Technical Report

NetApp Data Fabric with FlexPod and Cisco Intercloud Fabric

Nabil Fares, Ganesh Kamath, NetApp

March 2015 | TR-4391

Abstract

This document describes the integration and architecture of NetApp® Private Storage, the NetApp Cloud ONTAP™ operating system, and Cisco® Intercloud Fabric solutions. It includes case studies, deployment procedures, and validations of these technologies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

This technical report provides an insight into NetApp Private Storage (NPS), Cloud ONTAP, and their seamless integration with Cisco Intercloud Fabric (ICF). It provides a high-level summary of each technology, technical implementation on the premises and in the cloud, and a detailed configuration and validation of all the technologies working together for an enterprise hybrid cloud strategy.

It is becoming more critical for enterprise IT to find the right solutions and tools to enable seamless adoption between private cloud and on-premises and public cloud infrastructures while maintaining control of applications and providing a high-level user experience.

The NetApp Data Fabric provides flexibility with complete ownership of data while providing the ability to leverage multiple public clouds. NPS, Cloud ONTAP, NetApp SnapMirror® software, and Cisco Intercloud Fabric provide the key technologies to securely leverage a hybrid cloud for workload migrations, development/test, backup, and disaster recovery in a flexible approach without cloud provider lock-in.

Cisco Intercloud Fabric builds highly secure hybrid clouds and extends enterprise virtualized data centers to the public cloud while maintaining network and security policies. ICF provides complete freedom to place workloads across multiple public clouds based on business and cost needs. The mobility of ICF removes any demarcation between private and public clouds.

The unique partnership between NetApp cloud offerings (the NetApp Data Fabric) and Cisco Intercloud Fabric enables a successful shift to the hybrid cloud. Enterprise data, compute, and public cloud–based resources integrate for scalability with operational intelligence while enabling the ability to control costs and data ownership. ICF moves workloads to the public cloud and SnapMirror moves data from the enterprise to NPS, eliminating any potential latency impacting critical and noncritical applications.

Both NPS and ICF provide the capabilities for data and workload mobility with bidirectional migration, practically eliminating provider lock-in. The option to port data and applications is a critical part of hypercloud strategy, just as is pricing and flexibility.

1.1 Intended Audience

This document is intended for:

- Customers, partners, and service providers looking to implement and integrate NPS, Cloud ONTAP, and Cisco Intercloud Fabric as part of a hybrid cloud strategy
- End users and managers interested in continuous-availability solutions in the cloud for dev/test, compute augmentation, and disaster recovery strategies

1.2 Scope

The purpose of this report is to provide:

- A high-level technical review of NetApp cloud solutions and Cisco ICF
- A detailed design and implementation guide and configuration best practices
- A high-level overview of architectural use cases with expected behaviors
- Demonstrated solutions for Cisco Intercloud Fabric integration with NPS (section 9) and Cloud ONTAP (section 10)

The scope of this document is limited to the following:

- Validation is limited to AWS and Equinix. Visit each technology reference site links for each technology.
- It does not replace any official manuals or documents from NetApp and Cisco on the products used in the solution or documents from any other hardware vendor referenced in this report.

- It does not discuss any performance impact or analysis from an end-user perspective during a disaster.
- It does not discuss high-availability deployment and redundancy verification for hardware, tunnel, or virtualized environments. The assumption is that the end user follows the best practices provided for each of the technologies presented here.

1.3 Assumptions and Prerequisites

This document assumes that the reader has basic knowledge of the following:

- NPS architecture and deployment
- Amazon Web Services, specifically VPC, Routing, and Direct Connect
- Cisco technologies and products
- NetApp storage systems and the NetApp Data ONTAP® operating system
- VMware® virtualization technologies and products
- General networking

NetApp highly recommends that users follow the best practices for each technology presented in this report.

1.4 Glossary of Terms

Tables 1 through 3 define the terms used to describe the technical architecture of the solution.

Table 1) Cisco ICF glossary.

Terminology	Description
ICFD	Intercloud Fabric Director (the main appliance used to manage the ICF environment)
PNSC	Prime Network Services Controller
VSM	Virtual Switch Module
ICX	Intercloud Extender
ICS	Intercloud Switch
ICA	Intercloud Fabric Agent
ICL	Intercloud Link (TLS tunnel)
CSR	Cloud Services Router

Table 2) AWS glossary.

Terminology	Description
VPC	A virtual private cloud (VPC) is an isolated private (RFC 1918) IP address range (10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16). A VPC can be connected to other VPCs, to the Internet, or to other networks through a Direct Connect network connection.
VGW	A virtual private gateway (VGW) is a virtual router used to connect your VPC to other networks. The VGW is the AWS endpoint for the Direct Connect network connection.
Direct Connect	Direct Connect is a service offered by Amazon and participating colocation providers to establish a high-speed connection to the customer-provided network equipment in the colocation data center.

Terminology	Description
EC2	Amazon Elastic Compute Cloud (EC2) provides computing resources through VM operating systems (OSs) for the AWS cloud. The VMs can run either Microsoft® Windows® or Linux® OSs.
AMI	An Amazon Machine Image (AMI) is a VM image in Amazon EC2. EC2 VMs are deployed from AMIs. AMIs can be purchased from the AWS Marketplace, or customers can build their own.
AWS Region	An AWS region is a pool of AWS cloud resources tied to a geographic site. Each AWS region consists of multiple Availability Zones.
Availability Zone	Availability Zones are distinct locations within an AWS region that are engineered to be isolated from failures in other Availability Zones. They also provide inexpensive low-latency network connectivity to other Availability Zones in the same region.

Table 3) Industry glossary.

Terminology	Description
BGP	Border Gateway Protocol (BGP) is the layer 3 routing protocol that AWS Direct Connect uses to advertise routes between the VPC network and the customer network located in the Direct Connect data center. BGP configuration on the customer network switch is used to advertise routes from the customer network into the VPC network.
GRE	This stands for Generic Routing Encapsulation.
NAT	This stands for Network Address Translation.

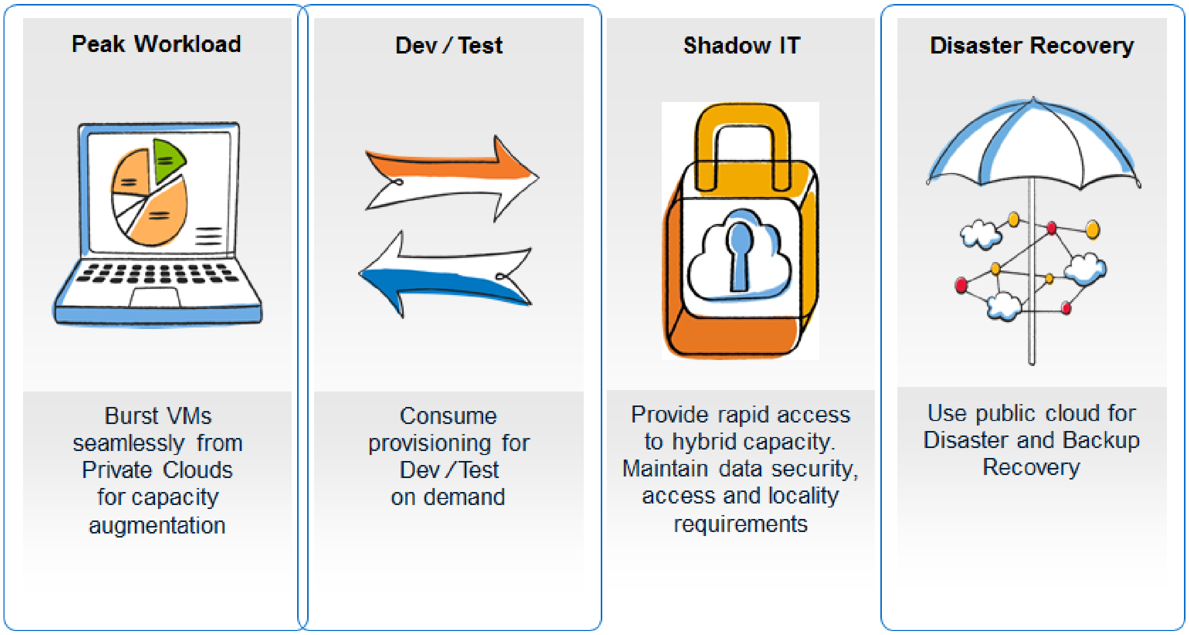
2 Background

The integration of NPS, Cloud ONTAP, and ICF enables us to deliver some very compelling solutions for customers deploying a hybrid cloud strategy. The integration of NetApp Data Fabric solutions with Cisco Intercloud Fabric paves the way for a solid entry into the hybrid cloud quickly and with minimal operational learning curves, shifting the focus from complex to simpler adoption.

2.1 Business Challenges

A hybrid cloud approach provides organizations with the best of private and public clouds. Organizations need the combined benefits with the advantages of a public cloud. They have become acutely aware that a hybrid cloud might prove to be the better choice.

Figure 1) Common cases for hybrid clouds.


Peak Workload
Burst VMs seamlessly from Private Clouds for capacity augmentation
Dev / Test
Consume provisioning for Dev / Test on demand
Shadow IT
Provide rapid access to hybrid capacity. Maintain data security, access and locality requirements
Disaster Recovery
Use public cloud for Disaster and Backup Recovery

We selected the most common enterprise needs for validation: workload augmentation, dev/test, and backup and recovery.

- High compute demands are seasonal in the enterprise. Enterprises can have a deployment model in which the hyperscaler VM instances are spun up immediately (or workload burst into the cloud) when the demand for computing capacity spikes during busy periods to meet peak demands. Enterprises only pay for extra compute when it is needed. The NetApp infrastructure in Equinix can provide instant access to the workloads by using cloning or mirroring technology.
- Enterprises can also quickly test new applications and quickly perform development and testing on demand with this cloud model. NetApp technology can be used to provision instant clones of the enterprise workload and make them accessible to the dev/test VMs in the cloud.
- Enterprises can also have cost-effective DR with NetApp SnapMirror technology.

3 Introduction to NetApp Private Storage for AWS

3.1 Overview

The NetApp Private Storage for AWS solution is a hybrid cloud architecture that allows enterprises to build an agile cloud infrastructure that combines the scalability and flexibility of the AWS cloud with the control and performance of NetApp storage.

NetApp storage is deployed at an Equinix colocation data center where the AWS Direct Connect service is available. The storage is connected to AWS computing resources through the AWS Direct Connect network service.

Typical use cases for the NetApp Private Storage for AWS solution include the following:

- Oracle®, Microsoft SQL Server®, and SAP® primary workloads
- Disaster recovery
- Development and testing

- Big data analytics
- Data with compliance requirements
- Data center migration and consolidation

The NetApp Private Storage for AWS solution deployed at an AWS Direct Connect data center can also be connected to on-premises data centers through multiprotocol label switching (MPLS) or through a point-to-point virtual private network (VPN). Customers can then use efficient NetApp SnapMirror and SnapVault® storage replication to move data closer to AWS computing resources.

From a business perspective, the solution offers customers the ability to shift capital expenses to operational expenses. Customers can dynamically allocate computing, application, or backup resources instead of building out on-premises data centers and infrastructure.

3.2 Technical Overview

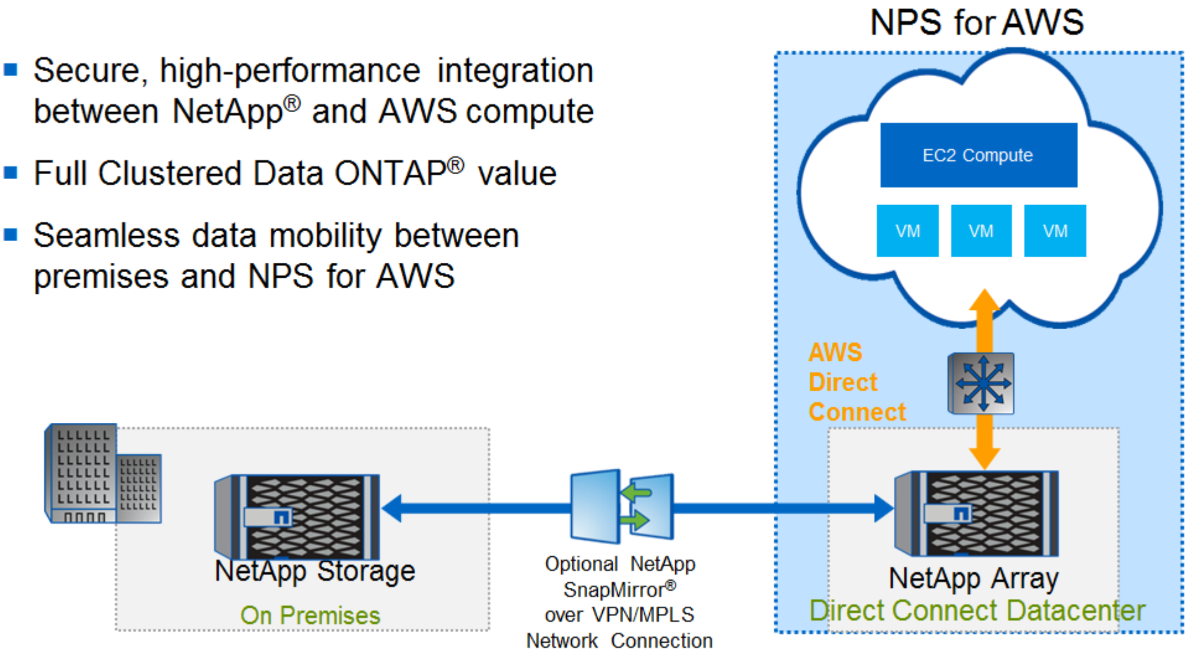
The NetApp Private Storage for AWS solution combines computing resources from AWS with NetApp storage deployed at AWS Direct Connect data centers. Connectivity from the NetApp storage to the AWS cloud is made possible by the AWS Direct Connect network service.

The AWS Direct Connect network service offers dedicated high-bandwidth, low-latency, secure network connectivity to the AWS cloud. When provisioned through the AWS Direct Connect dashboard, 1Gb/sec and 10Gb/sec network connections are available and are provisioned manually by cross connection in the AWS Direct Connect data center.

Customers who deploy the NetApp Private Storage for AWS solution at Equinix colocation data centers can also provision AWS Direct Connect network connections through the Equinix Cloud Exchange portal in 200Mb/sec or 500Mb/sec bandwidth sizes. 1Gb/sec and 10Gb/sec Direct Connect connections are provisioned manually by cross connection.

In the AWS Direct Connect data center, the customer provides network equipment (switch or router) and NetApp storage systems. Virtual machines (VMs) in the AWS cloud connect to the NetApp storage through IP-based storage protocols (iSCSI, CIFS, or NFS). Additional MPLS or point-to-point VPN network resources can be used to provide connectivity between AWS regions as well as connectivity to on-premises data centers.

Figure 2) NPS high-level architecture.



- Secure, high-performance integration between NetApp® and AWS compute
- Full Clustered Data ONTAP® value
- Seamless data mobility between premises and NPS for AWS

NPS for AWS
EC2 Compute
VM
VM
VM
AWS Direct Connect
NetApp Storage
On Premises
Optional NetApp SnapMirror® over VPN/MPLS Network Connection
NetApp Array
Direct Connect Datacenter

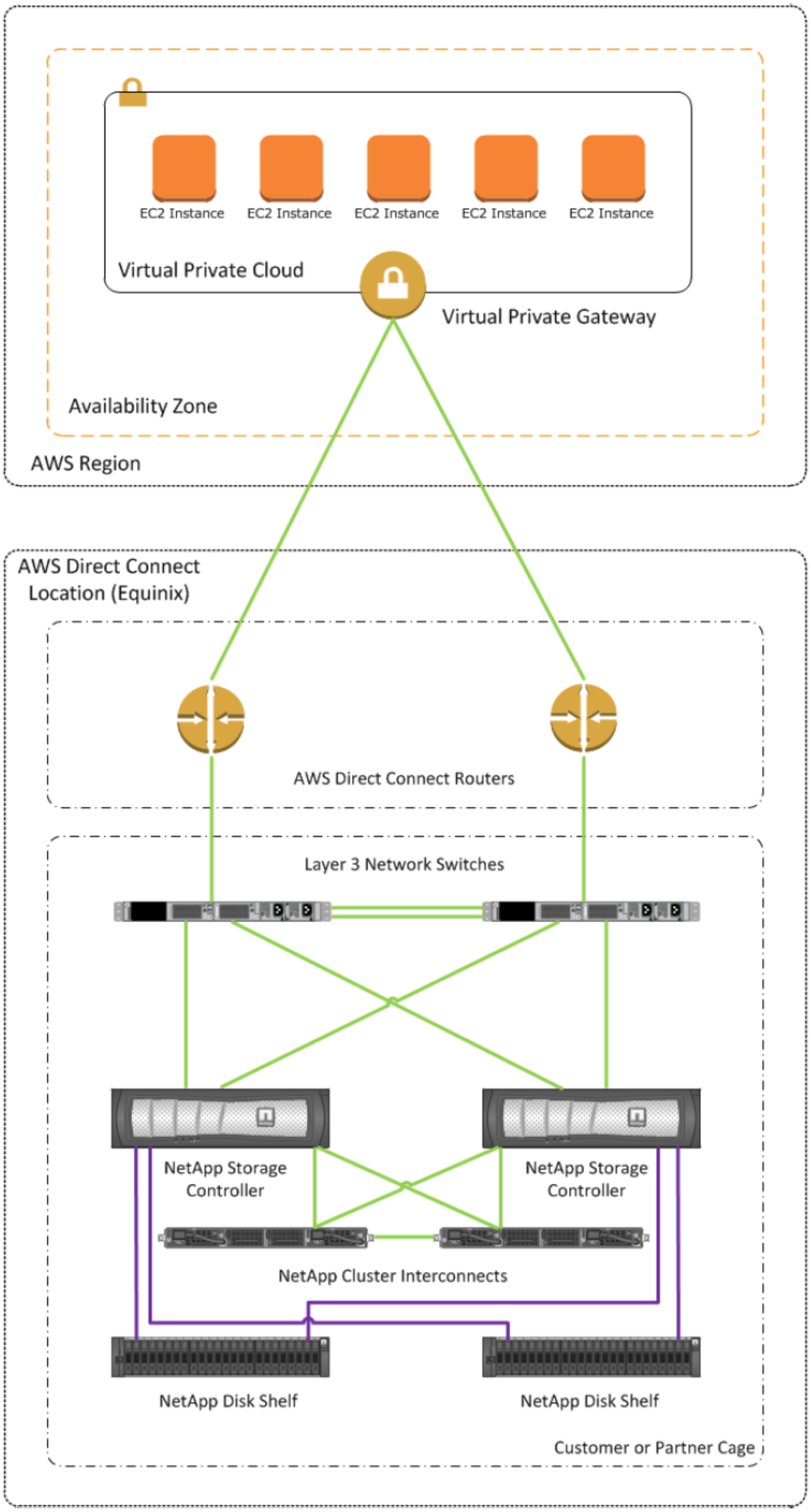
3.3 Solution Architecture

The solution architecture consists of the following components:

- AWS EC2
- AWS VPC
- AWS Direct Connect
- Equinix colocation data center (AWS Direct Connect data center)
- Equinix Cloud Exchange
- Border Gateway Protocol (BGP)
- Customer-provided layer 3 network equipment
- NetApp storage (FAS and NetApp FlexArray™ software)
- Solution architecture diagrams

Figure 3 shows the architecture of the NetApp Private Storage for AWS solution.

Figure 3) NetApp Private Storage for AWS.



3.4 References

NetApp Private Storage for AWS Solution Architecture

NVA-0009: NetApp Private Storage for Public Cloud for AWS

4 Introduction to NetApp Cloud ONTAP

4.1 Overview

NetApp Cloud ONTAP for AWS is a software-only storage appliance that runs the NetApp clustered Data ONTAP storage OS in the cloud. Cloud ONTAP manages general-purpose Amazon Elastic Block Storage (GP2 EBS) with clustered Data ONTAP and provides enterprise-class features on top of EBS. This gives the customer access to NFS, CIFS, and iSCSI protocol support as well as to a rich feature set that enhances the management and efficiency of your storage. Customers also have access to industry-leading technologies such as NetApp SnapMirror and NetApp SnapVault data replication that enable seamless connectivity for hybrid cloud resources.

Cloud ONTAP is launched and managed using the NetApp OnCommand® Cloud Manager application. Cloud Manager is a web front end that enables the deployment and management of AWS public cloud resources associated with Cloud ONTAP. Cloud Manager provides a flexible, intuitive interface for activities such as deploying Cloud ONTAP working environments, intelligent allocation of additional AWS EBS storage, creation of NetApp flexible volumes, and so on.

Cloud Manager can be deployed several different ways, including:

- Into your local data center from the NetApp Support Software downloads site
- Into an existing EC2 instance running a supported version of Windows
- From the AWS Marketplace from an AMI into an EC2 instance

Refer to the OnCommand Cloud Manager Installation and Setup Guide and the OnCommand Cloud Manager User Guide for more information.

Amazon Web Services Virtual Private Cloud

Amazon Web Services allows customers to create logically isolated areas called VPCs within an EC2 environment. A VPC gives customers a secure container for the deployment and management of EC2 resources. When connected by an IPsec-based VPN, a VPC acts as an extension to a local data center, with security controls handled at several access points. Cloud ONTAP must be deployed within an AWS VPC and subnet. Deployments into AWS EC2 Classic are not supported.

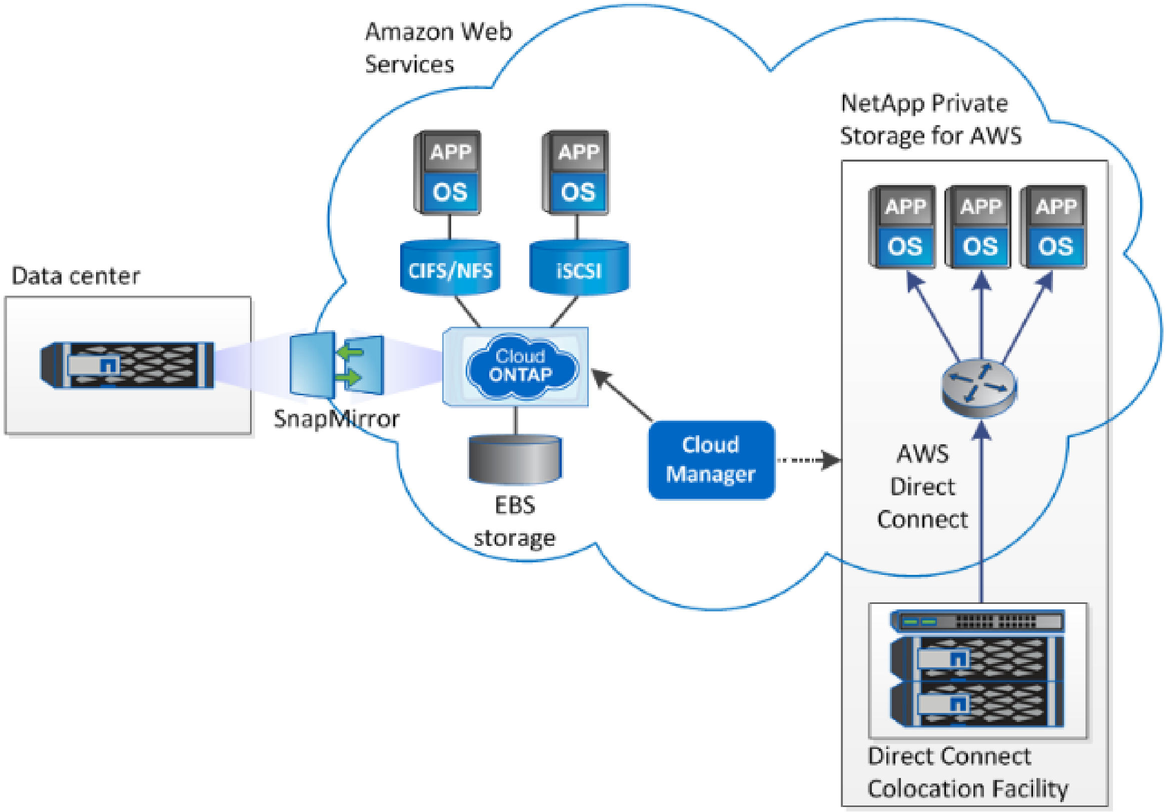
Cloud ONTAP Benefits and Use Cases

- Deploy new storage systems in minutes
- Leverage elastic cloud compute
- Multiprotocol in the cloud
- Data mobility: move data into and out of the cloud
- Disaster recovery
- On-demand test/dev

4.2 Solution Architecture

Figure 4 depicts the Cloud ONTAP architecture in AWS. Note that Cloud Manager is necessary to manage Cloud ONTAP in AWS. Optionally, Cloud Manager can also be used to manage NPS (hence the dotted line).

Figure 4) Cloud ONTAP high-level architecture.



4.3 References

TR-4352: Networking Configurations for NetApp Cloud ONTAP for Amazon Web Services

5 Introduction to NetApp FlexPod

5.1 Overview

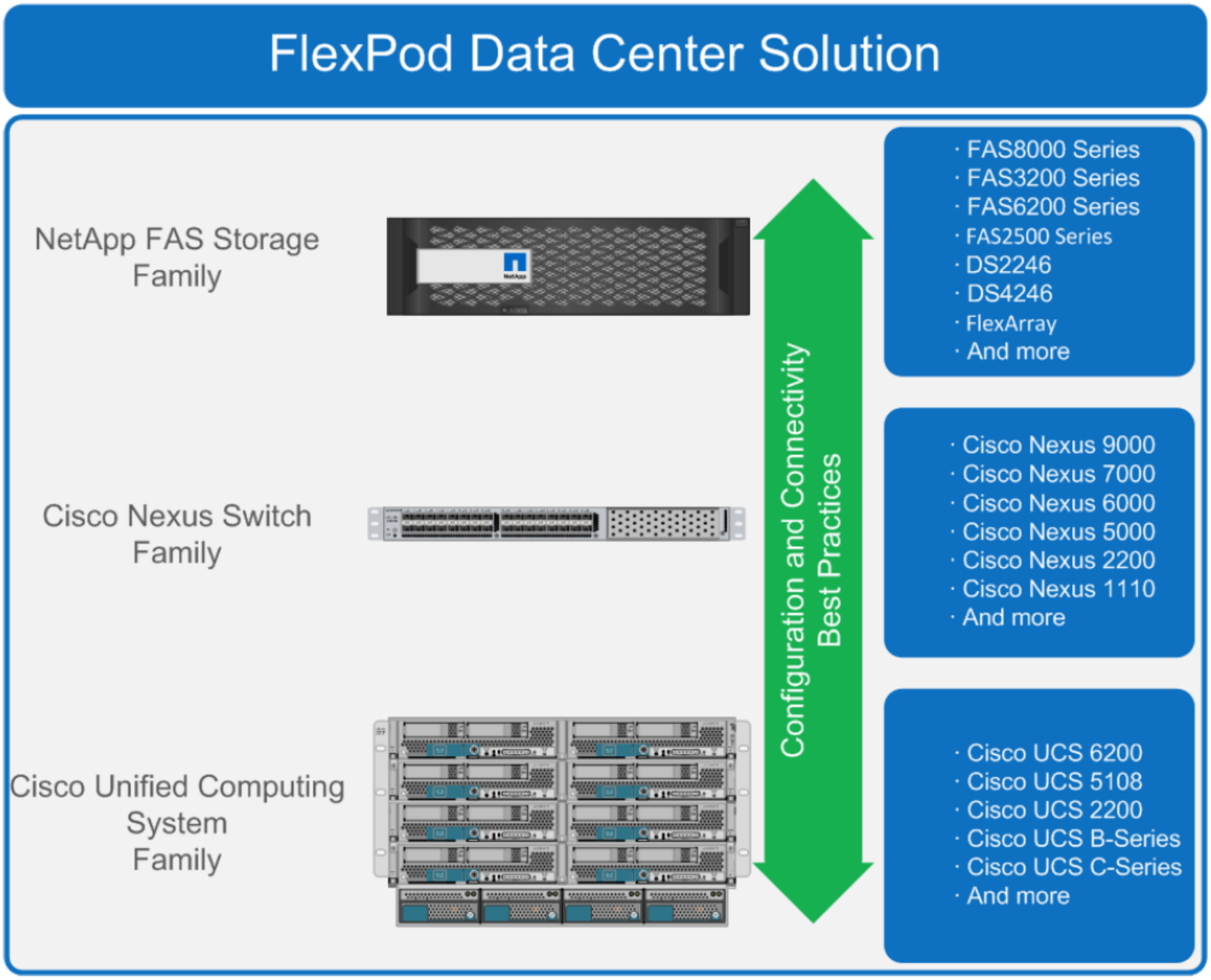
FlexPod is a best practice data center architecture with a validated, standardized configuration. It can be optimized to fit a variety of mixed application workloads and use cases as the customer moves to virtualization and private or public cloud environments. It is built on three components:

- Cisco Unified Computing System™ (Cisco UCS®)
- Cisco Nexus® switches
- NetApp Fabric-Attached Storage (FAS) systems

These components are connected and configured according to both Cisco and NetApp best practices and they provide the ideal platform for running a variety of enterprise workloads with confidence. The NetApp FlexPod® platform can scale up for greater performance and capacity (by adding compute, network, or storage resources individually as needed), or it can scale out for environments that need multiple consistent deployments (by rolling out additional FlexPod stacks). FlexPod delivers a baseline configuration and also has the flexibility to be sized and optimized to accommodate many different use cases.

Typically, the more scalable and flexible a solution is, the more difficult it becomes to maintain a single unified architecture capable of offering the same features and functionality across each implementation. This is one of the key benefits of FlexPod. Each of the component families shown in Figure 5 (Cisco UCS, Cisco Nexus, and NetApp FAS) offers platform and resource options to scale the infrastructure up or down while supporting the same features and functionality that are required under the configuration and connectivity best practices for FlexPod.

Figure 5) FlexPod component families.



The deployment uses standard recommendations from the FlexPod Validation Guides (see the links below) to configure the infrastructure.

5.2 References

FlexPod Datacenter DesignZone

FlexPod Datacenter Design and Deployment Guides

6 Introduction to Cisco Intercloud Fabric

6.1 Overview

Cisco Intercloud Fabric for Business gives you choices. You choose how much added capacity you need and when you need it; you can choose one or a group of providers, and you choose the rules that govern access and use of this extension of your data center. You also choose when you use your capacity so you can easily provide for peak times.

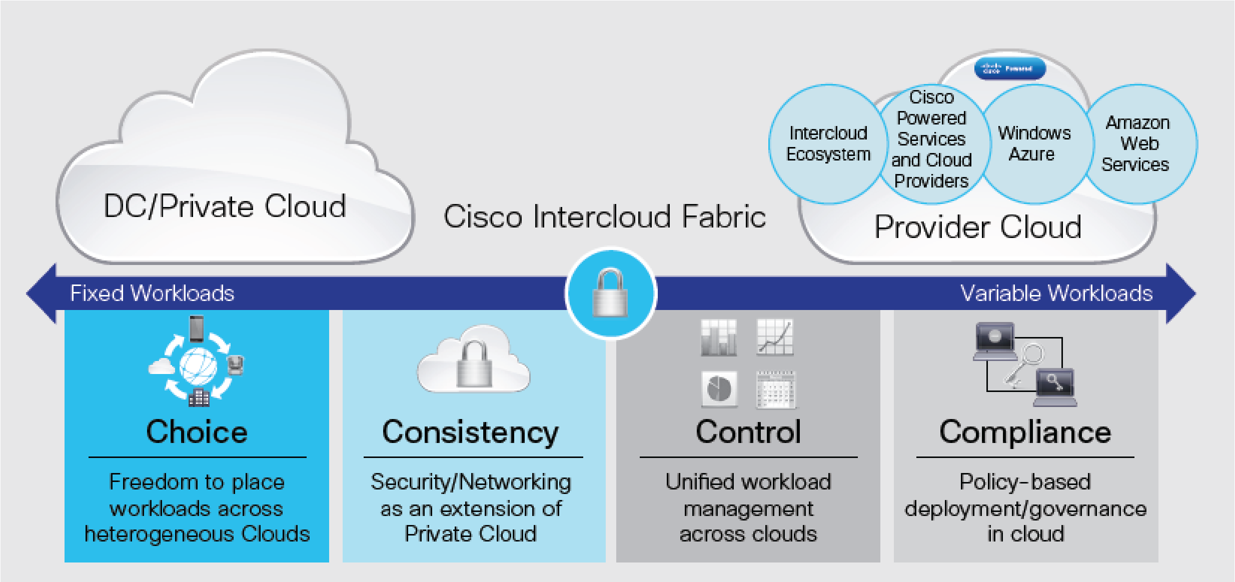
Cisco Intercloud Fabric for Business also gives you a unified system based on a single data center fabric. Applications don't know where the on-premises system ends and the cloud system begins, but you will have all the visibility you need to manage the application and the hybrid cloud infrastructure.

With Cisco® Intercloud Fabric for Business, you can extend your data center or private cloud to the public cloud, allowing you to acquire the added capacity you need, with no demarcation between your internal cloud and the external one. You can also integrate your private cloud with clouds run by more than one service provider, with consistent network and security policies across private and public clouds, With Cisco Intercloud Fabric for Business, you get the agility, capacity you need, as well as security and control.

6.2 Intercloud Fabric Components and Features

Figure 6 shows the Cisco Intercloud Fabric architecture. Figure 7 illustrates its main services, and Table 4 describes the services.

Figure 6) Cisco Intercloud Fabric.



DC/Private Cloud
Cisco Intercloud Fabric
Intercloud Ecosystem
Cisco Powered Services and Cloud Providers
Windows Azure
Amazon Web Services
Provider Cloud
Fixed Workloads
Variable Workloads
Choice
Freedom to place workloads across heterogeneous Clouds
Consistency
Security/Networking as an extension of Private Cloud
Control
Unified workload management across clouds
Compliance
Policy-based deployment/governance in cloud

Figure 7) Cisco Intercloud Fabric services.

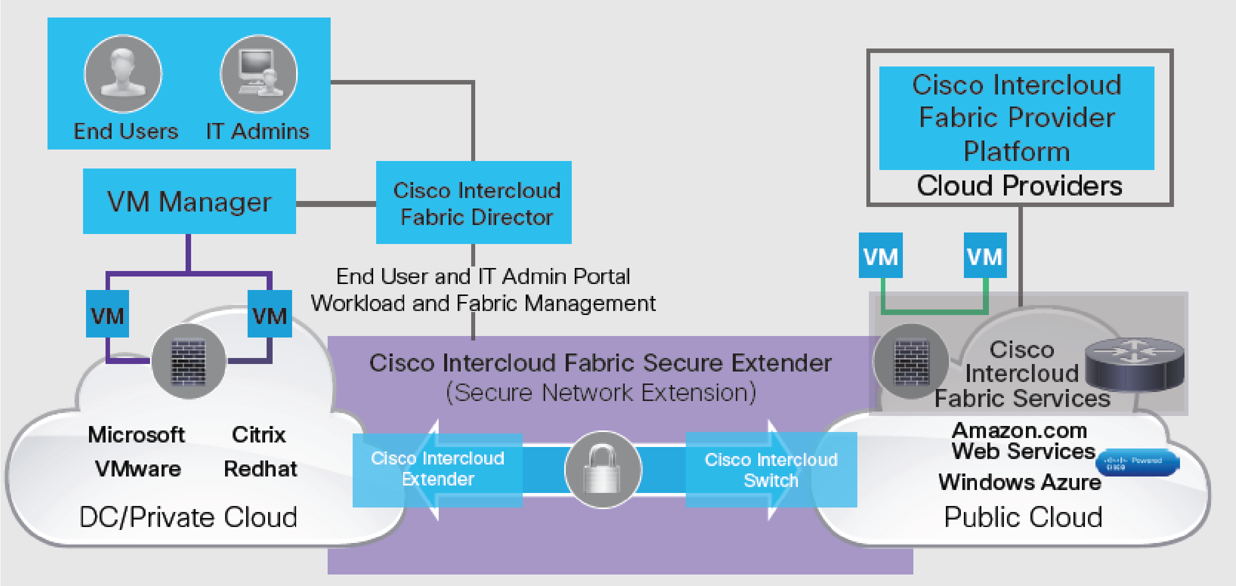

End Users
IT Admins
VM Manager
Cisco Intercloud Fabric Director
Cisco Intercloud Fabric Provider Platform
Cloud Providers
VM
VM
VM
VM
End User and IT Admin Portal
Workload and Fabric Management
Cisco Intercloud Fabric Secure Extender
(Secure Network Extension)
Cisco Intercloud Fabric Services
Microsoft
Citrix
VMware
Redhat
DC/Private Cloud
Cisco Intercloud Extender
Cisco Intercloud Switch
Amazon.com Web Services
Windows Azure
Public Cloud

Table 4) ICF main services.

