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Building a Home Lab for VMware vSphere 6.0

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Introduction

Before virtualization, I had many computers around my house that required maintenance, upgrading, replacement, etc., as well as the power to run all of the equipment. This was very time-consuming and expensive. In 1999, I began using VMware Workstation 2.0 to create virtual machines (VMs) to study NetWare, NT 4.0, Windows 2000, etc. Since that time, I have used it in all of my studies and reduced my lab equipment to one computer, a powerful laptop. Originally, Elastic Sky X (ESX) didn't run in a VM, requiring more hardware to study and learn ESX. As of ESX 3.5 and Workstation 6.5.2, it is possible to virtualize ESX in a Workstation VM (or inside a vSphere server, for that matter, but we won't be discussing that in this white paper), although this required workarounds and was not supported. It is possible to run ESXi 6.0 inside of ESXi 6.0 or VMware Workstation 8.0 or higher. In fact, VMware and Global Knowledge teach their vSphere 6.0 courses in this manner (running ESXi inside ESXi). Using ESXi as the host virtualization platform works, but it requires a dedicated machine. This is often possible in a business setting, but may be difficult for the small business or in circumstances where spare hardware is not available. Hence, this white paper will discuss how to use Workstation 11.0 (the latest version) to create the simulated environment.

I often get asked by my students how to (relatively) inexpensively setup this kind of lab for study after class, and the result is this white paper. When specific vendors are mentioned, it is not an endorsement, but rather just an example of something that I have used and know works.

This white paper is broken down into three major sections; the first and most detailed is about the hardware required, the second is about the VMware Workstation configuration, and the third is about installing vSphere (ESXi) 6.0 and Virtual Center (VC). Note that this white paper is not intended to be an in-depth review of how to install and configure vSphere as that is taught in the VMware classes and a VMware class is required for certification.

Lab Hardware

The biggest question is whether to build your lab at a stationary location, such as in your home or on a spare server at work, or whether it needs to be portable. In many cases, a stationary configuration is sufficient, so the desktop/server route works well and is usually less expensive. If you need to do demonstrations for customers, study at multiple locations, etc., then a laptop configuration may work better for you, though it will cost more for a similar configuration.

As far as *minimum* central processing unit (CPU) requirements are concerned, you'll need at least two cores (or CPUs) to be able to install ESXi and/or VC, but this will be *very* slow. I suggest a *minimum* of 4 cores (or CPUs, preferably hyperthreaded) so there is enough CPU power to run the VMs and the host operating system (OS). Eight or more cores work well. If you're planning on creating and using input/output (I/O)-intensive VMs, and/or running many VMs, and/or doing a lot on the host OS while VMs are running, you should consider more than 12 cores. Remember that ESXi 6.0 (vSphere 6.0) requires 64-bit-capable CPUs to run, so be sure to purchase 64-bit-capable CPUs with either Intel virtualization technology (VT) or Advanced Micro Dynamics virtualization (AMD-V)

support (both physically on the CPU and enabled in the basic input/output system [BIOS]). I point this out not because you are likely to purchase a decade-old computer that doesn't have a 64-bit CPU, but rather that the virtualization extensions in the processor may not be made available via the BIOS. ESXi also requires the No Execute/Execute Disable (NX/XD) feature to be enabled in the BIOS.

As far as *minimum* memory requirements are concerned, you'll need at least 4 gigabytes (GB) of random access memory (RAM) to be able to install ESXi and/or VC, but this will be *extremely* slow. In fact, the VMs will run primarily from the hard disk and will probably be so slow as to be unusable. vCenter requires at least 8 GB, not counting the virtualization overhead, the OS that will be the running workstation, VMware Workstation overhead, or any other apps you wish to run at the same time. For this reason, I suggest 24 to 32 GB of RAM to give you enough resources to run all the VMs below (plus additional memory if you want to run other applications and/or VMs on the host). It will run with 16 GB, but you will probably see a lot of paging to disk resulting in reduced performance for all the VMs as well as any other apps you have running on the host computer. I would suggest you use either the OpenFiler or the Windows option from table 1 below to reduce the hardware requirements. By the way, the Windows method is the approach I used when writing my book on vSphere 5, *Administering vSphere 5*, and it worked well. The actual requirements will vary depending on what you choose to install (both for VMs as well as VMs inside the ESXi VMs), but I base this on the following configuration (table 1).

