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# Creating Virtual Desktop Infrastructure Using Xen Desktop 7.1 and Vsphere 5.1

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# **Creating Virtual Desktop Infrastructure Using Xen Desktop 7.1 and Vsphere 5.1**

by

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## **Abstract**

Technology now demands secure centralized management of their services. Desktop virtualization allows isolation of the operating system and desktop using Xen Desktop. Now the users of any organization could connect to their own desktops from anywhere and from any client device. Xen Desktop delivers windows applications and desktops as secure mobile service and is capable of delivering full desktops or the applications that are required. It offers storefront software which allows the users to self-service what they wanted. This paper solely focuses on building a Virtual desktop infrastructure, a cloud-ready Desktop as a Service platform using which a company can reduce the cost, time for management and patching the desktops along with independence for applications.

*Keywords:* desktop virtualization, virtual desktop infrastructure

## Table of Contents

	Page
List of Figures .....	4
List of Acronyms .....	5
Chapter	
1. Introduction .....	7
Problem Statement .....	7
2. Background and Literature Review .....	9
Desktop Virtualization .....	9
Architecture .....	10
What has Changed? .....	15
3. Methodology .....	25
Working of Xen Desktop .....	25
Setup Process Flowchart .....	26
Hardware and Software Requirements .....	27
Implementation .....	28
Xen Desktop Installation .....	45
4. Analysis of Results .....	79
5. Discussion and Conclusion .....	81
Future Work Recommendation .....	86
References .....	88

## List of Figures

Figure	Page
1. Citrix XenDesktop 7 Architecture .....	10
2. Xen desktop overview .....	12
3. ESXi architectures .....	22
4. vCenter .....	23
5. High-level architecture of HA .....	23
6. Working of DRS .....	24
7. Xen desktop process flowchart .....	26
8. Components of Xen desktop 7 .....	27

## List of Acronyms

VDI: Virtual Desktop Infrastructure

IT: Information Technology

CPU: Central Processing Unit

VM: Virtual Machine

OS: Operating system

VDA: Virtual Delivery Agent

UPM: User Profile Management

FMA: Flexcast Management Architecture

SaaS: Software as a Service

AMD: Advanced Micro Devices

PC: Personal Computer

SSL: Secure Socket Layer

VPN: Virtual Private Network

DMZ: Demilitarized Zone

WAN: Wide Area Network

LAN: Local Area Network

DDC: Delivery Controller

XA: XenApp

XD: XenDesktop

XML: Extensible Markup Language

IIS: Internet Information Services

DA: Delivery Agent

HA: High Availability

DRS: Distributed Resource Scheduler

LUN: Logical Unit Number

RAM: Random Access Memory

AD: Active Directory

AWS: Amazon Web Services

iSCSI: Internet Small Computer System Interface

## Chapter 1: Introduction

Desktop virtualization makes the desktops run centrally on the server and typically establishes a client-server model computing. The end user will have a client installed on their machines, which they can access the running desktop connected through a broker. This means the instance of a desktop operating system runs on a virtual machine in a server. If desktops are run on virtual machines, their management can be carried out from a central location. This way, the desktop environment of the user is also secured. Similarly, patching and other hardware and software upgrades will take much less time.

This research paper solely focuses on building a virtual desktop infrastructure (VDI) using Xen Desktop on a VMware vSphere platform, and will also address the problem statement discussed in the following section. The VDI infrastructure can be further extended to build a Desktop as a Service platform.

### Problem Statement

- Users load and run different applications on their desktops, which are out of reach for troubleshooting. This can cause some difficulties, such as:
  - Very hard to support and no standard software is available
  - Hard to identify what programs are installed and hard to manage and configure them
  - Data security and the risk of data loss is a possibility, which is an obvious business loss for the company
- Compliance to IT security is compromised
- One machine for multiple users so resources are shared

- A single user can use all the resources such as CPU and memory
- Multiple users need multiple applications, which can be conflicting

This paper shows a solution to address the problems stated above.

## Chapter 2: Background and Literature Review

### Desktop Virtualization

Desktop virtualization offers a way to centrally manage desktops, thereby allowing a company to be in compliance with their security policies and restrict end users from installing unauthorized software (Porter, 2010)

Similar to server virtualization, desktop virtualization depends on a thin layer of software known as the hypervisor, which runs on physical server hardware and provides a platform where administrators can manage and configure virtual machines (VMs). Here, every user will get a VM with a different instance of the desktop operating system (OS) and the installed applications. To the desktop OS, the applications, and the user, the VM does a fair job of impersonating a real desktop machine (Knorr, 2010).

#### **Xen desktop.**

- Xen desktop allows windows applications and desktops as mobile services.
- It gives users a self-service portal where they can select an application from a pre-built catalog from any device.
- It provides a high definition performance on mobile networks.
- It has a simple management platform that allows for faster deployment of desktops, which is a cloud-ready platform (Citrix Product Documentation, 2015).

## Architecture

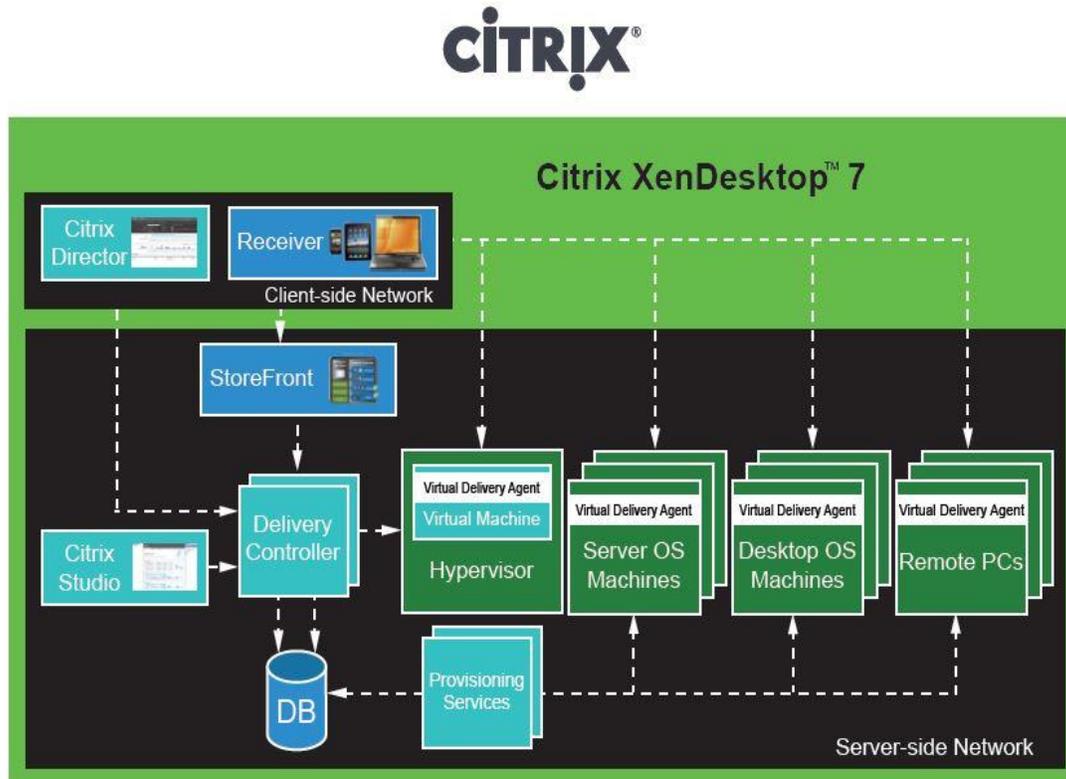


Figure 1. Citrix XenDesktop 7 Architecture (Anderson, 2013).

### Desktop communication layers.

- User Layer
  - Citrix Receiver
- Access Layer
  - Citrix NetScaler
  - Citrix StoreFront
- Control Layer
  - Delivery Controller
  - Machine Creation Services
  - Citrix Provisioning Services

- Hypervisor
- Virtual Delivery Agent (VDA)
- Resource Layer
  - Applications
  - Operating System Image
  - Citrix User Profile Management (UPM)
  - Policies
  - Personal vDisk
- Management Layer
  - Citrix Studio
  - Citrix Director (Citrix XenDesktop 7.6 Blueprint, 2013).

#### **New features in Xen desktop 7.**

- Combined Infrastructure – Flexcast Management Architecture (FMA)
- Windows Server 2012 Support
- System Center 2012 SP1 Support
- Machine Creation Services for Windows Server OS
- App-V 5 Integration
  - XenApp Steaming is available for Windows 7 and Server 2008R2 only
  - XenApp Streaming is accomplished by publishing RADERUN command in the console
- Profile Management in Citrix Policies
- Universal Printer Server Integration

- Universal Printer Server
- Windows 2008 R2 SP1 Print Servers
- Windows 2008 32bit Print Servers

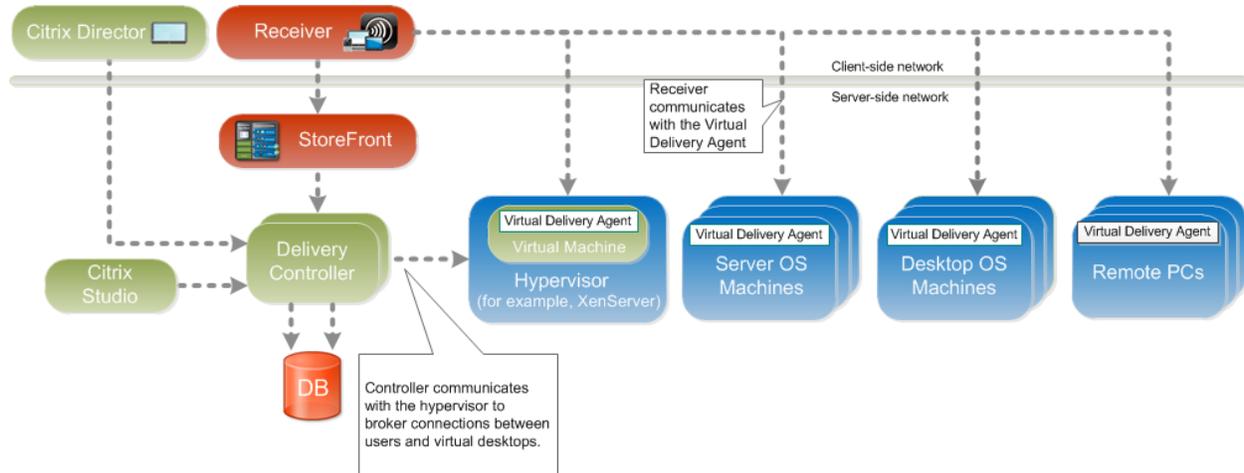


Figure 2. Xen desktop overview (Citrix XenDesktop 7.6 Blueprint, 2013).

Under the new architecture, XenDesktop and XenApp application delivery are integrated, including management and delivery components, to give administrators a unified management experience.

*Director:* Director is a web-based tool that enables IT support and help desk teams to monitor an environment, troubleshoot issues before they become system-critical, and perform support tasks for end users. Consumers can also view and interact with their session using Microsoft Remote Assistance.

*Receiver:* Citrix Receiver is installed in devices which provides users with quick, secure, self-service access to documents, applications, and desktops from any of the user's devices including smartphones, tablets, and PCs. Citrix Receiver provides on-demand access to Windows, Web, and Software as a Service (SaaS) applications.

*StoreFront*: StoreFront authenticates users to sites hosting resources and manages stores of desktops and applications that they access.

*Studio*: Studio is the management console that enables users to configure and manage their deployment, eliminating the need for separate management consoles for managing the delivery of applications and desktops. Studio provides various wizards to guide the process of setting up an environment, creating workloads to host applications and desktops, and assigning applications and desktops to users.

*Delivery Controller*: Installed on servers in the data center, the delivery controller consists of services that communicate with the hypervisor to distribute applications and desktops, authenticate and manage user access, and broker connections between users and their virtual desktops and applications. The controller manages the state of the desktops, starting and stopping them based on demand and administrative configuration. In some editions, the controller allows the user to install profile management to manage user personalization settings in virtualized or physical Windows environments. Each site has one or more delivery controllers.

*XenServer*: XenServer is an enterprise-class virtual machine infrastructure solution that creates the foundation for delivering virtual desktops and offers advanced management features. Multiple VMs can run on XenServer, which takes advantage of the advanced virtualization features of the latest virtualization-enabled processors from Intel and AMD.

*Delivery Agent (VDA)*: Installed on server or workstation operating systems, the VDA enables connections for desktops and apps. For remote PC access, install the VDA on the office PC.

*Machine Creation Services:* A collection of services that work together to create virtual desktops from a master desktop image on demand, optimizing storage utilization, and providing a pristine virtual desktop to users every time they log on.

*Windows Server OS Machines:* VMs or physical machines based on the Windows Server operating system used for delivering applications or hosted shared desktops to users.

*Desktop OS Machines:* VMs or physical machines based on Windows Desktop operating system used for delivering personalized desktops to users, or applications from desktop operating systems.

*Remote PC Access:* User devices that are included on a white list, enabling users to access resources on their office PCs remotely, from any device running Citrix Receiver.

Additional components provide the following features:

*Secure delivery:* When users connect from outside the corporate firewall, this release can use Citrix NetScaler Gateway (formerly Access Gateway) technology to secure these connections with Secure Socket Layer (SSL). NetScaler Gateway or NetScaler VPX virtual appliance is an SSL Virtual Private Network (VPN) appliance that is deployed in the demilitarized zone (DMZ) to provide a single secure point of access through the corporate firewall.

WAN optimization—In deployments where virtual desktops are delivered to users at remote locations such as branch offices, Citrix NetScaler CloudBridge (formerly Citrix Branch Repeater or WANScaler) technology can be employed to optimize performance. Repeaters accelerate performance across wide-area networks (WAN), so with Repeaters in the network, users in the branch office experience Local Area Network (LAN) like performance over the WAN. NetScaler CloudBridge can prioritize different parts of the user experience so that, for

example, the user experience does not degrade in the branch location when a large file or print job is sent over the network. Xen Desktop WAN Optimization with NetScaler CloudBridge provides tokenized compression and data de-duplication, dramatically reducing bandwidth requirements and improving performance. For more information, see the Citrix NetScaler CloudBridge documentation (Citrix Product Documentation, 2015).

### **What has Changed?**

The meaning behind acronym VDA has been changed from Virtual Desktop Agent to Virtual Delivery Agent. The VDA is the piece of software that is installed on the physical or virtual system that users will connect to. The change was made to reflect the fact that users can now deliver desktops and applications from VDAs with both desktop and server operating systems.

Additionally, the Quick Deploy option has been removed. Quick Deploy was an initial setup wizard that was run through the Citrix Studio console and did everything required to bring up an environment with provisioned desktops within a few minutes. The problem was that all components needed to be installed on the same system and there were limited configuration options, so Quick Deploy wasn't often used.

Storefront is now the official standard platform for accessing resources in a XenDesktop environment. It replaces Web Interface, which was end-of-life by 2015. Using Web Interface with this release is not supported.

There are no longer any device drivers on the controller. Previously, there existed a driver for diagnostic tracing; however, this code has been moved to user space. Now, when upgrading from a previous version, a reboot is not required. This also improves system stability.

*Desktops:* Deliver managed desktops to multiple, simultaneously connected remote users. Server OS Machine and Desktop OS Machine desktops provide features such as session reliability and Desktop Viewer. This release introduces Windows Server OS Machine catalogs and desktops, and also provides a remote PC desktop that lets users access resources on their office PCs remotely from any device running Citrix Receiver.

*Applications:* Integrates XenApp publishing capabilities within a deployment that delivers shared hosted applications to multiple, simultaneously-connected remote users (Citrix XenDesktop 7.6 Blueprint, 2013).

### Xen desktop terminology installation phase.

Current Terms	Purpose
Delivery Controller	<p>A server-side component responsible for distributing desktops and applications to users, managing user access through policies, power managing desktops, and rebooting cycles for servers.</p> <p><b>Deprecated Terms:</b> DDC, XD Broker, XA Controller, Data Collector, XML Broker, Legacy Broker (IMA), Flexcast Broker, XenDesktop Controller</p>
Delivery agent	<p>Software agent installed on the virtual or physical machine (RemotePC) and provides the virtual desktop or application to the user. It enables the machines to register with delivery controllers and manage the connection between the machines and the user devices.</p> <p><b>Deprecated terms:</b> Virtual desktop agent</p>
Citrix Studio	<p>Management console that allows administrators to create and manage infrastructure and resources to deliver to desktops and applications.</p> <p><b>Deprecated terms:</b> Desktop Studio</p>
Citrix Director	<p>Monitors the console providing detailed trends and diagnostic information on applications and desktops, in addition to providing a detailed and intuitive overview of Excalibur environments. Support and helpdesk teams can use it to quickly identify and resolve problems affecting users. Administrators can monitor and troubleshoot at the system level with performance, session usage data, and configuration changes.</p> <p><b>Deprecated terms:</b> Desktop Director</p>

(Citrix Product Documentation, 2015)

### Xen desktop terminology: The infrastructure configuration phase.

Current Terms	Purpose
Site	<p>The core Excalibur environment consisting of the delivery controller and database. The closest equivalent in a XenApp deployment is a Zone. Please note that there are some differences, and these should be called out for XenApp administrators.</p> <p><b>Deprecated terms:</b> Branch, Grid, Production Farm, Design Validation Farm, Pilot Farm XenApp Web Site, XenApp Services Site, Zne</p>
Connection	<p>Connection between the delivery controller and the provider of the resources. The resources are available through an XS Server pool, Hypervisor Management Server vCenter or SCVMM, or a cloud provider (e.g. AWS or CloudStack)</p> <p><b>Deprecated terms:</b> Virtualization Settings, Host, Host Connection</p>
Resources	<p>Compute (in case of vSphere or SCVMM), storage and networking resources for hosting and delivering applications and desktops.</p> <p><b>Deprecated terms:</b> Virtualization Settings</p>
<p><b>Database*</b></p> <p>Collective name for the three databases:</p> <ul style="list-style-type: none"> <li>• Monitoring Database</li> <li>• Configuration Logging Database</li> <li>• Site Configuration Database</li> </ul>	<p>Stores all the configuration, session, logging, and monitoring information for a Site.</p> <p><b>Deprecated terms:</b> IMA Datastore (XA), FMA Database (XD), Default Database Existing Database, Logging Database, Data Store, Site Database</p>
Machine	<p>Physical or virtual machine used to deliver applications and desktops to the end user; the machine to which the user connects.</p> <p><b>Deprecated terms:</b> Session Host, Worker, Server, Workload Machine, Single-session Machines, Multi-session Machines, VDI Machine, RDS Machine,</p> <p><b>Does Not Replace:</b> Server, Virtual Machine, Physical Machine</p>

(Citrix Product Documentation, 2015)

### Xen desktop—The resource configuration phase.

Current Terms	Purpose
Master Image	<p>An installed instance of a server or desktop operating system, including all the applications installed and the VDA (optional). The master image can be duplicated using a provisioning technology to create machines that can host applications and desktops to end users.</p> <p><b>Deprecated Terms:</b> Golden Image, Base Image, Master VM, Image</p> <p><b>Does Not Replace:</b> Operating System, Virtual Machine, Image, Template, Snapshot</p>
Machine Catalog	<p>A collection of machines. These machines could have been created from the same master image; the provisioning technology and process must ensure that each machine has a unique identity (in Active Directory and on the network.) Can be used to create applications and desktop for users.</p> <p><b>Deprecated terms:</b> Assignment, Application Desktop Group, Assignments (Same as Desktop Groups), Pool, Collection, Desktop Catalog, Workload Catalog, Workload, Workload Group, Bundle, Service Offering, Service, Plan, Service Catalog, Silo, Application Silo, Distribution Group, User Group</p>
Machine Creation Services	<p>Services that run on the delivery controller and uses a master image to create a server or desktop machine(s) with a unique identity on the network and in Active Directory.</p>
Provisioning Service	<p>Service that allows the administrator to create virtual or physical instances of desktop or server machines.</p>
Desktop	<p>The instance of an operating system delivered to the end user's device and that the end user interacts with.</p> <p><b>Does Not Replace:</b> Operating System, Virtual Machine, Master Image</p>
Machine	<p>Any physical or virtual machine managed by Excalibur.</p> <p><b>Deprecated terms:</b> Session Host, Worker, Server, Workload Machine</p> <p><b>Does Not Replace:</b> Operating System, Virtual Machine or VM, Master Image</p>

(Citrix Product Documentation, 2015)

**Xen desktop: Resource assignment phase.**

<b>Current Terms</b>	<b>Purpose</b>
Delivery Group	The machine(x) used to deliver applications and/or desktops to a specific group of users.  <b>Deprecated terms:</b> Desktop Groups
Application	The instance of a software application that runs on the end user's client device or virtual desktop.
Policy	A feature for controlling connection, security, and bandwidth settings. <b>Deprecated terms:</b> HDX Policy, Citrix Policy

**System requirements.**

<b>Component</b>	<b>System details</b>	<b>Requirements</b>
Delivery Controller	Supported OS: Windows Server 2012, Windows Server 2008 R2 (Standard/Enterprise)	Disk space: 100 MB; Microsoft .NET Framework 3.5 SP1; Microsoft .NET 4.0; Windows PoSH 2.0 or 3.0 ; ASP.NET 2.0 and Internet Information Services (IIS); Visual C++ 2008 SP1 Redistributable Package
Site database	Supported SQL Server: SQL Server 2012; SQL Server 2008 R2 SP1 (Express/Standard/Enterprise/Datacenter editions)	
Studio	Supported OS: Windows 8, Windows 7, Windows Server 2012, Windows Server 2008 R2	Disk space: 75 MB; Microsoft .NET Framework 3.5 SP1; Microsoft Management Console 3.0; Windows PowerShell 2.0 or 3.0

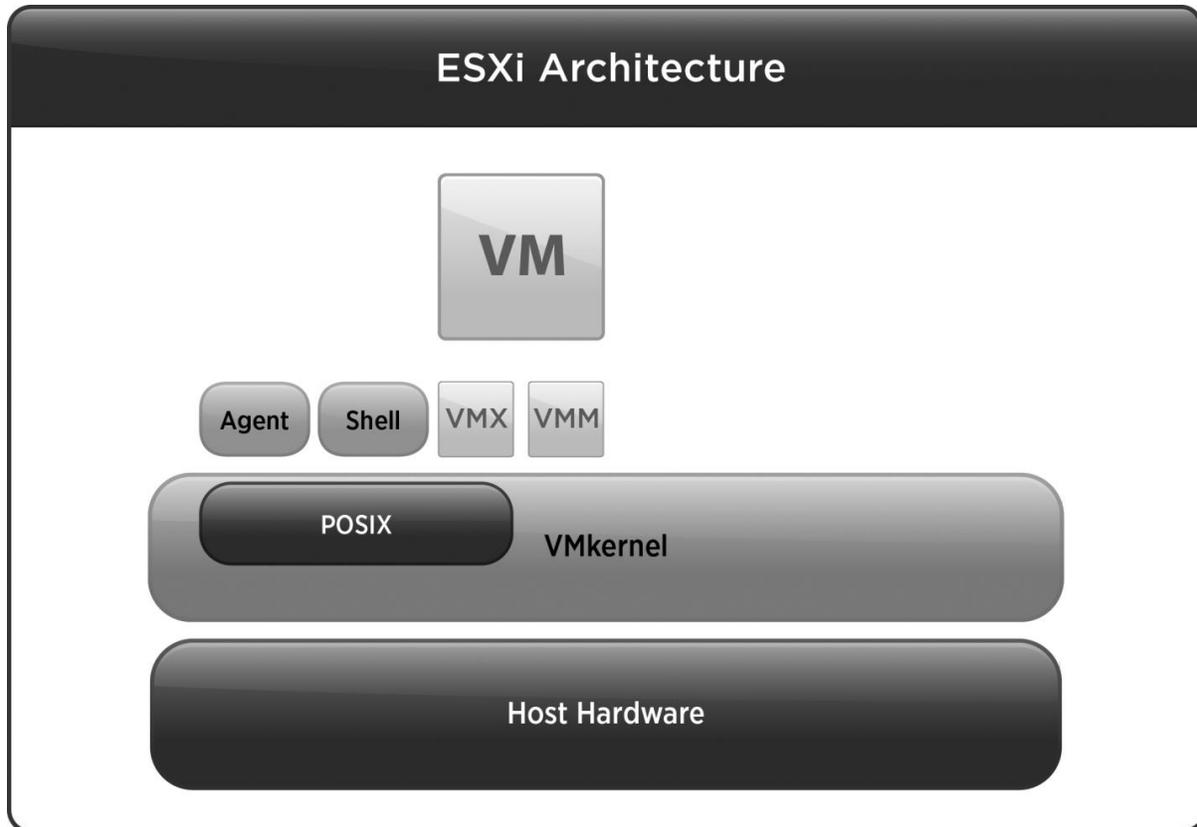
Director	Supported OS: Windows Server 2012, Windows Server 2008 R2 (Standard/Enterprise)	Disk space: 50 MB;Microsoft .NET Framework 4.0; Microsoft Internet Information Services (IIS) and ASP.NET 2.0; Browsers: Internet Explorer 8 and 9; Firefox 14 and 15
Delivery Agent (DA)	Supported OS: Windows Desktops (Windows 8, Windows 7 Enterprise/Professions Editions); Windows Servers (Windows Server 2012, Windows Server 2008 R2 SP1 Datacenter/Enterprise and Standard Editions)	
Host	Supported hosts: XS 6.0.2; Vmware vSphere 5.0 (ESXi 5.0 and vCenter 5.0), VMWare vSphere 4.1 Update1; SCVMM 2012 Rollup 1	

### **vSphere.**

vSphere, just like Xen Desktop, is a package of many components which includes important features like:

- ESXi
- vCenter Server
- HA
- DRS (VMware, Inc., 2015b).