Component Name	Description
Cisco Intercloud Fabric Secure Extender	Cisco Intercloud Fabric Secure Extender provides enterprise with secure extension to public clouds. It is integrated with links to several public cloud providers. Cisco offers Cisco Intercloud Fabric for Providers so that additional service providers can quickly integrate their environments with the Cisco solution to create a hybrid cloud offering.
Cisco Intercloud Fabric Director	Cisco Intercloud Fabric has an end-user and IT portal, Cisco Intercloud Fabric Director, for administration and management of the public cloud extension. This single console manages a company's private and hybrid clouds, and it is used for managing cloud network services and cloud virtual machine lifecycles. Cisco Intercloud Fabric provides open APIs, which allow integration of third-party management tools. Additional management systems can provide advanced application deployment, monitoring, and assurance, as well as enforcement of business policies and compliance for network and security policies.

Cisco Intercloud Fabric for Business consists of the Secure Extender and Director components. The solution is supported by Cisco Virtual Security Gateway (VSG) and Cisco Cloud Services Router (CSR) solutions.

6.3 Intercloud Fabric Use Cases

- **Capacity augmentation**: During the year, you may need more capacity, for example, during peak shopping seasons, or more computing power to generate quarterly reports. You also may need more capacity when your contact center is handling a peak numbers of calls and needs more support from your data center, or when you're opening a new facility that strains your existing data center. With Cisco Intercloud Fabric for Business, the capacity you add will be indistinguishable from what your own data center already provides. In this hybrid cloud, the public and private systems merge transparently, both in what your employees can do using it, and in your management of it.
- **Development and testing**: Your encapsulated data center in a public cloud is an excellent place to test and develop new software. Development and testing don't drain data center resources that your

company needs for day-to-day operations, and when you’re finished, it is easy to move the new software into your regular operations because the environment in which it was tested is the same as your existing production environment.

- **Disaster recovery**: If a disaster occurs, having your applications and basic data center configuration available in a transparent extension of your on- premises data center will let you regenerate your policies and rules, recover much of your data, and continue to work even if your primary data center is down for some time.

6.4 References

Cisco Intercloud Fabric Main Page

7 NetApp and Cisco ICF Solution Architecture

This section describes the architecture for NetApp Private Storage, NetApp Cloud ONTAP, and Cisco Intercloud Fabric solutions, integrations of these technologies, case studies, deployment procedures, and validations.

7.1 Solution Architecture Components

The solution architecture includes the following components:

- NetApp storage (FAS)
- NetApp Cloud ONTAP
- Equinix colocation data center (NPS)
- Cisco Nexus 3048 and 5548
- Cisco ICF (including ICFD, PNSC, VSM, and CSR)
- AWS default VPC (required by ICF)
- AWS EC2
- AWS Direct Connect
- AWS EBS (Cloud ONTAP only)
- BGP
- GRE
- NAT
- VMware ESXi™
- VMware vCenter™

The architecture components listed previously are not needed in each phase; they are a consolidated list for the completed integrated solution of NPS, Cloud ONTAP, and ICF. As each phase is built, the minimum required components are referenced again for clarification.

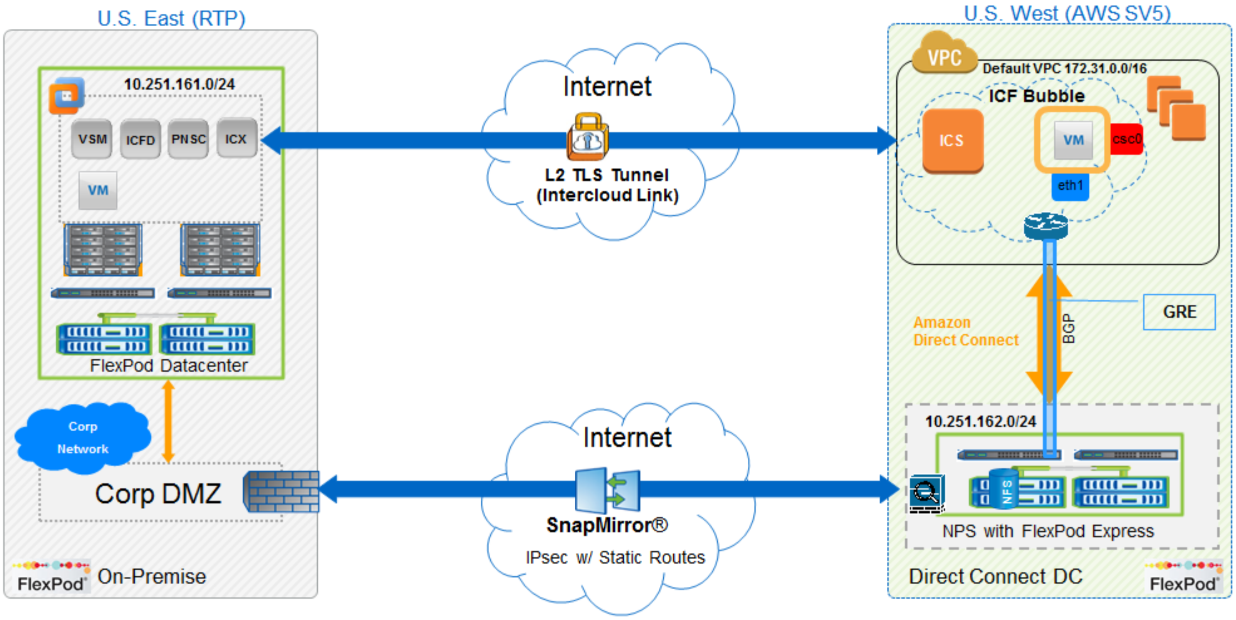
7.2 Integration

This solution integrates three product offerings from NetApp and Cisco: NPS, Cloud ONTAP, and Cisco Intercloud Fabric. Each product is depicted individually and finally as a single architecture. Figure 8 shows a high-level architectural diagram with the different components integrated together.

The VLANs that are shown are:

- On-premises VLAN—10.251.161.0/24
- NPS AWS VLAN—10.251.162.0/24
- AWS default VPC VLAN—172.31.0.0/16

Figure 8) NetApp and Cisco ICF architecture.

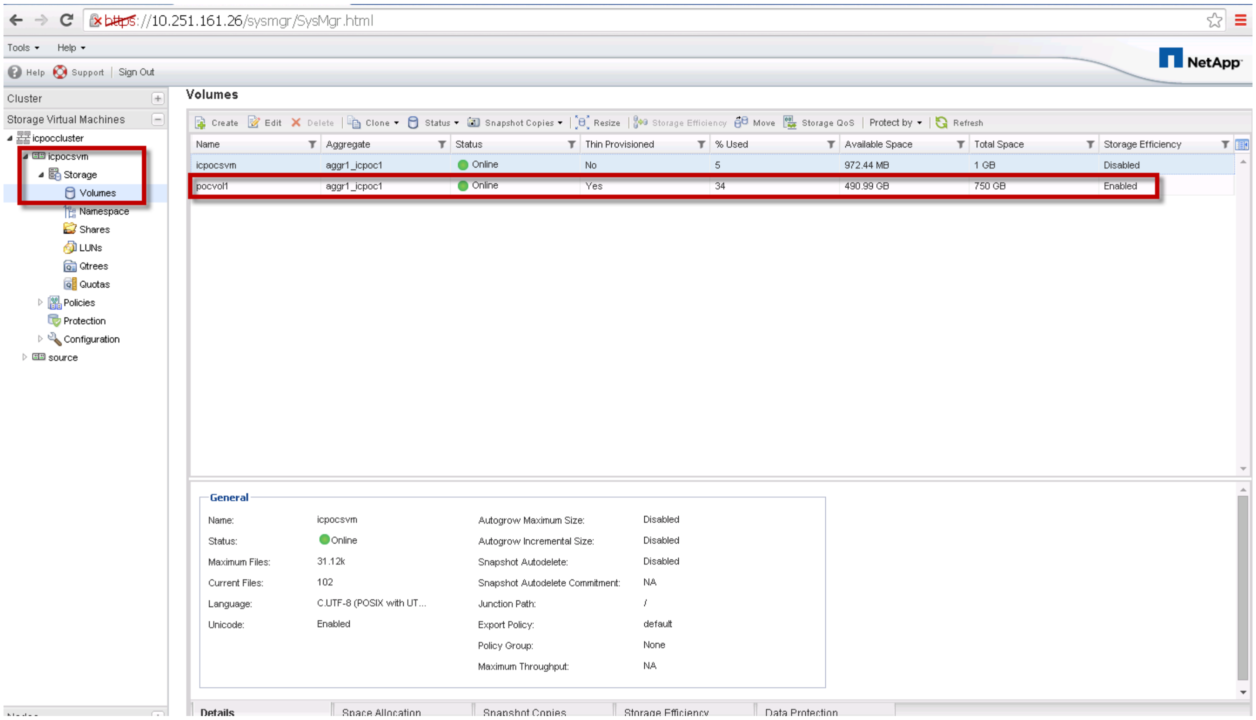


Note: The deployment guides describe a base FlexPod installation and configuration process and do not detail the additional components necessary for deploying ICF. However, the additional components are deployed as part of the on-boarding process because they are standard components, such as VLANs, VMKernel, port-groups, SVMs, LIFs, and so on. The screenshots of the components as they pertain to the ICF deployment are shown in subsequent sections.

We have a storage virtual machine (SVM) at the enterprise site with an NFS volume for hosting all the ICF infrastructure components: ICFD, PNSC, VSM, ICX, and so on.

Figure 9 shows the SVM with the NFS volume that is mounted on all the ESXi hosts.

Figure 9) NFS volume at the enterprise site.



Volumes

Name	Aggregate	Status	Thin Provisioned	% Used	Available Space	Total Space	Storage Efficiency
icpocsvm	aggr1_icpoc1	● Online	No	5	972.44 MB	1 GB	Disabled
pocvol1	aggr1_icpoc1	● Online	Yes	34	490.99 GB	750 GB	Enabled

General

Name:	icpocsvm	Autogrow Maximum Size:	Disabled
Status:	● Online	Autogrow Incremental Size:	Disabled
Maximum Files:	31.12k	Snapshot Autodelete:	Disabled
Current Files:	102	Snapshot Autodelete Commitment:	NA
Language:	C.UTF-8 (POSIX with UT...	Junction Path:	/
Unicode:	Enabled	Export Policy:	default
		Policy Group:	None
		Maximum Throughput:	NA

Note: Some of the FlexPod on-premises components (Cisco UCS and Cisco Nexus) are not necessary to accomplish the case studies in this TR. NetApp storage, however, is needed as an overall hybrid cloud strategy for DR and data storage mobility because SnapMirror is imperative.

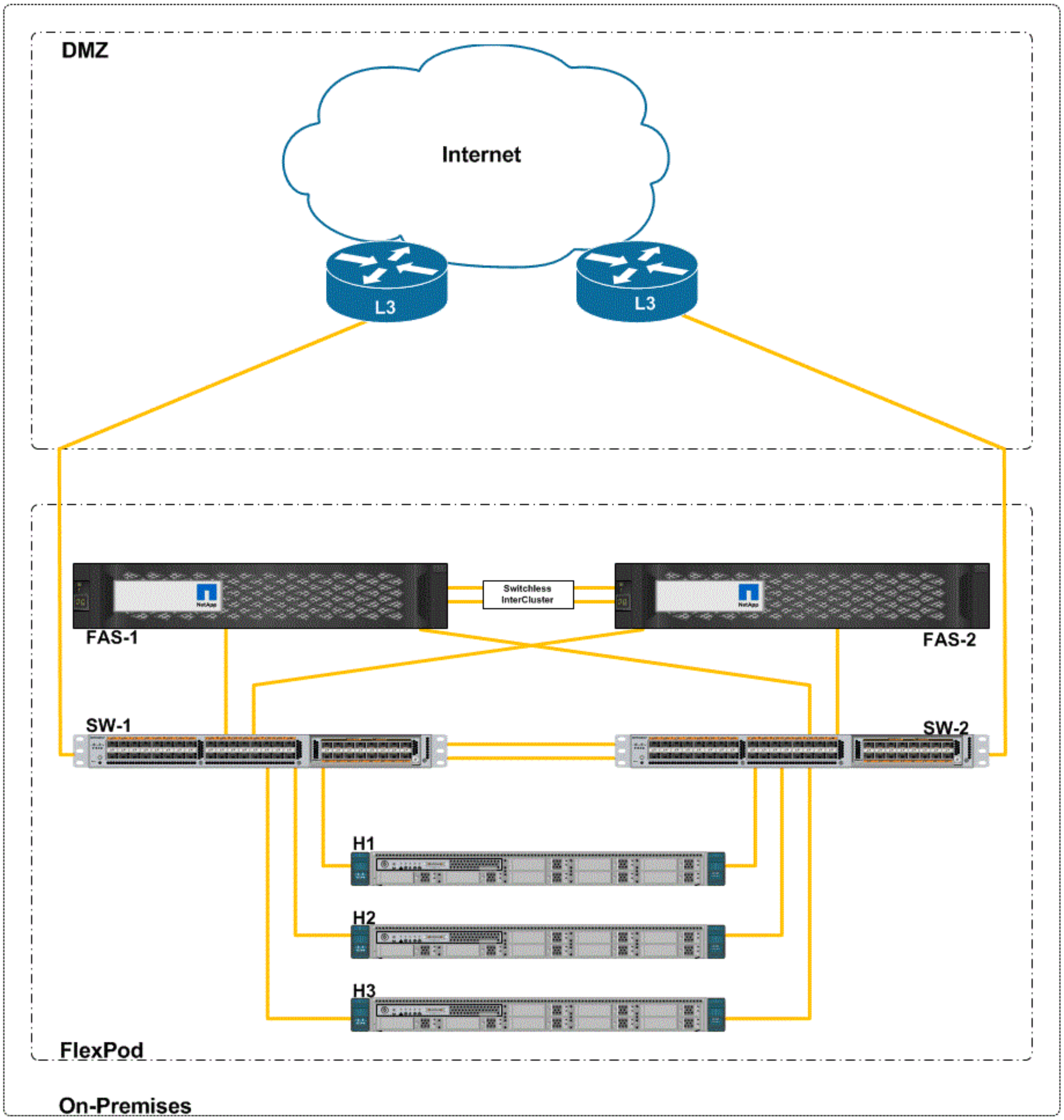
Assumptions

The on-premises FlexPod platform, as noted in Figure 10, has direct connectivity to our enterprise DMZ infrastructure. Your environment's connectivity might vary; however, as long as routing is operating properly for ICF to reach AWS, the outcome will be the same. An additional assumption is that the storage is properly configured for SnapMirror to reach NPS or Cloud ONTAP.

On-Premises FlexPod Network Architecture

Figure 10 shows the on-premises FlexPod network architecture diagram. Connectivity between the FlexPod and the DMZ is layer 3, and static routing is used to exchange routes between the two environments.

Figure 10) On-premises FlexPod network architecture.



VLAN Configuration

Table 5 shows the VLANs and corresponding IP addresses provisioned on the on-premises FlexPod configuration. The number of VLANs needed in production varies depending on the environment. The on-premises VLAN is 10.251.161.0/24 and subnets of the VLAN were created to further aid in traffic segregation.

Table 5) On-premises FlexPod VLAN and IP assignments.

VLAN/Interfaces	IP Address	VLAN Name
10	10.251.161.0/27	D09-MGMT-10.251.161.0/27

VLAN/Interfaces	IP Address	VLAN Name
20	10.251.161.32/27	D09-TUNL-10.251.161.32/27
1000	10.251.161.64/27	D09-NFS-10.251.161.64/27
1002	10.251.161.128/27	D09-INTG-10.251.161.128/27
103	10.251.240.40/29	DMZ-P2P-10.251.240.40/29

VLANs in Table 1 are used as follows:

- **VLAN10**. This is the “management” VLAN and is used in the enterprise site for all in-band host management, including ESX® hosts, vCenter, ICFD, PNSC, and VSM. This management VLAN can also be used as the ICF link tunnel VLAN (ICL), but it is recommended to separate the management traffic from the tunnel traffic.
- **VLAN20**. This is the tunnel VLAN that is dedicated for the ICF link tunnel provisioning. Although not mandatory, it’s recommended to separate the management and ICL traffic.
- **VLAN1000**. This VLAN is specifically used for NFS storage traffic at the enterprise site, and is configured on the storage and server trunk interfaces.
- **VLAN1002**. This VLAN is configured on the servers for user-facing traffic. We refer to it as Integration (Intg) but this is typically referred to as app VLAN or the workload VLAN. This VLAN is the primary VLAN used to extend to the AWS part of the ICF validation.
- **VLAN103**. This is the Point2Point VLAN for layer 3 connectivity to our enterprise DMZ. There are no restrictions on using options such as switch virtual interface (SVI), P2P interfaces, or subinterfaces.

IP Addresses

There are no specific requirements for subnet sizes for ICF deployment. It is recommended that the in-band management subnet have sufficient of IPs to accommodate your environment and ICF virtual appliances. Depending on your deployment, plan at least five IP addresses for ICF without HA deployment.

If you choose the option to use a separate VLAN for ICF tunnel, additional IP addresses are needed. ICF tunnels require a pair of IP addresses per tunnel, so plan accordingly.

Routing

The Cisco Nexus 5548 switches handle all VLAN layer 3 interfaces and routing. The switches are licensed with enterprise features.

To aid simplicity, we opted to use static routing with the DMZ. We advertise the enterprise VLAN—10.251.161.0/24—and receive the default route from the DMZ. BGP and other routing protocols are possible depending on the environment.

Physical Servers

Three physical top-of-rack (ToR) servers are used for our validation. For FlexPod Datacenter your options are UCS C-Series (ToR) or Chassis; we opted to use ToR because of availability, not for technical reasons. Any Cisco UCS servers in a FlexPod configuration can be used for deploying the infrastructure.

VMware ESX

ICF requires minimum ESX and vCenter versions for successful deployment. Reviews of Cisco’s supported versions for ICF deployment and details of the latest ICF release notes and deployment guides are available on the Cisco ICF website. Table 5 shows the versions that were used for this validation.

Table 6) Components.

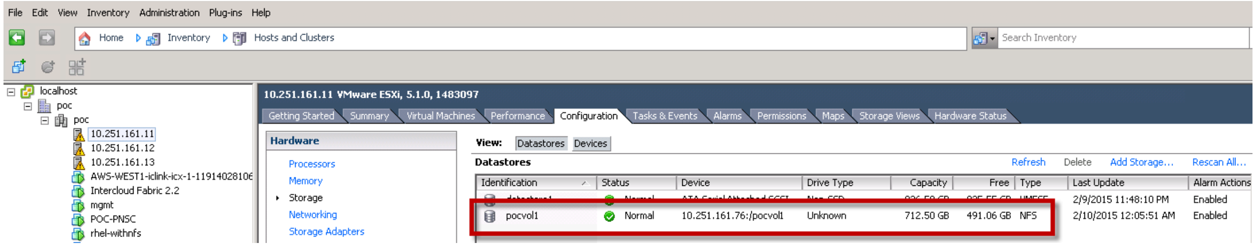
Component	Version
ESXi	5.1 with VMware
vCenter	vCenter appliance 5.1 update 2a
Data ONTAP	Data ONTAP 8.3

Note: If the environment runs different versions, then verify the interoperability of the different components using the NetApp Interoperability Matrix (IMT). Also verify the minimum requirements for ICF.

Note: Deploy the ESXi hosts according to the FlexPod data center design and deployment guides. Also follow the best practices that are documented in TR-4068: VMware vSphere on NetApp Clustered Data ONTAP Best Practices.

Figure 11 shows the ESXi hosts used for deploying the ICF infrastructure. All servers are identical in configuration and have the NFS volume mounted on them. Multiple servers are used to demonstrate the distributed nature of ICF as long as the VLANs are extended to all hosts.

Figure 11) ESX hosts with the mounted NFS volume.



10.251.161.11 VMware ESXi, 5.1.0, 1483097

Datastores

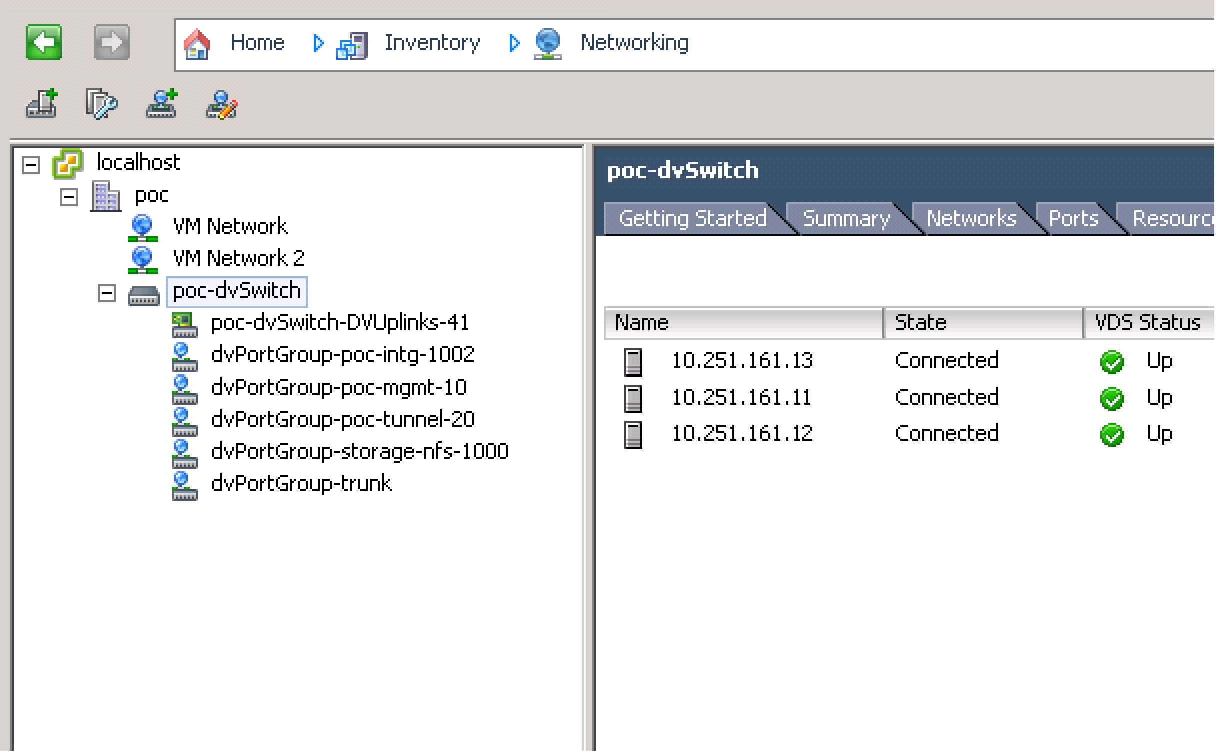
Identification	Status	Device	Drive Type	Capacity	Free	Type	Last Update	Alarm Actions
datastore1	Normal	ATA Serial Attached SCSI	Non-SSD	[illegible]	[illegible]	[illegible]	2/9/2015 11:48:10 PM	Enabled
pocvol1	Normal	10.251.161.76:/pocvol1	Unknown	712.50 GB	491.06 GB	NFS	2/10/2015 12:05:51 AM	Enabled

VMware Networking Configuration

This validation uses a VMware vSphere® Distributed Switch (vDS) deployment for the configuration on the enterprise side. All the ESXi hosts are part of the enterprise vDS, and all the VLAN port-groups are defined on the vDS.

Figure 12 shows the VMware vDS port-group configuration on the enterprise side. View the different port-groups with the appropriate VLANs defined for each of them.

Figure 12) VMware vDS configuration on the enterprise side.

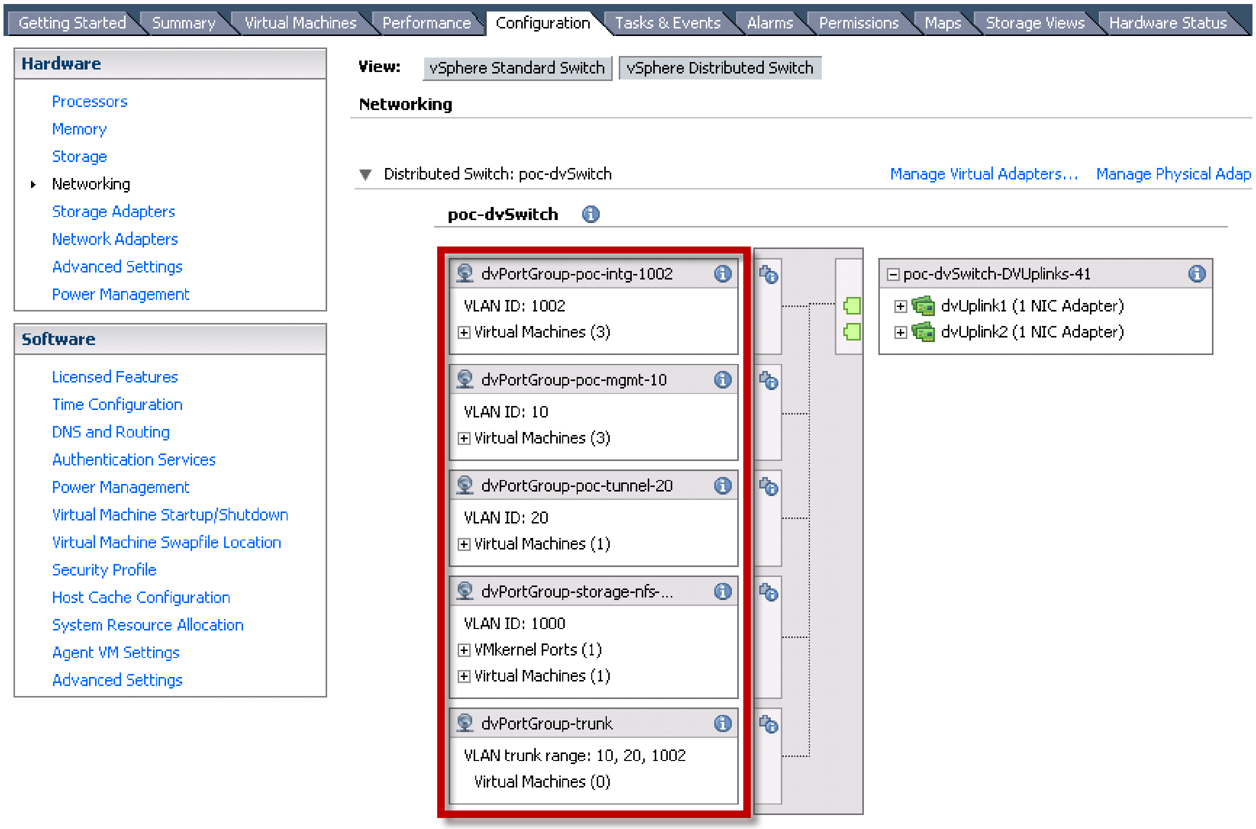


localhost
poc
VM Network
VM Network 2
poc-dvSwitch
poc-dvSwitch-DVUplinks-41
dvPortGroup-poc-intg-1002
dvPortGroup-poc-mgmt-10
dvPortGroup-poc-tunnel-20
dvPortGroup-storage-nfs-1000
dvPortGroup-trunk

Name	State	VDS Status
10.251.161.13	Connected	✓ Up
10.251.161.11	Connected	✓ Up
10.251.161.12	Connected	✓ Up

Figure 13 shows a view of the port-group configuration on a specific ESXi host.

Figure 13) vDS port provisioning.



Distributed Switch: poc-dvSwitch

poc-dvSwitch

dvPortGroup-poc-intg-1002
VLAN ID: 1002
Virtual Machines (3)

dvPortGroup-poc-mgmt-10
VLAN ID: 10
Virtual Machines (3)

dvPortGroup-poc-tunnel-20
VLAN ID: 20
Virtual Machines (1)

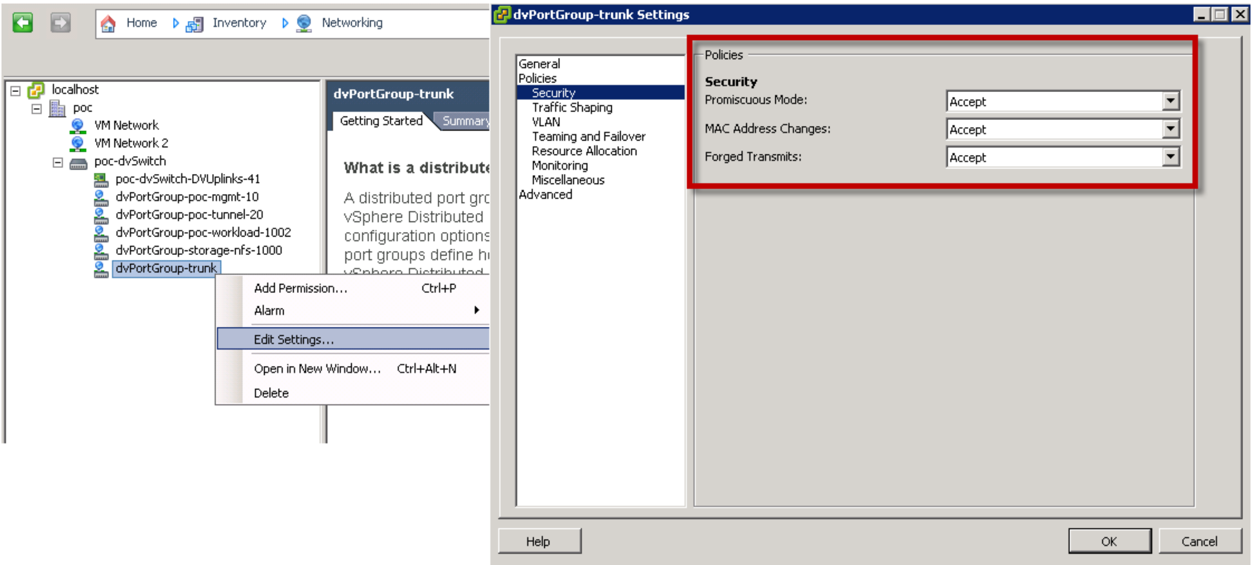
dvPortGroup-storage-nfs-...
VLAN ID: 1000
VMkernel Ports (1)
Virtual Machines (1)

dvPortGroup-trunk
VLAN trunk range: 10, 20, 1002
Virtual Machines (0)

poc-dvSwitch-DVUplinks-41
dvUplink1 (1 NIC Adapter)
dvUplink2 (1 NIC Adapter)

Note: In the security policies screen for the trunk port-group on the VMware virtual switch, set Promiscuous Mode, MAC Address Changes, and Forged Transmits to Accept in the VMware vSphere GUI. This requirement is applicable only if you use a VMware virtual switch and a distributed switch; it does not apply if you use a Cisco Nexus 1000V switch. The ICF installation will not succeed if the parameters are not set to "Accept." Make sure that these changes do not affect your enterprise security policies.

Figure 14) VMware vDS security policy configuration for ICF.



Policies

Security

Promiscuous Mode: Accept

MAC Address Changes: Accept

Forged Transmits: Accept

8 NetApp Private Storage for AWS

Typically, there is no requirement for servers (compute) in the NPS architecture at the colocation facility. As such, our deployment has all the necessary components to build the NPS to leverage AWS compute and create the necessary VPN tunnels back to the enterprise. The configuration of the NetApp arrays at the colocated site is similar to that of the enterprise, and it follows the guidelines for installing and configuring FlexPod Express that are detailed in the TR.

This section describes the NPS deployment relevant to the overall solution integration. For an in-depth NPS deployment workflow and step-by-step guide, refer to TR-4133: NetApp Private Storage for AWS Solution Architecture and Deployment Guide.

8.1 Deployment Workflow and Assumptions

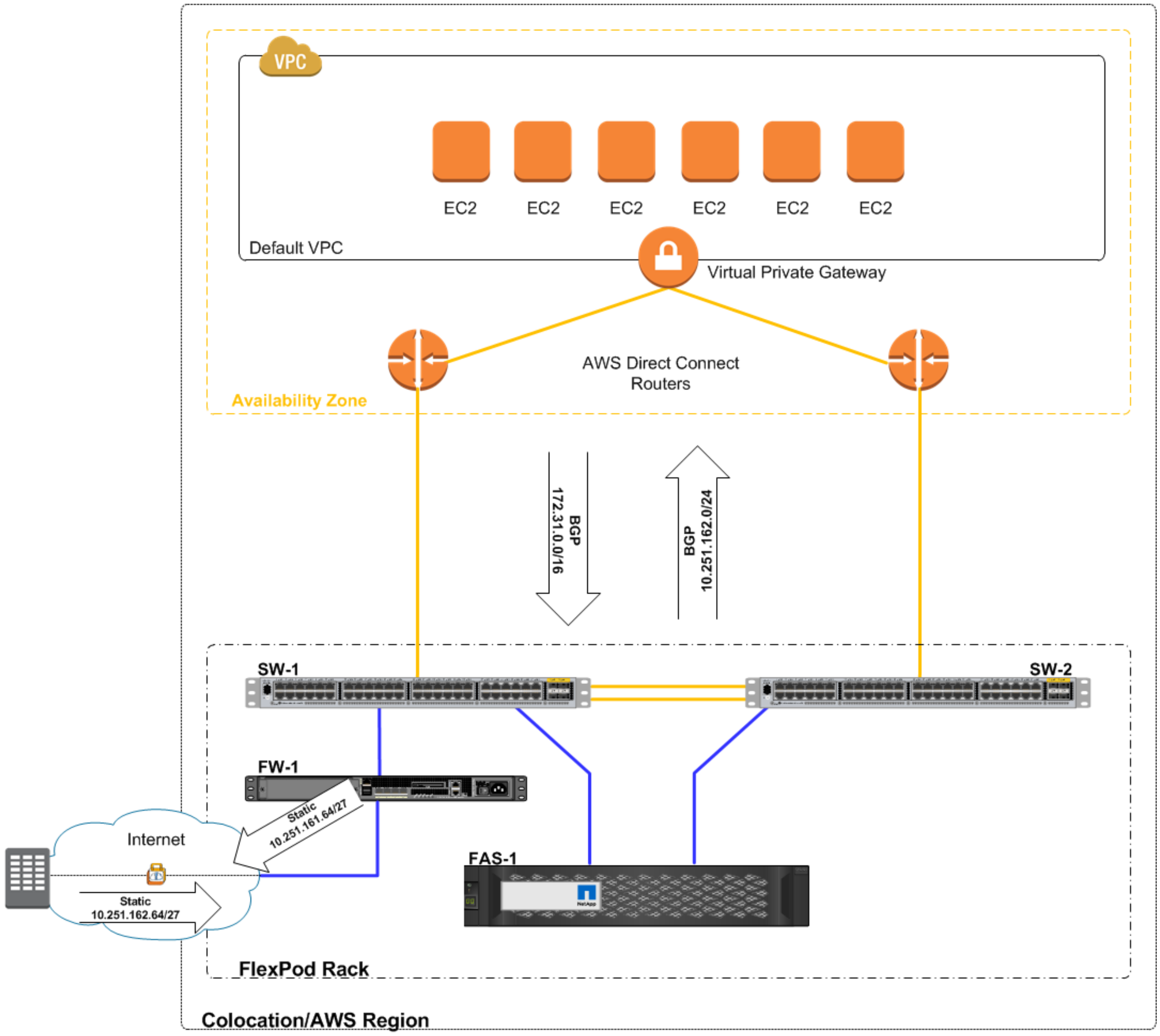
The workflow for deploying NPS for AWS includes the following tasks and assumptions:

1. An AWS account with the access key credentials.
2. Default VPC (this is a Cisco ICF requirement; NPS is compatible with all VPC types). If the default VPC is deleted, AWS Support can recreate it.
3. A Direct Connect service. This can be either 1G or 10G or single or dual connections for redundancy and HA.
4. BGP routing for Direct Connect. This is the only protocol supported by AWS.
5. Internet connectivity for VPN tunnel back to the enterprise. This tunnel is used for SnapMirror and NPS management. P2P and other WAN connectivity to the enterprise are also an option, but typically higher costs are associated with these options. Internet services are provided by any local provider to the colocation (Equinix) site or from Equinix as an OOB management service.
6. Hardware to support VPN tunnel back to the enterprise. We used an ASA5510, but any other device with VPN support suffices.
7. VPN tunnel to NPS permitting necessary subnets and TCP ports for SnapMirror. In addition to SnapMirror we also permit ICMP and SSH for troubleshooting purposes. SnapMirror ports are TCP 11104 and 11105.

8.2 NPS Network Architecture

Figure 15 shows the NPS diagram with FlexPod Express and Cisco ASA5510 for VPN connectivity back to the enterprise. It also shows connectivity to AWS through Direct Connect and Virtual VGW to the default VPC.

Figure 15) NPS network architecture.



VLAN Configuration

Table 7 shows the VLANs and corresponding IP addresses provisioned at the Direct Connect data center. The NPS-assigned subnet block is 10.251.162.0/24; the block is broken into smaller subnets for other network services. Other IP addresses are used for P2P links for NPS and AWS connectivity.

Table 7) NPS VLAN and IP assignments.

