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WAN Optimization for Data Transfer in Branch to Headquarter Scenarios

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WAN OPTIMIZATION FOR DATA TRANSFER IN BRANCH TO HEADQUARTER SCENARIOS

By

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Abstract

WAN OPTIMIZATION FOR DATA TRANSFER IN BRANCH TO HEADQUARTER SCENARIOS

By Pooriya Aghaalitari, MSc

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Introduction

Business requirements have impelled IT organization to deploy their applications over wide area network (WAN) connections to increase productivity, provide ubiquitous access, enhance collaboration, and reduce costs. Although application deployment over WAN connections provides considerable number of advantages, it also comes with some performance limitations and disadvantages such as limited bandwidth, application contention, high latency, and packet loss. As the distance between source and destination of WAN connections and packet loss increase, there is substantial WAN throughput degradation. As mentioned in [1], "given a commonly used maximum window size of 64 KB in the original TCP protocol and 45 Mbps bandwidth, the effective TCP throughput of one flow over a source-to-destination distance of 1000 miles is only around 30% of the total bandwidth. With the source-to-destination distance of 100 miles, the effective TCP throughput degrades from 97% to 32% and 18% of the whole 45 Mbps bandwidth when the packet loss rate increases from 0.1% to 3% and 5%, respectively".

As discussed in the paper "On Wide Area Network Optimization", there are some barriers not normally encountered in LANs that can lead to performance degradation of applications that run across WAN connections. These are network and transport barriers, application and protocol barriers, operating system barriers, and hardware barriers which are briefly discussed below.

1) Network and Transport Barriers

   WAN connections are characterized by limited bandwidth, high latency, high congestion and packet loss compared to LANs.

   1.1) Limited Bandwidth: Although there have been considerable improvements in terms of speed in LANs, there have not been similar improvements in WANs. For instance, 1000 Mbps connection in modern LANs is common and application deployed in these environments are provided enough throughput for optimal performance, but WANs are still bound by old bandwidth limitations. At the same time, trends toward data center consolidation, cloud computing, and mobile users have caused WAN oversubscription, which further impacts applications' performance.

   1.2) High Latency: The two main sources of latency in WAN environments are distance and routers. As the distance between source and destination of the WAN end points increases, the round-trip time of the packets transmitted between source and destination end points increases,

which further translates into higher latency. Routers are used to route packets from source to destination. In order to route a packet, a router needs to copy the packet from an incoming interface to the appropriate outgoing interface. This action introduces a slight delay in transmission of the packet and as the number of routers between the source and destination increases the total latency increases. Finally, other factors such as saturated routers and protocol translation can also increase the overall latency. Latency is the main source of slow application response time over WAN connections.

1.3) High Congestion and Packet Loss: Congestion happens when there is excessively large number of network packets accumulated at a router or link and it may deteriorate network service quality resulting in queuing delays and packets loss. Excessively large and full buffer on a router also results in a culprit called bufferbloat, which results in higher latency and poor system performance in WAN environments.

2) Application and Protocol Barriers

Some applications use protocols that are designed to run smoothly in LAN environments, but the same protocols perform poorly in WAN environments simply because they are not considered to run over WAN. Microsoft CIFS infamous for being a chatty application performs quite well in LAN environment. However, it does not perform as expected over WAN because CIFS client and server exchange large number of control and status messages to transfer a relatively small file. “As an example, accessing a 1.5-MB file over the network that resides on a Windows file server requires well over 1000 messages to be exchanged between the client and the server.” [2] Once implemented over WAN, performance of chatty protocols/applications such as CIFS decreases as the amount of latency on WAN increases.

3) Operating System and Hardware Barriers

Other factors that are commonly ignored once checking the performance of an application are the operating system hosting the application and the server platform hosting the operating system. Proper planning, selection and configuration of server’s hardware and operating system components such as CPU, memory, disks and disk controllers, cache size, and correct operating system and processor combination (32-bit or 64-bit) improves the overall performance of the application. At the same time, various operating system vendors provide

software based functionalities aimed to improve application performance. For example, Microsoft provides TCP Chimney Offload, Receive-side Scaling (RSS), and Network Direct Memory Access (NetDMA) to accelerate the Windows network stack.

The need for WAN Optimization

Transferring information and application delivery are among the most important goals of using networks. Continuous performance and speed improvements in components making up computers and LANs have made it easy to efficiently transfer information and deliver applications in LANs. However, performance improvements in WAN speed and technology have not been able to keep pace with LANs. Furthermore, recent trends toward virtualization and cloud computing, data center consolidation, and increased demand for data backup and recovery have placed huge demand on WAN connections and changed the way applications are delivered. Taking into considerations the limitations of WAN connections and massive demand on these connections, enterprise IT organizations have felt the need to optimize their WAN environments to improve network availability, reliability, and performance. WAN optimization is defined as a collection of techniques used for increasing/improving data transfer efficiencies across wide area networks [3]. It uses various techniques such as de-duplication, compression, caching, latency optimization, forward error correction, traffic shaping and other techniques to address application performance issues caused by latency, bandwidth constraints, and inherent protocol limitations.

Project Purpose

The purpose of this implementation is to evaluate the efficiency of WOCs or similar WAN optimization appliances in acceleration of file data transfers for Branch-to-Headquarter scenario. As it is demonstrated at the end of this document, Riverbed Virtual Steelhead appliance uses deduplication, LZ compression, and caching techniques to optimize Microsoft Server Message Block (SMB) files transferred across the WAN link.

Market Analysis of Solution

WAN Optimization Techniques

Some of the most common WAN optimization techniques used across the WAN optimization industry are discussed below.

Deduplication: Eliminates redundant data transfer across WAN connections by sending references of data rather than the actual data. "By having this WAN Optimization technique work at the byte level, benefits are achieved across multiple IP applications." [4] Deduplication also reduces storage utilization by eliminating duplicate copies of redundant data. Redundant data are simply replaced by pointers pointing to the unique copy of data.

Compression: Is used to save bandwidth by reducing the size of data as it is transferred over the WAN. Compression works in symmetric fashion in that two appliances are required on each WAN end points. The sending device uses compression techniques such as ZIP and RAR to compress the traffic as it is being transferred to the destination. At the receiver side, the same compression technique is used to decompress the traffic. Compression works well with various kind of traffic, but it is not recommended for real-time multimedia such as voice over IP and video conferencing. However, Compressed Real Time Traffic Protocol(CRTP) is an emerging protocol that can compress real time traffic over reliable point to point links with short delay.

Caching: Is one of the most common methods used in WAN optimization. It reduces bandwidth consumption by maintaining a local copy of frequently/recently requested data at the remote site. If the same file is requested a second time within the cache aging timer, WAN accelerator intervenes and provides the file from its cache. If the same file at the headquarter is changed, only changes to the file is transferred to the remote site. Caching is a very useful technique in scenarios where file server or e-mail server such as Microsoft Exchange is hosted in the headquarter (main office) and users in the branch office (remote site) need to use the services of these applications.

Latency Optimization: "Can include TCP refinements such as window-size scaling, selective acknowledgements, Layer 3 congestion control algorithms, and even co-location strategies in which the application is placed in near proximity to the endpoint to reduce latency. In some implementations, the local WAN optimizer will answer the requests of the client locally instead of forwarding the request to the remote server in order to leverage write-behind and read-ahead

mechanisms to reduce WAN latency." [5] For example, in case of a chatty application like CIFS, when the WAN accelerator at the headquarter understands that a file transfer is running, it pre-sends some or parts of the file to the WAN accelerator at the branch office. On the other hand, the WAN accelerator at the branch office intercepts messages destined for the server at the headquarter and generates the appropriate response. In this case, although WAN accelerator prevents CIFS from congesting the WAN link, the actual file transfer takes place over the WAN.

Forward Error Correction: Uses redundant data at the source to enable the destination to detect and correct limited number of errors that might occur in packets while transiting the WAN and avoid retransmissions caused by errors in packets. Since Forward Error Correction consumes more bandwidth to transfer the packets, it only applies to scenarios where retransmission is either costly or impossible.

Traffic Shaping: Also known as packet shaping refers to manipulation and prioritization of network traffic so that some applications take precedence over other applications in WAN environments. Voice over IP and video conferencing traffic are some of the candidates for traffic prioritization.

Common WAN Topologies

Two common forms of using WAN connections are Branch-to-Headquarter and Datacenter-to-Datacenter. Branch-to-Headquarter WAN connections are generally characterized by limited bandwidth, and latency issues, and are mainly used to connect users to business applications such as mail, database, and web. Datacenter-to-Datacenter connections are often characterized by high bandwidth, lower latency compared to Branch-to-Headquarter connections, and are primarily used for bulk data transfers such as backup, replication, virtualization, and traffic migration.

Why WAN Optimization from Riverbed

WAN optimization is relatively new in IT industry, but there have emerged big number of companies that provide WAN optimization solutions for various purposes. According to a study done by Research and Markets [7], WAN optimization market is estimated to be $5.2 in 2014 and is estimated to reach $12.1 billion in 2019. Although there are many documents related to the

features and capabilities of the available solutions from various WAN optimization vendors, most of the documents are commercial and biased in contents. In order to select a vendor and appropriate solution for the purpose of the project, an article titled “Magic Quadrant for WAN Optimization” by Gartner was used. In this article, the authors use a set of criteria to select the WAN optimization industry vendors for evaluation. They then evaluate the vendors in terms of product/service, maturity, viability, sales execution, marketing execution, and customer experience and then provides ranking for each one of the vendors. There are four ranks, which are Leaders, Challengers, Visionaries, and Niche Players. Leaders are the companies, which have the ability to shape the market by introducing additional capabilities in their products. Challengers are market followers in terms of products or innovation and might have less-complete feature sets compared to the leaders. Visionaries are the vendors who exhibit strong market understanding, but currently lack the ability to influence a large portion of the market [7]. And, finally, Niche Players have a limited set of features and capabilities and do not have a demonstrated vision. The ranking, advantages, and disadvantages of the products provided by each vendor enable companies planning to optimize their WAN environments to make the right choice for their environments. Comparing the same article “Magic Quadrant for WAN Optimization” via graphs depicted in figure 1, 2, 3 for the years of 2014, 2015, and 2016, it is evident that Riverbed is the leader of WAN optimization industry. The authors provide a relatively comprehensive overview of WAN optimization industry vendors in terms of vision, sales strategy, products, and features. By explaining the advantages and disadvantages of the vendors’ products and the various forms (physical appliance, virtual appliance, etc) that the products are provided to the market, the paper provides WAN optimization industry customers with insight regarding the vendors and their products. Furthermore, recommendations are provided in terms of the scenarios that the products by different vendors should be used for. For example, it is recommended to consider Circadence when mobile application performance is critical to the business. Riverbed is selected for the purpose of this project as it has been the industry top leader for Branch-to-Headquarter and Datacenter-to-Datacenter scenarios for several years. At the same time, Riverbed provides trail virtual appliances, which serves the purpose of this project.

Figure 1. Magic Quadrant for WAN Optimization 2014

Figure 2. Magic Quadrant for WAN Optimization 2015

Figure 3. Magic Quadrant for WAN Optimization 2016

Source: Gartner (May 2016)

Following are the strengths and cautions for Riverbed products mentioned in “Magic Quadrant for WAN Optimization 2016”.

STRENGTHS

- Riverbed offers broadest set of capabilities in terms of features for large branch office networks, data center replication, storage networking protocols, single remote user, and cloud services optimization.
- Riverbed offers a good direct internet solution with IP VPN and single-ended HTTP caching, advanced SSL proxy for public SaaS connectivity, and internet- and SaaS-specific visibility.
- The combination of SteelHead and SteelCentral AppResponse provides very good visibility and reporting capabilities for drill-down reporting across networks, servers, applications, web apps, pages, objects, sites and users (including end-user experience).
- The new Secure Transport feature supports an IPsec-encrypted overlay mesh network, and a partnership with Zscaler provides the ability to scan optimized traffic for security purposes before going to the cloud.

CAUTIONS

- Riverbed's price can be significantly higher than its leading competitors, and although it does respond when competitively challenged, its discount policies can be inflexible and inconsistent.
- Riverbed's portfolio is extensive and has a broad solution scope, with six product ranges and multiple options within each range. However, this can make it difficult to understand how to meet functional needs.
- Riverbed has innovated less in the past 12 months than previously, and has been slow to embrace hybrid and SD-WAN. Its WAN path selection capabilities are more basic than segment-leading vendors.
- Gartner clients have reported that the solution can be difficult to manage in complex application environments, which can lead to misconfiguration and degraded application performance. However, Riverbed is adding autoconfiguration capabilities, and support is very responsive and highly rated by Gartner clients.

Real-Time Traffic Optimization

Although there exists a UDP optimization module in Riverbed optimization operating system, it is designed to deal with what is known as Bulk UDP Traffic. UDP optimization module is used for backup, data replication, and other purposes that use UDP as their transport mechanism to de-duplicate redundant data and ultimately reduce the amount of data transferred over WAN. On the other hand, Real-time UDP/TCP traffic such as video and VOIP is very latency sensitive and do not have large amount of redundant and repeated data payload. To efficiently transport real-time traffic such as video and VOIP, Riverbed recommends traffic prioritization based on bandwidth and latency to protect the traffic against congestion and latency. At the same time, dynamic path control enables real time traffic to be routed via the fastest and least congested route to achieve better quality of service and experience.

Solution Setup

In order to set up and implement the project, solutions from various leading industry vendors were used, which are further discussed below.

HP Proliant DL380 G5

HP Proiant DL380 series servers are commercial servers that provide performance, availability and expandability for small to medium range workloads. A single HP Proliant DL380 G5 server platform with following specification was used to implement the solution using industry leading virtualization solution VMware vSphere 6.

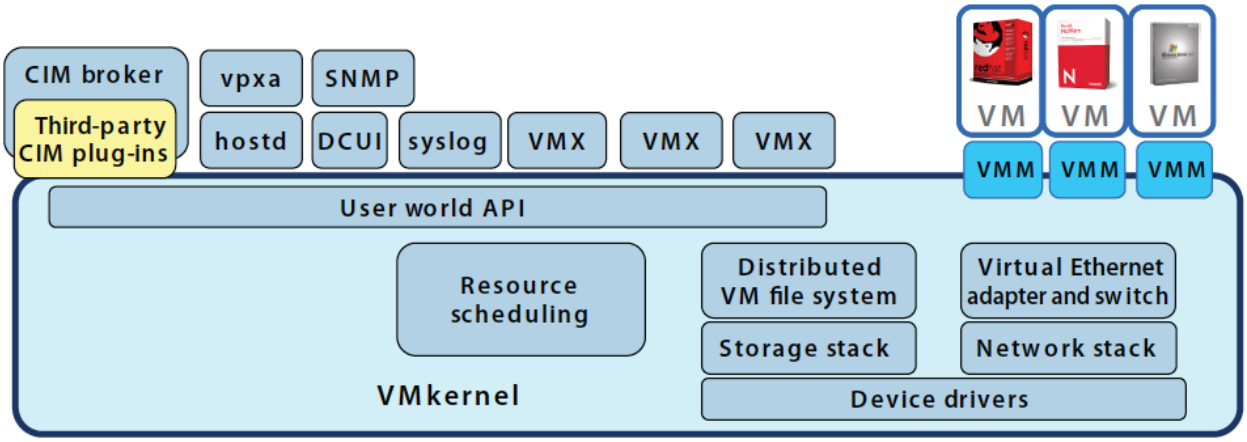
Manufacturer	**HP**
Model	Proliant DL380 G5
CPU Cores	8 CPUs * 2.499 GHz
Processor Type	Intel(R) Xeon(R) CPU E5420 @ 2.50GHz
Processor Sockets	2
Core per Socket	4
Logical Processors	8
Memory	32 GB

Number of NICs	4
Storage	2.09 TB SAN Storage Space

VMware vSphere Hypervisor 6

VMware vSphere hypervisor 6 also known as VMware ESXi version 6 is the slimmest hypervisor in the industry with less than 150 MB of install footprint. At the very core of ESXi, there exists the VMKernel (the operating system) and a number of processes running atop VMkernel. VMkernel, shown in figure 20, is the foundation of the virtualization process in ESXi and manages the virtual machine's access to the underlying hardware resources by providing CPU scheduling, memory management, I/O management, file system and other related functions [8]. There is a fundamental difference between VMware ESXi and most other hypervisors such as Microsoft Hyper-V and Citrix XenServer in that VMware ESXi handles I/O within the hypervisor itself. Since ESXi handles I/O within the hypervisor and does not depend on any general-purpose operating systems, it has greater throughput and lower overhead in terms of I/O management compared to other hypervisors. At the same time, since the I/O stack and device drivers are within the hypervisor itself [8], it has stricter hardware compatibility compared to Microsoft Hyper-V and other similar solutions. VMware ESXi6 is currently the latest version of bare-metal hypervisor from VMware and is used for the purpose of this project to implement either side of the WAN link (headquarter and branch office).

Figure 4. VMware ESXi Architecture



Windows Server 2012 R2

Windows Server 2012 R2 is the latest production release of server operating system from Microsoft currently. It has been one of the most famous server operating systems in data centers and is used for various roles such as file server, Web server, LDAP server and others. For the purpose of this project, Windows Server 2012 R2 is used to implement Microsoft file service so that clients in branch office are able to share and transfer files through headquarter. WAN optimization is used to accelerate file transfers between the clients and server.

Active Directory

Active Directory is the most popular LDAP server in data centers throughout the world. Windows Server 2012 R2 is also used to implement Active Directory directory service. Although Active Directory is not to the core of the project, it used for the sake of authentication and authorization between the clients and file server.

Windows 10

Windows 10 is the latest workstation operating system from Microsoft and is used to share and transfer files to and from the file server. The main purpose of this project to accelerate and facilitate Windows 10 clients access to file server through the WAN connection.

Cisco 1000v Router

Cisco 1000v is a software based router, which comes in virtual form factor and provides routing, firewalling and VPN functionality for single or multi-tenant, private, public or provider-hosted clouds. It is used in this project in either side of the WAN connection to connect headquarter and branch office to one another using a 2 Mbps emulated WAN connection.

WAN Emulator

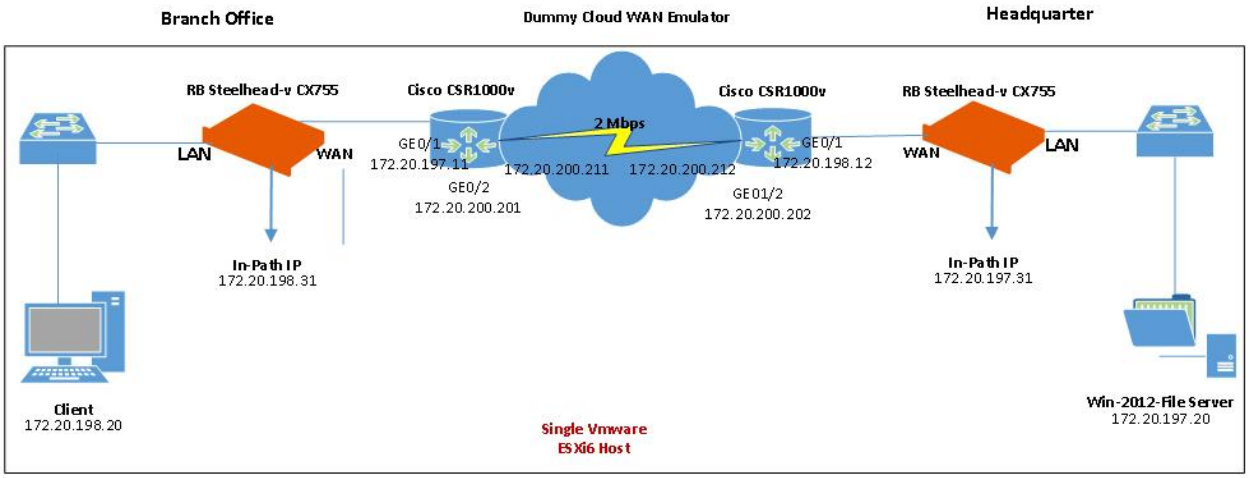
Dummy Cloud is a comprehensive WAN emulator solution that is cable of emulating WAN characteristics such as bandwidth restrictions, latency, packet loss, queue depth, asymmetric link

environment and some other characteristics. Dummy Cloud is used in this project to emulate WAN environment with 2 Mbps bandwidth and latency of 20ms. At the same time, as per recommendation in WAN Optimization Test Plan 8.0 by riverbed [9], simulated packet loss was not configured in the WAN emulator machine.

Riverbed Steelhead-v CX755

Steelhead-v CX755 is a virtual WAN optimization controller from Riverbed that optimizes performance of various applications including on-premises, cloud and SaaS across WAN connections. In this project, two Steelhead-v CX755 are imported into the VMware vSphere environment using an OVA file format. Then each of the appliances sits between virtual switch implemented in VMware vSphere environment and Cisco 1000v in either side of the WAN connection to perform the actual optimization. Figure 5 demonstrates the project topology along with all the components involved in the project implementation.

Figure 5. Project Topology



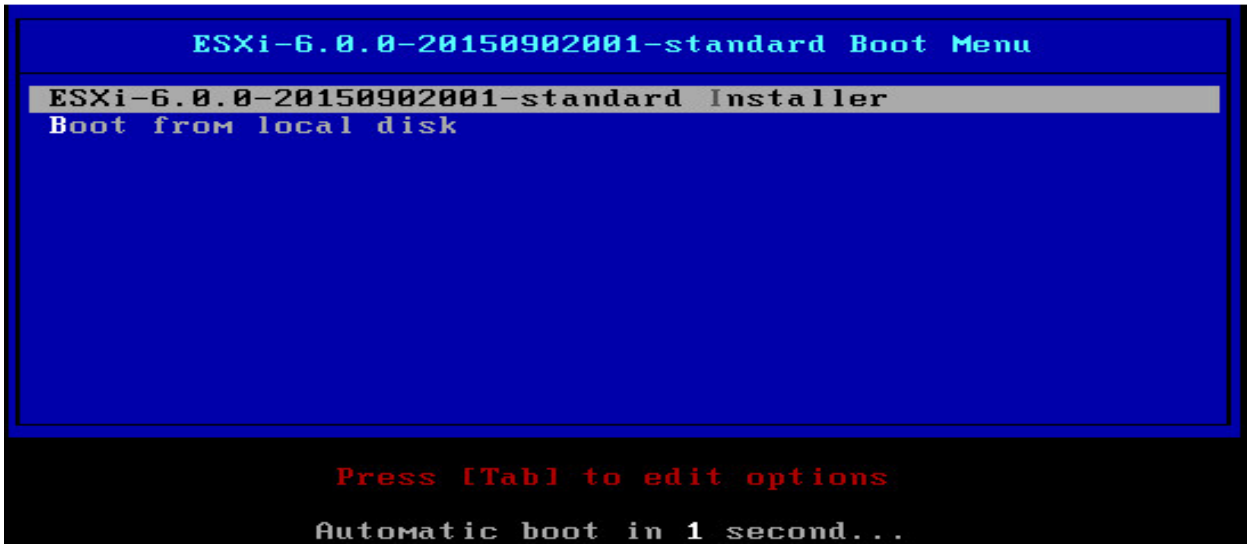
Lab Implementation

This section explains a step by step procedure that was used to implement the project.

VMware ESXi6

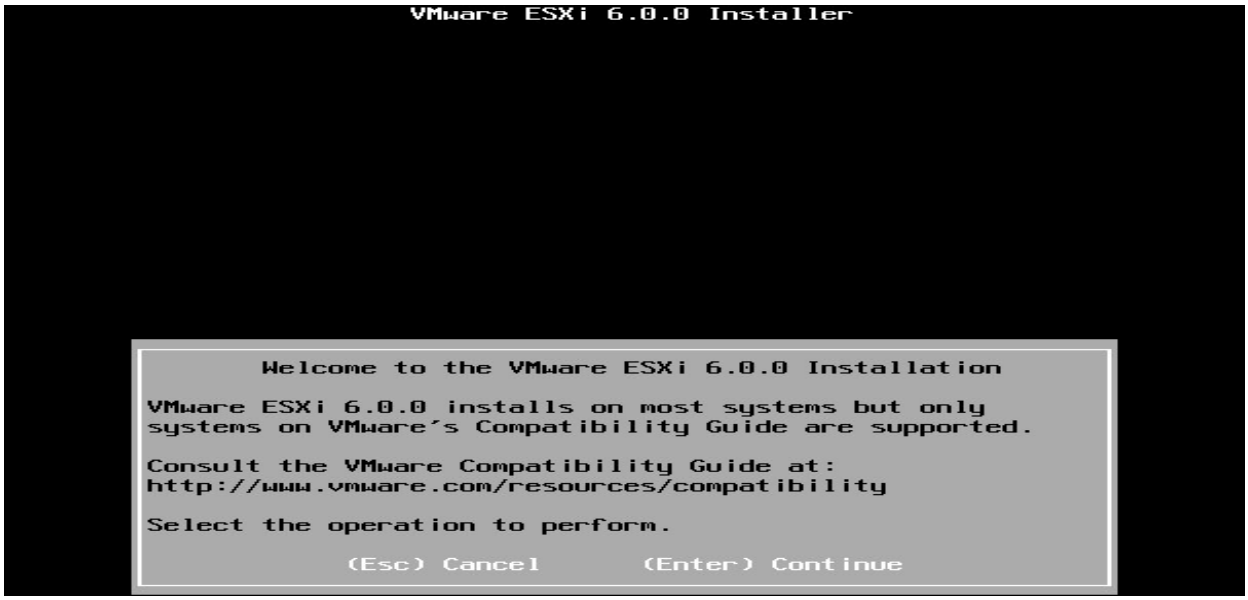
1. Start the HP Server machine and make sure it is configured to boot from the DVD-ROM.
2. Place the bootable DVD in the DVD-ROM.
3. On the following screen, leave the default and hit Enter.

Figure 6. ESXi Boot Menu



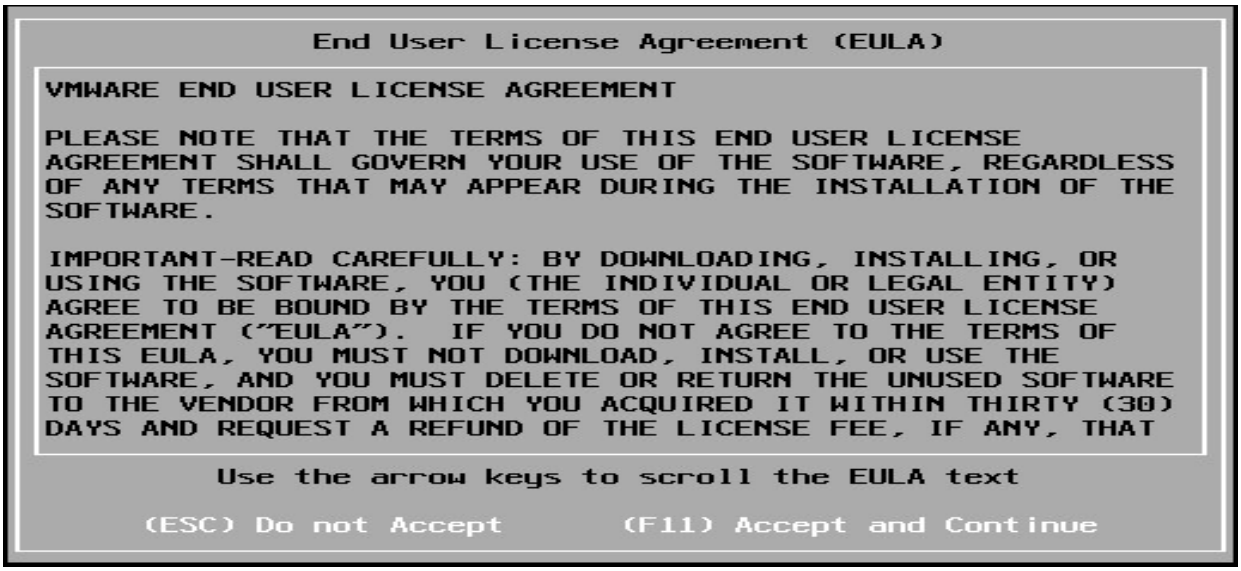
4. On the welcome screen, hit Enter.

Figure 7. ESXi Welcome Screen



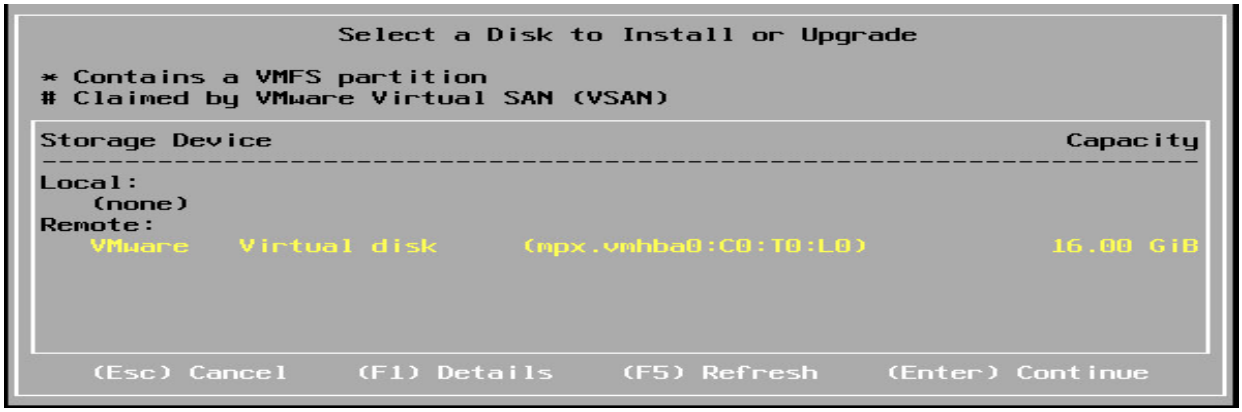
5. On the End User License Agreement page, hit F11 to accept the EULA and continue.

Figure 8. ESXi License Agreement



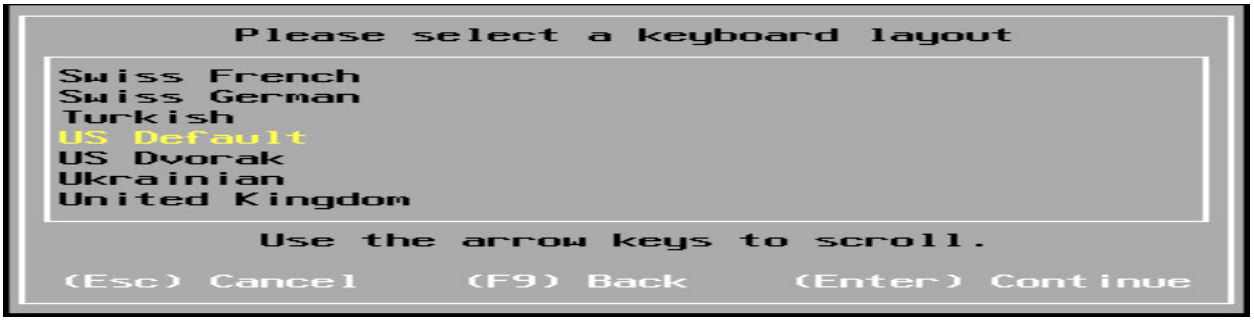
6. Select an appropriate disk to install ESXi hypervisor.