**ESXi.** ESXi is an industry-leading bare metal or type 1 hypervisor which otherwise is called a virtualization software or OS. It allows us to create and run multiple operating systems.



*Figure 3.* ESXi architecture (VMware, Inc., 2015a).

**vCenter Server.** The vCenter Server is a single page management tool which can manage multiple virtual machines and ESXi servers running in a data center.

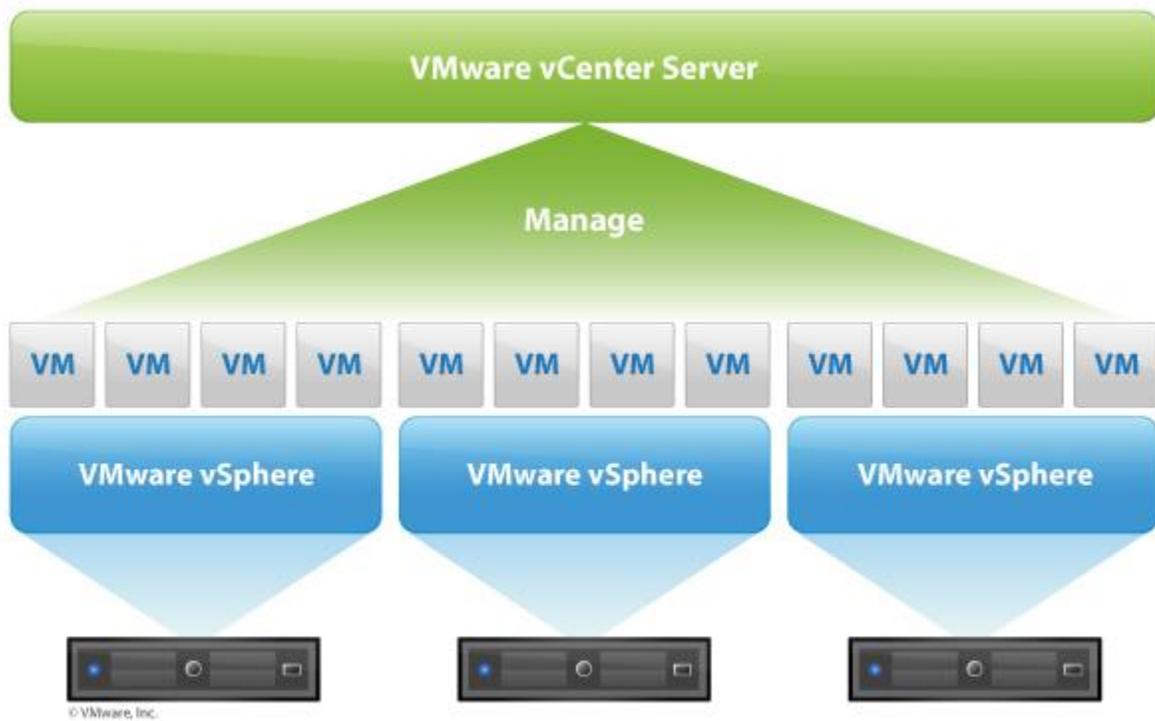


Figure 4. vCenter (Lee, 2011)

**High availability.** High availability is a solution from VMware which can be used to recover virtual machines from a failed ESXi server to a running ESXi server in the same cluster.

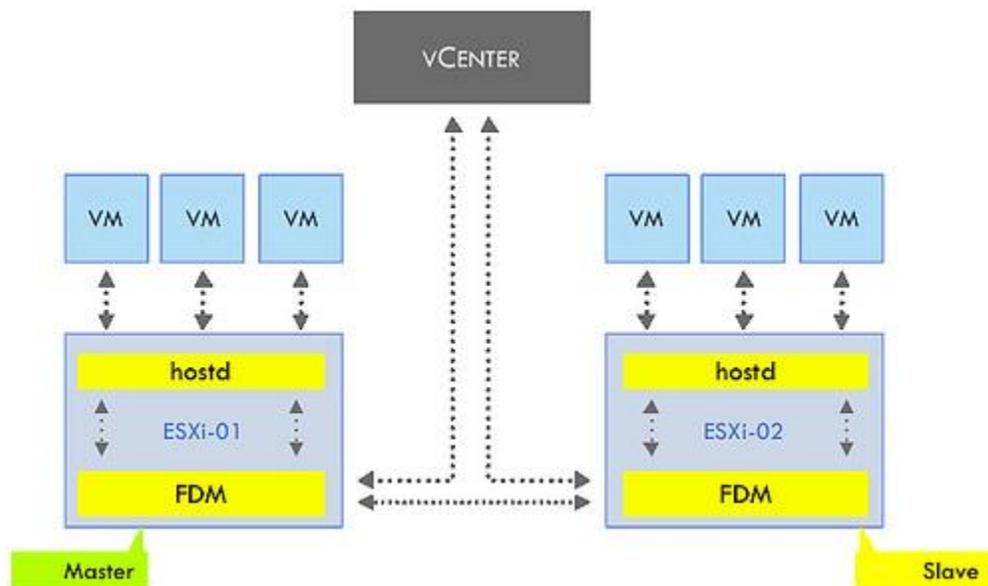
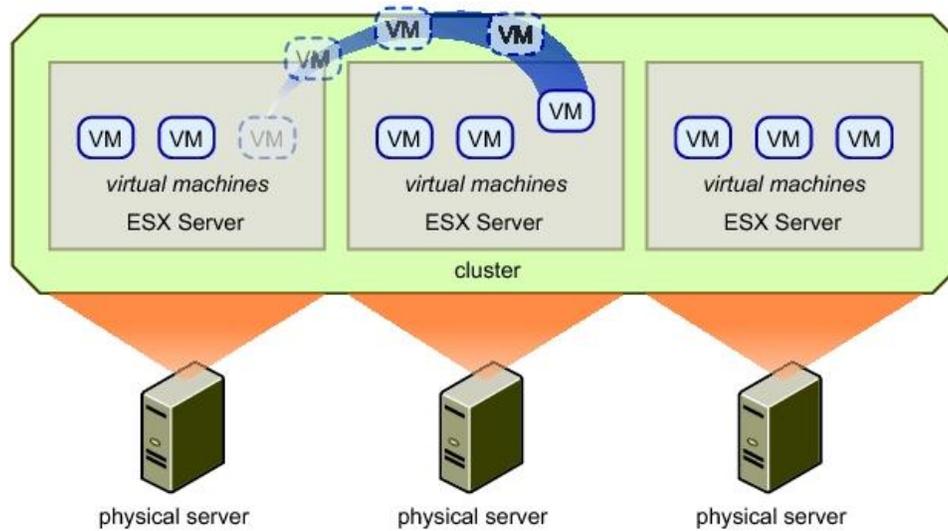


Figure 5. High-level architecture of HA (Epping, 2010).

**Distributed resource scheduler.** This is a solution from VMware which can be used to load balance the cluster and take care of initial placement of virtual machines.



*Figure 6. Working of DRS (Hosts, Clusters, and Resource Pools, 2009).*

## Chapter 3: Methodology

### Working of Xen Desktop

In XenDesktop 7, the merging of XenDesktop and XenApp into a single architecture and management has occurred. This means all hosted desktops and applications can be managed through a single console and can also be delivered through a single console. All the Xen App features will now be delivered through Xen Desktop.

Essential Elements for Xen Desktop site include:

- One or more desktop controllers
- Citrix License Server
- Storefront (Web interface)
- Site database
- Desktop Studio and Desktop Director
- Regardless of the size of the deployment, Xen Desktop site also requires:
  - Domain Controller running Active Directory
  - Virtual desktops managed by a hypervisor
  - Access Gateway (if the desktop is accessed remotely)
  - User devices running Citrix receiver
- For PVS, we need CITRIX Provisioning Services.

## Setup Process Flowchart

### New Environment Installation: Process Flowchart

For current XenApp customers migrating to XenDesktop 7

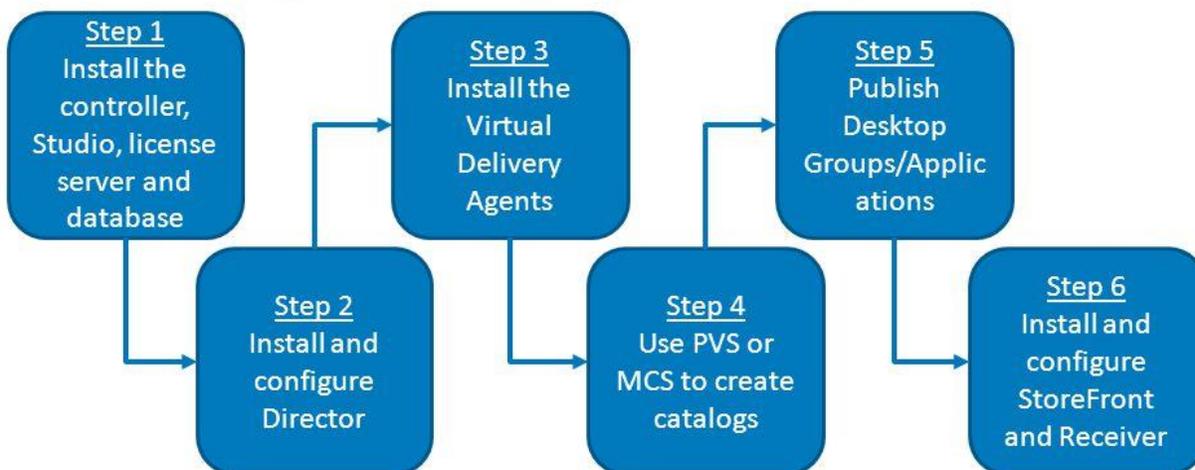


Figure 7. Xen desktop process flowchart

#### Step by step configuration of Xen desktop.

1. Install Desktop delivery controller
2. Configure the site (hypervisor required for creating virtual desktops)
3. Install and configure License Server and StoreFront
4. Create a master image on the hypervisor and install the VDA on the master image
5. Create a catalog (required OS and resource requirements for each desktop)
6. Publish the virtual desktops to end users by creating a delivery group
7. Install and configure Citrix Director for monitoring purpose
8. Install Citrix Receiver on end client devices to access the virtual desktops

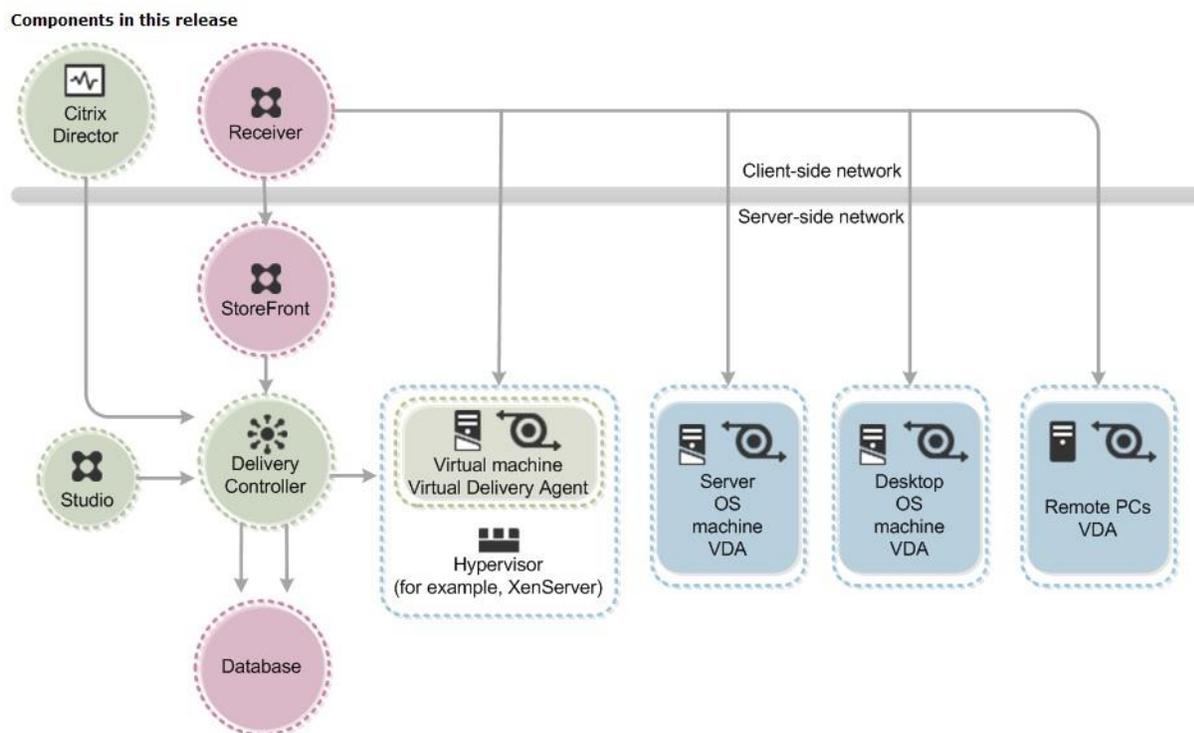


Figure 8. Components of Xen desktop 7 (Citrix XenDesktop 7.6 Blueprint, 2013).

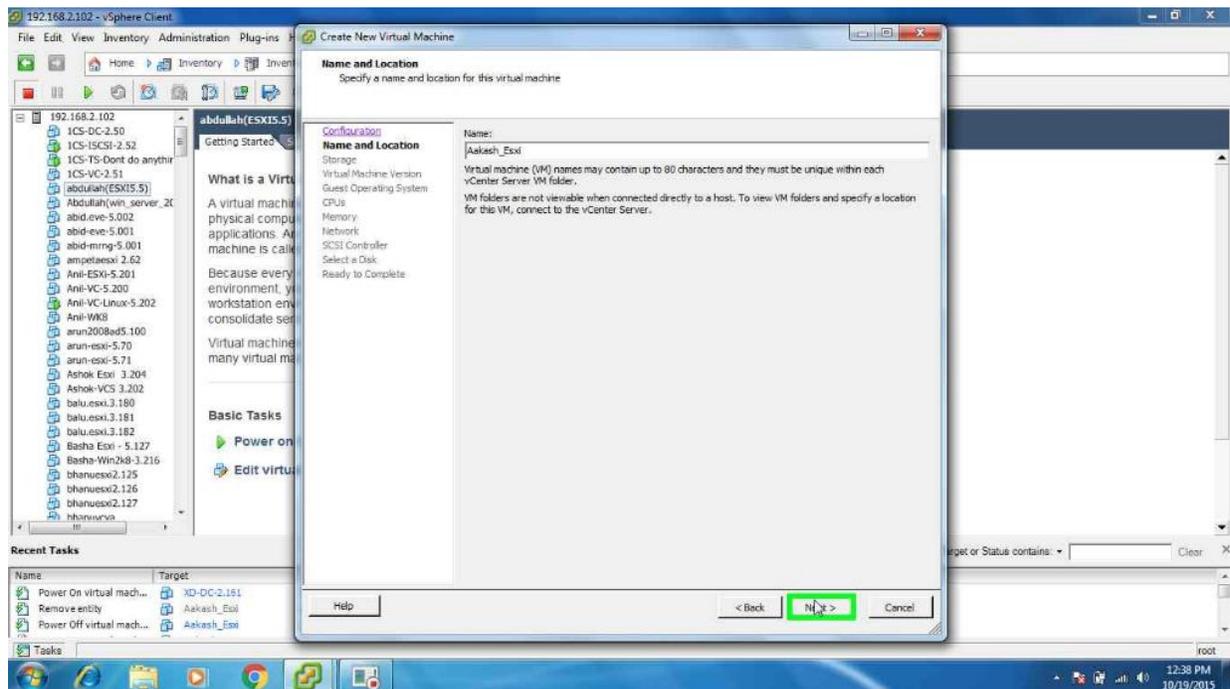
### Hardware and Software Requirements

- 1 Domain controller
- 2 Servers with 16 GB RAM
- 2 x HP Proliant DL 360 e Gen 8 servers
- 2 VMware ESXi Servers
- 1 x Dell PowerVault MD 3200i ISCSI storage
- vCenter Server on a Windows machine
- Windows VM for installing Citrix studio, director, StoreFront, License Server.
- Citrix Xen Desktop
- SQL database for vCenter Server and Xen Desktop
- Windows 7 or 8 client machine for creating a master image

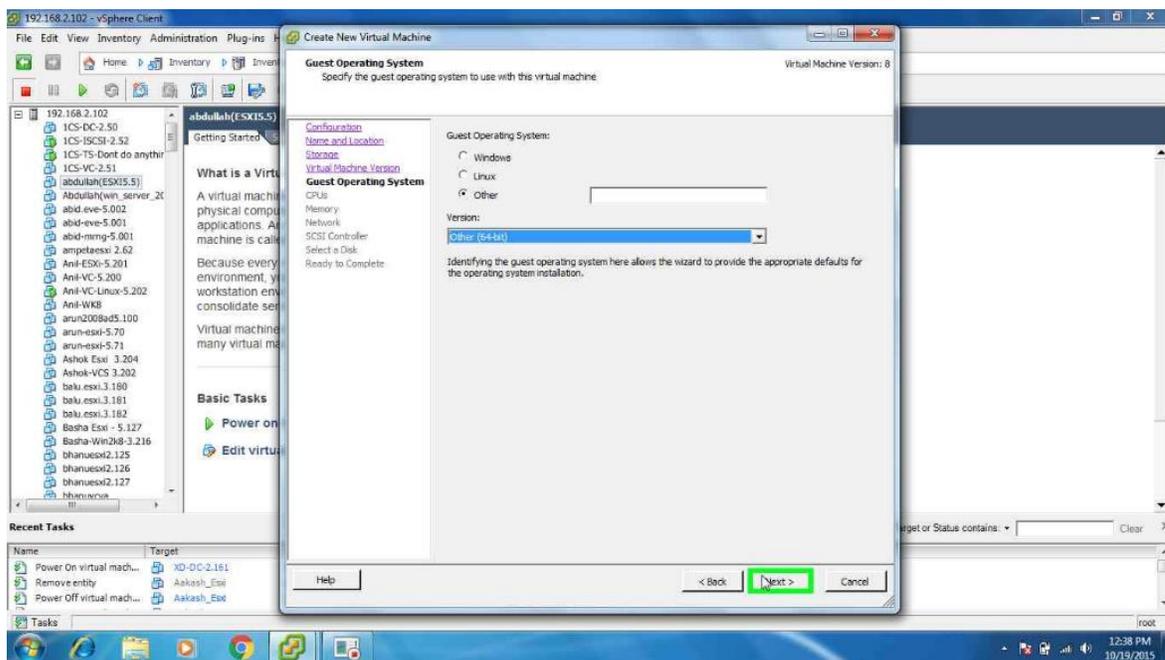
## Implementation

### ESXi installation.

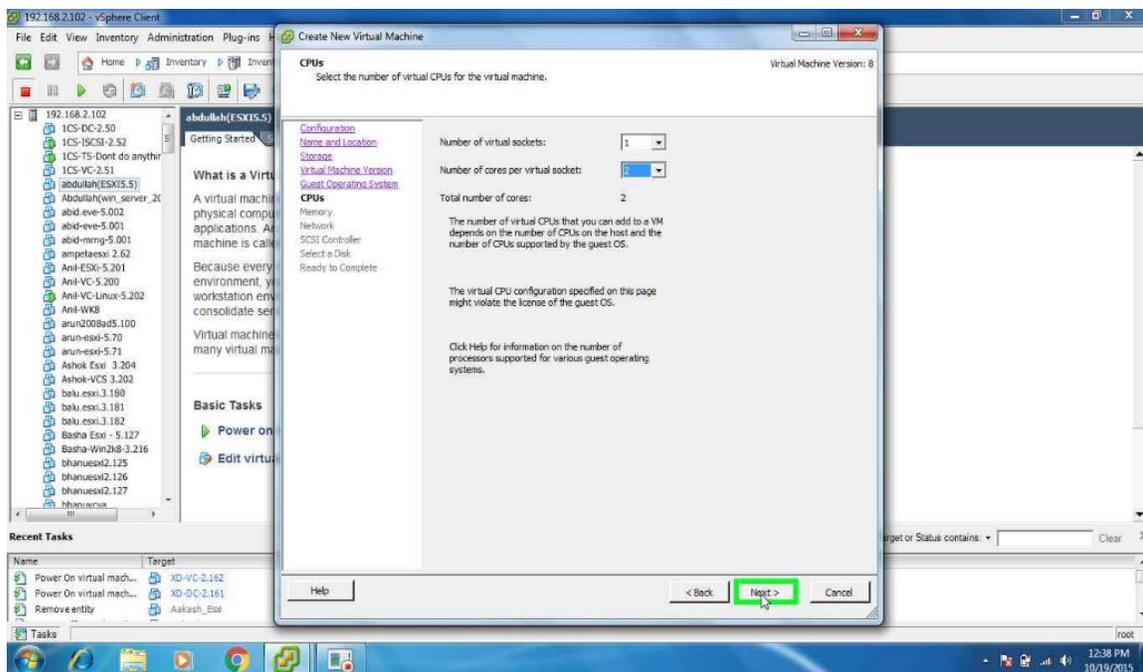
1. Create a virtual machine.



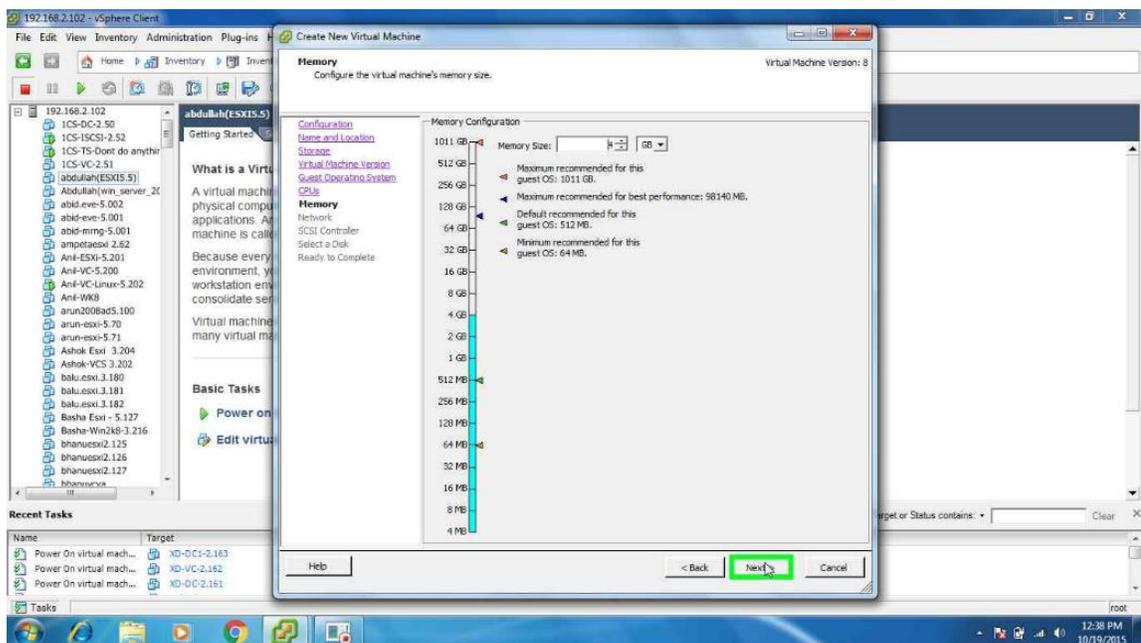
2. Click *Next*. Select OS as *Other (64 bit)*, as ESXi is not listed.



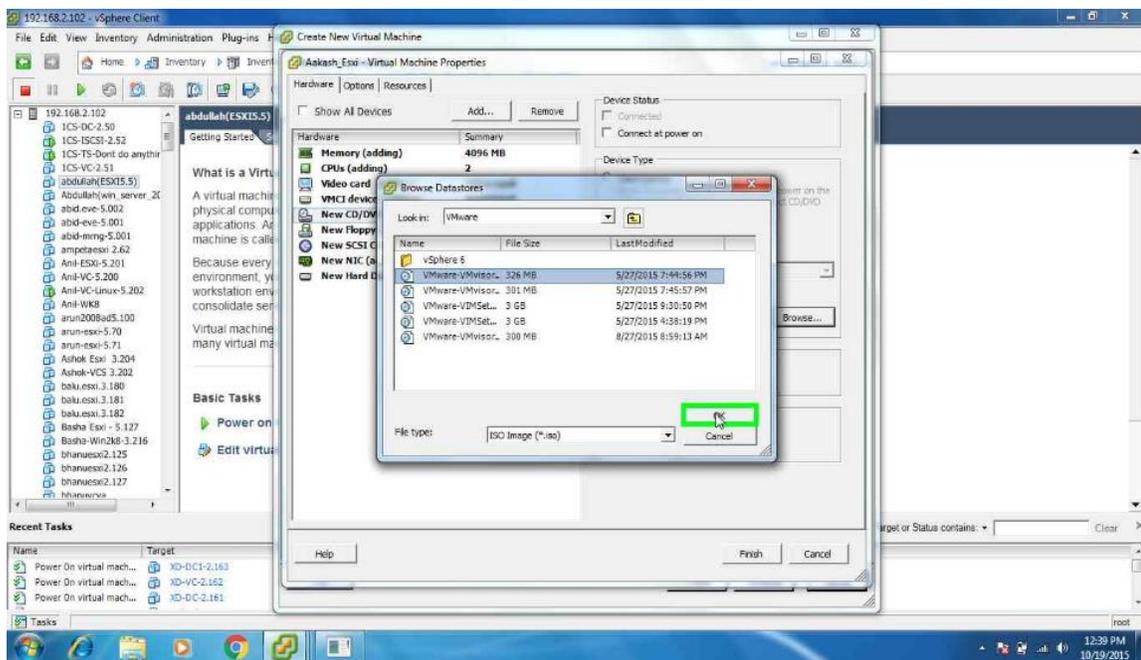
3. Select the number of CPU required.



