Intel® Cloud Builders Guide
Intel® Xeon® Processor-based Servers
Fujitsu Primergy* VMware vCloud Director*

Intel® Cloud Builders Guide: Cloud Design and Deployment on Intel® Platforms

FUJITSU PRIMERGY*
VMWARE VCLOUD DIRECTOR*

Intel® Xeon® Processor 5500 Series

Intel® Xeon® Processor 5600 Series

AUDIENCE AND PURPOSE

This reference architecture seeks to simplify the deployment and operation of a cloud. We built a cloud with VMware vCloud* Director and the cloud eXtention platform, PRIMERGY CX1000, on an Intel® Xeon® processor-based server platform and documented the work involved with this particular cloud configuration.

The content is targeted to IT professionals responsible for the design, implementation, validation, and utilization of cloud structures. We describe details on the hardware configuration, software configuration, and results from specific test cases we implemented that demonstrate basic operational capabilities.

This paper should complement product documentation and is provided as a starting point for the actual development of an enterprise or service provider cloud.

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Table of Contents

Executive Summary

With the arrival of cloud computing, IT decision makers have been given a unique opportunity to lead their organizations through challenging times.

Cloud computing brings with it a level of flexibility, efficiency and cost-control that was impossible even a few short years ago.

This approach abstracts applications and information from the complexity of underlying infrastructure, so IT can support and enable business value. Cloud computing architectures are built on the foundation of virtualization. Fujitsu Dynamic Cloud* is built on the Dynamic Infrastructures strategy. Based on that strategy, Fujitsu has developed customer-centric solutions, which enable you to use Cloud Computing in your enterprise in ways that are easy and secure. It is a very flexible concept that helps IT organizations meet the challenges posed by their IT more effectively.

Dynamic Cloud Services include standardized IT services from the cloud, which you can use within a very short space of time. And this is possible without having to deal with complex hardware and software. Furthermore, for enterprises that would like to implement their own cloud infrastructure, Fujitsu offers Dynamic Cloud Infrastructures that already have pre-integrated and tested infrastructures.

This reference architecture builds upon innovative scale-out cloud server infrastructure platform, the PRIMERGY CX1000 and the virtualization technology of VMware vCloud Director, forming a foundation for such a Dynamic Cloud Infrastructure.

Fujitsu Dynamic Cloud is the most cost-effective and flexible model offered by Fujitsu for provisioning information technology and IT services.

Cloud Computing has caused a paradigm shift, which has profoundly changed the way in which IT supports business processes.

IT is thus evolving into a needs-based service that an enterprise can use for business purposes as required. The Internet, with its ubiquitous availability, is accelerating this development.

If one takes a closer look at the technologies behind this trend, one will clearly see that Cloud Computing is not a technological revolution, but rather the next evolutionary step in the development of IT. This development is the logical result of IT standardization and open source, along with virtualization and automation technologies. Elastic concepts with load-dependent scaling, models for billing performance according to usage, plus resource pools and shared use of infrastructures along with a high degree of automation for provisioning: All of these elements have proven themselves in dynamic data centers for some time now.

This guide, as part of the Intel® Cloud Builders Program, provides a comprehensive solution overview that covers technical planning as well as deployment considerations.

Introduction

Fujitsu´s Intel Cloud Builders Reference Architecture

Fujitsu Dynamic Cloud reference architecture is the continuing development of the Dynamic Infrastructures strategy. Based on that strategy Fujitsu has developed customer-centric solutions which enables you to use Cloud Computing in your enterprise in ways that are easy and secure. Within the wider frame of Fujitsu Dynamic Cloud, customers have the option to either use our trusted cloud services or build their own cloud on the basis of pre-integrated and tested infrastructure.

Taking Fujitsu´s Intel Cloud Builders Reference architecture ahead we defined the Fujitsu Dynamic Cloud Infrastructure as a dedicated environment always consisting of a build in billing, provisioning and security functionality that also bridges into our Dynamic Cloud Services enabling a hybrid cloud scenario bridging between Trusted and Private Clouds.

The reference architecture itself is built upon innovative scale-out cloud server infrastructure platform the PRIMERGY CX1000. It enables to scale big by packaging 38 industry standard x86 server nodes, based on Intel® Xeon® processor , into a dedicated datacenter rack unit with shared cooling architecture and low footprint. PRIMERGY CX1000 provides massive scale-out computing power and optimizes the data center DENSITY, POWER consumption and HEAT dissipation problems in a one step approach. Its innovative shared cooling architecture Cool-Central™ enables to build new economics into scale-out Cloud Data Centers by significant reduction of energy consumption coupled with dramatic savings in data center space – thus removing the strong inhibitors for cloud data center setup.

VMware vCloud™ Director has been chosen as the software solution stack in this reference architecture, since it builds upon customer proven, industry wide accepted virtualization technology and enables for pooled IT resource allocation and consumption. Moreover, it also enables for new economics in the data center by maximizing efficiency without compromising service delivery, and at the same time it accelerates an organization´s transition to the cloud.