Figure 9. ESXi Disk Selection



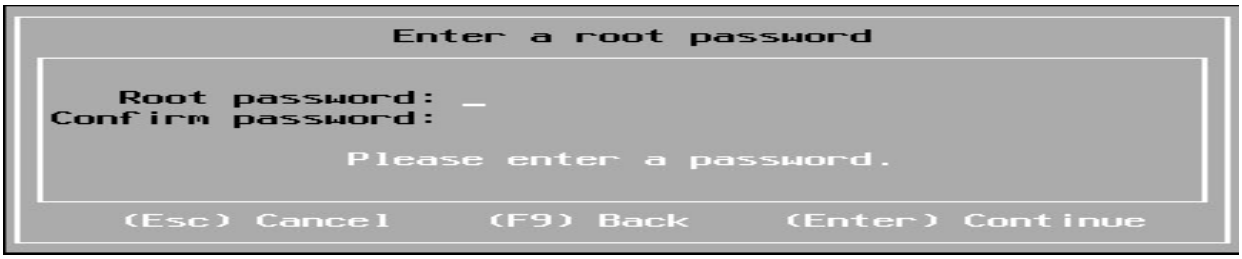
7. Select a keyboard layout.

Figure 10. ESXi Keyboard Selection



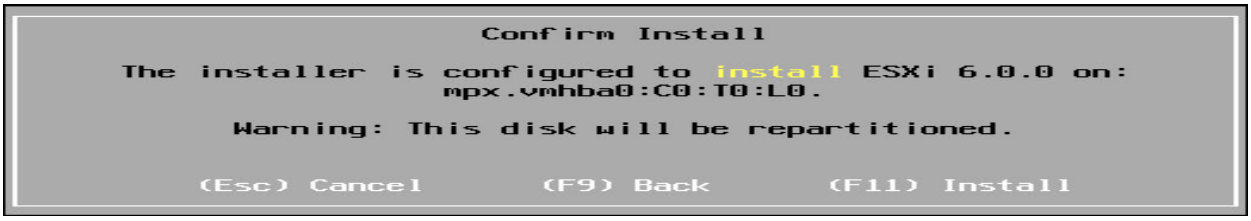
8. Enter your desired password.

Figure 11. ESXi Password Selection



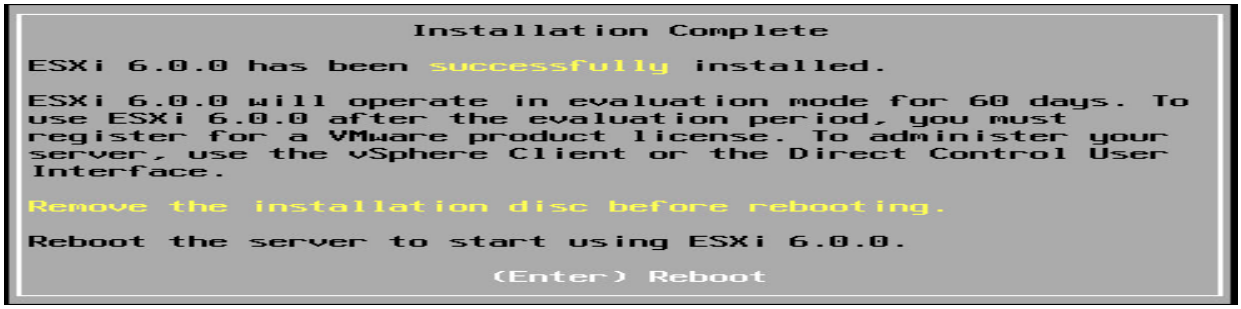
9. Hit F11 to perform the installation.

Figure 12. ESXi Installation Confirmation



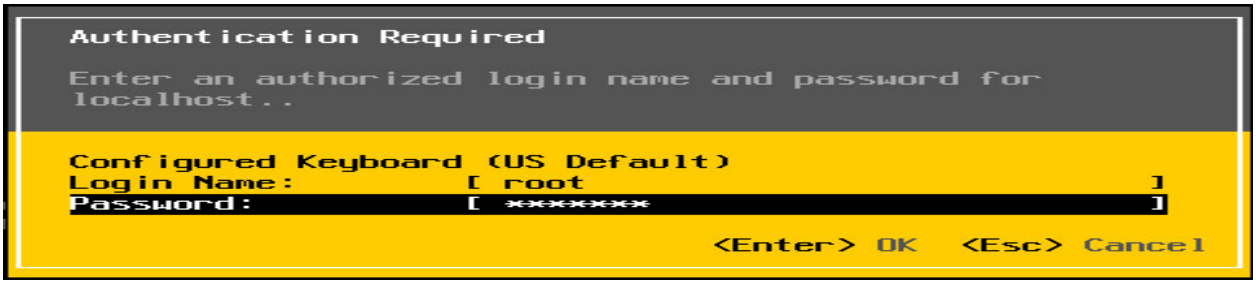
10. Upon successful installation of ESXi, remove the DVD from DVD-ROM and hit Enter to reboot.

Figure 13. ESXi Installation Completion



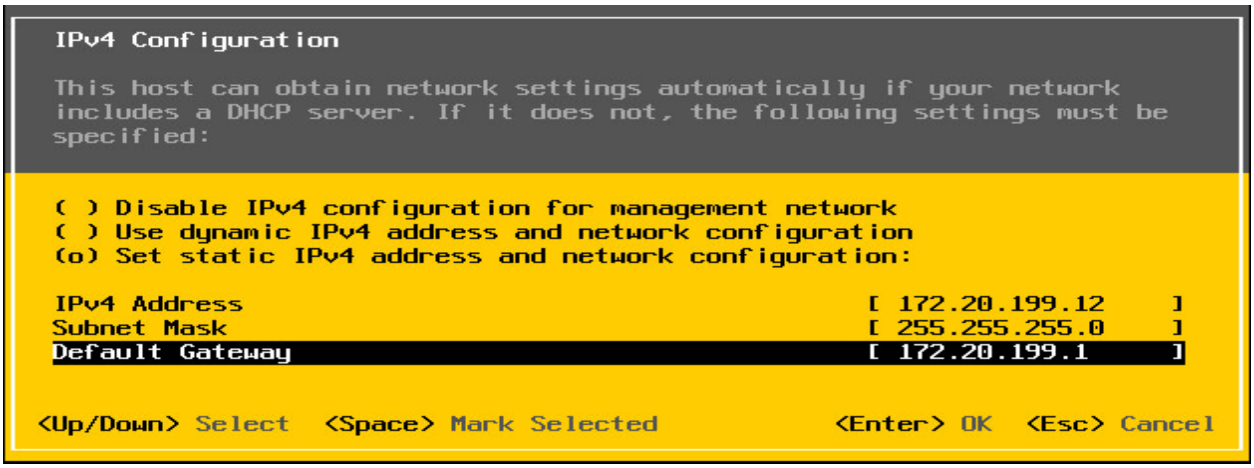
11. Once the server is rebooted, hit F2 and enter your password to customize ESXi host settings.

Figure 14. ESXi Authentication Page



12. Navigate to Configure Management Network and configure the appropriate settings such as IPv4 address, DNS server, VLAN and other relevant settings.

Figure 15. ESXi IPv4 Settings



13. Once network related configuration is done, we need to connect to ESXi host using VMware vSphere Client, which is a Windows based software. Open vSphere Client and enter appropriate information to connect to the ESXi host.

Figure 16. vSphere Client Authentication Page

VMware ESXi Network Implementation

This project extensively depends on the network and network configuration.

In order to simulate LAN and WAN environments in a single ESXi machine, we need specific network configuration so that the solution will work as required. Followings are required for the lab.

1. Two internal only switches, which are not connected to any uplink interfaces on the physical host. These switches are required to simulate LAN switches on headquarter and branch office sites. The server in the headquarter and client in the branch office are connected to these switches. At the same time, each Riverbed WAN Optimizer in each site must also have a connection to the switch on its site to forward and optimize the traffic.
2. Two external switches for connection between Cisco virtual routers and Riverbed WAN Optimizers.
3. An external switch for connection between WAN emulator and Cisco virtual routers.

Once all the virtual switches are configured, networking in ESXi will resemble the following figure.

Figure 17. ESXi Networking Configuration

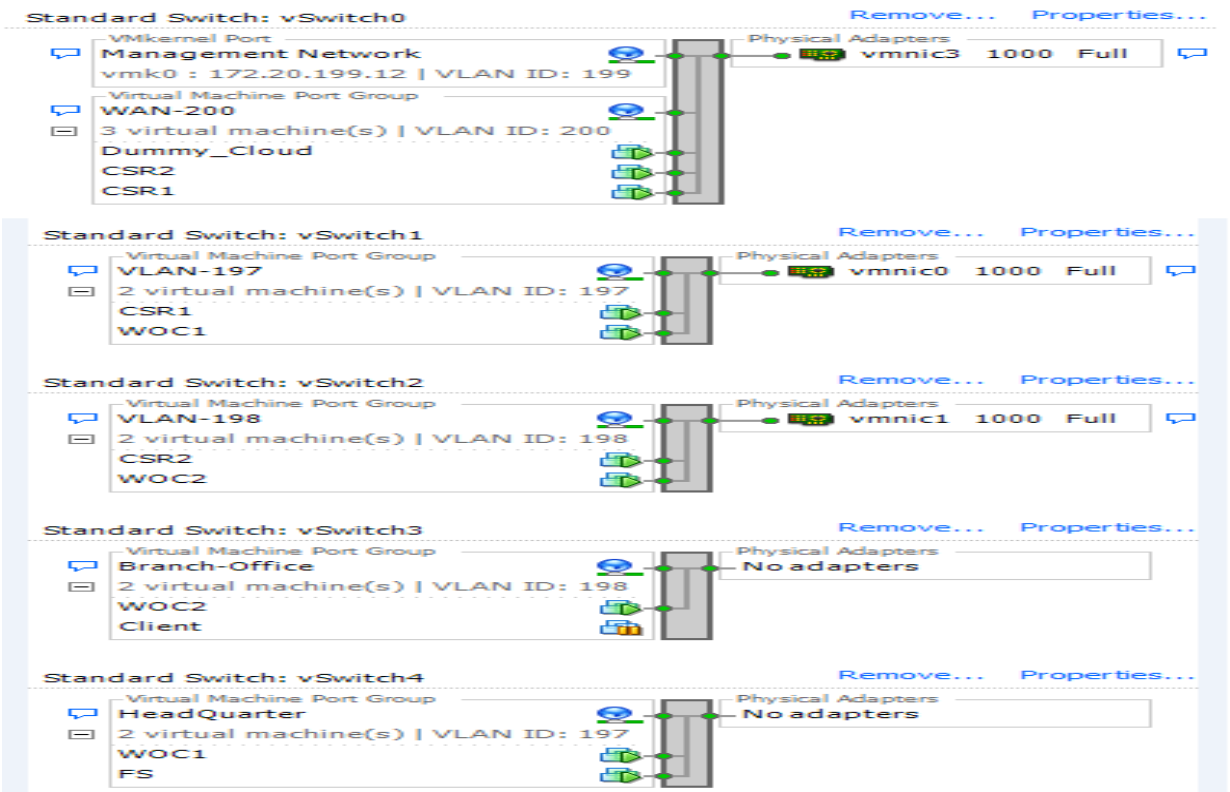
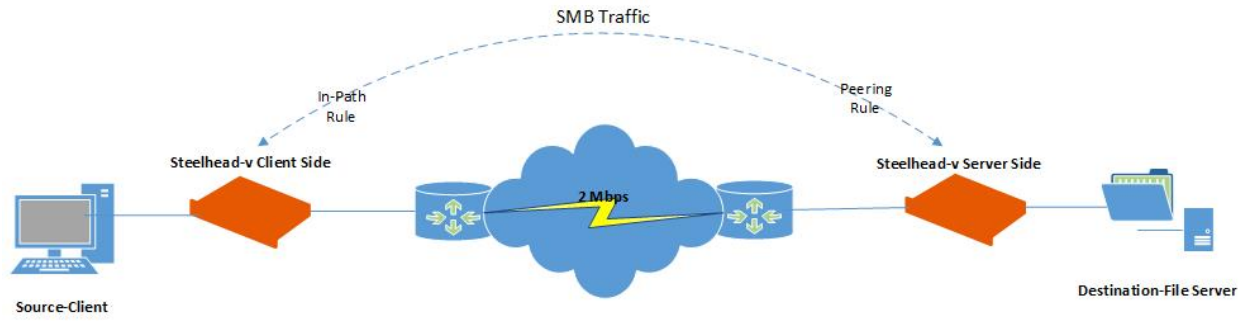


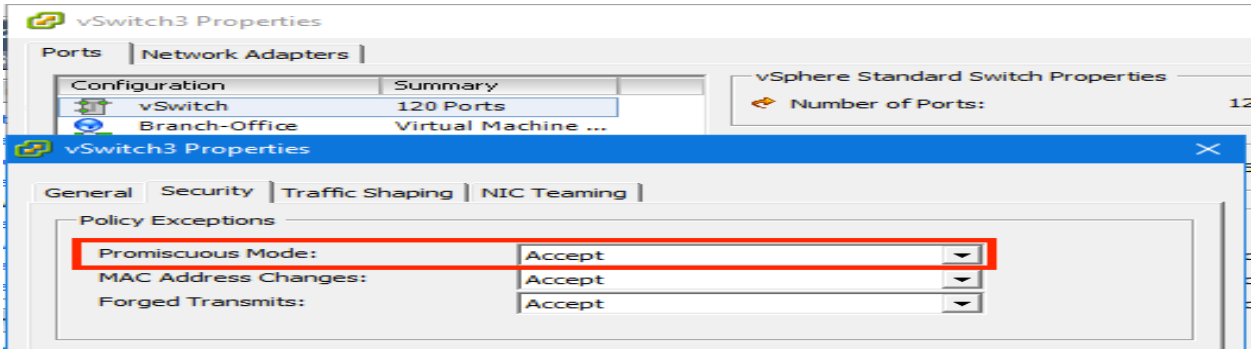
Figure above implements the following logical network topology required for the project.

Figure 18. Project Topology



Note: Internal switches attached to Riverbed WAN optimizers in both sites need to have promiscuous mode enabled as per the following figure.

Figure 19. vSwitch Promiscuous Mode Configuration

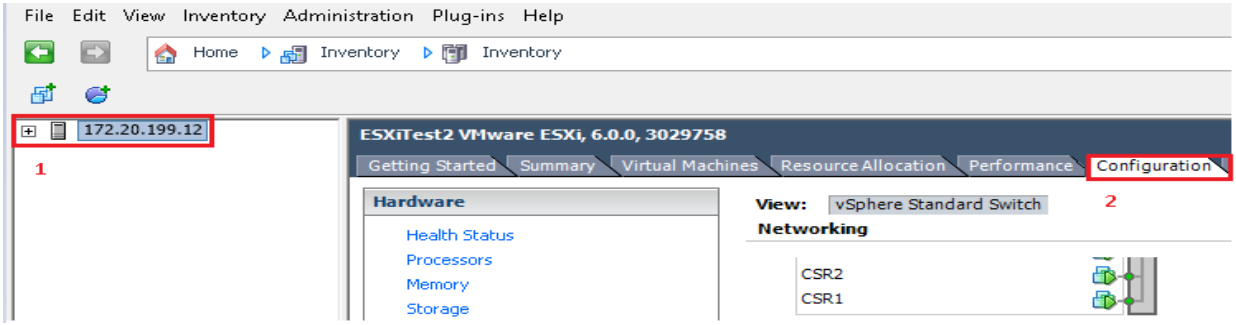


Internal Switch Configuration

In order to implement the internal switch, we need to take the following steps.

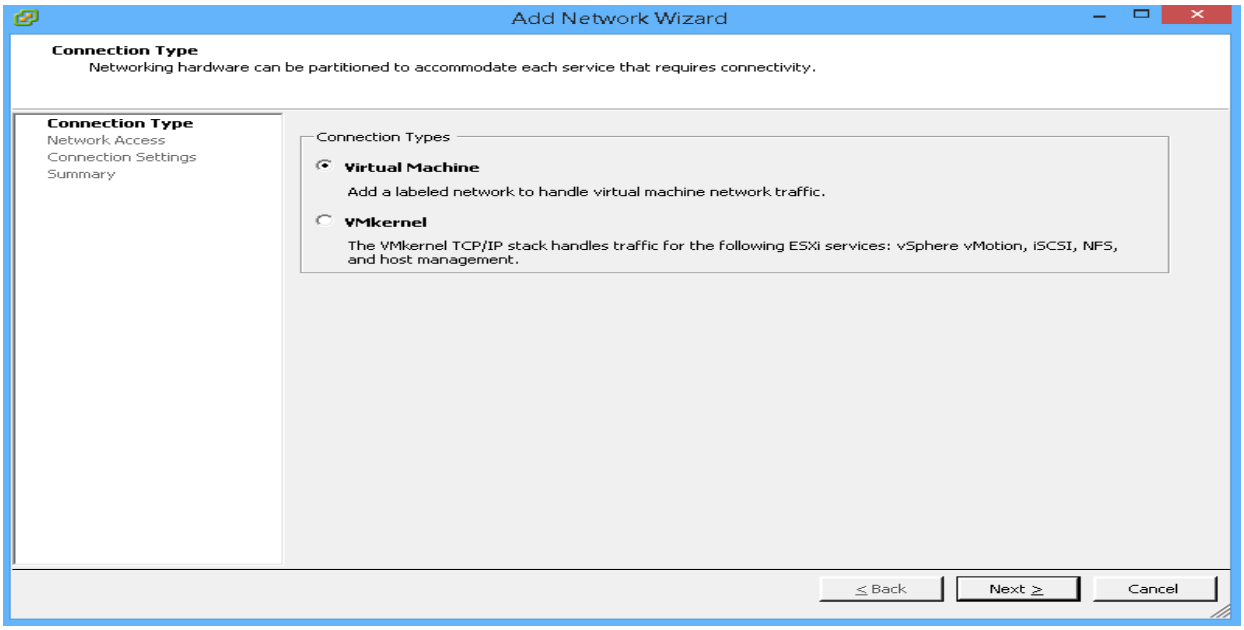
1. From the inventory list, select the ESXi host and then click Configuration tab.

Figure 20. Navigating to ESXi Networking Page



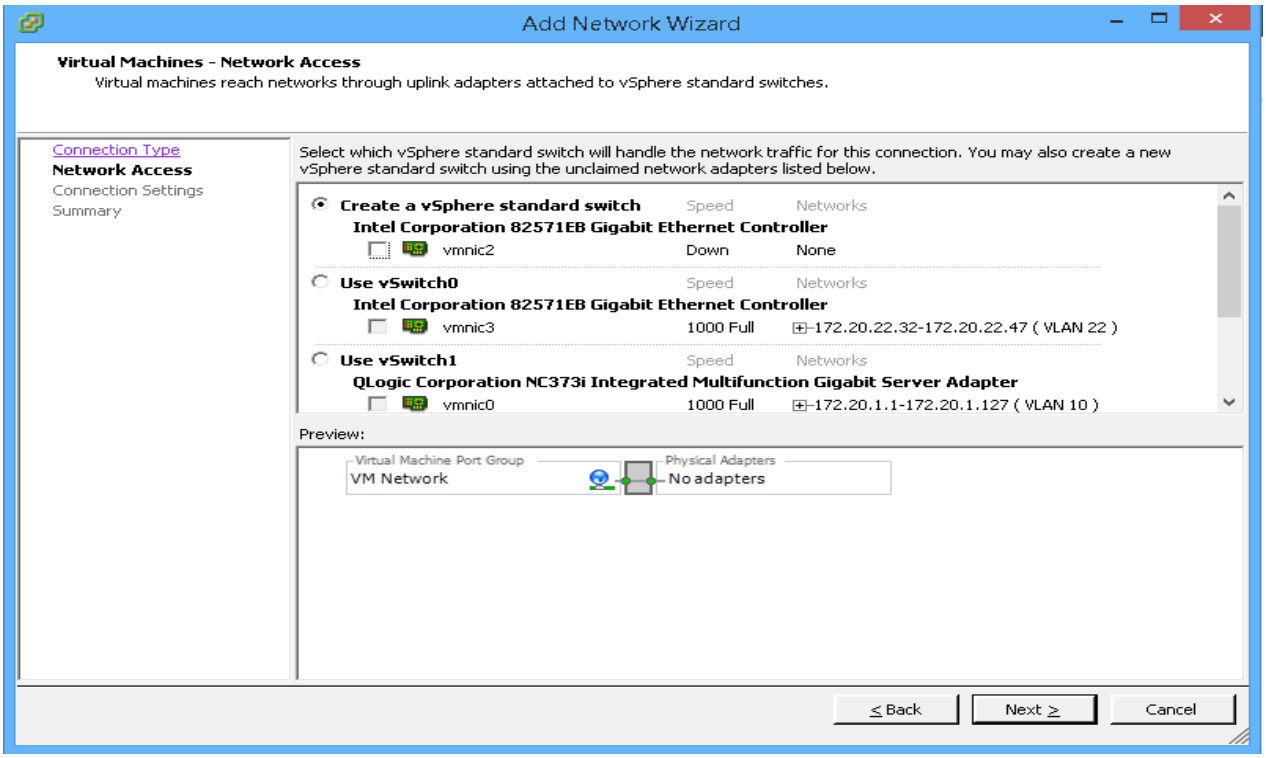
2. From the upper right corner of vSphere Client console, click Add Networking, leave Virtual Machine selected and click Next.

Figure 21. vSwitch Connection Type



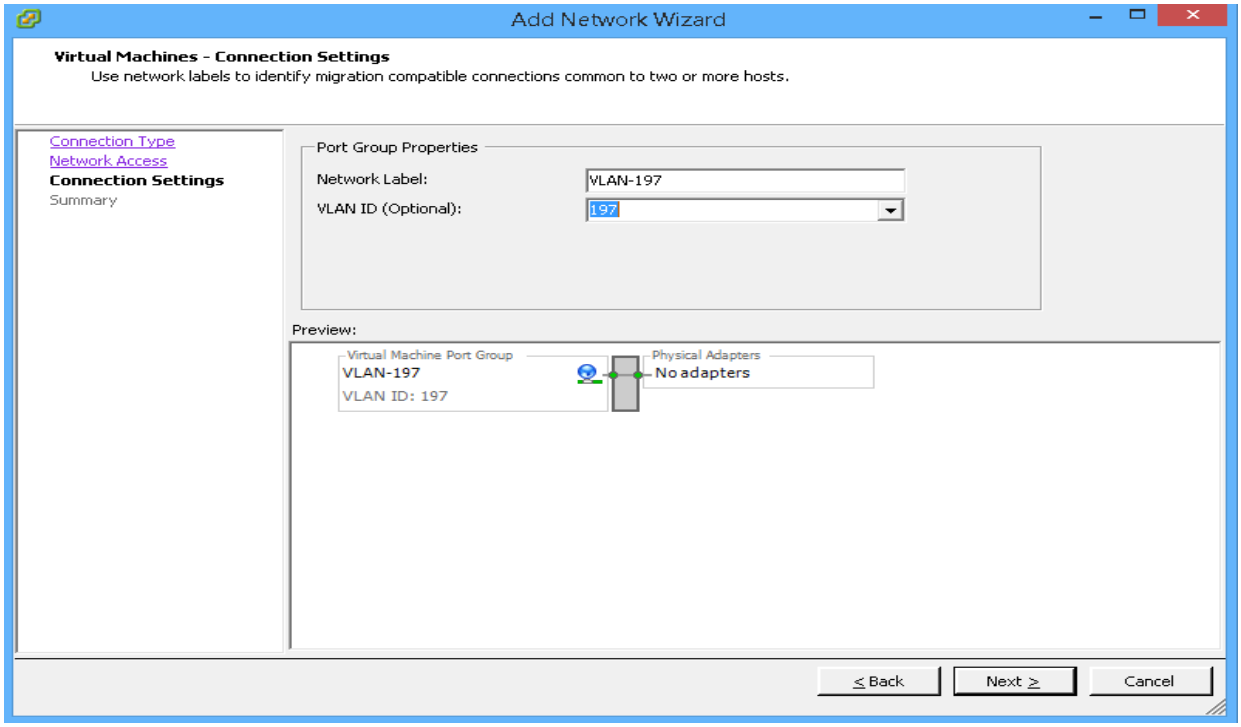
3. Make sure no uplink interface is selected and click Next.

Figure 22. vSwitch Virtual Machine – Network Access



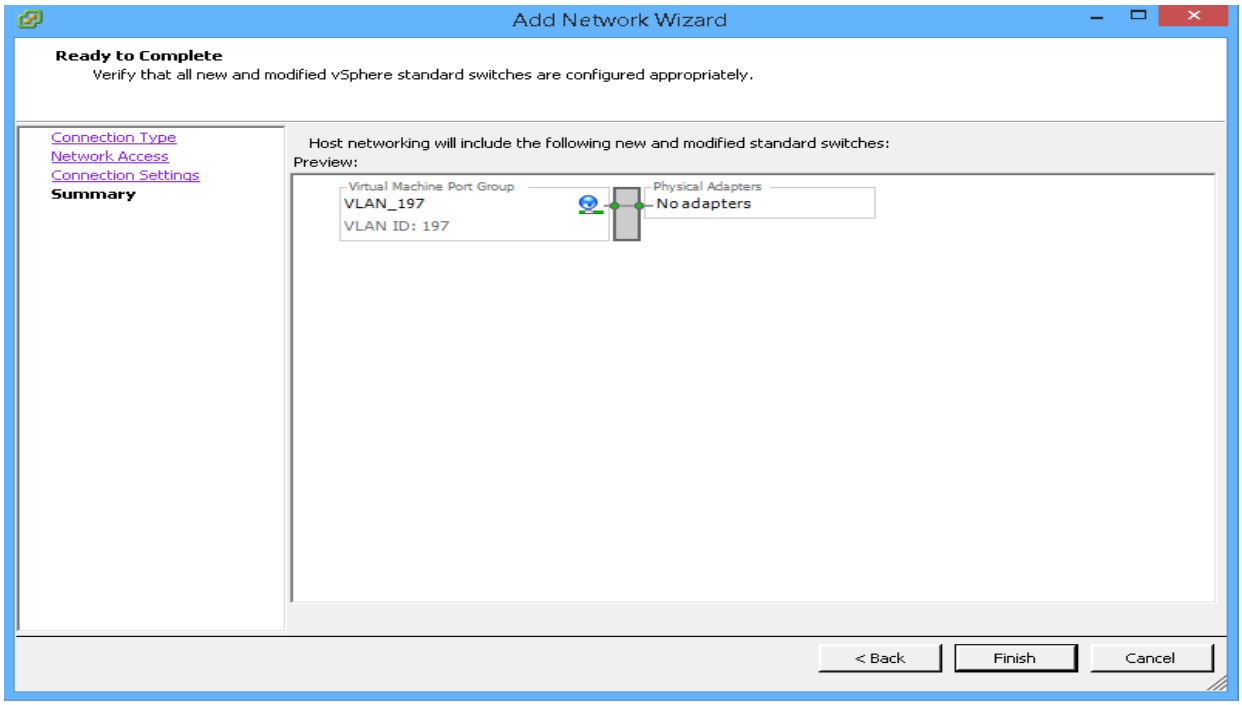
4. Enter appropriate Network Label and VLAN ID and click Next.

Figure 23. vSwitch Virtual Machine – Connection Settings



5. On the Ready to Complete page, click Finish.

Figure 24. vSwitch Ready to Complete Page



External Switch Configuration

In order to implement the external switch, we need to take the same steps as the internal switch except we need to select a network interface card on Virtual Machine-Network Access page.

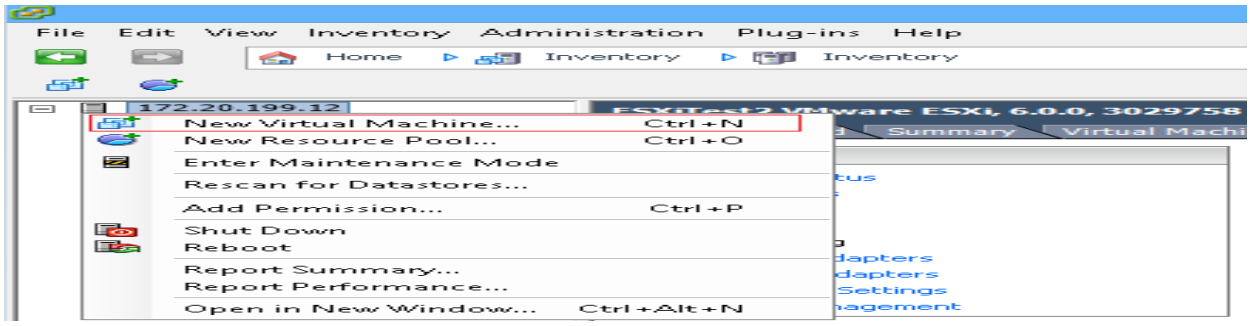
Server and Client Implementation

Virtual Machine Creation

The ultimate purpose of this project is to optimize the communication between the client and the server. The server and the client are the end points at either side the of LAN and are implemented through virtual machines. Following are the steps taken to create the virtual machines. This section needs to be done once for the client and once for the server.

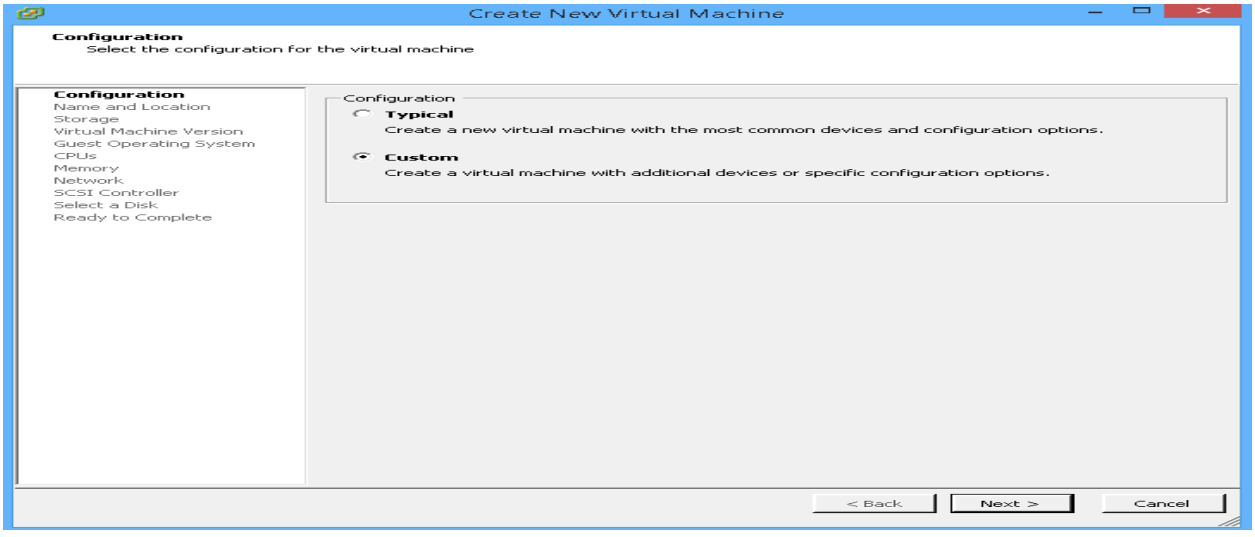
1. Right click ESXi host name/IP address and select New Virtual Machine.