VLAN/Interfaces	IP Address	Description
10	10.251.162.160/27	SV5-MGMT-10.251.162.160/27
1000	10.251.162.64/27	SV5-NFS-10.251.162.64/27
Eth2.1.100	169.254.253.16/30	AWS-P2P-169.254.253.16
Eth1/1	192.168.254.252/30	FW1-P2P-192.168.254.252/30

IP Addresses

NPS and ICF don't require any specific IP addressing scheme; the only requirement is that NPS-assigned addresses must be reachable from AWS through Direct Connect. Typically, addresses in AWS and NPS use RFC 1918 ranges. We suggest that you plan your address assignments to avoid any overlap conflicts with enterprise ranges.

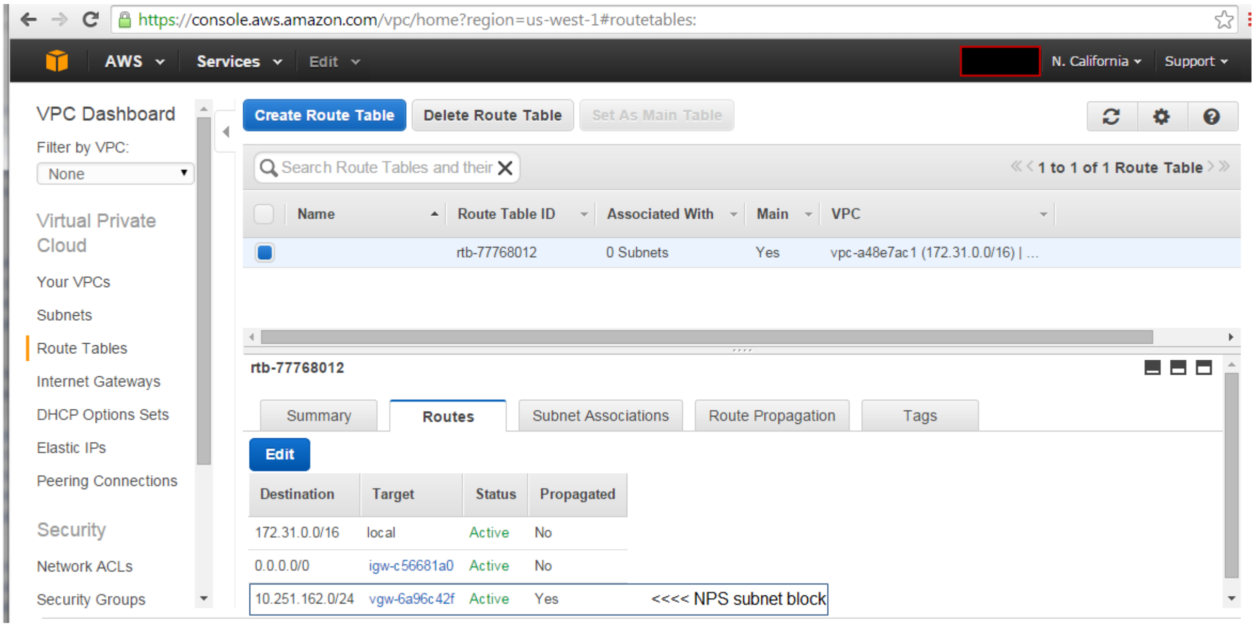
8.3 Routing

Routing protocols are selected based on requirements and convenience. For this deployment, for example, we used static routes between NPS and the enterprise. Routing between NPS and AWS requires BGP; this requirement stems from AWS for any type of Direct Connect service.

As seen in Figure 16, we're accepting 172.31.0.0./16 from AWS and advertising 10.251.162.0/24 from NPS. The NPS subnet is broken into smaller chunks to accommodate multiple VLANs, as noted in Table 7.

We're accepting /27 from the enterprise FlexPod DC and sending /27. These subnets are specific to permit SnapMirror relationships between the two locations.

Figure 16) AWS routing table.



https://console.aws.amazon.com/vpc/home?region=us-west-1#routetables:

[redacted]

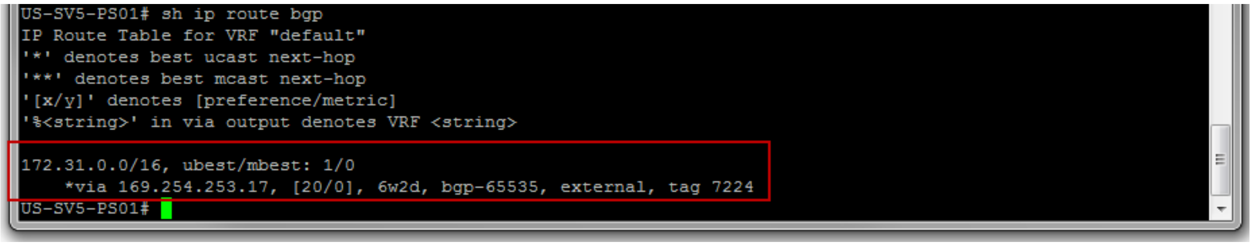
Name	Route Table ID	Associated With	Main	VPC
	rtb-77768012	0 Subnets	Yes	vpc-a48e7ac1 (172.31.0.0/16) | ...

rtb-77768012

Destination	Target	Status	Propagated
172.31.0.0/16	local	Active	No
0.0.0.0/0	igw-c56681a0	Active	No
10.251.162.0/24	vgw-6a96c42f	Active	Yes

<<<< NPS subnet block

Figure 17) NPS routing table.



```
US-SV5-PS01# sh ip route bgp
IP Route Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

172.31.0.0/16, ubest/mbest: 1/0
    *via 169.254.253.17, [20/0], 6w2d, bgp-65535, external, tag 7224
US-SV5-PS01#
```

8.4 Replication and Data Protection

SnapMirror technology offers a fast and flexible enterprise solution for mirroring or replicating data over local area networks (LANs) and wide area networks (WANs). SnapMirror is a key component in enterprise data protection strategies.

Replication can be performed within the same cluster or remotely to another cluster. NetApp Data ONTAP provides integrated data replication technologies for creating replica copies that can be for DR to off-load tape backup processes from the primary, to distribute datasets to other locations, and to create read/write clones for test and development environments.

Some of the SnapMirror use cases and benefits are:

- Integrated data protection
- SnapMirror for disaster recovery
- NetApp FlexClone® volumes for disaster recovery testing and application test/development
- Data distribution and remote data access

This integration effort showcases the benefits of SnapMirror for these use cases:

- Peak workload in AWS
- Dev/test environments in AWS
- DR purposes

We can quickly instantiate VMs in the AWS EC2 and those VMs can mount storage that is mirrored from the enterprise site to the colocated data center. This can be done in one of two ways:

- Make the destination volume read-write by breaking the SnapMirror relationship.
- Clone the SnapMirror destination volume. Use a labeled Snapshot® copy for clone creation instead of using a parent Snapshot copy that is used for the SnapMirror relationship.

The steps that are involved for the AWS EC2 VMs to mount NPS for AWS SnapMirror destination storage are:

1. Use SnapMirror to mirror data from enterprise to NPS in the colocated data center.
2. Instantiate AWS EC2 VMs (if there aren’t any running currently).
3. Break the SnapMirror relationship or create FlexClone volumes of the SnapMirror destination in NPS AWS.
4. Mount the mirrored/cloned destination NFS volumes in NPS on the AWS EC2 VMs created in step 1.

Assumptions

- The infrastructure for performing the SnapMirror replication is in place. All the intercluster LIFs should be configured and every intercluster LIF on every node in a cluster must be able to connect to every intercluster LIF on every node in the peer cluster. That is, all the intercluster LIFs on all the cluster nodes in the enterprise site should be able to reach all the intercluster LIFs on all the cluster nodes in the colocated data center.
- Another assumption is that a few AWS EC2 VMs are currently up and running.

Refer to the following documentation and guides for SnapMirror on clustered Data ONTAP:

- TR-4015: SnapMirror Configuration and Best Practices Guide for Clustered Data ONTAP
- Clustered Data ONTAP Data Protection Guide

SnapMirror Data from Enterprise to NPS

The high-level steps for creating a SnapMirror relationship are as follows:

1. Create cluster peers (between enterprise cluster and NPS cluster at the colocated data center).

   After the nodes in both clusters are configured with intercluster LIFs, the clusters have to be peered together to allow the creation of replication relationships between the clusters. Cluster peering must be configured to allow any replication to occur between different clusters. Essentially, the cluster peer feature allows two clusters to coordinate and share resources between them.

2. Create an SVM peer (between the SVMs at the enterprise cluster and the NPS cluster at the colocated data center).

   SVM peering is the act of connecting two SVMs to allow replication to occur between them. Before creating any SnapMirror relationships between a pair of SVMs, you must have an SVM peer relationship between the pair of SVMs. SVM peering is a permission-based mechanism and is a one-time operation that must be performed by the cluster administrators.

3. Create a SnapMirror relationship.

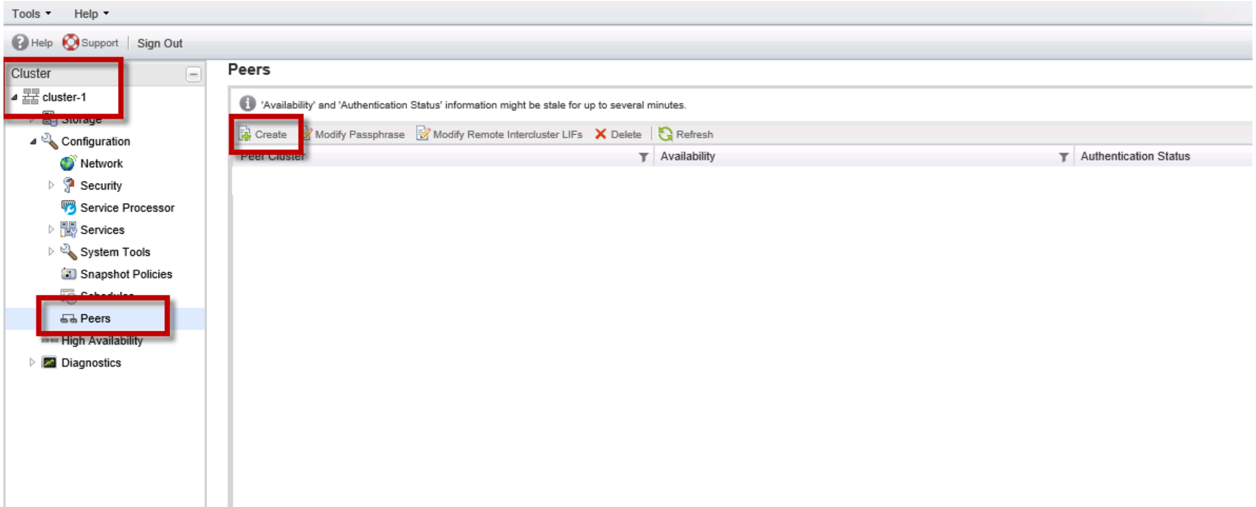
   After the cluster peer relationship and SVM peer relationship have been successfully created between the two clusters, create the intercluster SnapMirror relationships. Replication between volumes in two different SVMs in different clusters operating in clustered Data ONTAP is primarily used for providing DR to another site or location.

Cluster Peering

NetApp OnCommand System Manager can be used for creating and managing SnapMirror relationships. OnCommand System Manager includes a wizard used to create SnapMirror DP relationships, schedules to assign to relationships, and the destination volume, all within the same wizard.

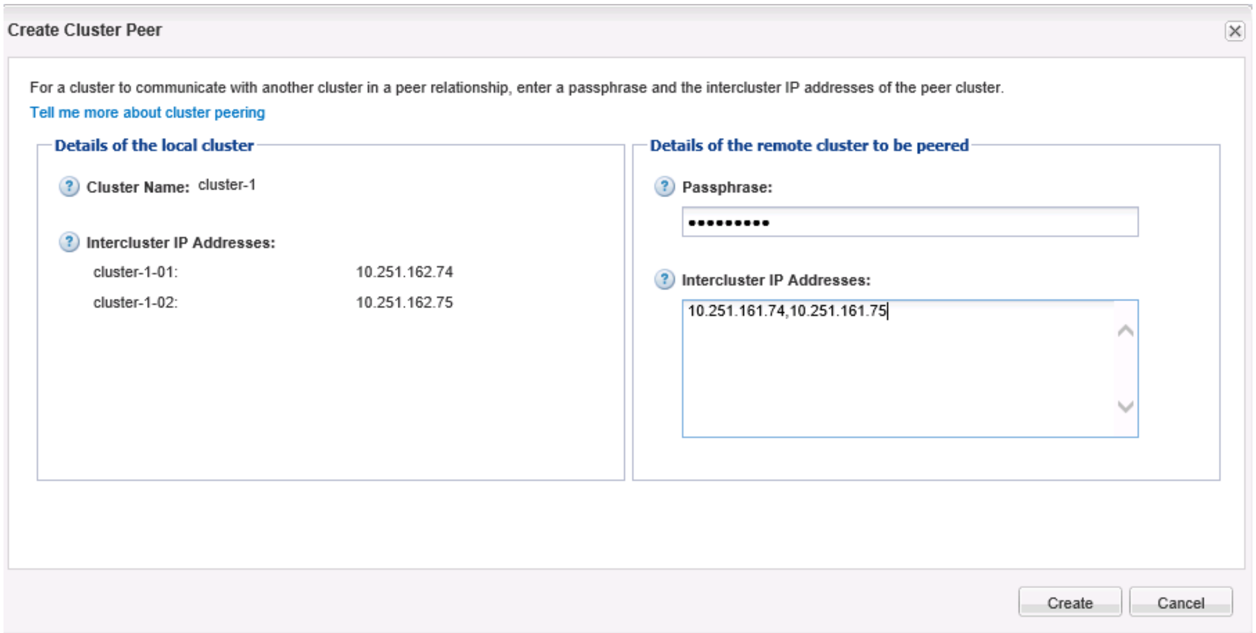
Note: The new relationship has to be created from the destination cluster, which is from the NPS in the colocated data center.

1. Start the OnCommand System Manager managing the NPS cluster at the colocated site. Because OnCommand System Manager is on box for clustered Data ONTAP 8.3, enter the cluster management IP in a browser to open the OnCommand System Manager.
2. Create an authenticated cluster-peer relationship from System Manager. Click the Cluster hierarchy in the left navigation pane. Click Peers and then Create.



'Availability' and 'Authentication Status' information might be stale for up to several minutes.

3. Enter a passphrase and the intercluster LIF IPs of the nodes at the enterprise site (on-premises cluster) and click Create.



Create Cluster Peer

For a cluster to communicate with another cluster in a peer relationship, enter a passphrase and the intercluster IP addresses of the peer cluster.

Tell me more about cluster peering

Details of the local cluster

Cluster Name: cluster-1

Intercluster IP Addresses:

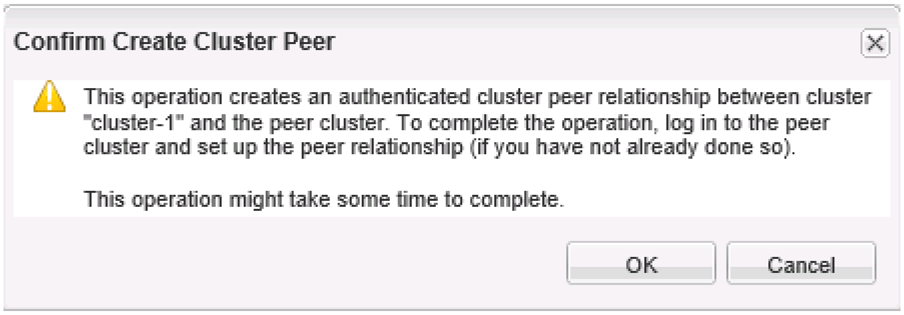
cluster-1-01:	10.251.162.74
cluster-1-02:	10.251.162.75

Details of the remote cluster to be peered

Passphrase: ••••••••••

Intercluster IP Addresses: 10.251.161.74,10.251.161.75

A pop-up message appears advising you to perform the same operation at the enterprise site.

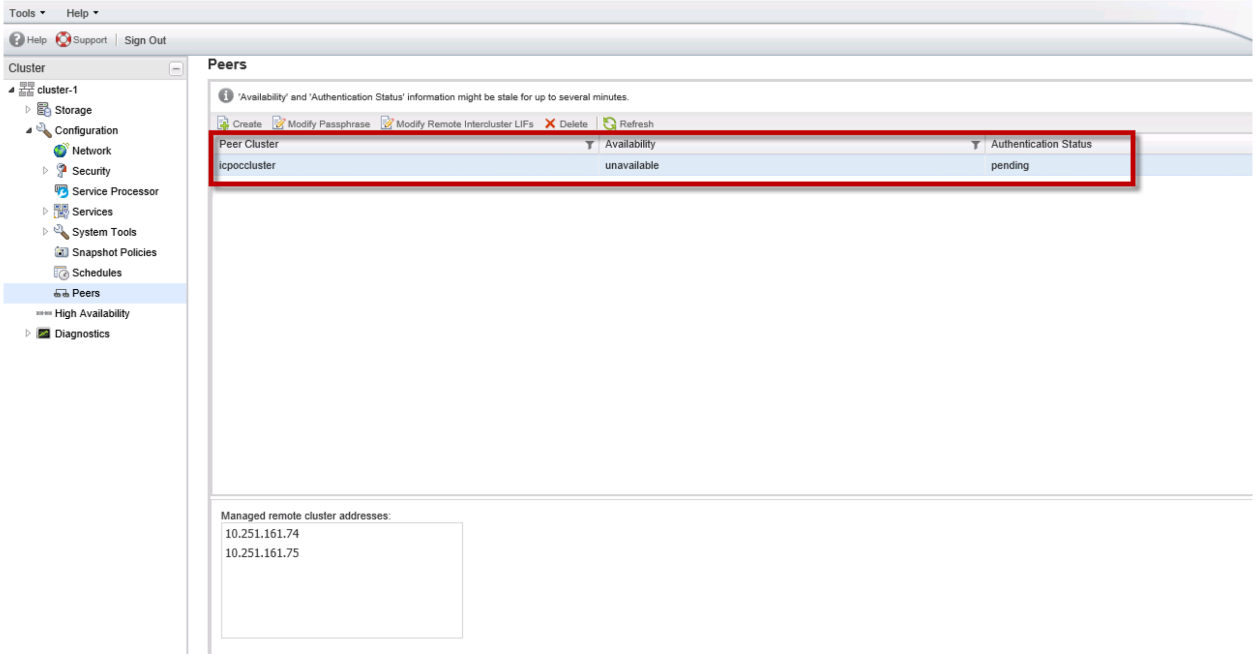


Confirm Create Cluster Peer

This operation creates an authenticated cluster peer relationship between cluster "cluster-1" and the peer cluster. To complete the operation, log in to the peer cluster and set up the peer relationship (if you have not already done so).

This operation might take some time to complete.

4. The peer status appears as “unavailable” and “pending” until the same operation is repeated at the peer cluster site, which is the enterprise site.



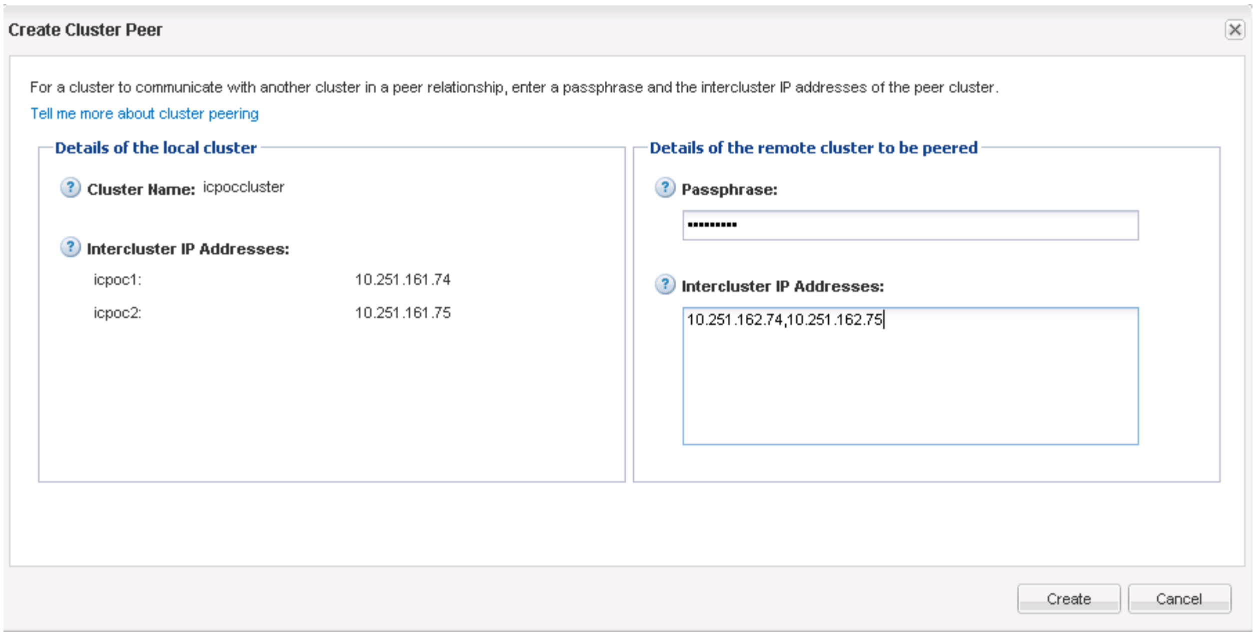
Peers

'Availability' and 'Authentication Status' information might be stale for up to several minutes.

Peer Cluster	Availability	Authentication Status
icpoccluster	unavailable	pending

Managed remote cluster addresses:
10.251.161.74
10.251.161.75

5. Using OnCommand System Manager, repeat the same peer creation process at the enterprise site. Supply the matching passphrase and the intercluster LIF IPs of the nodes in the NPS cluster at the colocated site.



Create Cluster Peer

For a cluster to communicate with another cluster in a peer relationship, enter a passphrase and the intercluster IP addresses of the peer cluster.

Tell me more about cluster peering

Details of the local cluster

Cluster Name: icpoccluster

Intercluster IP Addresses:

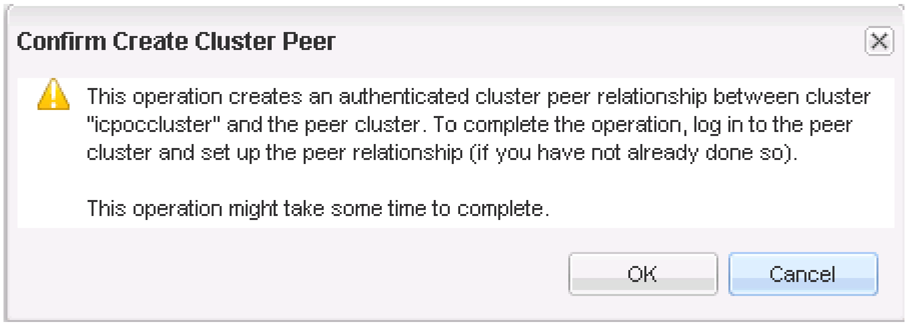
icpoc1:	10.251.161.74
icpoc2:	10.251.161.75

Details of the remote cluster to be peered

Passphrase: ••••••••••

Intercluster IP Addresses: 10.251.162.74,10.251.162.75

6. The same warning pop-up message appears again advising you to create the peer, the operation that was performed in step 4. Click OK.

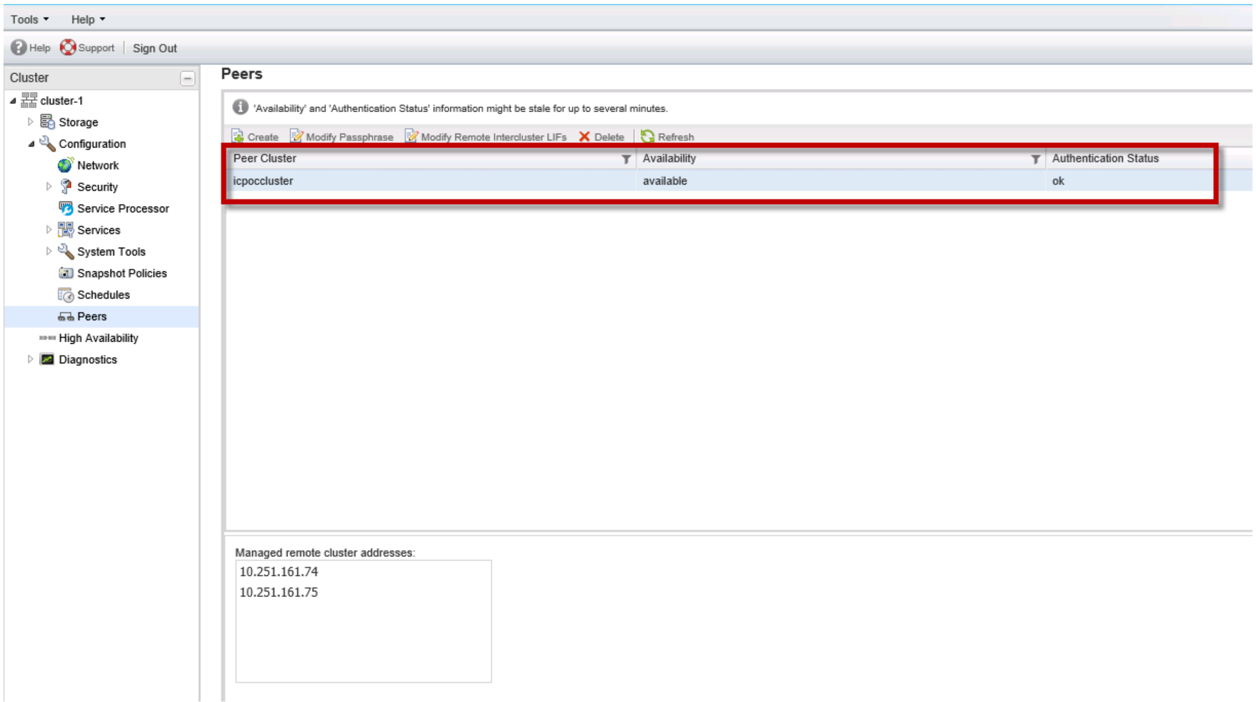


Confirm Create Cluster Peer

This operation creates an authenticated cluster peer relationship between cluster "icpoccluster" and the peer cluster. To complete the operation, log in to the peer cluster and set up the peer relationship (if you have not already done so).

This operation might take some time to complete.

7. View the cluster peer relationship details from OnCommand System Manager. Confirm that the cluster peer was configured successfully at both ends.
   - At the enterprise site:



Peers

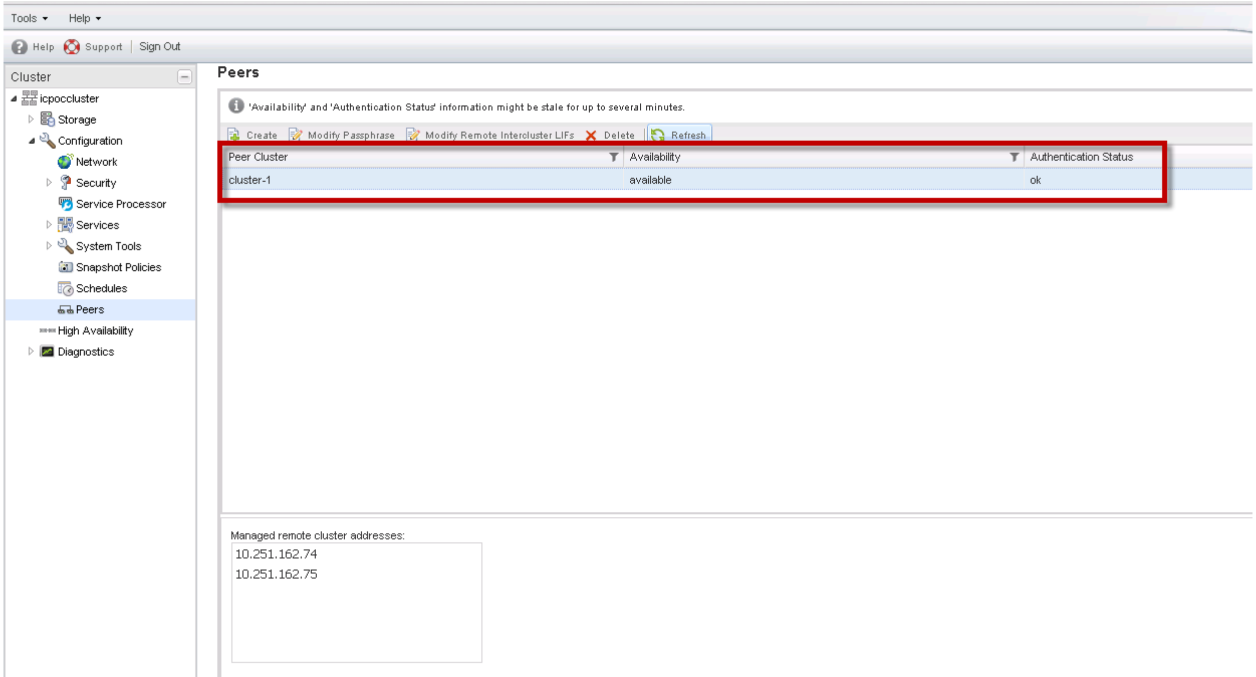
'Availability' and 'Authentication Status' information might be stale for up to several minutes.

Peer Cluster	Availability	Authentication Status
icpoccluster	available	ok

Managed remote cluster addresses:

10.251.161.74
10.251.161.75

   - At the colocated site:



Peers

'Availability' and 'Authentication Status' information might be stale for up to several minutes.

Peer Cluster	Availability	Authentication Status
cluster-1	available	ok

Managed remote cluster addresses:
10.251.162.74
10.251.162.75

SVM Peering

SVM peering is a two-step process:

1. Step 1: Create an SVM peer from the destination.
2. Step 2: Accept the SVM peer from the source.

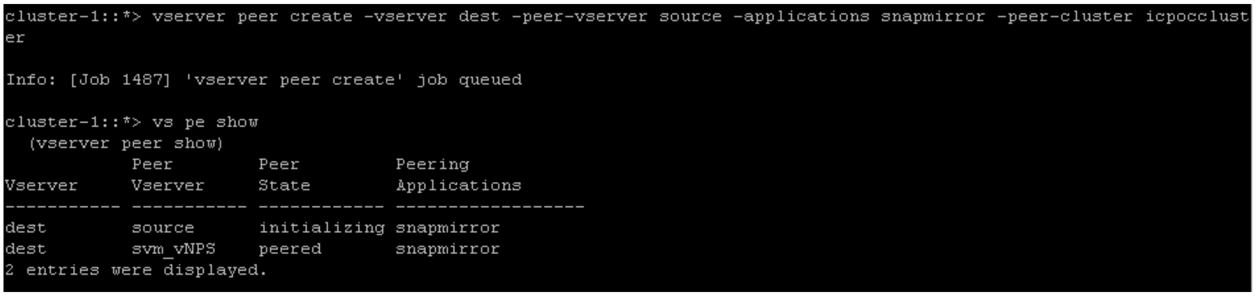
Step 1

1. Create an SVM peer by issuing the following command from the SVM on the destination cluster, which is the NPS at the colocated data center:

```
vserver peer create –vserver <destination vserver name> -peer-vserver <source vserver> -
applications snapmirror -peer-cluster <source cluster>
```

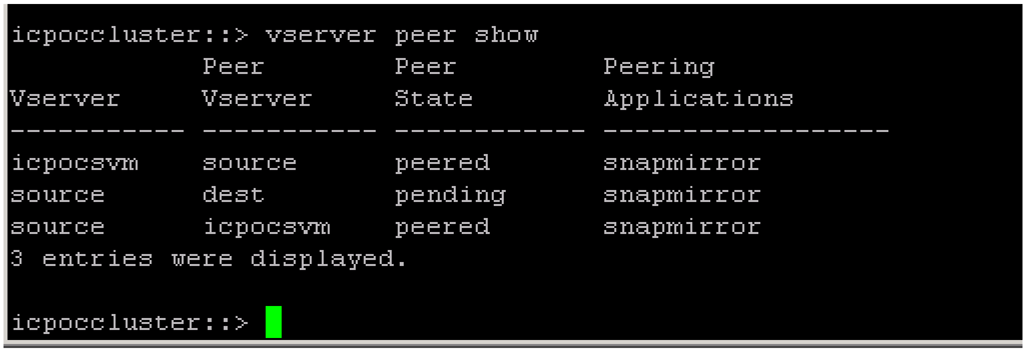
2. Issue a “`vserver peer show`” command to view the status.

   At the destination colocated site, the peering status appears as “`initializing`.”



```
cluster-1::*> vserver peer create -vserver dest -peer-vserver source -applications snapmirror -peer-cluster icpocclust
er

Info: [Job 1487] 'vserver peer create' job queued

cluster-1::*> vs pe show
  (vserver peer show)
            Peer        Peer         Peering
Vserver     Vserver     State        Applications
----------- ----------- ------------ ------------------
dest        source      initializing snapmirror
dest        svm_vNPS    peered       snapmirror
2 entries were displayed.
```

   At the source-enterprise site, the peering status appears as “`pending`.”