The VMware vCloud™ Director evolutionary product feature set for setting up multi-tenant Private Clouds perfectly combines with the new economic benefits that PRIMERGY CX1000 Cloud servers provide, resulting in a pragmatic approach to enable the benefits of cloud computing as they turn today´s data center into secure private clouds at affordable costs.

A completely automated on-premise compute cloud. Providing a one-stop virtual data center management solution, it isolates customers from the operational and hardware complexity associated with deploying and managing compute resources in a private data center.

The VMware vCloud Director™ Cloud Solution

VMware vCloud Director enables customers to build secure private clouds, transforming the way IT delivers and manages infrastructure services and the way users access and consume these services.

- Increase business agility by empowering users to deploy pre-configured services or custom-built services with the click of a button
- Maintain security and control over a multi-tenant environment with policy-based user controls and VMware vShield security technologies external compute capacity.
- Reduce costs by efficiently delivering resources to internal organizations as virtual datacenters to increase consolidation and simplify management
- Follow an evolutionary path to the cloud by leveraging existing investments and open standards for interoperability and application portability between clouds

VMware vCloud Director provides the interface, automation, and management features that allow enterprises and service providers to supply vSphere resources as a Web-based service.

VMware vCloud Director is a software solution that enables enterprises to build secure, multi-tenant, private clouds as they pool infrastructure resources into virtual data centers (VDCs) and expose them to users through web-based portals and programmatic interfaces as fully-automated, catalog based services. Internal IT organizations can build secure and cost-effective private clouds with VMware vSphere and VMware vCloud Director, and thus act as true service providers for the businesses they support. As such, they can drive innovation and agility, and at the same time increase IT efficiency and enhance security. This solution provides a pragmatic path to cloud computing because it gives customers the power to use existing investments and the flexibility to extend capacity between clouds.

Key Features and Benefits

- **Deliver Infrastructure as a Service:** VMware vCloud Director enables IT organizations to deliver resources to internal users as VDCs. IT organizations can logically pool compute, storage, and network capacity into Virtual Data Centers, to manage resources more efficiently, with complete abstraction between consumption and delivery of IT services. Instead of providing users or organizations with siloed physical infrastructures, IT teams can deliver

isolated VDCs that draw resources from a common physical infrastructure. By pooling these physical resources on the back end, hardware utilization and consolidation increases. Similarly, underlying infrastructure can be pooled into tiers and offered to users at distinct service levels and prices.

- **Consume Infrastructure as a Service:** VMware vCloud Director also changes the way that users consume IT services. There is no need to file service desk tickets and wait in queues; instead, application and line-of-business owners can utilize self-service portals to access their own VDC. VMware vCloud Director enables users to consume these resources as a catalog based service through a web portal and programmatic interfaces. IT teams can define multiple consumption models that use the same infrastructure, which range from capacity-as-you-go to reserved pools. These can be delivered at an appropriate cost model with VMware vCenter* Chargeback, which helps drive accountability and enables granular usage monitoring. Ultimately, IT organizations maintain control with permissions, quotas, and leases governed by role-based access controls that utilize existing LDAP directory services.
- **Support Multi-Tenant Environments:** Administrators can group users into organizations that may represent any policy group, such as business unit, subsidiary company, sales group or accounting. Each group has isolated, virtual resources, independent LDAP authentication, unique catalogues of resources and policy controls. These features allow for secure multi-tenancy and safe sharing of resources.
  - Deliver Standardized Infrastructure and Application Services:
    - Users are enabled to deploy and consume pre-configured infrastructure and application services such as virtual machines, virtual appliances , OS images and other media from central or group specific catalogues,
- **Improved Security:** Integrated VMware vShield edge security technologies such as perimeter protection, port-level firewalling, network address translation and DHCP services offer virtualization aware security, simplify application deployment and enforce boundaries required by compliance standards.

The use of the VMware Private Cloud Solution Stack leads to valuable competitive advantages, like:

- vCloud ™ Director 1.0 enables enterprises to build secure, multitenant private clouds
- Pooled virtual resources are exposed to users via fully automatic, catalog based services
- Integrated vShield ™ Edge technologies provide virtualization aware security and multi- tenancy
- vCenter Chargeback 1.5 enables IT organization to meter and charge users based on policies
- Internal IT organizations can build secure and cost effective Private Clouds, acting as a true service provider.