Figure 25. New Virtual Machine Wizard



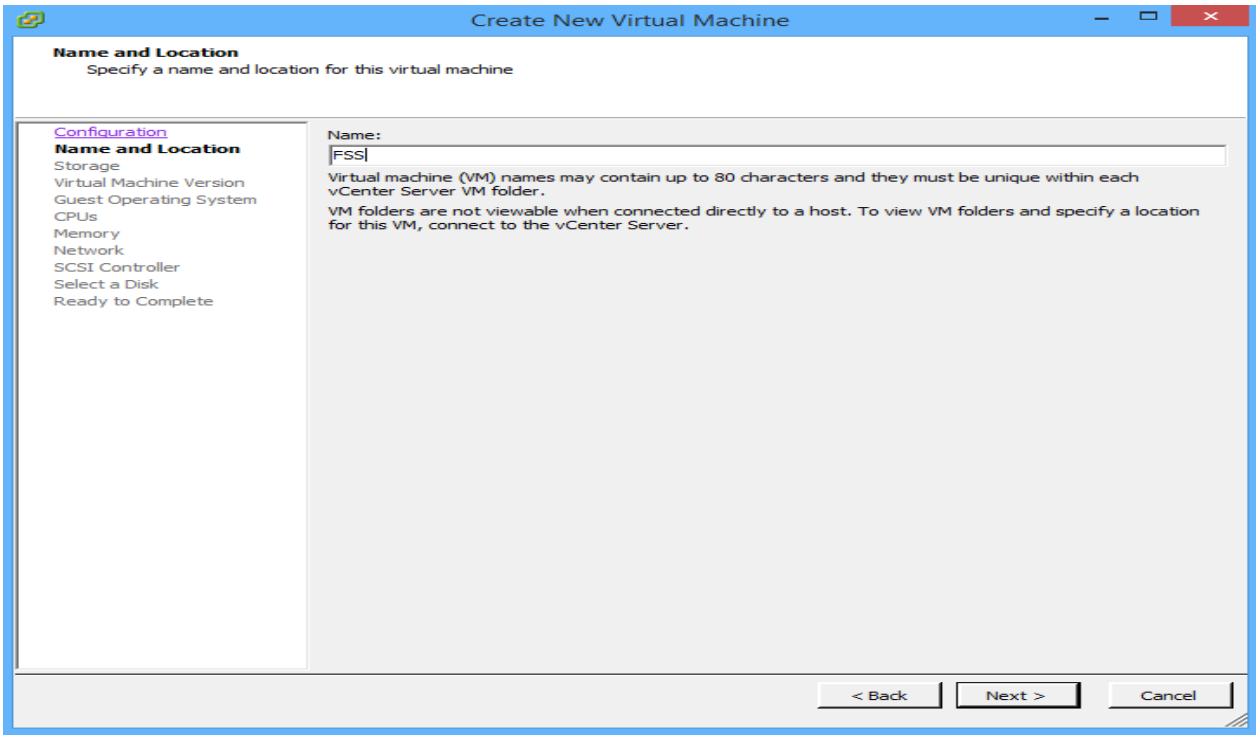
2. Select Custom and Click Next.

Figure 26. Type or Custom Virtual Machine



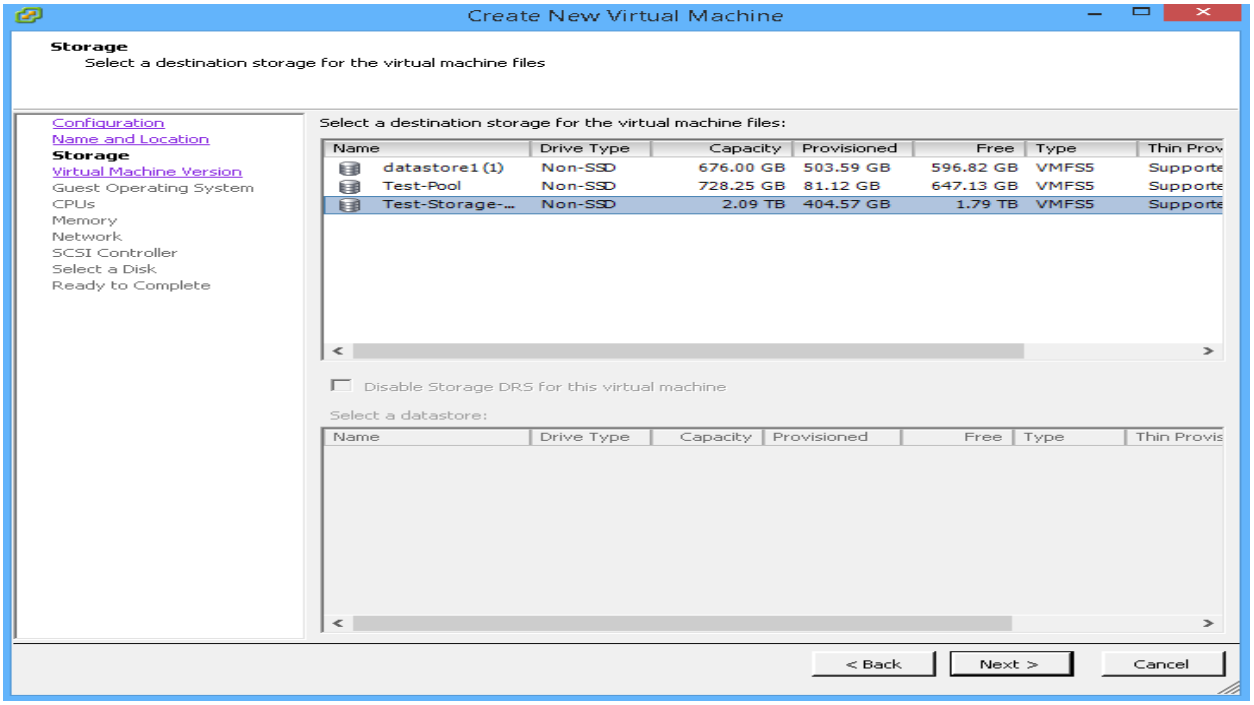
3. Select a Name and click Next.

Figure 27. Virtual Machine Name



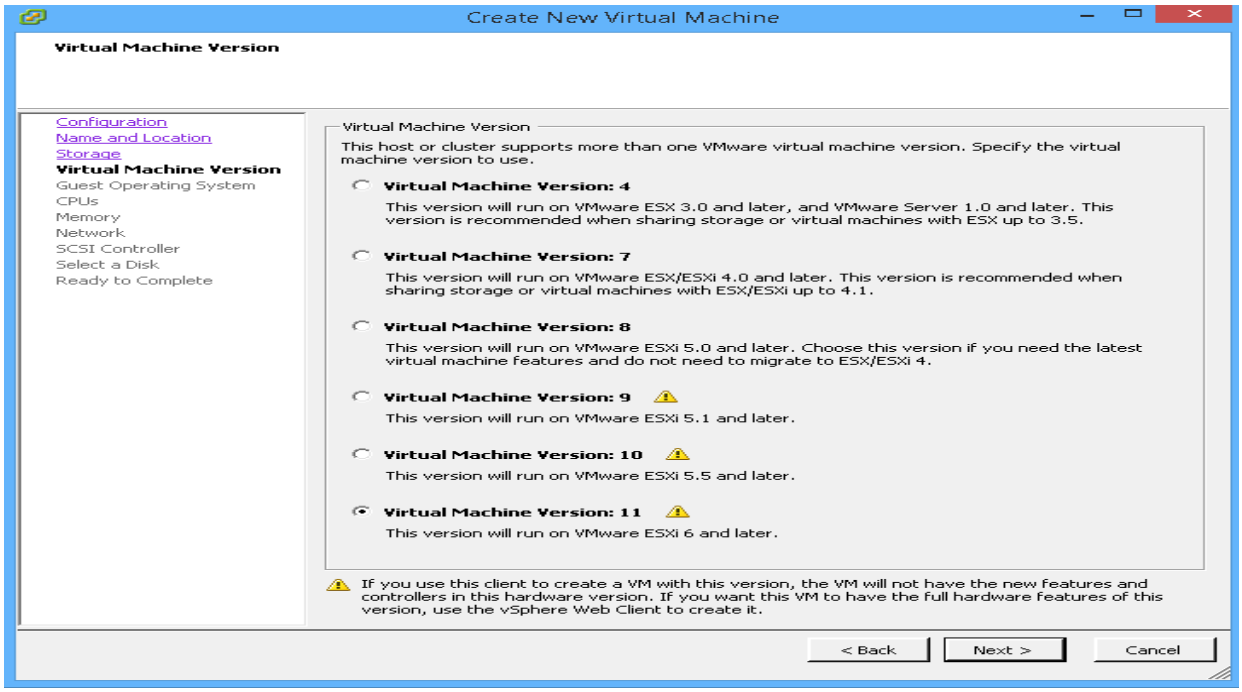
4. Select a data store to place the virtual machine and click Next.

Figure 28. Virtual Machine Datastore



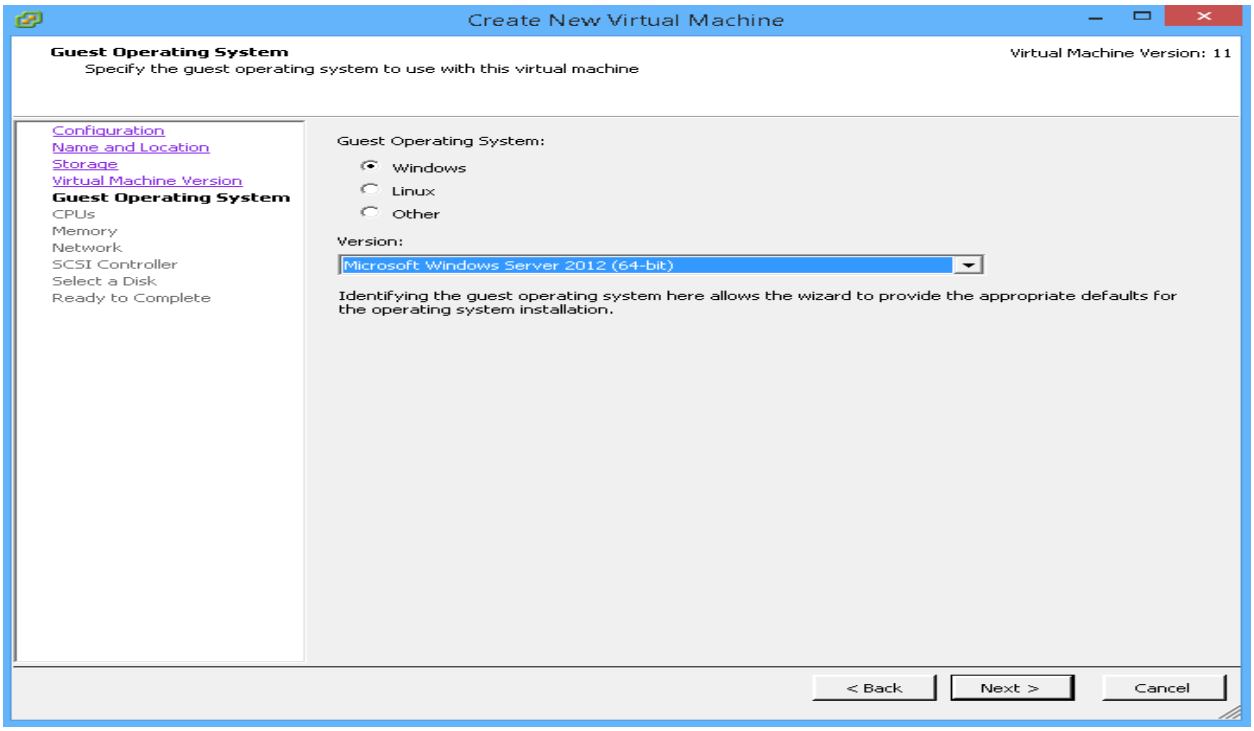
5. Select a Virtual Machine Version and click Next.

Figure 29. Virtual Machine Version



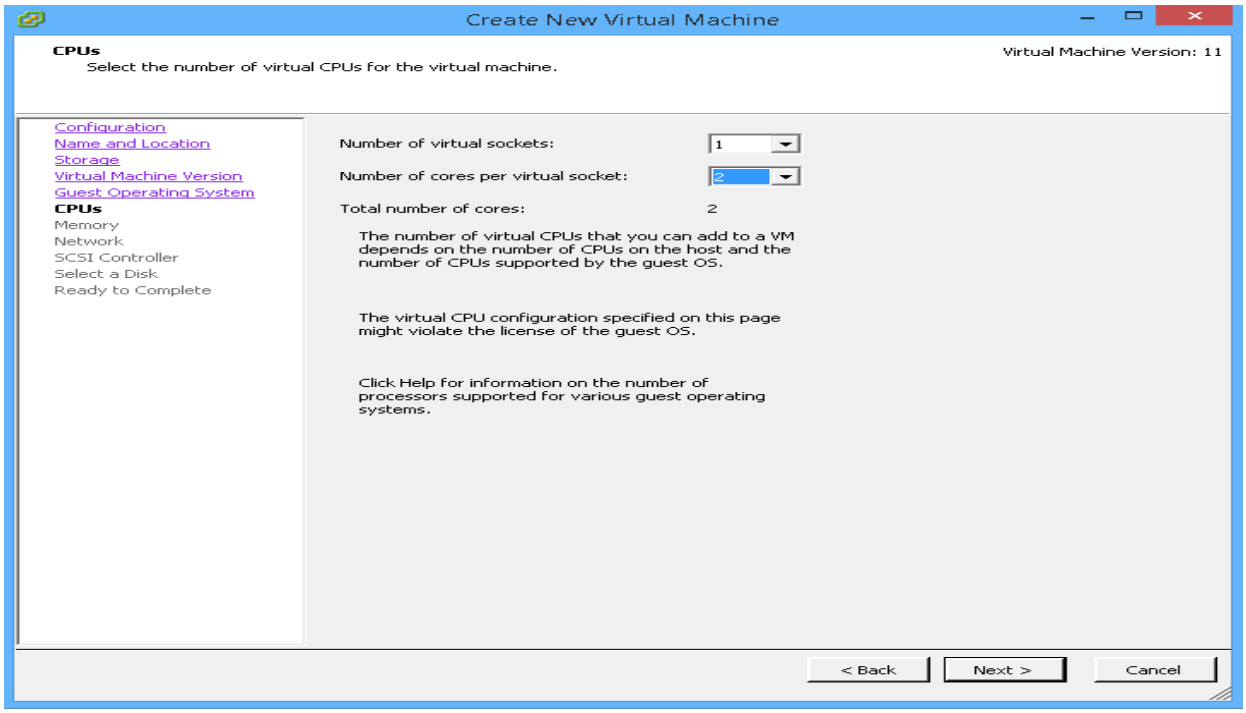
6. Select an appropriate operating system and click Next. For the server, select Windows Server 2012 R2 and for the client select Windows 10 (64-bit).

Figure 30. Virtual Machine Guest Operating System



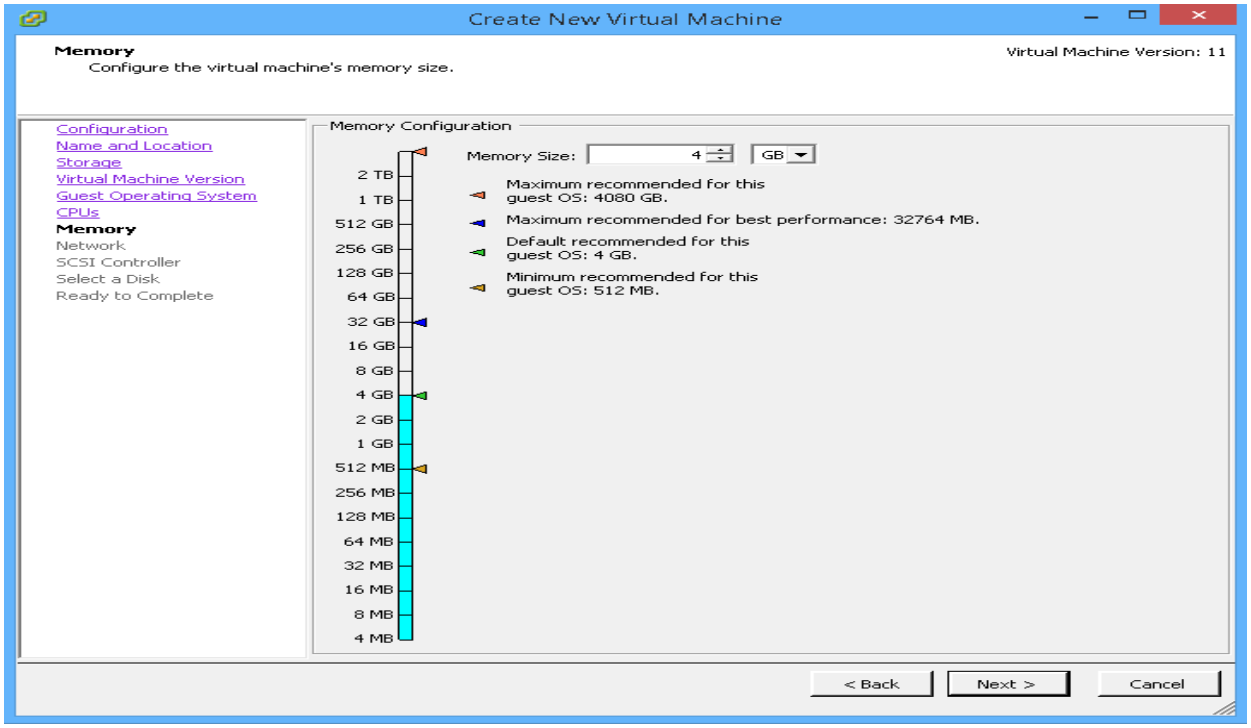
7. Select the required number of CPUs and click Next.

Figure 31. Virtual Machine CPUs



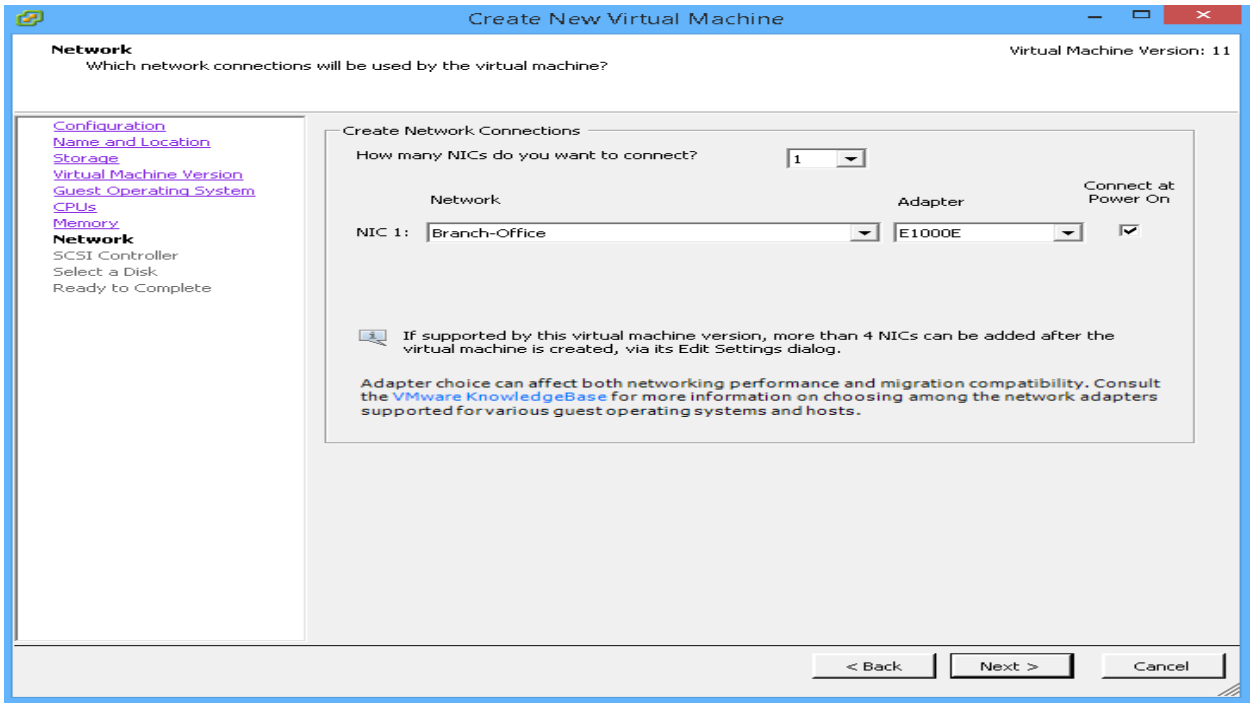
8. Select the appropriate amount of RAM and click Next.

Figure 32. Virtual Machine Memory



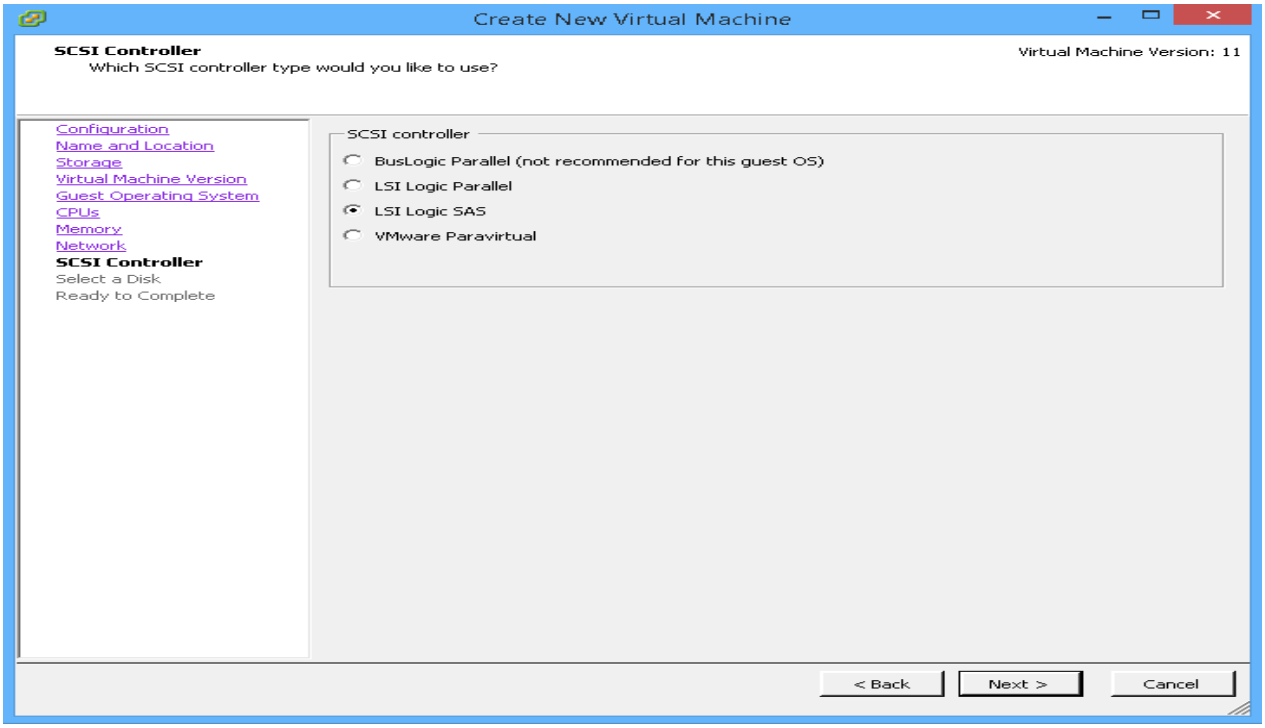
9. Select an appropriate port-group and click Next.

Figure 33. Virtual Machine Network



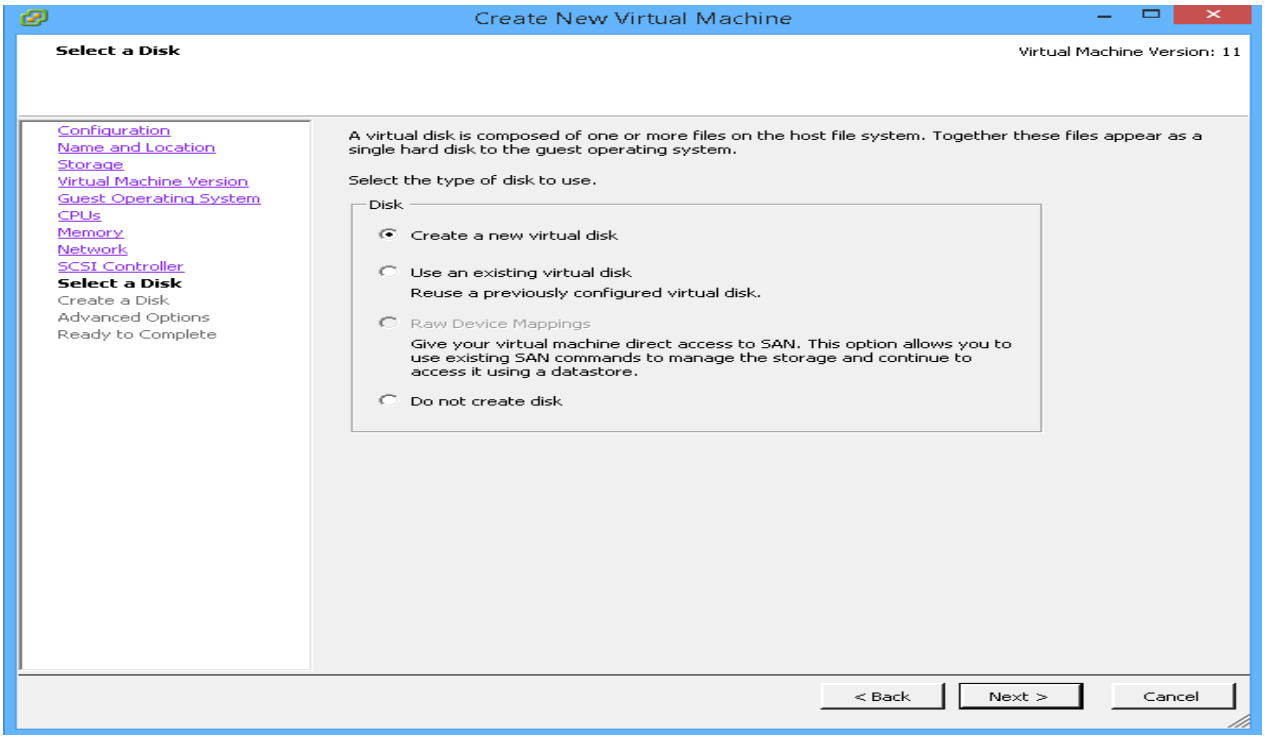
10. Leave the default for the SCSI controller and click Next.

Figure 34. Virtual Machine Disk Controller



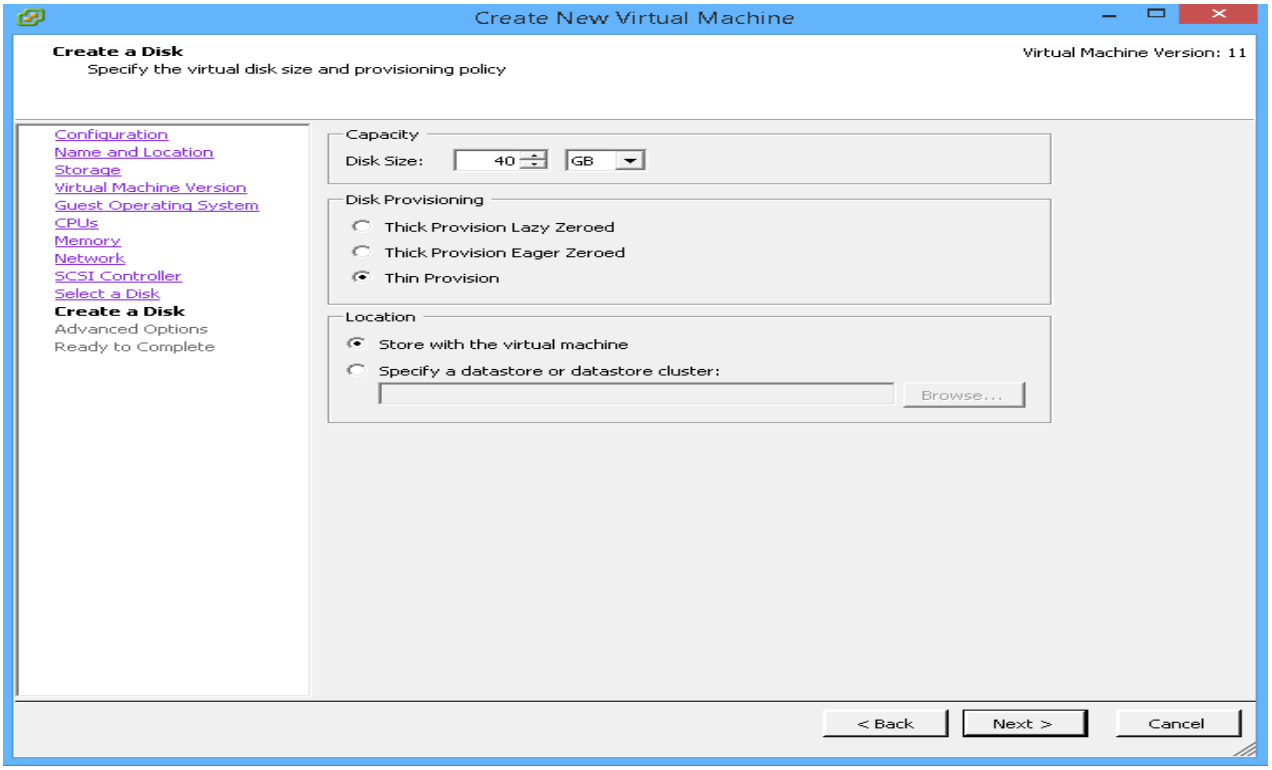
11. Select create a new virtual disk and click Next.