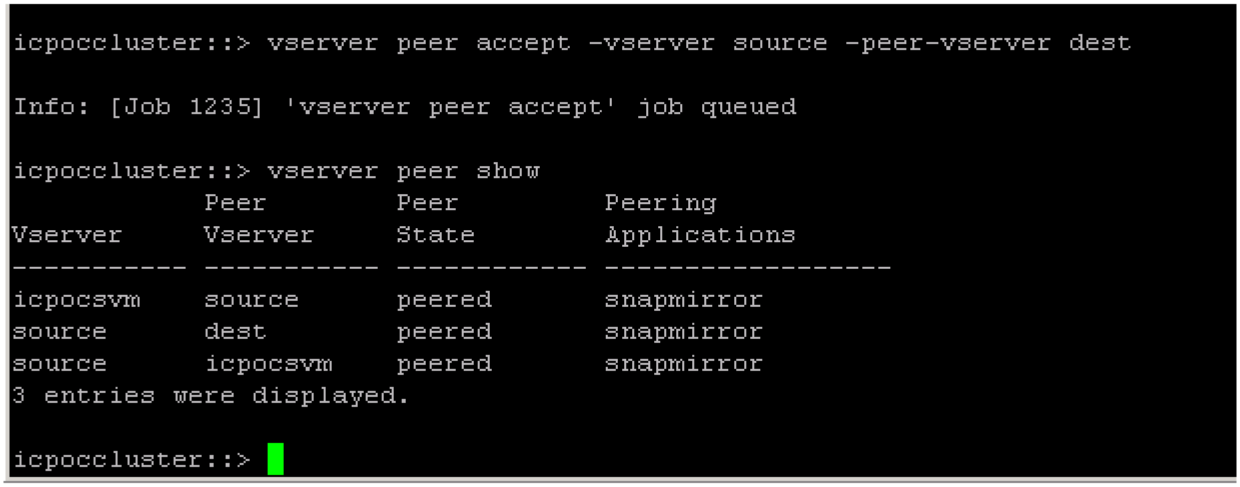


```
icpoccluster::> vserver peer show
            Peer        Peer           Peering
Vserver     Vserver     State          Applications
----------- ----------- ------------ ------------------
icpocsvm    source      peered       snapmirror
source      dest        pending      snapmirror
source      icpocsvm    peered       snapmirror
3 entries were displayed.

icpoccluster::> 
```

Step 2

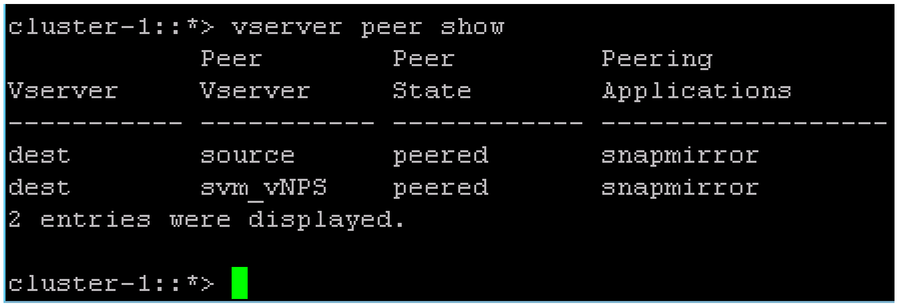
1. Accept the SVM peer from the source. Issue the following command at the source SVM, which is the enterprise site.

```
vserver peer accept -vserver <source vserver> -peer-vserver <destination vserver>
```



```
icpoccluster::> vserver peer accept -vserver source -peer-vserver dest

Info: [Job 1235] 'vserver peer accept' job queued

icpoccluster::> vserver peer show
            Peer        Peer           Peering
Vserver     Vserver     State          Applications
----------- ----------- ------------ ------------------
icpocsvm    source      peered       snapmirror
source      dest        peered       snapmirror
source      icpocsvm    peered       snapmirror
3 entries were displayed.

icpoccluster::> 
```

2. Issue the `vserver peer show` command and confirm that the peering is successful.

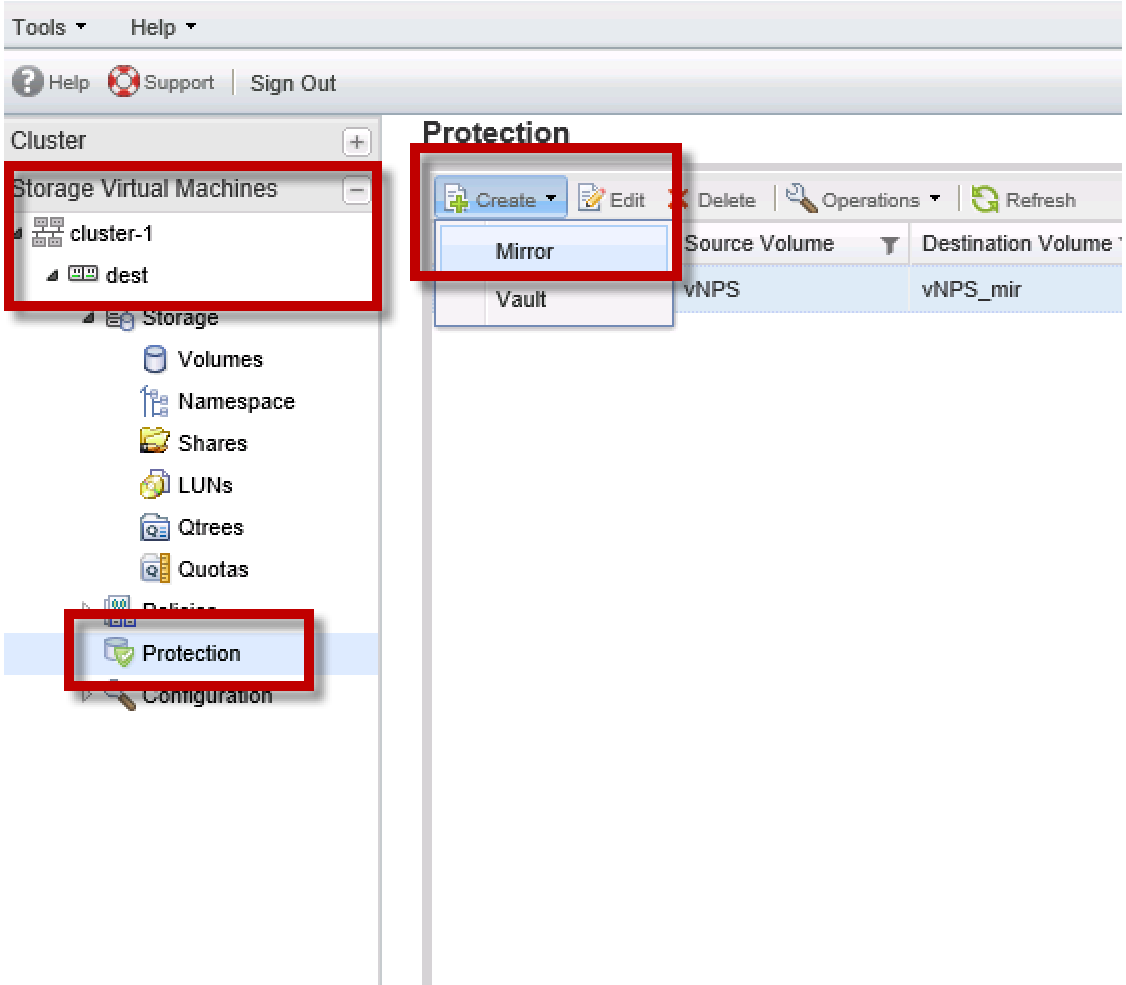


```
cluster-1::*> vserver peer show
            Peer        Peer           Peering
Vserver     Vserver     State          Applications
----------- ----------- ------------ ------------------
dest        source      peered       snapmirror
dest        svm_vNPS    peered       snapmirror
2 entries were displayed.

cluster-1::*> 
```

Creating SnapMirror Relationships

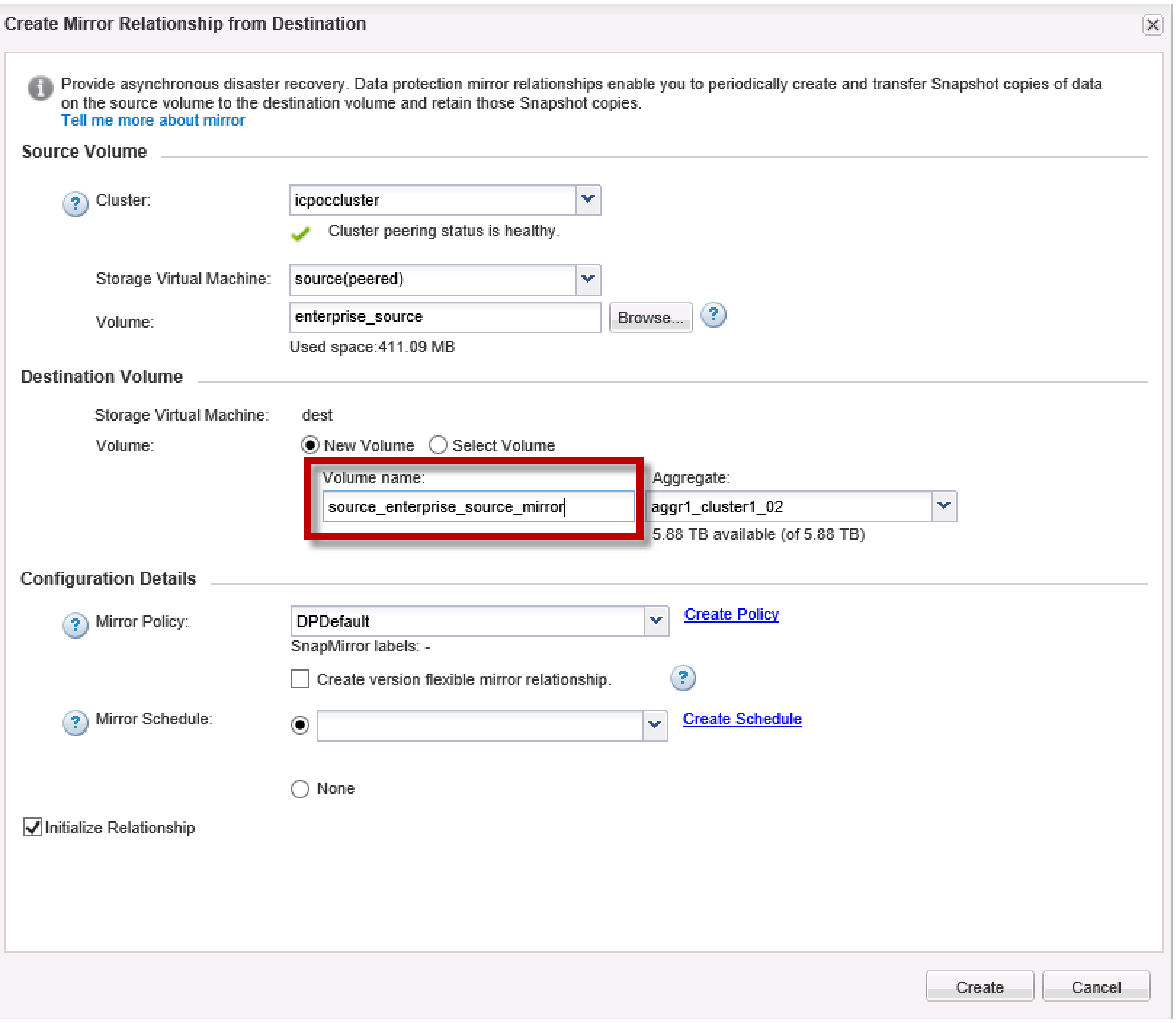
The SnapMirror relationship has to be created at the destination. Bring up the System Manager managing the NPS cluster at the colocated site.

1. Expand the Storage Virtual Machines hierarchy. Select the destination SVM and navigate to Protection > Create > Mirror.



2. The SnapMirror creation wizard appears. Select the relevant source cluster, the source SVM, and the source volume that needs to be mirrored.

   By default, the destination volume name is in the `<SourceSVM_SourceVolumeName_Mirror>` format. You can either select the destination volume on the destination SVM or create a destination volume on the destination SVM.



Create Mirror Relationship from Destination

Provide asynchronous disaster recovery. Data protection mirror relationships enable you to periodically create and transfer Snapshot copies of data on the source volume to the destination volume and retain those Snapshot copies.
Tell me more about mirror

Source Volume

Cluster: icpoccluster
✓ Cluster peering status is healthy.

Storage Virtual Machine: source(peered)

Volume: enterprise_source
Used space:411.09 MB

Destination Volume

Storage Virtual Machine: dest

Volume: ● New Volume ○ Select Volume

Volume name: source_enterprise_source_mirror

Aggregate: aggr1_cluster1_02
5.88 TB available (of 5.88 TB)

Configuration Details

Mirror Policy: DPDefault
SnapMirror labels: -

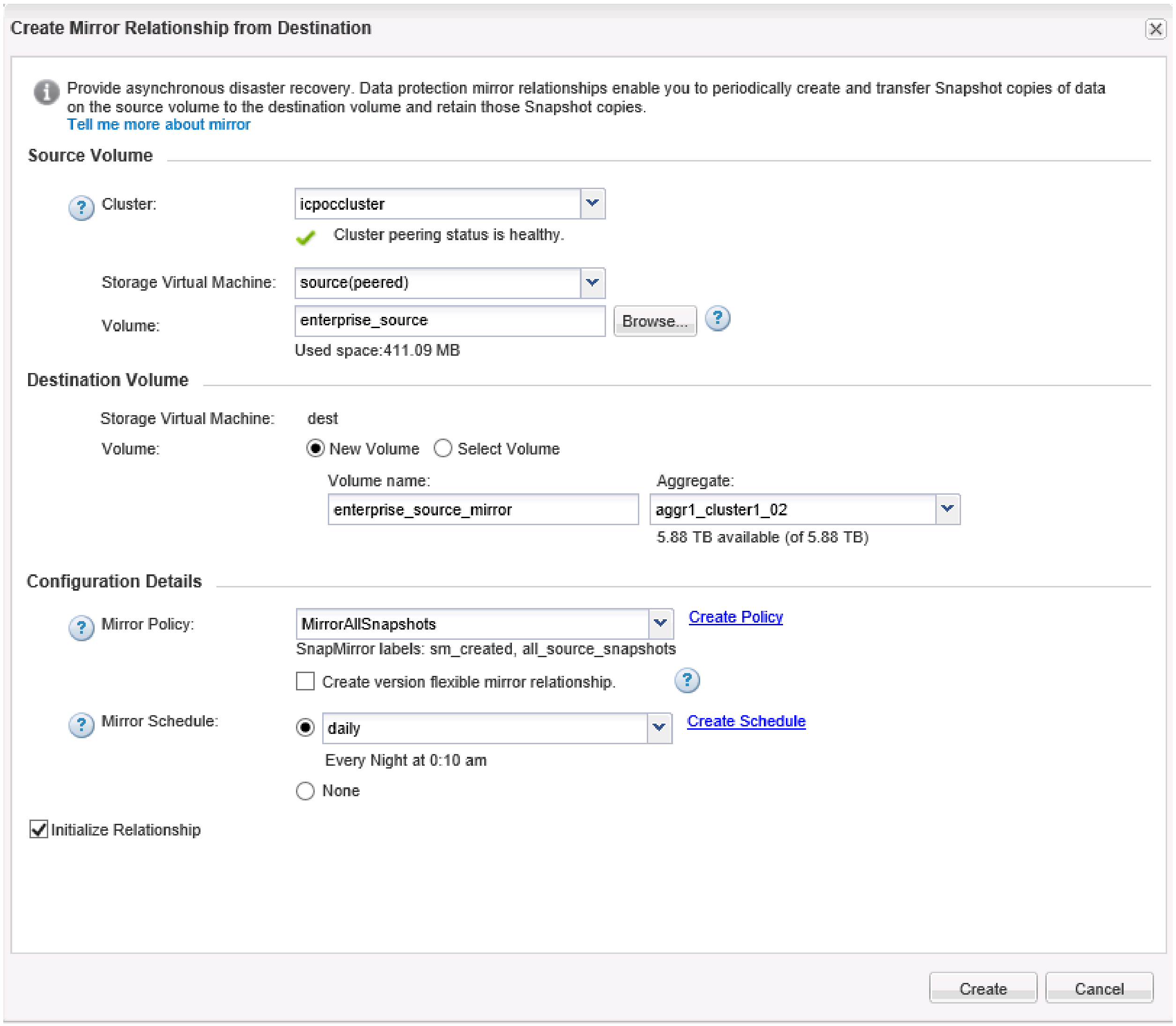
□ Create version flexible mirror relationship.

Mirror Schedule: ●

○ None

☑ Initialize Relationship

3. You can also select or create a SnapMirror policy and schedule. Select the “Initialize Relationship” checkbox to start the baseline transfer and click Create.



Create Mirror Relationship from Destination

Provide asynchronous disaster recovery. Data protection mirror relationships enable you to periodically create and transfer Snapshot copies of data on the source volume to the destination volume and retain those Snapshot copies.
Tell me more about mirror

Source Volume

Cluster: icpoccluster
✓ Cluster peering status is healthy.

Storage Virtual Machine: source(peered)

Volume: enterprise_source
Used space:411.09 MB

Destination Volume

Storage Virtual Machine: dest

Volume: ● New Volume ○ Select Volume

Volume name: enterprise_source_mirror

Aggregate: aggr1_cluster1_02
5.88 TB available (of 5.88 TB)

Configuration Details

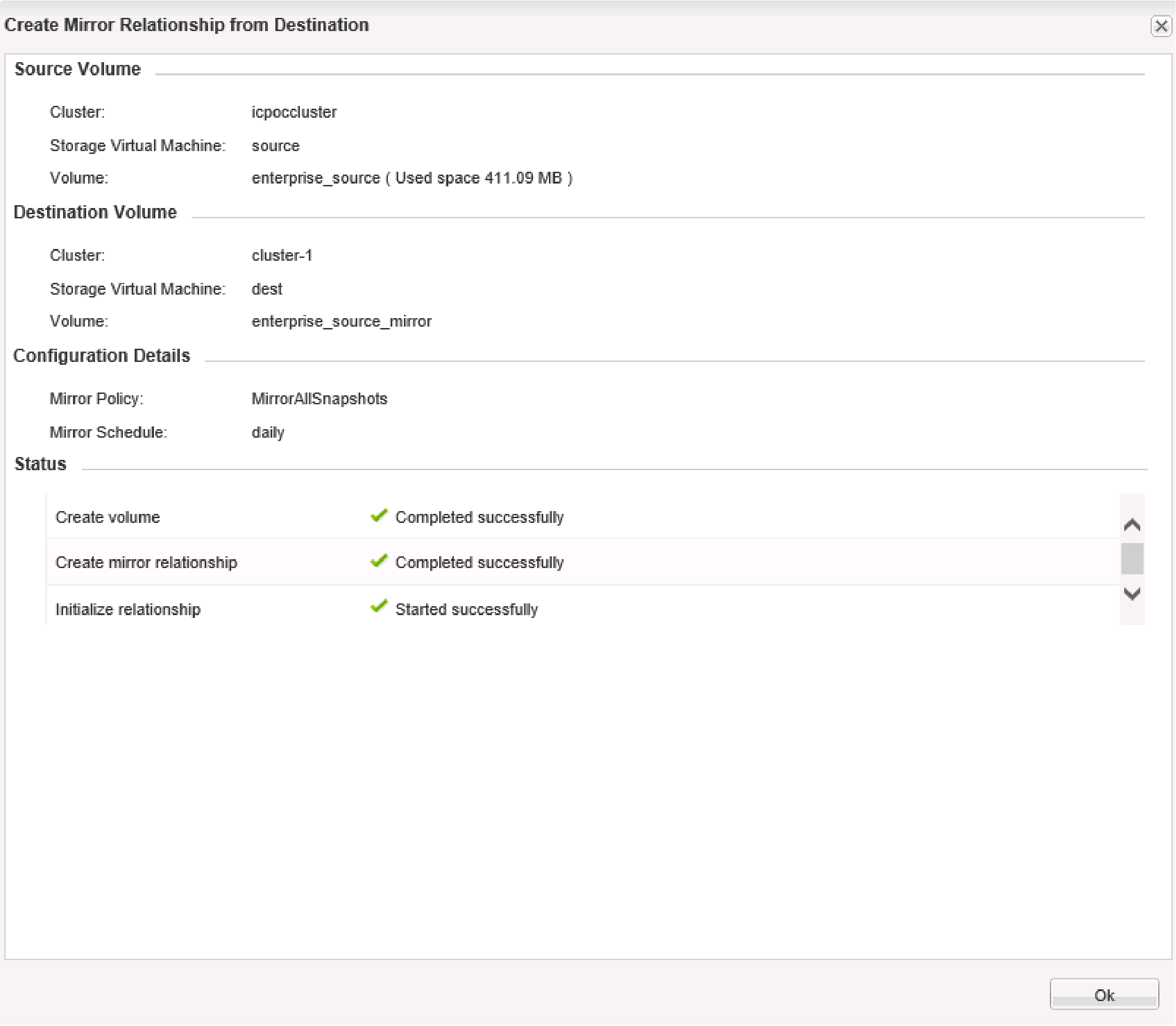
Mirror Policy: MirrorAllSnapshots
SnapMirror labels: sm_created, all_source_snapshots

□ Create version flexible mirror relationship.

Mirror Schedule: ● daily
Every Night at 0:10 am
○ None

☑ Initialize Relationship

The summary of the SnapMirror relationship configuration and status appears as follows:



Create Mirror Relationship from Destination

Source Volume

Cluster:	icpoccluster
Storage Virtual Machine:	source
Volume:	enterprise_source (Used space 411.09 MB)

Destination Volume

Cluster:	cluster-1
Storage Virtual Machine:	dest
Volume:	enterprise_source_mirror

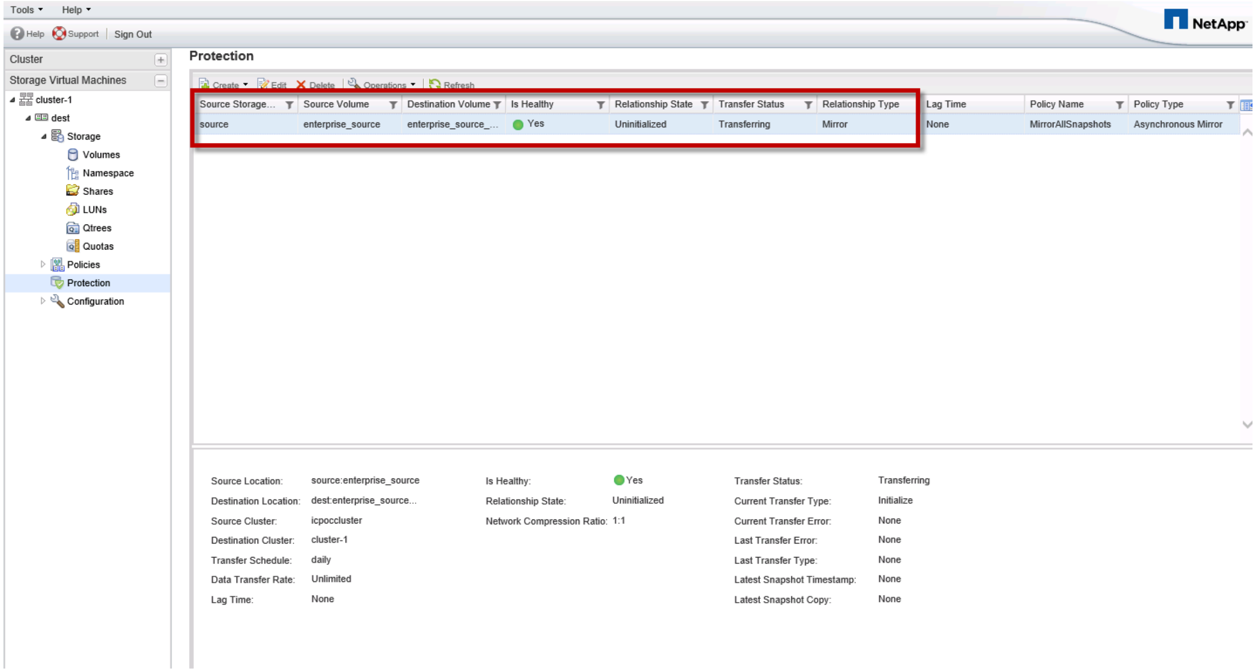
Configuration Details

Mirror Policy:	MirrorAllSnapshots
Mirror Schedule:	daily

Status

Create volume	✓ Completed successfully
Create mirror relationship	✓ Completed successfully
Initialize relationship	✓ Started successfully

4. View the relationship status of the baseline data transfer either through the CLI or the GUI.
   – From the UI:



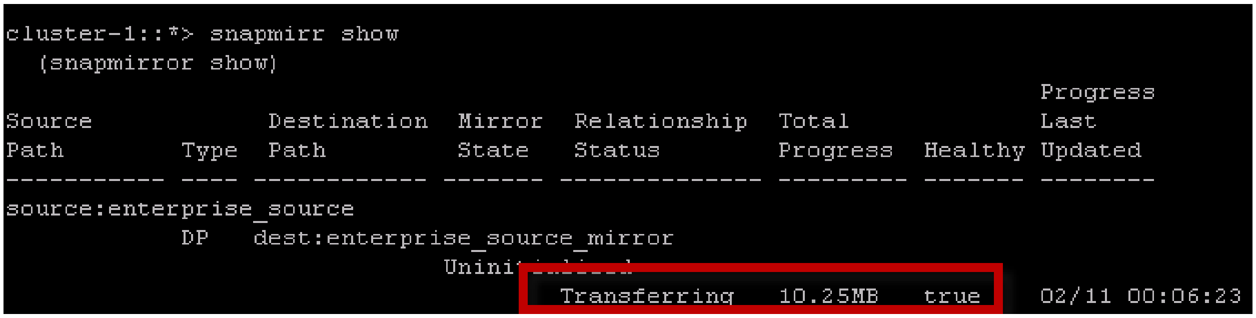
Protection

Source Storage...	Source Volume	Destination Volume	Is Healthy	Relationship State	Transfer Status	Relationship Type	Lag Time	Policy Name	Policy Type
source	enterprise_source	enterprise_source_...	● Yes	Uninitialized	Transferring	Mirror	None	MirrorAllSnapshots	Asynchronous Mirror

Source Location:	source:enterprise_source	Is Healthy:	● Yes	Transfer Status:	Transferring
Destination Location:	dest:enterprise_source...	Relationship State:	Uninitialized	Current Transfer Type:	Initialize
Source Cluster:	icpoccluster	Network Compression Ratio:	1:1	Current Transfer Error:	None
Destination Cluster:	cluster-1			Last Transfer Error:	None
Transfer Schedule:	daily			Last Transfer Type:	None
Data Transfer Rate:	Unlimited			Latest Snapshot Timestamp:	None
Lag Time:	None			Latest Snapshot Copy:	None

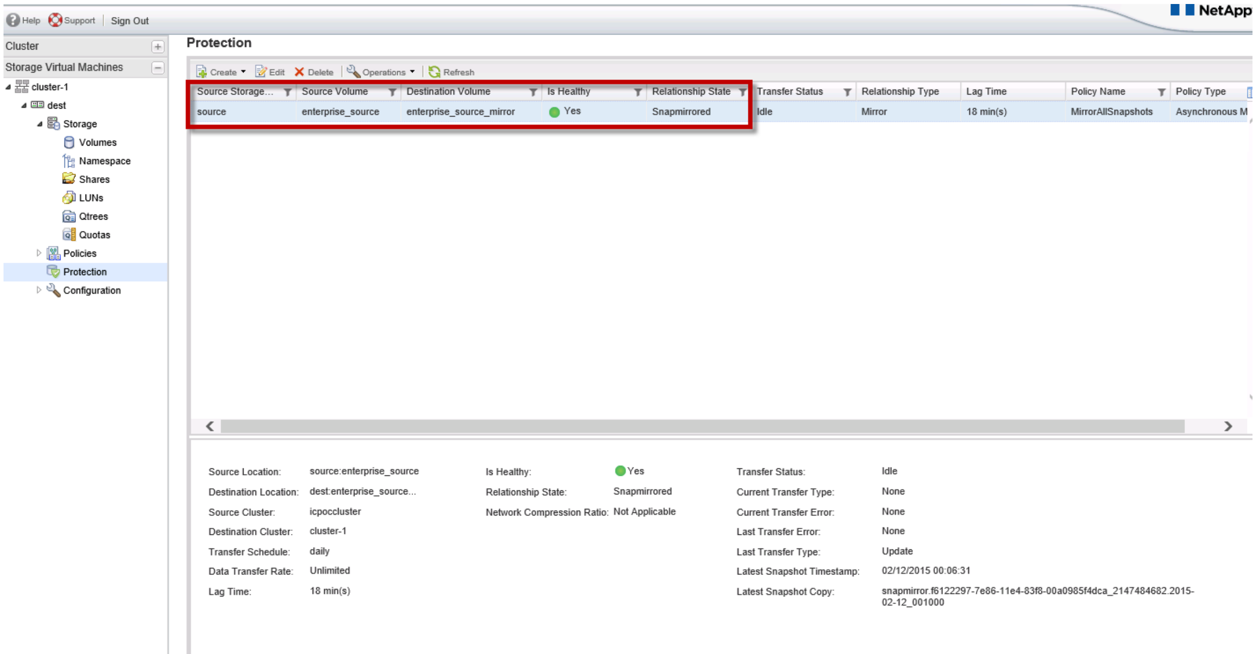
– From the CLI:

Issue a “`snapmirror show`” command on the destination cluster to view the SnapMirror relationship status and the transfer progress of the baseline mirror.



```
cluster-1::*> snapmirr show
  (snapmirror show)
                                                                       Progress
Source                  Destination  Mirror  Relationship  Total               Last
Path        Type  Path         State   Status        Progress  Healthy Updated
----------- ---- ------------ ------- -------------- --------- ------- --------
source:enterprise_source
            DP   dest:enterprise_source_mirror
                              Uninitialized
                                      Transferring   10.25MB   true    02/11 00:06:23
```

5. Verify that the baseline transfer completed successfully.

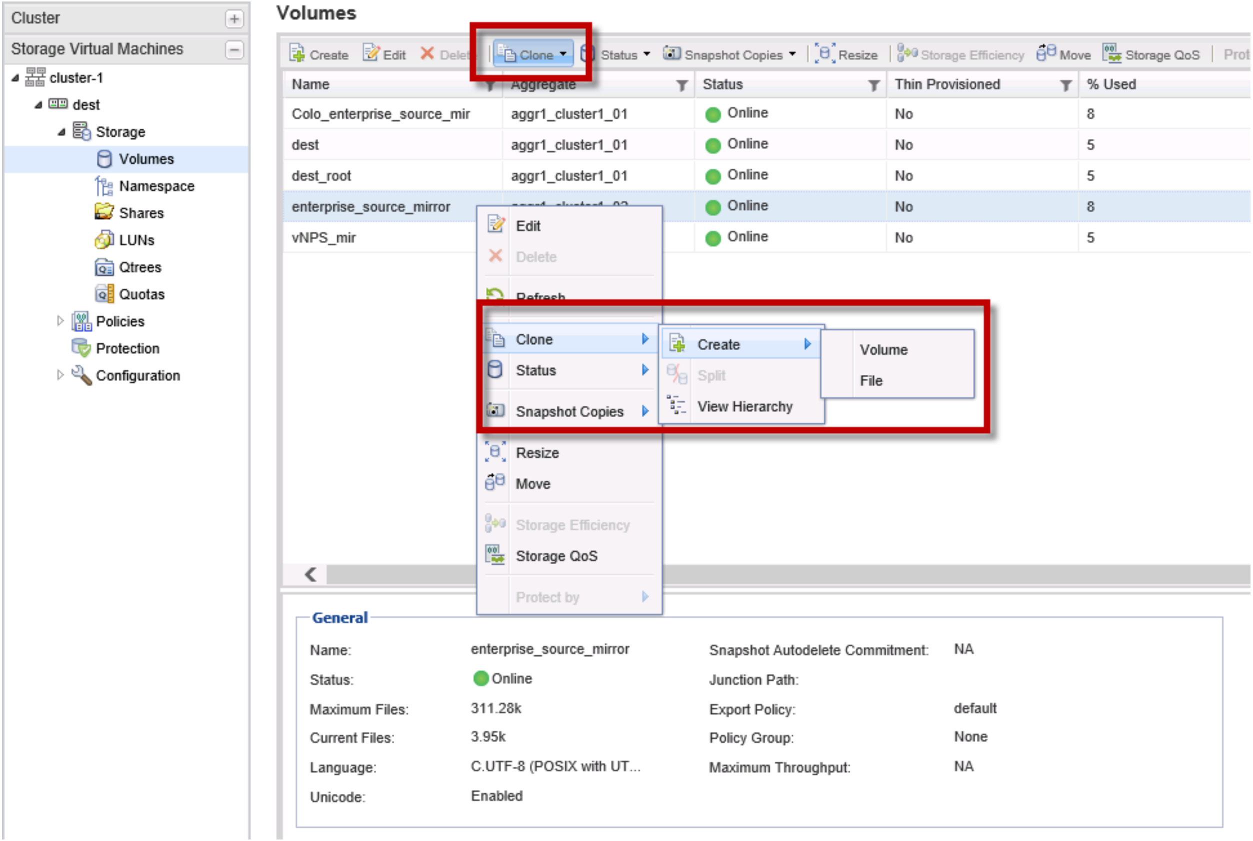


Source Storage...	Source Volume	Destination Volume	Is Healthy	Relationship State	Transfer Status	Relationship Type	Lag Time	Policy Name	Policy Type
source	enterprise_source	enterprise_source_mirror	● Yes	Snapmirrored	Idle	Mirror	18 min(s)	MirrorAllSnapshots	Asynchronous M

Source Location:	source:enterprise_source	Is Healthy:	● Yes	Transfer Status:	Idle
Destination Location:	dest:enterprise_source...	Relationship State:	Snapmirrored	Current Transfer Type:	None
Source Cluster:	icpoccluster	Network Compression Ratio:	Not Applicable	Current Transfer Error:	None
Destination Cluster:	cluster-1			Last Transfer Error:	None
Transfer Schedule:	daily			Last Transfer Type:	Update
Data Transfer Rate:	Unlimited			Latest Snapshot Timestamp:	02/12/2015 00:06:31
Lag Time:	18 min(s)			Latest Snapshot Copy:	snapmirror.f6122297-7e86-11e4-83f8-00a0985f4dca_2147484682.2015-02-12_001000

Create FlexClone Volume of the Destination SnapMirror Volume

1. Navigate to the Storage Virtual Machines hierarchy in the left pane. Select the destination SVM and navigate to Storage > Volumes.
2. Click the Clone option in the menu bar or right-click the SnapMirror destination volume. Select Clone > Create > Volume.



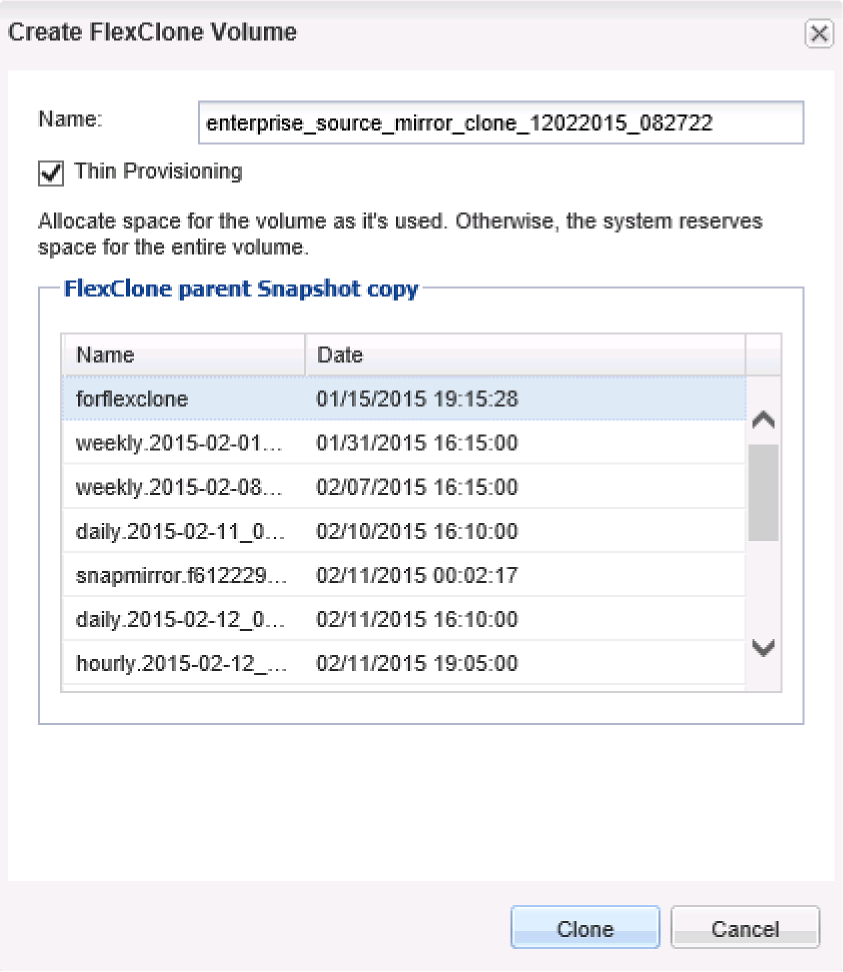
Name	Aggregate	Status	Thin Provisioned	% Used
Colo_enterprise_source_mir	aggr1_cluster1_01	● Online	No	8
dest	aggr1_cluster1_01	● Online	No	5
dest_root	aggr1_cluster1_01	● Online	No	5
enterprise_source_mirror	aggr1_cluster1_02	● Online	No	8
vNPS_mir		● Online	No	5

General

Name:	enterprise_source_mirror	Snapshot Autodelete Commitment:	NA
Status:	● Online	Junction Path:	
Maximum Files:	311.28k	Export Policy:	default
Current Files:	3.95k	Policy Group:	None
Language:	C.UTF-8 (POSIX with UT...	Maximum Throughput:	NA
Unicode:	Enabled		

3. Enter a name for the FlexClone volume or retain the default name. Select the Thin Provisioning checkbox to allocate space as used. This might vary depending on the customer environment.

   Also, choose the relevant FlexClone parent Snapshot copy on which the cloned volume will be based. This example has a labeled Snapshot copy that was created on the source for cloning purposes. Selecting a Snapshot copy that was created by the SnapMirror relationship will cause SnapMirror updates to fail.



Create FlexClone Volume

Name: enterprise_source_mirror_clone_12022015_082722

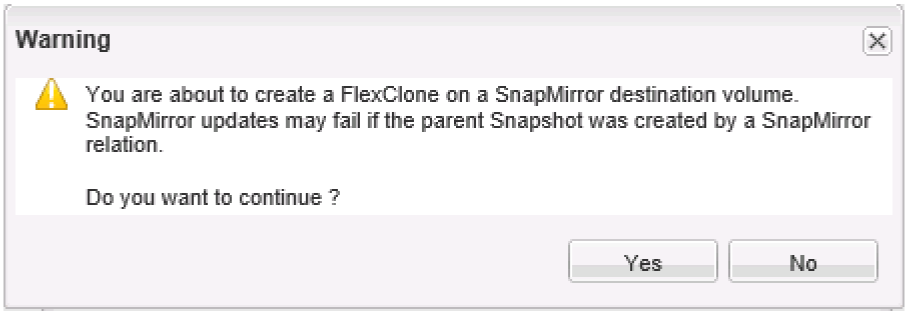
☑ Thin Provisioning

Allocate space for the volume as it's used. Otherwise, the system reserves space for the entire volume.

FlexClone parent Snapshot copy

Name	Date
forflexclone	01/15/2015 19:15:28
weekly.2015-02-01...	01/31/2015 16:15:00
weekly.2015-02-08...	02/07/2015 16:15:00
daily.2015-02-11_0...	02/10/2015 16:10:00
snapmirror.f612229...	02/11/2015 00:02:17
daily.2015-02-12_0...	02/11/2015 16:10:00
hourly.2015-02-12_...	02/11/2015 19:05:00

4. A pop-up message appears that states that SnapMirror updates might fail if the clone is based on a Snapshot copy created by the SnapMirror relationship. Click Yes to create the cloned volume.