The Fujitsu Cloud Server Platform PRIMERGY CX1000

- Despite the continuously growing performance of individual x86 processor chip technologies from Intel, the demand for aggregated data center compute capacity is continuously rising as well. This is especially true for companies using new and emerging technologies such as Web 2.0, SOA architectures, Virtualization, and Cloud Computing to enlarge their current business processes or provide new ways of delivering "IT as a service" to their internal or external clients.
- For High Performance Computing, the use of hundreds of parallel processing Intel Xeon processor-based server units, running parallel application programs for physical modeling, forecasting and scientific research in a combined cluster has already become a de facto design standard.
- Hosting providers deliver various services and hosting models to different client segments, based on x86 technologies combined with virtualization and associated service levels, that are based upon scale-out computing farms of hundreds or thousands of Intel Xeon processor-based servers.
- Large enterprises are starting their cloud computing initiatives, setting up their private cloud scenarios to test-drive the cloud computing software technologies and the promoted benefits.
- Other enterprises are already implementing public cloud services to expand or create new business models with "xxx as a service" offerings.
  - Social networks like Facebook, Twitter etc, and functional hosting services (example: Windows Azure) are cloud implementations that proof-point rapid adoption and are geared for massive growth.
  - What is in common to those different industry scenarios is the fact, that they require massive scale-out server computing resources that take advantage of Intel Xeon processor-based servers to compete in and benefit from the rapid growth of those markets.

- On the other side, traditional Data centers facilities do not easily keep pace with those massive compute capacity demands, since they have to master additional challenges:
  - Increased power envelopes and cooling requirements for those servers and related infrastructure
  - Limitation in data center floor space, and the requirement for more computing power in a limited amount of space
  - Limited budgets enforcing minimized initial purchase costs and subsequent maintenance costs and operational spending
  - The need for more efficient manageability and less complexity in operation of massive scale-out compute resources

The problem thus has four dimensions:

- **Scale out compute power:** Scale out as business workloads dynamics grow up
- **Data Center Density:** Run more compute power with less operational footprint in the current DC space
- **Power/Heat Economics:** energy consumption per Rack has moved up from some 2-3 kW/rack to typically 12-15 kW/rack today. And since heat dissipation is directly aligned with server power consumption, the power/ heat economics of traditional data centers are at their critical physical limits – or at least have become critical cost factors. And even if energy costs are not the problem of "IT"-since it is in the facility budgets-, in many parts of the world legal and governmental legislation shows up to demand new "green" economics.

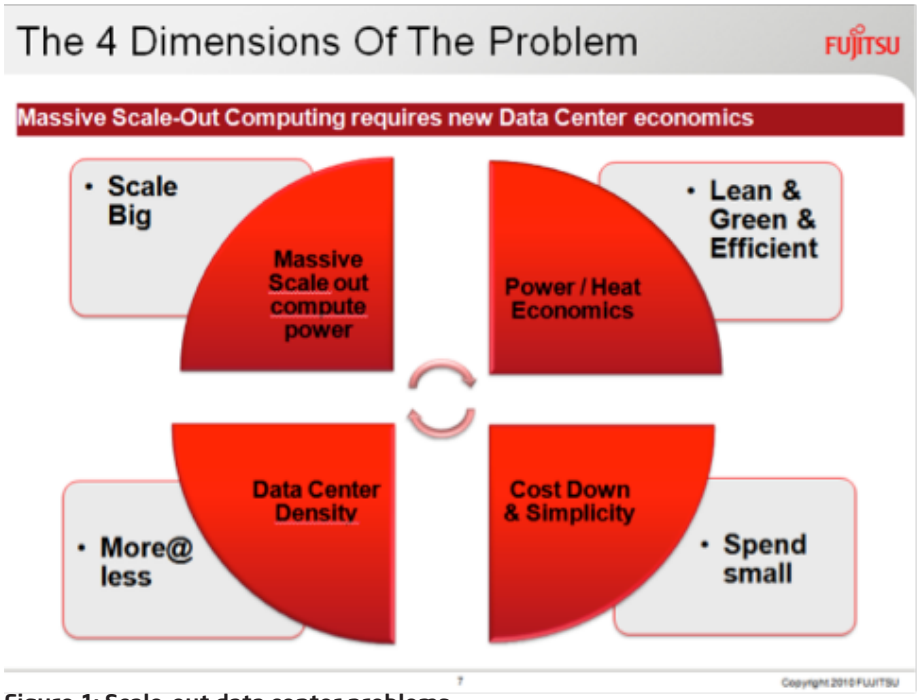


Figure 1: Scale-out data center problems

- **Cost Down & Simplicity:** Running businesses that can best perform on small-but scale- out server building blocks will generate more server units- virtual or physical- to be managed and surveyed, so simplicity for management of a complete rack server farm rather than the individual server unit is a cost cutting factor driving OPEX down. In addition, by using less featured server nodes- with small or only little variances, the initial acquisition costs can be significantly lowered and the packaging density per square meter in the data center can be expected to be lifted up- this will contribute to the CAPEX down budget policy.

PRIMERGY CX1000- expanding the product family into the Scale-Out Data center

PRIMERGY CX1000 is a new Product Category within the PRIMERGY server family. Its focus is on providing large data centers with massive scaling using Intel Xeon processor-based server power while at the same time delivering new economics for density, power, heat and acquisition costs.

The PRIMERGY CX1000 is our solution to deliver a cloud- enabled server infrastructure platform, targeting Internet scale-out data centers, Managed Domains, "As- a-Service" providers, Hosting industries, cloud computing and also HPC markets.