Figure 35. Virtual Machine Disk Selection



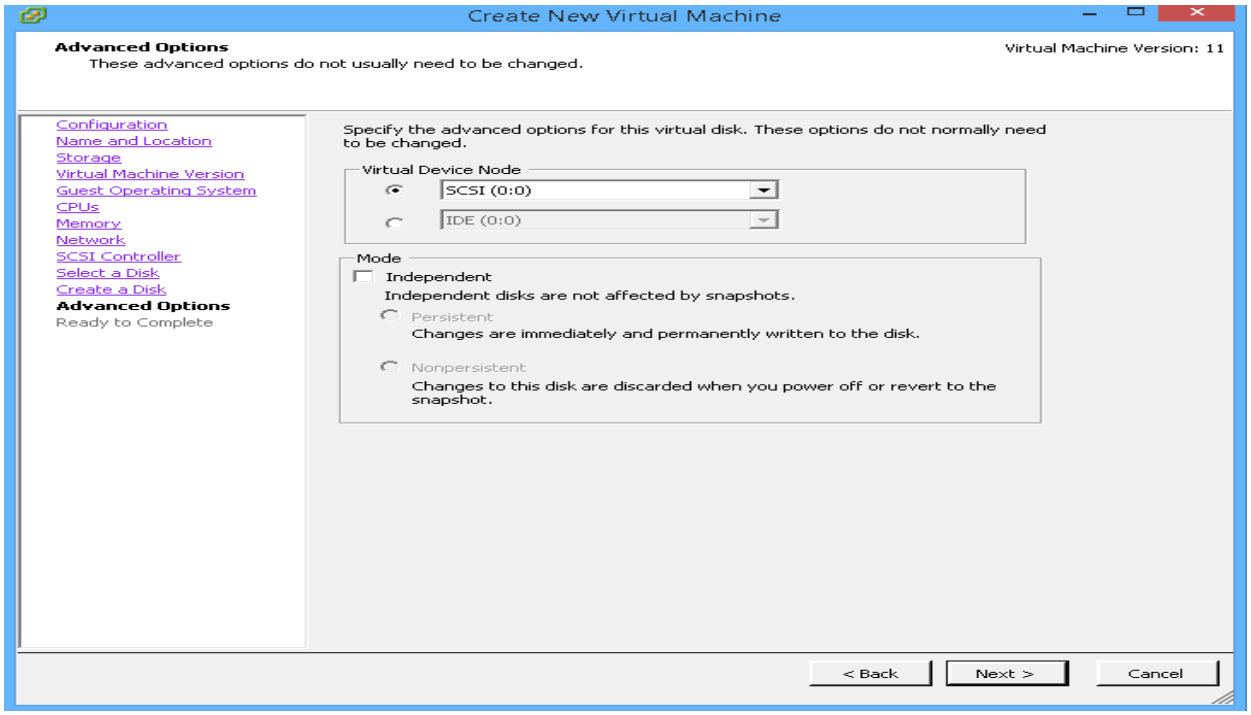
12. Select Thin Provision and click Next.

Figure 36. Virtual Machine Disk Size and Type



13. Leave the default selected and click Next.

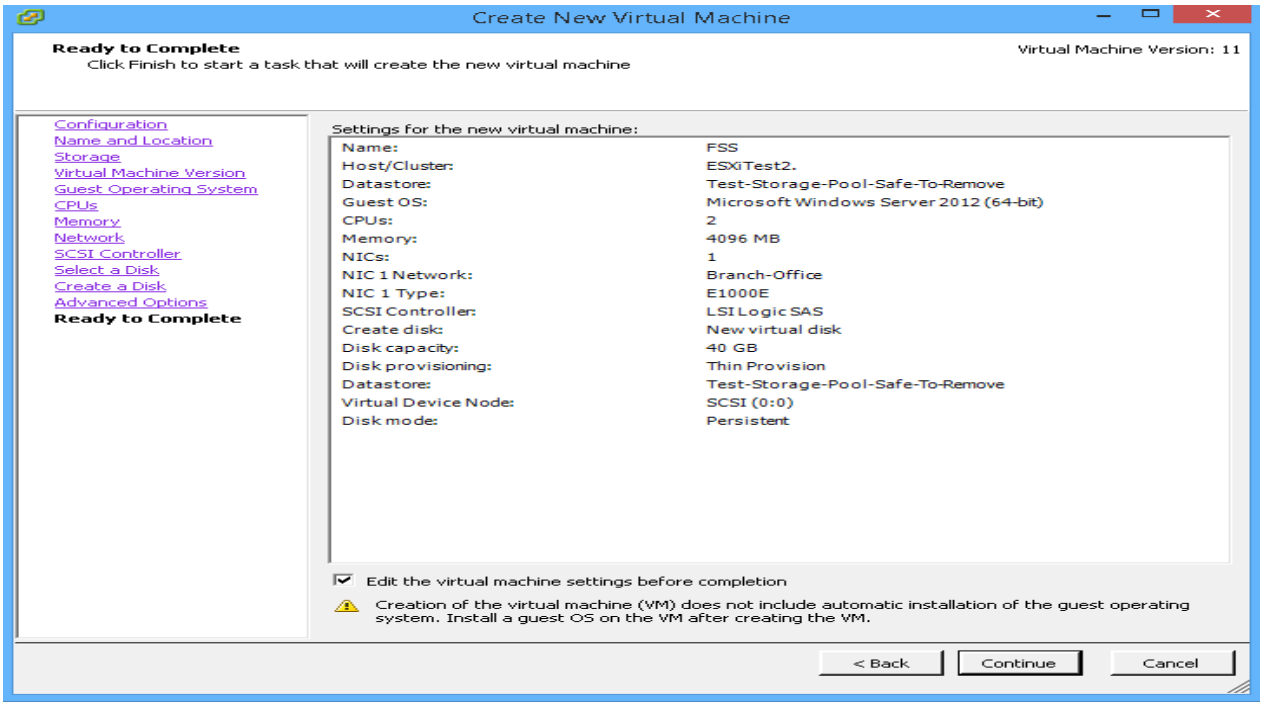
Figure 37. Virtual Machine Disk Advanced Options



14. On the final page, select edit virtual machine settings before completion and click Finish.

Now move to the next section, which is operating system installation.

Figure 38. Virtual Machine Read to Complete



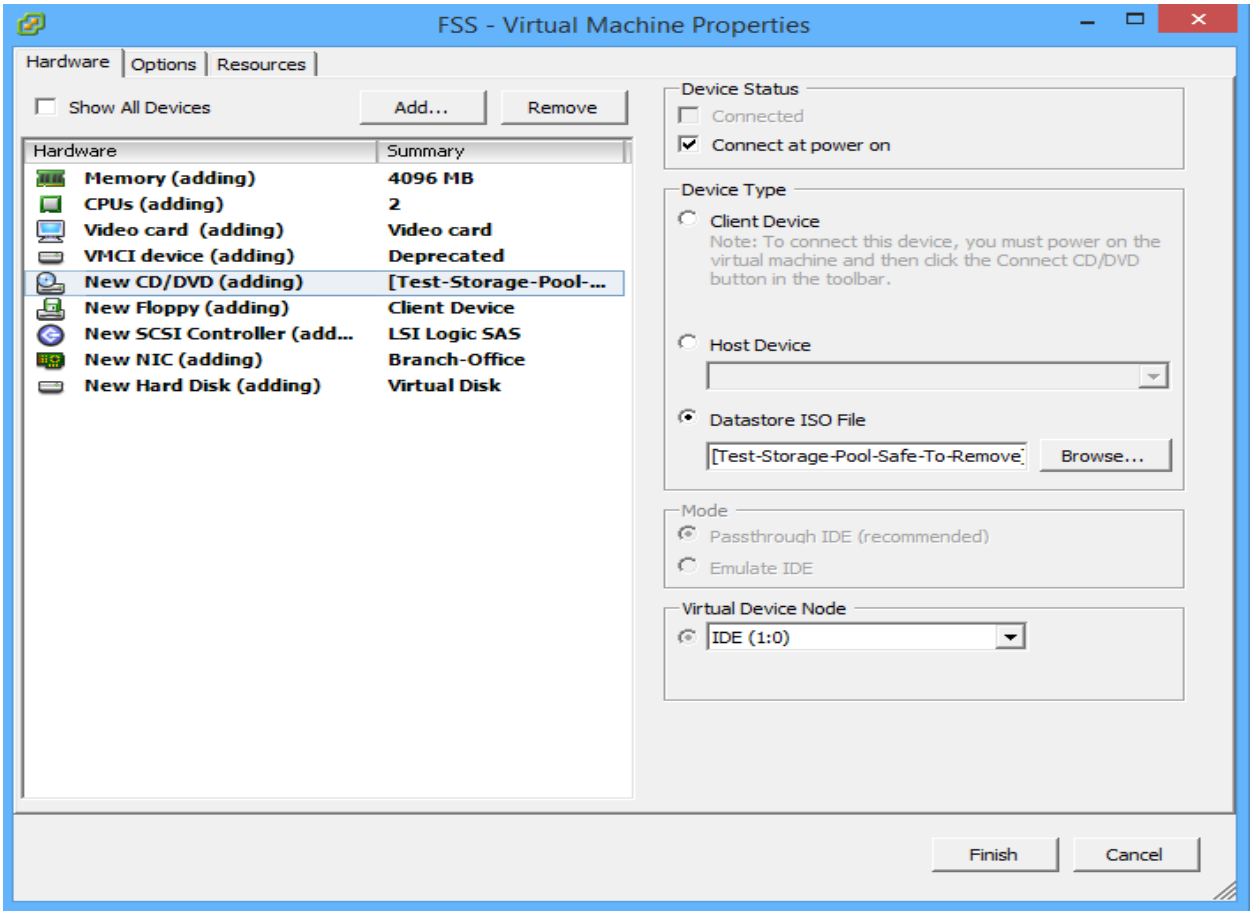
Server and Client Installation

Taking into consideration Windows Server 2012 R2 and Windows 10 installation involves similar steps, this section only goes through the installation of Windows Server 2012 R2.

1. Picking up from previous section, click CD\DVD drive, select Datastore ISO File, browse to the location of Windows Server 2012 R2 ISO file, click OK two times and then click Finish.

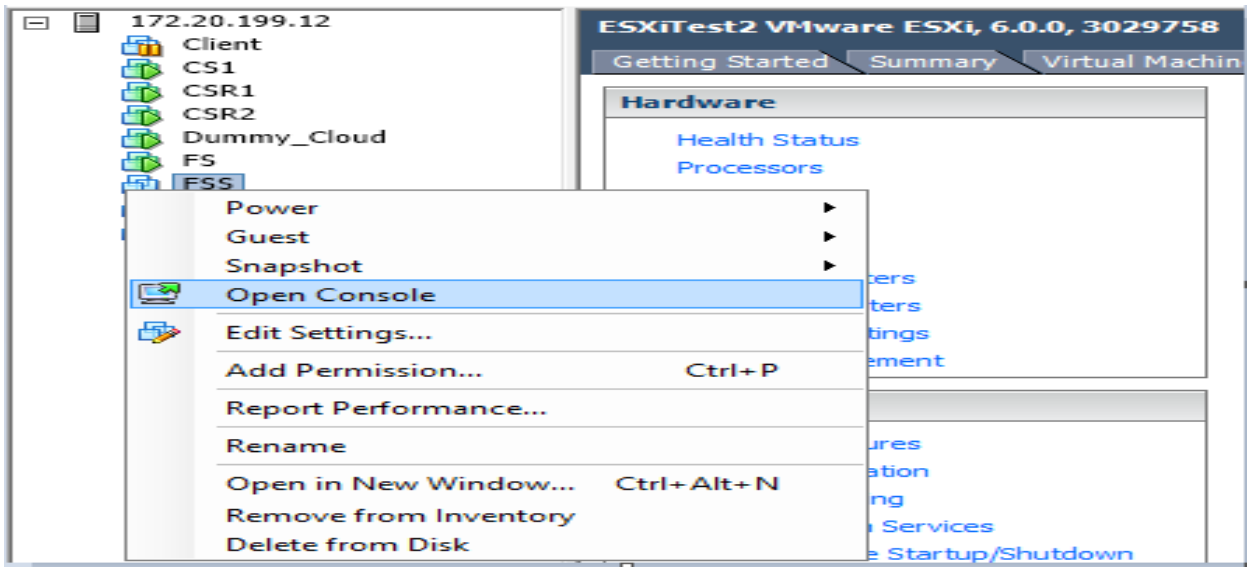
   Note: You should have already uploaded the Windows Server 2012 R2 ISO file to ESXi host datastore.

Figure 39. Virtual Machine Properties



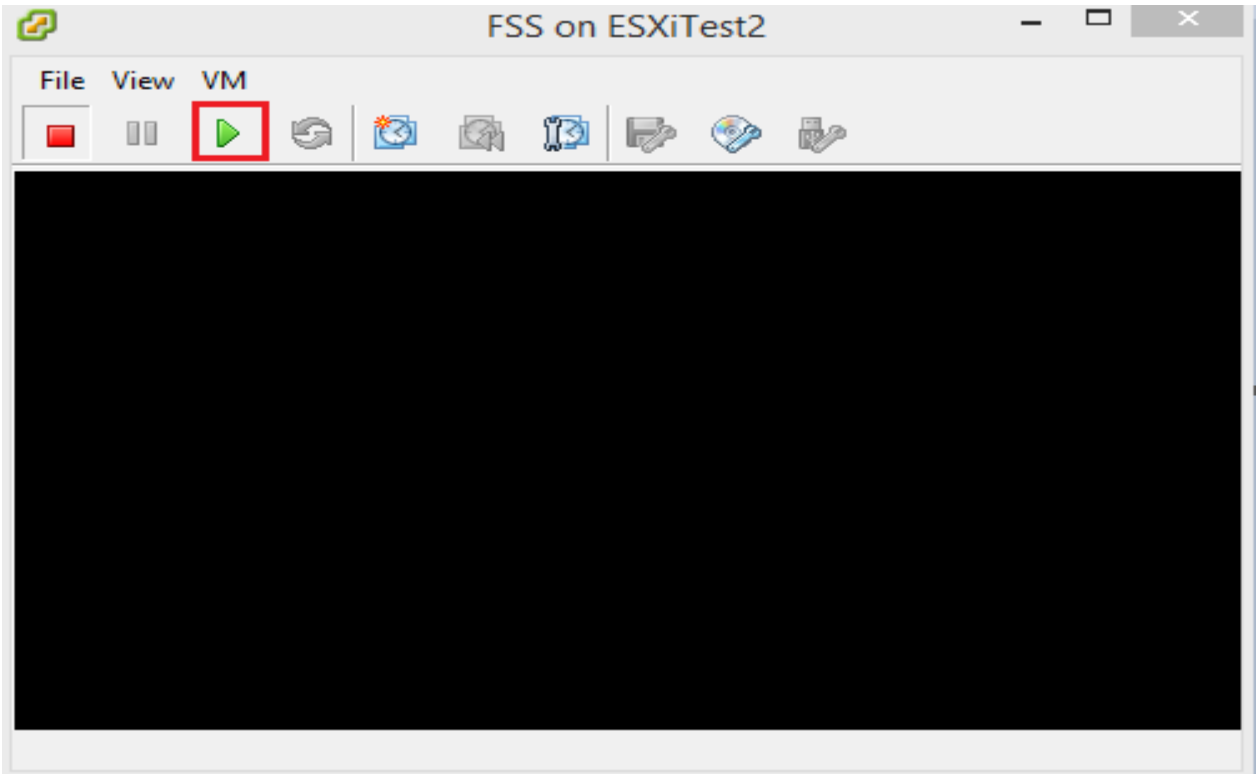
2. Right click the virtual machine and click Open Console.

Figure 40. Virtual Machine Menu Options



3. Click the Power On button.

Figure 41. Virtual Machine Console

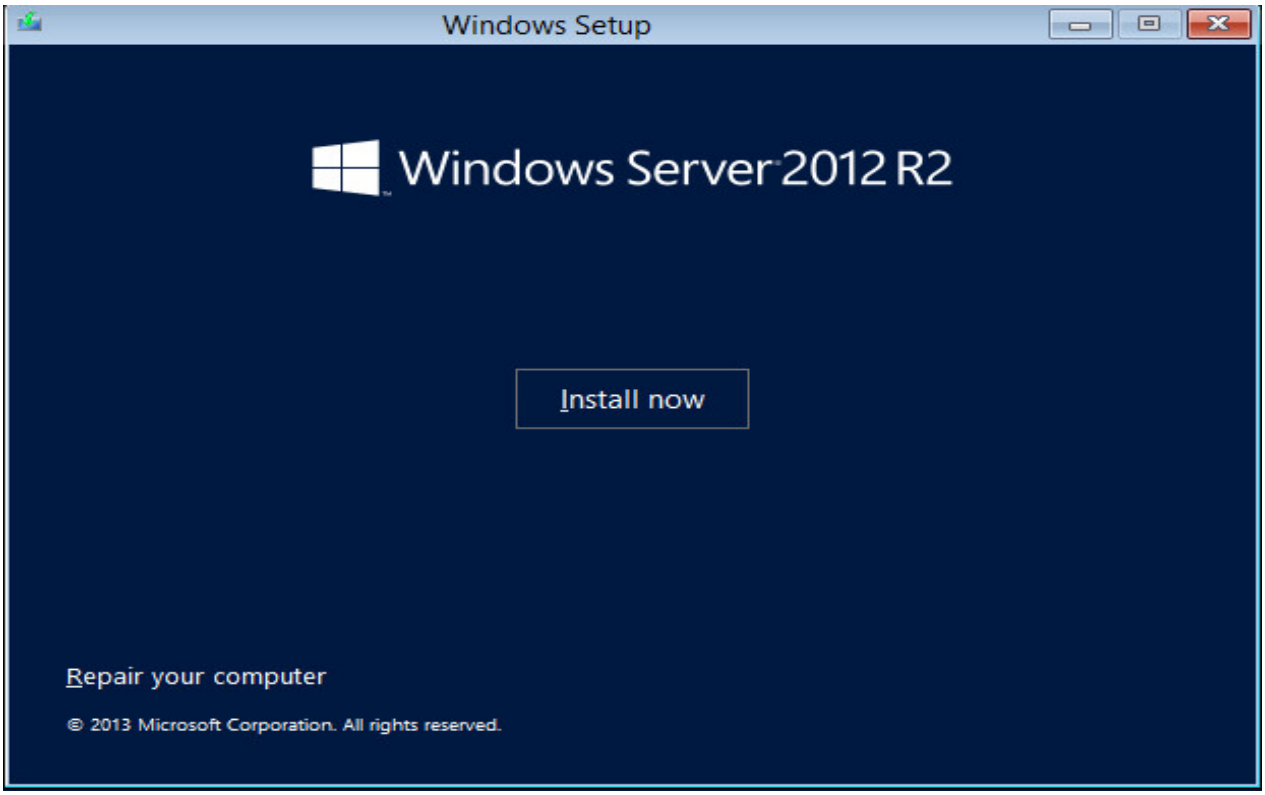


4. Let the Windows boot up and then click Next on Windows Set Up page.

Figure 42. Windows Server 2012 R2 Setup Page

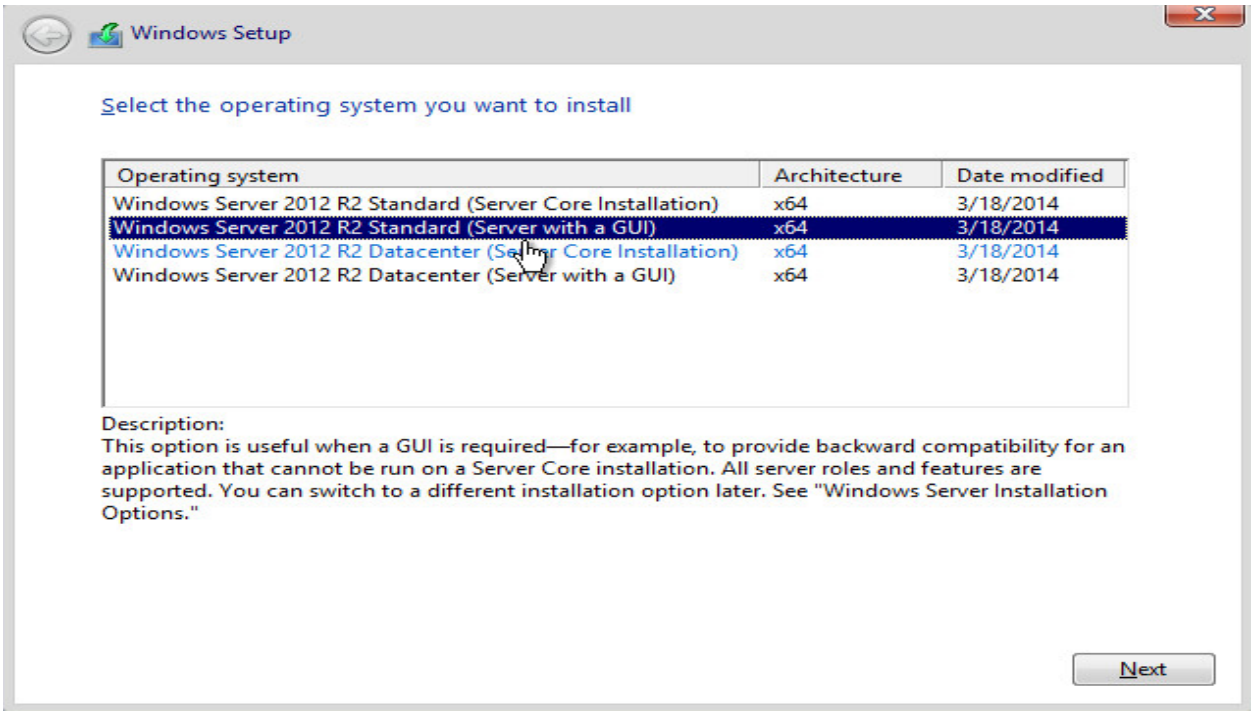
5. On the next screen click Install now.

Figure 43. Windows Server 2012 R2 Installation



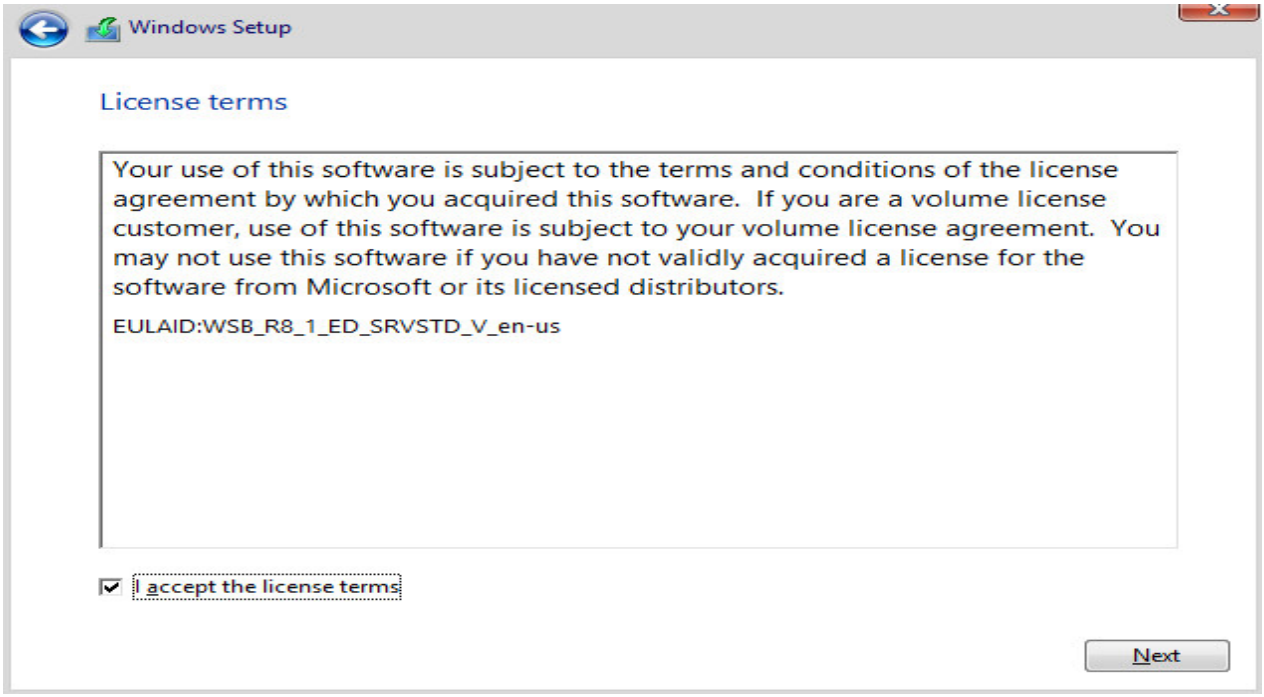
6. Select an appropriate edition of Windows and click Next.

Figure 44. Windows Server 2012 R2 Edition Selection



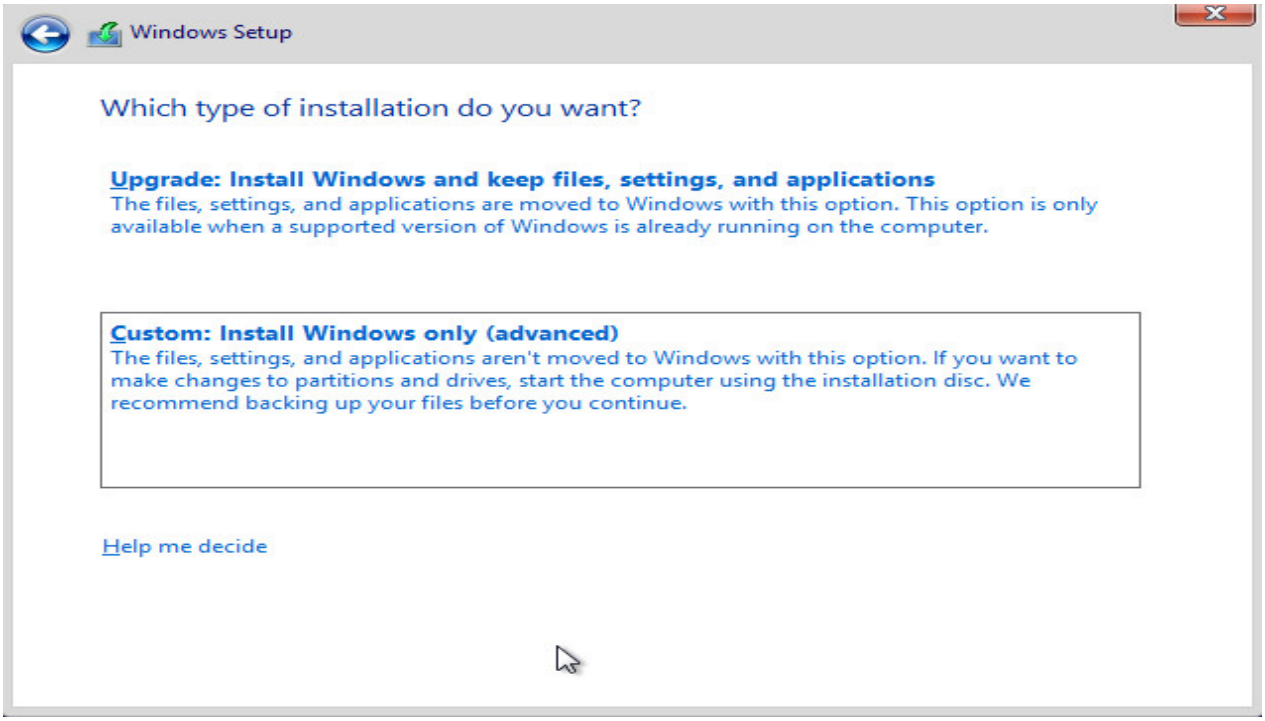
7. Accept the license terms and click Next.

Figure 45. Windows Server 2012 R2 License Terms



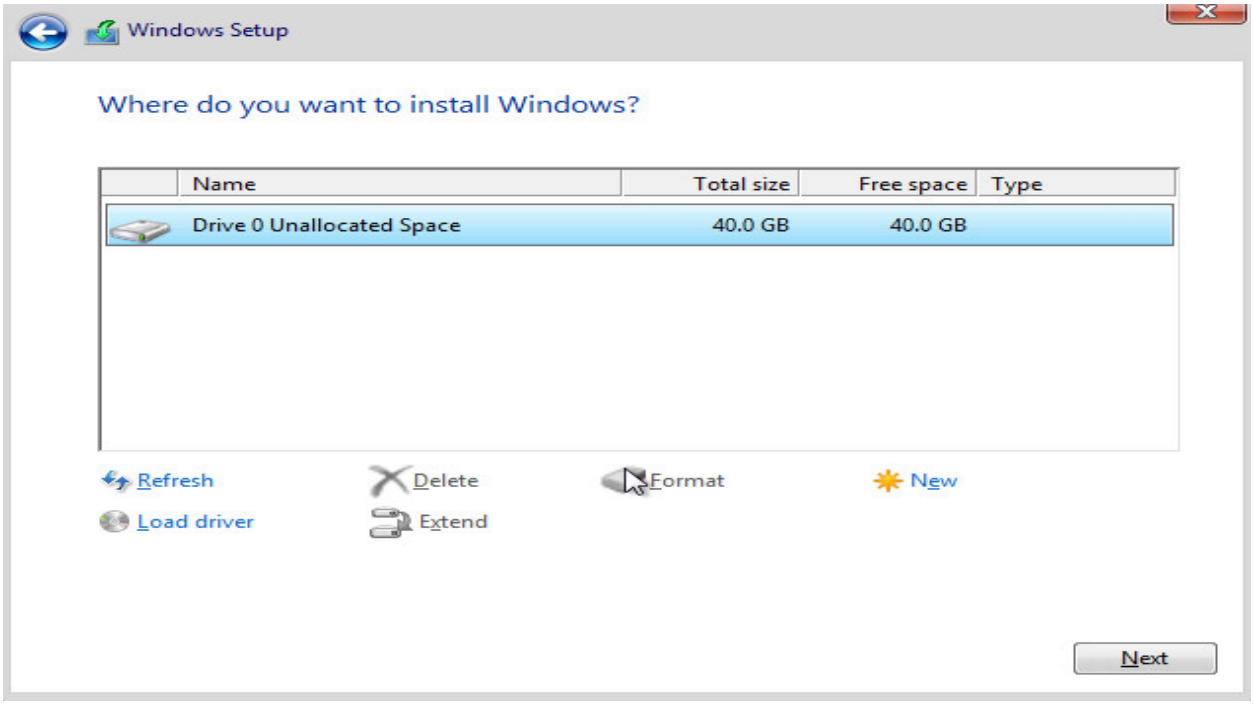
8. Select Custom: Install Windows only (advanced).

Figure 46. Windows Server 2012 R2 Upgrade/Custom Installation



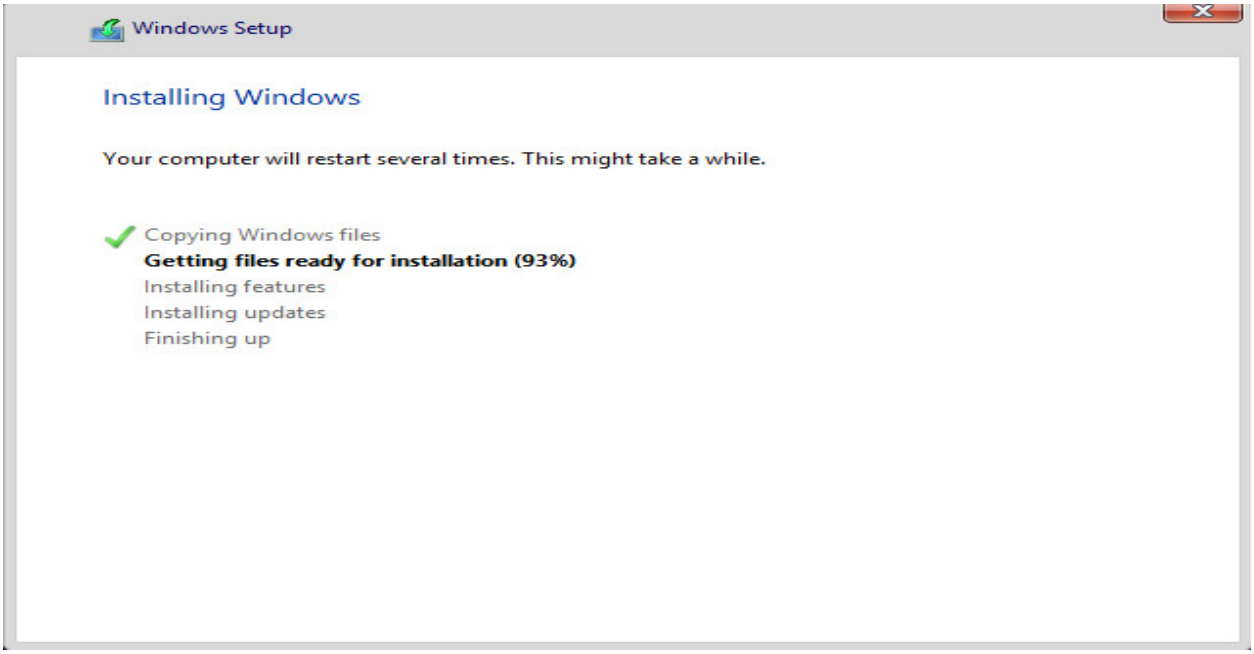
9. Select an appropriate drive to install Windows and click Next.