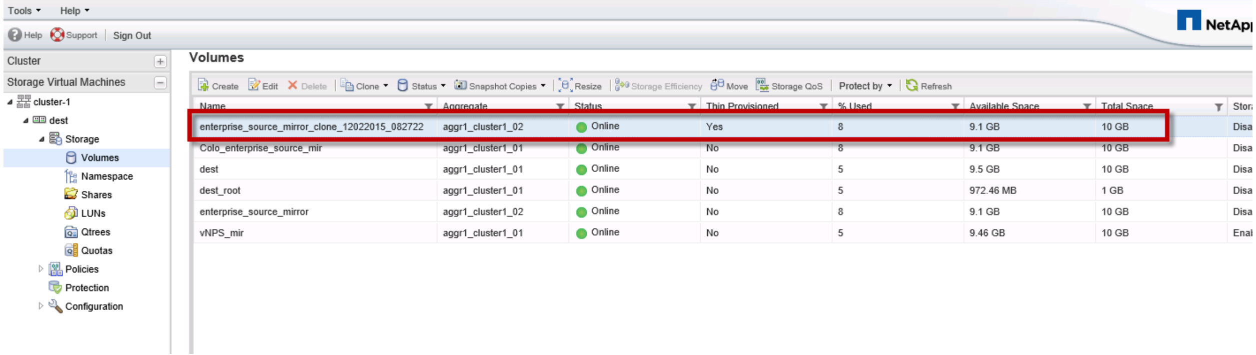


Warning

You are about to create a FlexClone on a SnapMirror destination volume. SnapMirror updates may fail if the parent Snapshot was created by a SnapMirror relation.

Do you want to continue ?

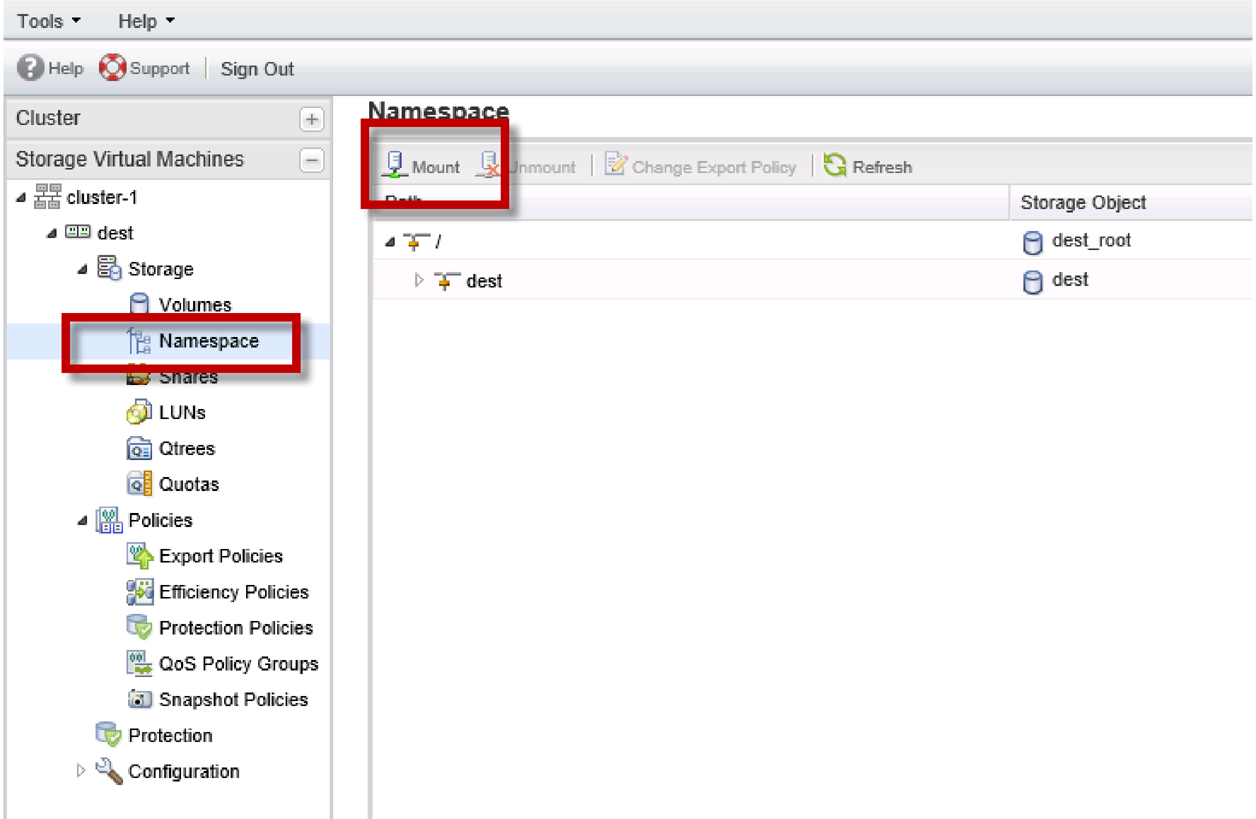
5. Verify that the volume was cloned successfully.



Volumes

Name	Aggregate	Status	Thin Provisioned	% Used	Available Space	Total Space	Stor
enterprise_source_mirror_clone_12022015_082722	aggr1_cluster1_02	● Online	Yes	8	9.1 GB	10 GB	Disa
Colo_enterprise_source_mir	aggr1_cluster1_01	● Online	No	8	9.1 GB	10 GB	Disa
dest	aggr1_cluster1_01	● Online	No	5	9.5 GB	10 GB	Disa
dest_root	aggr1_cluster1_01	● Online	No	5	972.46 MB	1 GB	Disa
enterprise_source_mirror	aggr1_cluster1_02	● Online	No	8	9.1 GB	10 GB	Disa
vNPS_mir	aggr1_cluster1_01	● Online	No	5	9.46 GB	10 GB	Enal

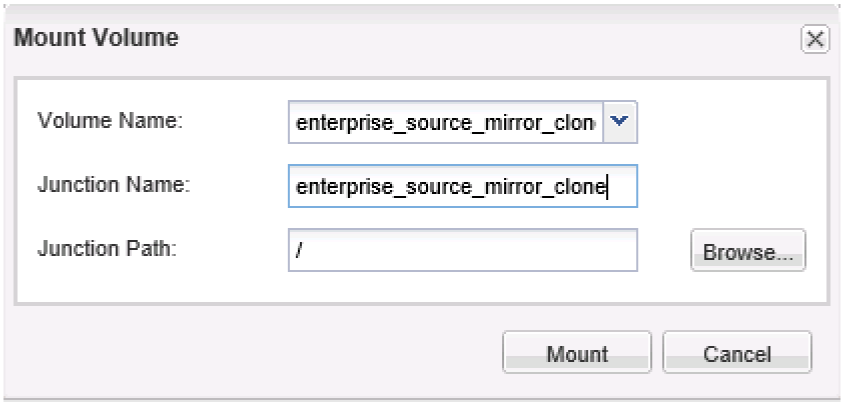
6. Mount the volume to a junction path. Navigate to Storage > Namespace, and click Mount.



Namespace

Path	Storage Object
/	dest_root
dest	dest

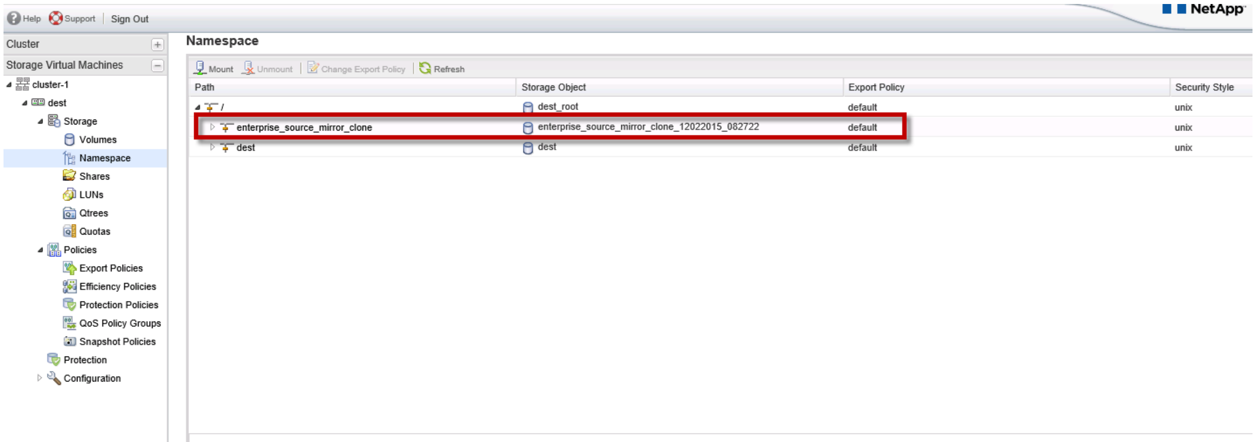
7. Select the cloned volume and enter a junction name. This name will be used to mount the volume on the AWS EC2 VMs.



Mount Volume

Volume Name:	enterprise_source_mirror_clon
Junction Name:	enterprise_source_mirror_clone
Junction Path:	/

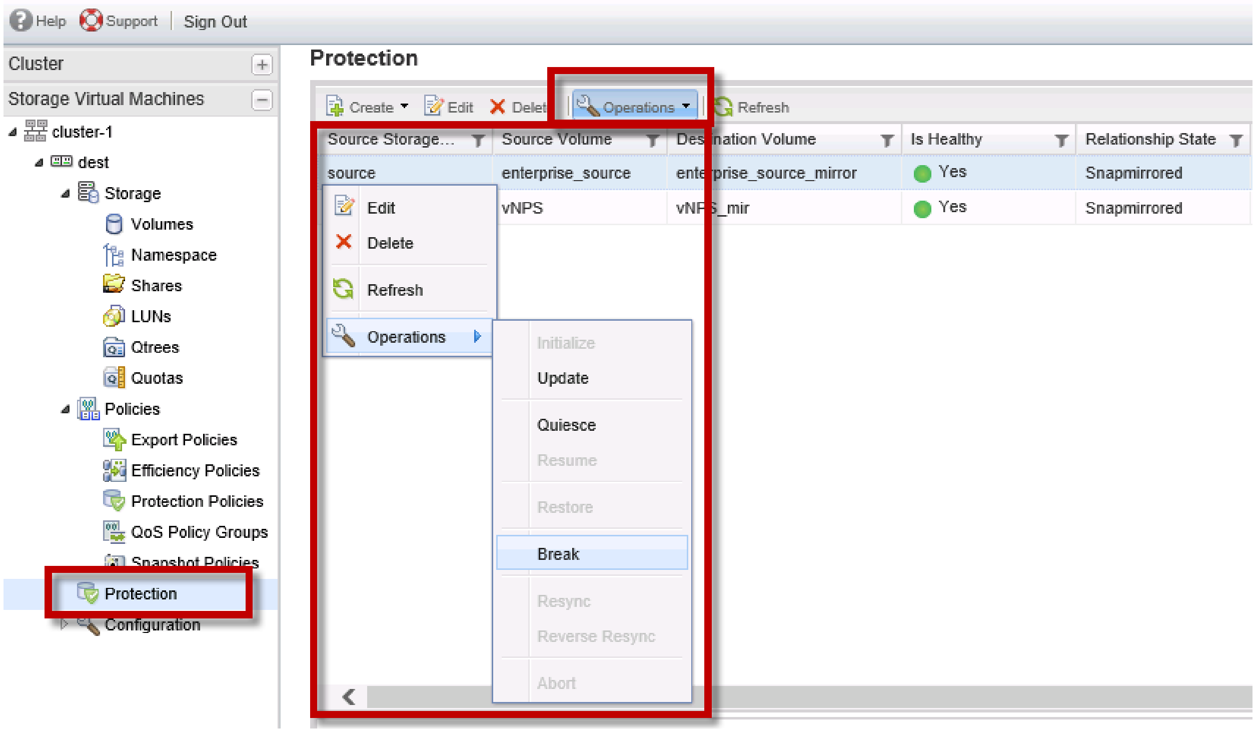
8. Verify that the volume is mounted successfully at the junction. Also note that the export policy for the NFS volume will be set to "default." In this example we modified the default export policy rules to allow the EC2 VMs to mount the NFS volume.



Namespace

Path	Storage Object	Export Policy	Security Style
/	dest_root	default	unix
enterprise_source_mirror_clone	enterprise_source_mirror_clone_12022015_082722	default	unix
dest	dest	default	unix

Note: The same operation can also be repeated by breaking the SnapMirror relationship and creating a read-write flexible clone of the destination volume. After the relationship is broken, the volume needs to be junctioned, as shown in step 6.

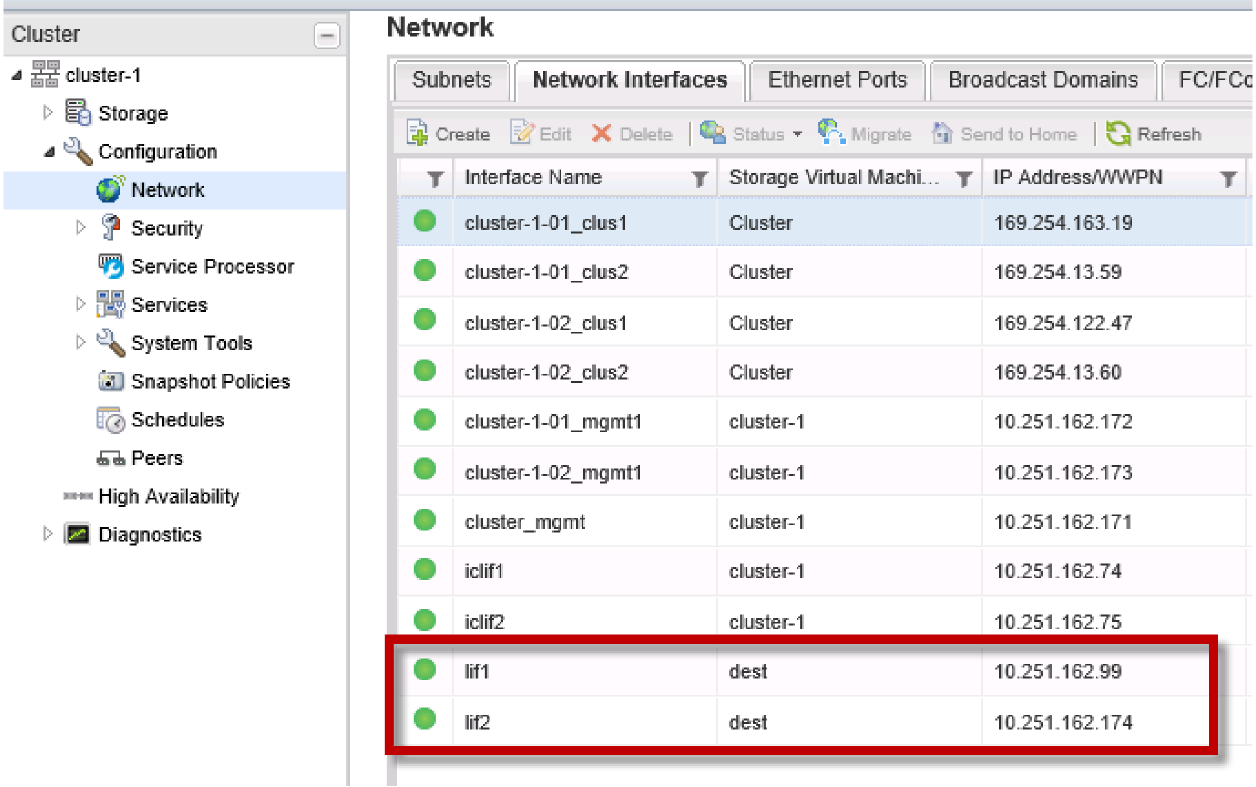


Source Storage...	Source Volume	Destination Volume	Is Healthy	Relationship State
source	enterprise_source	enterprise_source_mirror	● Yes	Snapmirrored
	vNPS	vNPS_mir	● Yes	Snapmirrored

Mount the Volume on AWS EC2 VMs

This example uses a UNIX®-based EC2 instance and mounts an NFS volume. You could also use a Windows EC2 instance to access a CIFS or any other EC2 instance type to mount an iSCSI LUN from the destination SVM based on the configuration. The EC2 instances can be present in any Availability Zones, but they should be in the same region as NPS. You could also access a CIFS share or an iSCSI LUN based on the SVM configuration at the destination.

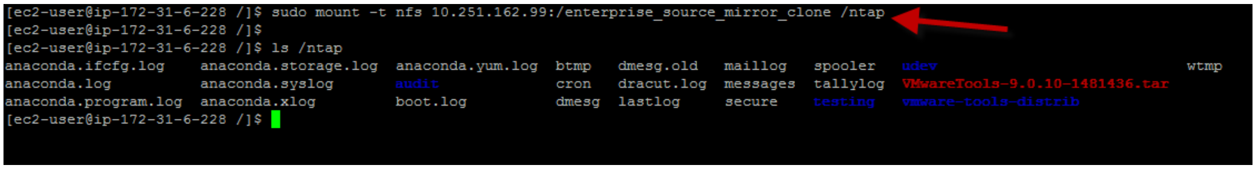
1. Note the relevant data LIF IPs of the destination SVM. Navigate to the Cluster hierarchy pane and expand Configuration. Navigate to Network > Network Interfaces and note the relevant Data LIF IP that will be used to mount the FlexClone volume using NFS.



	Interface Name	Storage Virtual Machi...	IP Address/WWPN
●	cluster-1-01_clus1	Cluster	169.254.163.19
●	cluster-1-01_clus2	Cluster	169.254.13.59
●	cluster-1-02_clus1	Cluster	169.254.122.47
●	cluster-1-02_clus2	Cluster	169.254.13.60
●	cluster-1-01_mgmt1	cluster-1	10.251.162.172
●	cluster-1-02_mgmt1	cluster-1	10.251.162.173
●	cluster_mgmt	cluster-1	10.251.162.171
●	iclif1	cluster-1	10.251.162.74
●	iclif2	cluster-1	10.251.162.75
●	lif1	dest	10.251.162.99
●	lif2	dest	10.251.162.174

2. Log in to a UNIX-based AWS EC2 VM and mount the FlexClone volume.

```
mount -t nfs <Data LIF IP noted earlier>:/<junctioned_volume_name> <mountpoint>
```



```
[ec2-user@ip-172-31-6-228 /]$ sudo mount -t nfs 10.251.162.99:/enterprise_source_mirror_clone /ntap
[ec2-user@ip-172-31-6-228 /]$
[ec2-user@ip-172-31-6-228 /]$ ls /ntap
anaconda.ifcfg.log    anaconda.storage.log  anaconda.yum.log  btmp   dmesg.old    maillog   spooler   udev                            wtmp
anaconda.log          anaconda.syslog       audit             cron   dracut.log   messages  tallylog  VMwareTools-9.0.10-1481436.tar
anaconda.program.log  anaconda.xlog         boot.log          dmesg  lastlog      secure    testing   vmware-tools-distrib
[ec2-user@ip-172-31-6-228 /]$
```

Summary

We saw a practical demonstration of the use cases that were discussed in the earlier sections. NetApp Data Fabric integration with Cisco Intercloud helps businesses be agile and realize benefits quickly.

9 NPS and Cisco Intercloud Fabric Integration

This section describes the deployment methodology of ICF on FlexPod Datacenter in the enterprise and AWS and the integration with NPS. The integration of ICF and Cloud ONTAP is also described in subsequent sections.

The steps in this section do not focus on a step-by-step installation process of ICF; instead, they focus on requirements for, recommendations for, and validation concerning how to leverage ICF with NPS and Cloud ONTAP for an overall hybrid cloud strategy. Up-to-date and step-by-step ICF installation guides are available from the Cisco website.

9.1 Solution Workflow Overview

The following is a summary of the solution workflow:

1. Create the enterprise VMs and mount NFS shares from the enterprise FlexPod platform.
2. Set up the SnapMirror relationships between the enterprise on-premises FlexPod and NPS in AWS.
3. Install and configure ICF and its components, including Intercloud Services (CSR and VSG).
4. Import templates into ICF from ESX and instantiate cloud VMs in AWS using ICF.
5. Build the necessary tunnels and NAT from ICF to NPS.
6. Break the SnapMirror relationship or clone the SnapMirror destination.
7. Mount NFS shares on destination ICF cloud VMs.

9.2 ICF Deployment Overview

To deploy ICF, complete the following steps:

1. Verify that the ESX deployment meets the minimum ICF version requirements listed in Table 8.
2. Verify that enterprise firewalls permit all required outbound ports.
3. Create an AWS account in the default VPC with restricted access credentials.
4. Install Intercloud Fabric Director and its components using the OVA in the infrastructure bundle.
5. Apply the necessary ICF licenses.
6. Create the Intercloud Fabric Cloud and enable the necessary services (CSR, VSG, and so on).
7. Configure the Cloud Services Router.
8. Create the public virtual data centers (VDCs) from the ICF GUI and create the desired VM templates.
9. Migrate VMs from the enterprise to the cloud or instantiate VMs in AWS using the templates that were created in previous steps.
10. Access NPS storage from the AWS EC2 instances.

9.3 ICF Requirements and Prerequisites

Intercloud Fabric has several networking and infrastructure requirements. However, security requirements are most critical for a successful and streamlined deployment.

The integration assumes successful deployments of VMware ESXi and vCenter with the required versions listed in Table 8, NPS readiness at the colocation, and proper enterprise firewall rules allowing ICF communication with AWS.

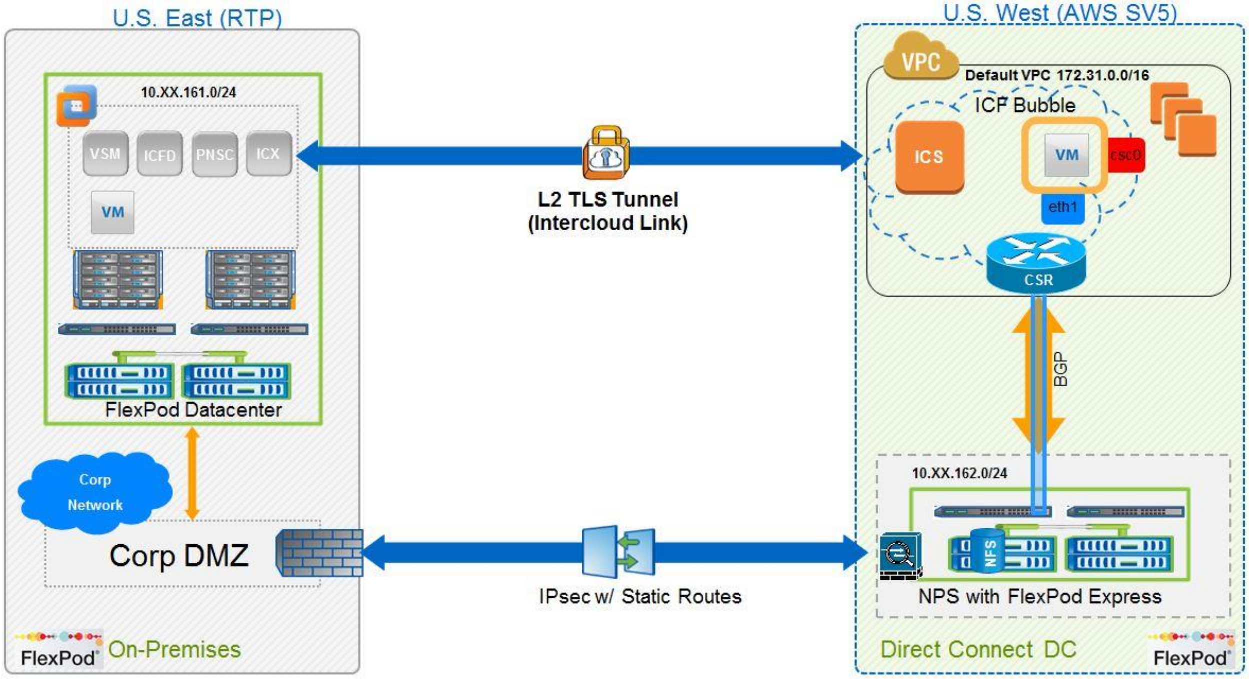
Note: Our ICF deployment was simplified by working closely with our enterprise security team. This was very critical since the deployment was connected to our production network as in any customer environment. We chose this approach to understand all required phases based on production deployment and not a closed-lab setup.

Table 8) ICF component versions.

Component	Version
ESXi	5.1 with VMware vDS (Cisco Nexus 1000v was not used in the validation testing)
vCenter	vCenter appliance 5.1 update 2a
ICF	2.1.2 (this is an infrastructure bundle that contains PNSC, VSM, ICX, and ICS images)

Architecture

Figure 18) NPS and ICF high-level architecture.



Networking

Intercloud Fabric requires several networking requirements for connectivity. At a minimum, you will require:

- A common "management" VLAN. This VLAN will be used for management of all ICF components (PNSC, ICX, cVSM, and so on). IPs in this VLAN will be needed for all Intercloud components. This is VLAN10 in our on-premises FlexPod configuration.
- A VLAN for the site-to-site tunnel. This is optional because the management interfaces of ICX/ICS can be used as the endpoints of the tunnel. The endpoint IP addresses obviously need to be able to communicate with the public cloud provider across the ports outlined. In this validation effort, we have taken the view that we want management traffic contained internally and not mixed with external traffic, and that it should be completely isolated for performance and security reasons. Therefore, we separated the management and the tunnel VLANs, and IPs from this VLAN20 will be assigned to the tunnel interfaces of ICX/ICS. Those IPs will comprise the endpoints of the site-to-site tunnel. In this implementation the ICX tunnel interface IP will be the "source" address in creating firewall rules and our NAT rules on the enterprise firewall.
- More than one workload VLAN. These workload VLANs will be trunked from the enterprise to the public cloud across the site-to-site tunnel. This validation effort has a single workload VLAN (VLAN1002) that is extended to the public cloud. You can also trunk workload VLANs that are deployed according to the standard three-tier stack model comprised of a "web" tier, an "app" tier, and a "db" tier, with each tier a unique VLAN. Then these three VLANs will be trunked from the enterprise to the public cloud across the site-to-site tunnel.

Cloud Provider and Firewall Ports

- Create an AWS account if you don't already have one.
- Create an AWS access key with restricted access.

- A default VPC is required for ICF. Make sure that your AWS supports this option and that the VPC is not deleted.
- If you select to have your firewall rules created with destination IP addresses for granular security controls, Amazon’s IP address blocks are available at Amazon EC2 Public IP Ranges.
- ICF requires that the following ports be opened on the enterprise firewalls to communicate successfully with AWS:
  - TCP 22, 80, 443, 843, 3389, 6644, and 6646
  - UDP 6644 and 6646
  - Additional ports required during our deployment were NTP (123) and DNS (53)
- The firewall rules can be outbound only from the enterprise to the cloud provider, assuming that the firewall is stateful. Communication between ICF and AWS is always initiated from the enterprise side (ICX). The cloud provider switch never initiates any traffic for the tunnel initiation and build.
- Cisco Intercloud Fabric Director and the Cisco Prime Network Services controller must have IP connectivity on port 443 to all ESXi hosts. The Cisco Prime Network Services controller uses this path to upload the Intercloud Fabric Extender image to the host.

Best Practice
When creating an AWS Access Keys for ICF Cloud link, make sure that you attach a security policy from the AWS console. For example, access keys do not need billing access or account management.

Guidelines to Follow Before Deployment

- Know the IP/subnet mask/gateway information for the Cisco Prime Network Services controller.
- Know the administrator password, shared_secret, and host name that you want to use. Have a shared secret password available. This password enables communication between the Cisco Prime Network Services controller, Cisco Intercloud Fabric VSM, and Cisco Intercloud Fabric.
- Know the DNS server and domain name information and make sure that you are using the correct NTP server.
- Verify that the date and time are set accurately to connect to the cloud provider. It is important to have NTP working to deploy the ICF cloud successfully.
- Know the management and tunnel VLANs and port profiles. Also, make sure that you have enough spare IPs for the ICF infrastructure in the management subnet.
- Make sure that the host has 4GB RAM and 125GB of available hard disk space. Check the Cisco Intercloud Fabric installation guides.
- Have admin access to VMware vCenter.
- Make sure that Cisco Nexus 1000V or VMware vSwitch or vDS is already installed in the private cloud.
- For a security policy for the trunk port-group on the VMware virtual switch, set Promiscuous Mode, MAC Address Changes, and Forged Transmits to Accept in the VMware vSphere GUI. This requirement applies only if you use a VMware virtual switch and distributed switch; it does not apply if you use a Cisco Nexus 1000V switch.

Best Practice
ICF and its components use multiple management IP addresses. Include these numbers in your in-band management subnet. At a minimum plan five IPs per ICX/ICS in HA mode.

Build Phases and Our Recommendations

During our deployment of ICF and the validation process, we learned a few lessons. Some of the lessons surfaced during the planning phase and some during the implementation and validation phases. All of them can help with your deployment.

Phase 1: Planning

- We spent a lot of time with our enterprise security team. We made sure that they understood the solution and how it fit in the data center and the enterprise. Their understanding eased the initial rollout of firewall rules and subsequent changes.
- ICF VM templates are time consuming when initially moved to AWS. The bandwidth of the Internet links is important and therefore should be planned for accordingly. We focused mainly on RHEL-provisioned VMs. Actual data is transferred through SnapMirror to NPS so the VMs' size was consistent and predictable through the validation.
- We used NetApp's enterprise standards for on-premises and NPS FlexPod systems including IP block assignments (NFS, Data, MGMT and ICF Tunnel). FlexPod guides were used for infrastructure deployment for consistency between the enterprise and NPS.
- AWS default VPC was the only supported option by ICF at the time of the validation. NPS works with all VPC options—there are no restrictions. ICF does not support custom VPCs; only the default VPC is supported.
- Assign separate subnets for NetApp storage and servers. Doing so simplifies the environment and provides granular control.

Phase 2: Staging

- We started with a stable ESX environment. Using the requirements from ICF for minimum ESX versions to build the environment, review Cisco's ICF updated requirements before starting your deployment.
- We verified that all ports are open on the firewalls.
- We created AWS access keys. Limit the scope of these keys with policies. There is no need for ICF to have full control over the AWS account.
- Understand and limit the Security Groups (SGs) to your enterprise subnet blocks. ICX adds the proper ports to the default SG, but we suggest additional controls for the IP address level as a best practice.
- Make sure that ICF Services (VSG and CSR) are selected during ICL tunnel creation to access NPS; these options might not be clear during the ICL provisioning process. If these services are not selected the ICL tunnel must be deleted and rebuilt.

Note: NTP must be on the same MGMT VLAN; NTP on different VLANs or external ones did not work. We reported the issue to Cisco and it is investigating.

Phase 3: Deployment

- All deployment steps are completed from ICF Director (ICFD) with the exception of CSR. In this version the CSR package is installed from PNSC.
- ICFD, PNSC, and VSM are installed during the initial steps. ICX and ICS are created when building an ICL tunnel to AWS. CSR is then instantiated from PNSC in AWS.
- ICFD gives you control over which AWS region and Availability Zone you choose to deploy ICS in. Make sure that you select the correct ones.
- Create VM templates from vCenter and import them into ICF. OVA templates are preferred over cold VMs.
- Create templates in the cloud based on your enterprise standards. These AMIs are created from templates imported into ICF and subsequently prepared in the cloud. Instantiate templates for load augmentation and dev/test and still have security and network control.

Phase 4: NPS/ICF Integration

- Instantiate CSR in AWS using PNSC and extend only workload VLANs. CSR requires two workload VLANs; we opted to extend VLAN1000 and VLAN1002. In addition Tunnel and MGMT VLANs are also needed. Without CSR, ICF VMs are isolated and only accessible from the enterprise. NPS storage is also not accessible without CSR. Later we explain how to achieve routing between the two environments.
- We used GRE tunnels between ICF VMs in AWS and NPS; other options are also available.
- Validate ICF VMs' visibility to NPS through NFS mounts.
- Validate NPS availability for both ICF and non-ICF EC2 instances.
- NAT on CSR is required to access Cloud ONTAP. This solution is demonstrated in section 11.5, "Cloud ONTAP and ICF."

IP Addresses of ICF Components and Servers

The following IP addresses are used in our solutions list.

- ESXi HOST1 = 10.251.161.11
- ESXi HOST2 = 10.251.161.12
- ESXi HOST3 = 10.251.161.13
- vCenter Appliance = 10.251.161.16
- ICFD = 10.251.161.17
- PNSC = 10.251.161.5
- Cloud VSM = 10.251.161.6
- Two Intercloud Extenders (for HA IC-Link) for each AWS region; we used only one ICL for our validation
- Two Intercloud Switches (for HA IC-Link) for each AWS region; we used only one ICL for our validation
- RHEL-WITHNFS = 10.161.251.136 (this is used to create cloud AMI templates and for live migrations)
- RHEL-WITHOUTNFS = 10.161.251.138 (this is used to create cloud AMI templates and for live migrations)

Note: This document does not cover the installation of ICF. Refer to Cisco's website for the latest installation guides for up-to-date information and version-specific steps. We like to focus more on the steps that integrate ICF with NPS, including necessary configuration and verification along the way.

9.4 ICF Cloud VM Behavior

A summary of an ICF VM (moved or instantiated) to the cloud provider helps pave the way to understanding the need for CSR to access NPS and Cloud ONTAP. The behavior is the same for any ICF VM once an activity is triggered.

ICF Cloud Bubble

Following an ICF live VM migration from the enterprise to the cloud, a VM goes through the process noted below. Creating a template for later instantiation in the cloud consists of similar steps excluding step 1.

1. The admin triggers VM migration to the cloud (or template creation).
2. The VM process takes place:
   – The VM is shut down.

- The VM image is made ready for ICF by inserting an ICF driver (agent) and its associated configuration into the image.

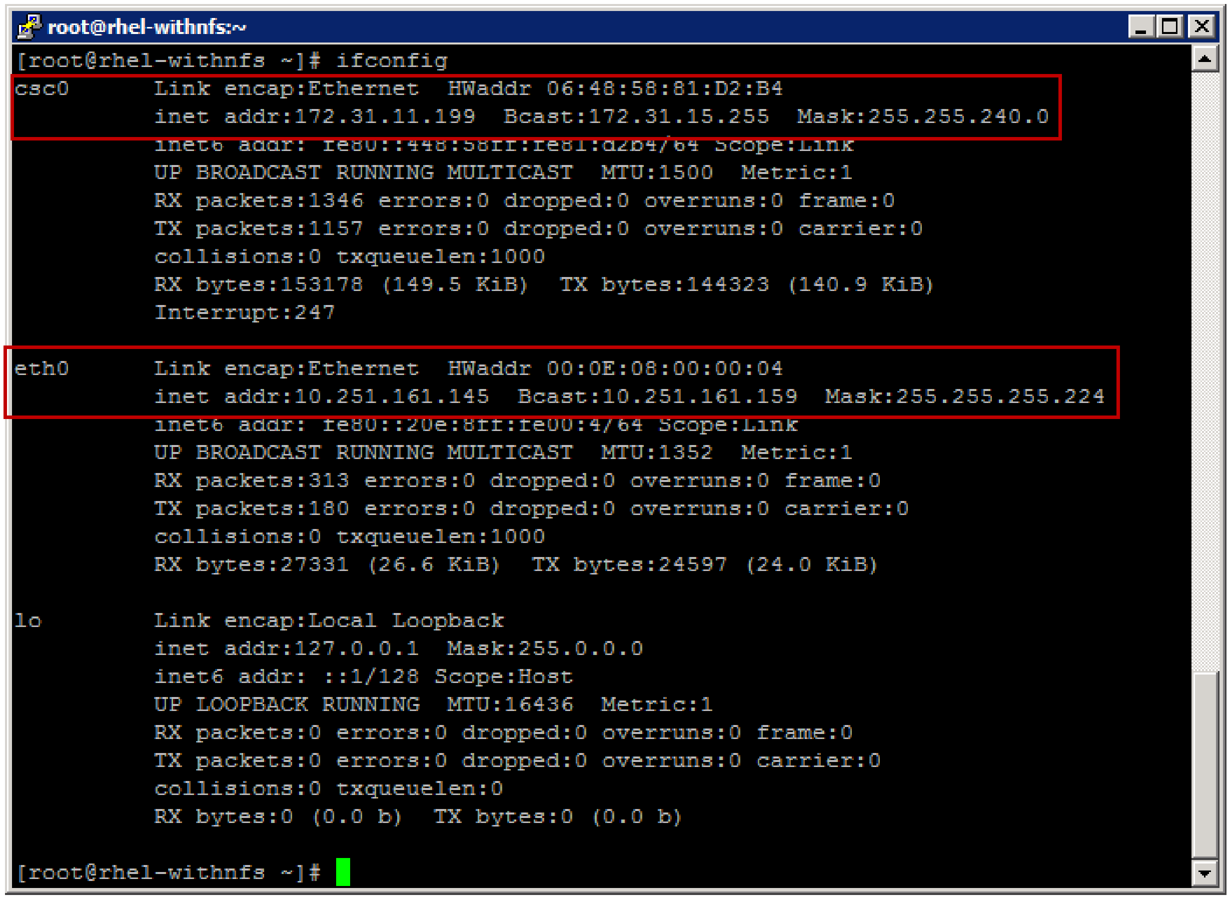
3. The image is converted to AWS AMI format and then moved to AWS.
4. The VM is powered up on AWS and subsequent management continues through ICFD.