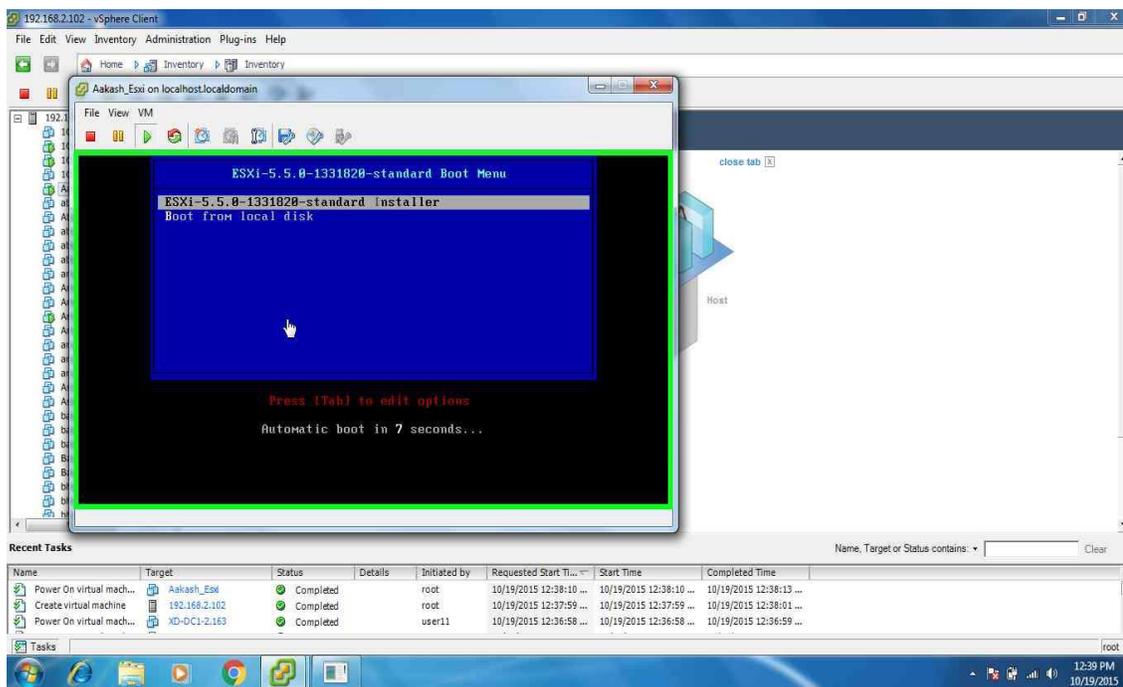
## 4. Select the amount of RAM required.



## 5. Mount ESXi 5.5 image and click Next.



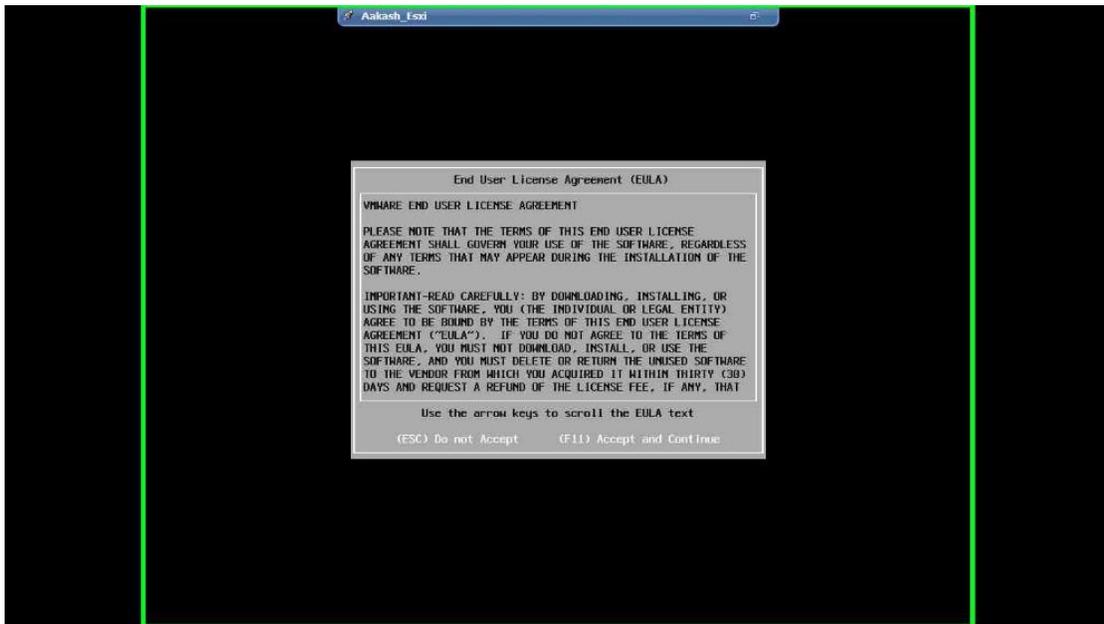
6. Power the virtual machine to *ON* to start installing ESXi.



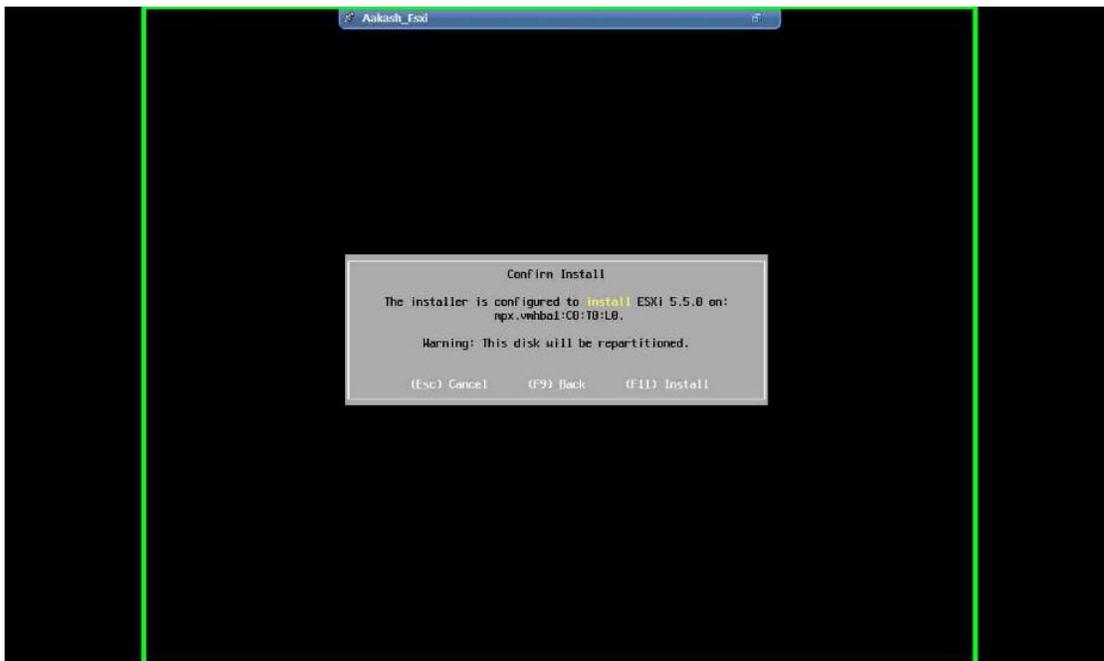
7. Click *Enter* to continue with the installation.



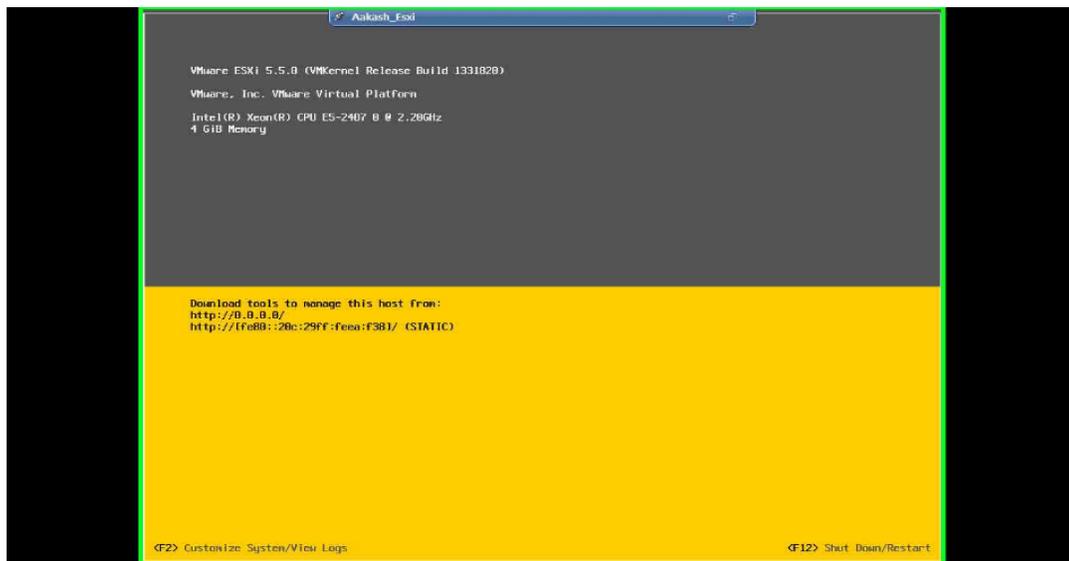
8. Accept the End User License Agreement and click F11 to continue.



9. Click on F11 to start the installation. Once the installation is complete, click on *Reboot*.

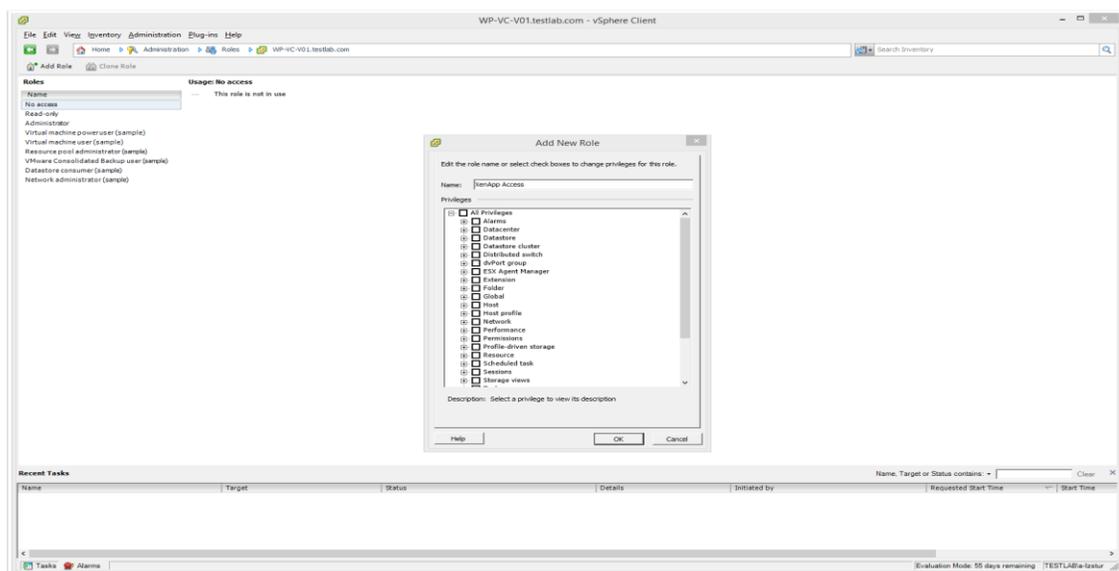


10. Configure the ESXi. The installation is complete.

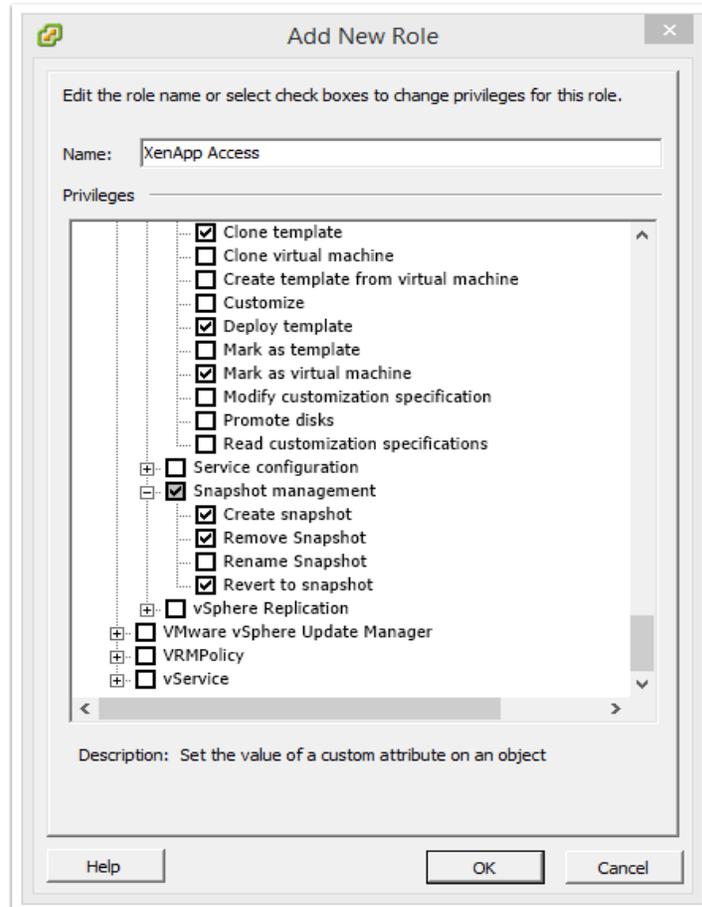


**vCenter integration with Xen desktop.** From Active Directory Users and Computers, create a Citrix Desktop domain service account

1. Log into VMware vCenter Client with admin rights
2. Navigate to Home >> Administration >> Roles
3. Create a new Security Role for XenDesktop Access

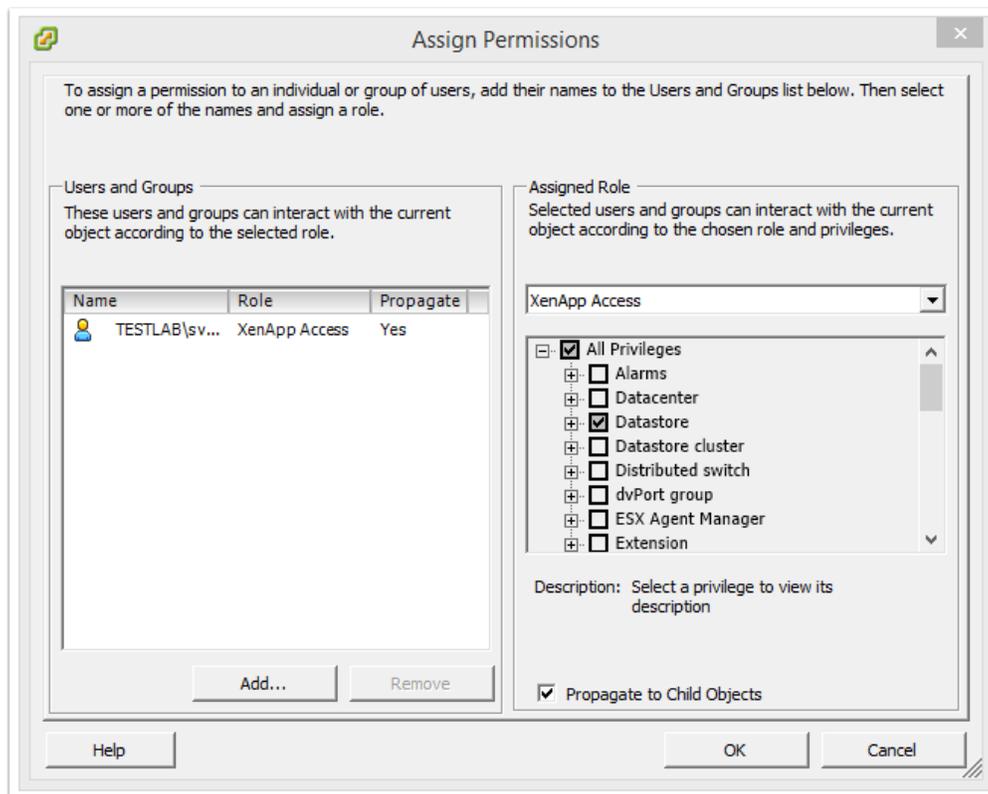


4. Configure the Xen Desktop security role with the permissions required by Citrix Xen Desktop server.



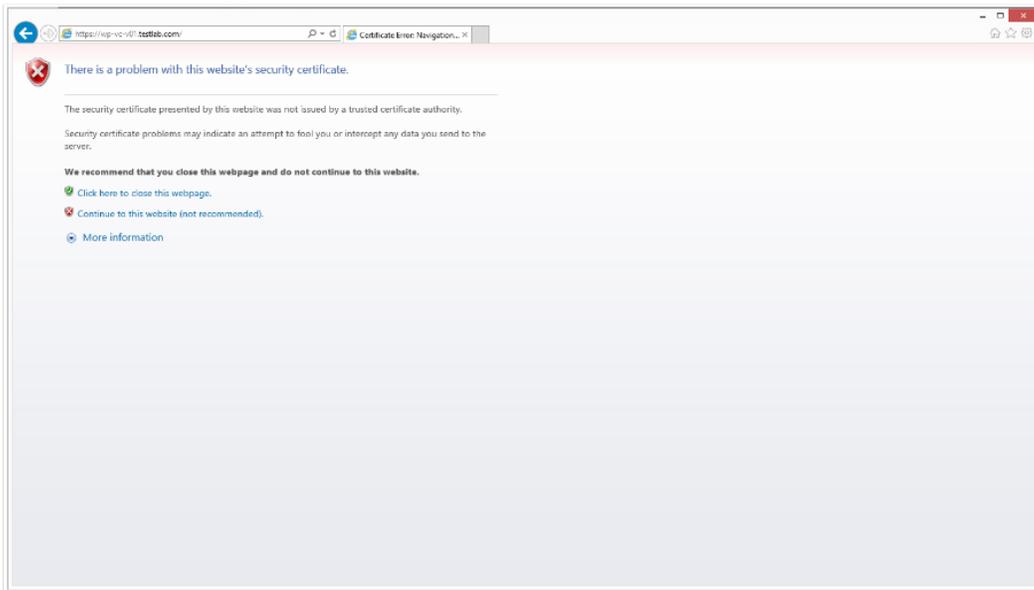
5. Navigate to Home >> Inventory >> Hosts & Clusters >> vCenter >> Permissions tab

Assign XenDesktop Access security role to XenDesktop Service Account.

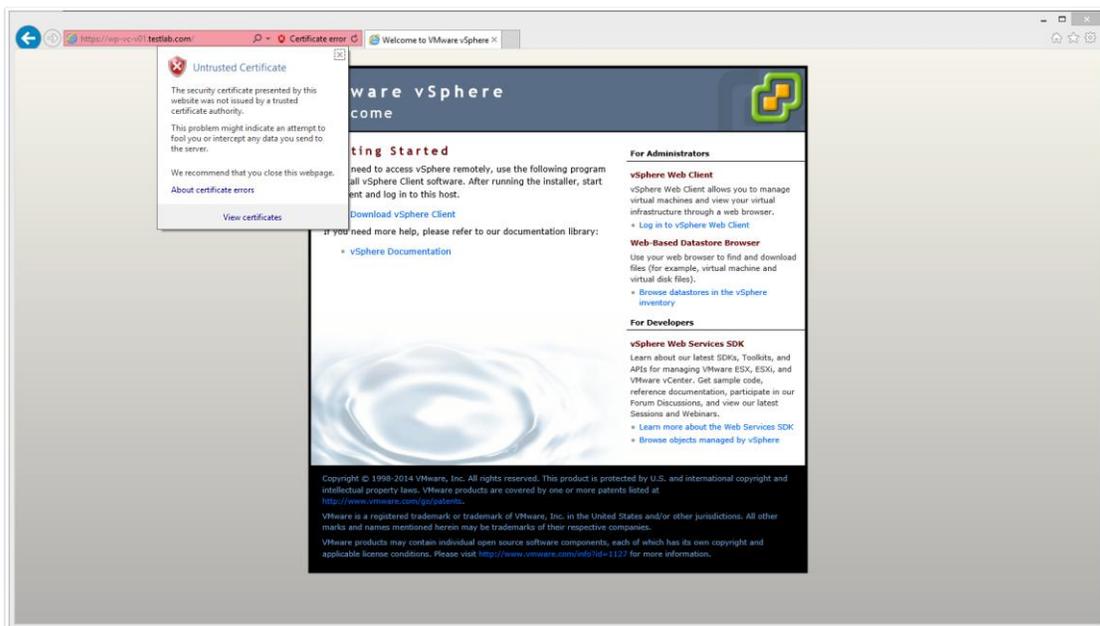


Next, the Virtual Center certificate must be installed on each delivery controller.

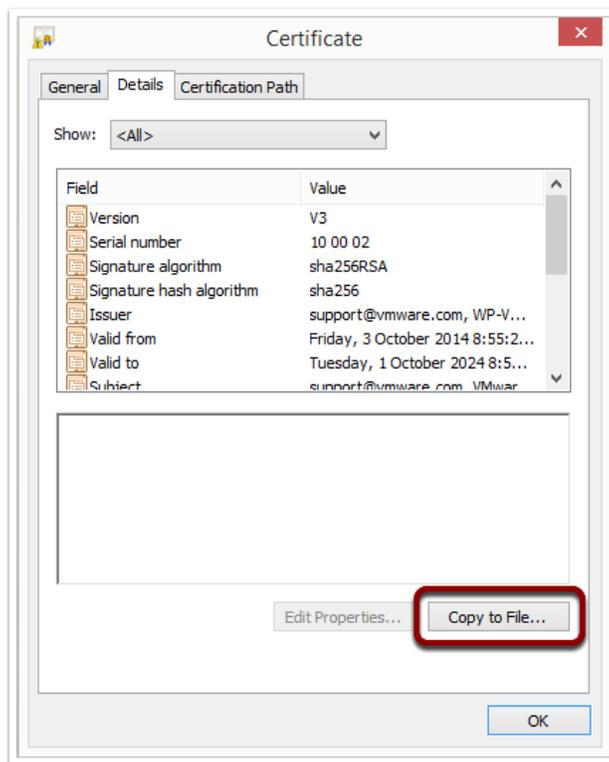
1. Log into the Citrix Delivery Controller Server as a user with administrative rights
2. Download and install the VMware vCenter server certificate. To do this, complete the following:
  - Launch Internet Explorer and browse to the VMware vCenter URL. Click *Continue to this website (not recommended)*.



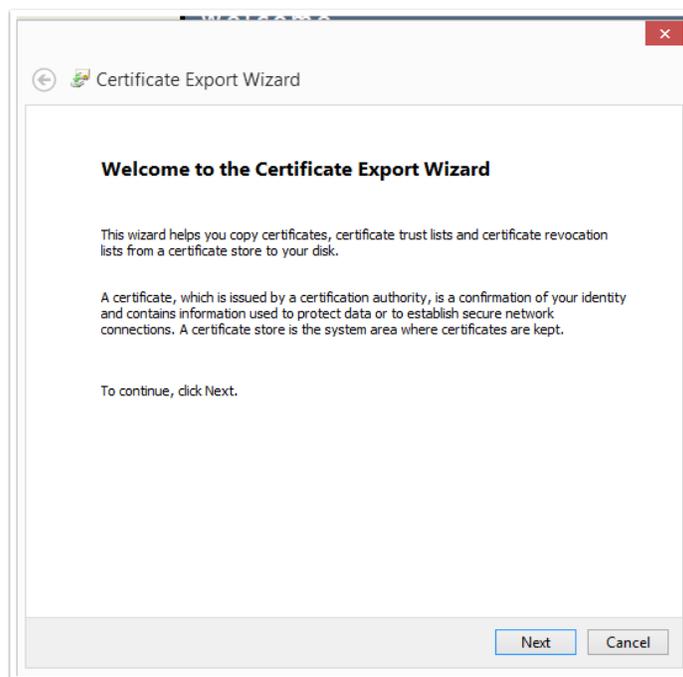
- From the address bar, click on *Certificate Error* and select *View Certificates*.



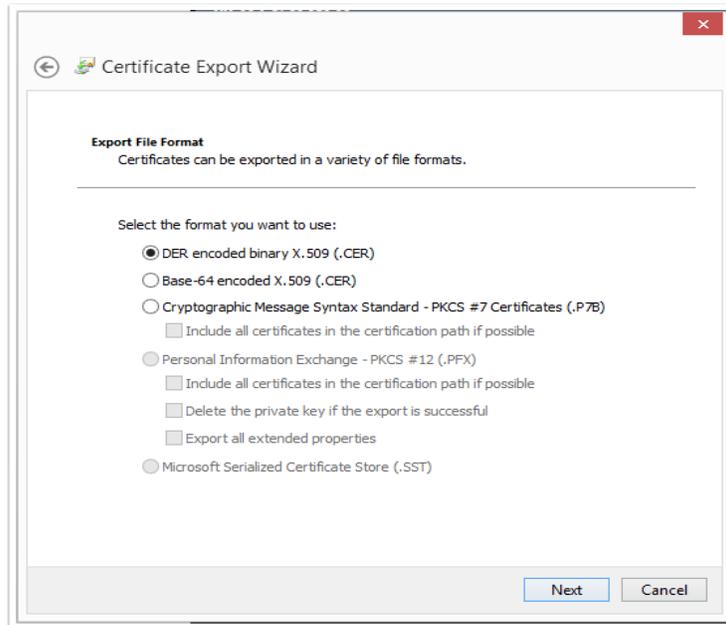
- From the Certificate Properties window, click the *Details* tab and click *Copy to File*.