Figure 47. Windows Server 2012 R2 Datastore



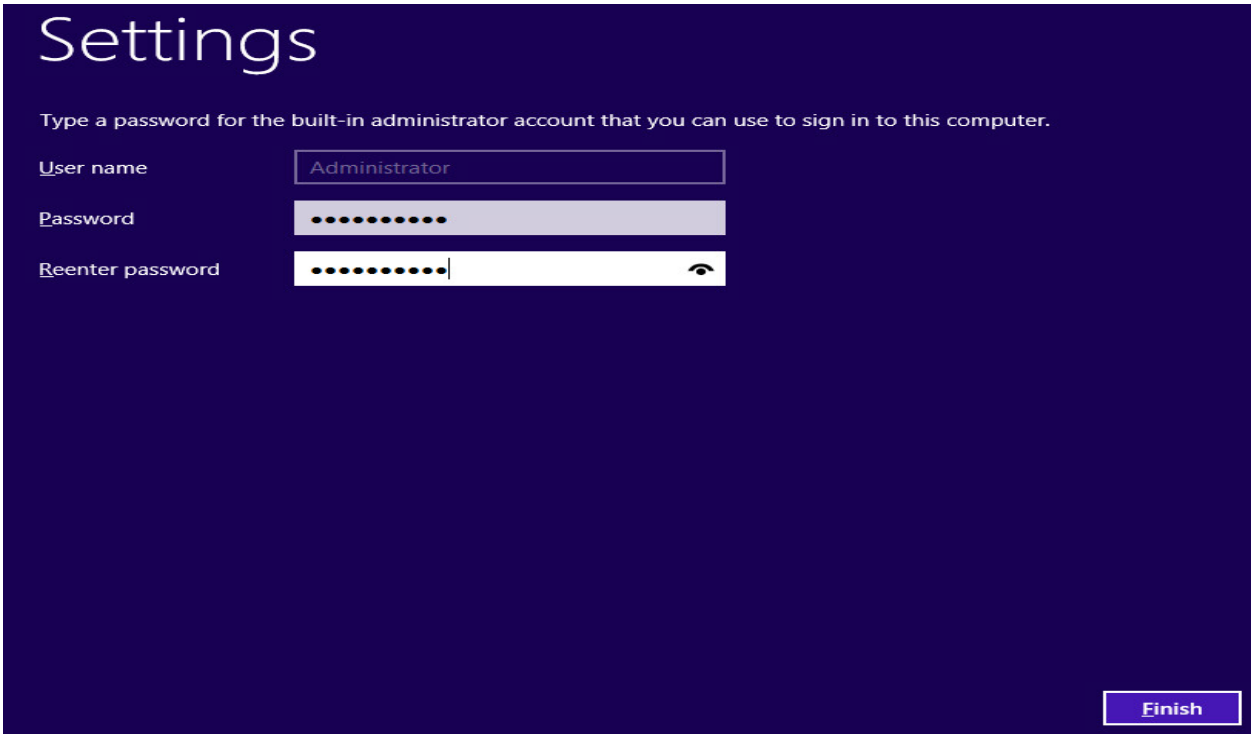
10. Wait for the installation to finish.

Figure 48. Windows Server 2012 R2 Installation Progress



11. On the final page, enter a password and click Finish.

Figure 49. Windows Server 2012 R2 Settings



Network Share Set up

In order to test the implementation, a network share was set up on the Server with the following share and NTFS permission.

Figure 50. Windows File Share/Share Permission

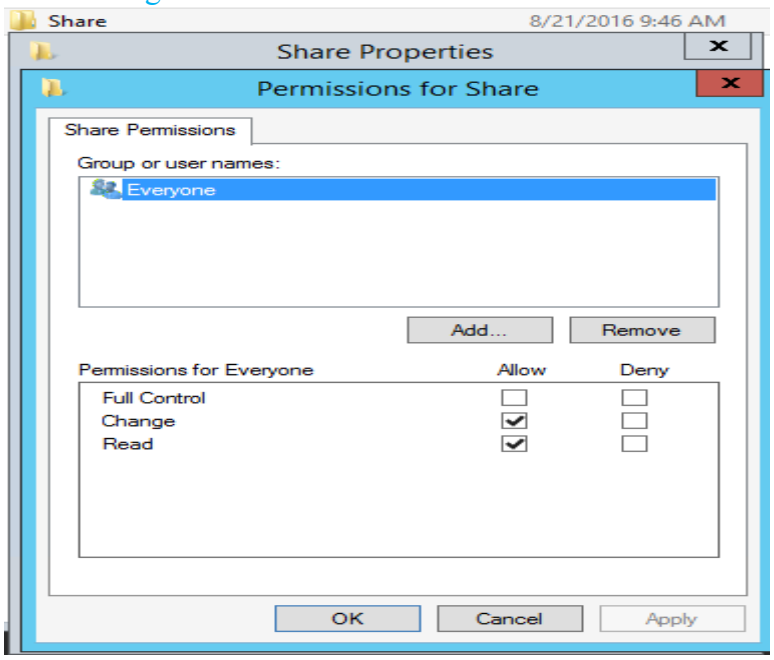
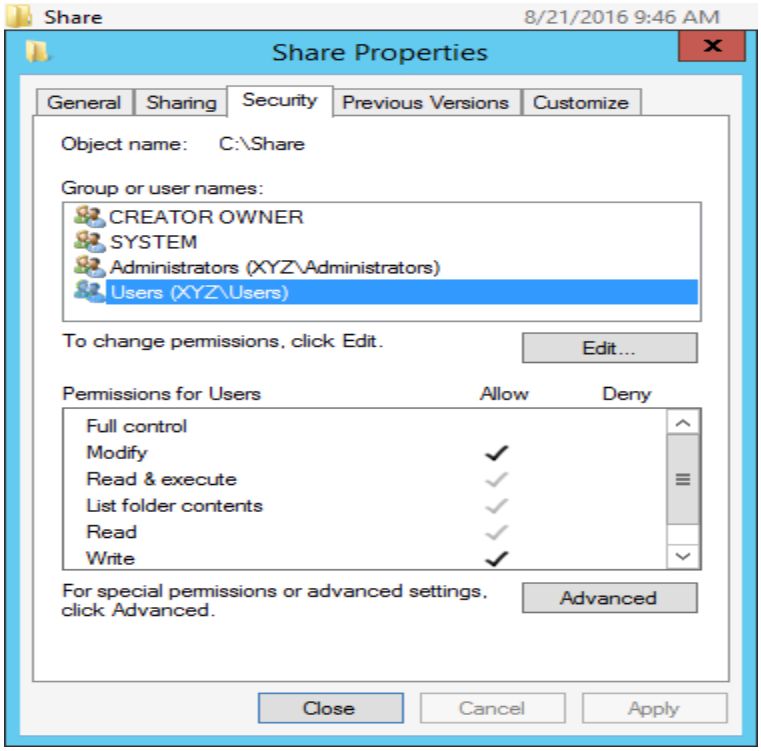


Figure 51. Windows File Share NTFS Permission

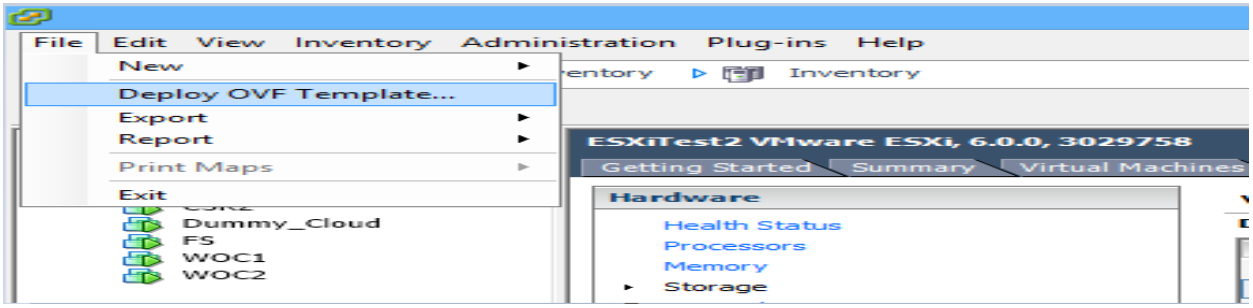


Cisco CSR1000v Cloud Services Router Implementation

Two Cisco CSR1000v Cloud Services Routers appliances are implemented in this project and they will be connected to the Dummy Cloud WAN Emulator from one side and to the Riverbed Virtual Steelhead appliances on the other side. Below is the step by step procedure to implement a Cisco CSR1000v appliance. Configurations for each one of the appliances are provided in the appendices section.

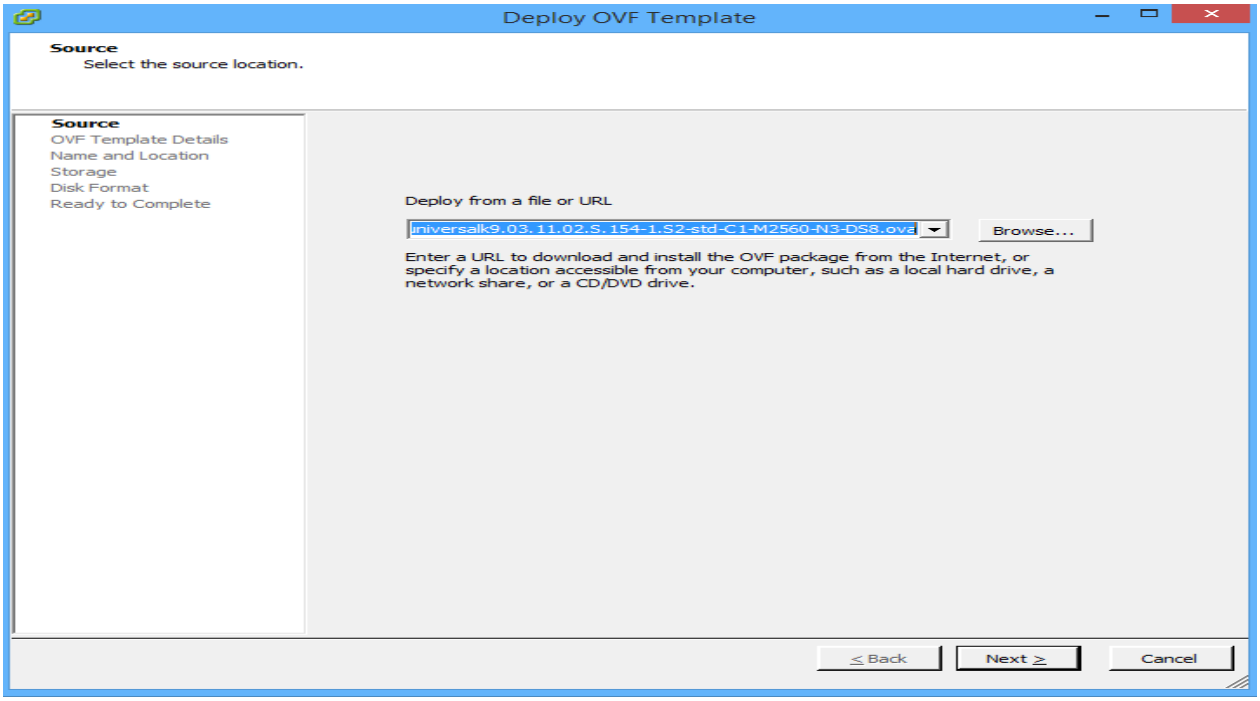
1. From file menu in the vSphere Client, click Deploy OVF Template.

Figure 52. Deploying an OVF Template



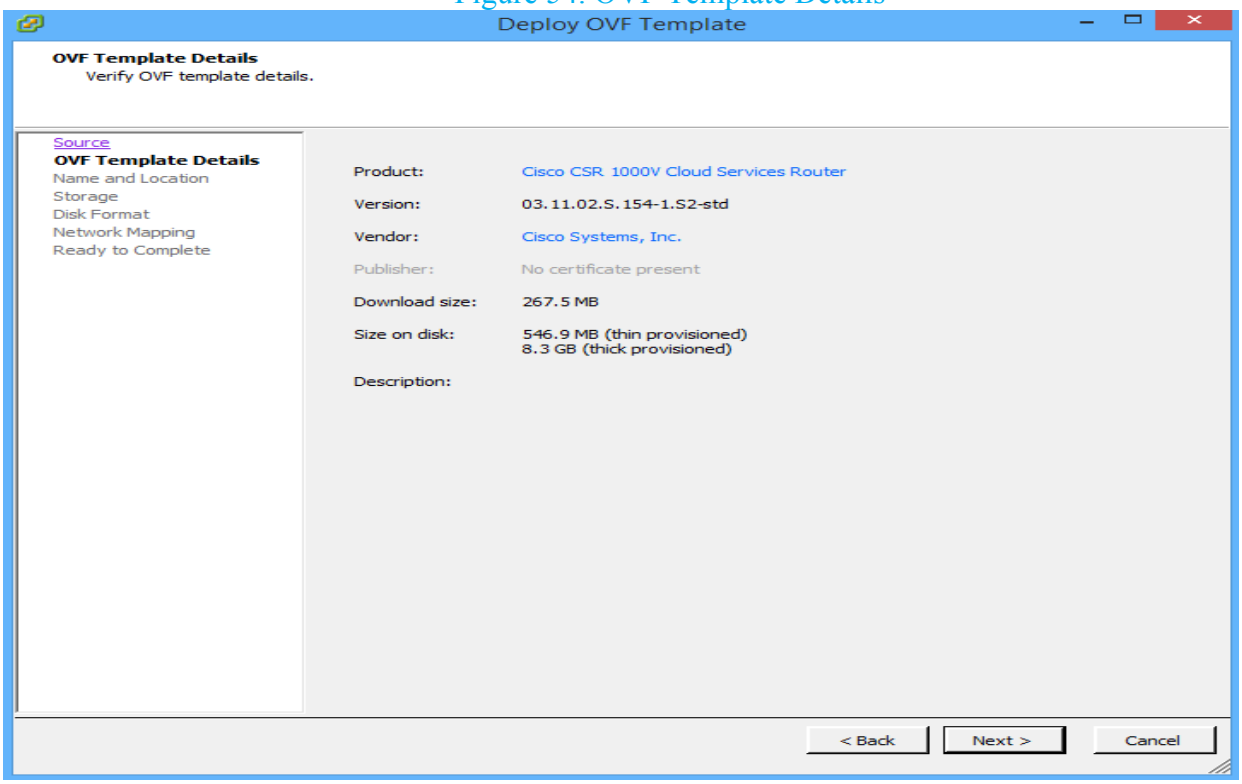
2. Browse to the location of Cisco virtual router OVA file and click Next.

Figure 53. OVF Template Source



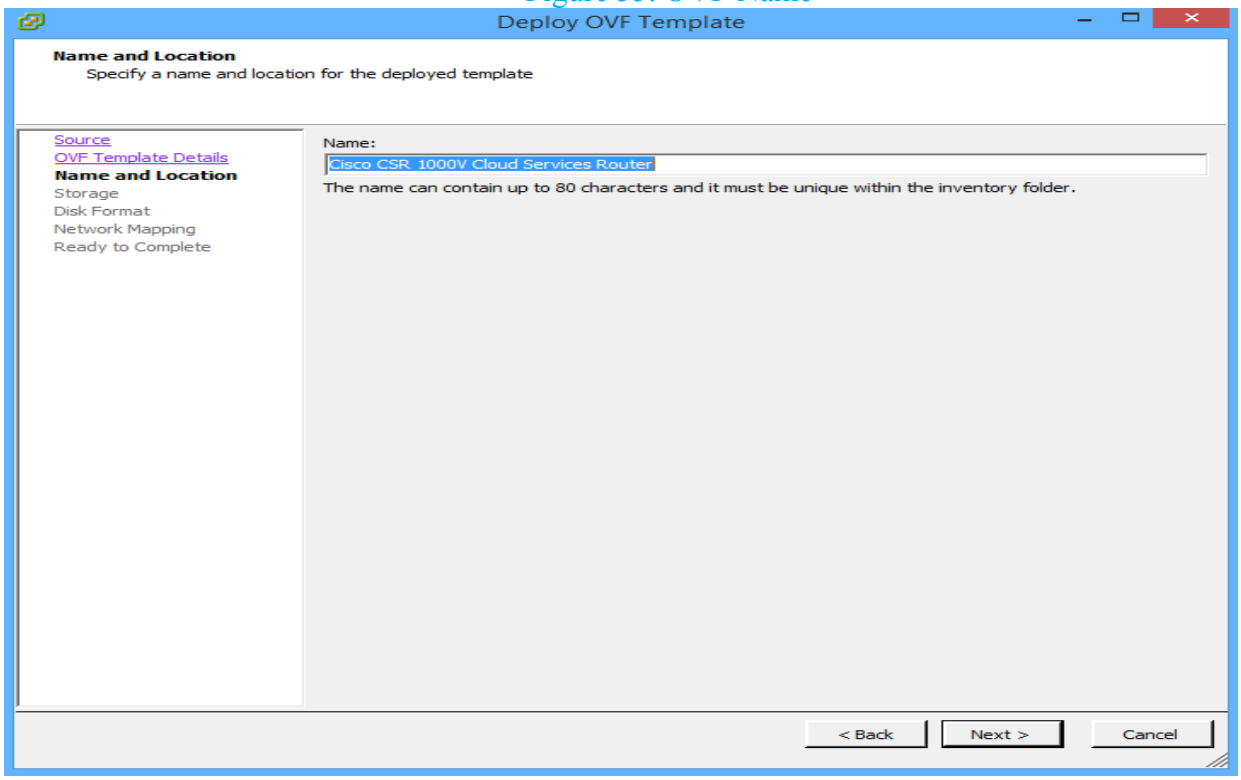
3. On the next page, click Next.

Figure 54. OVF Template Details



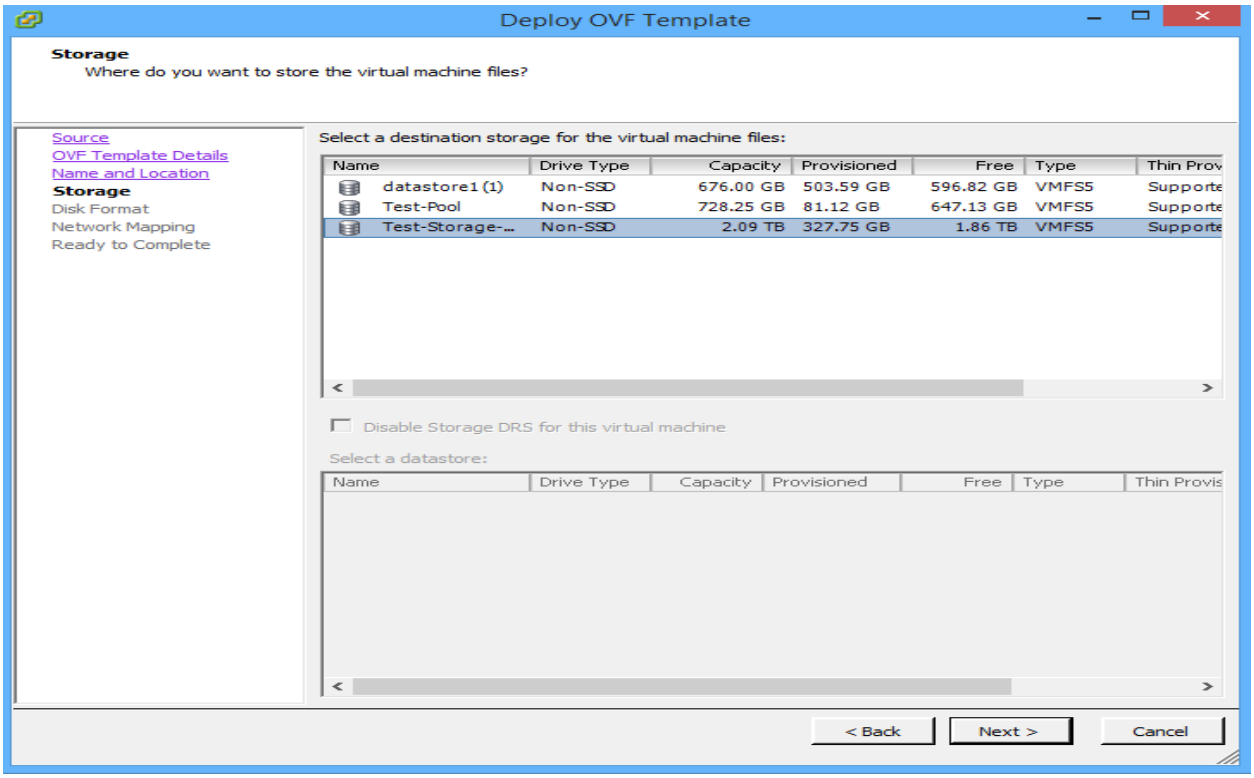
4. Pick up a Name and click Next.

Figure 55. OVF Name



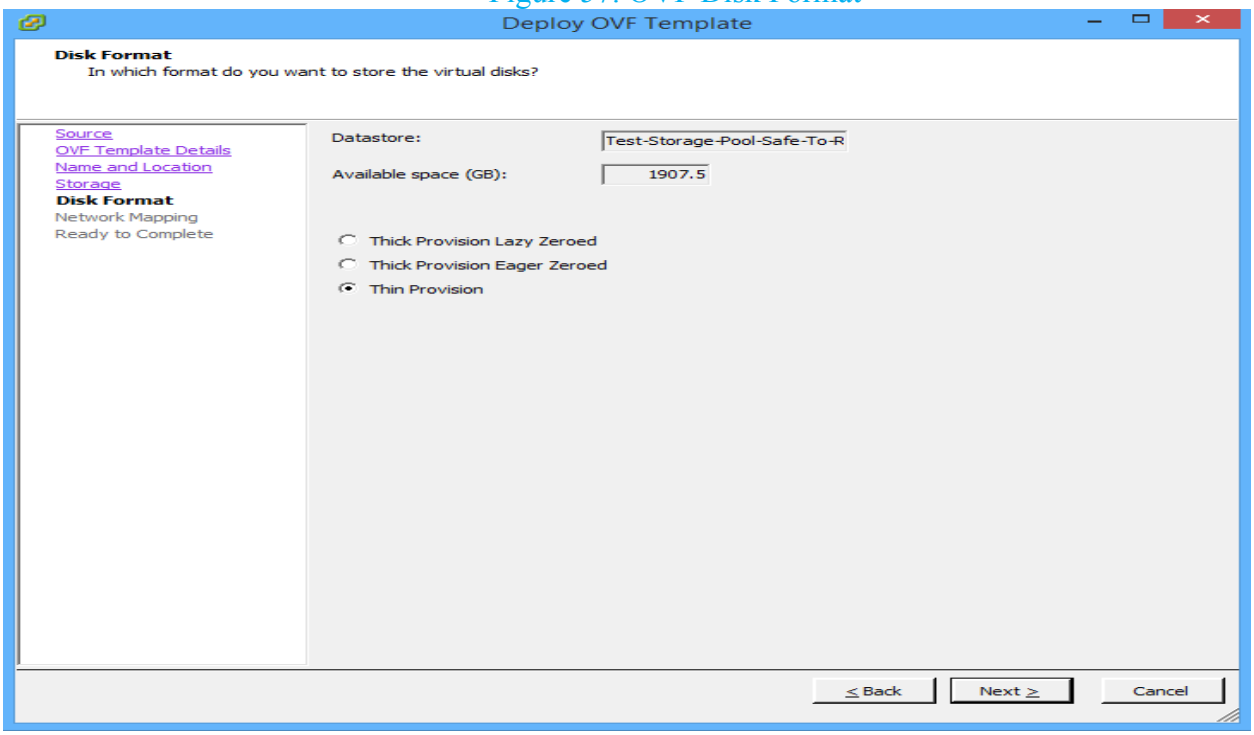
5. Select a data store and click Next.

Figure 56. OVF Datastore



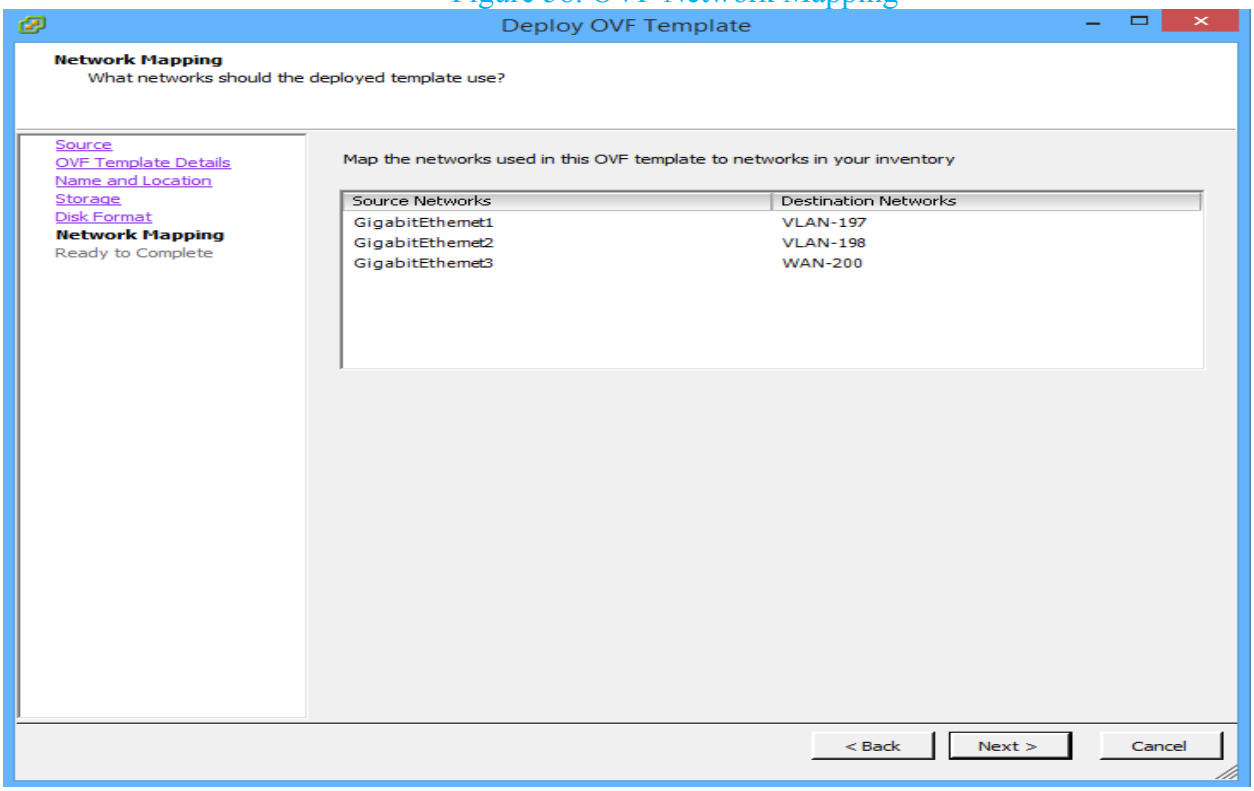
6. Select Thin Provision and click Next. (For production environment. It is recommended to use thick disks)

Figure 57. OVF Disk Format



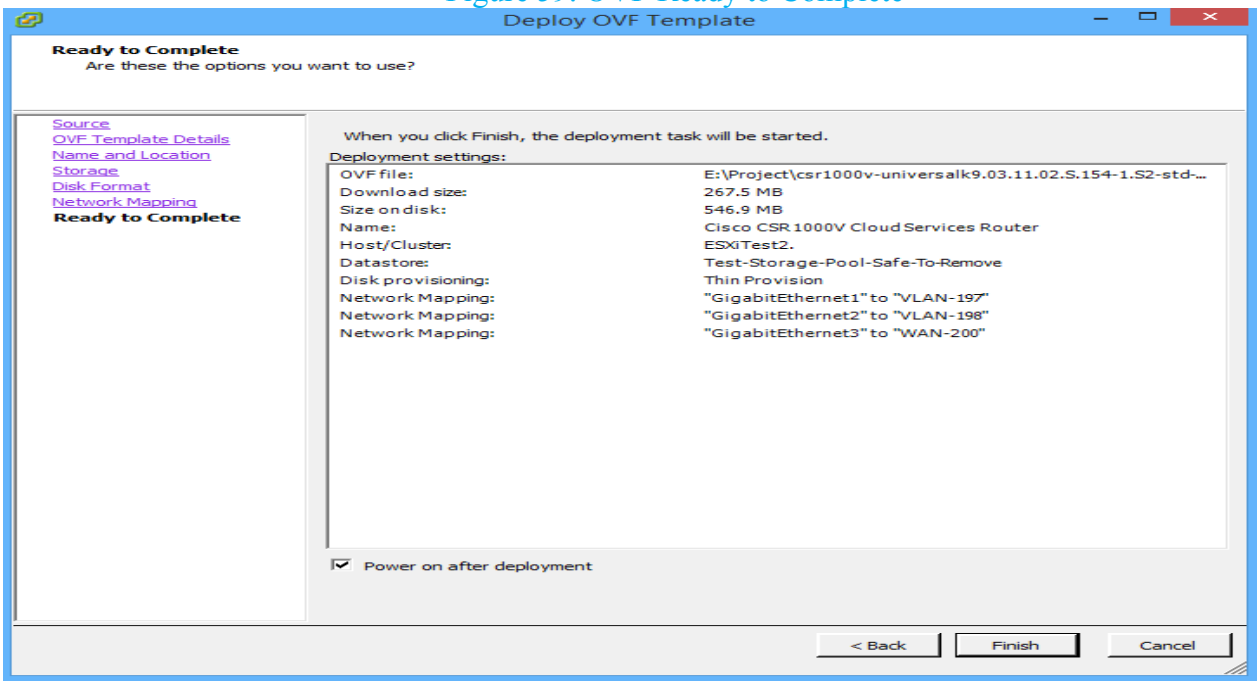
7. Select an appropriate VLAN for each interface and click Next.