The PRIMERGY CX1000 platform is designed to exactly solve the 4 dimensions problem to deliver new cloud data center economics:

- PRIMERGY CX1000 is a new server-infrastructure platform that solves the 4 dimension problem in a unified approach.
- PRIMERGY CX1000 enables scale-out computing from 100s to 1000s of server nodes- easily with industry x86 standards using Intel Xeon processors and replicable building blocks. New power and heat economics are achieved by the innovative Cool-Central design of CX1000 which enables up to 20 % power consumption saving versus standard Rack server technologies.
- Data center footprint space is reduced by up to 40 % compared with Rack servers- and even a higher data center compute density than with Blade servers may be achieved by back-to-back setup of the PRIMERGY CX1000 server racks and the Cool-Central cooling technology. Cost down design & simplicity of management and operation are implemented to provide CAPEX savings of up to 20 % versus traditional Rack server design.

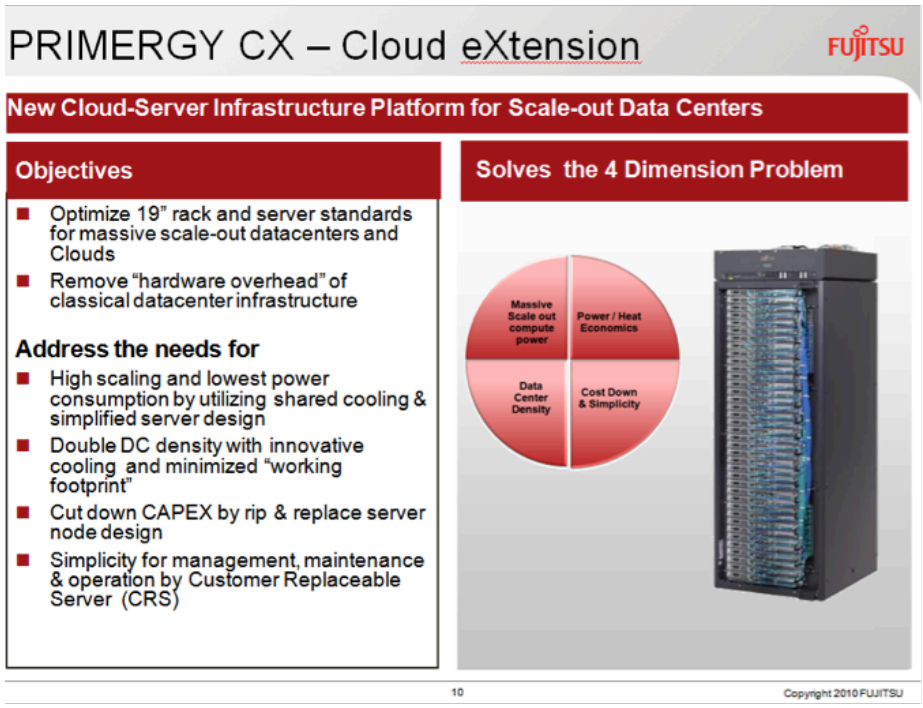


Figure 2: PRIMERGY CX-Cloud eXtension

All those achievements have been packed into the new PRIMERGY CX1000 Cloud Extension product range.

The PRIMERGY CX1000 addresses the MORE@LESS challenge resulting in more computing power at up to 40 % less data center footprint, Its unique Cool-Central airflow system eliminates the need for spacey "Hot Aisle" zones in the DC floor plan. And thus Data center Density is improved by enabling more compute power at 40 % less space vs conventional Rack server deployment. (see a sample comparison for datacenter space requirements of CX1000 setup for 5000 nodes in the appendix).

The server nodes in scale-out Cloud scenarios have different customer requirements to fulfill than "general purpose" Rack or Blade form factor servers. Instead of providing a "built-in redundancy" as with conventional Rack servers, a server failure in scale-out server Clouds is typically handled by software that will relocate/reload the application services onto another server unit- or just initiate a restart of the server unit. Thus the CX server nodes can follow a minimalistic design approach, eliminating the need for local fans, hot-swap components or redundancy functions within the node. While this does not make a difference in server node performance, it pays back into lower CAPEX with PRIMERGY CX1000, and up to 20 % less costs as compared to a conventional Rack configuration with 38 rack servers can be achieved depending upon the detailed system configuration.

PRIMERGY CX1000 is positioned as New Cloud-Server Infrastructure Platform for Scale -out Data Centers.

Focusing on those targets, PRIMERGY CX1000 significantly differs from the traditionally well known product categories of Tower Servers (PY TX), Rack servers (PY RX) or Blade servers (PY BX).

As a consequence the PRIMERGY product family is now enhanced with the CX Product group (Cloud-servers) to enable "best fit" new product offerings to the internet scale-out data centers, Cloud data centers, Managed Domains, High Performance Computing, Hosting , Service Providers and other scale-out computing markets.