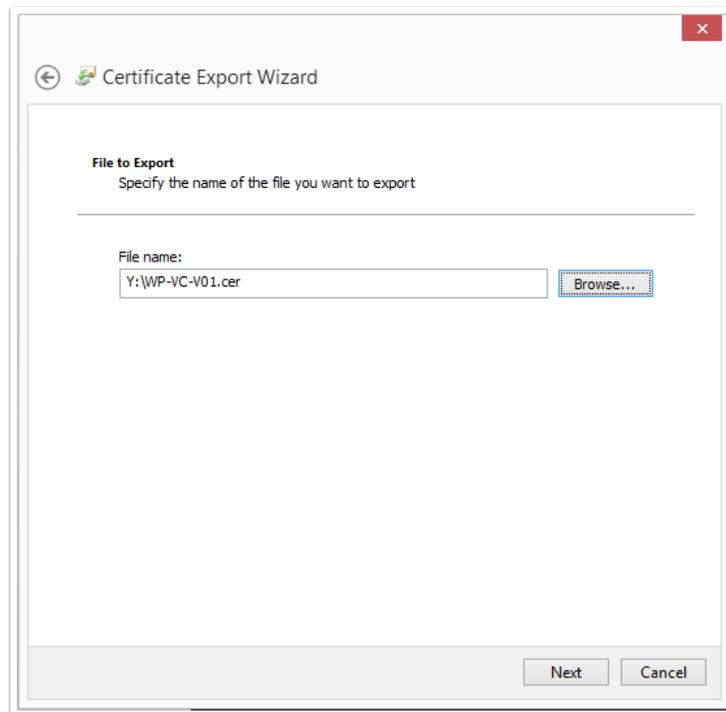
- Click *Next*



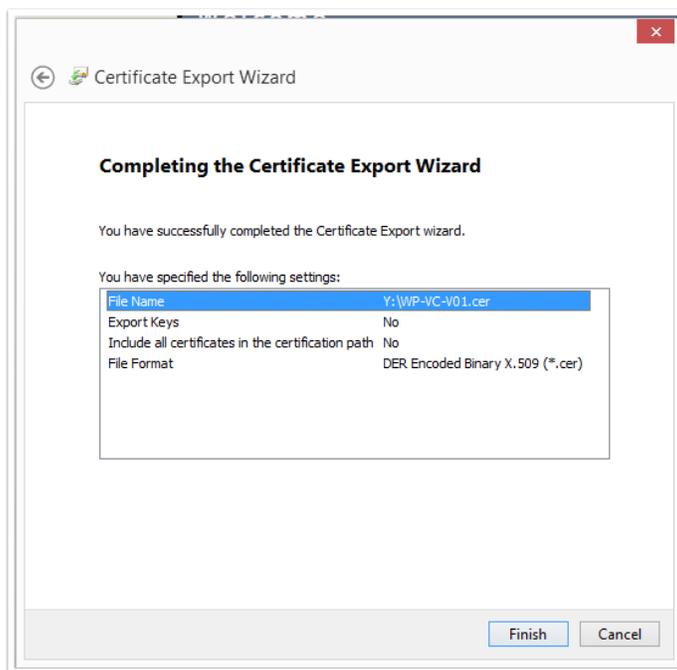
- Select the *DER encoded binary X.509 (.CER)* option and click *Next*



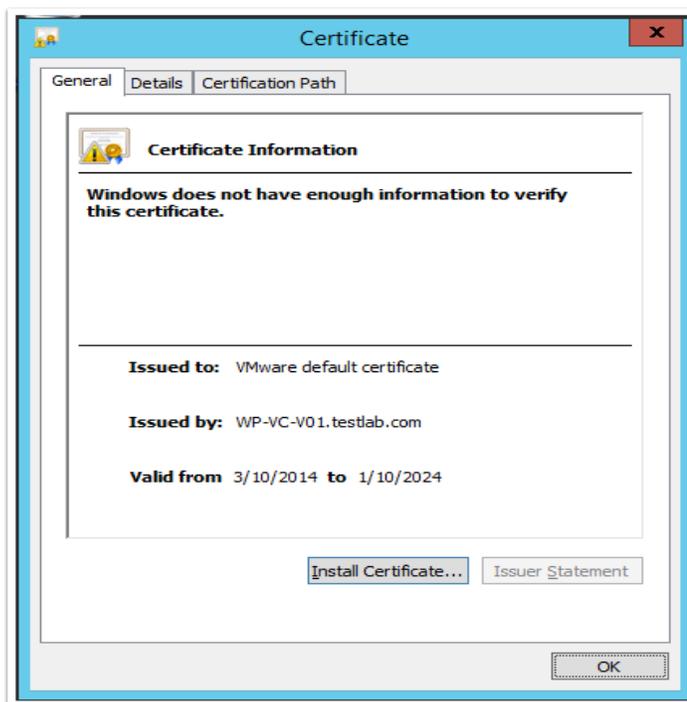
- Store the certificate on the local disk and click *Next*



- Click *Finish*



- Navigate to the saved location and double click on the certificate to view the properties window. From here, click *Install Certificate*.

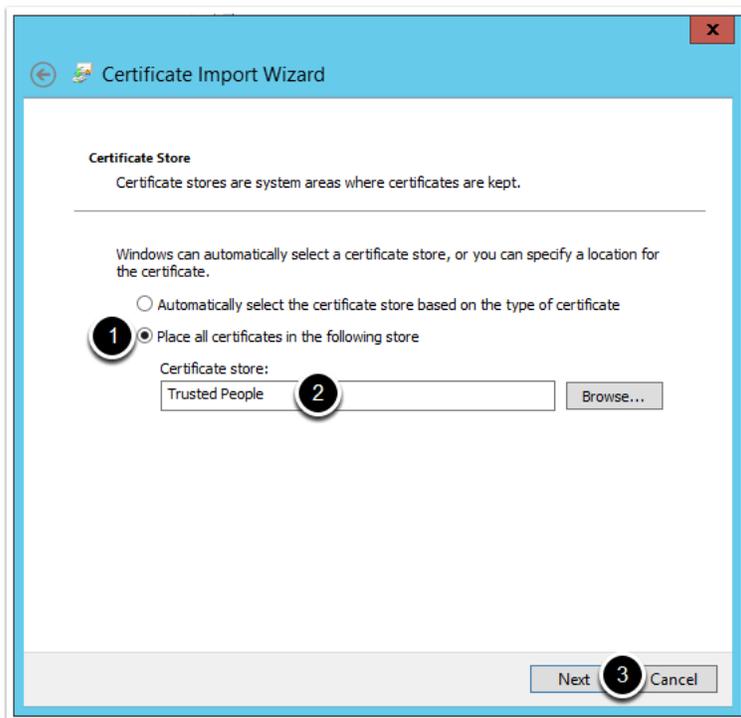


- Select *Local Machine* and click *Next*.

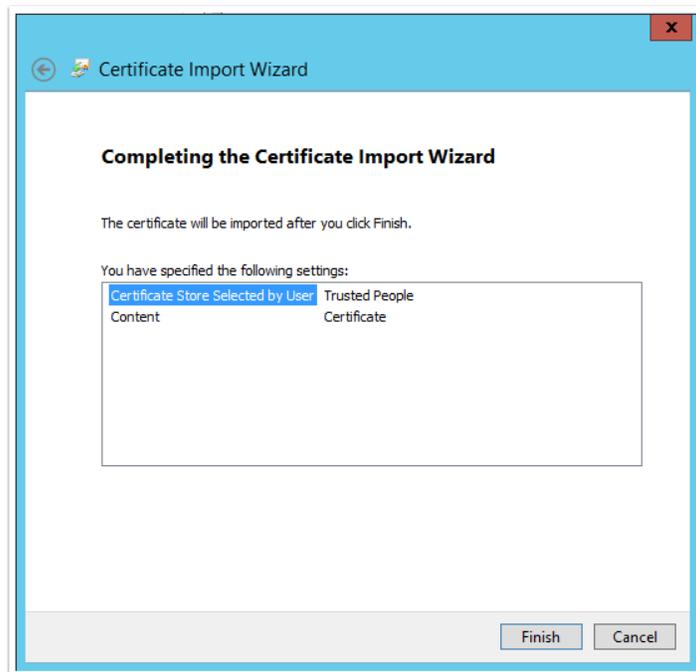


From the Certificate Store screen, complete the following:

- Select the *Place all certificates in the following store* option
- From the browse button, select *Trusted People*
- Click *Next*



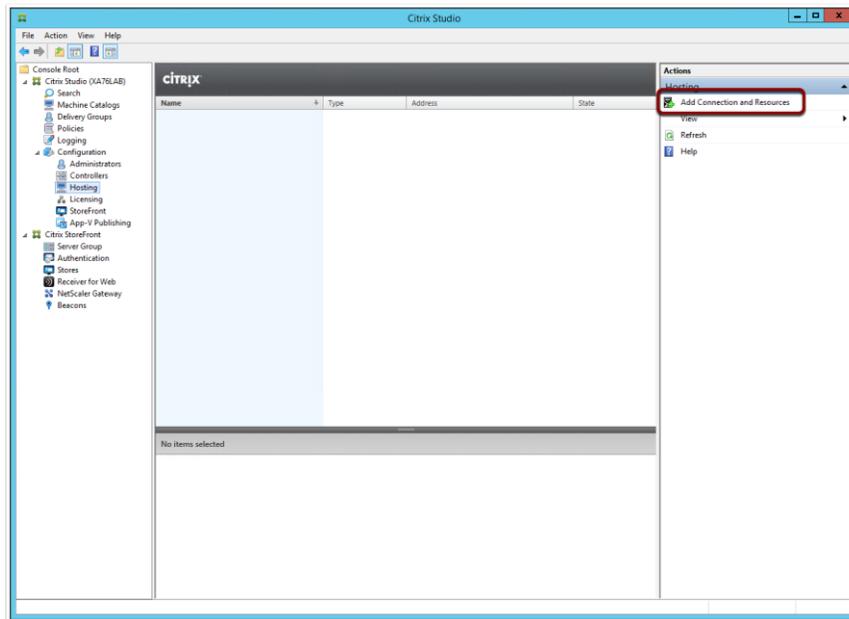
- Click *Finish*



- Repeat the steps above for all delivery controllers

Now that we have prepared the environment and assigned permissions, we are now ready to create the VMware connection in Citrix Studio.

1. Launch Citrix Studio >> Configuration >> Hosting >> Add Connections and Resources



2. From the Connection screen, complete the information as per the screenshot below and then click Next

Add Connection and Resources

**Studio**

Connection type: VMware vSphere®

Connection address: https://wp-vc-v01.testlab.com/sdk

User name: testlab\svxA76Admin

Password: ●●●●●●

Connection name: WP-VC-V01

The Connection name appears in Studio; it helps administrators identify the Connection.

Create virtual machines using:

Studio tools (Machine Creation Services)

Other tools

Back Next Cancel

3. From the Resources screen, complete the following:

- Enter a name for the resources
- Select a cluster where new VMs will be provisioned
- Select the Networks that can be used by Citrix VMs
- Click *Next*

Add Connection and Resources

**Studio**

✓ Connection

**Resources**

Storage

Summary

Name for these resources:

Citrix Server VMs

Cluster

Select a cluster for the new virtual machines.

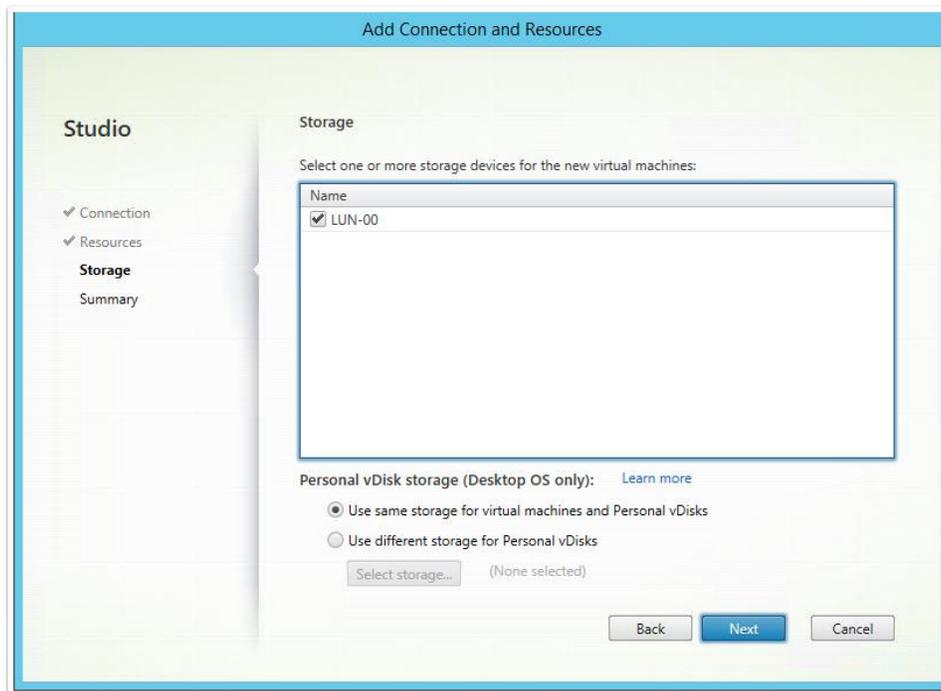
vp-host-p03.testlab.com Browse...

Select one or more networks for the virtual machines to use:

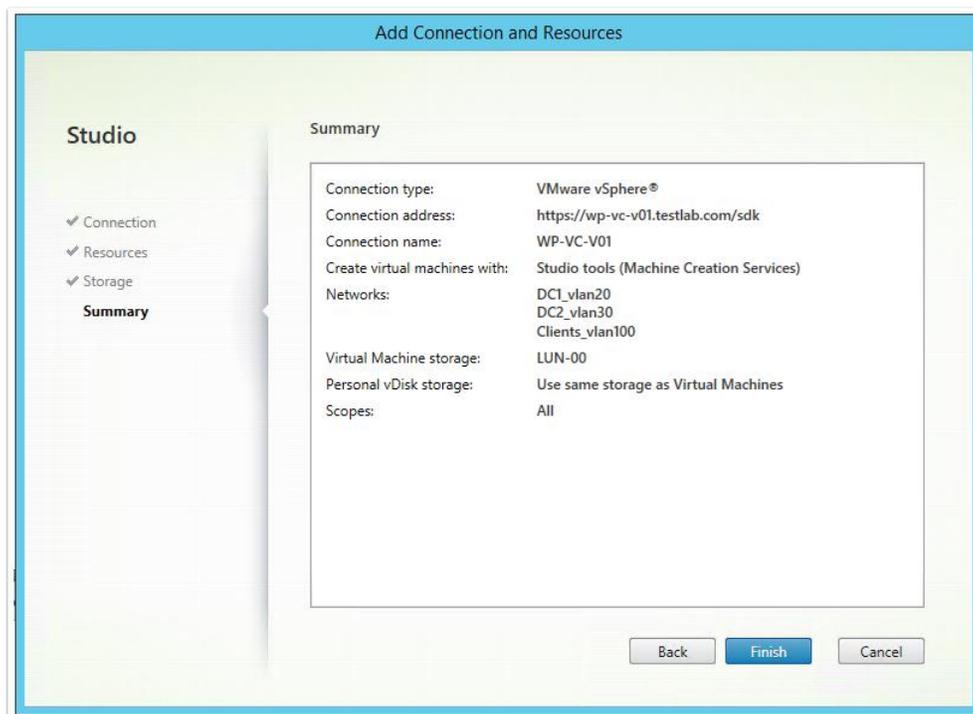
✓	Name
✓	Clients_vlan100
✓	DC1_vlan20
✓	DC2_vlan30

Back Next Cancel

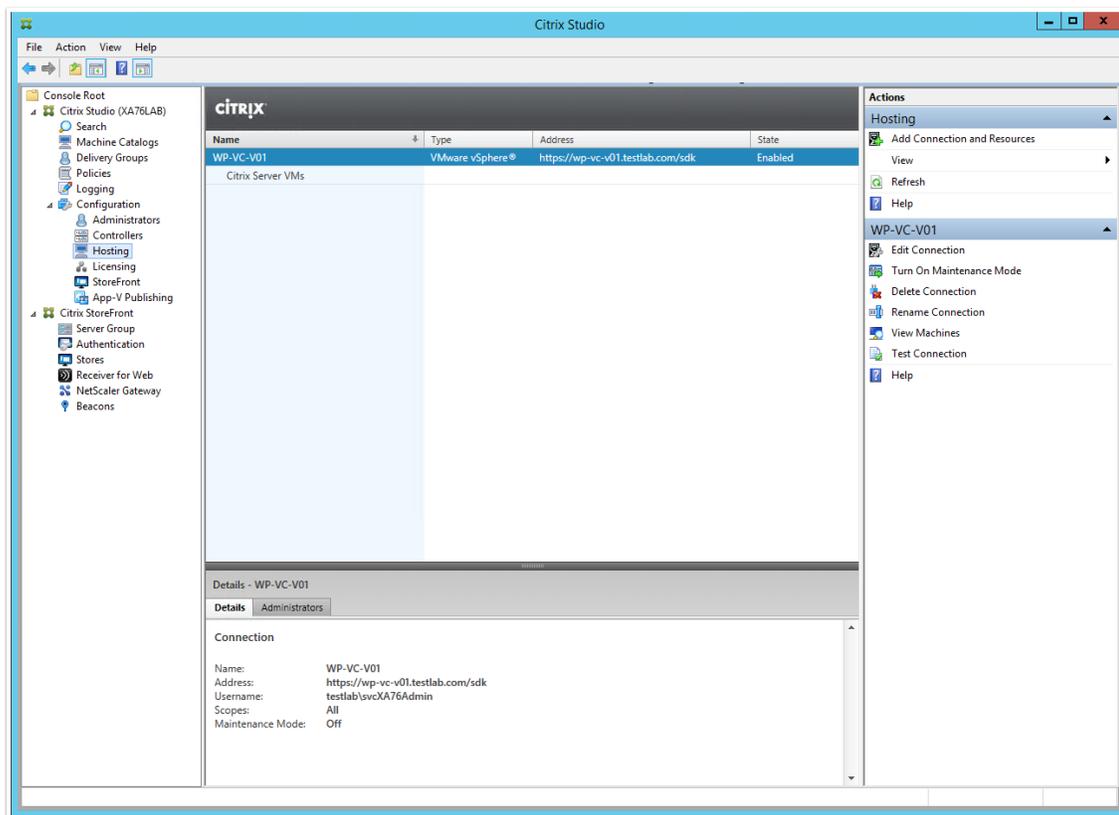
4. Select the Datastores you want to allow Citrix to use and click *Next*



- Click *Finish*

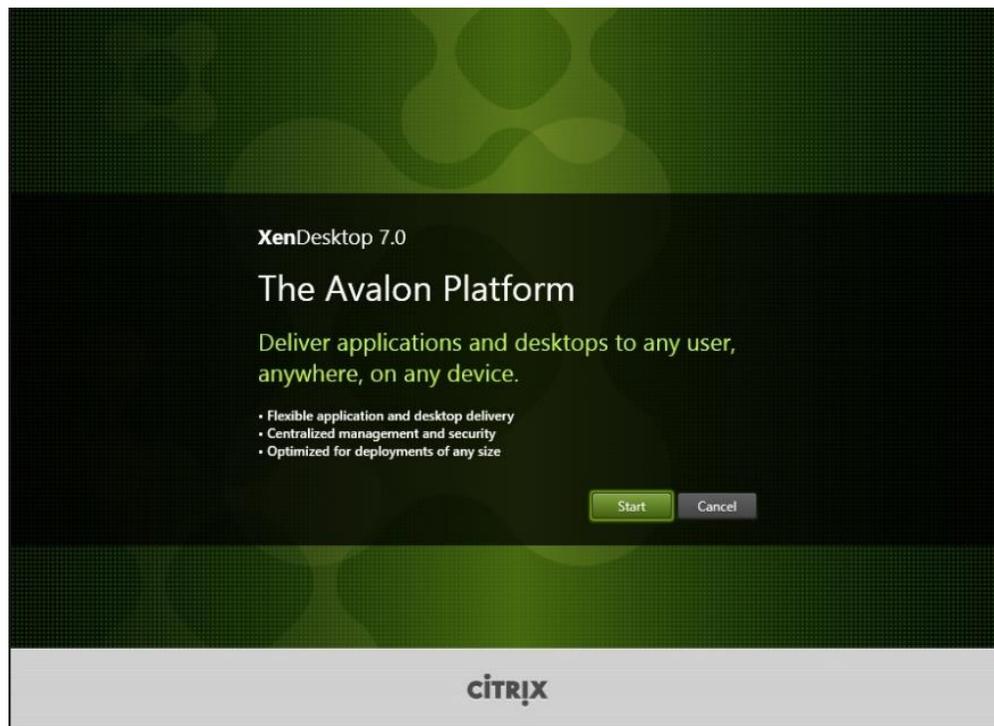


5. Ensure the similar details are seen in Configuration >> Hosting as per the screenshot below:

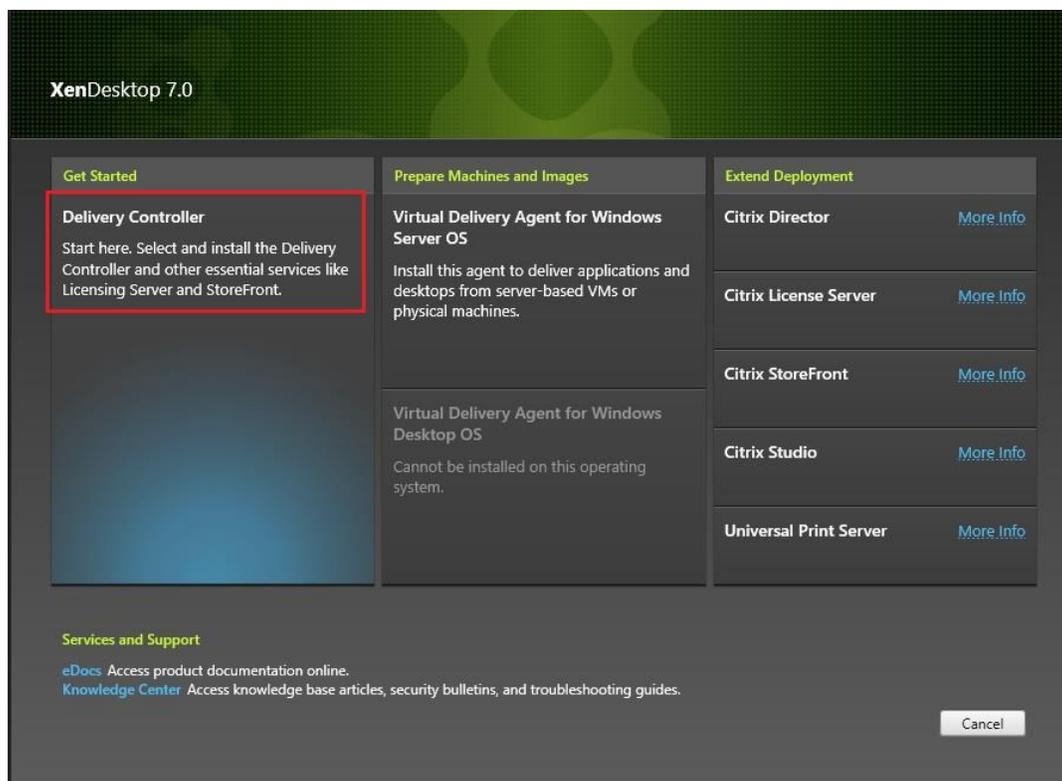


## Xen Desktop Installation

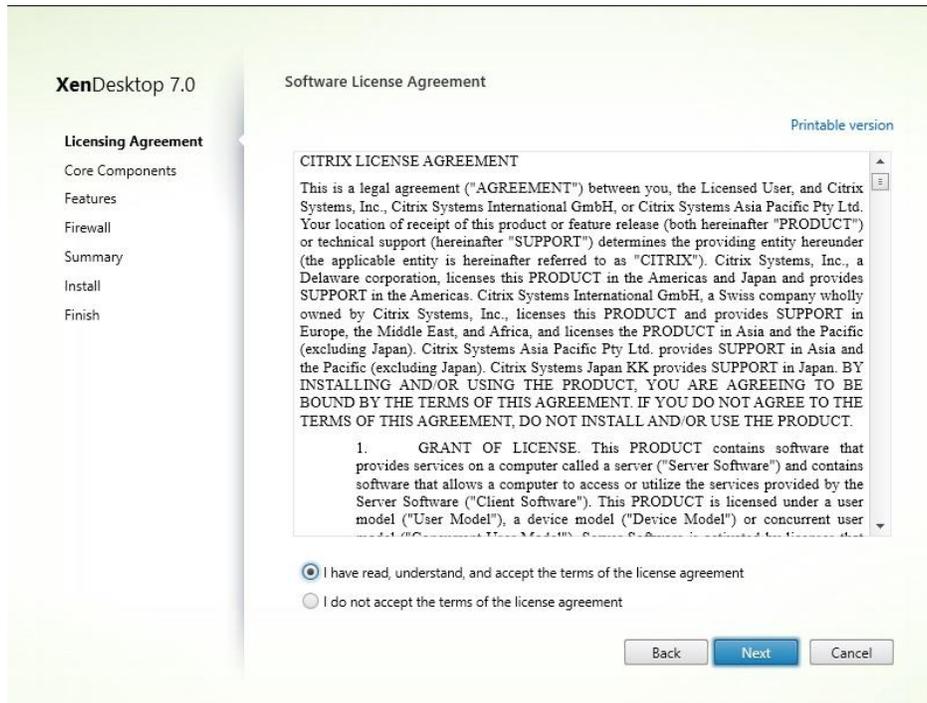
**Installation in first server.** XenDesktop 7 ISO is downloaded and copied on the Dell storage box LUN. Windows 2012 VM is created and XD is installed on it. Double click *Launch the Installer* and click on *START*.