VM	Number	Purpose
ESXi 6.0	2	2 VMs allow for VMotion, high availability (HA) clusters, Distributed Resource Scheduler (DR)S, etc., to be used and studied.
Virtual Center	1	Most businesses use VC for management tasks, and you'll be tested on using VC. If you'll be deploying the vCenter Server Appliance (vCSA), it will need to be inside an ESXi VM, so be sure that ESXi server has the memory (8 GB for the vCSA, plus 4 GB for ESXi), CPU, and disk space (about 125 GB for a tiny install) available. If it is a Windows server, make sure it isn't a domain controller; it can be a Workstation VM.
Openfiler or other iSCSI or Network Attached Storage (NAS) VM	1	Allows VMotion, HA, DRS, etc., to be used (shared storage is used frequently by many features). In addition, you'll want to learn more about Internet Small Computer System Interface (iSCSI) if you haven't already, and Openfiler is a free way to do so. **This is the preferred option for those with experience in Linux.**
Windows Server with the iSCSI Target and File Services for NFS installed	1	Setting up Network File System (NFS) and/or iSCSI allows VMotion, HA clusters, DRS, etc., to be used (shared storage is used frequently by many features and you'll have the ability to study and use both NFS and iSCSI with this method). **This is the preferred option for those with experience in Windows.** You can't install vCenter on a domain controller, so you'll need to either deploy a separate VM for vCenter or deploy the vCSA and make the server a domain controller or skip Active Directory and save a server, putting vCenter on this server as well.

Table 1. VMs required to study vSphere.

In addition, remember that the host OS will require some resources (typically the better part of a core and 2 to 4 GB of RAM, depending on what you want to do).

Desktop/Server

The big question that needs to be addressed is what kind of performance you require. If it is purely for study and performance doesn't matter, an inexpensive desktop will be sufficient, assuming the specs below are met. On the other hand, if you will be doing a lot of work and/or performance is a bigger factor, consider getting a high-end

workstation or a server so that you can have more disk drives/CPUs/RAM installed for better performance as well as more expandability. If disk drives are your biggest issue (and they often are), you could use Solid State Drives (SSD) instead of Serial Advanced Technology Attachment (SATA) or Statistical Analysis System (SAS) drives and any kind of desktop or server that meets the other requirements described here.

I use my computer for many learning projects as well as development projects for custom courseware and design projects, in addition to the book projects I work on, so in the past I chose a server for my lab setup, though today laptops have gotten powerful enough that I'm using the laptop configuration described in the next section. The remainder of this section is based on an upgraded version of the server I formerly used.

I bought a tower server over a rack mount version as I wanted the maximum number of disk drives possible. My server was a Dell PowerEdge 2900 (which is somewhat old, but that meets all the requirements and is fairly inexpensive due to its age), but most vendors have equivalent or better models (such as the Dell T320 or T430 for servers or the Precision 810 or 910 for high-end desktops) or you could build one yourself. I am also primarily a Windows user, so I created my server with Windows 7.0 in mind (though it would work on Windows 8.x or 10.0 as well). I outfitted my server as follows (table 2).

Component	Number	Reason	Recommendation
Xeon E5-2660 (Ten Core, 2.6 GHz, 25 MB L2 cache)	2 sockets, ten core each	I wanted the most CPUs possible so I could run multiple VMs at the same time; I also wanted the most L2 cache available to make them as efficient as possible, given that the host OS, many VMs, and often Office applications and web browsers would all be used at the same time.	Buy the latest CPU family with the most cores and L2 cache at the fastest speeds in demanding environments. One socket is sufficient with this CPU level, but buying a dual socket system allows for future expandability and/or better performance today. Note that Windows 7.0 only supports 2 physical sockets, so more physical CPU sockets will be wasted money in Windows-hosted environments. It will use all the cores in each socket however.
RAM	32 GB	I wanted the ability to run multiple VMs at once with RAM left over for Office, Acrobat, Web Browsers, etc.	Get at least 24 GB; 32–64 GB would give you more room for more VMs and/or larger VMs.
1 GB Ethernet NICs	2	Came with server; minimum of 1, with 2 if you want the VMs to have a separate network interface card (NIC) for their traffic (1 for host I/O and 1 for VM I/O).	Get a 3rd if using NAS or iSCSI not in a VM on the same computer. If all the VMs listed in Table 1 are running on the same computer, you can use a host-only network for them to communicate with each other only, or a NAT or Bridged network to provide access to the outside world. In this case, a single NIC would be sufficient.