Best Practice
Always assign your servers eth1 because AWS assigns eth0 to all EC2 instances by default. Doing so prevents any confusion during troubleshooting. We did not see any technical impact if we used either eth0 or eth1 in our RHEL images during the validation, as seen in some of our captures.

ICF VM Interfaces

After a VM is migrated or instantiated and the ICF agent is inserted during the process, the VM is in an ICF bubble. Figure 19 shows the output from a VM instantiated in the cloud. The VM now has two interfaces: csc0 and eth0. Interface csc0 is mapped to the AWS network while eth0 is mapped to the enterprise network through the ICF agent. Only SSH and ICMP are permitted on csc0; therefore it is isolated from other EC2 instances created outside ICF, as seen in Figure 20.

Figure 19) ICF VM interfaces.



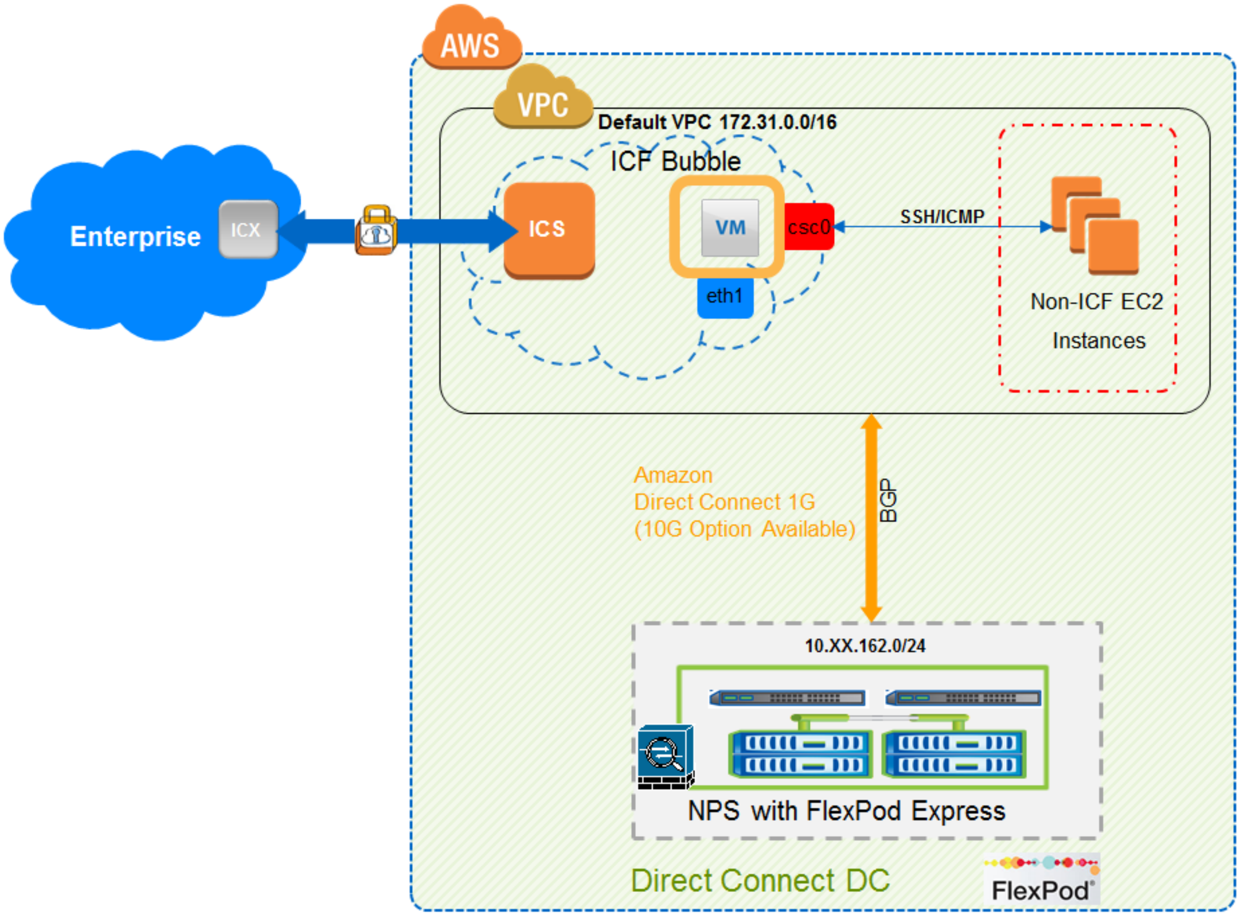
```
[root@rhel-withnfs ~]# ifconfig
csc0      Link encap:Ethernet  HWaddr 06:48:58:81:D2:B4
          inet addr:172.31.11.199  Bcast:172.31.15.255  Mask:255.255.240.0
          inet6 addr: fe80::448:58ff:fe81:d2b4/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1346 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1157 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:153178 (149.5 KiB)  TX bytes:144323 (140.9 KiB)
          Interrupt:247

eth0      Link encap:Ethernet  HWaddr 00:0E:08:00:00:04
          inet addr:10.251.161.145  Bcast:10.251.161.159  Mask:255.255.255.224
          inet6 addr: fe80::20e:8ff:fe00:4/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1352  Metric:1
          RX packets:313 errors:0 dropped:0 overruns:0 frame:0
          TX packets:180 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:27331 (26.6 KiB)  TX bytes:24597 (24.0 KiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 b)  TX bytes:0 (0.0 b)

[root@rhel-withnfs ~]#
```

An instantiated or migrated ICF VM in AWS always uses the ICL tunnel to forward the traffic to the enterprise. The gateway of the ICF VMs in AWS remains the same—the enterprise router, therefore, maintains normal operation as if the VM is on the premises. Typically, this is fine for servers without external data requirements, a tier 3 application, or compute load augmentation.

Note: The assumption for this deployment is that enterprise storage is not available through the TLS tunnel. NetApp does not recommend that the data be served over the tunnel because of latency and bandwidth issues.

Figure 20 demonstrates the separation of ICF VMs, non-ICF EC2 instances, and NPS. In this deployment the ICF VMs are completely isolated from other EC2 instances and NPS. SnapMirror data is only available to non-ICF VMs.

Figure 20) ICF VM interface mapping.



Limitations

Regardless of how a VM is prepared on the premises, an ICF network agent is inserted before it’s converted to AMI and moved to the AWS. After an ICF VM is moved, the default behavior for ICF VMs is limited to communication with other ICF VMs and the enterprise infrastructure only. It cannot communicate with other cloud VMs (non-ICF VMs). This is intentional to maintain a secure deployment in the public cloud. Although this limits the use cases of ICF in certain designs, to workloads only without the need to access the data, for example, this is not a typical scenario because most enterprises do require close proximity of data and compute because of latency.

Plan Ahead

It's important to understand the added impact of the ICF process for moving a VM from the enterprise to the public cloud. The process includes inserting ICF Network Agent on each ICF VM migrated or instantiated, and this agent consumes CPU resources. The overhead might not be significant depending on the VM instance size. However, it is important to validate your environment to make sure that applications are not affected.

Cisco realizes that enterprises need to expand beyond peak-workload augmentation. The need for DR, dev/test, and shadow IT with latency-sensitive data accessibility is utmost to leveraging the public cloud. To leverage NPS and provide accessibility to ICF VMs in the cloud, an additional ICF service is needed: Cloud Services Router (CSR). The subsequent section shows how NetApp validated CSR to give ICF VMs access to NPS and Cloud ONTAP.

9.5 Cloud Services Router (CSR)

The Intercloud Fabric Router (CSR 1000V) provides a cloud-based virtual router that is deployed on a VM instance on x86 server hardware. The Intercloud Fabric Router is a virtual platform that provides selected Cisco IOS XE security and switching features on a virtualization platform.

The Intercloud Fabric Router can also be deployed on AWS for private and provider cloud solutions. Refer to the Cisco CSR 1000V Series Cloud Services Router Deployment Guide for Amazon Web Services for information on deploying the Intercloud Fabric Router AMI.

The Intercloud Fabric Router acts as the edge device in the Intercloud Fabric and provides the following functionality:

- Provides inter-VLAN routing for the virtual machines in the provider cloud
- Serves as the NAT gateway to the virtual machines in the provider cloud
- Serves as a default gateway for cloud virtual machines, avoiding traffic hairpinning to the enterprise for cloud VM communication
- Provides direct VPN connectivity to cloud workloads from enterprise branch offices; supports IPsec, DMVPN, and Flex VPN and GRE tunneling, allowing access to NPS
- Provides direct access to cloud workloads and Cloud ONTAP using static NAT

Without CSR, the ICF VMs in AWS are isolated from NPS and Cloud ONTAP. This can be considered a limitation of the hybrid cloud strategy since the SnapMirror data is not accessible with the CSR in an ICF environment.

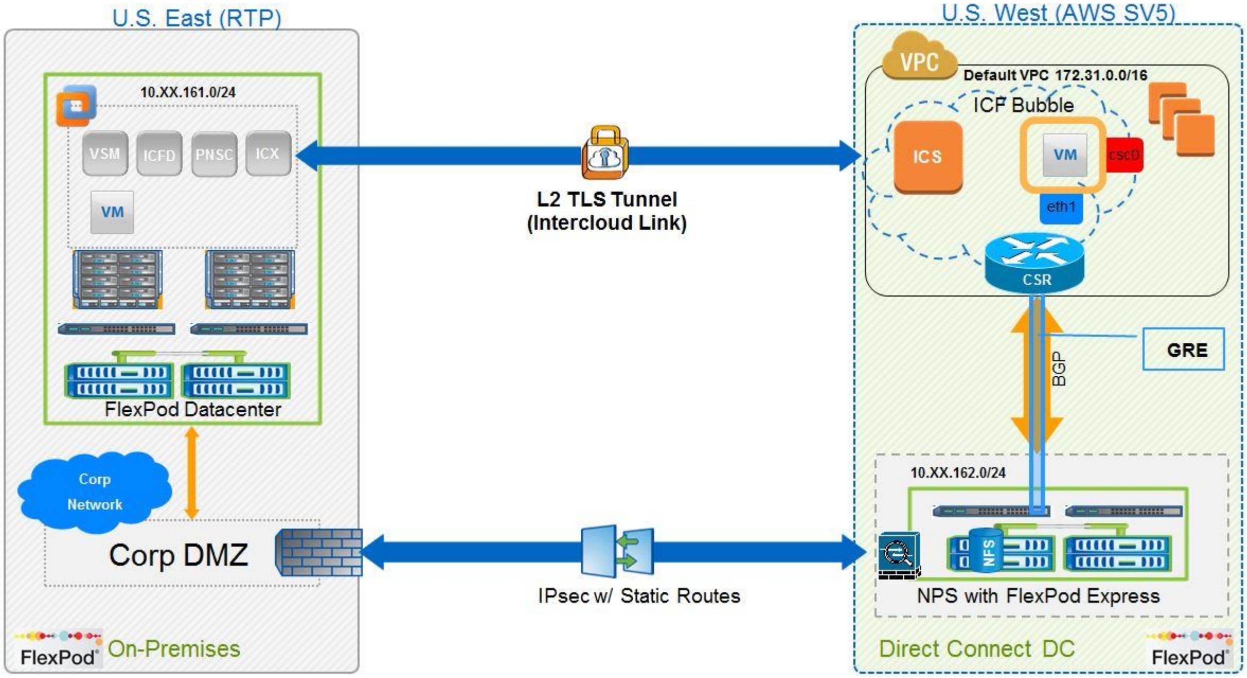
CSR Architecture

This section details the requirements for installing CSR as part of ICF, integration with NPS, and the configuration needed to expand ICF VMs' functionality to NPS and Cloud ONTAP.

Architecture

Figure 21 shows the position of the CSR in relation to ICF VMs, AWS EC2s, and NPS. After CSR is installed and configured with the proper VLANs, routing and necessary tunneling interface, and/or NAT, ICF VMs have the capabilities to reach the external services.

Figure 21) NPS and CSR architecture.



Guidelines and Limitations

- The Intercloud Fabric Router is only supported on AWS. Although our validation focuses on AWS, we thought to note this limitation. Support for other hyperscalers is on the roadmap permitting access to NPS regardless of the provider.
- The Intercloud Fabric Router version 3.13.1 is required for Intercloud Fabric.
- NAT functionality for the Intercloud Fabric Router is available only if there is a default VPC in the AWS account.
- During deployment of the Intercloud Fabric Router in the provider cloud, inter-VLAN traffic might stop working between the private cloud and the provider cloud virtual machines for VLANs that are not extended to the provider cloud. You must add routing for private cloud VLANs that are not extended on a data interface configured as the default gateway. If there is no data interface configured as the default gateway, add one with one of the private cloud VLANs that is not extended. Then, add routing for the remaining VLANs under that interface.

Note: Although not mentioned in the current requirements, more than one payload VLAN is needed for CSR deployment. Minimum requirements are one MGMT VLAN, one public cloud interface, and two Gigabit Ethernet (enterprise) VLANs.

Best Practice

CSR for AWS currently has throughput limitations; plan and design your environment accordingly to avoid bottlenecks. Refer to the current CSR datasheets for up-to-date limitations.

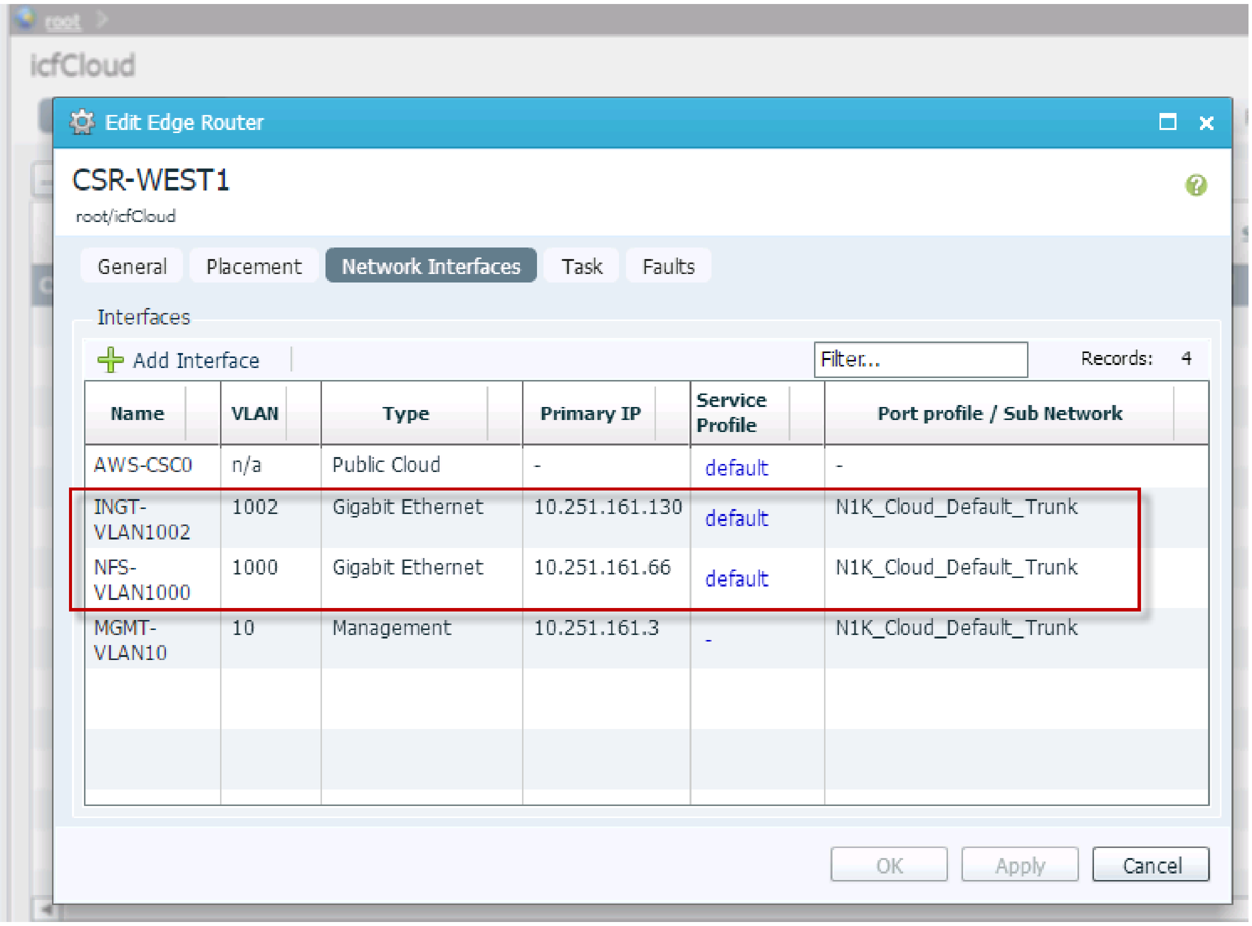
Prerequisites

- Before launching the Intercloud Fabric Router AMI from Intercloud Fabric you have to accept the terms and conditions in the following ways:
  - In the Amazon Web Services Marketplace, search for Cisco CSR and accept the terms for Cisco CSR release 3.13.01.S Bring Your Own License (BYOL).

  - From your Amazon Web Services Marketplace account, launch an EC2 instance with the CSR release 3.13.01.S Bring Your Own License (BYOL) and accept the terms and conditions.
- You have now created the management port profile in Intercloud Fabric. The port profile should include the management VLAN ID so that when you instantiate the Intercloud Fabric Router using PNSC, the management VLAN ID is displayed in the VLAN drop-down list in the Edit Edge Router page (Figure 22).
- You have now created the port profile for the subinterface in Intercloud Fabric. The port profile should include the VLAN ID so that when you instantiate the Intercloud Fabric Router using PNSC, the VLAN ID is displayed in the VLAN drop-down list in the Edit Edge Router page (Figure 22).

As noted earlier, a minimum of two payload VLANs is needed. Figure 22 shows the VLANs that we extended as part of the validation even though VLAN1000 is not needed.

Figure 22) CSR-required VLANs.



CSR-WEST1

root/icfCloud

Records: 4

Name	VLAN	Type	Primary IP	Service Profile	Port profile / Sub Network
AWS-CSC0	n/a	Public Cloud	-	default	-
INGT-VLAN1002	1002	Gigabit Ethernet	10.251.161.130	default	N1K_Cloud_Default_Trunk
NFS-VLAN1000	1000	Gigabit Ethernet	10.251.161.66	default	N1K_Cloud_Default_Trunk
MGMT-VLAN10	10	Management	10.251.161.3	-	N1K_Cloud_Default_Trunk

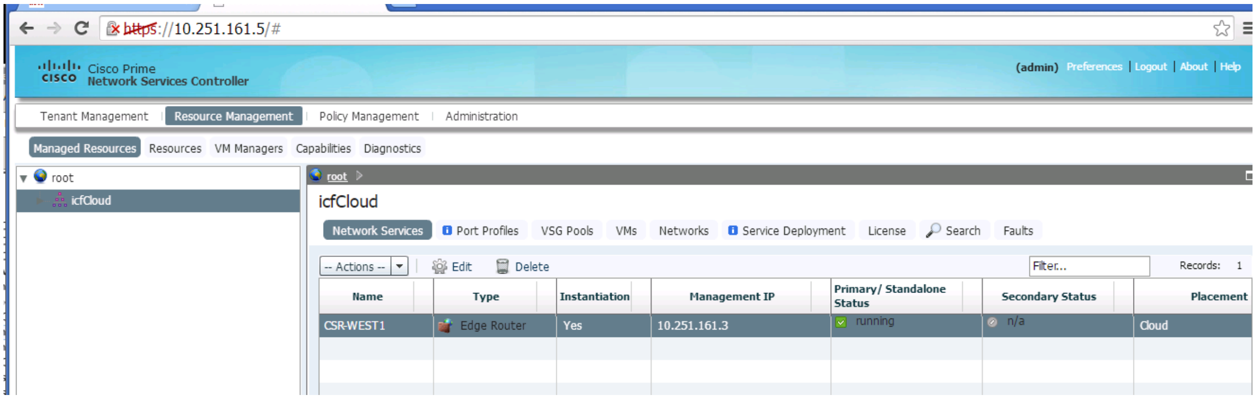
Best Practice

As mentioned previously, this guide does not focus on step-by-step installation for ICF or its components, including CSR. Refer to the online links for the latest deployment guides to match your ICF version.

CSR Verification

After the CSR is installed, verify that it has been instantiated successfully and can be reached from the enterprise network.

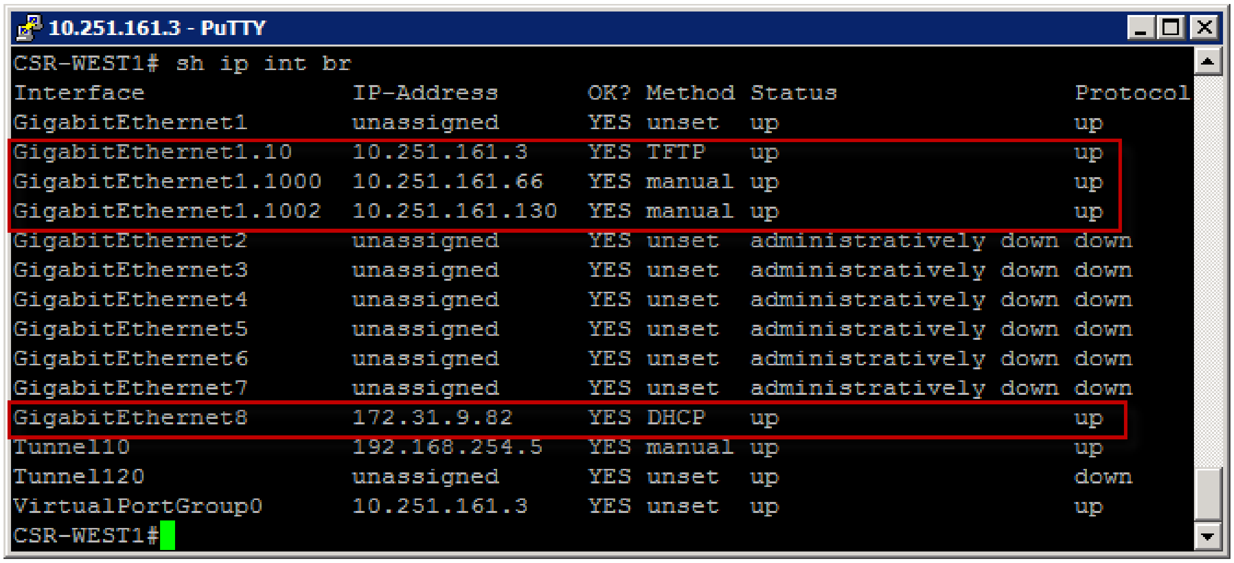
Figure 23) CSR verification from PNSC.



Name	Type	Instantiation	Management IP	Primary/ Standalone Status	Secondary Status	Placement
CSR-WEST1	Edge Router	Yes	10.251.161.3	✓ running	n/a	Cloud

Figure 24 shows that CSR has been instantiated, is running, and is placed in the cloud. The IP address assigned during the instantiation is 10.251.161.3. We'll use that address to further manage it from CLI.

Figure 24) CSR CLI.

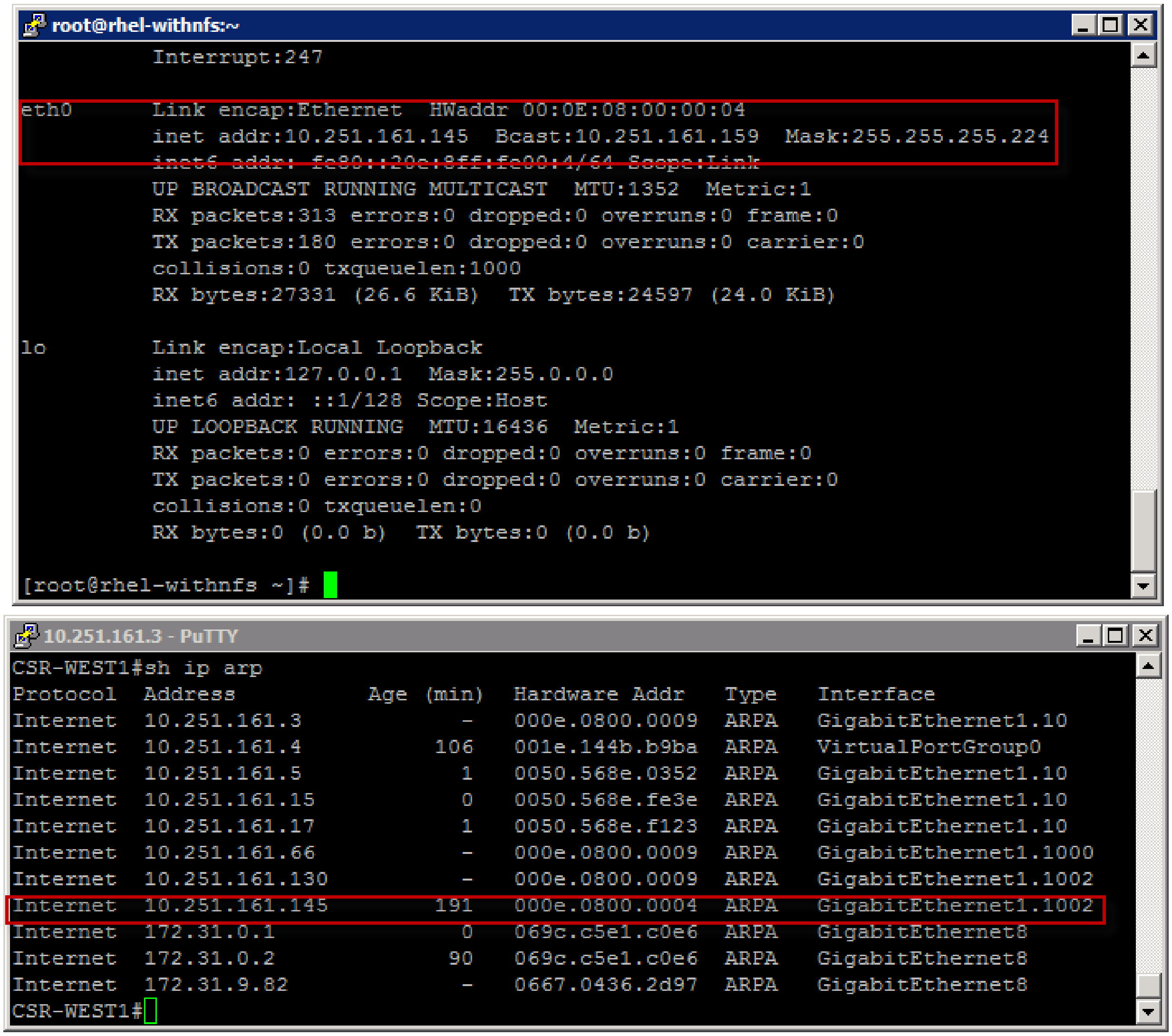


```
CSR-WEST1# sh ip int br
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet1       unassigned      YES unset  up                    up
GigabitEthernet1.10    10.251.161.3    YES TFTP   up                    up
GigabitEthernet1.1000  10.251.161.66   YES manual up                    up
GigabitEthernet1.1002  10.251.161.130  YES manual up                    up
GigabitEthernet2       unassigned      YES unset  administratively down down
GigabitEthernet3       unassigned      YES unset  administratively down down
GigabitEthernet4       unassigned      YES unset  administratively down down
GigabitEthernet5       unassigned      YES unset  administratively down down
GigabitEthernet6       unassigned      YES unset  administratively down down
GigabitEthernet7       unassigned      YES unset  administratively down down
GigabitEthernet8       172.31.9.82     YES DHCP   up                    up
Tunnel10               192.168.254.5   YES manual up                    up
Tunnel120              unassigned      YES unset  up                    down
VirtualPortGroup0      10.251.161.3    YES unset  up                    up
CSR-WEST1#
```

The output in Figure 25 shows the interfaces configured during the instantiation process for CSR from PNSC. The tunnel interfaces are configured later as part of the integration with NPS.

Best Practice
Extend the cloud VMs' gateway using the CSR; otherwise traffic will be hairpinned to the enterprise, which is a suboptimal configuration and will incur additional charges for VM-VM traffic in the cloud.

Figure 25) CSR ARP table.



```
          Interrupt:247

eth0      Link encap:Ethernet  HWaddr 00:0E:08:00:00:04
          inet addr:10.251.161.145  Bcast:10.251.161.159  Mask:255.255.255.224
          inet6 addr: fe80::20c:8ff:fe00:4/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1352  Metric:1
          RX packets:313 errors:0 dropped:0 overruns:0 frame:0
          TX packets:180 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:27331 (26.6 KiB)  TX bytes:24597 (24.0 KiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 b)  TX bytes:0 (0.0 b)

[root@rhel-withnfs ~]#
```

```
CSR-WEST1#sh ip arp
Protocol  Address          Age (min)  Hardware Addr   Type   Interface
Internet  10.251.161.3            -   000e.0800.0009  ARPA   GigabitEthernet1.10
Internet  10.251.161.4          106   001e.144b.b9ba  ARPA   VirtualPortGroup0
Internet  10.251.161.5            1   0050.568e.0352  ARPA   GigabitEthernet1.10
Internet  10.251.161.15           0   0050.568e.fe3e  ARPA   GigabitEthernet1.10
Internet  10.251.161.17           1   0050.568e.f123  ARPA   GigabitEthernet1.10
Internet  10.251.161.66           -   000e.0800.0009  ARPA   GigabitEthernet1.1000
Internet  10.251.161.130          -   000e.0800.0009  ARPA   GigabitEthernet1.1002
Internet  10.251.161.145        191   000e.0800.0004  ARPA   GigabitEthernet1.1002
Internet  172.31.0.1              0   069c.c5e1.c0e6  ARPA   GigabitEthernet8
Internet  172.31.0.2             90   069c.c5e1.c0e6  ARPA   GigabitEthernet8
Internet  172.31.9.82             -   0667.0436.2d97  ARPA   GigabitEthernet8
CSR-WEST1#
```

As seen in Figure 25, CSR handles ARP requests for the ICF VM. This prevents hairpinning to the enterprise for VM-VM traffic.

9.6 Integrating ICF with NPS Using CSR

After CSR is installed, you can integrate ICF with NPS by using the NAT or GRE options. Although NAT works optimally, we wanted unrestricted and set-it-and-forget-it ease between the two environments.

Before demonstrating how to approach this solution, it’s worth noting why we need this solution in the first place. When CSR is instantiated in the cloud, the router is booted with a static route pointing to the AWS network from its Availability Zone. This is an acceptable way to reach NPS through the AWS routing table, and since traffic is sourced from ICF VMs (enterprise IP addresses), NPS doesn’t know how to return the traffic to the source. Even if NPS has a default route to AWS VPC (it’s possible to accept a default route from AWS), the AWS routing table is not aware of the enterprise subnet block. The traffic is black-holed at the VPC, breaking any communication between ICF and NP (Figure 26).

Figure 26) Default routing behavior.

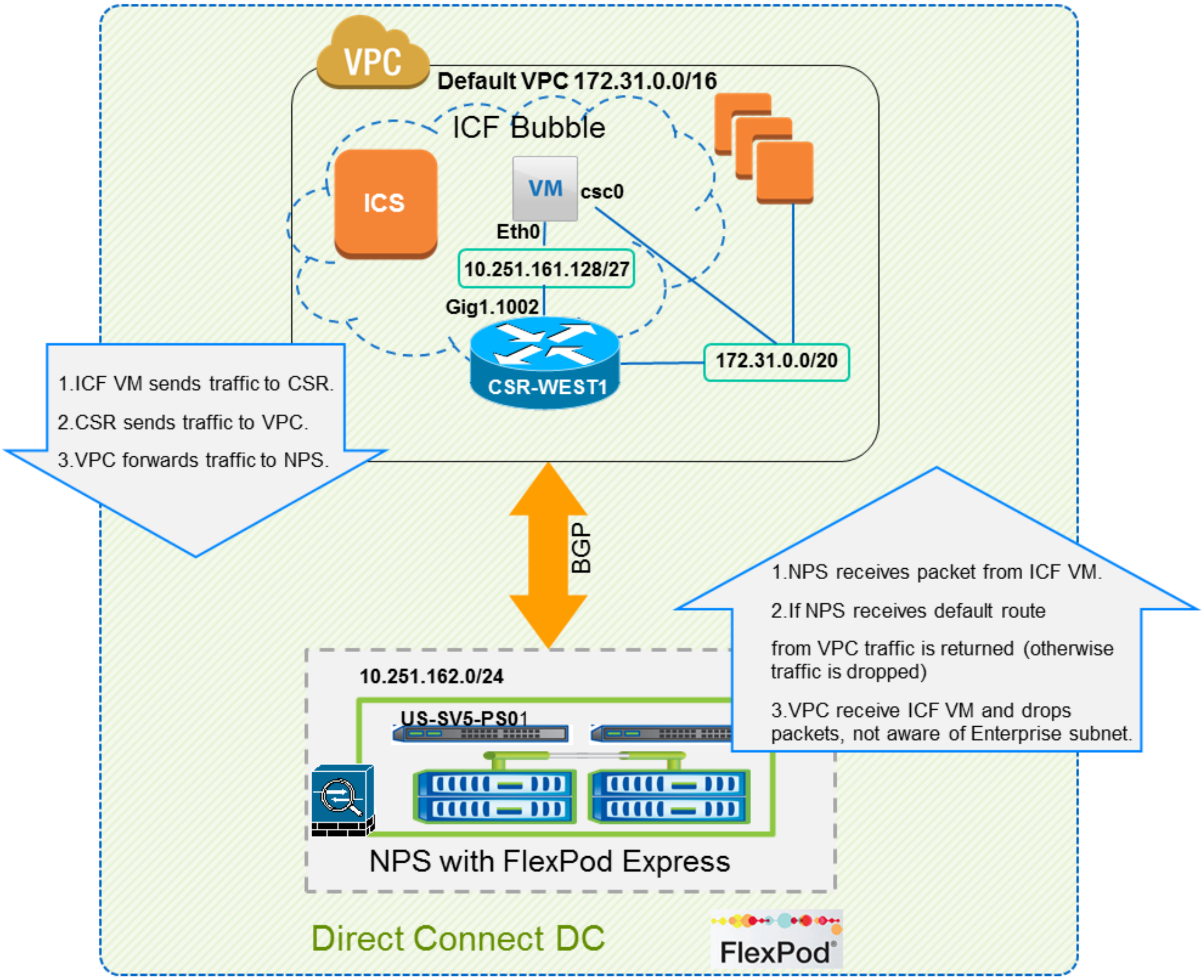
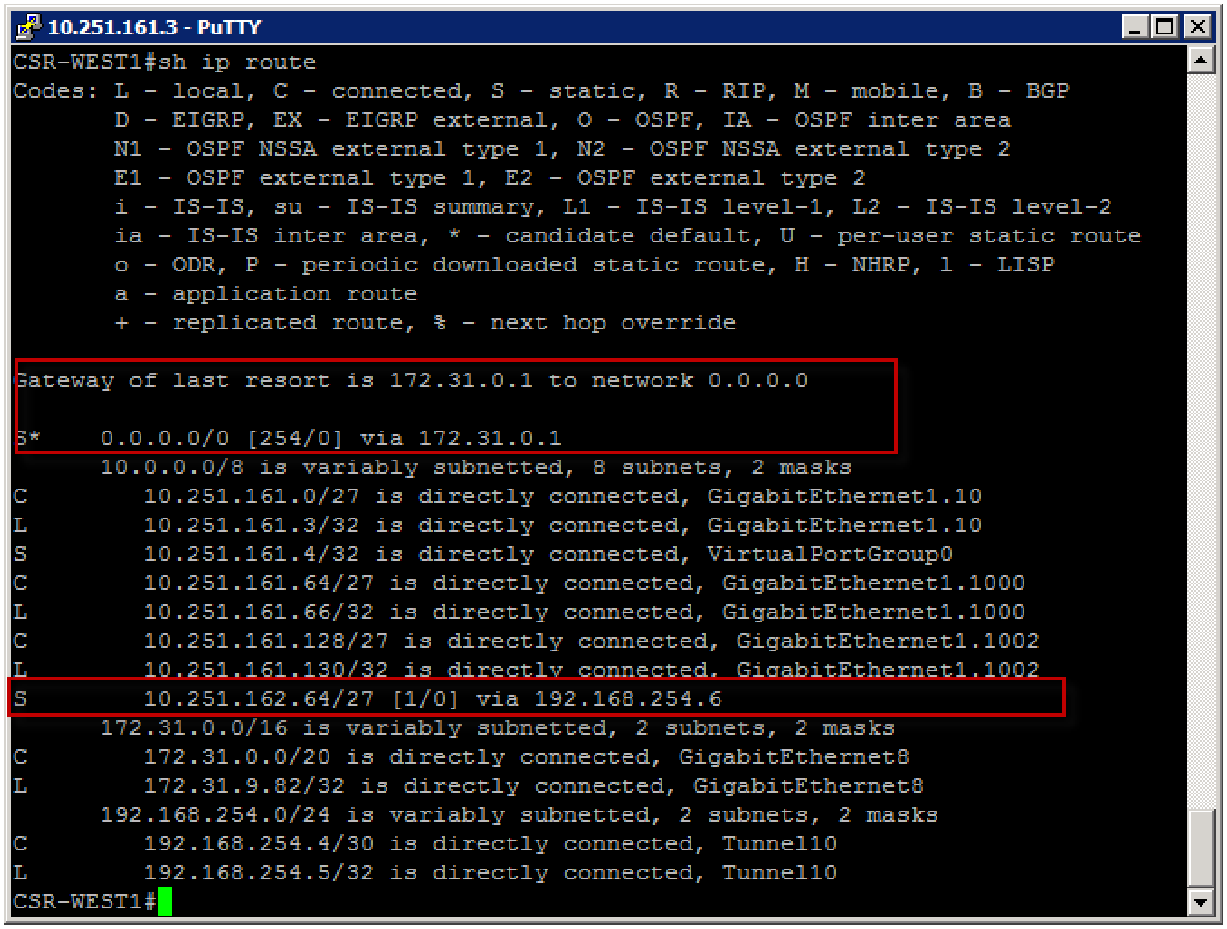

VPC
Default VPC 172.31.0.0/16
ICF Bubble
ICS
VM
csc0
Eth0
10.251.161.128/27
Gig1.1002
CSR-WEST1
172.31.0.0/20
1.ICF VM sends traffic to CSR.
2.CSR sends traffic to VPC.
3.VPC forwards traffic to NPS.
BGP
1.NPS receives packet from ICF VM.
2.If NPS receives default route
from VPC traffic is returned (otherwise traffic is dropped)
3.VPC receive ICF VM and drops packets, not aware of Enterprise subnet.
10.251.162.0/24
US-SV5-PS01
NPS with FlexPod Express
Direct Connect DC
FlexPod

Figure 27 shows the routing table of CSR. It also includes the static routes added and explains how routing is accomplished.