Cloud Computing is predicted to become a very important market within the next few years. Gartner predictions state that not only will cloud computing change the way IT will be delivered, it will also have a potential to make up for almost 28 percent of x86 server unit shipments until 2012. Yet there are many Cloud concepts and a wide range of application areas, management stacks, hardware infrastructures and related services.

Public Clouds have already become a reality, looking at the mega data centers run by Google, Amazon and Microsoft and their related offers and business models. Those have mostly built up their current infrastructures by their own, using low cost, commodity and ubiquitous servers, having low level IPMI as common management part.

Private Clouds are showing up to be constructed in the Large Enterprise markets, and new services are prepared to be used by other clients as well as by the own business groups of those enterprises. Many customers are preparing to identify their appropriate cloud solution stacks and run their initial projects.

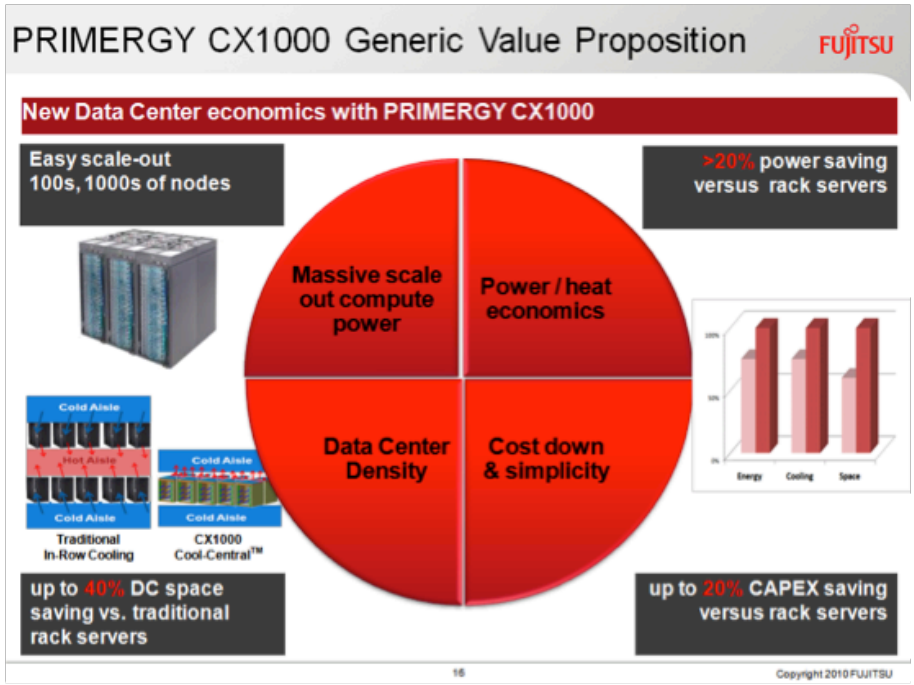


Figure 2: PRIMERGY CX1000 New Data Center Economics

This is where this guide will provide valuable guidance and insight in to building up a Cloud Computing based Dynamic IT infrastructure.

Cloud Computing is generating a massive customer interest, from public to telco to private large enterprises – and this will emphasize the need for new cloud-ready platform products such as the PRIMERGY CX1000 Cloud eXtension product category within the PRIMERGY server family.

With its 100% compatibility to the industry x86 server standards, including Intel Xeon processors, PRIMERGY CX1000 is enabled to run the different cloud architecture solutions stacks that cloud architects will select for their cloud models - without risk.

In addition, it perfectly fits to the demands for massive scale-out computing by solving the 4 dimension problem in a one-step approach. PRIMERGY CX1000 addresses Cloud providers, Service Providers, Hosting industries, "As-A-Service" industries, Outsourcers and High Performance Computing customers with its unique value contributions.

PRIMERGY CX1000 solves some of today most "hot and burning" large Data Center challenges: Scale Big and Spend Small!

Test Bed Overview

Physical Architecture

Figure 3 indicates the physical architecture of the test bed used for the testing done in this whitepaper. All VMware ESXi* hypervisor nodes have three separate network interface cards (NICs) for management, virtual machine, and storage network interfaces. For the sake of cost effectiveness and simplicity, a single network file system (NFS) store was used as shared storage for virtual machine images. Both VMware vCenter* Server and VMware vCenter Database were installed on the same machine with the default database setting. VMware vShield* Manager 4.1 was deployed with the OVF template on one of the hosts within the VMware ESXi host cluster.

In this configuration, we used the Intel® Xeon® processor E5506 for the ESXi* hypervisor nodes, which provides a foundation to design more efficient cloud data centers that can achieve greater performance and at the same time use less energy and space, to dramatically reduce operating costs.[1] For the PRIMERGY CX1000 both Intel Xeon 5500 and 5600 series processors are released and can be used in such vCloud solutions.

The Intel® Xeon® processor 5600 series delivers substantial increases in performance and energy efficiency over the previous generation Intel® Xeon® processor 5500 series, while it continues to support features from the previous generation that enable it to respond intelligently to workloads.