960 GB SSD Drive	2	1 for the OS, applications, etc. (everything except VMs—if you have smaller data needs, you could get a 500 GB SSD drive for this) and 1 for the VMs (a smaller drive could be used just for this set of VMs, but 500 GB minimum; little room for growth)	Buy SSD drives if possible for their high I/O rate (usually the bottleneck in a VM environment, especially with so many VMs on 1 server). You may wish to purchase more, smaller drives to spread the load (verify the number of slots for drives available and the cost per GB of each drive). If SSD drives aren't an option, get the fastest, smallest drives available and get lots of them for good I/O performance. Get iSCSI or SAS drives if possible (15K v. 7200 RPM with SATA). No redundant array of inexpensive disks (RAID) was used in this design, so be sure to back them up to the cloud, an external hard drive, etc. With the high cost and high reliability of SSD drives, a 2 terabyte (TB) external drive for $100 or a backup solution in the cloud such as Crash Plan is probably a better option, leaving money to spend on the other components.
Monitors	2	I can see multiple VMs at once this way, for example 1 for the ESXi servers and 1 for VC or 1 for the VMs and 1 for documentation, email, etc. Note that on my server, I needed to get an x16 to x8 peripheral component interconnect (PCIe) adapter as my server didn't come with an x16 slot and all video cards are x16 (search for x16 to x8 adapter for companies that sell this kind of product). Note as well that the riser card may make ports near the top of the video card inaccessible, so choose your video card carefully. This isn't an issue for most desktops. Choose a video card that supports the type of connection your monitors will use (High-Definition Multimedia Interface [HDMI], Digital Video Interface [DVI], or Video Graphics Array [VGA]) as well as the number of monitors you want to use.	2 or more monitors will make it much easier to study; I'd suggest at least 2 monitors if you have paper documentation and training materials or at least 3 monitors if the documentation and/or training materials are in an electronic format.

Table 2. Server configuration recommendations.

My server configuration retailed for about $8,000, but I got most of it from various online sources for under $5,000. A quick search online for this paper returned desktops with 1 to 2 hard SSD drives, 32 GB of RAM, and a quad core processor without a monitor for $2,500 or less.

Laptop

If portability is important to you, consider a laptop instead. The laptop should support at least a quad-core CPU, at least 2 hard drives, and a minimum of 16 GB of RAM (with 32 GB or more, a better idea). For my lab, I chose an Alienware 17 laptop (which supports 3 hard drives and up to 32 GB of RAM) with a Core i7 processor. As with the desktops and servers described above, you'll need a substantial system to run well. A laptop with these specifications will typically run more than $3,000.

Purchase an SSD (or two); SSD drives today are fairly inexpensive, so they are the best option. My laptop has 32 GB of RAM and 3 SSD drives (1 256 GB for the OS and 2 960 GB SSD drives for data and VMs). That added almost $2,000 to the price, making my laptop about $5,000 total (I bought the drives separately and installed them myself as that was much cheaper).

Plugging in an external monitor may make it much easier to study, as mentioned above, so consider a laptop with at least 1 external VGA, Display Port, or HDMI port or a docking station that supports 1 or more such ports. In my case, I purchased a USB 3.0 docking station and plugged in 2 external monitors to it, giving me 3 monitors to work with.

Tip: If you have an Android-based tablet or an iPad, you can get a program called "Air Display" that will allow you to use it as an additional monitor. I have used it quite a bit and find it works very well. It also makes possible a 3rd monitor on a laptop (the built-in, an external, and the tablet). Note that for this to work, your computer and laptop must belong to the same Wi-Fi network. Most desktops and servers don't support Wi-Fi, so either a wireless card will need to be installed or another solution used.

VMware Workstation Installation

One of the benefits of earning your VMware Certified Professional (VCP) is a copy of VMware Workstation. This is a great benefit, but not very helpful while you are studying to pass the exam. You can get an evaluation copy of the software from VMware that is good for 30 days. It is available at https://my.vmware.com/web/vmware/info/slug/desktop_end_user_computing/vmware_workstation/11_0 or you can purchase the software for less than $200 (or upgrade for less than $100). Students and educators can get it even cheaper if they qualify for the academic discount.

