hands-on work.

We will publish this content as a separate document linked to the report.

We must receive your approval on both the report and this document before taking them public simultaneously.



The science behind the report:

Reap the full potential of workload mobility within the cloud by using consistent processor architecture

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report [“Reap the full potential of workload mobility within the cloud by using consistent processor architecture.”](#)

On November 14, 2018, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on December 17, 2018.

Service disruption during VM migration

The table below presents our findings. We performed three runs to confirm repeatability. The results we cite in the report are the medians from these three runs.

	Move compute only	Move compute and storage
Between two Intel® Xeon® Platinum 8160 processor-powered servers	Run 1: No disruption Run 2: No disruption Run 3: No disruption	Run 1: No disruption Run 2: No disruption Run 3: No disruption
From a legacy server powered by Intel Xeon E5-2680 v2 processors to an Intel Xeon Platinum 8160 processor-powered server	Run 1: No disruption Run 2: No disruption Run 3: No disruption	Run 1: No disruption Run 2: No disruption Run 3: No disruption
From an Intel Xeon Platinum 8160 processor-powered server to an AMD EPYC 7601 processor-powered server	Run 1: 42 seconds Run 2: 41 seconds Run 3: 45 seconds	Run 1: 18 minutes, 51 seconds Run 2: 18 minutes, 20 seconds Run 3: 18 minutes, 31 seconds

System configuration information

The table below presents detailed information on the systems we tested.

Server configuration information	Intel R2208WFTZS	Dell EMC™ PowerEdge™ R720	Supermicro 829UAS-16
Number of nodes	2	1	1
Number of sockets	2	2	2
BIOS name and version	Intel SE5C620.86B	Dell 2.7.0	American Megatrends 1.1b
Non-default BIOS settings	Virtualization enabled	None	None
Operating system name and version/build number	VMware ESXi™ 6.7.0, 10764712	VMware ESXi 6.7.0, 10764712	VMware ESXi 6.7.0, 10764712
Date of last OS updates/patches applied	11/14/2018	11/14/2018	11/14/2018
Power management policy	Balanced	Balanced	Balanced
Mitigation variants	1,2,3,3a,4,L1TF	1,2,3,3a,4,L1TF	1,2,3,3a,4,L1TF
Testing details			
Tested by	PT	PT	PT
Test date	12/17/2018	12/17/2018	12/17/2018
Processor			
Number of processors	2	2	2
Vendor and model	Intel Xeon Platinum 8160	Intel Xeon E5-2680 v2	AMD EPYC 7601
Cores/threads (per processor)	24/48	10/20	32/64
Core frequency (GHz)	2.10	2.80	2.20
Stepping	4	4	2
Microcode	0x0200004d	0x0000042d	0x08001227
SMT	On	On	On
Clock boost	On	On	On
Memory module(s)			
Total memory in system (GB)	384	96	512
Number of memory modules	12	6	16
Vendor and model	Samsung® M393A4K40BB2-CTD	Hynix® HMT42GR7AFR4C-RD	Samsung M393A4K40BB2-CTD
Size (GB)	32	16	32
Type	PC4-21300	PC3-14900	PC4-21300
Speed (MHz)	2,667	1,866	2,667
Speed running in the server (MHz)	2,667	1,866	2,667

Server configuration information	Intel R2208WFTZS	Dell EMC™ PowerEdge™ R720	Supermicro 829UAS-16
SATA storage			
Number of drives	1	4	1
Drive vendor and model	Intel SSDSC2BA400G4	Seagate® ST9300605SS	Intel SSDSC2BA400G4
Drive size (GB)	400	300	400
Drive information (interface, type)	SATA SSD	SAS HDD	SATA SSD
Integrated network adapter			
Vendor and model	Intel X722	Intel X540-AT2	Intel X540-AT2
Number and type of ports	4x 10Gb Ethernet	2x 10Gb Ethernet	2x 10Gb Ethernet
Driver version	i40en 1.3.1-22vmw.670.1.28.10302608	ixgben 1.7.10-1OEM.670.0.0.8169922	ixgben 1.7.10-1OEM.670.0.0.8169922
10Gb network adapter			
Vendor and model	Intel 82599EB	Intel 82599EB	Intel 82599EB
Number and type of ports	2x 10Gb Ethernet	2x 10Gb Ethernet	2x 10Gb Ethernet
Driver version	ixgben 1.7.10-1OEM.670.0.0.8169922	ixgben 1.7.10-1OEM.670.0.0.8169922	ixgben 1.7.10-1OEM.670.0.0.8169922
Cooling fans			
Vendor and model	Intel FR2UFAN60HSW	Dell WCRWR	San Ace 80 FAN-0094L4
Number of cooling fans	6	6	4
Power supplies			
Vendor and model	SoluM® PSSF132202A	Dell 0CC6W	Supermicro® PWS-920P-SQ
Number of power supplies	2	2	2
Wattage of each (W)	750	1,100	920

The table below provides detailed configuration information for the network switches we used.