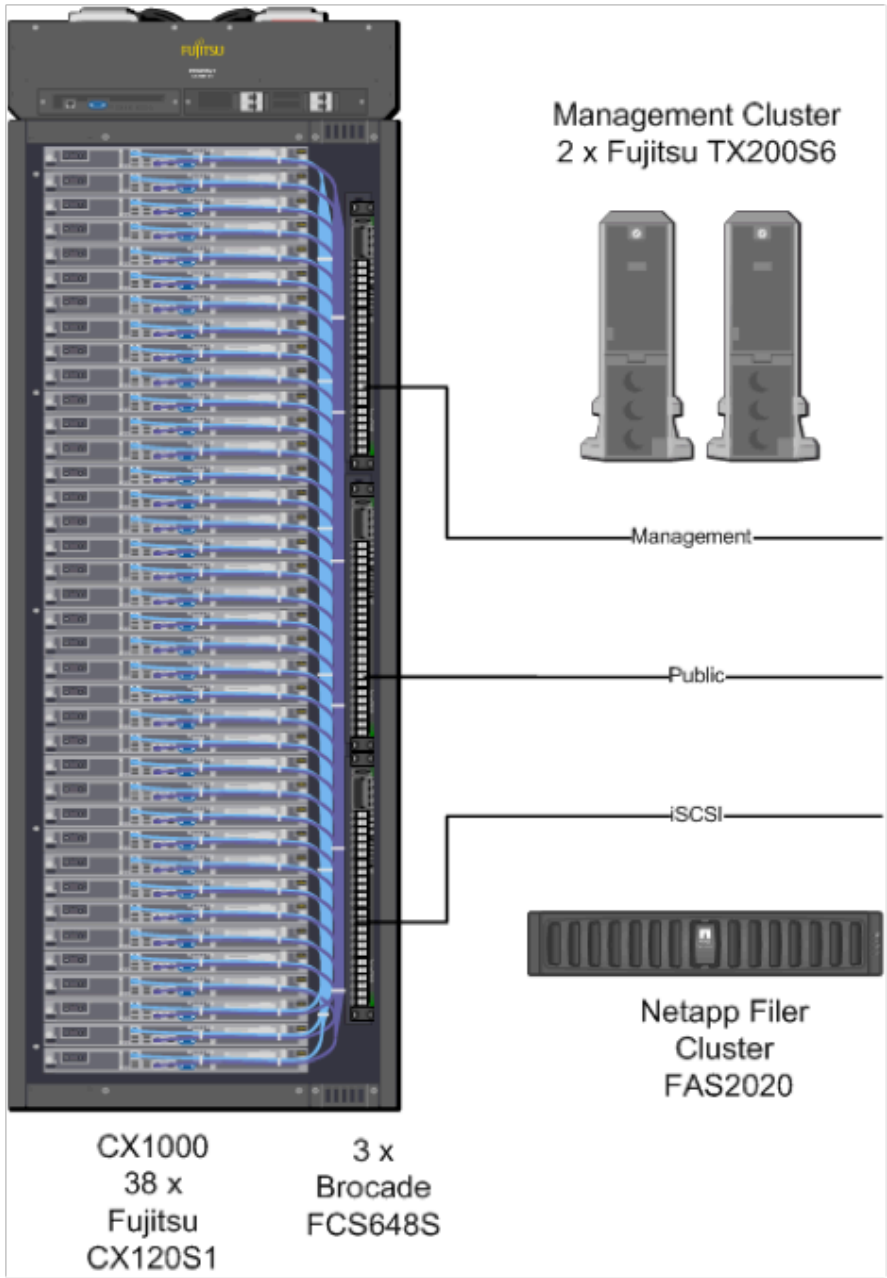


Figure 3: Test Bed Physical Overview

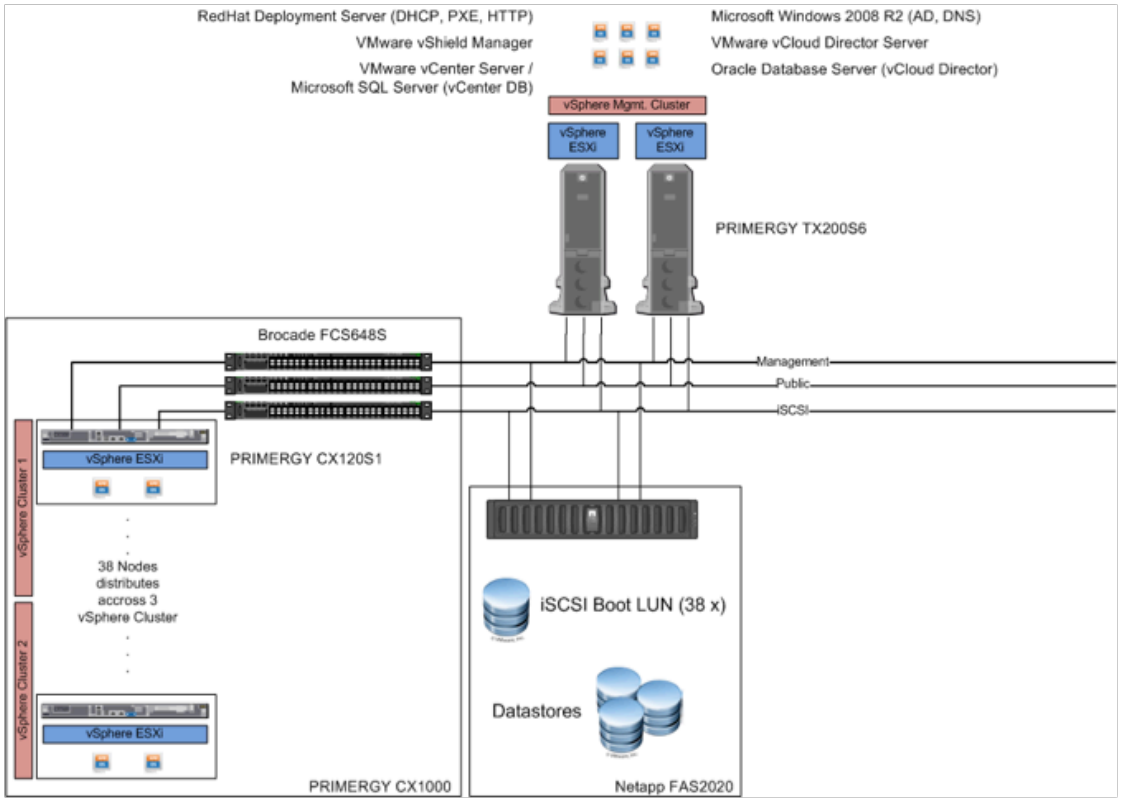


Figure 4: Test Bed Physical Architecture

- Intel® Virtualization Technology[2] increases manageability, security, and flexibility in IT environments, and improves system utilization as it consolidates multiple compute environments. The abstraction of the underlying hardware enables new usage models which reduce costs, increase management efficiency, alleviate security issues, and improve computing infrastructure resiliency
- Intel® Turbo Boost Technology boosts performance as needed through dynamic adjustments to core frequency to increase execution speed for peak workloads.
- Intel® Intelligent Power Technology adjusts core frequencies to conserve power when demand is lower.
- Intel® Trusted Execution Technology (Intel® TXT) is a hardware solution that validates the behavior of key components within a server or PC at startup. Known as the "root of trust," the system checks the consistency in behaviors and launch time configurations against a "known good" sequence. Using this verified benchmark, the system can quickly assess whether any attempts to alter or tamper with the launch time environment have been made.
- Intel Advanced Encryption Standard-New Instructions (AES-NI) is a set of seven new instructions that speed encryption and are part of the Intel Xeon processor 5600 series. The result is faster, more secure encryption, and to help prevent software side channel attacks, and make encryption feasible where it was not possible before due to the performance penalty incurred.
- Intel® Hyper-Threading Technology improves throughput and reduces latency for multithreaded applications and for multiple workloads that run concurrently in virtualized environments.