Figure 27) CSR default routing table.



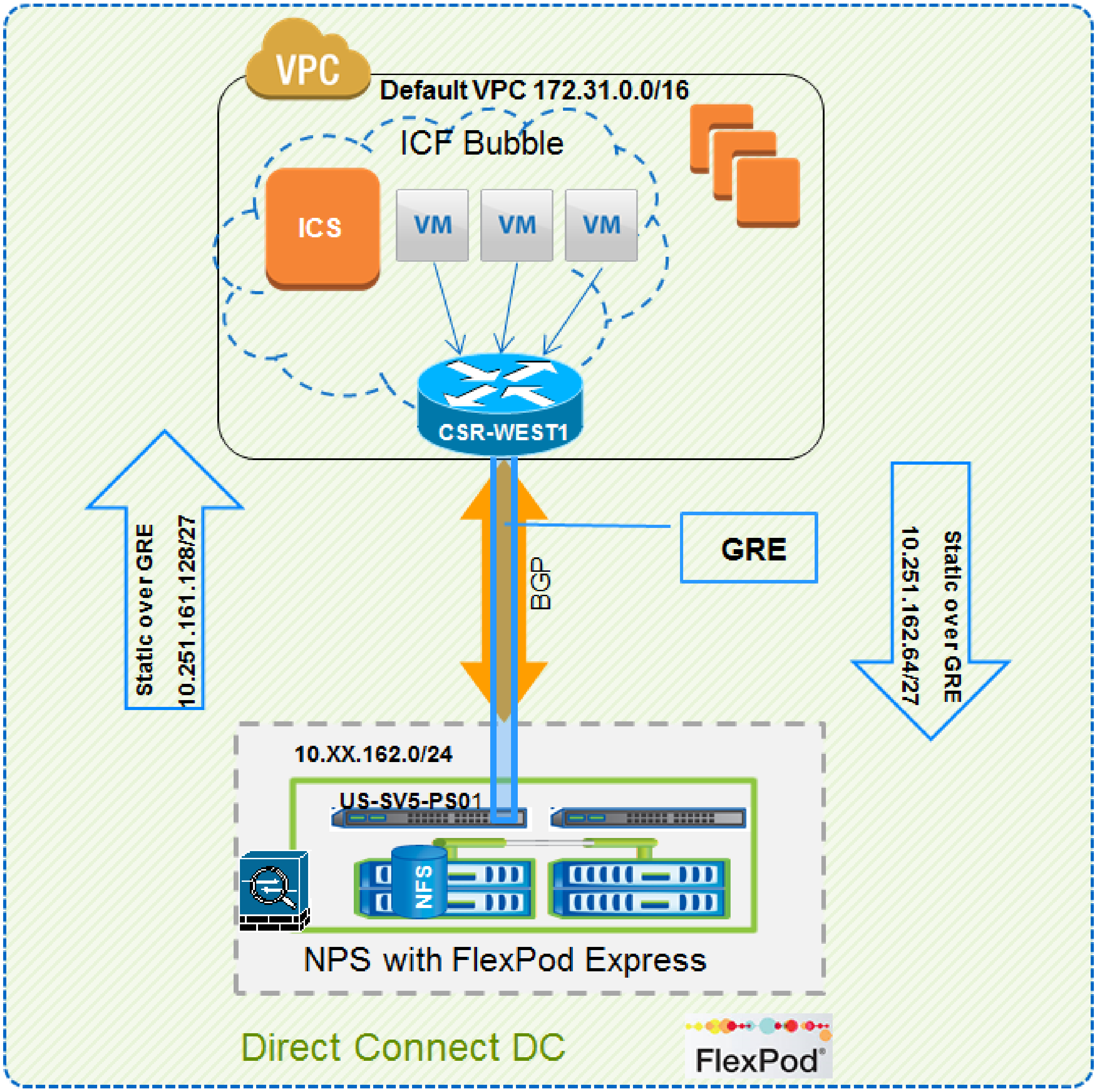
10.251.161.3 - PuTTY

```
CSR-WEST1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is 172.31.0.1 to network 0.0.0.0

S*    0.0.0.0/0 [254/0] via 172.31.0.1
      10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
C        10.251.161.0/27 is directly connected, GigabitEthernet1.10
L        10.251.161.3/32 is directly connected, GigabitEthernet1.10
S        10.251.161.4/32 is directly connected, VirtualPortGroup0
C        10.251.161.64/27 is directly connected, GigabitEthernet1.1000
L        10.251.161.66/32 is directly connected, GigabitEthernet1.1000
C        10.251.161.128/27 is directly connected, GigabitEthernet1.1002
L        10.251.161.130/32 is directly connected, GigabitEthernet1.1002
S        10.251.162.64/27 [1/0] via 192.168.254.6
      172.31.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.31.0.0/20 is directly connected, GigabitEthernet8
L        172.31.9.82/32 is directly connected, GigabitEthernet8
      192.168.254.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.254.4/30 is directly connected, Tunnel10
L        192.168.254.5/32 is directly connected, Tunnel10
CSR-WEST1#
```

9.7 NPS and CSR Implementation

We’re basing the implementation steps on our deployment of NPS and on-premises FlexPod and the usage of CSR in the deployment. Figure 28 depicts the device names so that you can follow the configuration easily.

Figure 28) Routing reference for NPS and ICF with CSR.



CSR Configuration

To configure the CSR-WEST CSR router, complete the following steps.

CSR-WEST1		
Step	Command	Description
1	interface GigabitEthernet8 no ip access-group extended default-egress out no ip access-group extended default-ingress in end	1. Remove or modify the default ACLs on the external (Gig8) interface. We opted to remove it. The permit GRE protocol suffices for restricting security policy.

CSR-WEST1		
2	interface tunnel 10 ip address 192.168.254.5 255.255.255.252 ip mtu 1328 tunnel source GigabitEthernet8 tunnel destination 10.251.162.254 end	2. Create the GRE tunnel using the Gig8 interface. Either use IP as a source or the interface. Either case works fine, even though it’s DHCP; the IP address is persistent unless the VM is deleted. 3. The destination IP address is a loopback created on the NPS router. We opted to use loopback because P2P uses the 169 subnet block. 4. Modify the MTU to make sure that there is no fragmentation on the network. 5. The tunnel IP is configured with the 192 subnet. However, any subnet can be used since this is P2P.
3	ip route 10.251.162.64 255.255.255.224 192.168.254.6	Create a static route for NPS; this is the IP subnet serving NFS on the FlexPod Express FAS.

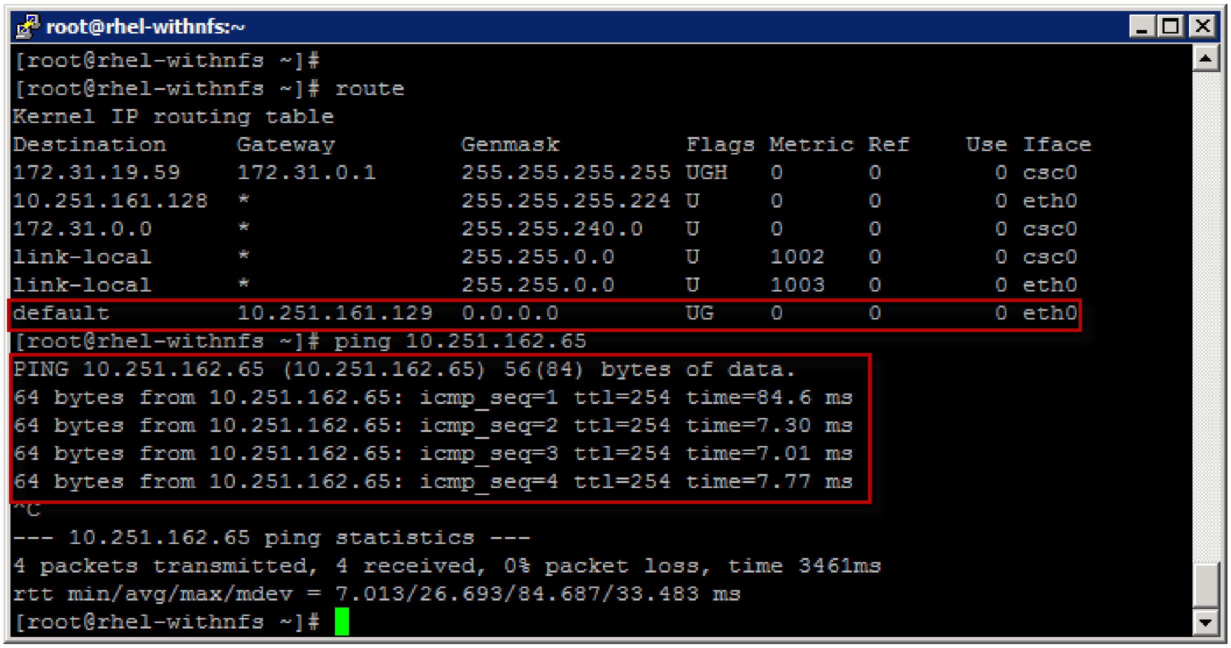
US-SV5-PS01		
Step	Command	Description
1	interface loopback0 ip address 10.251.162.254/32	Create the loopback interface. Select your preferred interface number and a curved block routable to AWS VPC.
2	interface Tunnel10 ip address 192.168.254.6/30 tunnel source loopback0 tunnel destination 172.31.9.82 mtu 1328	Create the GRE tunnel using the loopback0 as a source. The destination IP is the DHCP assigned to Gig8. Modify the MTU to make sure that there is no fragmentation on the network. The tunnel IP is configured with the 192 subnet. However, any subnet can be used since this is P2P.
3	ip route 10.251.161.128/27 192.168.254.5	Create a static route for NPS. This is the IP subnet serving NFS on the FlexPod Express FAS.

Best Practice
Make sure that the MTU size is adjusted for GRE tunnels. Otherwise, packet fragmentation will occur for traffic traversing the tunnel.

Verify Reachability

After the configuration is complete, NPS can be reached from ICF VMs. Figure 29 shows network reachability between the instantiated VM and NPS. Section 8.4 shows the NFS mount after using SnapMirror from on the premises to NPS.

Figure 29) Routing verification between ICF and NPS.



```
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
172.31.19.59    172.31.0.1      255.255.255.255 UGH   0      0        0 csc0
10.251.161.128  *               255.255.255.224 U     0      0        0 eth0
172.31.0.0      *               255.255.240.0   U     0      0        0 csc0
link-local      *               255.255.0.0     U     1002   0        0 csc0
link-local      *               255.255.0.0     U     1003   0        0 eth0
default         10.251.161.129  0.0.0.0         UG    0      0        0 eth0
[root@rhel-withnfs ~]# ping 10.251.162.65
PING 10.251.162.65 (10.251.162.65) 56(84) bytes of data.
64 bytes from 10.251.162.65: icmp_seq=1 ttl=254 time=84.6 ms
64 bytes from 10.251.162.65: icmp_seq=2 ttl=254 time=7.30 ms
64 bytes from 10.251.162.65: icmp_seq=3 ttl=254 time=7.01 ms
64 bytes from 10.251.162.65: icmp_seq=4 ttl=254 time=7.77 ms
^C
--- 10.251.162.65 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3461ms
rtt min/avg/max/mdev = 7.013/26.693/84.687/33.483 ms
[root@rhel-withnfs ~]#
```

Summary

With this solution we’re able to integrate ICF VMs with NPS. Although we used a GRE tunnel to complete the integration, other tunneling options are possible, depending on your NPS design. GRE is supported on Cisco Nexus 3k as part of the enterprise license. There are no additional requirements.

10 Cloud ONTAP and Intercloud Fabric Integration

As an alternative to NPS, Cloud ONTAP is a full-featured solution for an immediate public cloud presence. There are no dependencies between NPS and Cloud ONTAP. There are no specific requirements to deploy Cloud ONTAP; deployment is really as simple as following the deployment guide noted earlier in this document and that is available on AWS Marketplace.

There are a couple of requirements to keep in mind, as noted in section 10.1. These are limitations that result from routing behavior on the CSR.

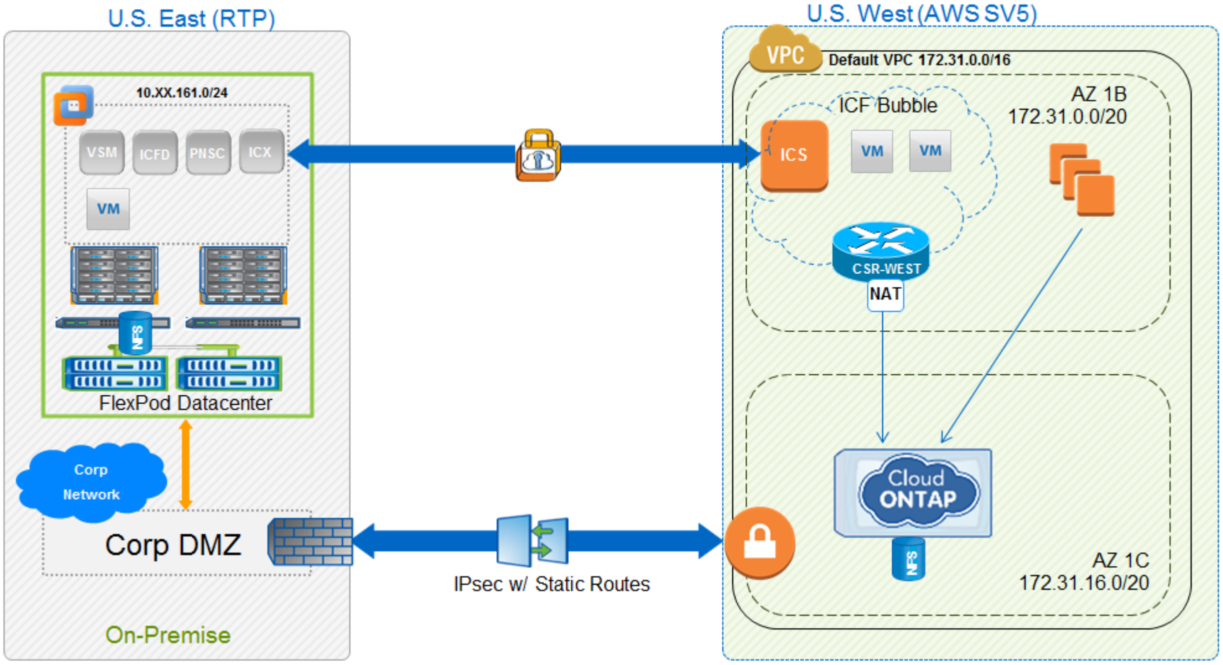
10.1 Guidelines and Limitations

- Cloud ONTAP must be installed in an Availability Zone different from the CSR and ICF VMs.
- Unlike NPS, NAT configuration is required on CSR because GRE is not possible. For more details on why GRE is not possible, refer to the section “Why NAT and Not GRE.”

10.2 Solution Architecture

Figure 30 shows the overall architecture and the integration of ICF, Cloud ONTAP, and the enterprise. Bear in mind that the VPN tunnel from the enterprise terminates on AWS VPC; this is a standard deployment to permit traffic between on-premises FlexPod and AWS. This is the same whether ICF is used or not. The difference, however, is that ICF requires a default VPC.

Figure 30) Cloud ONTAP architecture.



Availability Zones

Cloud ONTAP must be installed in a different Availability Zone from CSR and ICF VMs because of the nature of routing and subnets. If Cloud ONTAP and an ICF VM are installed in the same Availability Zone, traffic will default out of csc0, black-holing traffic to and from Cloud ONTAP. The reasonable solution at this time is to install ICF components in one Availability Zone and Cloud ONTAP in another.

Why NAT and Not GRE

Because Cloud ONTAP technically is another EC2 on AWS, GRE is not a possible solution at this time. NAT is an alternative service available on the CSR and can be used in both Static and Overload options. Depending on your environment, the external interface of the CSR (Gig8) can be configured with multiple private IPs and an Elastic IP Address (EIP) to accommodate Static NAT. In this guide we focus on Payload NAT.

CSR NAT Configuration

To configure the CSR with NAT, complete the following steps.

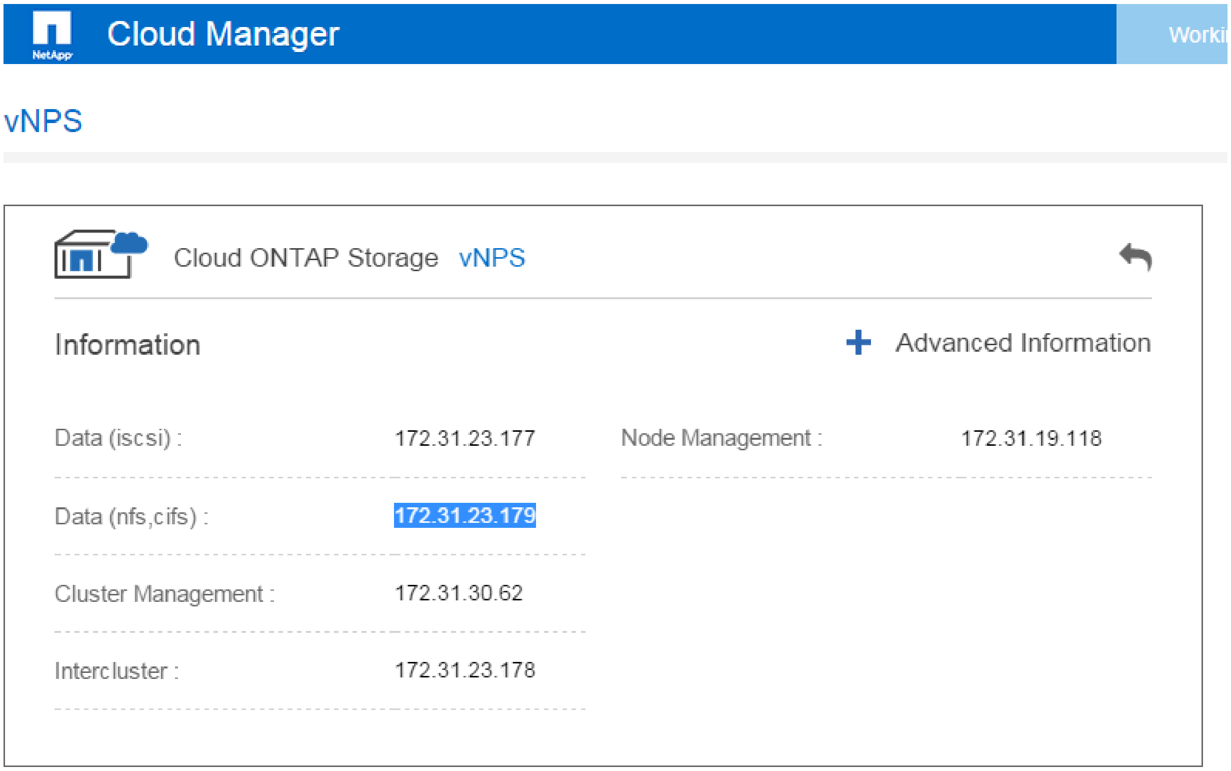
CSR-WEST1		
Step	Command	Description
1	access-list 1 permit 10.251.161.128 0.0.0.31	Identify the interesting traffic for NAT. In this case it's Payload VLAN1002.
2	interface GigabitEthernet1.1002 encapsulation dot1Q 1002 ip address 10.251.161.130 255.255.255.224 ip mtu 1352 ip nat inside end	This interface is configured automatically during CSR provisioning. However, we added the "IP NAT Inside" to enable natting for this interface.

CSR-WEST1		
3	interface GigabitEthernet8 ip address dhcp ip mtu 1352 ip nat outside negotiation auto end	We added the outside NAT configuration “IP NAT Outside” to complete the NAT rule.

Verify Reachability

The NFS destination IP on Cloud ONTAP is 172.31.23.179, as shown in Figure 31. Figure 32 shows the output from CSR for testing ICMP.

Figure 31) Cloud ONTAP Cloud Manager.



Cloud Manager

Worki

vNPS

Cloud ONTAP Storage vNPS

Information

Advanced Information

Data (iscsi) : 172.31.23.177

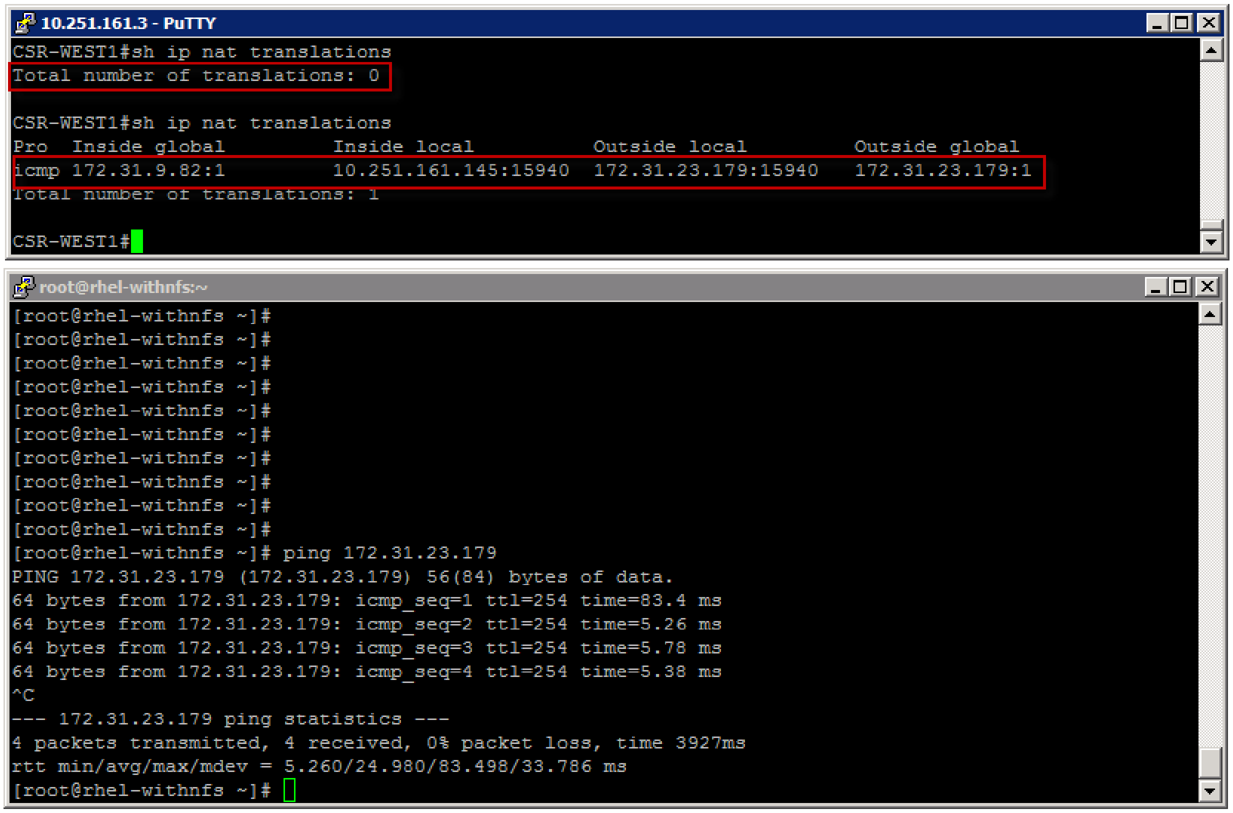
Node Management : 172.31.19.118

Data (nfs,cifs) : 172.31.23.179

Cluster Management : 172.31.30.62

Intercluster : 172.31.23.178

Figure 32) Cloud ONTAP network reachability from ICF VM.



```
CSR-WEST1#sh ip nat translations
Total number of translations: 0

CSR-WEST1#sh ip nat translations
Pro  Inside global         Inside local          Outside local         Outside global
icmp 172.31.9.82:1         10.251.161.145:15940  172.31.23.179:15940   172.31.23.179:1
Total number of translations: 1

CSR-WEST1#
```

```
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]#
[root@rhel-withnfs ~]# ping 172.31.23.179
PING 172.31.23.179 (172.31.23.179) 56(84) bytes of data.
64 bytes from 172.31.23.179: icmp_seq=1 ttl=254 time=83.4 ms
64 bytes from 172.31.23.179: icmp_seq=2 ttl=254 time=5.26 ms
64 bytes from 172.31.23.179: icmp_seq=3 ttl=254 time=5.78 ms
64 bytes from 172.31.23.179: icmp_seq=4 ttl=254 time=5.38 ms
^C
--- 172.31.23.179 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3927ms
rtt min/avg/max/mdev = 5.260/24.980/83.498/33.786 ms
[root@rhel-withnfs ~]#
```

Summary

This solution integrates ICF VMs with Cloud ONTAP. This is an entry option for enterprises exploring a hybrid cloud or whose environment is not large enough to warrant an NPS deployment. In both implementations, NPS and Cloud ONTAP, data is protected and mobile without hyperscaler lock-in.

11 Testing and Validation

A workflow of the testing and validation process after the ICF cloud setup is completed as follows:

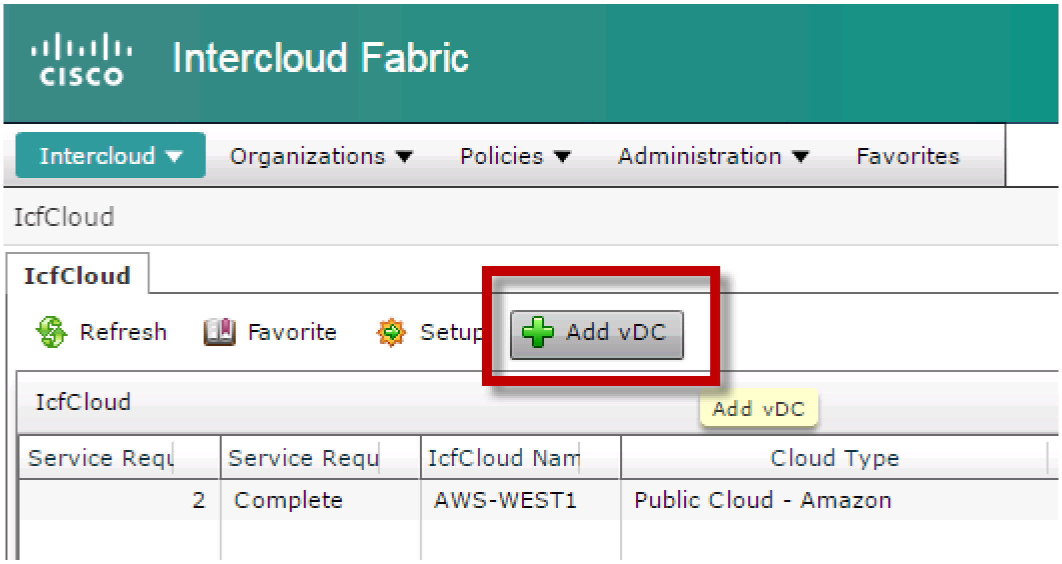
1. Create the public virtual data centers (VDCs) from the ICF GUI and create the desired VM templates.
2. Migrate VMs from the enterprise to the cloud, or
3. Instantiate VMs in AWS using the templates that were created in previous steps.
4. Access NPS storage from the AWS EC2 instances.

11.1 Create the Public VDC

A virtual data center (VDC) is an environment or a container that combines virtual resources, operational details, rules, and policies to manage specific group requirements. A group or tenant(s) can manage multiple VDCs with images, templates, and policies.

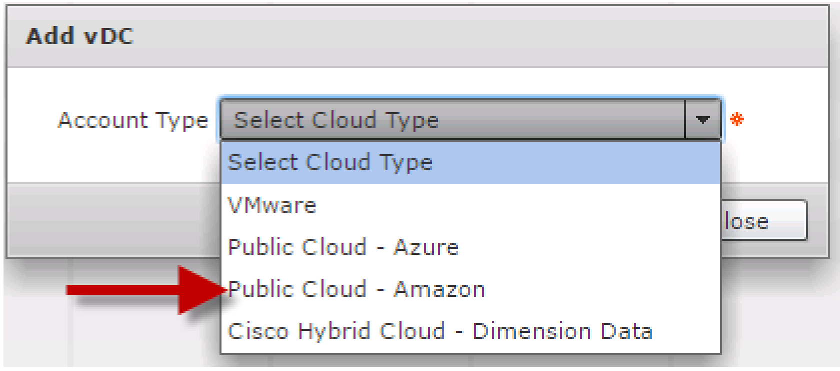
After the ICF cloud is set up and configured, we have to create a public cloud VDC using Intercloud Fabric Director. All of the ICF cloud VMs that will be deployed in AWS will be in this VDC and will use the relevant system and network policies to control VM parameters during deployment.

1. Log into Intercloud Fabric and select Intercloud > IcfCloud. Click Add vDC.



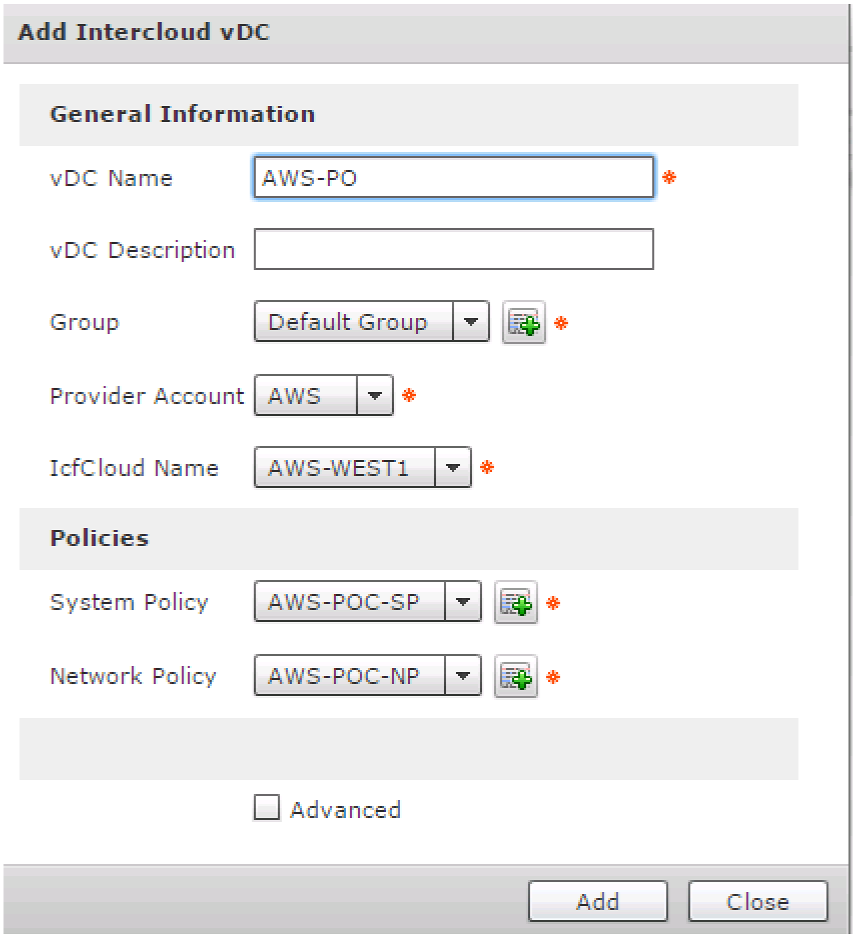
Service Requ	Service Requ	IcfCloud Nam	Cloud Type
2	Complete	AWS-WEST1	Public Cloud - Amazon

2. Create a vDC for the public cloud – Amazon.


Add vDC

Account Type: Select Cloud Type *

3. Supply the relevant information for the Intercloud vDC.



Add Intercloud vDC

General Information

vDC Name	AWS-PO *
vDC Description	
Group	Default Group *
Provider Account	AWS *
IcfCloud Name	AWS-WEST1 *

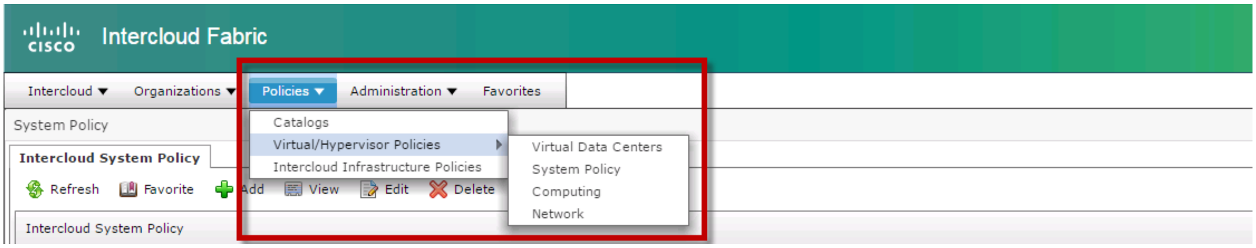
Policies

System Policy	AWS-POC-SP *
Network Policy	AWS-POC-NP *

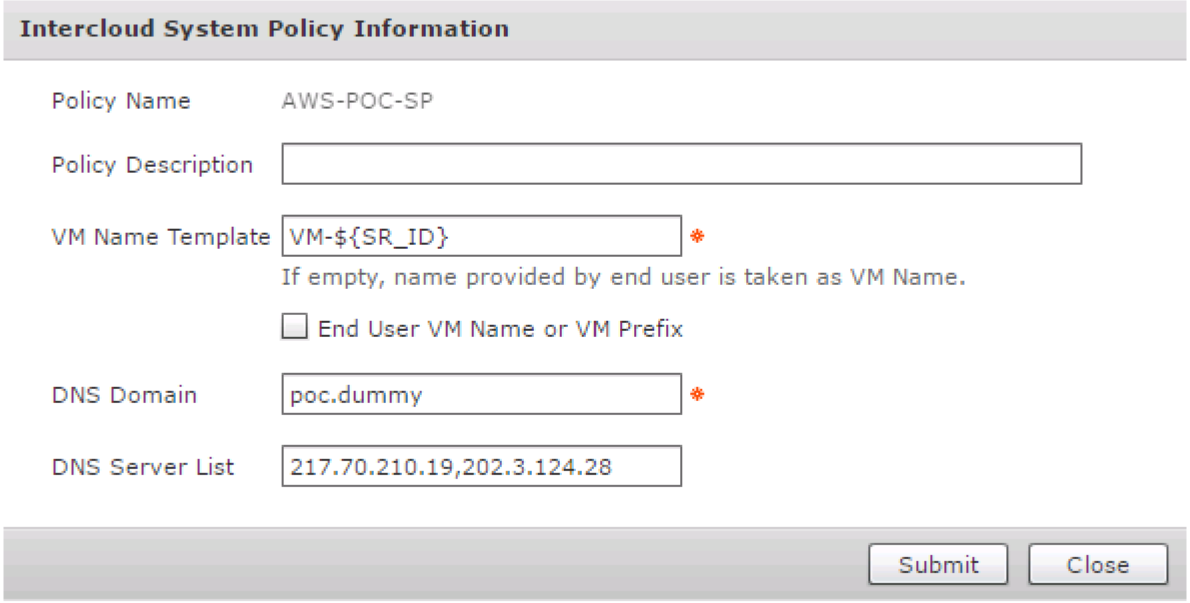
□ Advanced

- – Choose an existing system policy or choose to create a system policy for the vDC.
- – Choose an existing network policy or choose to create a network policy for the vDC.