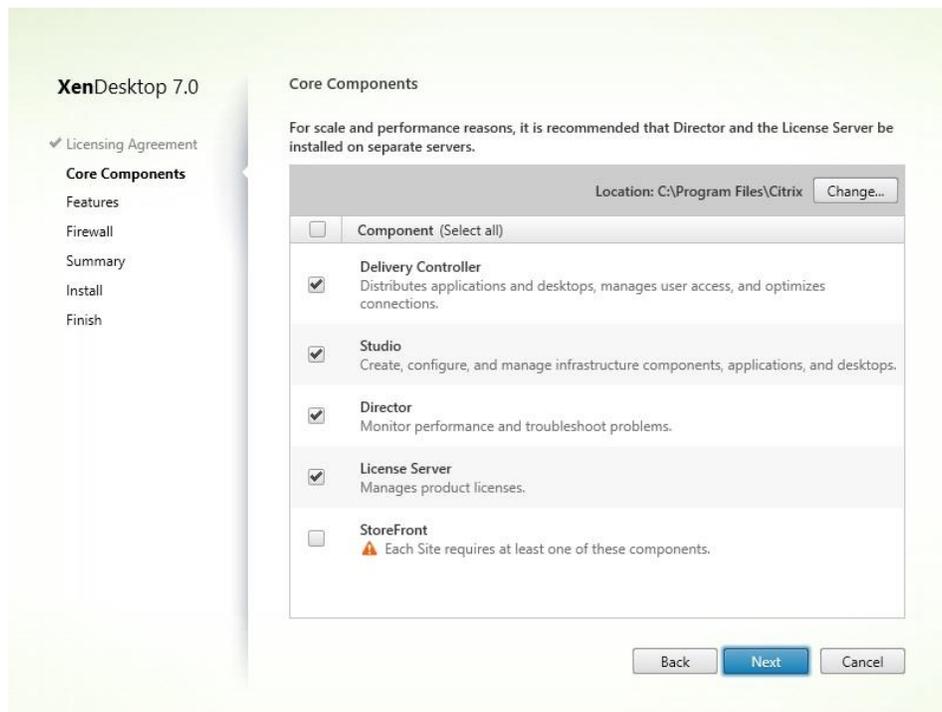
- Click on *Delivery Controller*



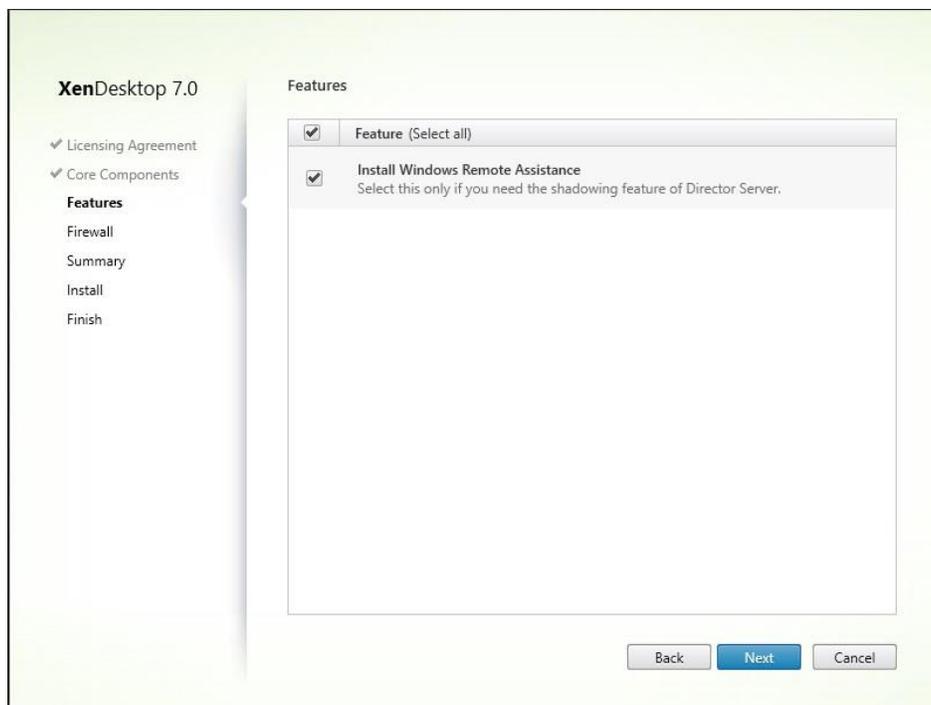
- Click *Next*



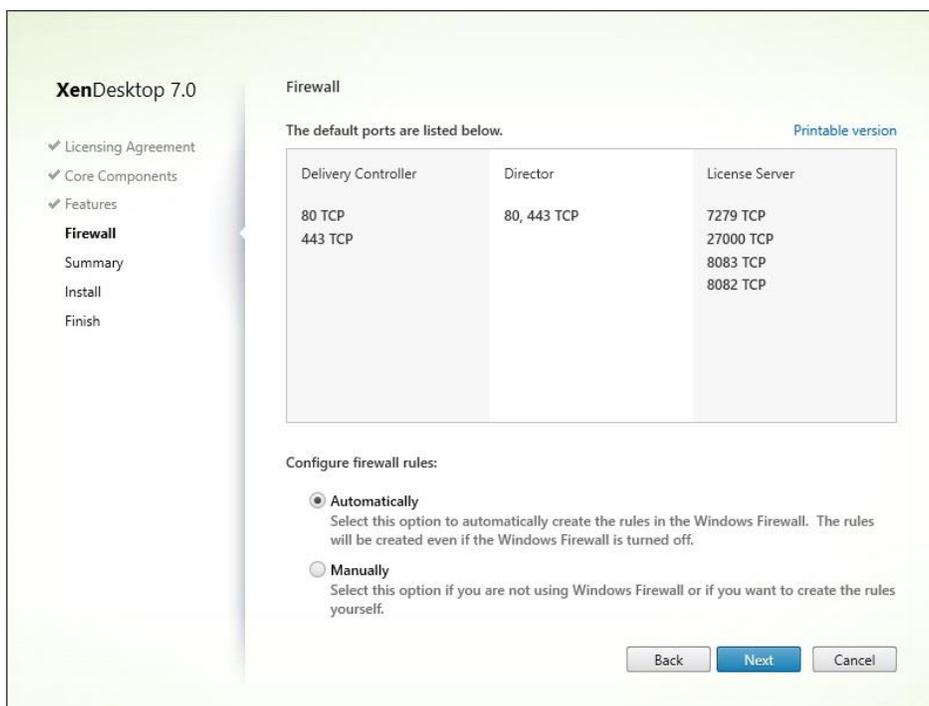
- StoreFront will be installed on a separate server. On this VM Delivery controller, Studio, Director, and License Server will be selected. Click *Next*.



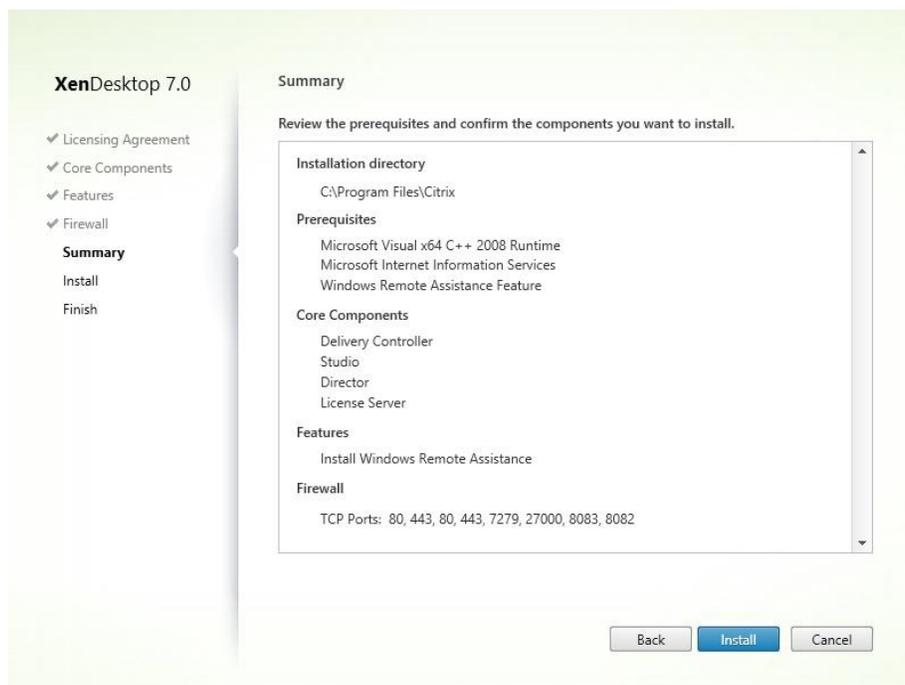
- Click *Next*.



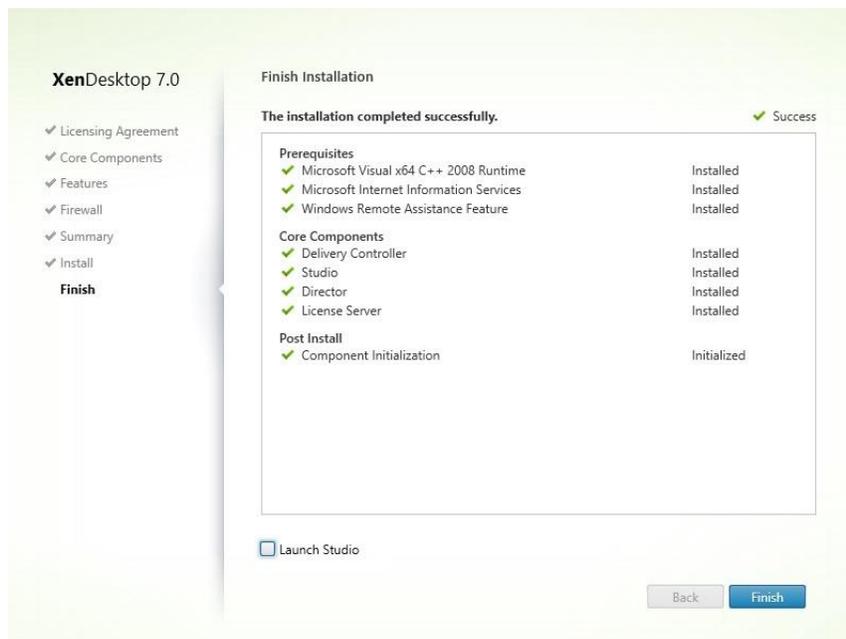
- Click *Next*



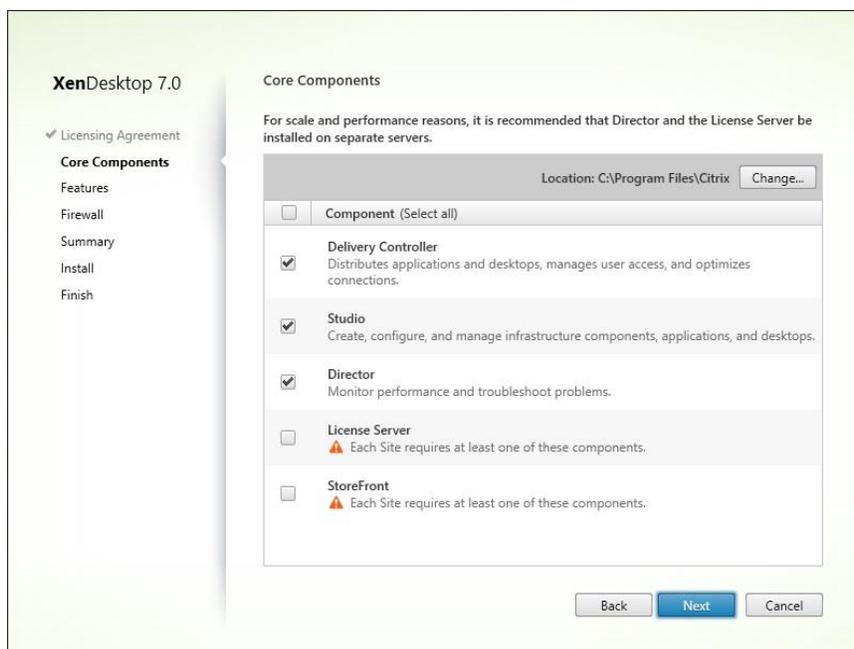
- Click *Install*



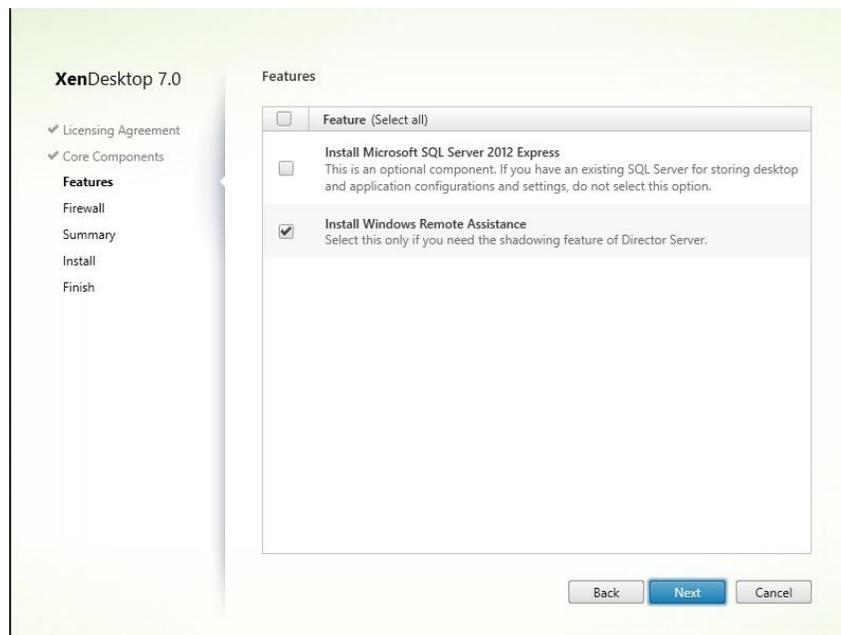
- Unselect *Launch Studio* and click *Finish*



**Installing in second server.** The same steps for the previous section have been followed to install on the second server, but StoreFront and License Server have been deselected on the core components page.



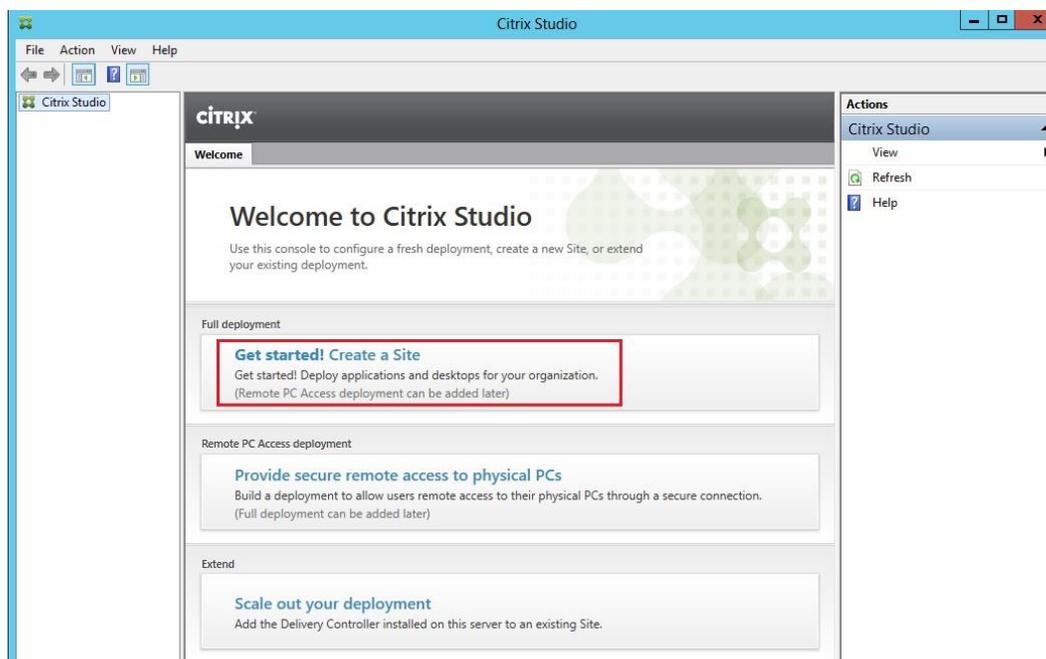
- On the Features screen, uncheck *Install Microsoft SQL Server 2012*



Now Desktop Studio is ready to launch and start Xen Desktop site configuration.

### Configuring Citrix studio site.

- Click on *Get started!* on the Desktop Studio welcome screen.



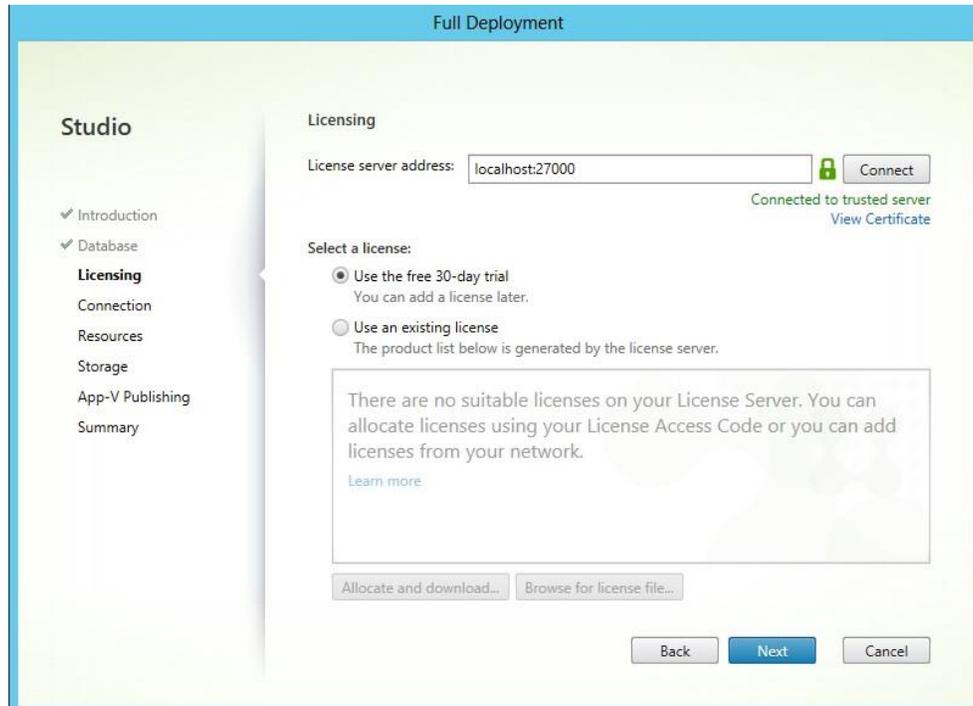
- A full site will be created. Select the default option and click *Next*.

The screenshot shows the 'Full Deployment' wizard window. The title bar reads 'Full Deployment'. On the left is a 'Studio' sidebar with a list of steps: Introduction, Database, Licensing, Connection, Resources, Storage, App-V Publishing, and Summary. The 'Database' step is currently selected. The main content area is titled 'Build and customize a full production environment.' and asks 'What would you like to create?'. There are two radio button options: the first is selected and reads 'Configure the Site and start delivering applications and desktops to users (recommended for new users). Provides the Site name, connection details, network and storage resources, plus database and license information; creates machines from a master image and delivers assigned applications and desktops to users.' The second option is 'Create an empty Site (recommended for advanced users who want to add the Site later). Provides minimum information to start using Studio (Site name, database, and license); other Site details can be set up manually later. This option can also be used if the supporting infrastructure is not currently available.' Below the options is a text box labeled 'Name your Site:' containing the text 'XD7\_LAB'. At the bottom right are three buttons: 'Back', 'Next', and 'Cancel'.

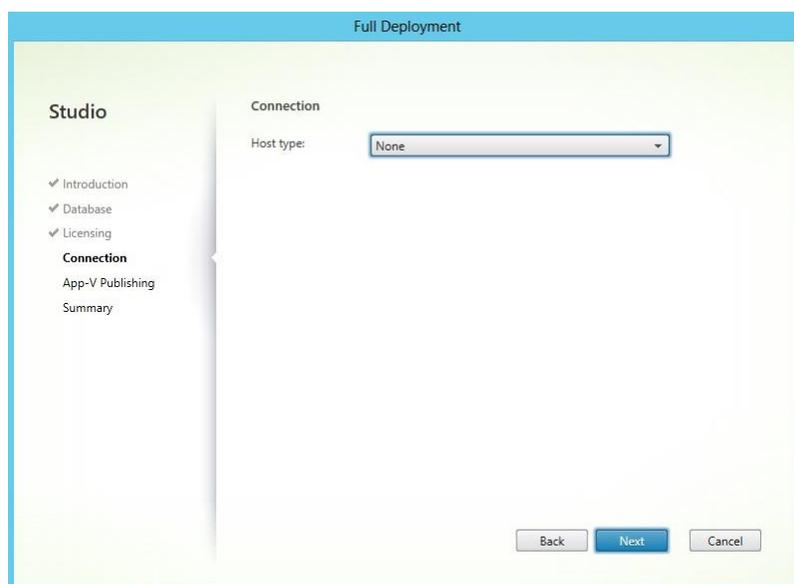
- The setup wizard will auto-populate the database name based upon the site name configured in previous steps.

The screenshot shows the 'Full Deployment' wizard window at the 'Database' step. The title bar reads 'Full Deployment'. The 'Studio' sidebar on the left has 'Database' selected. The main content area is titled 'Database' and contains the text: 'The database stores all Site configuration, logging, and monitoring data.' Below this, there are two text boxes: 'Database server location:' with the value '.\SQLEXPRESS' and 'Database name:' with the value 'CitrixXD7\_LAB'. The 'Database name' text box is highlighted with a red rectangle. To the right of the 'Database name' text box is a 'Test connection...' button. Below these is a button labeled 'Generate database script...' with '(Optional)' next to it. At the bottom right are three buttons: 'Back', 'Next', and 'Cancel'.

- Leave the default settings on the license page. A 30-day free trial is included with the installer. A proper license can be added later.



- In the connections page, select *None* as the host type. A hypervisor connection will be established later.



- As this research paper is focused on Xen Desktop, APP-V publishing will be ignored. Click *Next*.

The screenshot shows the 'Full Deployment' wizard at the 'App-V Publishing' step. The 'Studio' pane on the left has 'App-V Publishing' selected. The main area asks 'Do you want to add an App-V publishing server to this deployment?' with 'No' selected. Below are text boxes for 'App-V management server' (http://MyManagementServer.example.com:81) and 'App-V publishing server' (http://MyPublishingServer.example.com:82), along with a 'Test connection...' button. At the bottom are 'Back', 'Next', and 'Cancel' buttons.

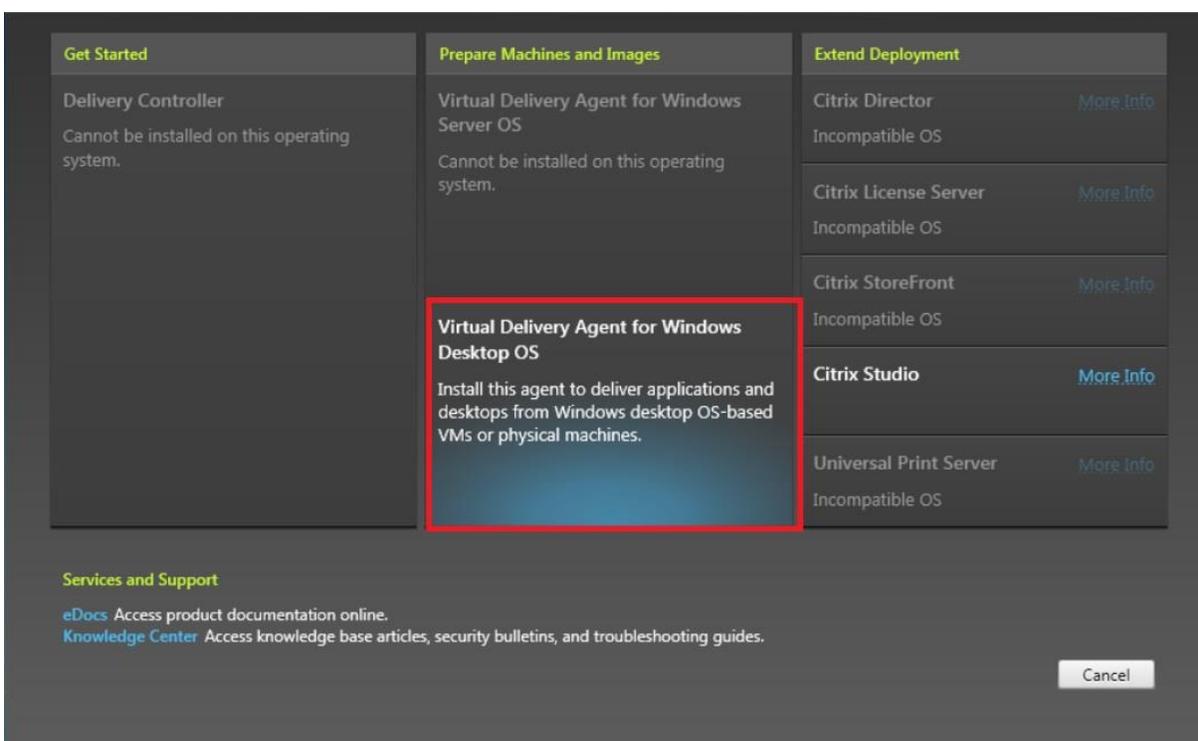
- Click *Finish*

The screenshot shows the 'Full Deployment' wizard at the 'Summary' step. The 'Studio' pane on the left has 'Summary' selected. The main area displays a summary of the deployment configuration in a table format. At the bottom are 'Back', 'Finish', and 'Cancel' buttons.