Figure 58. OVF Network Mapping



8. Select Power on after deployment and click Finish.

Figure 59. OVF Ready to Complete

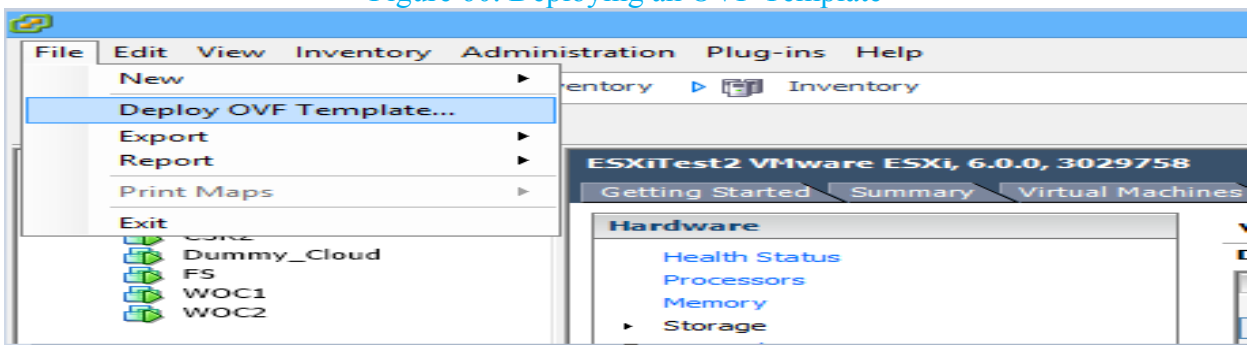


Riverbed Virtual Steelhead CX 755V Implementation

Two Riverbed Virtual Steelhead appliances are implemented in this project and they will be connected to two Cisco CSR1000V cloud services routers and LAN switches on each side of the WAN connection. Below is the step by step procedure to implement a Riverbed Virtual Steelhead appliance. Initial configurations for each one of the appliances are provided in the appendices section.

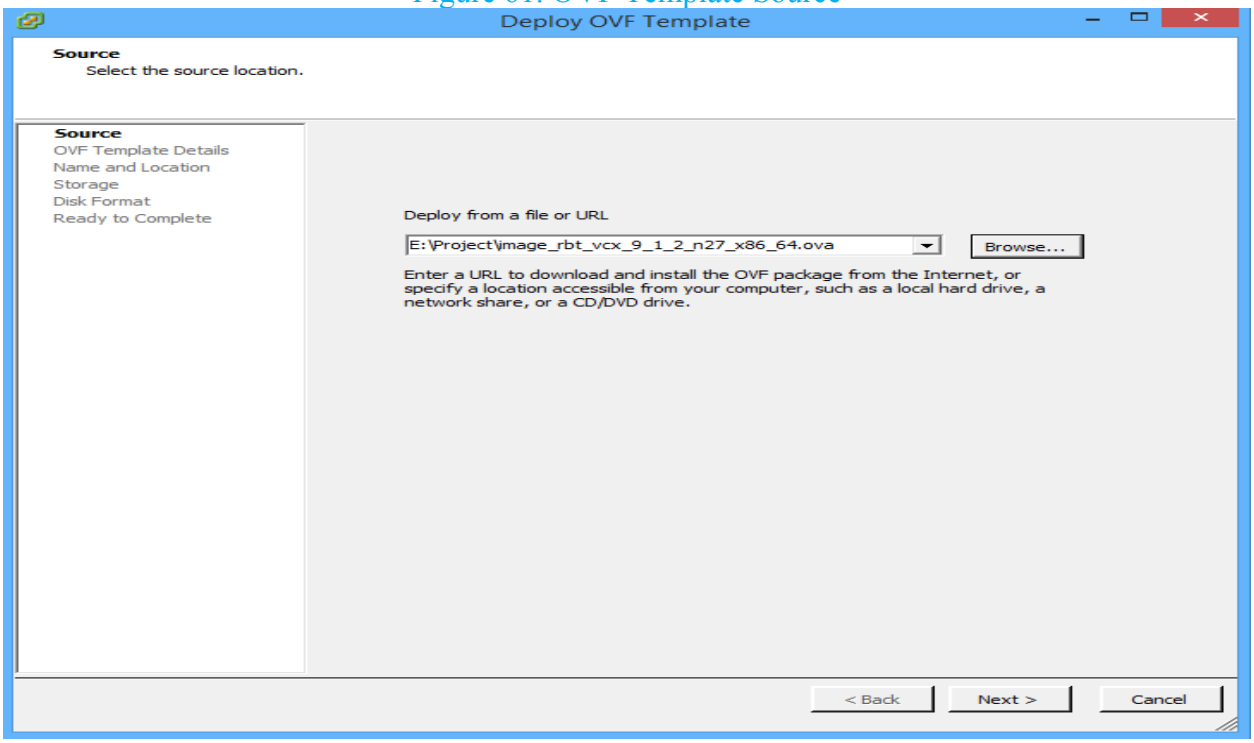
1. From file menu in the vSphere Client, click Deploy OVF Template.

Figure 60. Deploying an OVF Template



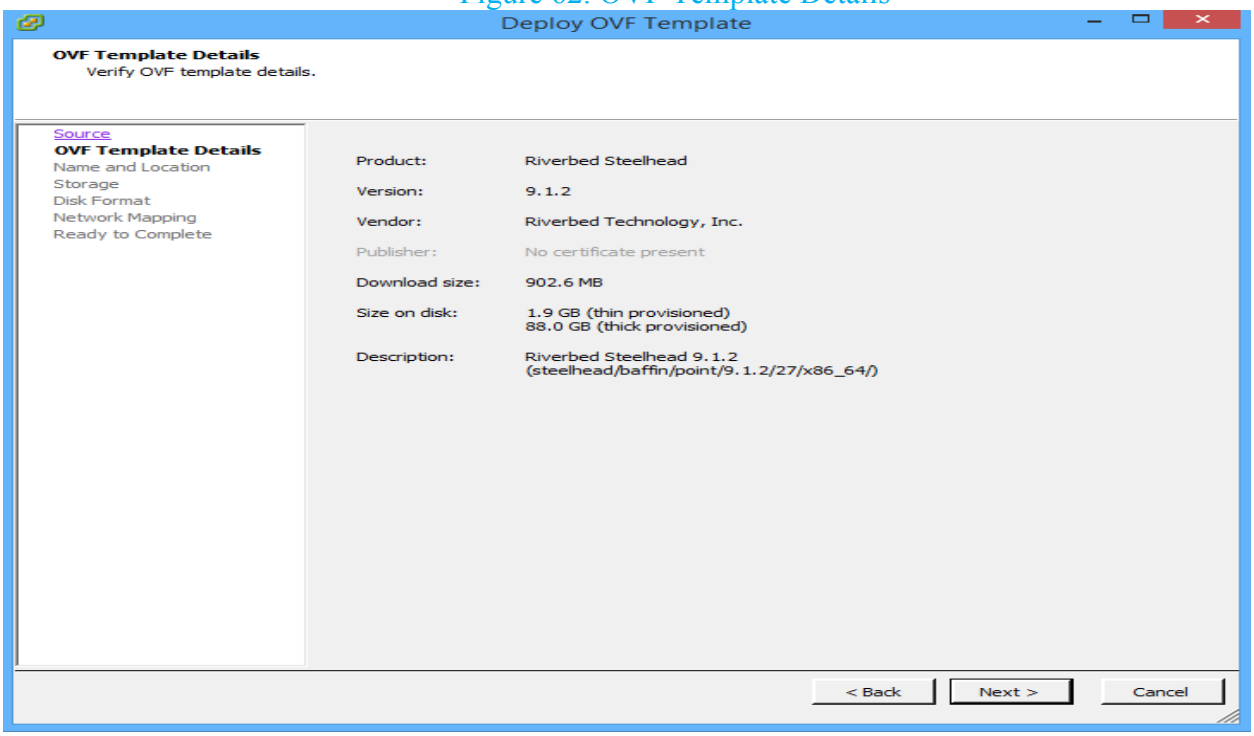
2. Browse to the location of Riverbed Virtual Steelhead CX 755V OVA file and click Next.

Figure 61. OVF Template Source



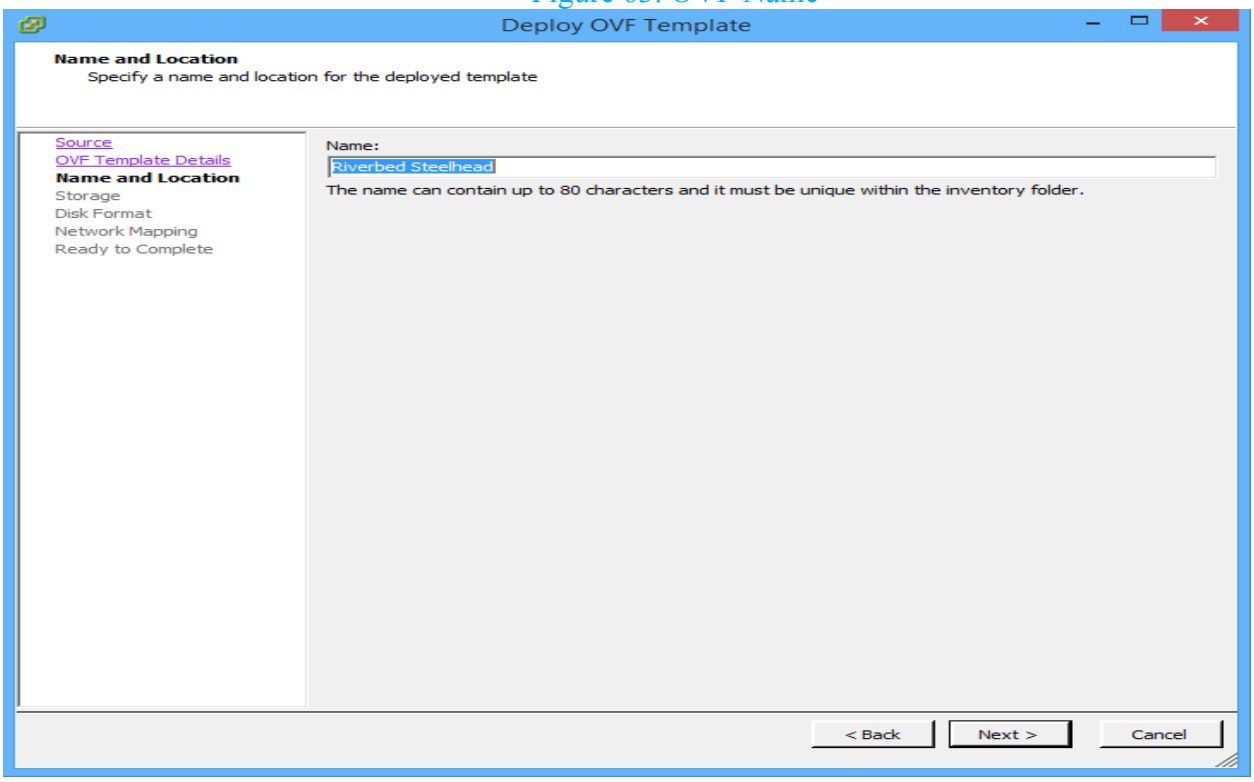
3. On the next page, click Next.

Figure 62. OVF Template Details



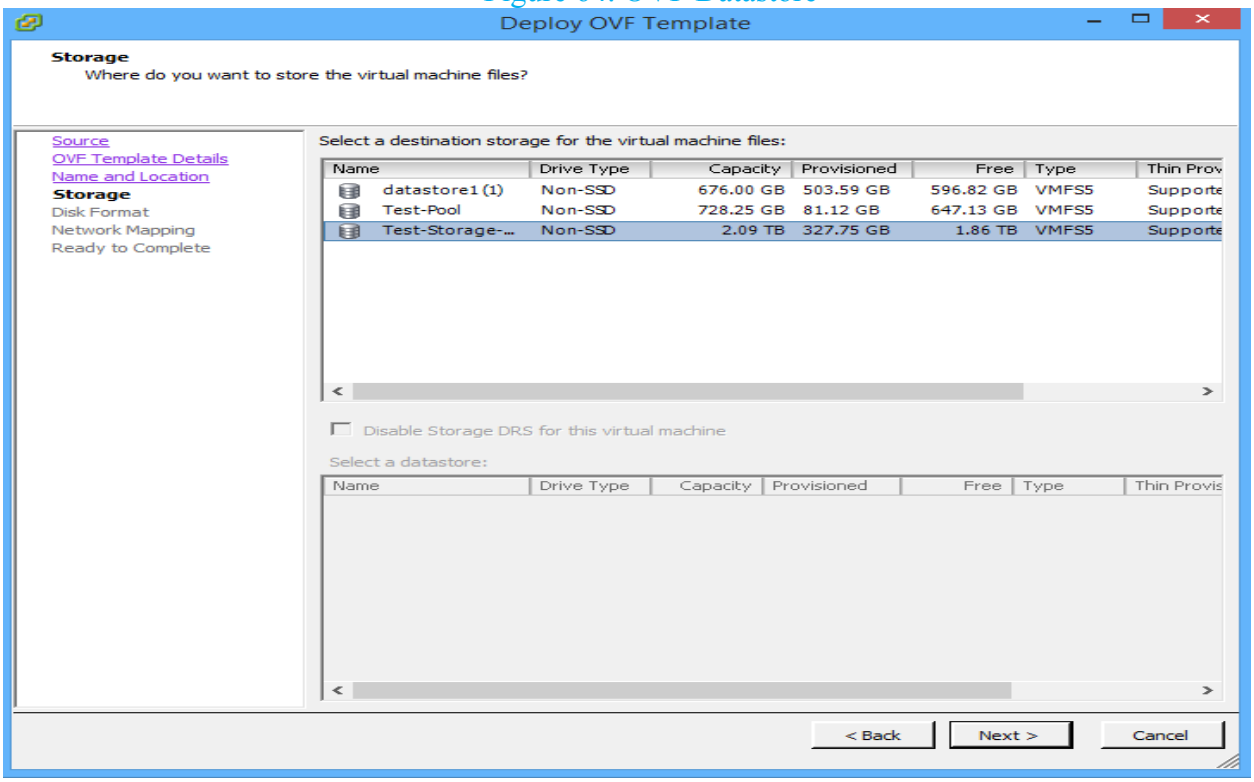
4. Pick up a Name and click Next.

Figure 63. OVF Name



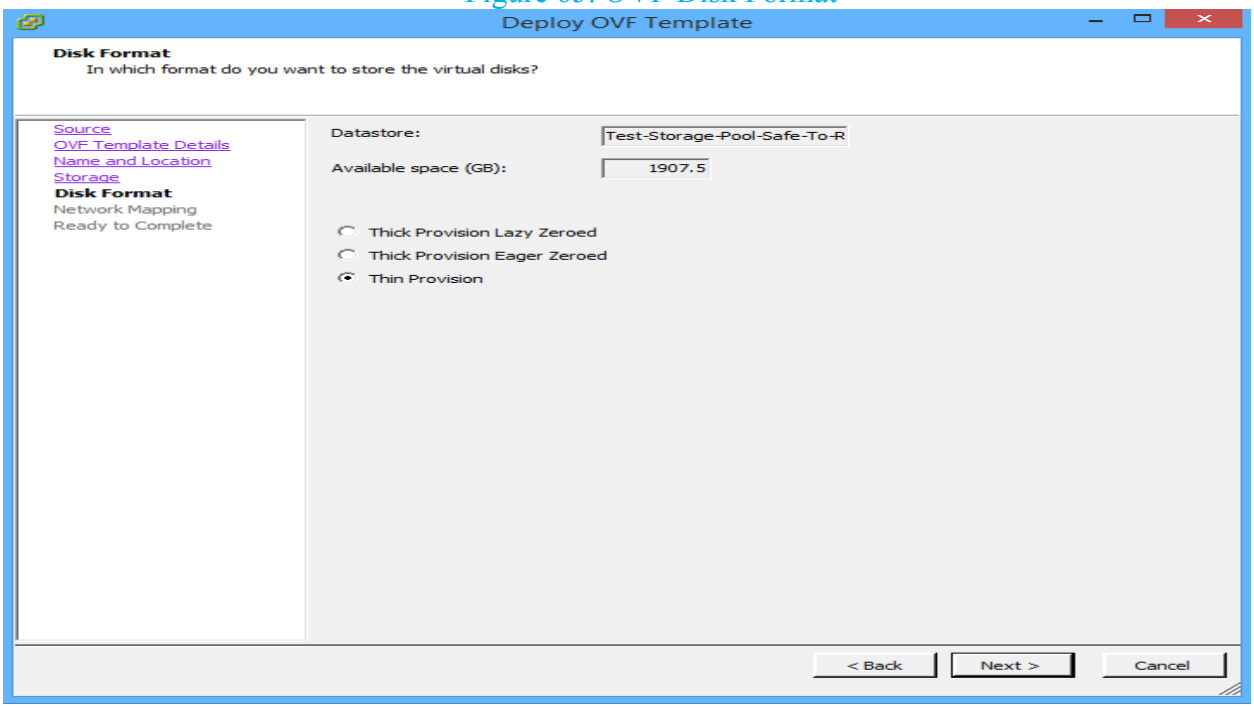
5. Select a data store and click Next.

Figure 64. OVF Datastore



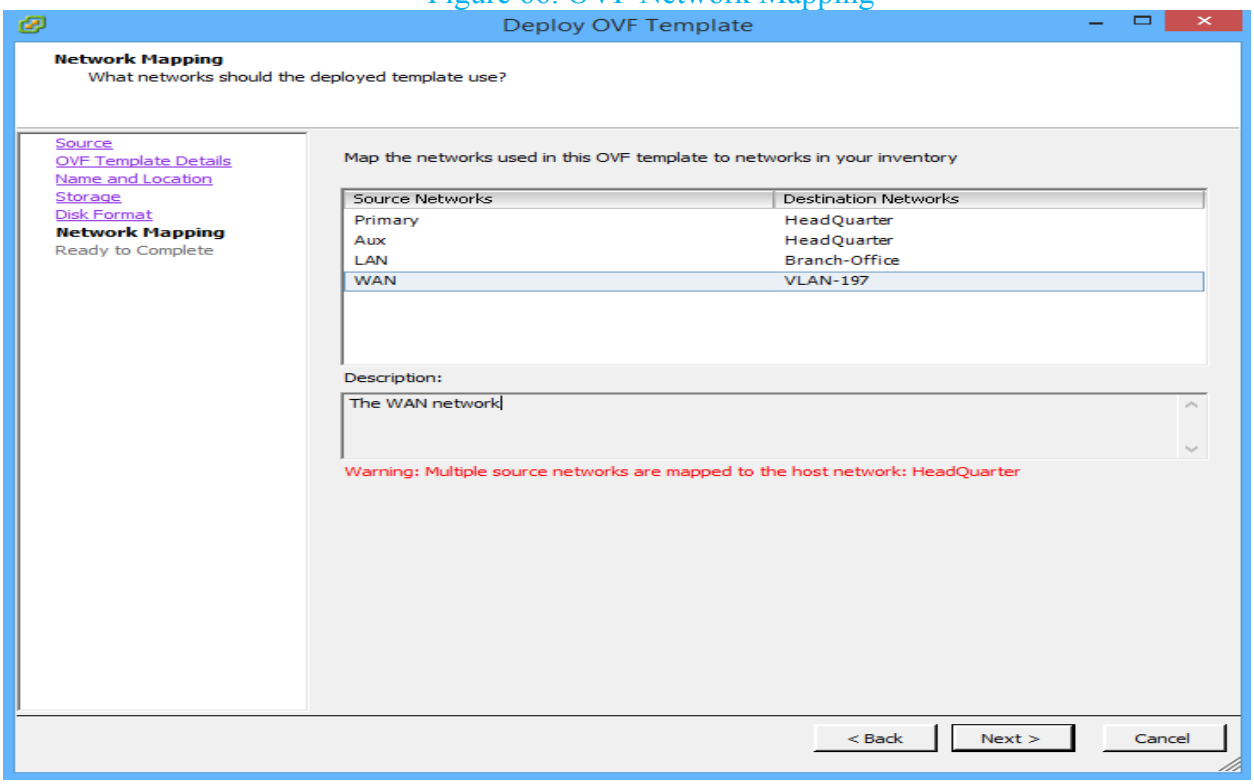
6. Select Thin Provision and click Next. (For production environment. It is recommended to use thick disks)

Figure 65. OVF Disk Format



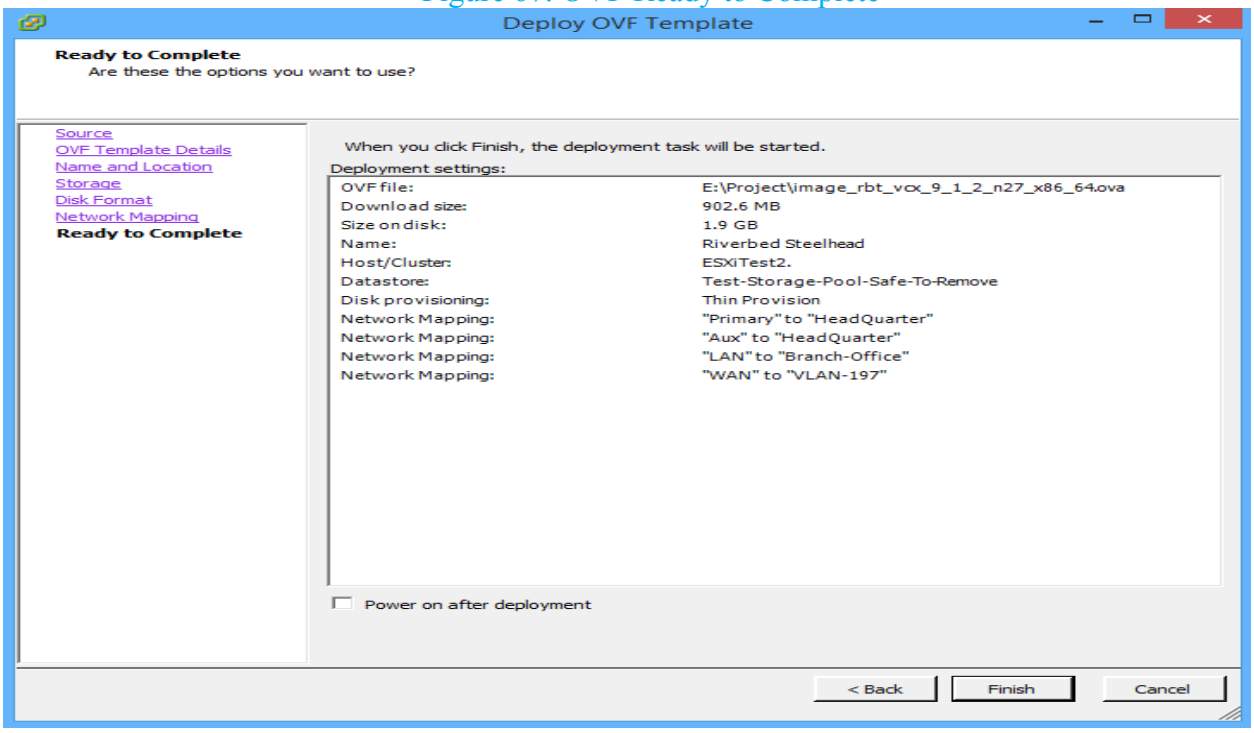
7. Select an appropriate VLAN for each interface and click Next.

Figure 66. OVF Network Mapping



8. Select Power on after deployment and click Finish.

Figure 67. OVF Ready to Complete



Riverbed Virtual Steelhead CX 755V Optimization Configuration

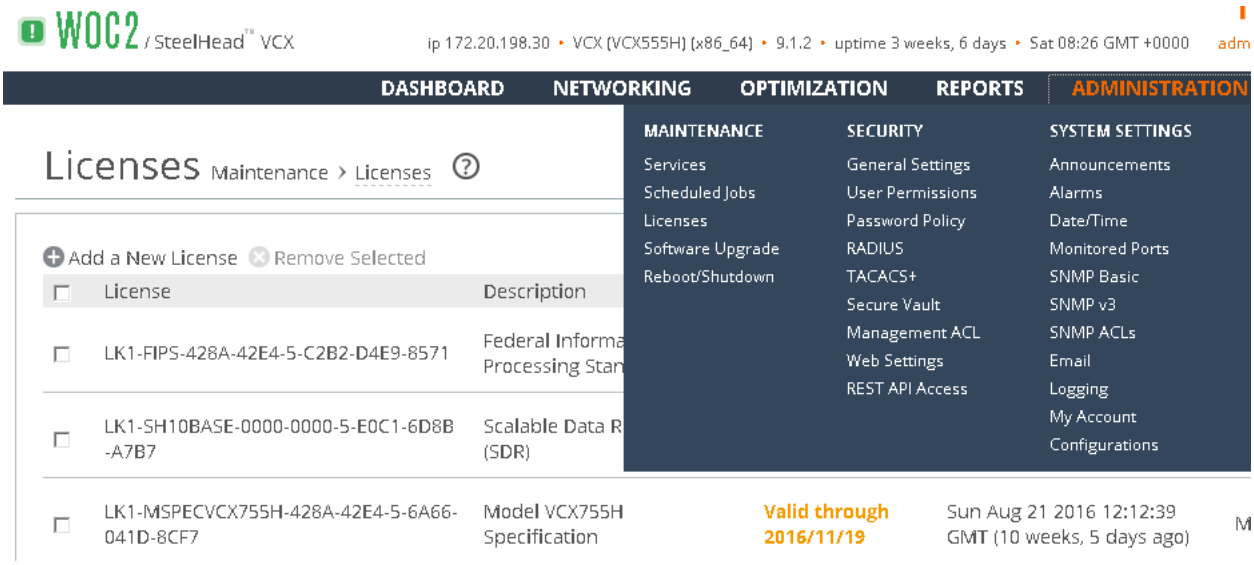
Configuring Virtual Steelhead CX 755V in Branch Office

1. Enter the management IP address of the headquarter Virtual Steelhead that was configured during initial configuration in your browser. Then enter your username and password.

Figure 68. Riverbed Steelhead Authentication

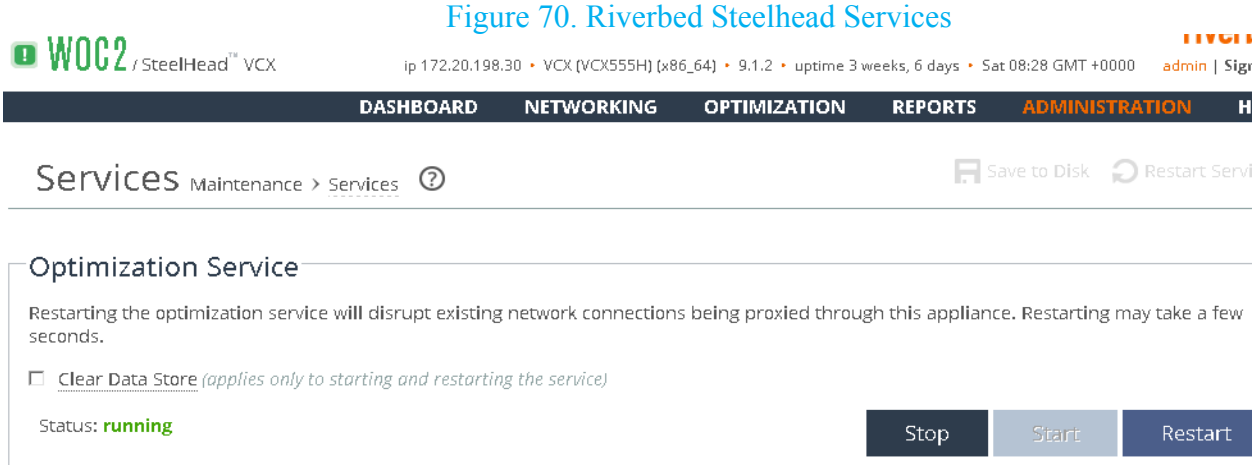
2. Once logged in, navigate to Administration →Licenses and enter your trial or production licenses. The optimization service will not start until the time the appliance is licensed.

Figure 69. Riverbed Steelhead Licenses



3. Once the appliance is licensed, restart the optimization service by navigating to Administration→Services and then click the restart bottom.

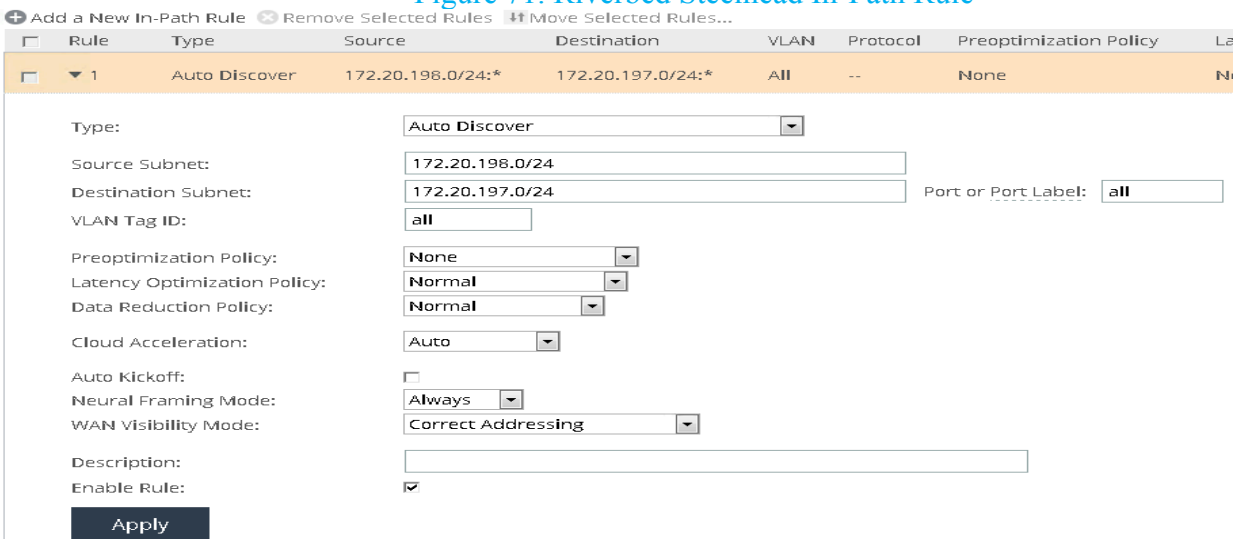
Figure 70. Riverbed Steelhead Services



4. In order to optimize a specific application or specific kind of traffic, we need to create optimization rules, which work very similar to firewall rules. Optimization service checks the rules from top to bottom and where there is a match to a rule, it will apply that rule. In-path rule is configured on the steelhead appliance where a new connection is being stablished by a client. It does this to determine the steelhead behavior with TCP sync packet being sent.

   In order to create an In-Path rule, navigate to Optimization → In-Path Rules and then click Add a New In-Path Rule. Select Auto Discover for the type, and then enter the source and destination subnet leaving all the other options to the default, and then click Apply.

Figure 71. Riverbed Steelhead In-Path Rule

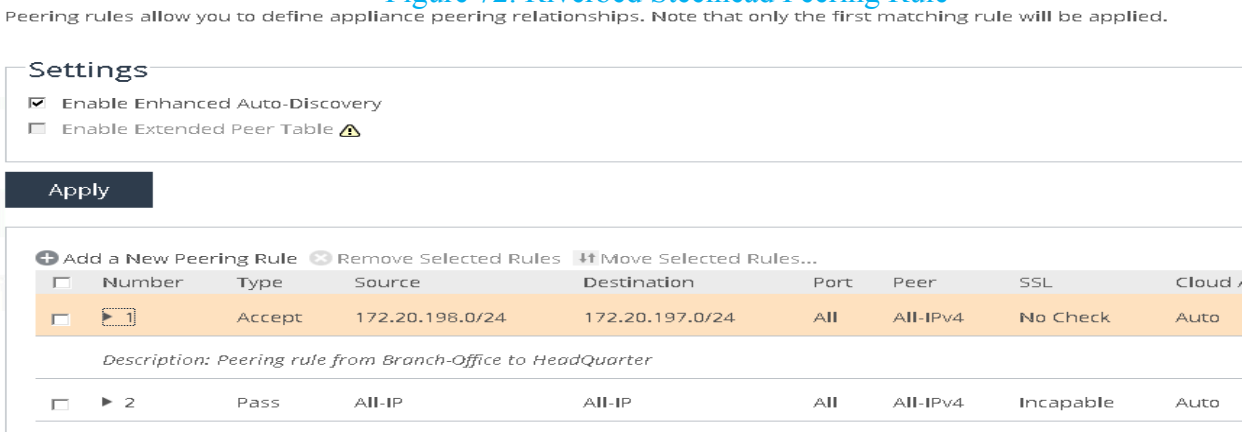


Note: Auto Discover type use TCP SYN packet to automatically discover if the remote Steelhead appliance is able to optimize the traffic being attempted.