Network switch configuration information	Dell EMC Networking S4048-ON
Firmware revision	9.9 (0.0P9)
Number and type of ports	48 x SFP+ 10GbE, 6 x QSFP 40GbE
Number and type of ports used in test	2 x SFP+ 10GbE, 6 x QSFP 40GbE
Non-default settings used	MTU 9216

How we tested

Configuring the servers under test

We set BIOS settings to default except for enabling virtualization on the current-generation servers powered by Intel Xeon Platinum 8160 processors. Each server had a 1Gb connection to an infrastructure network for ESXi management traffic, and a 40Gb connection to a testing network for vMotion and Provisioning traffic. We installed VMware ESXi 6.7 onto the SATA SSD on the current-generation server powered by Intel Xeon Platinum 8160 processors and the server powered by AMD EPYC 7601 processors. We placed the OS onto the virtual RAID10 disk on the legacy server powered by Intel Xeon E5-2680 v2 processors.

Installing VMware ESXi 6.7

1. Boot the server to the VMware ESXi 6.7 installation media.
2. At the boot menu, press Enter.
3. Press Enter to continue.
4. To accept the license terms, press F11.
5. Select the SATA SSD or the RAID10 virtual disk, and press Enter.
6. At the keyboard layout screen, press Enter.
7. Enter a password for the root user, and press Enter.
8. At the installation confirmation screen, press Enter.
9. After the installation completes, press Enter to reboot the server.

Installing VMware vCenter 6.7

1. Mount the VMware vCenter installation media to a server or client computer running Windows.
2. Navigate to the `vcsa-ui-installer/win32` directory, and run `installer.exe`.
3. At the home page, click Install.
4. Click Next.
5. Check the I accept the terms of the license agreement checkbox, and click Next.
6. Click Next.
7. Enter the IP address or FQDN of an infrastructure server running VMware ESXi 6.7.
8. Enter the username and password for the infrastructure host.
9. Click Next.
10. Set a root password for the VCSA appliance, and click Next.
11. Click Next.
12. Provide networking details for the VCSA appliance, and click Next.
13. When the deployment completes, click Continue.
14. Click Next.
15. Click Next.
16. Enter a username and password for the SSO domain, and click Next.
17. Uncheck the Join the VMware's Customer Experience Improvement Program (CEIP) checkbox, and click Next.

Adding hosts to VMware vCenter

1. Use a web browser to navigate to the VCSA IP address and log in with the SSO domain credentials.
2. Right-click the VCSA appliance, and click New Datacenter.
3. Enter a name for the datacenter, and click OK.
4. Right-click the datacenter, and click New Host.
5. Enter the IP address of the host, and click Next.
6. Enter the root account credentials of the host, and click Next.
7. Click Next.
8. At the Assign license screen, click Next.
9. At the Lockdown mode screen, click Next.
10. Click Next.
11. Click Finish.

Creating the test VM

1. Right-click one of the hosts, and click New Virtual Machine.
2. Click Next.
3. Enter a name for the virtual machine, and click Next.
4. Select a host for the VM location, and click Next.
5. Ensure the default datastore is selected, and click Next.
6. Click Next.
7. Select Windows and Microsoft Windows Server 2016 (64-bit) for the Guest OS Family and Guest OS Version dropdown menus, and click Next.
8. Use the dropdown menus to select the following:
 - Four virtual CPUs
 - 16GB virtual memory
 - 60GB hard disk
9. From the New CD/DVD Drive drop-down menu, select Datastore ISO File.
10. Select the Microsoft Windows Server 2016 Datacenter installation ISO, and click OK.
11. Click Next.
12. Click Finish.

Installing Microsoft Windows Server 2016 Datacenter

1. Using the remote console, boot the VM to the Microsoft Windows Server 2016 Datacenter installation media.
2. Press any key to boot to the CD/DVD.
3. Click Next.
4. Click Install Now.
5. Select Windows Server 2016 Datacenter (Desktop Experience), and click Next.
6. Check the I accept the license terms checkbox, and click Next.
7. Click Custom: Install Windows only (advanced).
8. Click Next.
9. When the installation completes, enter a password for the administrator user, and click Finish.