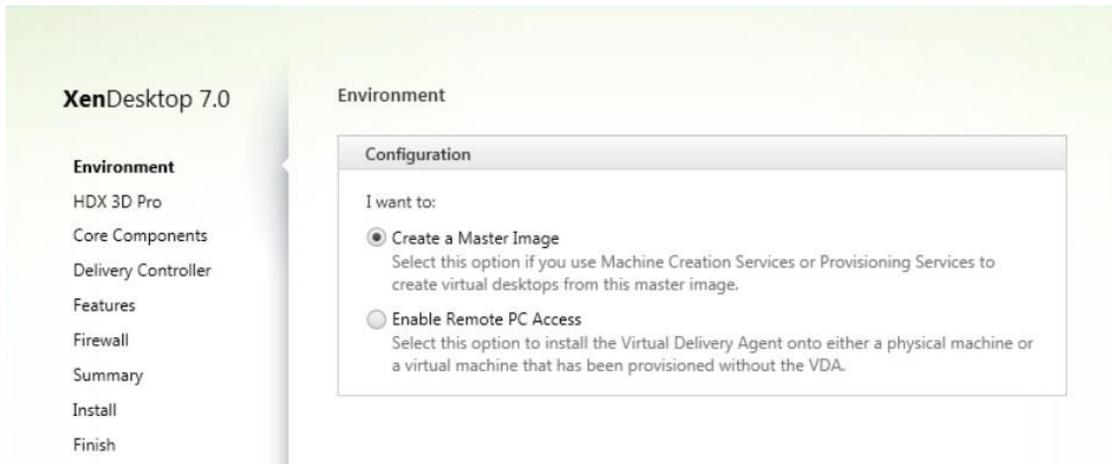
Site name:	XD7_LAB
Database server:	.\SQLEXPRESS
Database name:	XD7LAB_SiteConfig
License server:	localhost:27000
Connection type:	None
Network:	
Virtual Machine storage:	
Personal vDisk storage:	Use same storage as Virtual Machines
App-V:	Not configured

**Installing the operating system.** Install a new operating system, update it with all security patches and make all necessary changes to the system, configure security hardening, and join the computer to the domain.

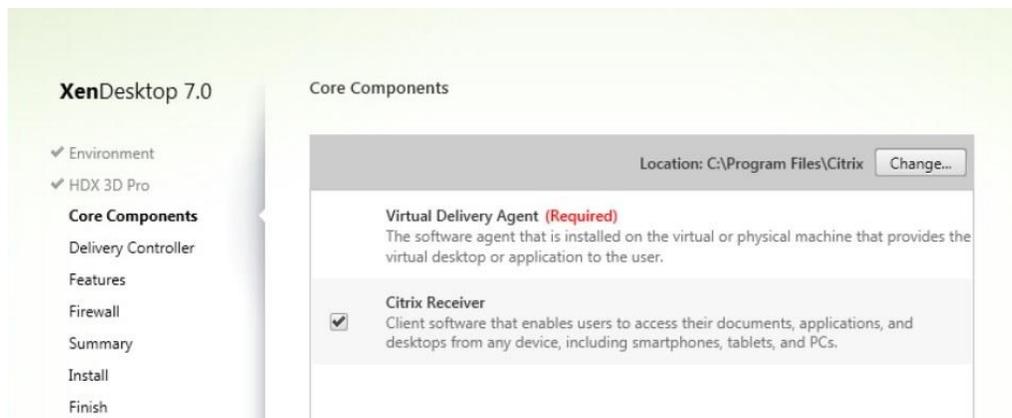
**Configure virtual delivery agent software.** Mount the XD ISO on the machine and double click *Start the Installer*. Prechecks of the compatible options are available for that OS. Virtual Desktop Agent will be installed.



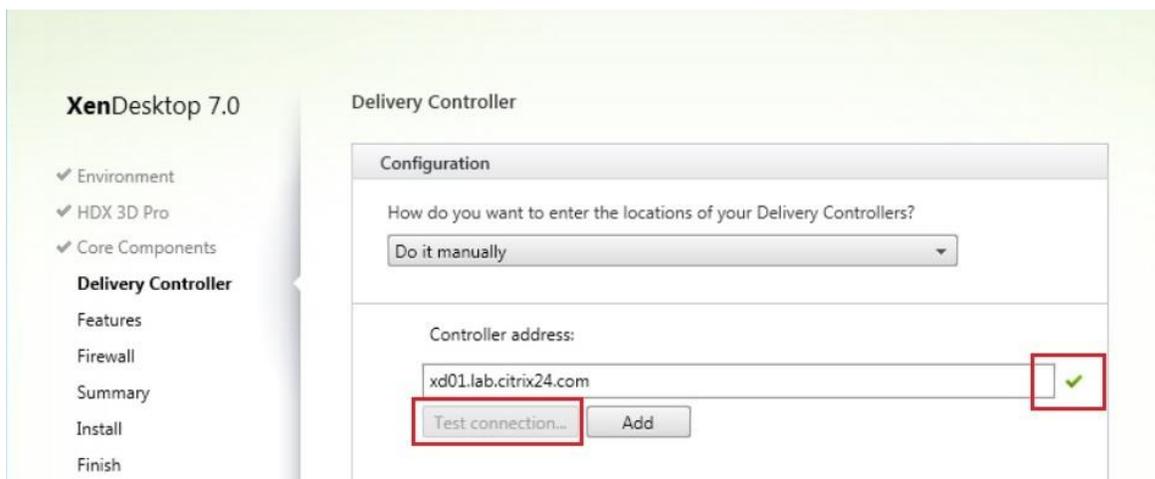
- Leave to defaults and click *Next*.



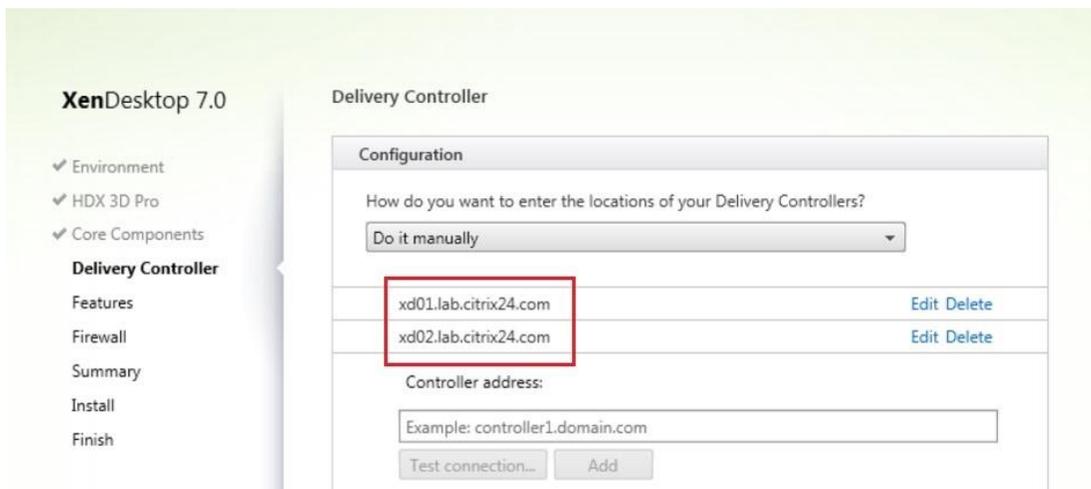
- Leave the default options and press *Next* to continue.



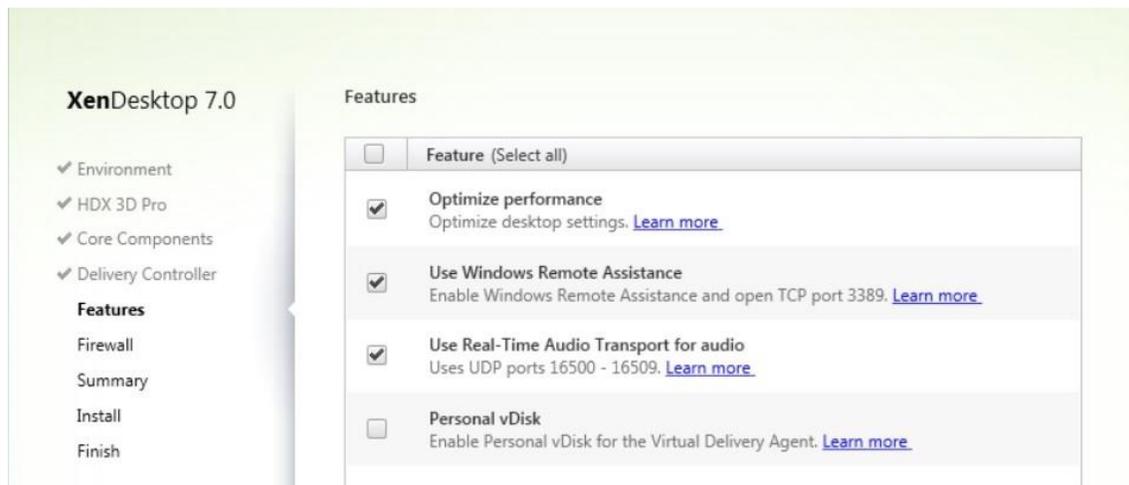
Configure the Xen Desktop controller address and click on *Test Connection* to verify the authenticity. Once successful, a green checkbox will be seen. Click on the *Add* button to add the controller address to the list.



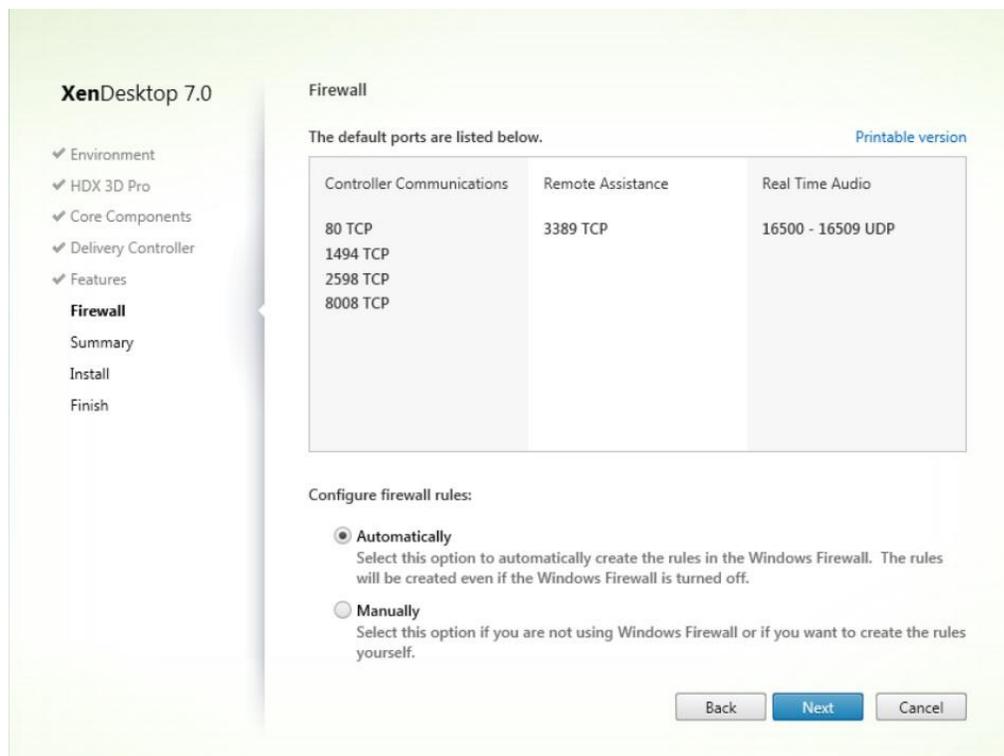
- Perform the same step to add more controllers.



- Press *Next* to continue



- Port numbers will be displayed and options to automatically create rules on the Windows firewall will be available. Leave the options at default and click *Next*.



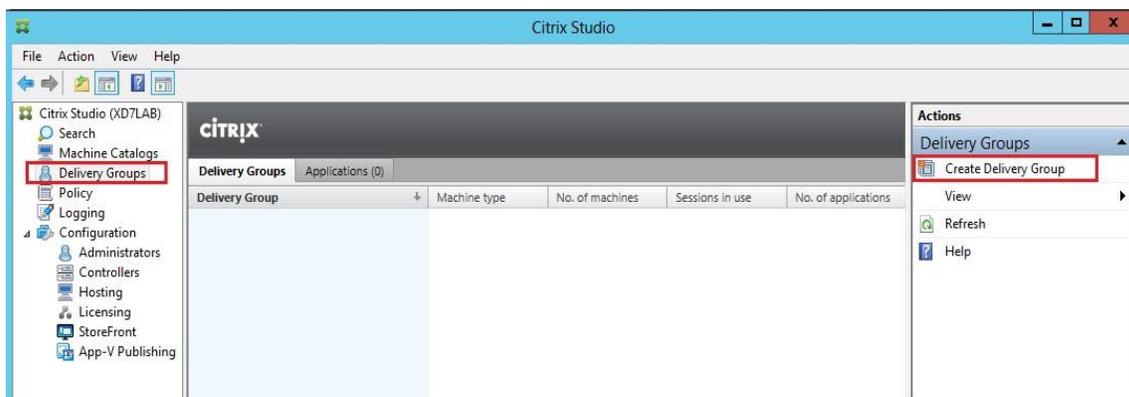
- Click on *Install*. Once the installation is complete, restart the computer.



- Shut down the virtual machine and take a snapshot. Now the VDA is installed.

### Configuring the delivery group.

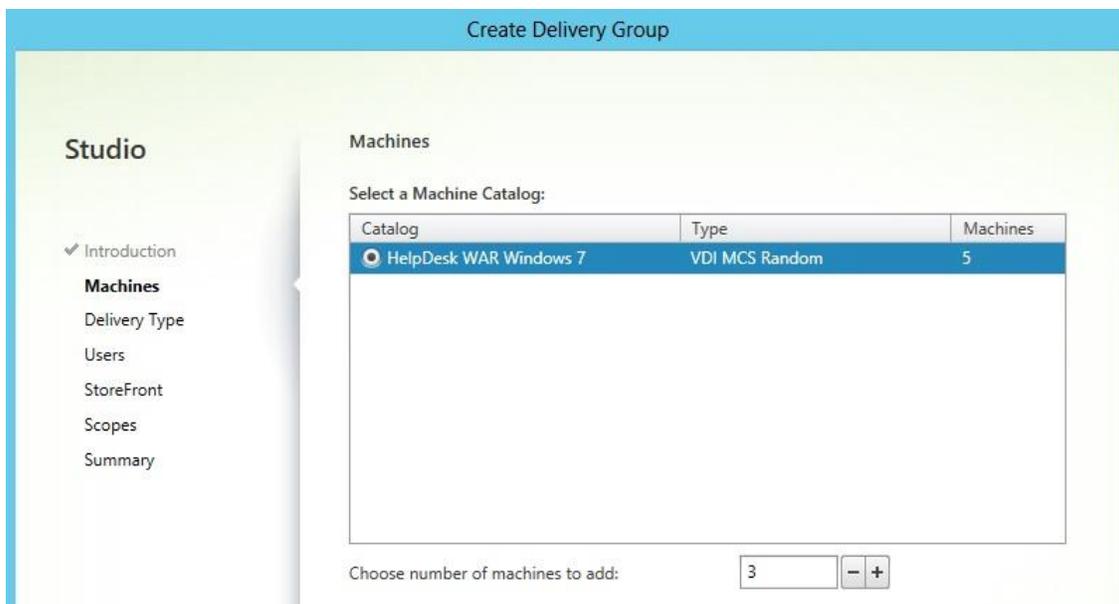
- Open the Citrix Studio. Click *Delivery Groups*, and then click on *Create Delivery Group*.



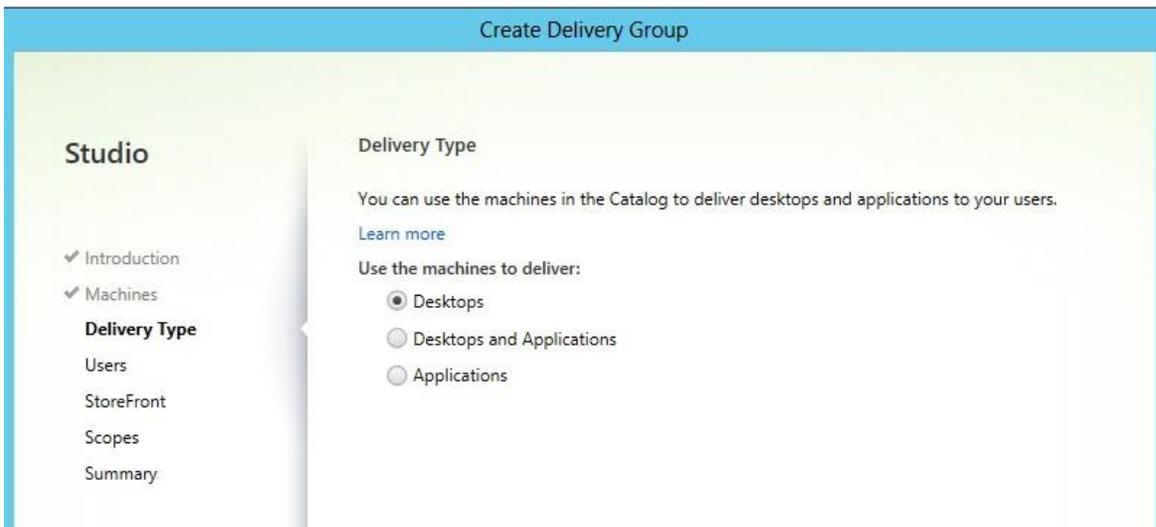
- Click *Next*



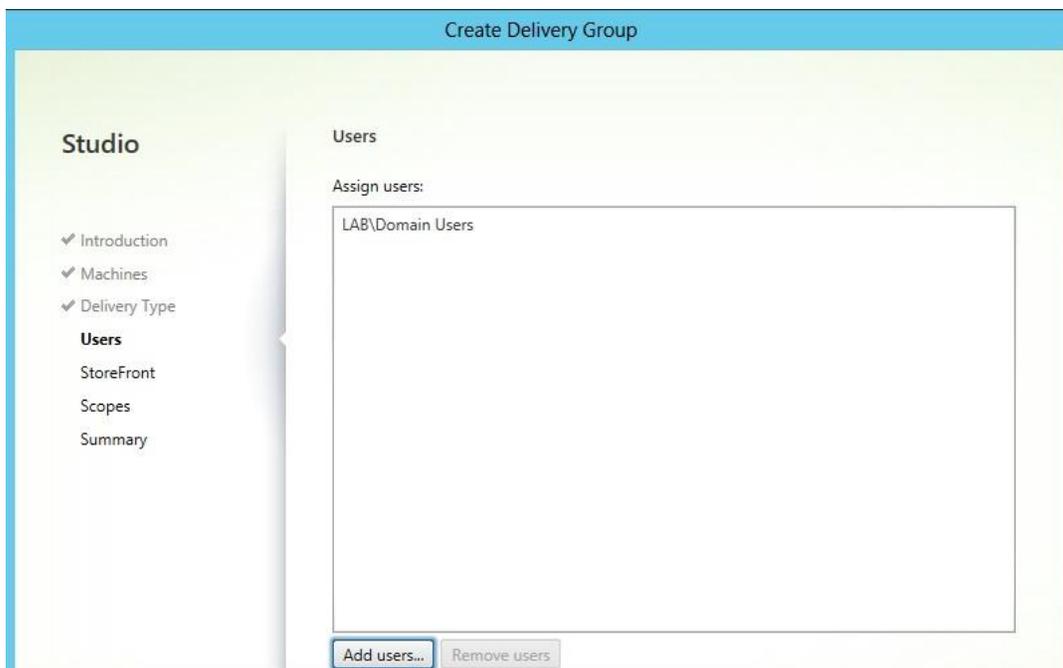
- Select the existing machine catalog and enter the number of machines to be added. Click *Next* to continue.



- Select the delivery type to the desktops, as this research paper focuses on creating virtual desktops. Click *Next* to continue.



- Add users and click *Next* to continue.



- Create the StoreFront address to be configured in the next step. Click *Next*.

The screenshot shows the 'Create Delivery Group' wizard in Citrix Studio. The left-hand navigation pane is titled 'Studio' and includes the following items: Introduction, Machines, Delivery Type, Users, StoreFront (highlighted), Scopes, and Summary. The main content area is titled 'StoreFront' and contains the following text: 'How would you like to configure the version of Receiver that is installed on the machines in this Delivery Group?'. There are two radio button options: 'Manually, using a StoreFront server address that I will provide later' (which is selected) and 'Automatically, using the StoreFront servers selected below'. Below this, the text reads 'Select the StoreFront servers for Receiver:'. A table with two rows is displayed: the first row has a checkbox and the text 'Receiver Storefront URL'; the second row has a checked checkbox and the URL 'https://xd03.lab.citrix24.com/Citrix/TestLABWeb'.

- Click *Next* to continue.

The screenshot shows the 'Create Delivery Group' wizard in Citrix Studio. The left-hand navigation pane is titled 'Studio' and includes the following items: Introduction, Machines, Delivery Type, Users, StoreFront, Scopes (highlighted), and Summary. The main content area is titled 'Scopes' and contains the following text: 'A scope represents a collection of objects the user is allowed to administer, for example Connections, Machine Catalogs, and Delivery Groups. Objects are grouped into scopes that are relevant to your organizational structure.' Below this, the text reads 'Select scope(s):'. A table with three rows is displayed: the first row has a checkbox and the text 'Scope Name'; the second row has a checked checkbox and the text 'All' with 'All objects' below it; the third row has a checked checkbox and the text 'Optional Scopes' with 'Scope Hosting' below it.

- Enter the delivery group name and click *Finish* to continue.

**Create Delivery Group**

**Studio**

- Introduction
- Machines
- Delivery Type
- Users
- StoreFront
- Scopes
- Summary**

**Summary**

Source Machine Catalog: HelpDesk WAR Windows 7  
Machine type: Windows Desktop OS  
Allocation type: Random  
Number of machines added: 3 unassigned  
Delivery type: Desktops  
Users: LAB\Domain Users  
Scopes: All

Delivery Group name:

Display name:

Delivery Group description for users: (Optional)

Back Finish Cancel

- Now a delivery group has been created. Double click on the delivery group to display the machines created. The entire powered-on machines should be in registered status.