Configuring Virtual Steelhead CX 755V in Headquarter

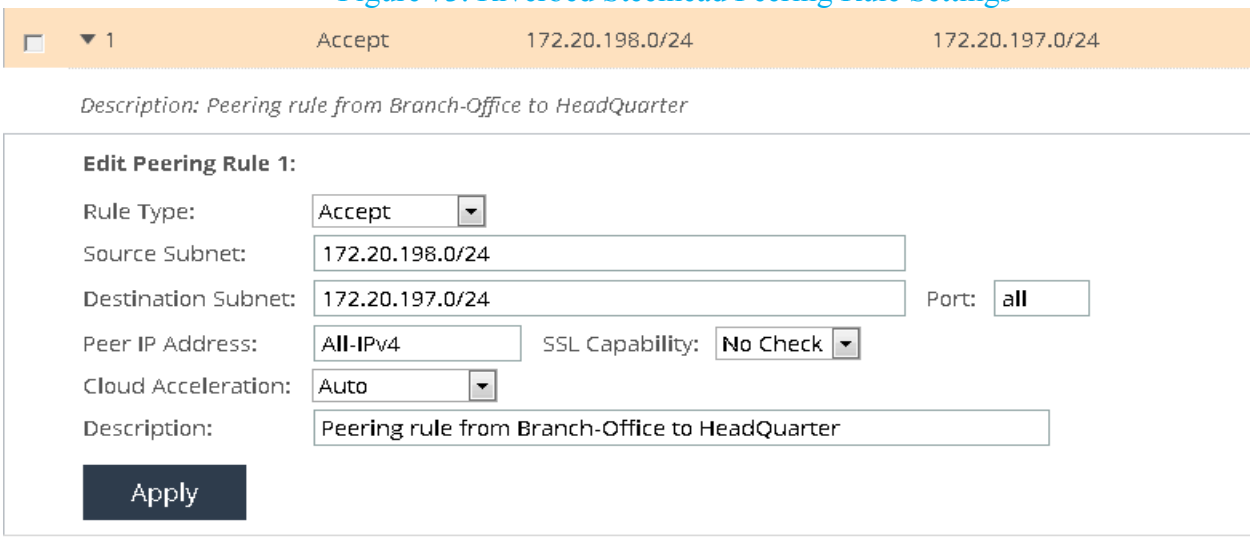
1. Follow the steps 1 to 3 from the previous section to login, license and start the Riverbed appliance service.
2. Configure a Peering rule by navigating to Optimization → Peering Rules to accept connection attempts for In-Path rule created earlier in the previous section.

Figure 72. Riverbed Steelhead Peering Rule



3. On the Peering Rules page click Add a New Peering Rule. For the Rule Type select Accept, enter source and destination subnet, leave all other options to the default and click Apply.

Figure 73. Riverbed Steelhead Peering Rule Settings



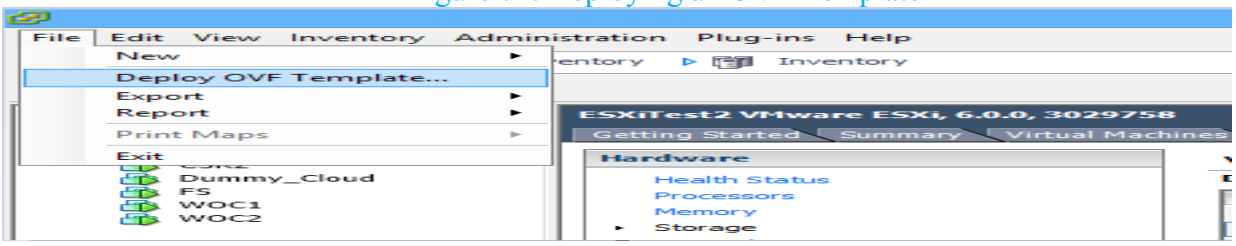
As per the rule configured between the two Steelhead appliances, all IPv4 traffic between the specified source and destination subnets will be optimized. For the purpose of this project, SMB3 traffic is optimized.

Dummy Cloud WAN Emulator Implementation

One Dummy Cloud virtual appliance is implemented in this project and it is connected to two Cisco CSR1000V cloud services routers from either side. Below is the step by step procedure to implement Dummy Cloud virtual appliance. Configuration for the appliance is provided in the appendices section.

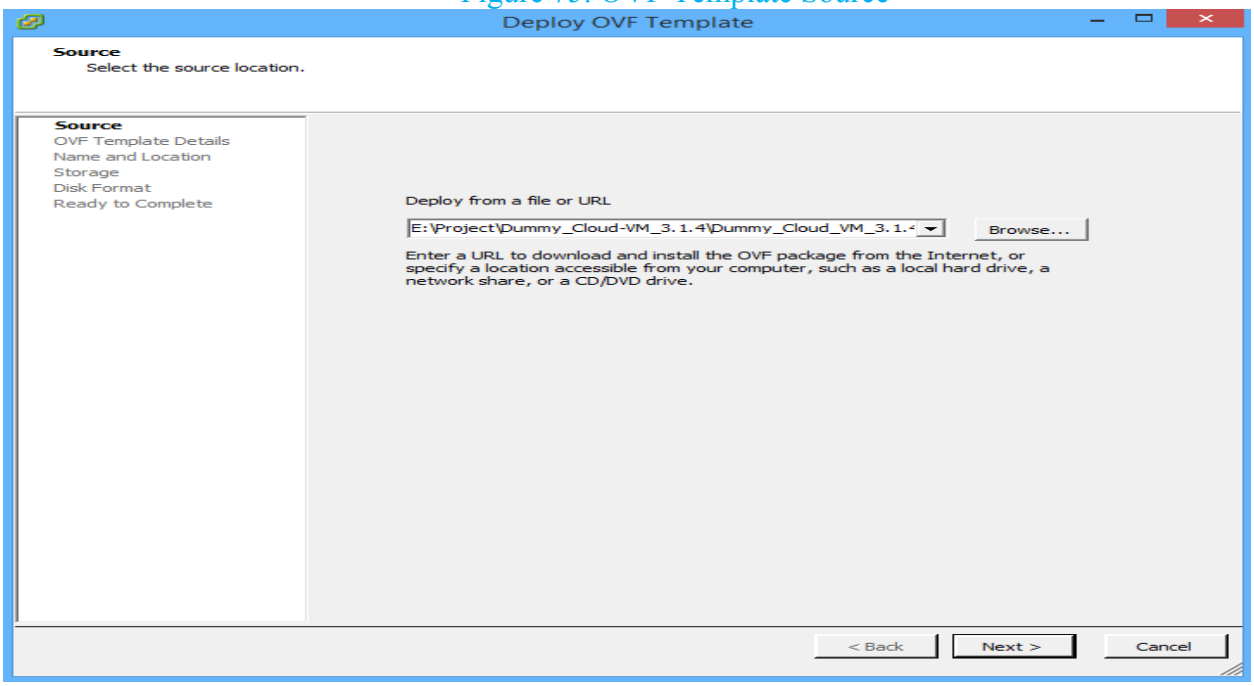
1. From file menu in the vSphere Client, click Deploy OVF Template.

Figure 74. Deploying an OVF Template



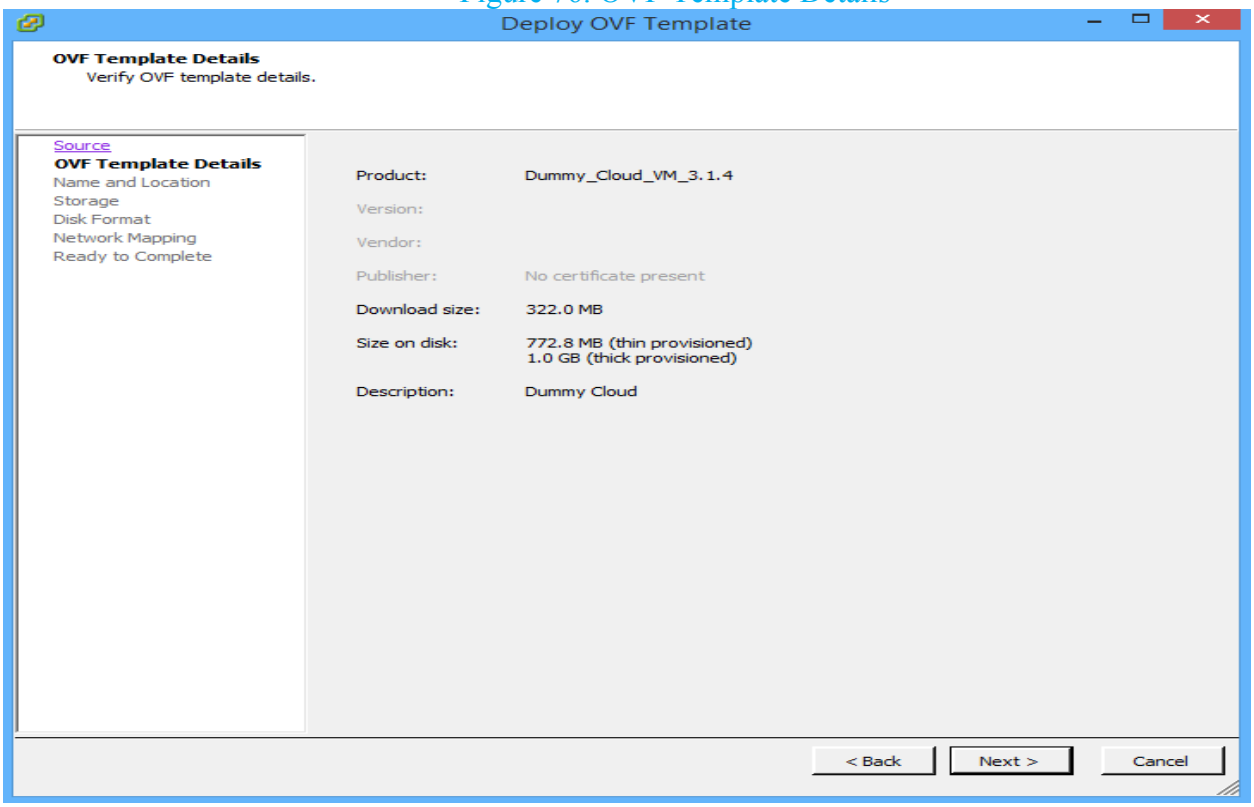
2. Browse to the location of Dummy Cloud WAN Emulator OVA file and click Next.

Figure 75. OVF Template Source



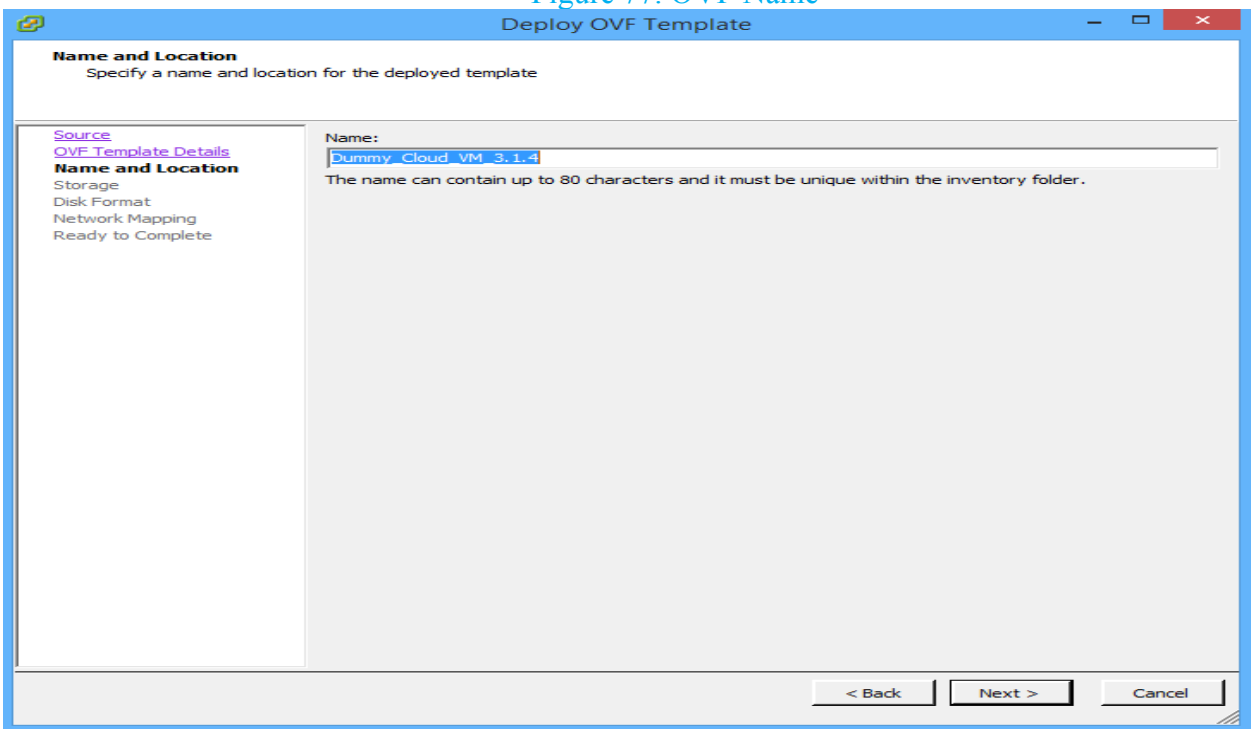
3. On the next page, click Next.

Figure 76. OVF Template Details



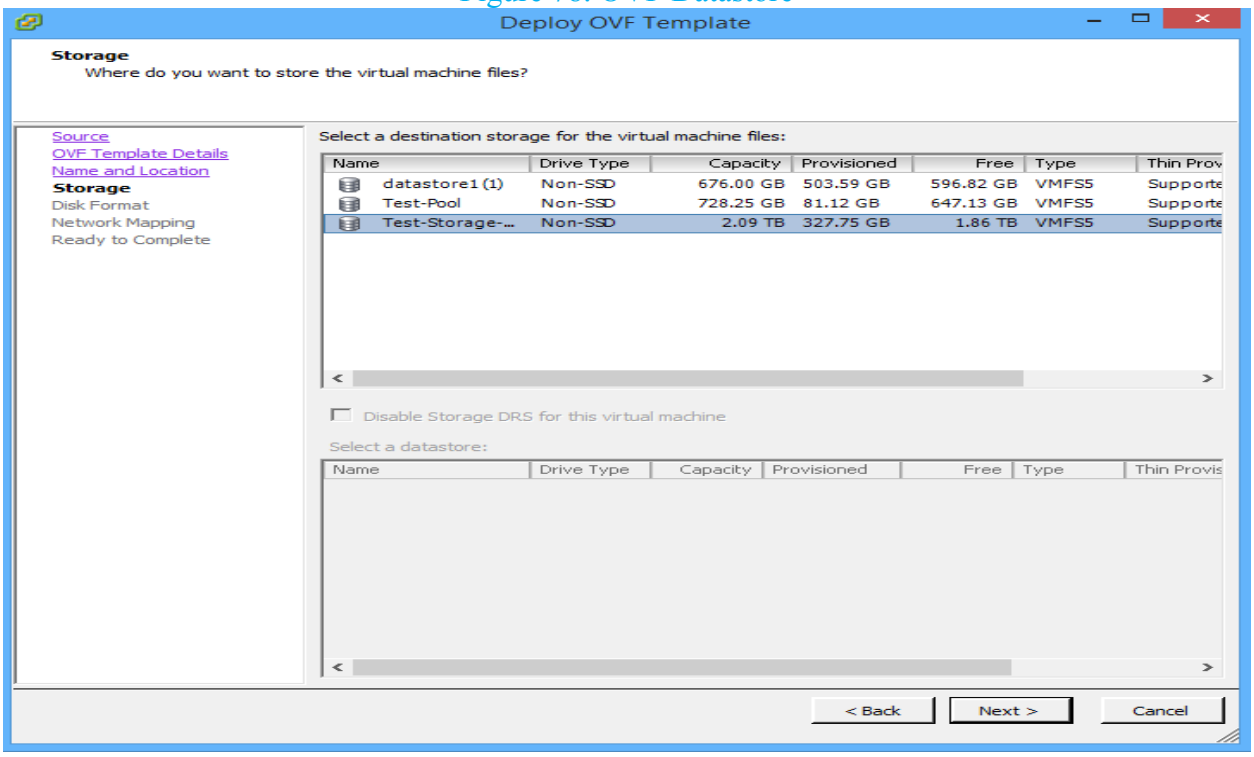
4. Pick up a Name and click Next.

Figure 77. OVF Name



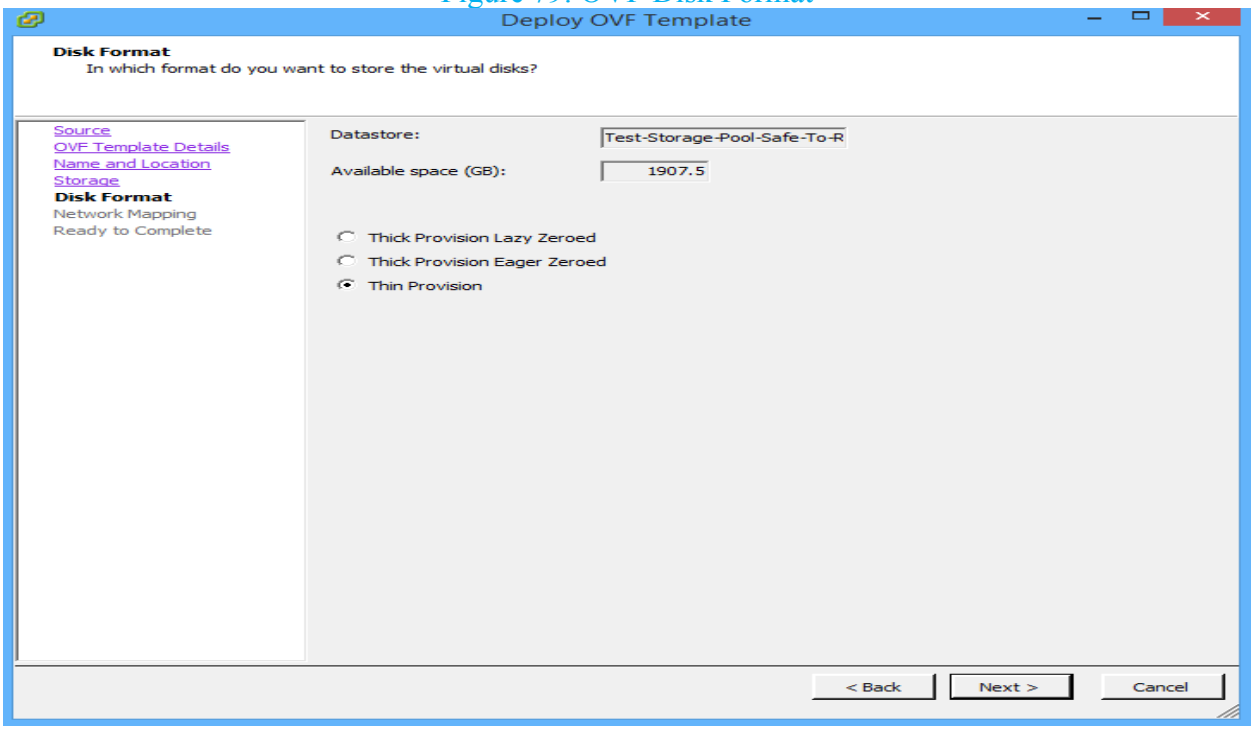
5. Select a data store and click Next.

Figure 78. OVF Datastore



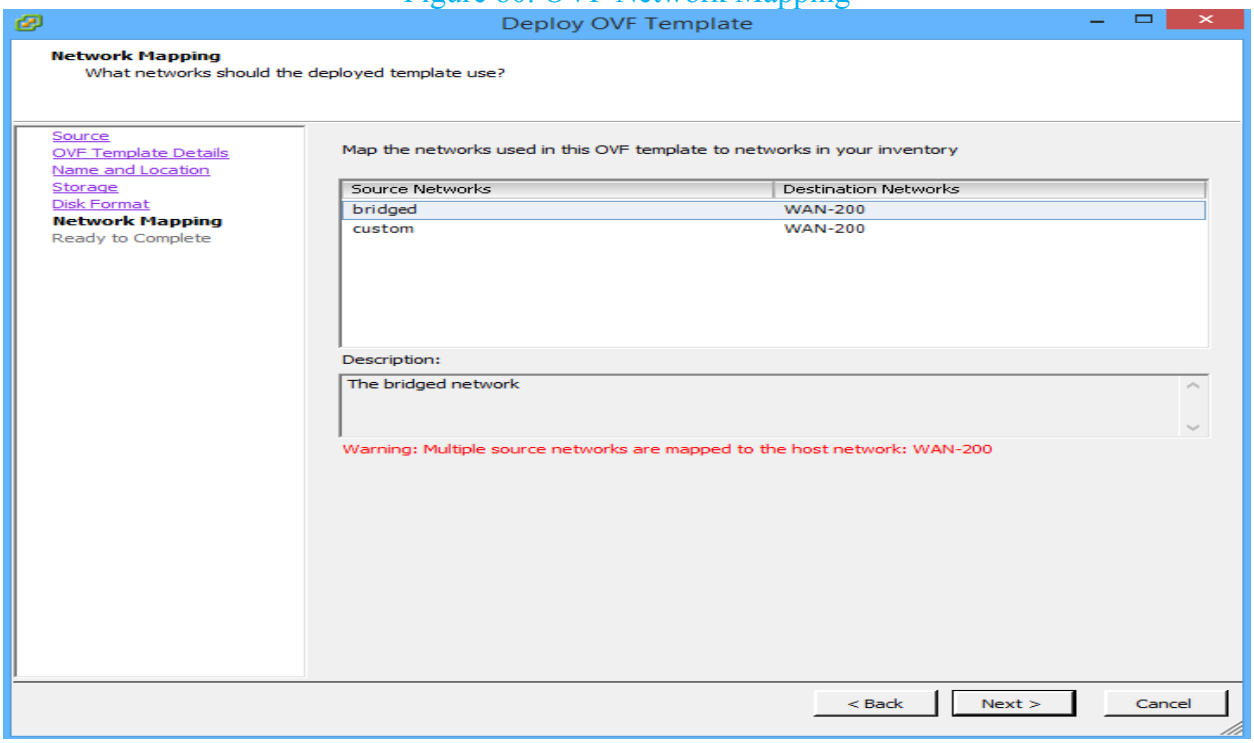
6. Select Thin Provision and click Next. (For production environment. It is recommended to use thick disks)

Figure 79. OVF Disk Format



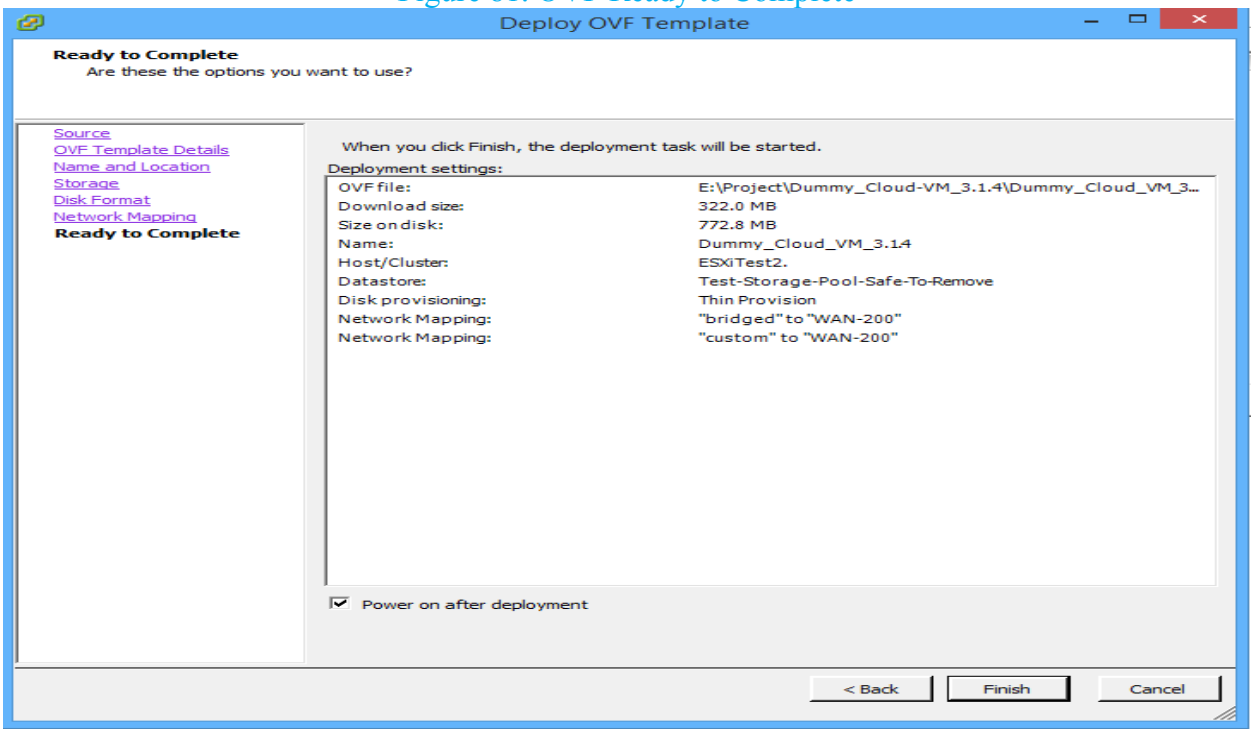
7. Select an appropriate VLAN for each interface and click Next.

Figure 80. OVF Network Mapping



8. Select Power on after deployment and click Finish.

Figure 81. OVF Ready to Complete



Test Procedure

WAN Optimization Test Plan 8.0 provided by Riverbed was used to set up and test the implementation set-up. Following steps were taken to set up the test procedure:

- A Windows file share that was part of Active Directory domain (xyz.local) was set up in the headquarter as the repository to download and upload files.
- A Windows client part of Active Directory domain (xyz.local) was set up in the branch office to download and upload files from and to the network share.
- Riverbed virtual steelhead appliance CX 755V was set up and configured in each site to optimize SMB traffic. (SMB traffic from the client to the server and vice versa was forced through Riverbed appliances)
- Typical test files were put on the file server to be downloaded by the client. (Riverbed recommends files of different types and sizes)
- **Un-optimized operations**: Files were downloaded by the client from the server bypassing Riverbed Virtual Steelhead appliances. Stop watch was used to estimate the amount of time that it took for the files to be copied.
- **Optimized operations:** Same files were downloaded by the client from the server with Riverbed Virtual Steelhead configured between the client and server and simultaneously stop watch was used to estimate the amount of time that it took for the files to be copied. There are performance improvements for the first few times that the files are copied.
    - **Cold test: "**Because most WAN optimizers include a data store and some type of compression, the first optimized test will often show very little performance improvement and a reduction in bandwidth use." [9]
    - **Warm test: "**The second time an operation is performed will often show more dramatic improvements." [9]
- Results from Un-optimized operations and Optimized operations were compared.

Results Analysis

Although there are performance improvements in terms of WAN bandwidth and time for files of different sizes, as the size of files gets larger, savings in terms of bandwidth and time are much more considerable. As a result, considering WAN optimizers for data transfers requires an

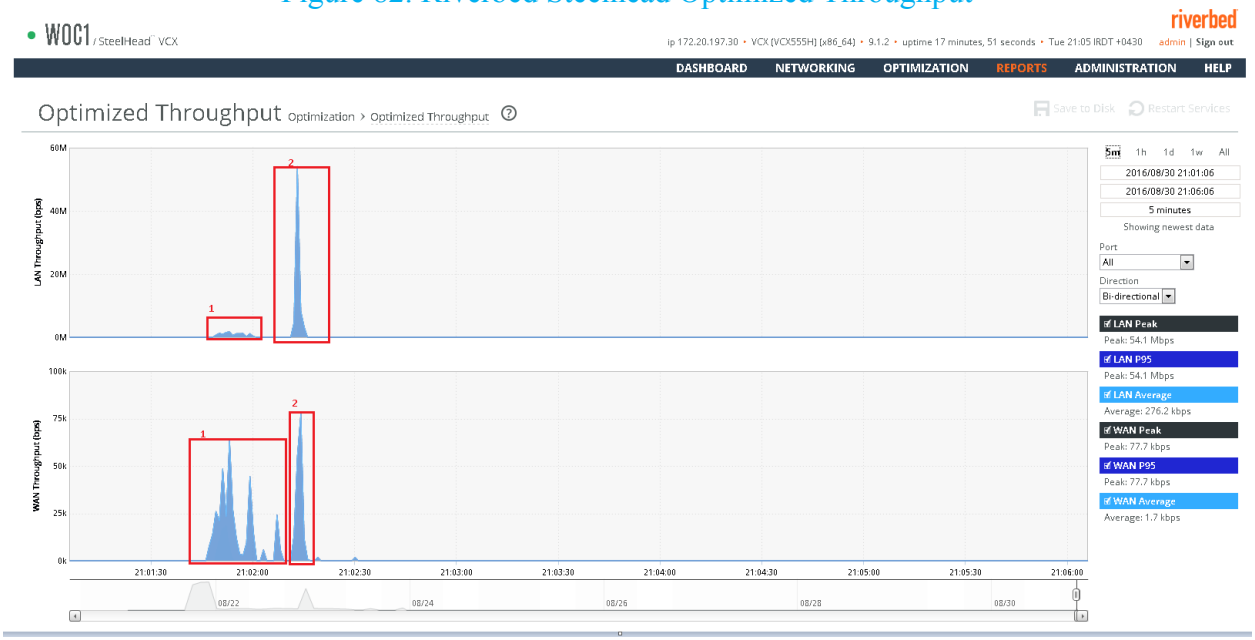
understating of the sizes of files to be transferred so that proper decisions could be made. For this project, two files were selected to be transferred in un-optimized, optimized (cold test), and optimized (warm test) fashion and the results are provided below.

The result for transfer of a file with the size of 8,594 KB is provided in the table below.

File Size	8,594 KB
un-optimized test	25.43 seconds
optimized (cold test)	21.61 seconds
optimized (warm test)	2 seconds

The following diagram taken from Riverbed appliance reporting section also demonstrates the cold and warm test transfer over LAN and WAN. For the first transfer (cold test), LAN throughput is very low and is taking longer time compared to the second transfer, which has a sharp spike in the LAN throughput and is taking over much less time. At the same time, in the WAN throughput diagram (graph at the bottom), it can be noted that the first transfer is taking longer time with less throughput compared to the second transfer.