Each host in a VMware vCloud Director cluster must meet certain software and hardware prerequisites. In addition, a database must be available for use by all hosts in the cluster. Each cluster requires access to VMware vCenter Server, VMware vShield Manager, and one or more VMware ESXi hosts. For more information on configuration, software prerequisites, supported databases, disk, memory and network requirements please see VMware vCloud Director Installation and Configuration Guide (http://www.vmware.com/pdf/vcd_10_install.pdf).

Table 1: shows specifications of systems used to build the cloud test bed.

System	Processor Configuration	Detail Configuration
PRIMERGY CX120 S1	Intel® Xeon® Processor E5506	Form Factor: 1U Rack Mount Server Processor: Intel® Xeon® processor E5506; 2.13 GHz; 2-way x 4 cores = 8 cores Memory: 16 GB RAM Storage: no local storage Network: 2 x 1Gbit/s onboard NICs (82576)/Kawela Software: VMware vSphere Hypervisor (VMware ESXi 4.1.0)
Management Station **PRIMERGY TX200 S6**	Intel® Xeon® Processor E5620	Form Factor: Tower Server Processor: Intel® Xeon® processor E5620; 2.4 GHz; 2-way x 4 cores = 8 cores Memory: 32 GB RAM Storage: 4x 146 GB disks (RAID 5) Network onboard: 2 x 1Gbit/s (82574L) Network PCIe Card: 2 x 1Gbit/s (82546EB)
Storage **NetApp FAS2020** **& Expansion Shelf**		Form Factor base shelf: 2U Rack Mount Form Factor expansion shelf: 3U Rack Mount Base Shelf: 12 disks each 136 GB Expansion Shelf: 14 disks each 400 GB Connection: 4 x 1 Gbit/s network Controllers: 2 x controllers with each 2 NIC ports
Network **Infrastructure** **Brocade FCX648S**		Form Factor: 1 U Rack Mount Ports: 48 Switching Bandwidth: 200 Gbit/s Stacking Ports: 2 Features: L2/L3 Switch including High Availability; QoS; Management and Security features
VMware vCloud* **Director** **Database**	Virtual Machine	Windows Server* 2008 R2 (64-bit) Oracle* 11g Enterprise Edition
VMware vCenter* **Server and VMware** **vCenter* Database** **VMware vCenter*** **Server 4.1.0**	Virtual Machine	
VMware vCloud* **Director**	Virtual Machine	RHEL 5.4 (64-bit) Update 4