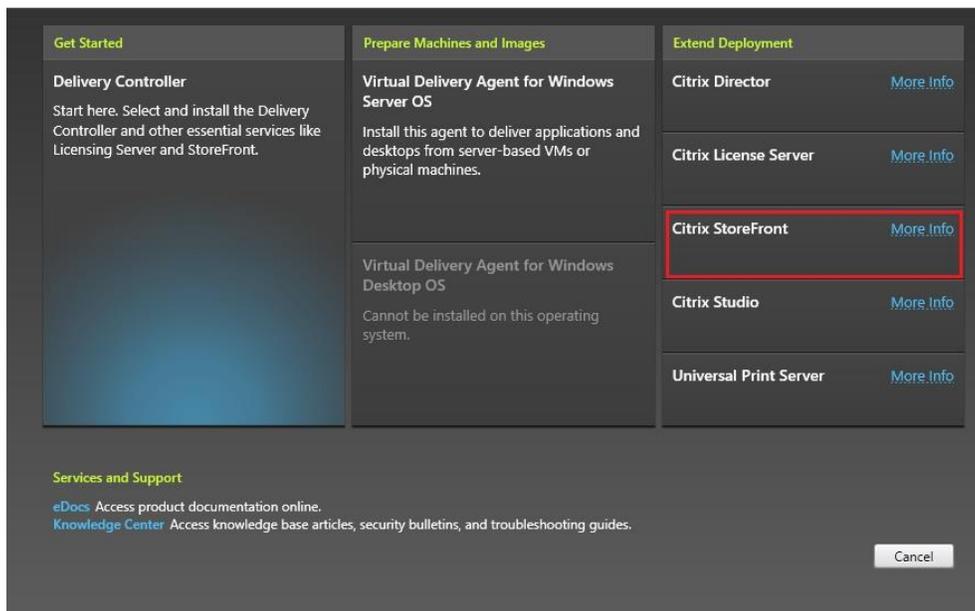
Citrix Studio

Search results for '(Delivery Group is "HelpDesk Warsaw Win7")'

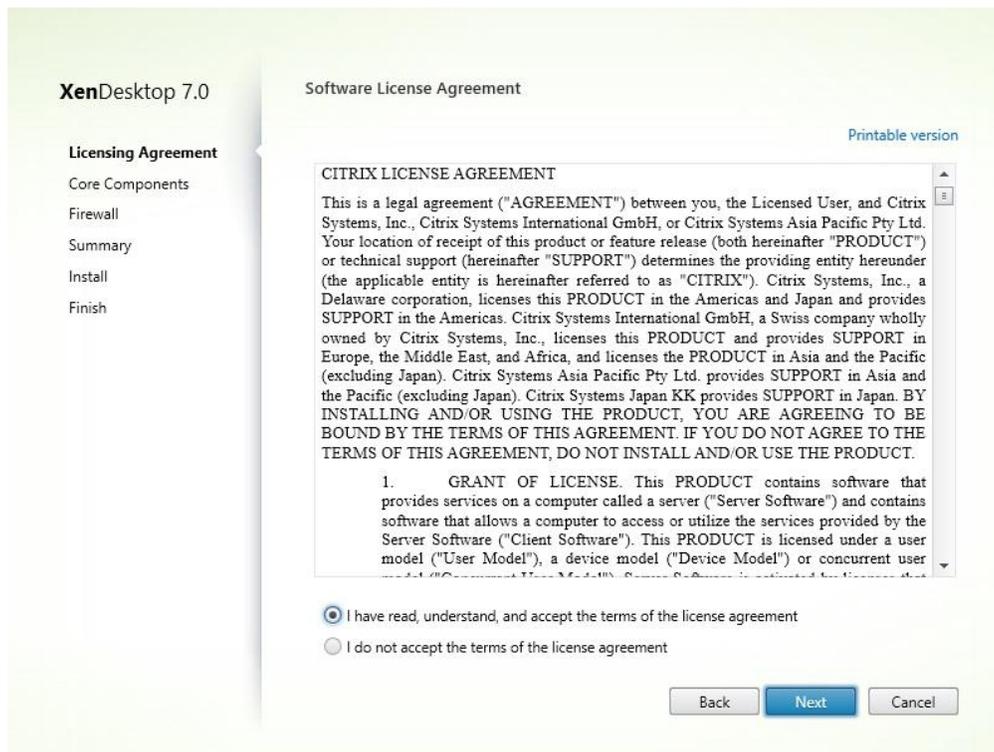
Name	Machine Catalog	Delivery Group	User	Maintenance Mode	Persist User Changes	Power State	Registration State
W7En001.lab.citrix24.com	HelpDesk WAR Windo...	HelpDesk Warsaw Win7	-	Off	Discard	Off	Unregistered
W7En002.lab.citrix24.com	HelpDesk WAR Windo...	HelpDesk Warsaw Win7	-	Off	Discard	On	Registered
W7En003.lab.citrix24.com	HelpDesk WAR Windo...	HelpDesk Warsaw Win7	-	Off	Discard	Off	Unregistered

## Installing Citrix StoreFront.

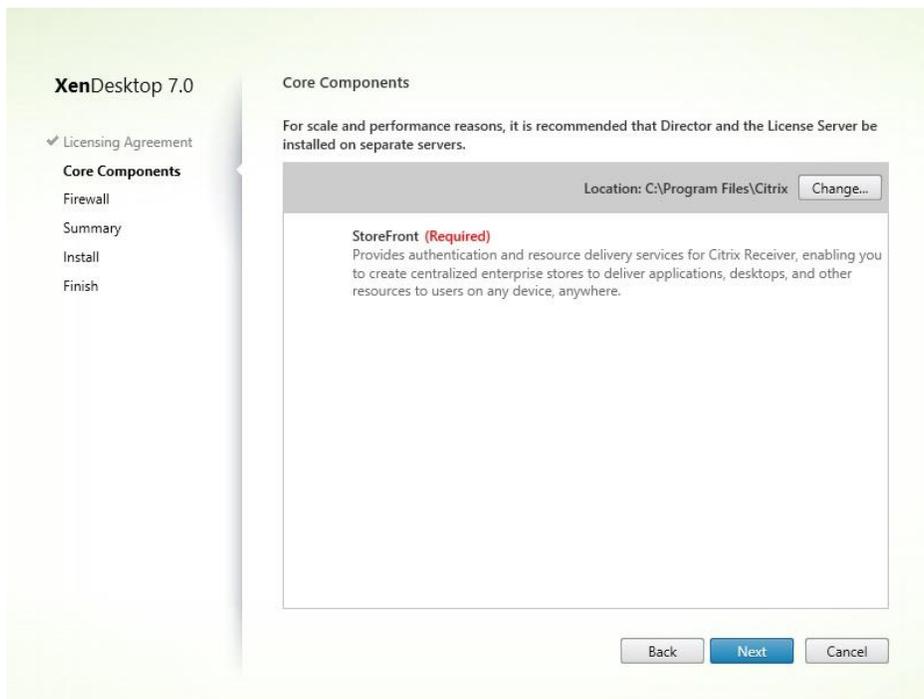
- Mount XD ISO, launch it and click on *Citrix StoreFront* to install it.



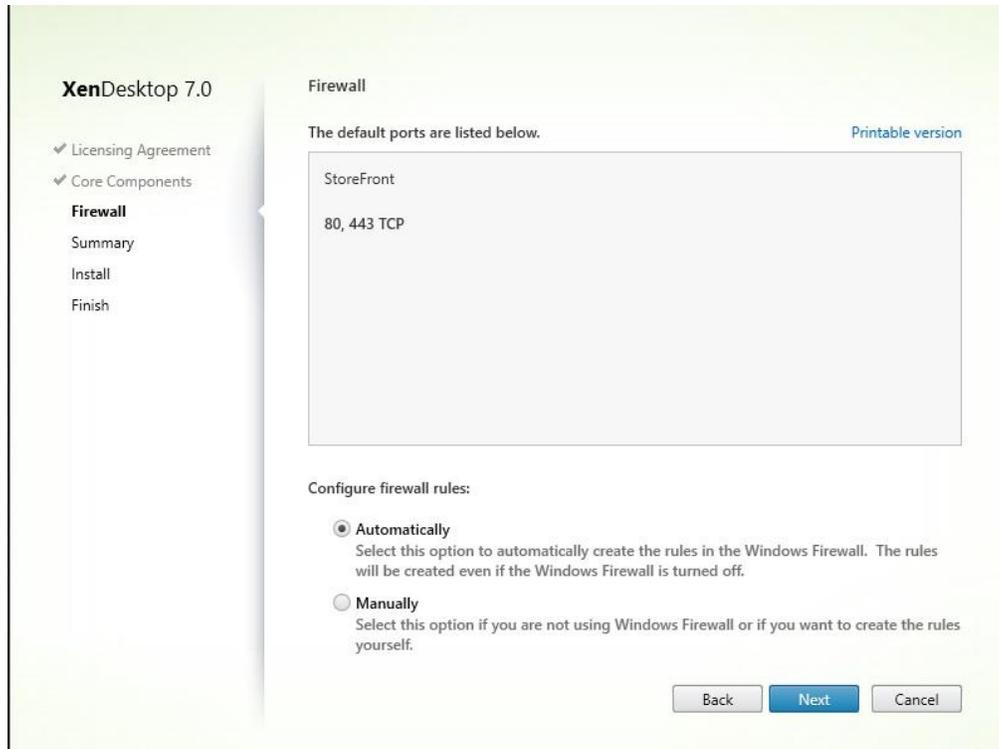
- Accept the end user license agreement and click *Next*.



- Click *Next* to continue.

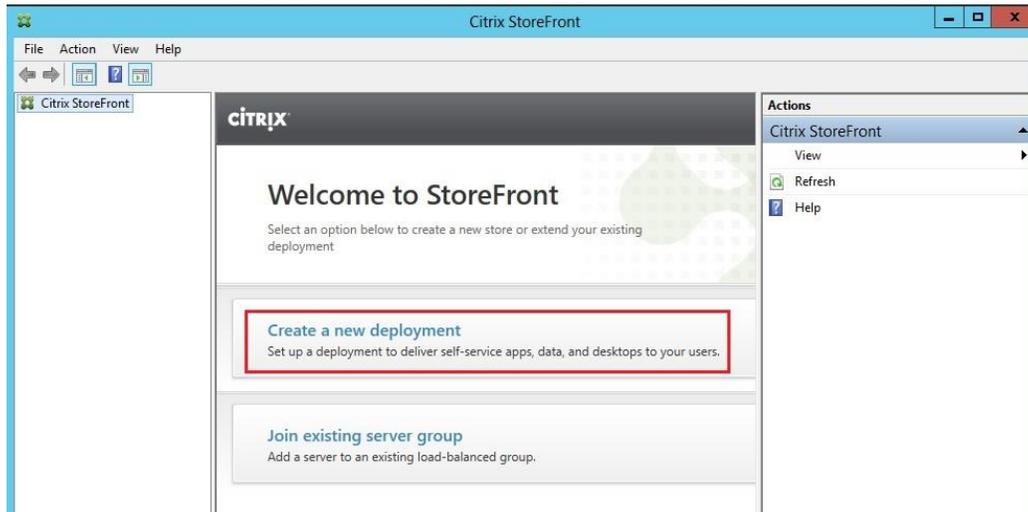


- Click *Next* to continue.

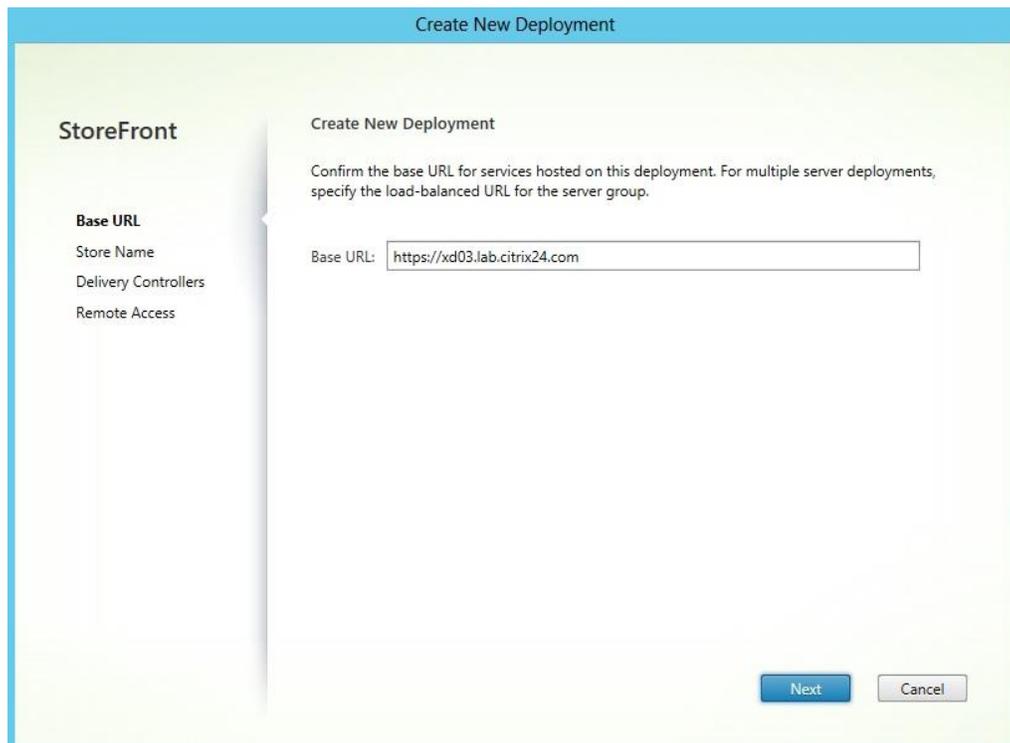


## Configuring StoreFront.

- Launch the Desktop StoreFront and click on *Create a New Deployment* on the welcome screen.



- Enter the base URL for the server with StoreFront installed. Click *Next* to continue.



- Create a store name and click *Next*.

The screenshot shows the 'Create Store' wizard at the 'Store Name' step. On the left, a sidebar lists 'StoreFront' options: 'Base URL' (checked), 'Store Name' (selected), 'Delivery Controllers', and 'Remote Access'. The main area is titled 'Store Name' and contains the instruction: 'Choose a name that helps users identify the store. The store name appears in Citrix Receiver as part of the user's account.' Below this is a text input field labeled 'Store name:' containing the text 'Test LAB'. At the bottom right, there are 'Next' and 'Cancel' buttons.

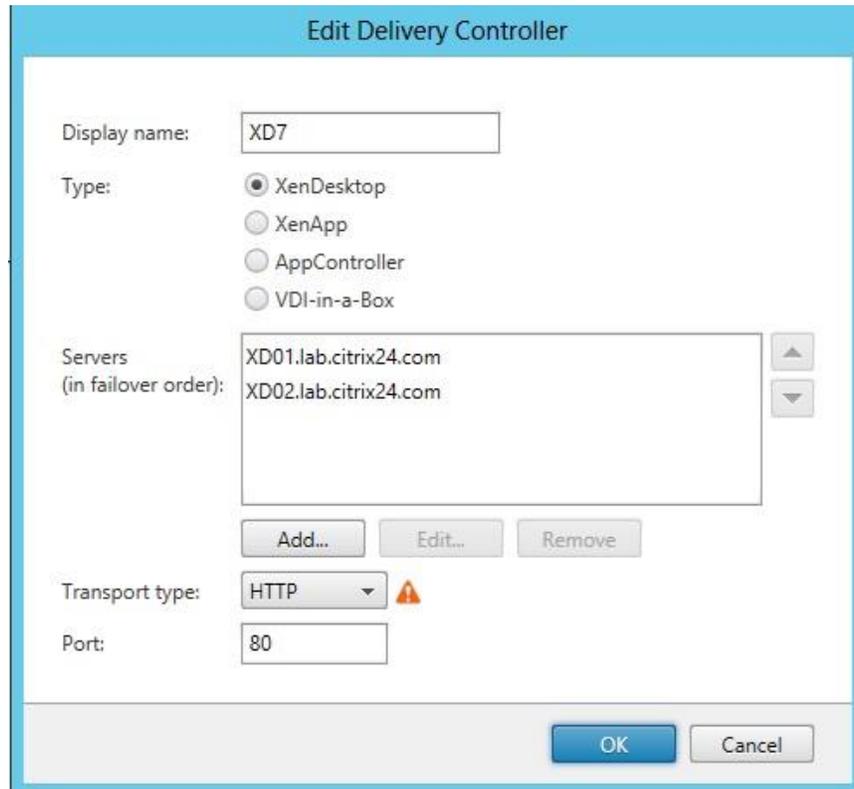
- Click the *Add* button to add a delivery controller.

The screenshot shows the 'Create Store' wizard at the 'Delivery Controllers' step. The sidebar on the left now has 'Base URL' and 'Store Name' checked, and 'Delivery Controllers' selected. The main area is titled 'Delivery Controllers' and contains the instruction: 'Specify the delivery controllers and servers for this store.' Below this is a table with the following structure:

Name	Type	Servers
------	------	---------

Below the table are three buttons: 'Add...' (highlighted with a red box), 'Edit...', and 'Remove'. At the bottom right, there are 'Back', 'Next', and 'Cancel' buttons.

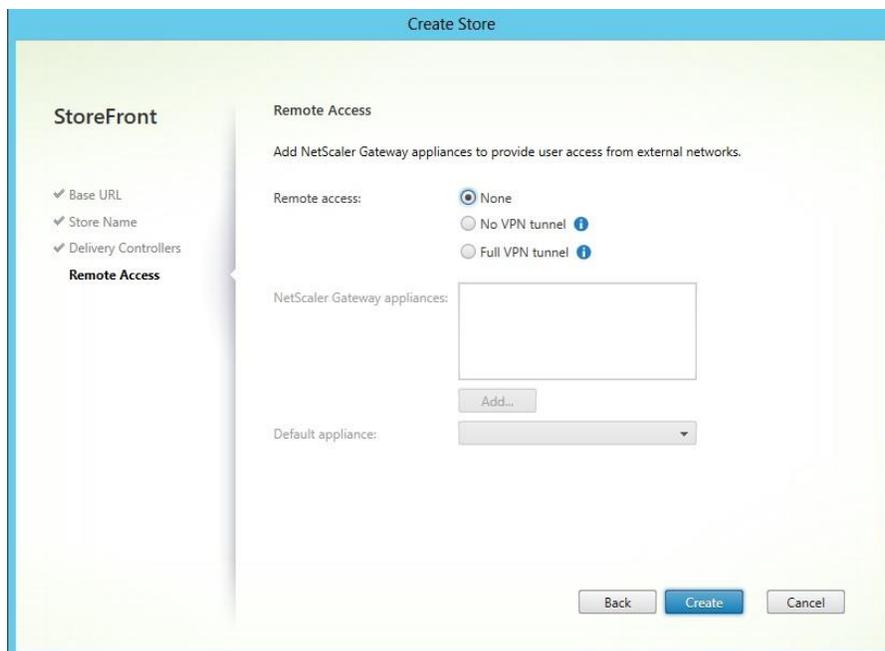
- Enter the controller information and click *OK*.



The screenshot shows the 'Edit Delivery Controller' dialog box. It has a light blue header with the title 'Edit Delivery Controller'. The main area is white and contains several fields and controls:

- Display name:** A text input field containing 'XD7'.
- Type:** A group of four radio buttons: 'XenDesktop' (selected), 'XenApp', 'AppController', and 'VDI-in-a-Box'.
- Servers (in failover order):** A list box containing two entries: 'XD01.lab.citrix24.com' and 'XD02.lab.citrix24.com'. There are up and down arrow buttons to the right of the list.
- Buttons:** Below the list box are three buttons: 'Add...', 'Edit...', and 'Remove'.
- Transport type:** A dropdown menu set to 'HTTP' with a warning icon to its right.
- Port:** A text input field containing '80'.
- Footer:** At the bottom right are two buttons: 'OK' and 'Cancel'.

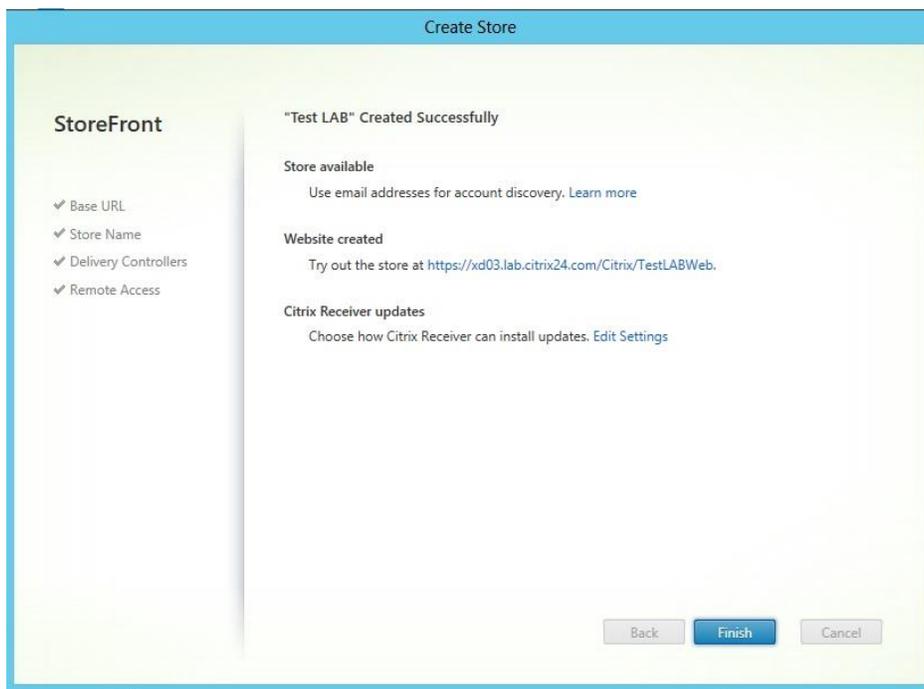
- On the Remote Access page, select *None* and click *Next* to continue.



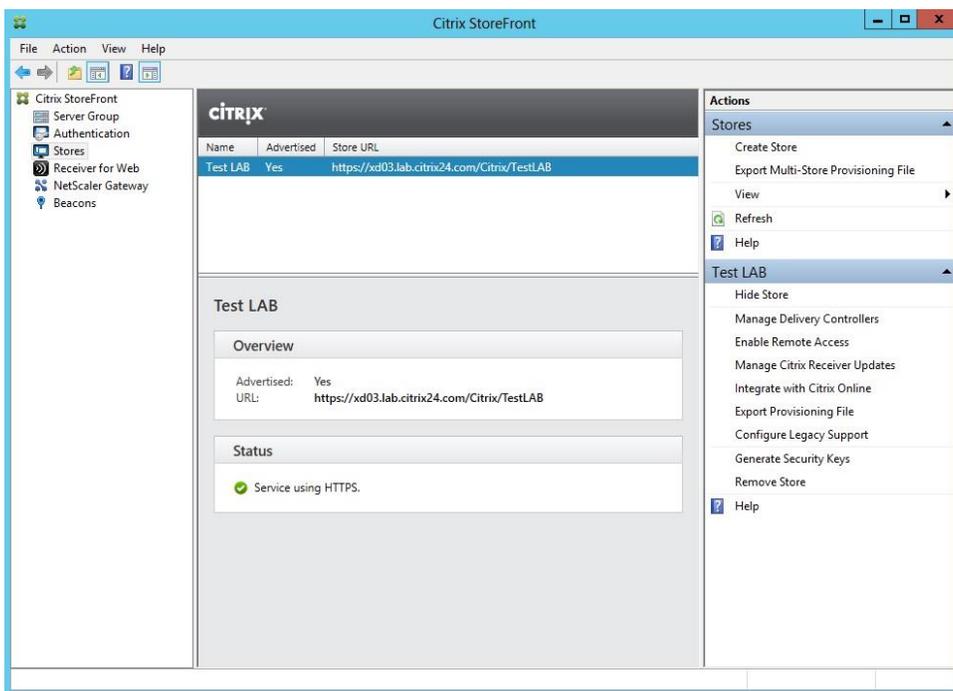
The screenshot shows the 'Create Store' dialog box, specifically the 'Remote Access' page. It has a light blue header with the title 'Create Store'. The main area is light green and contains several sections and controls:

- StoreFront:** A sidebar on the left with three checked items: 'Base URL', 'Store Name', and 'Delivery Controllers'. Below these is the 'Remote Access' section, which is currently selected.
- Remote Access:** The main content area has a sub-header 'Remote Access' and a description: 'Add NetScaler Gateway appliances to provide user access from external networks.' Below this are three radio buttons: 'None' (selected), 'No VPN tunnel' (with an information icon), and 'Full VPN tunnel' (with an information icon).
- NetScaler Gateway appliances:** A large empty text input field. Below it is an 'Add...' button.
- Default appliance:** A dropdown menu.
- Footer:** At the bottom right are three buttons: 'Back', 'Create', and 'Cancel'.

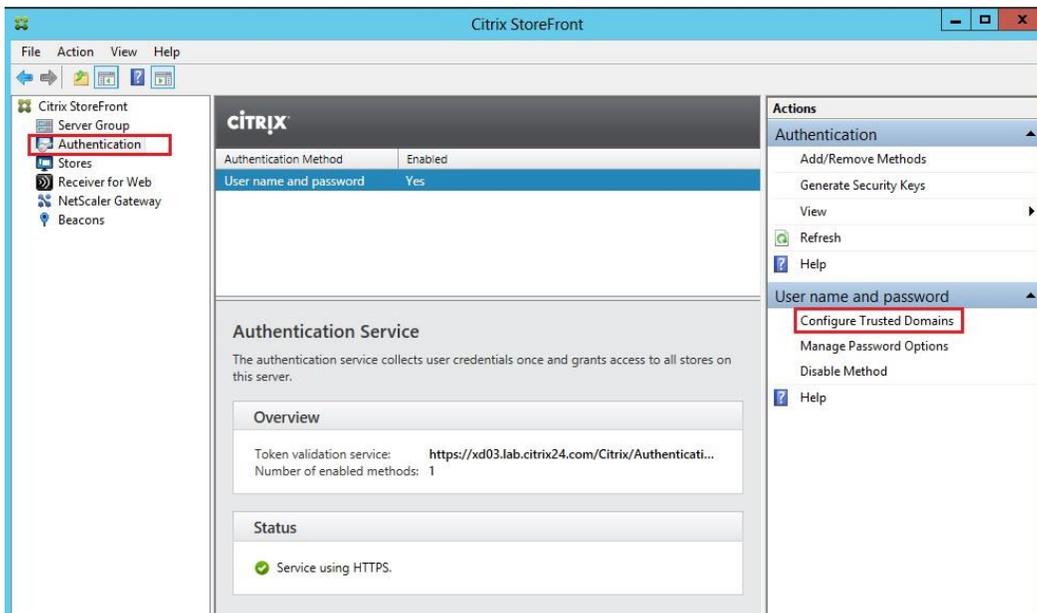
- Click *Finish* to close the configuration wizard.



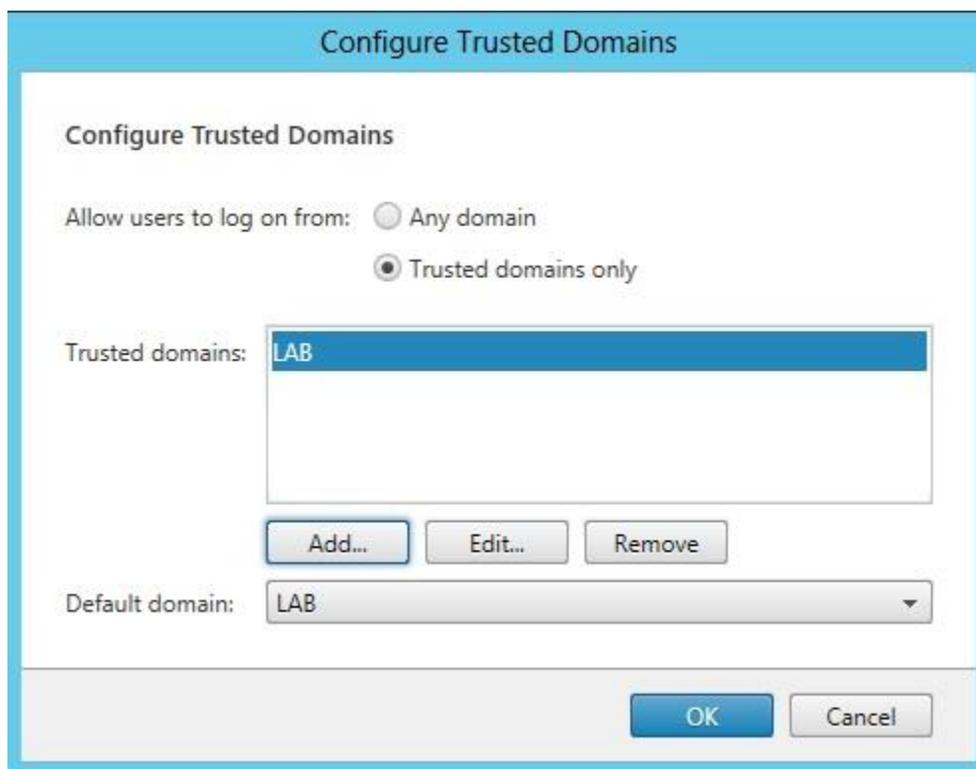
- Click on the *Stores* node to look at the display configuration details. These display options can be modified by clicking on the actions.