Installing Microsoft Windows SQL Server 2016

1. Mount the Microsoft Windows SQL Server 2016 installation ISO to the Microsoft Windows Server VM.
2. Click the Autorun prompt when it appears.
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Select the Specify a free edition radio button, and select Evaluation from the dropdown menu.
6. Click Next.
7. Check the I accept the license terms checkbox, and click Next.
8. Allow the Global Rules check to complete, and click Next.
9. Uncheck the Use Microsoft Update to check for updates (recommended) checkbox, and click Next.
10. Allow the Install Rules check to complete, and click Next.
11. Check the Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility checkboxes, and click Next.
12. Allow the Feature Rules check to complete, and click Next.
13. Click Next.
14. Click Next.
15. Select the Mixed Mode (SQL Server authentication and Windows authentication) radio button, and enter a password for the SQL user.
16. Click Add Current User.
17. Click Next.
18. Click Install.

Connecting an NFS datastore

1. In the Host and Clusters view of vCenter, right-click the host, and click Storage→New Datastore.
2. Select the NFS radio button, and click Next.
3. Click Next.
4. Enter connection details for the NFS storage, and click Next.
5. Check the checkboxes to select all hosts, and click Next.
6. Click Finish.

Configuring EVC mode

1. Right-click Datacenter, and click New Cluster.
2. Enter a name for the cluster, and click OK.
3. In the left pane, click VMware EVC.
4. Click Edit.
5. Select the Enable EVC for Intel Hosts radio button.
6. Select Intel "Ivy Bridge" Generation from the dropdown menu, and click OK.
7. Drag the legacy server powered by Intel Xeon E5-2680 v2 processors and the server powered by Intel Xeon Platinum 8160 processors into the EVC cluster.

Creating a vMotion or Provisioning network

1. Select one of the hosts, and click Configure.
2. Click VMkernel adapters.
3. Click Add Networking.
4. Click Next.
5. Select the New standard switch radio button, and enter 9000 for the MTU. Click Next.
6. Click the plus sign to add an adapter.
7. Select the 10Gb adapter, and click OK.
8. Click Next.
9. Give the network a name, and check either the vMotion or Provisioning checkbox depending on the test scenario.
10. Click Next.
11. Click Next.
12. Click Finish.

Configuring the database

We used the DVD Store 2.1 (DS2) benchmarking tool to test our SQL Server connectivity during migrations.

We generated the test database using the Install.pl script included with DS2 providing the parameters for our 10GB database size and the database platform on which we ran, Microsoft SQL Server 2016. We ran the Install.pl script on a utility system running Linux®. The Install.pl script also generated the database schema.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2008. We built the database in SQL Server 2008, and performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore the server between test runs.

The only modifications we made to the schema creation scripts were in the specified file sizes for our database. We deliberately set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. Other than this file size modification, we created and loaded the database schema according to the DS2 documentation. Specifically, we performed the following steps:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data-generation system to a Windows system running Microsoft SQL Server.
3. Using the provided DVD Store scripts, we created database tables, stored procedures, and objects.
4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.

- On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
    DEFAULT_DATABASE=[master],
    DEFAULT_LANGUAGE=[us_english],
    CHECK_EXPIRATION=OFF,
    CHECK_POLICY=OFF
GO
```

- We set the database recovery model back to full.
- We created the necessary full text index using SQL Server Management Studio.
- We created a database user and mapped this user to the SQL Server login.

Running the migration tests

We tested the live migration scenarios by starting the DS2 workload and then migrating the VM. We ran the workload with single-second report time and ensured that each report contained database activity.

We tested the cold migration scenarios by shutting down the VM and beginning the timer. We then initiated the VM migration. As soon as the migration completed, we started the VM and our DS2 workload. We stopped the timer when the DS2 workload established a connection with the database.

Migrating the virtual machines

- In the Hosts and Clusters view of vCenter, right-click the VM, and click Migrate.
- Select the radio button for the scenario under test, and click Next.
- Select the destination host from the dropdown menu, and click Next.
- If moving storage, select the default datastore, and click Next.
- Click Finish.

Running DVD Store 2

- Using the CMD utility, navigate to the location of the ds2sqlserverdriver.exe and run the following command to start the benchmark:
`./ds2sqlserverdriver.exe -report-rate=1 -target=<IP of SQL Server VM>`

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