Figure 82. Riverbed Steelhead Optimized Throughput



The result for transfer of a file with the size of 280,418 KB is provided in the table below.

File Size	280,418 KB
un-optimized test	16.21 minutes
optimized (cold test)	16.08 minutes
optimized (warm test)	7.67 seconds

The following diagram also demonstrate LAN and WAN throughput over time for cold and warm test transfers. As it can be noticed in the diagram, bandwidth and time savings for this large file is much noticeable and considerable compared to the previous file transfer.

Figure 83. Riverbed Steelhead Optimized Throughput

Issue and Challenges

There were two main challenges in the implementation of this project. One challenge was to find a scenario to implement various components of the project in a test environment using limited lab resources. Another challenge was WAN emulation, which also affected the scenario that was used to implement different components of the project.

After working out through the project for some time, it was understood that emulating WAN is the main challenge of the project and it affected the scenario that was used to implement the whole project. Taking into consideration that most WAN emulators from known vendors come in form of physical appliances, which also come at a cost, a more cost efficient method had to be used, which was a virtual appliance. After some research, it was also noticed that virtual appliances that emulate WAN need to work in routed mode not bridge mode so that they can be implemented in the virtualization environment. After some research, Dummy Cloud was used to implement WAN emulation. At the same time, a single HP Proliant DL380 G6 server platform along with bare-metal virtualization technology from VMware (VMware vSphere ESXi version 6) was used to implement all project components.

The network infrastructure implementation was an important part of the project and all the network infrastructure had to be implemented through a single hardware server platform. Implementation of the LANs in a way that the traffic from LAN connected machines only flows through WAN optimization appliances was also another challenge. Finally, taking into consideration that WAN optimization technology is relatively new compared to other technologies such as operating system from Microsoft, there were some difficulties on finding information on setting up and troubleshooting WAN optimizers from Riverbed.

Conclusion

In order to increase productivity, provide ubiquitous access, enhance collaboration, and reduce costs, companies of various sizes have deployed their applications over wide area network (WAN) connections. At the same time, recent trends toward virtualization and cloud computing, data center consolidation, and increased demand for data backup and recovery have placed huge demand on WAN connections and changed the way applications are delivered. Taking into considerations the limitations of WAN connections and massive demand on these connections, enterprise IT organizations have felt the need to optimize their WAN environments to improve network availability, reliability, and performance. The WAN optimizer from Riverbed used in this project accelerated file transfers between the two WAN end points by considerable amount. However, companies need to have a clear understanding of the type and size of the files if they plan to implement WAN optimization. WAN Optimization Controllers are useful in transferring files over WAN connections, but the real advantage comes when the sizes of files are large once compared to files of few Megabytes or Kilobytes.

Although WAN optimization industry is new compared to other industries such operation systems, the demand for WAN Optimization Controller has been very high in the past recent years and continue to grow. The fact that WAN optimization market is estimated to reach $12.1 billion in 2019 proves the matter. [7] As a result, the industry will demand for more and more professionals with expertise in the field of WAN optimization.

Appendices and References

Cisco Virtual Router Configurations

CSR1#show run
Building configuration...

```
Current configuration : 1092 bytes
!
! Last configuration change at 20:03:26 UTC Sat Aug 20 2016
!
version 15.4
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
platform console virtual
!
hostname CSR1
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$JXka$jhMvy.pl5kvhwDt3xNb2S.
!
no aaa new-model
!
no ip domain lookup
!
subscriber templating
multilink bundle-name authenticated
!
license udi pid CSR1000V sn 93UW7H831L0
!
redundancy
 mode none
!
interface GigabitEthernet1
 ip address 172.20.197.11 255.255.255.0
 negotiation auto
!
interface GigabitEthernet2
 ip address 172.20.200.201 255.255.255.0
 negotiation auto
!
virtual-service csr_mgmt
```

```
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
ip route 172.20.198.0 255.255.255.0 172.20.200.211
!
control-plane
!
line con 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0
 password 123
 login
line vty 1
 password 123
 login
 length 0
line vty 2 4
 password 123
 login
line vty 5 15
 password 123
 login
!
End
```

CSR2#show run

```
Building configuration...

Current configuration : 1071 bytes
!
! Last configuration change at 16:45:44 UTC Mon Sep 5 2016
!
version 15.4
service timestamps debug datetime msec
service timestamps log datetime msec
no platform punt-keepalive disable-kernel-core
platform console virtual
!
hostname CSR2
!
boot-start-marker
boot-end-marker
```

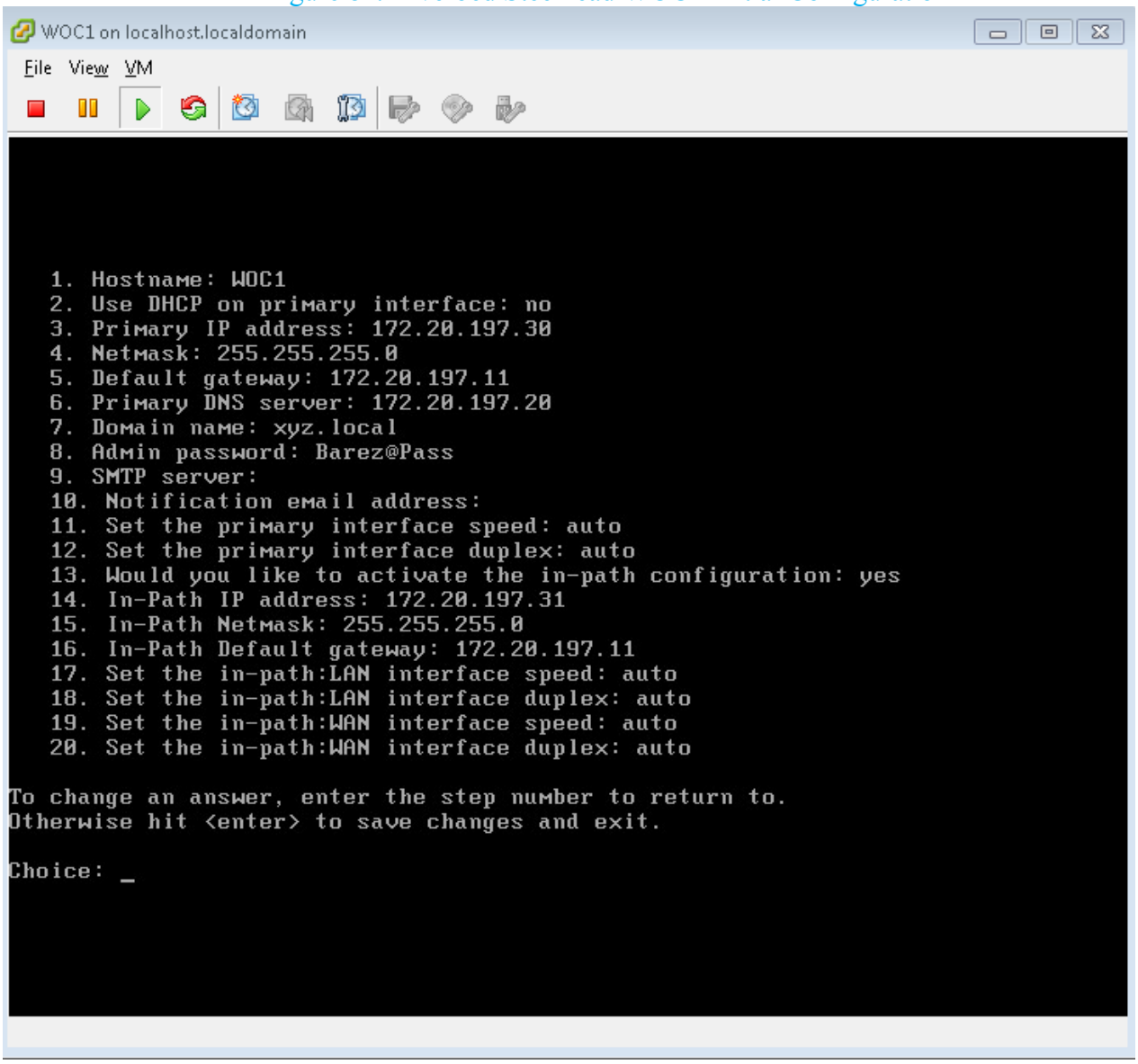
```
!
enable secret 5 $1$KbAe$I3qTIaQyRYlK13FGLCry91
!
no aaa new-model
!
subscriber templating
multilink bundle-name authenticated
!
license udi pid CSR1000V sn 94NSWC1TV55
!
redundancy
 mode none
!
interface GigabitEthernet1
 ip address 172.20.198.12 255.255.255.0
 negotiation auto
!
interface GigabitEthernet2
 ip address 172.20.200.202 255.255.255.0
 negotiation auto
!
virtual-service csr_mgmt
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
ip route 172.20.197.0 255.255.255.0 172.20.200.212
!
control-plane
!
line con 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0
 password 123
 login
line vty 1
 password 123
 login
 length 0
line vty 2 4
 password 123
 login
line vty 5 15
```

```
 password 123
 login
!
end
```

Riverbed Configuration

WOC1- Headquarter Site

Figure 84. Riverbed Steelhead WOC1 Initial Configuration



WOC2- Branch Site

Figure 85. Riverbed Steelhead WOC2 Initial Configuration

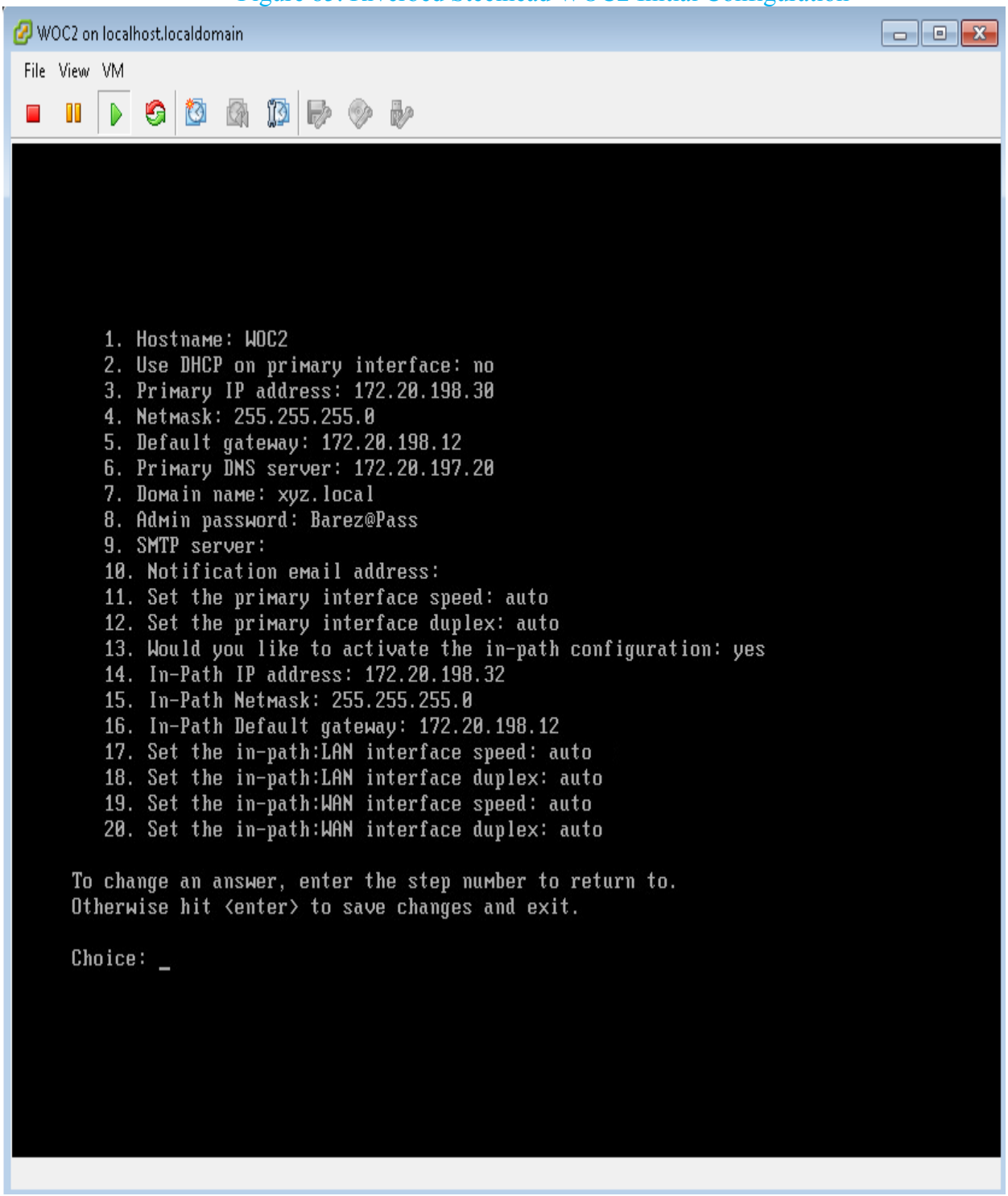


Figure 86. Riverbed Steelhead Peering Rule

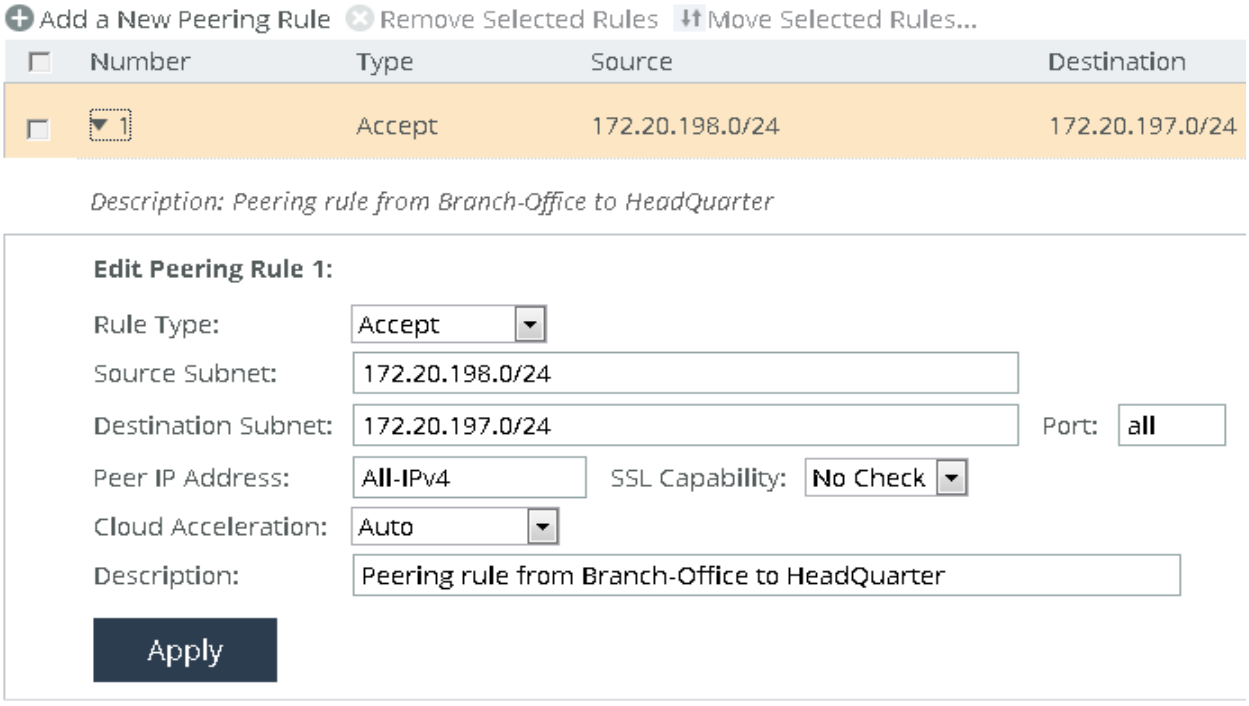
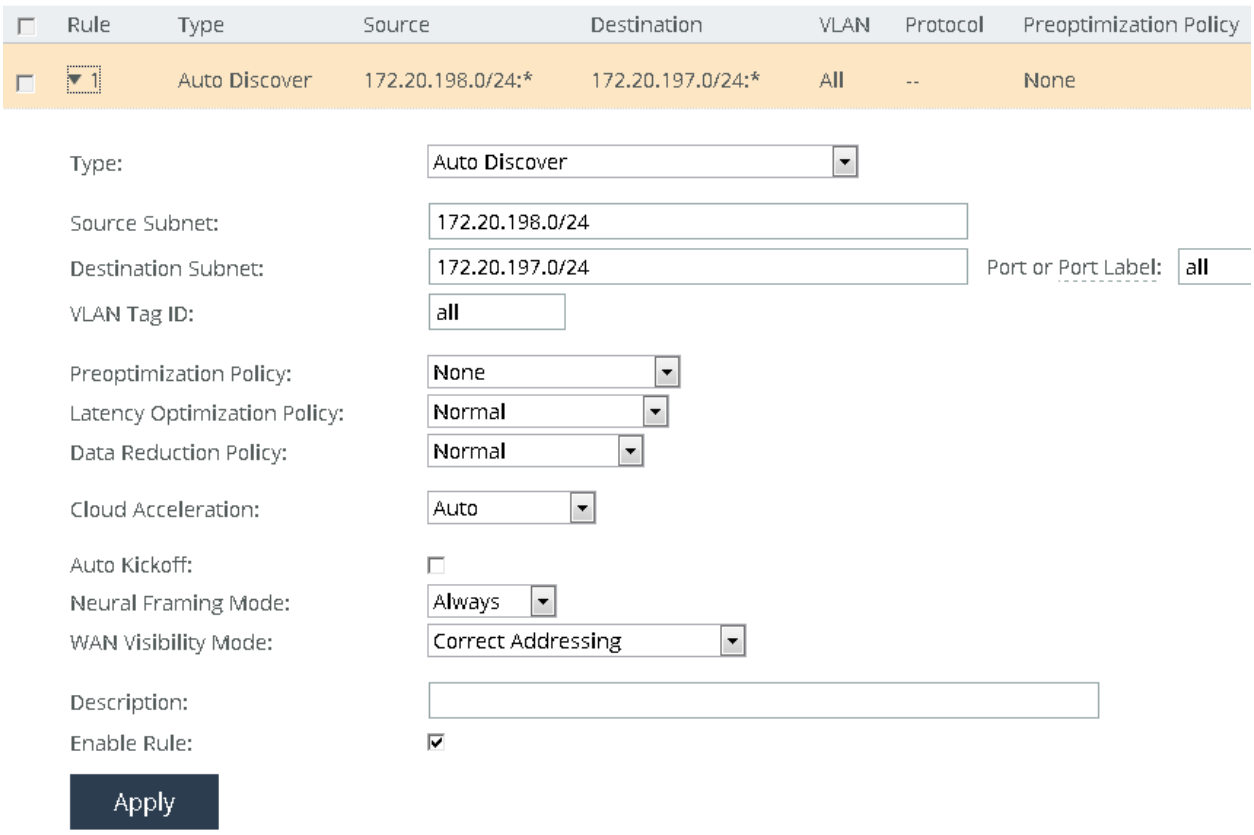


Figure 87. Riverbed Steelhead In-Path Rule



WAN Emulator Configuration

Figure 88. Dummy Cloud Emulator WAN Emulation Configuration

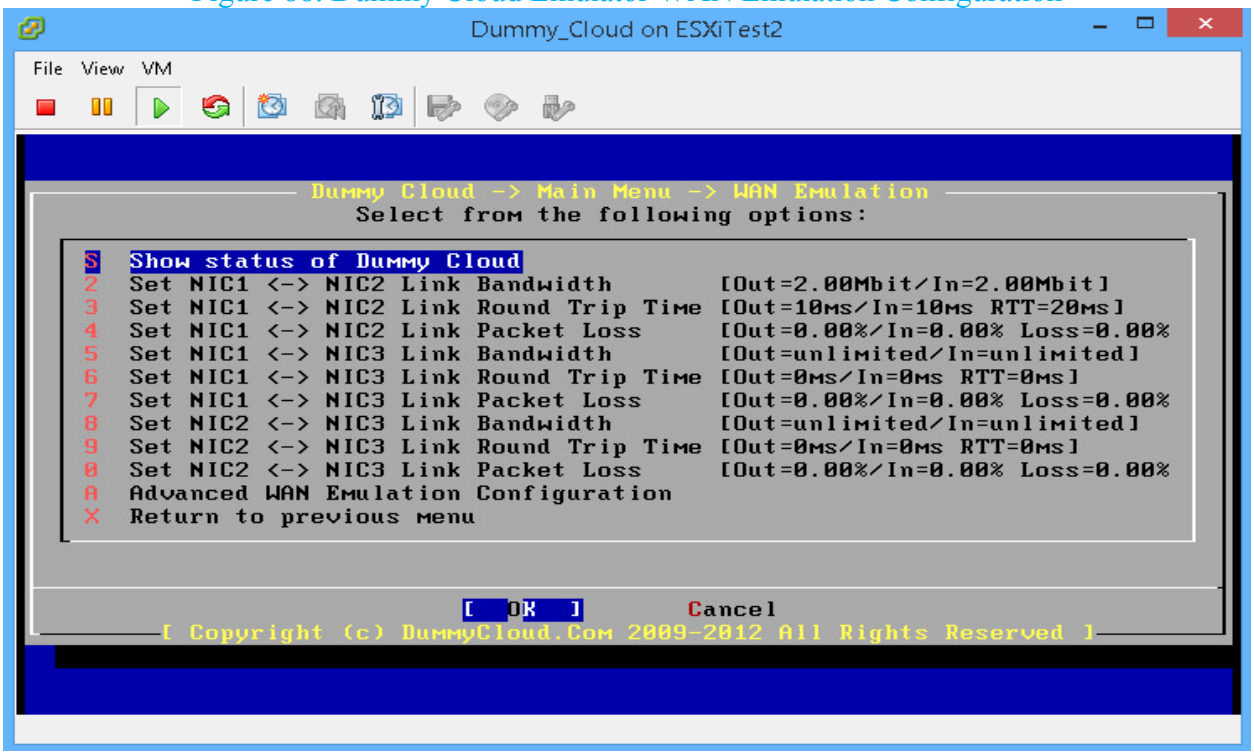


Figure 89. Dummy Cloud Emulator Advanced Network Settings

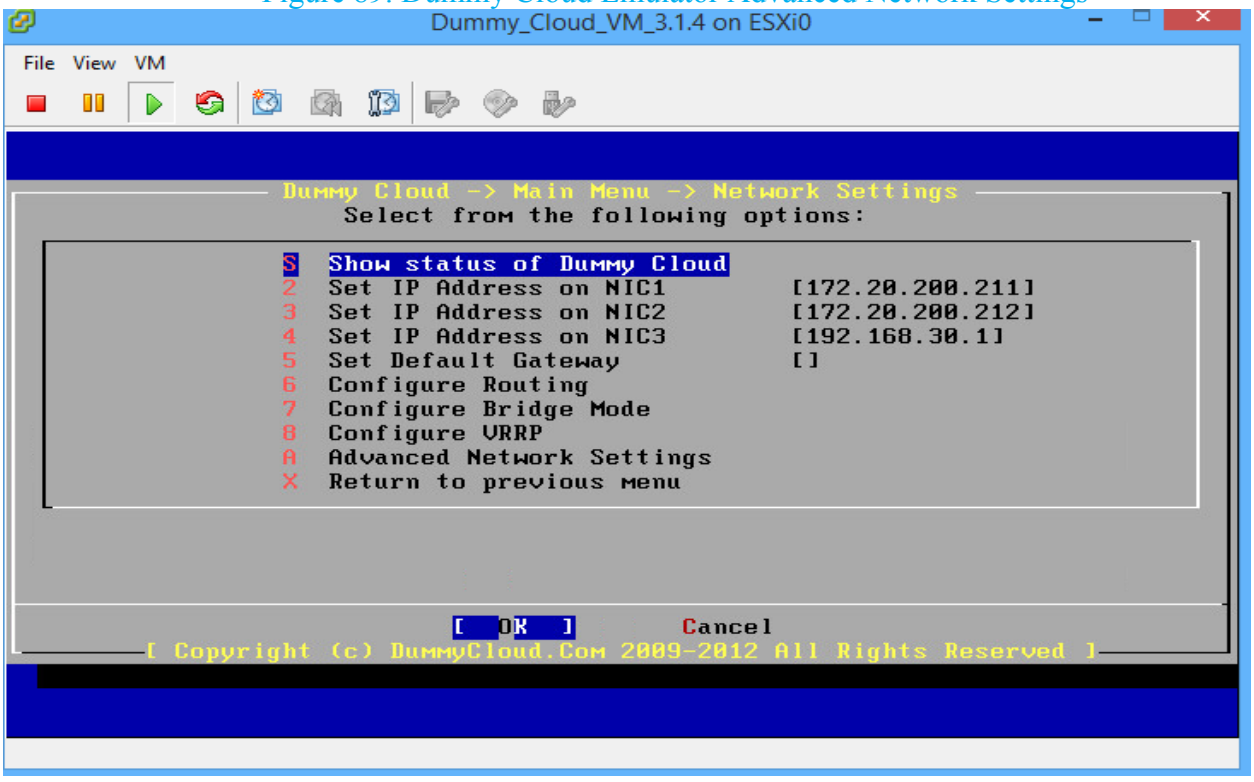


Figure 90. Dummy Cloud Emulator Static Routes

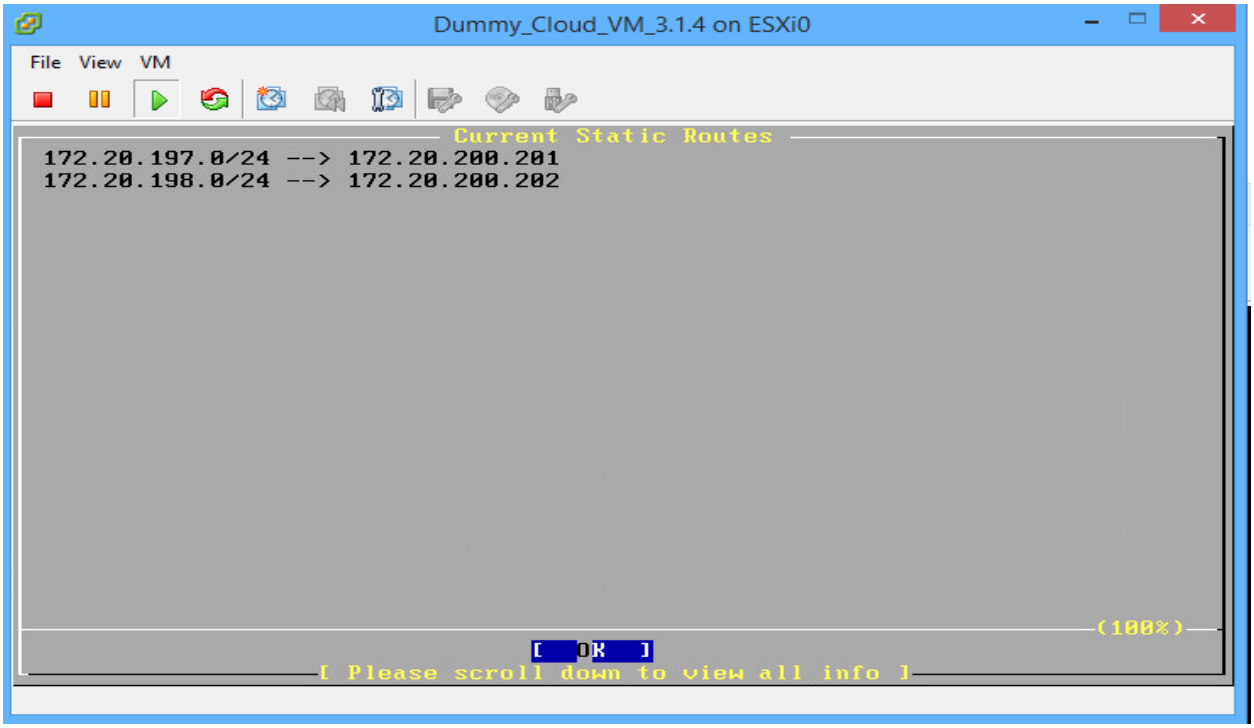
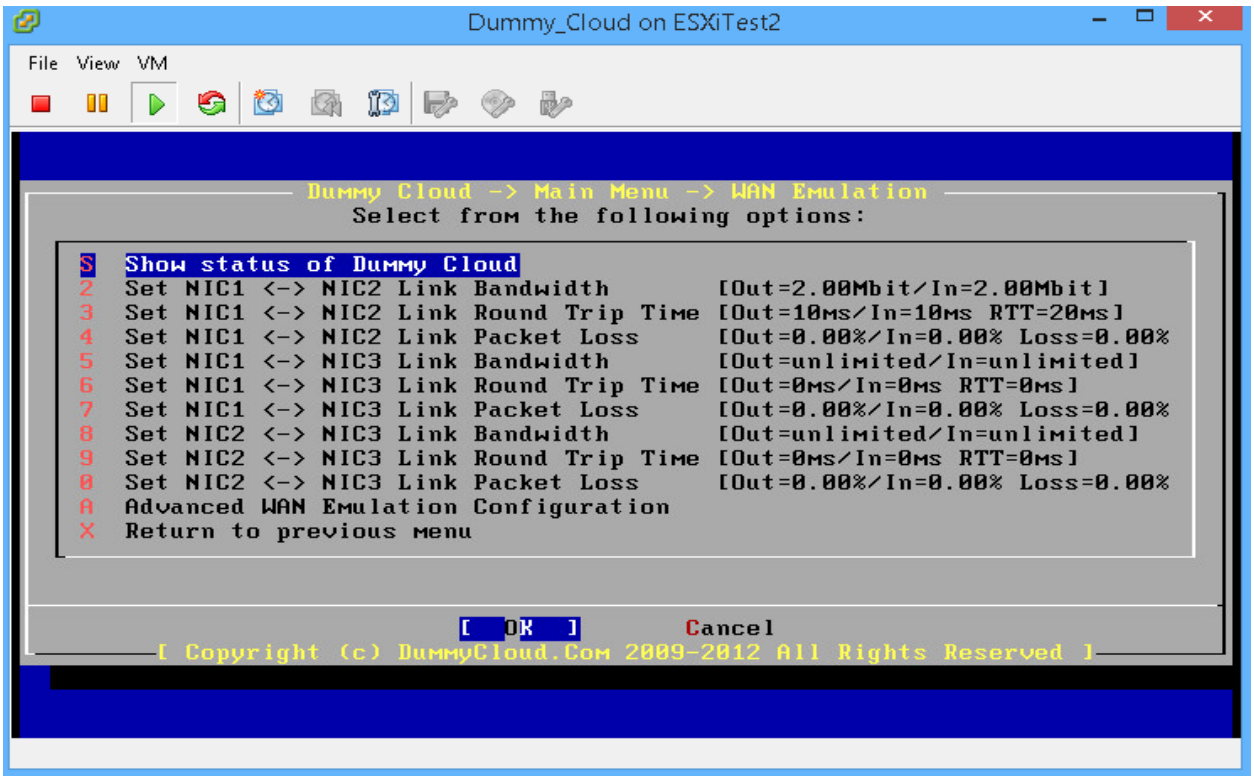


Figure 91. Dummy Cloud Emulator Advanced WAN Emulation Configuration



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