You can view the policies by navigating to Policies > Virtual/Hypervisor Policies.



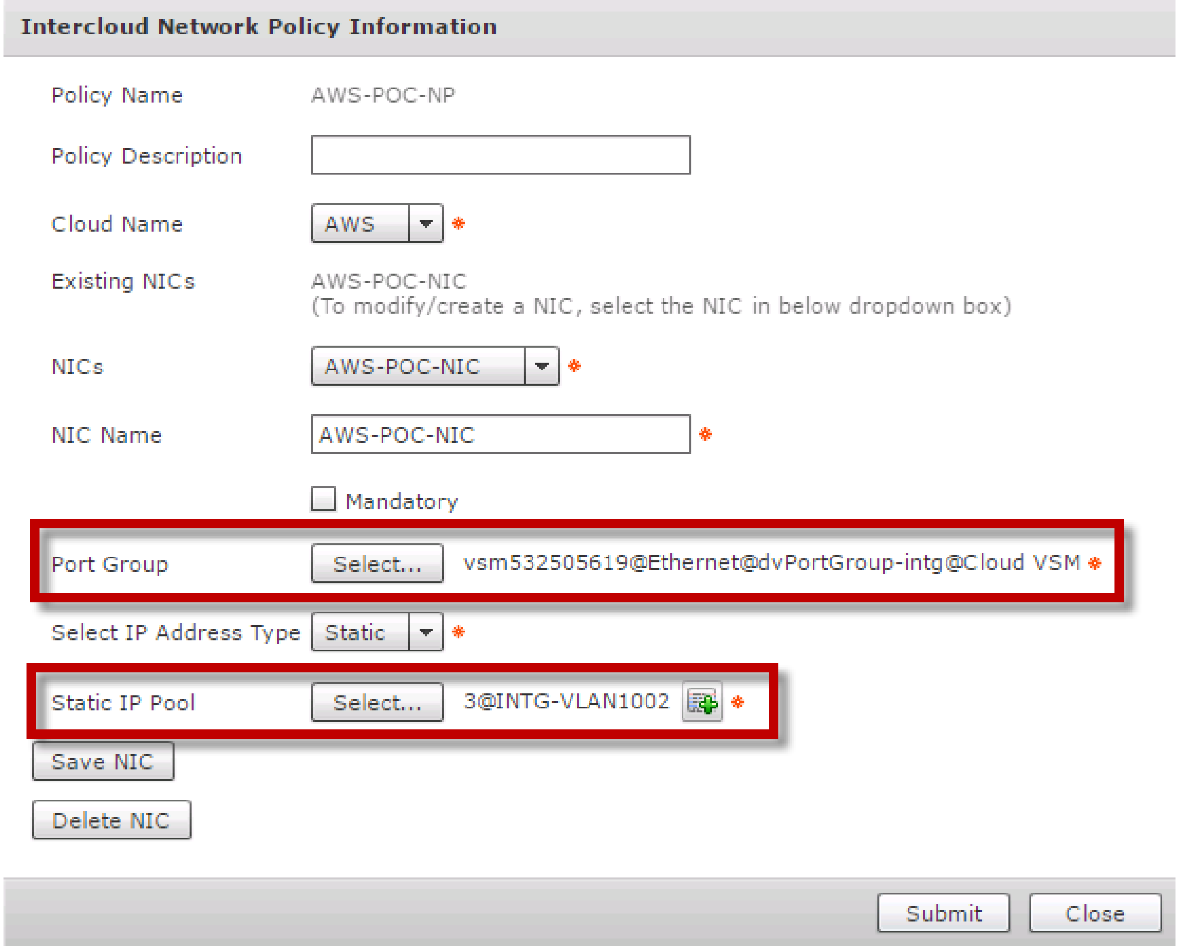
4. The Intercloud System Policy is used for naming the ICF VMs that are instantiated in AWS. It is also used for supplying the DNS domain name and name servers.



Intercloud System Policy Information

Policy Name	AWS-POC-SP
Policy Description	
VM Name Template	VM-${SR_ID} * If empty, name provided by end user is taken as VM Name. □ End User VM Name or VM Prefix
DNS Domain	poc.dummy *
DNS Server List	217.70.210.19,202.3.124.28

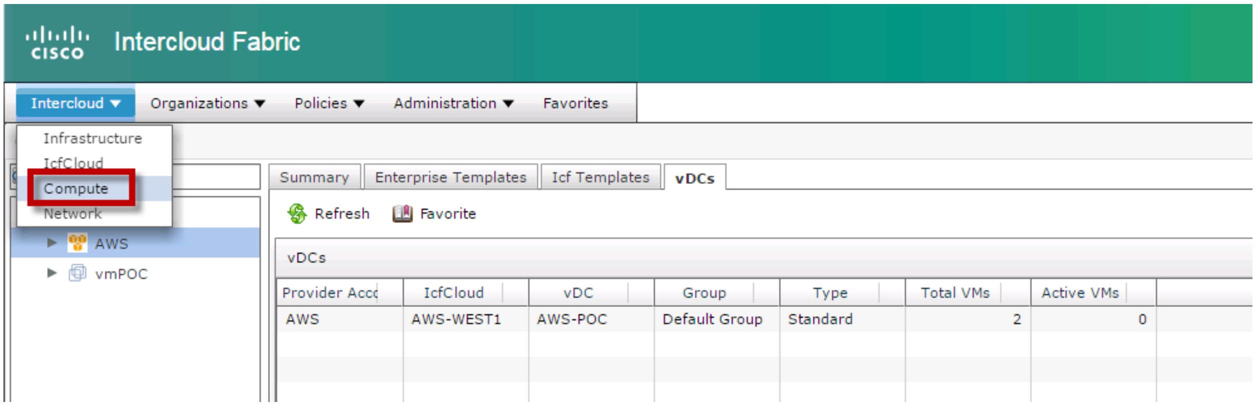
5. The Intercloud Network Policy specifies the NIC port-group information for the VLAN that is going to get extended to AWS. Select the relevant intg (workload) VLAN port group here. You also need an IP pool with spare IPs in the intg VLAN. All ICF AWS cloud VMs that are instantiated will get the enterprise IPs from this pool.



Intercloud Network Policy Information

Policy Name	AWS-POC-NP
Policy Description	
Cloud Name	AWS *
Existing NICs	AWS-POC-NIC (To modify/create a NIC, select the NIC in below dropdown box)
NICs	AWS-POC-NIC *
NIC Name	AWS-POC-NIC *
	□ Mandatory
Port Group	Select... vsm532505619@Ethernet@dvPortGroup-intg@Cloud VSM *
Select IP Address Type	Static *
Static IP Pool	Select... 3@INTG-VLAN1002 *

6. Verify that the vDC instantiation is successful.



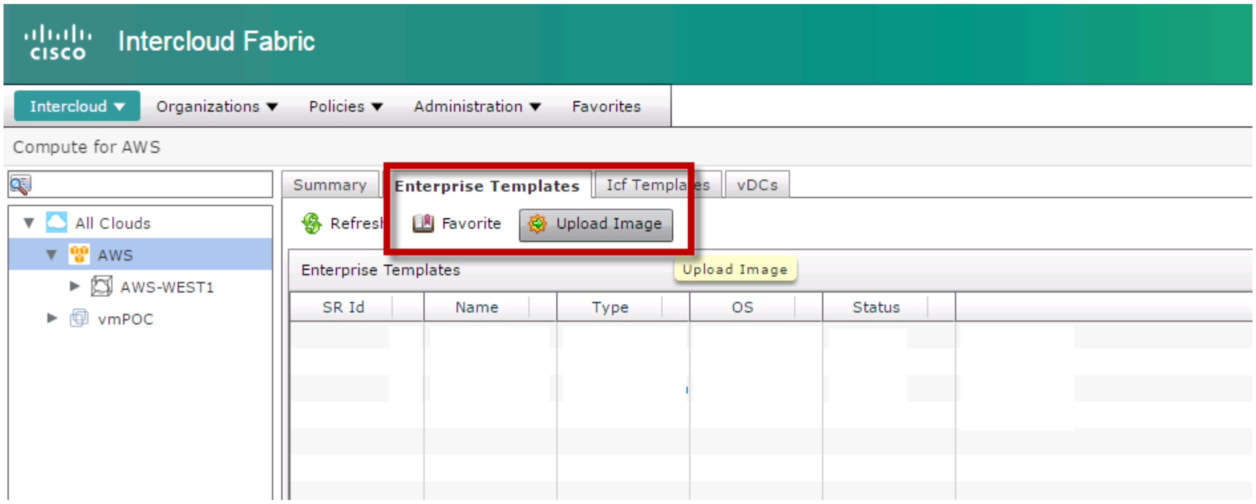
Provider Accc	IcfCloud	vDC	Group	Type	Total VMs	Active VMs
AWS	AWS-WEST1	AWS-POC	Default Group	Standard	2	0

The next step is to create an image template to use for instantiating the ICF cloud VMs in AWS.

7. Upload a VM image that will be used to create a template. Browse to IcfCloud > Compute and upload the image.

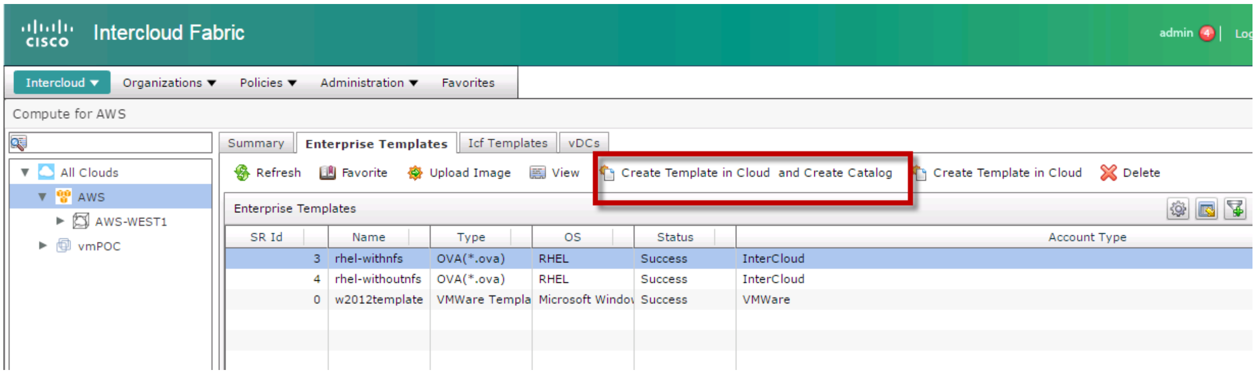
Plan Ahead

When ICF is moving a template or migrating a VM for the first time, the initial migration time will vary tremendously depending on the enterprise Internet facilities. A typical Linux VM is around 8GB; plan ahead for the transfer time calculating normal Internet usage.



SR Id	Name	Type	OS	Status

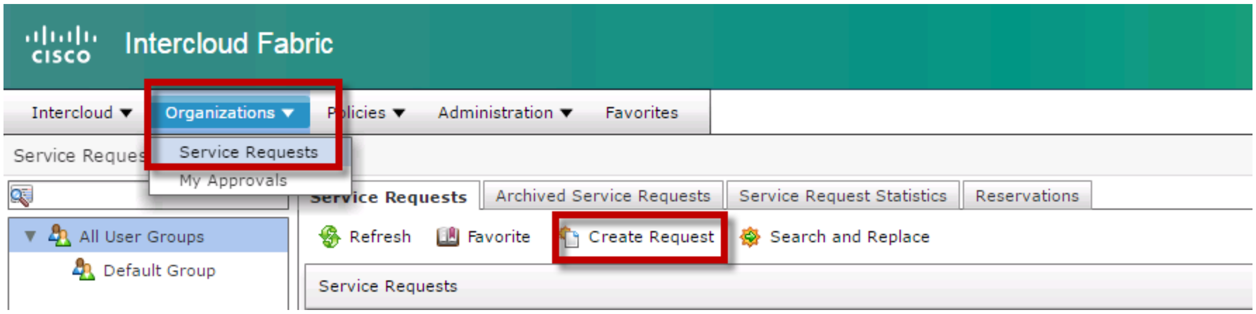
8. Create a template using the image that was uploaded. This process basically creates an Amazon Machine Image (AMI) in AWS with the necessary Cisco ICF Agent, allowing it to be part of the enterprise VLAN. This step also creates a “catalog” that can be used by tenant admins to provision VMs.



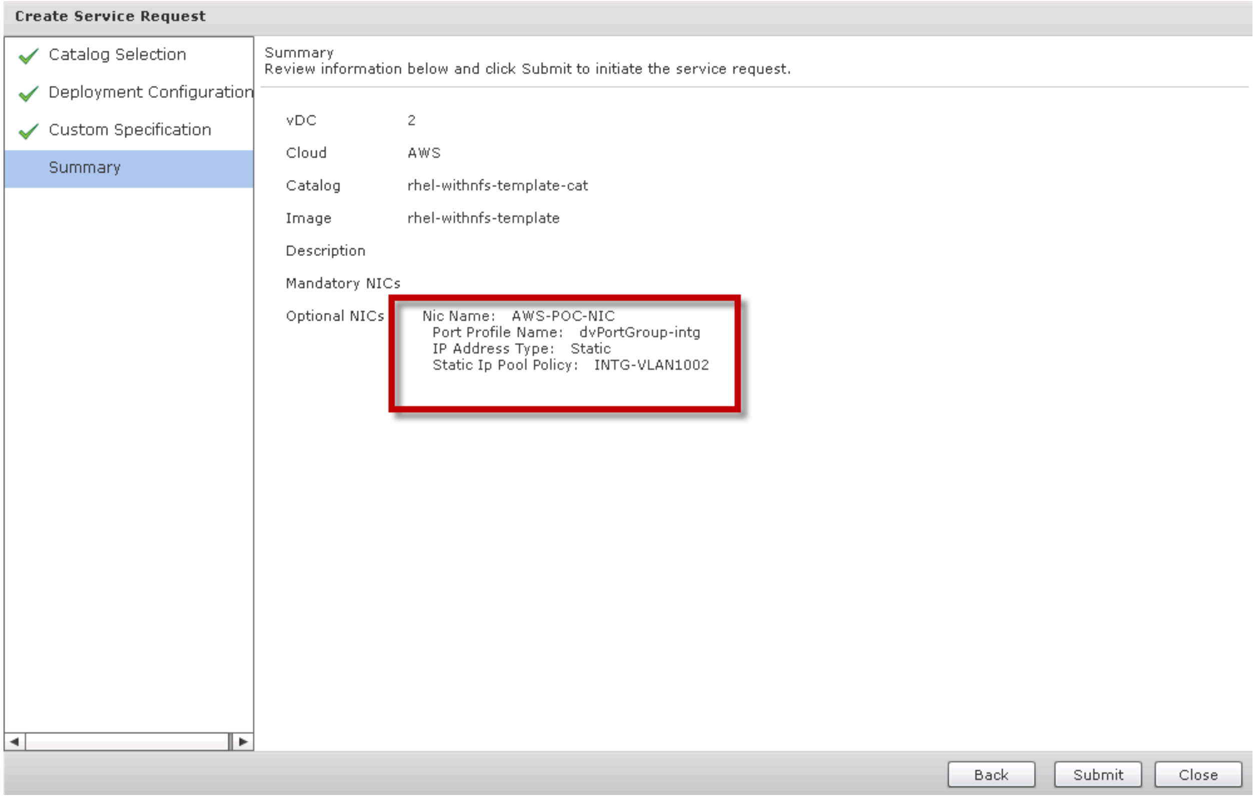
SR Id	Name	Type	OS	Status	Account Type
3	rhel-withnfs	OVA(*.ova)	RHEL	Success	InterCloud
4	rhel-withoutnfs	OVA(*.ova)	RHEL	Success	InterCloud
0	w2012template	VMWare Templa	Microsoft Windov	Success	VMWare

11.2 Provision ICF VMs in the Public Cloud

1. Provision a VM in AWS by creating a service request. Click Organization > Service requests > Create Request.



2. Select the catalog that was created in the previous steps. You can also view that the VM NIC is associated with the Intg (workload) VLAN, which is the VLAN that is extended to the public cloud from the enterprise. This was specified in the Intercloud Networking Policy that was created as part of the vDC instantiation detailed previously.

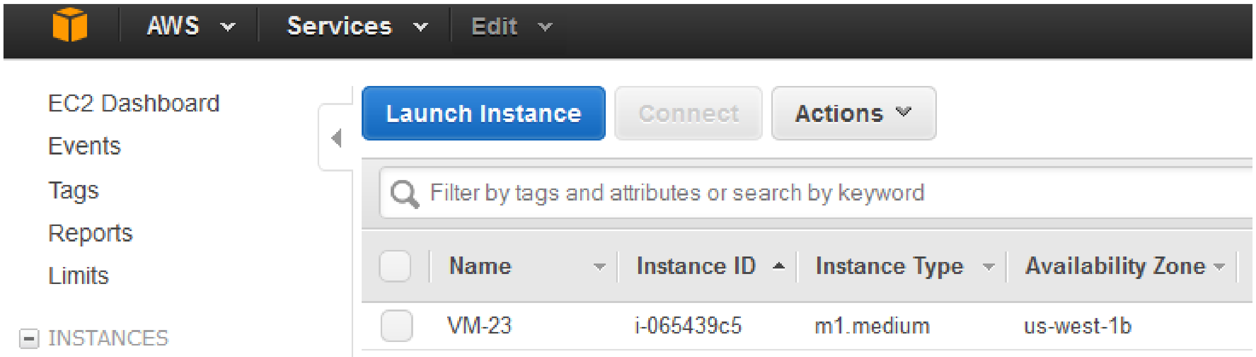


Summary
Review information below and click Submit to initiate the service request.

vDC	2
Cloud	AWS
Catalog	rhel-withnfs-template-cat
Image	rhel-withnfs-template
Description	
Mandatory NICs	
Optional NICs	Nic Name: AWS-POC-NIC Port Profile Name: dvPortGroup-intg IP Address Type: Static Static Ip Pool Policy: INTG-VLAN1002

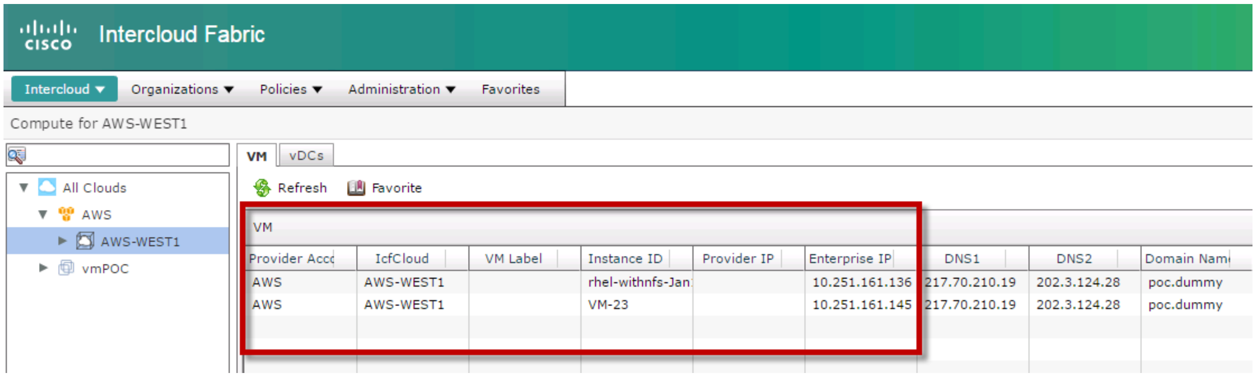
3. The VMs are instantiated in AWS using the uploaded template. The service request id is 23 so the VM name is VM-23. The VM names instantiated in the cloud will follow the pattern “**VM-${sr-id}**” as specified in the Intercloud system policy that was created as part of the vDC instantiation detailed previously.

Note
ICF provisions M1.Medium as the default EC2 instance. This might change in the future; refer to the version ICF release notes that you are installing. Note that it’s possible to change the CPU and memory requirements during the provisioning process.



Name	Instance ID	Instance Type	Availability Zone
VM-23	i-065439c5	m1.medium	us-west-1b

4. You can ping any VMs in the enterprise network from this VM. You can use SSH to connect to the ICF AWS cloud VM from the enterprise network because it has an IP in the same VLAN. All VM management should be done from Intercloud Fabric. You can view the VM status by browsing to Intercloud > Compute and selecting the public cloud vDC.

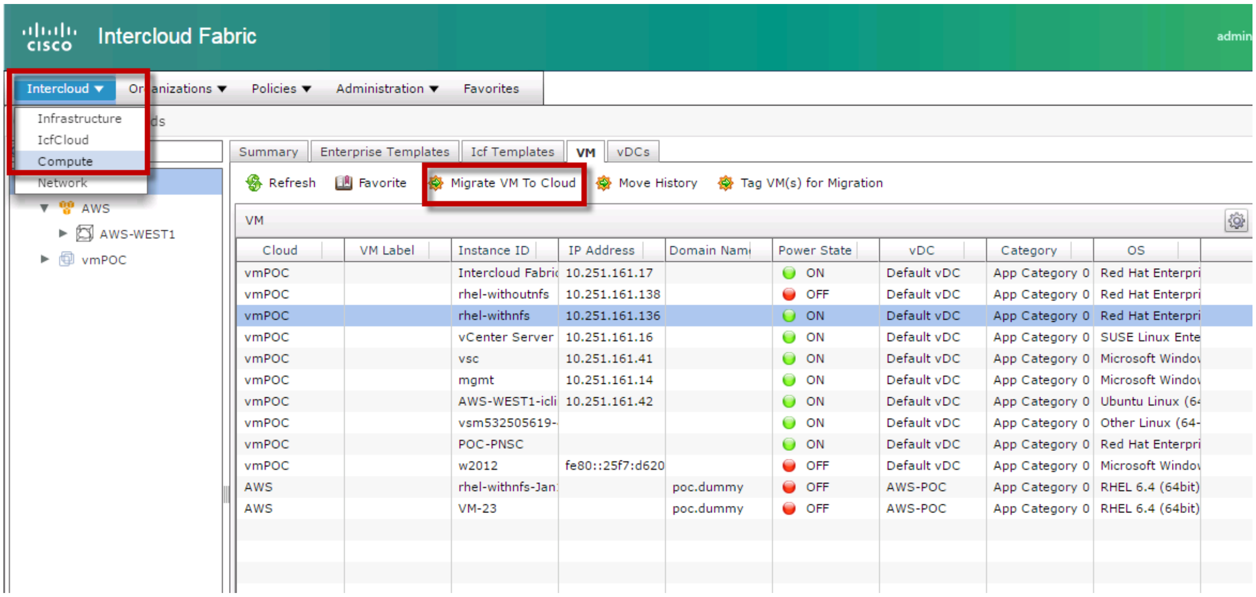


Provider Acco	IcfCloud	VM Label	Instance ID	Provider IP	Enterprise IP	DNS1	DNS2	Domain Name
AWS	AWS-WEST1		rhel-withnfs-Jan		10.251.161.136	217.70.210.19	202.3.124.28	poc.dummy
AWS	AWS-WEST1		VM-23		10.251.161.145	217.70.210.19	202.3.124.28	poc.dummy

VMs can also be migrated from the enterprise to the public cloud. Note that the VM migration can take some time since all the data has to be moved over the Internet to the public cloud.

- To migrate a VM, browse to Interclould > Compute and click the VM tab in All Clouds. This will list all the VMs in the enterprise and the public cloud. Select the VM to be migrated to AWS and click Migrate VM to Cloud.

  This process will shut down the VM, export the VM into .ova format, and upload the file to AWS. The image then will be converted to an AMI with a Cisco wrapper on top of it and booted in AWS.



Cloud	VM Label	Instance ID	IP Address	Domain Name	Power State	vDC	Category	OS
vmPOC		Intercloud Fabric	10.251.161.17		● ON	Default vDC	App Category 0	Red Hat Enterpri
vmPOC		rhel-withoutnfs	10.251.161.138		● OFF	Default vDC	App Category 0	Red Hat Enterpri
vmPOC		rhel-withnfs	10.251.161.136		● ON	Default vDC	App Category 0	Red Hat Enterpri
vmPOC		vCenter Server	10.251.161.16		● ON	Default vDC	App Category 0	SUSE Linux Ente
vmPOC		vsc	10.251.161.41		● ON	Default vDC	App Category 0	Microsoft Windo
vmPOC		mgmt	10.251.161.14		● ON	Default vDC	App Category 0	Microsoft Windo
vmPOC		AWS-WEST1-icli	10.251.161.42		● ON	Default vDC	App Category 0	Ubuntu Linux (6
vmPOC		vsm532505619-			● ON	Default vDC	App Category 0	Other Linux (64-
vmPOC		POC-PNSC			● ON	Default vDC	App Category 0	Red Hat Enterpri
vmPOC		w2012	fe80::25f7:d620		● OFF	Default vDC	App Category 0	Microsoft Windo
AWS		rhel-withnfs-Jan		poc.dummy	● OFF	AWS-POC	App Category 0	RHEL 6.4 (64bit)
AWS		VM-23		poc.dummy	● OFF	AWS-POC	App Category 0	RHEL 6.4 (64bit)

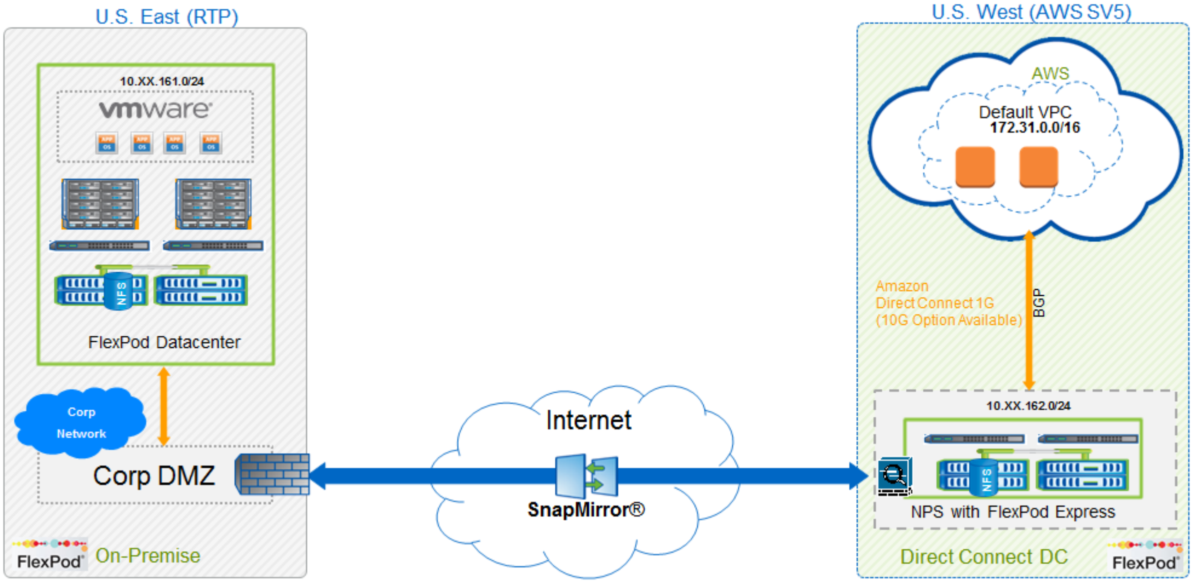
11.3 Access NPS Storage from the ICF Cloud VM Instance

After the ICF AWS VMs are instantiated, the VMs can mount storage from NPS in the colocated data center. A GRE tunnel between the CSR in AWS and the Cisco Nexus 3k in the colocated site has been established that allows data access from the ICF VMs.

There is a subtle difference in the way data is accessed from:

- EC2 VMs to NPS in AWS. Accessing NPS from EC2 VMs needs a VGW connection from the VPC using Direct Connect (using BGP). The EC2 VMs do not need a GRE tunnel or any other tunneling protocol to access NPS.

Figure 33) Data access from AWS EC2 instances to NPS.



- ICF AWS VMs to NPS in AWS. Because of the way the ICF VMs are instantiated in AWS, data access from the ICF VMs to the outside world is not directly allowed. All traffic outbound to the outside world is blocked from the ICF VMs. Traffic is only allowed outbound to the enterprise VLAN and not to any other destination. The CSR is configured and used as a default gateway for the ICF VMs in the cloud. A GRE tunnel is built from the CSR to the Cisco Nexus 3k in the colocated site to allow the ICF VMs to access NPS. After the GRE tunnel is configured, all the ICF VMs can access data in NPS like any other AWS EC2 instance.

  After the ICF VM is migrated or instantiated in AWS, it will have two interfaces: eth1* and csc0.

  – eth1 maps to the enterprise VLAN.

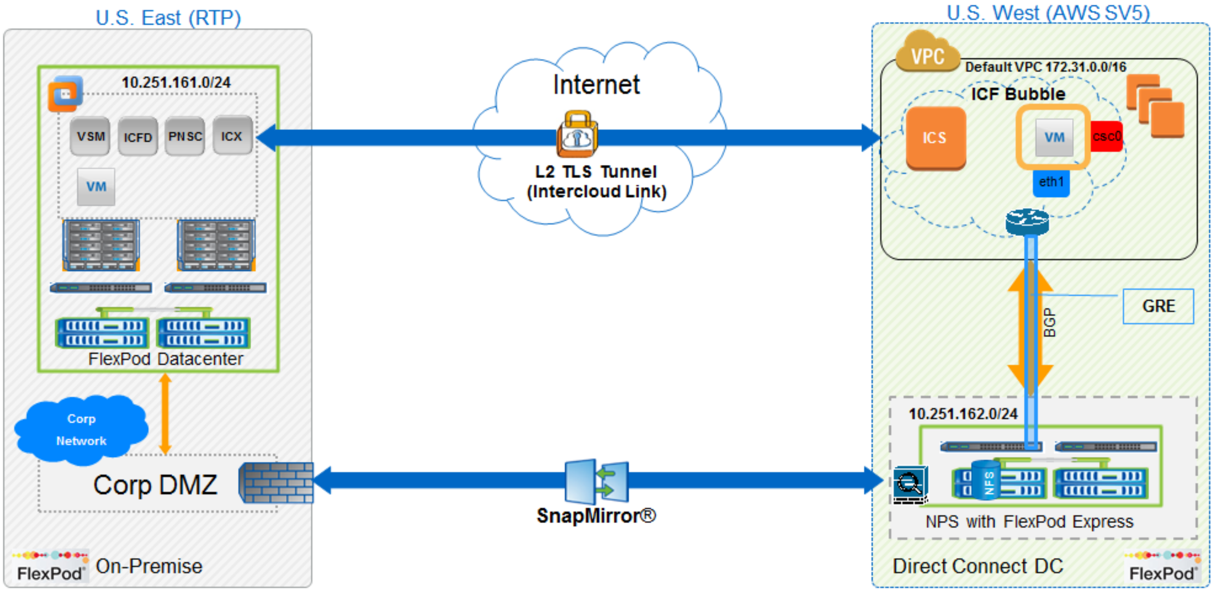
  – csc0 maps to AWS eth0 and consumes an IP from the default VPC.

  – csc0 supports **only** ICMP and SSH from devices outside the ICF bubble; otherwise it's completely locked down.

- A CSR router is required to allow access into the ICF bubble.
- Accessing NPS storage from the ICF VMs is performed by creating a GRE tunnel from the CSR to the Cisco Nexus 3k in NPS.

  Any VM moving from the enterprise or instantiated in AWS has complete visibility into NPS and the SnapMirror data from the enterprise.

Figure 34) Data access from the ICF cloud VMs to NPS using the GRE tunnel.



11.4 Use-Case Testing

The high-level steps to validate the use case are as follows.

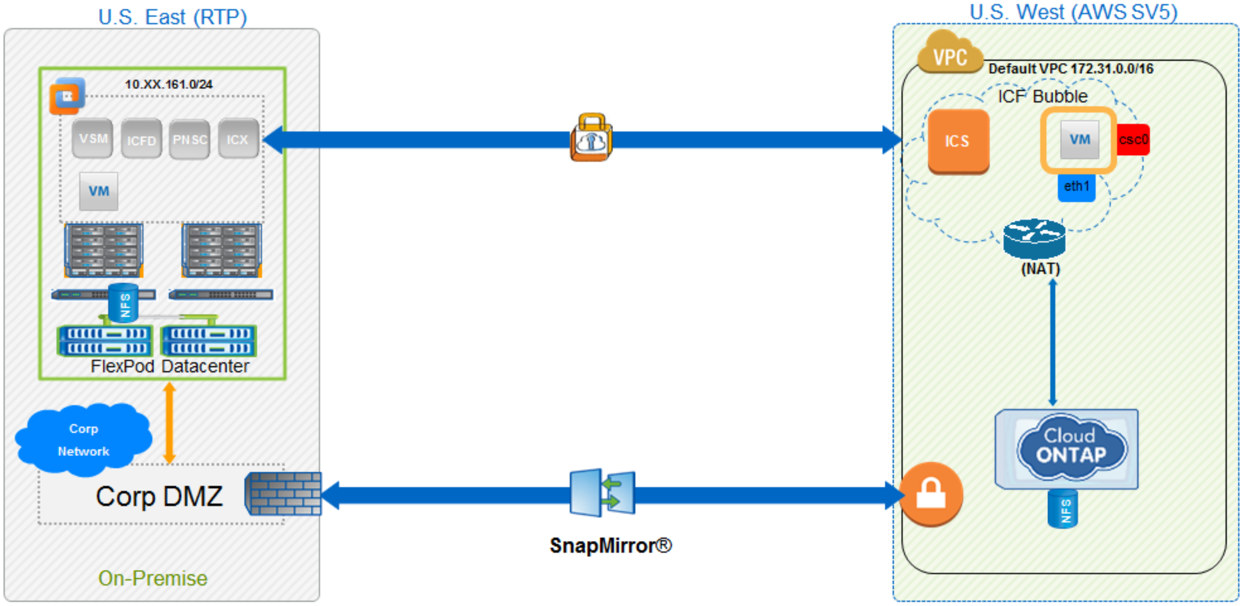
1. Break the SnapMirror relationship or create FlexClone volumes of the SnapMirror destination on NPS in AWS.
2. Mount the mirrored/cloned destination NFS volumes from NPS on the ICF cloud VM instances.

Note: The use-case testing and data access from the ICF cloud VM instances are done using the procedure documented in section 8.4.

11.5 Cloud ONTAP and ICF

Install and set up Cloud ONTAP in AWS following the procedures documented in Cloud ONTAP resources. Data access from the ICF cloud VMs to Cloud ONTAP is accomplished by using NAT for the outbound traffic from CSR (refer to Figure 35).

Figure 35) Data access from ICF cloud VMs to Cloud ONTAP using NAT.



- The Cloud ONTAP instance is assigned multiple IPs from the Availability Zone on which it resides.
- CSR's default route uses an interface attached to AWS.
- CSR can leverage EIP and multiple IP addresses on the AWS interface.
- Cloud ONTAP should not reside in the same Availability Zone as the CSR. This enables the traffic from ICF VMs to default to the CSR and not to the csc0 interface. If Cloud ONTAP resides in the same Availability Zone as the CSR, the ICF VMs will not use the CSR as the gateway, which prevents data access.
- NAT overload is used for outbound traffic from CSR.
- ICF VMs use their enterprise VLAN interface to send traffic to CSR.

Data access from Cloud ONTAP to the ICF cloud VMs follows the same procedure that was used for accessing data from NPS. After the NAT is established from the CSR, mount the relevant volume (along with the data LIF IP) from Cloud ONTAP on the ICF cloud VMs.

12 Conclusion

There is no shortage of hybrid cloud solutions available in the market. This makes it a challenge to choose the optimum business solution for the enterprise, one that can integrate seamlessly with the business but not compromise the enterprise's continuity and standards. This report addresses these challenges by presenting a consolidated solution for implementing NetApp NPS and Cloud ONTAP with Cisco ICF as a best-in-class hybrid cloud solution.

This solution presents an integrated approach to handle the business-critical requirement for extending the enterprise data center while maintaining security and operational controls. It also provides the capability to meet varying customer requirements for typical IT establishments. This solution works across the domain's requirements and elaborates upon use case–based implementations covering all hybrid cloud solutions. A key benefit of this solution is the tight integration between NetApp and Cisco's data and compute features. This benefit simplifies implementation and maintenance of disaster recovery solutions, high-compute demands, and shadow IT challenges.

Acknowledgements

The authors would like to thank the following individuals for their contribution to this report.

- Mark Beaupre, NetApp
- Jim Holl, NetApp
- Kevin Hill, NetApp
- John Fullbright, NetApp
- Dileep Devireddy, Cisco Systems

Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

Copyright Information

NetApp reserves the right to change any products described herein at any time, and without notice. NetApp assumes no responsibility or liability arising from the use of products described herein, except as expressly agreed to in writing by NetApp. The use or purchase of this product does not convey a license under any patent rights, trademark rights, or any other intellectual property rights of NetApp.

The product described in this manual may be protected by one or more U.S. patents, foreign patents, or pending applications.

Trademark Information