- Click on *Authentication* and then click on *Configure Trusted Domains* in the actions pane.



- Click on *Add* to add the domain information. Click *OK* to continue.



- Click on *Manage Passwords Options* and choose whether the users can change the password and different options. Click *OK* to continue.



The screenshot shows a dialog box titled "Manage Password Options". Inside the dialog, there is a section titled "Manage Password Options" with the text "Allow users to change passwords:". Below this text are three radio button options: "At any time" (which is selected), "When expired", and "Never". At the bottom right of the dialog are two buttons: "OK" and "Cancel".

- Click *Disable Method* in the actions pane and select the required option for authentication. Click *OK* to continue.



The screenshot shows a dialog box titled "Add/Remove Methods". Inside the dialog, there is a section titled "Add/Remove Authentication Methods" with the text "Choose the authentication methods with which users can authenticate to stores on this server." Below this text are four checkbox options: "User name and password" (which is checked), "Domain pass-through", "Smart card", and "Pass-through from NetScaler Gateway". At the bottom right of the dialog are two buttons: "OK" and "Cancel".

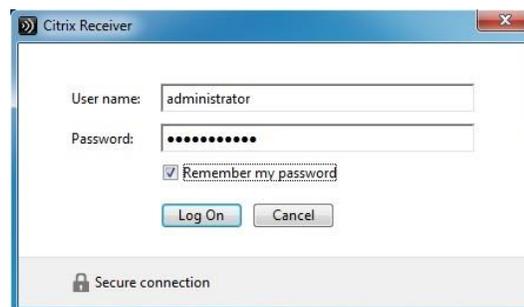
### **Installing Citrix receiver.**

Citrix Receiver will be available on the XD ISO.

**Configuring Citrix receiver.** There are two ways to connect to the desktop once the receiver installation is completed. One method is to use the full receiver client and the other is to utilize a web browser to access the StoreFront website. Double click Launch the Receiver and enter the StoreFront server address.



- When the receiver can find StoreFront, the server authentication dialog box will be displayed. Log in using domain credentials.



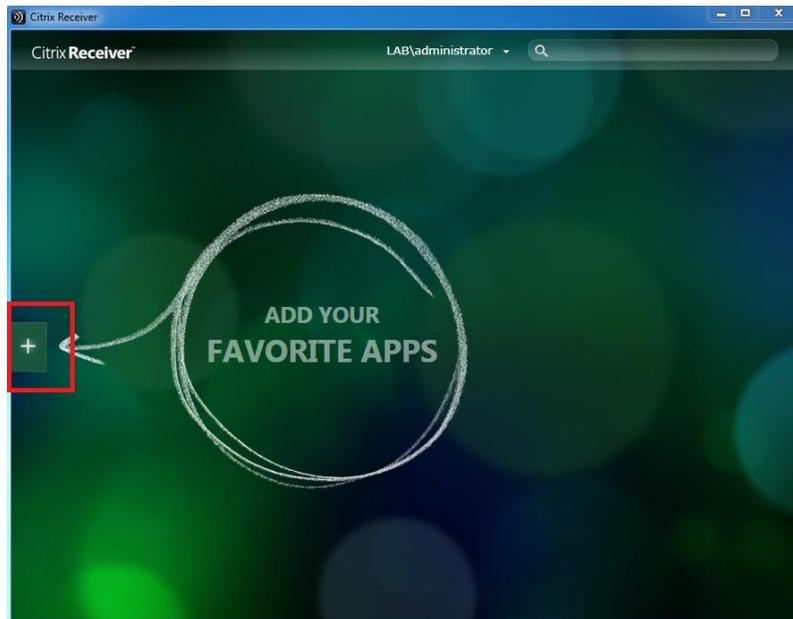
- Once authentication is successful, options to optimize client configuration will be available. Click *Yes*.



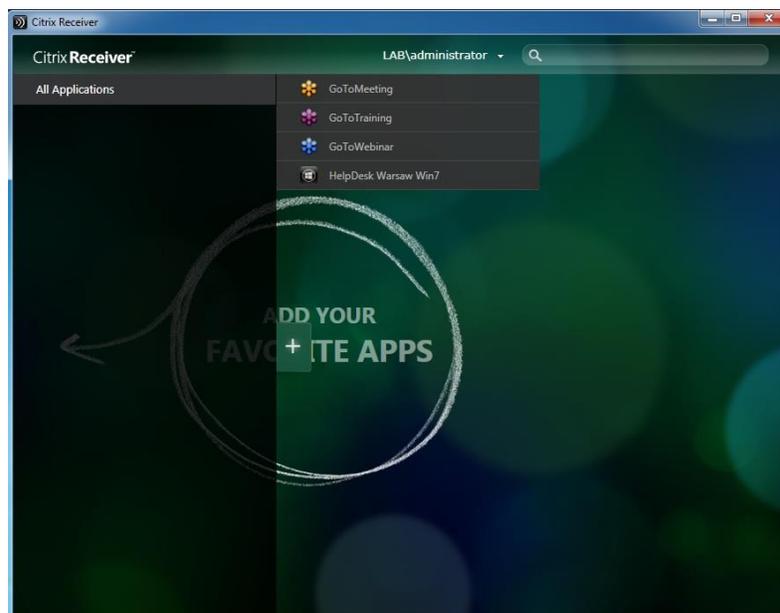
- When the optimization process is completed, the successful message will be displayed. Click *Finish* to continue.



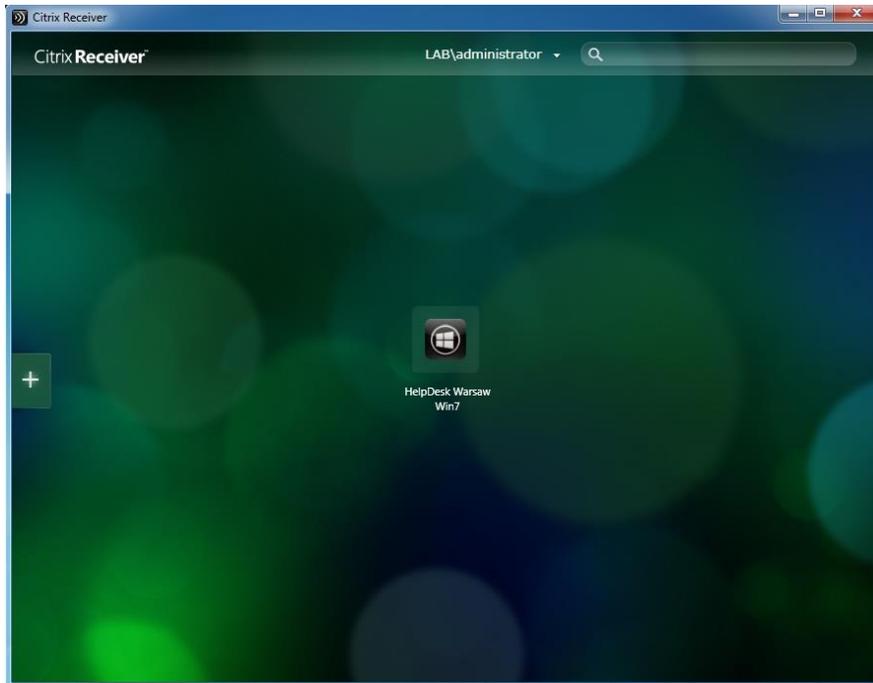
- When connected, the blank page is displayed. Click the + sign to continue.



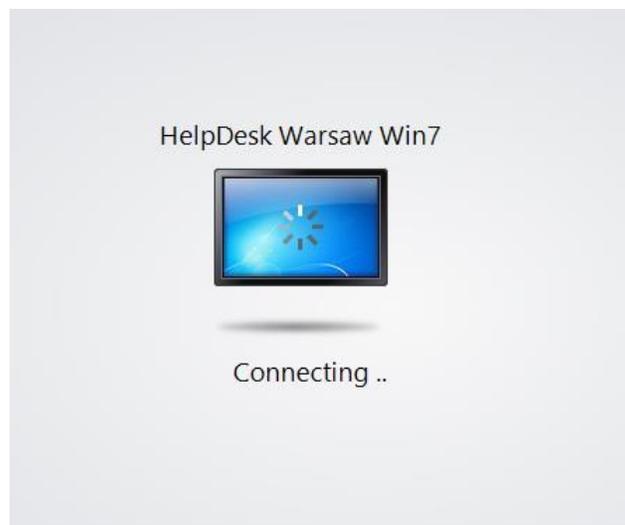
- A list of all desktops and applications that have been published is now visible (if StoreFront has been configured with XenApp controllers, all published applications will be displayed on this list as well). Click on *Available Desktop* to add it the Receiver landing page.



- Click on the desktop icon to launch the virtual desktop, which automatically logs into the user's desktop without any additional authentication prompts.



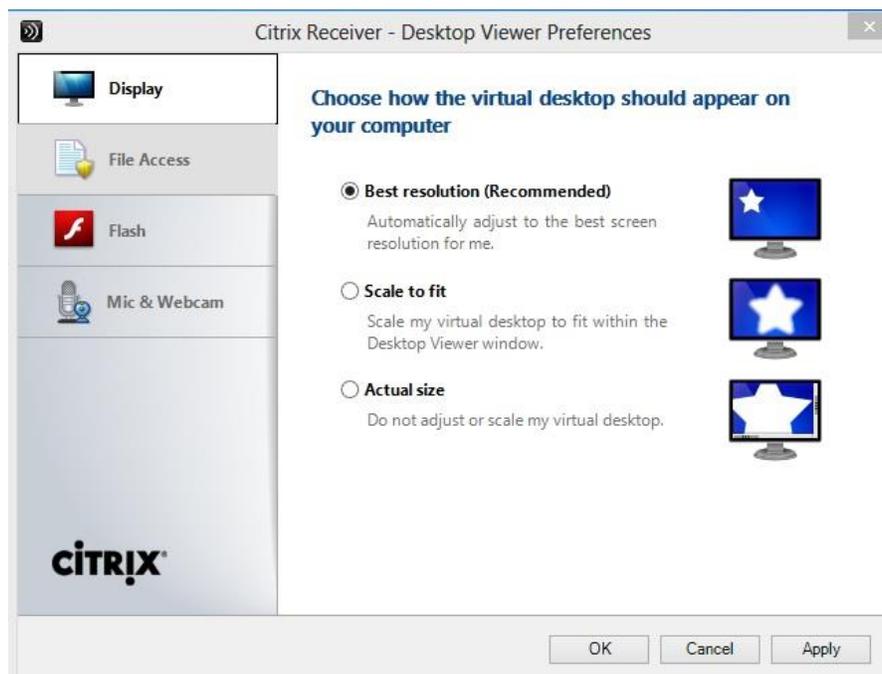
- Click on the Desktop Tool Viewer on the top of the desktop, once the desktop connection is successful.



- Click on the Desktop Viewer toolbar and select *Preferences*.



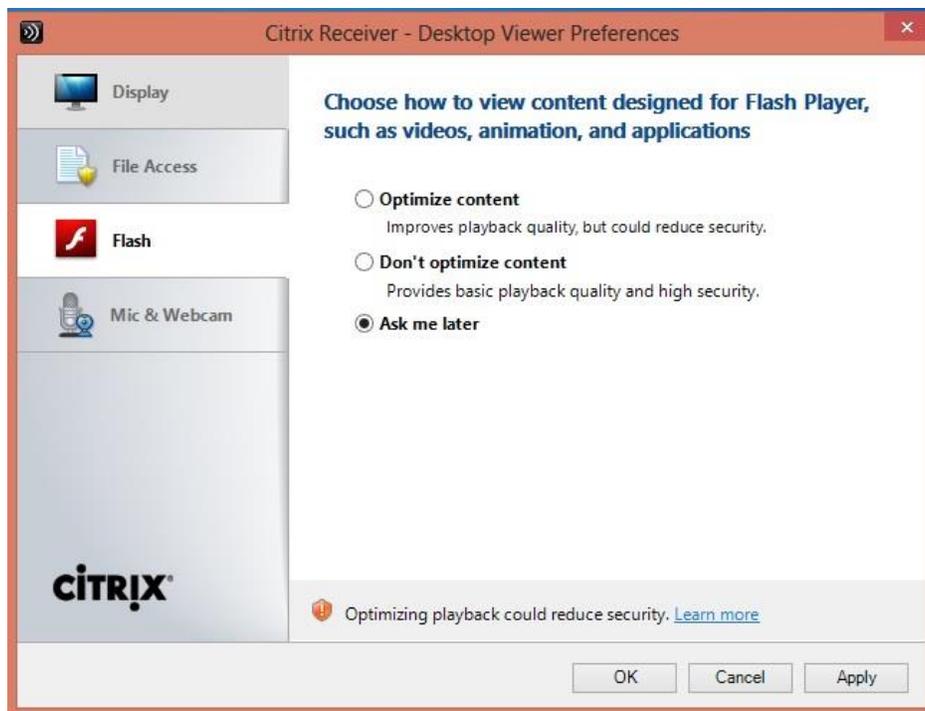
- Select *Display* to modify the display settings.



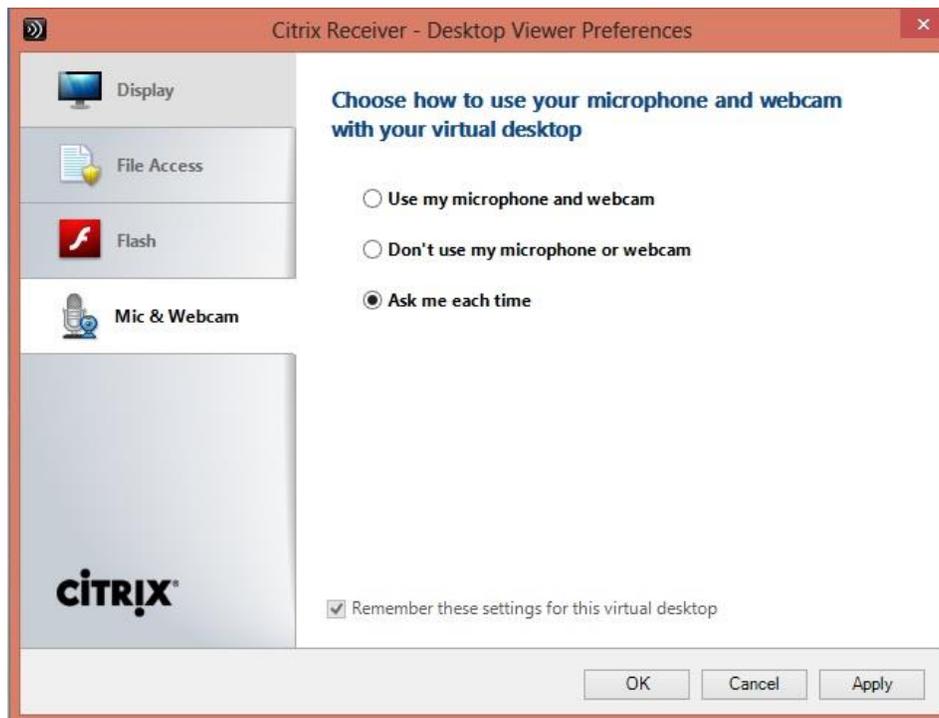
- Select *File Access* to configure the access mode to files on your computer.



- Click *Flash* to configure the settings for content designed for Flash Player.



- Click *Mic & Webcam* to configure the settings for voice and webcams.



Xen Desktop installation is now complete, and desktops can be tested (Citrix Systems, Inc., 2015).

## Chapter 4: Analysis of Results

Although deploying Citrix XenDesktop on VMware vSphere is not necessarily a brand new concept, the actual configuration can become tedious and troublesome as I have experienced while implementing the same. Since I was using the new version of XenDesktop, I always came across licensing issues. Also, I had to make sure that my infrastructure met the requirements for vSphere 5.1 and XenDesktop 7.1. Defining two separate clusters for Citrix and VMware was an additional decision that had to be made after a series of errors were encountered. After hours of research on this subject, an absolute need of a Domain Controller was established to provide virtual machines with the appropriate permissions.

XenDesktop and VMware vSphere are an industry-leading virtualization combination which every enterprise is starting to use as a blend to build both server and desktop virtualization solutions. With each release of the products, both the companies are enhancing the product features to solve and enhance the issues faced by having a physical desktop environment.

The findings of this study further prove that it is possible to modify XenDesktop and VMware vSphere technologies, which was something that remained somewhat unknown to many for a period of time. That is, even though XenDesktop and VMware vSphere technologies are significantly older innovations, the original creators of virtual systems employing the two different software doubted whether the scheme could work after alterations. For instance, this is shown by the innovators' conclusion that XenDesktop can only launch and work well in 'smaller' devices while coupled with the 'Quick Launch' feature. However, the study shows that this is not the case. The application utilized in this study worked excellently, save for the tedious and troublesome configuration encountered when installing XenDesktop and VMware vSphere into the 'users' devices.

The conducted study also shows that the combination of XenDesktop and VMware vSphere can run on a broader range of machines than was previously believed. The literature review section shows that the two applications were thought to only run only on the 2012 Window servers. As such, the study indicates that even earlier versions of Windows can support the virtual server and desktop application. Examples of these include Windows 2007 and 2008. Such realization is critical, especially when understanding that virtualization is rapidly gaining traction in the information technology sector.

## Chapter 5: Discussion and Conclusion

This paper focused entirely on building a Xen Desktop 7.1 environment on the vSphere 5.1. Intense research was conducted to gather data from both Citrix and VMware technologies. Every component required to build a successful desktop virtualization platform has been discussed in this research paper.

Desktop virtualization is becoming one of the most effective technologies among many institutions. The fact that many contemporary businesses surface restraining resources, indeterminate financing and stricter data security laws force them to adopt desktop virtualization. The new technology permits organizations to run modest, profitable, and safe ways for engaging workers. Employees belonging to businesses with desktop virtualization technology readily access applications, as well as resources required to execute their work tasks from whatever devices and location.

The term ‘virtual desktop infrastructure’ (VDI) connotes to a system where a user utilizes a computing machine that runs on remotely stored applications, or ‘desktop environments’. The applications in such a system are stored in a server, instead of a local PC. The ‘desktop virtualization software’ splits the desktop OS, applications, and data from the clients’ hardware by storing all of these on an isolated server. The ‘remote server’ then operates and backs virtual desktops using the hypervisor to establish a ‘simulated machine’ that mimics an ordinary desktop environment and competences. Users engaged in a ‘virtual desktop environment’ thus use their own desktops tenuously either through the Internet or via a client device.

Desktop virtualization is used today by numerous businesses to solve critical technological problems. The innovation offers profound benefits; an example of these paybacks concerns the reduction in cost involved in running businesses. Both hardware and software

management and services in an organization require a significant amount of money. The latter needs continuous updating and reinstallation in case software becomes outdated. The Kaspersky antivirus is an excellent example of such software that organizations need to spend on yearly. Adopting desktop virtualization thus solves such issues. A business only needs to buy one piece of software for the server and then let the other user computers utilize it. Additionally, organizations employing desktop virtualization technology would do not need to buy programs for all machines available in the business (e.g., Microsoft Windows Office Suite). Actions such as these end up cutting down operations cost and, in turn, boosting the level of profitability in an institution.

Virtual desktop infrastructure further helps in enhancing security in an organization. The twenty-first century is commonly known as the digital era. Key to note is the fact that technological innovations experienced today have both advantages and disadvantages. One of the significant issues with the growth in technology concerns data insecurity. Issues such as accounts' hacking, cyberbullying, and ransom attacks have become extremely costly for businesses. Desktop virtualization thus aids by offering reliable means through which data insecurity can be mitigated. Many potential attackers utilize employees' accounts or devices to hack organizations' systems. This has been possible in the past as many employees' personal computers that were used to access company accounts and information ran on independent applications. However, the illegal practice is quickly dying courtesy of VDI. Hackers targeting personal computers operating on a remote server hardly find business information in the employees' computers. The innovation thus offers significant benefits to businesses. Organizations operating a VDI only seek to secure a single system, which makes data security

easy and comprehensive. All these prove the usefulness and reliability of virtual desktop infrastructure.

Virtual desktop infrastructure also promotes data accessibility and thus safeguards businesses and employees from the problems caused by individual user computer breakdown. VDI enables workers to access business information from a central point without having to install programs into their personal machines. All that the workers do is launch the Citrix applications and desktops from whatever device and location. The personal computers utilize applications and desktop app from the remote server. A breakdown of a single 'client' computer, therefore, hardly impacts the performance of the business. The same failure also will not mean that the owner of the machine cannot work. This is because the crashed user's computer hardly contains any stored files or applications. The specific employee whose computer has stopped working needs to acquire a new device and continue working. Such is an excellent way of avoiding headaches brought about by computer failure in businesses. Being able to avoid the challenge thus proves the importance of VDI.

Organizations also manage to enjoy increased productivity due to desktop virtualization. This comes mainly through increased employee productivity. VDI allows workers to work from virtually all points of the globe. It is also possible for employees to use all sorts of devices to conduct work. The present study's realization that VDI can work on a broader range of devices proves this. Allowing employees to work from various points also means enabling them to work for more extended hours. This longer duration of commitment can increase the level of productivity. The fact that VDI enables businesses to utilize reduced software packages further combines with the increased productivity to promote the level of productivity of an organization.

The same impact is also brought about by the aspect of heightened security due to the use of virtual desktop applications.

The reduction of the number of software operated by an organization to one also aids in the simplification of business management. VDI enables companies to manage virtually all aspects from a central point. Data, one of the most critical elements in an organization, is, for instance, easily controlled by companies utilizing VDI. Issues such as intellectual property security hardly bother companies with desktop virtualization in the same way as organizations that operate manually. Virtual desktops eradicate the necessity to install, update applications, back up files, as well as, scan for ‘infections’ on discrete client computers. Additional advantage concerning VDI’s management simplification also touches on the streamlining of software assets’ management. VDI enables organizations to track all company certificates and formulations. It is also possible for entities to restrict the sharing of some information while using VDIs. The ‘Delivery Controller’ in the XenDesktop and VMware vSphere virtual desktop, for instance, tracks, as well as, restricts the content of information sharable between the ‘client’ computer and the server.

Virtual desktop infrastructure helps significantly in promoting the green economy. The technology aids in the creation of the so-called ‘thin clients.’ These are computers that exist without heavy applications and which require almost half of the energy needed by ordinary machines (fat clients) to operate. In some cases, the power consumption is reduced by 70%. Some computer operations are ‘heavy’ and thus require more energy to launch and run. VDI saves power by mandating a single server with the responsibility of running applications for the other devices in the setup. It not only costs a fraction of the amount an ordinary PC would do, but the durability factor also plays a major role as the typical output from implementing VDI

would be at least 6 years, which cannot be determined for a normal PC. The reduction in energy demand implies a reduced dependence on non-renewable energy such as coal. That further supports the 'going green initiative.' China, for example, relies on coal among other non-renewable energy sources to power its industries. The fact that China is the global leader in technological innovations thus means that the nation cut down its power consumption by almost a third by adopting VDI. The same case applies to the United States, which relies on a significant number of computerized systems to manage its operations. For any company that has a large number of users, the combination of costs from support along with costs from power consumption tells us that there is an obvious need for more cost-effective desktop computing. After receiving data on cost and environmental benefits coming from server virtualization, the use of VDI is growing among the IT departments in organizations.

VDI offers an adequate solution to organizations such as banks and hospitals that operate under stricter laws regarding customers' data protection. A majority of studies show that ransom attackers today focus their efforts towards hospitals, banks, large manufacturing companies, and higher learning institutions. The fact that virtually all hospitals in developed economies are migrating to the electronic record management system further means that the threat of attacks is also escalating. This exposes the organizations to increased pressure, especially due to the governments demand that all clients' personal data must be accorded the utmost security. Any facility failing to uphold their security policies faces not only severe consequences from the state but also acquires negative publicity. A majority of the attacks on these institutions emanate from employees' logged-in accounts that are mistakenly left open. Other incidences are also believed to occur through stolen job computers. All these situations can be managed by adopting VDI. The technology can minimize attacks because of its ability to operate centrally controlled

applications and desktops, thus leaving the 'steal-able' computer as mere vessels with no significant details that can lead to cases of hacking.

IT departments are facing a challenge in increasing costs with exponential growth in businesses and running applications that desire a sustainable and flexible work environment to get a competitive advantage. Desktop virtualization is a solution to all these concerns, reducing costs by enabling remote support of the entire infrastructure, dropping power consumption, and providing flexible work strategies. Moreover, VDI seems to be a good solution to all the IT related issues. The only problem now is the introduction of policies and plans to build such a virtualized infrastructure without which we cannot achieve cost control or a green economy.

### **Future Work Recommendation**

As per my research, only a small amount of production environments is based on both Citrix and VMware, and not enough materials can be found with information on how to integrate them. For future research, I would suggest more investigation on the integration of these two virtualization technologies. There has to be a cost-effective way to combine them both to improve the performance of virtual desktops. It is understandable that the integration could be challenging because of the fact that both the technologies are ever evolving and new updates are released every few weeks. For example, there is already a document on how to integrate Citrix server farm in VMware identity manager console. The document suggests deployment and configuration of an integration broker in a windows server and setting up a Citrix PowerShell that will enable communication between the integration broker and the Citrix server. However, hands-on implementation of such an idea remains to be seen.

Similarly, another great topic for research could be implementing VMware cloud on AWS, which is compatible with Citrix virtual apps and desktop services. In theory, such

integration is possible but it may come at a cost as it is known that VMware cloud on AWS is a combination of computer, storage, network and also vCenter server management. It could be very beneficial for businesses, as the IT specialists would not need to learn any new skills or tools and would already be familiar with the usual VMware management tools.

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