Workstation is available in versions for both Windows (2008 R2, 2012, 2012 R2, 7.0, 8.0, and 8.1, 64-bit only) and Linux (including CentOS, Red Hat, openSUSE, Oracle Linux, and Ubuntu, 64-bit only. The complete list is available here: http://kb.vmware.com/selfservice/search.do?cmd=displayKC&docType=kc&docTypeID=DT_KB_1_1&externalId=2088579. The application itself requires 1.5 GB of disk space for installation (deleting the installation file will save some space after installation is completed).

VMware Workstation version 11.0 supports up to 64 GB of RAM per VM with the total RAM for all VMs limited only by available host memory. It specifically supports ESXi as a VM.
The application itself installs like most other Windows or Linux applications so the specifics won't be described here. Online versions of the manual are available on VMware's website at http://www.vmware.com/support/pubs/ws_pubs.html.

For those using a MAC, check out VMware Fusion instead. It is similar to VMware Workstation. I use it on my Mac and it works well.

Installing vSphere Servers and Virtual Center

To install ESXi, simply create a VM in Workstation, pointing the installer location set to the VMware ESXi 6 ISO with at least 4 GB of RAM, a iSCSI virtual hard disk of at least 10 to 15 GB (6 GB is the minimum and will leave virtually no room for any VMs); more if you plan on installing many and/or large VMs inside the ESXi VM and are not using shared storage (such as the Openfiler iSCSI appliance or a Windows server with NFS and/or iSCSI Target support previously described). Be sure that all VMs that you want to talk to each other share a common network (typically, all will be set either to *Use bridged networking* if you want to see the VMs from other PCs on the network, or *Use host-only networking* if you want to restrict access to the vSphere VMs [and any VMs inside them] to the host that vSphere and the other VMs run on).

Once the VM for ESXi is created, simply power it on and install it as you would with a physical server. Once ESXi is installed, you can run it like you would on a physical server and create VMs inside it as desired. You may wish to install a second ESXi VM to practice vMotion, HA clustering, etc.

You can then create a VM for vCenter per the standard VC requirements and install it like you would in any other physical or virtual environment. This can be in Workstation directly (and which will generally perform better) or even as a VM inside one of the ESXi VMs. vCenter can be deployed in a Windows 2008 R2 or later server (as long as it's not a domain controller) or via the vCSA in its own VM. If you'll be deploying the vCSA, it will need to be inside an ESXi VM, so be sure that server has the memory (8 GB for the vCSA plus 4 GB for ESXi), CPU, and disk space (about 125 GB for a tiny install) available.

If you wish to use the Openfiler appliance, refer to either the document *How to Configure Openfiler iSCSI Storage for VMware ESX 4* or *Install and configure Openfiler for ESXi shared storage with NFS and iSCSI* listed in the References section. The information in the first document specifically references ESX 4, but also applies to ESXi 6 and is more up-to-date on the OpenFiler instructions for the latest version of OpenFiler.

On the other hand, if you wish to use a Windows box, install Windows 2008 R2 (or higher), and add the iSCSI Target (not Initiator) software and/or the File Services (to get NFS support) feature.

Note: References to Workstation in this section apply to Fusion or ESXi as the physical platform as well, but to keep things simple, all references in this section were just to Workstation. Note that the steps may vary for other platforms, but are similar.

Tip: At labguides.com, an automated solution for creating all the required VMs on Workstation 8 (also works with later versions) or ESXi is available for free. You will need access to the installation software (Windows and ESXi / vCenter), but it makes it much easier and faster to setup your environment. See http://www.labguides.com/autolab/ for details and to download the tool. I typically do it manually as described previously to better understand the process and prepare for use in the real world as well as on any VMware exams. It takes less than an hour to install everything (assuming you have created the Windows VM and patched it already if you'll be using Windows).

Summary

Carefully select hardware powerful enough to run ESXi as a VM. Remember that you'll probably want more than 4 cores (or at least hyperthreading on the 4 cores), 24 to 32 GB of RAM or more, and x64 CPUs with Intel-VT or AMD-V support and enabled in the BIOS, along with NX/XD enabled in the BIOS. The cost of such a system will be far lower than purchasing several systems and recreating the environment with physical systems, networking equipment, etc.

Done properly, you should be able to reproduce the training environment and run the labs from the courses you take. It is even possible to do advanced configurations, such as VMware vCloud Director, View and Storage Resource Management (SRM) inside VMs hosted on a single host, though this will require a much larger host with more CPUs and memory than described here (think 20+ cores and at least 64 GB RAM and SSD drives).

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