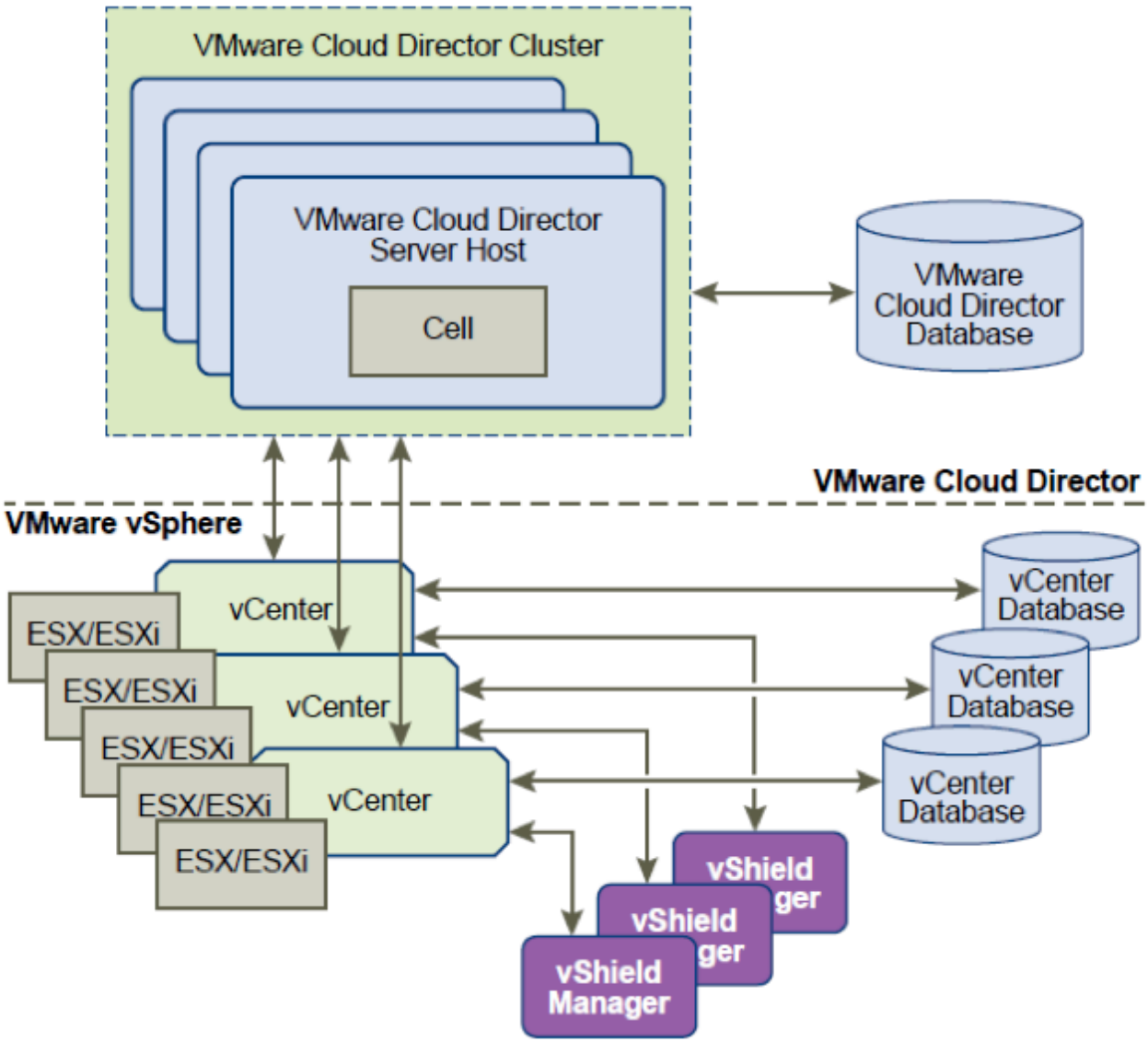


Figure 5: VMware vCloud* Director Architecture Diagram

Logical Architecture

In a cloud infrastructure, a VMware vCloud Director cluster is linked with one or more VMware vCenter Server installations, a VMware vShield Manager server, and an arbitrary number of VMware ESXi hosts. The VMware vCloud Director cluster and its database manage access to VMware vCenter resources by VMware vCloud clients. Figure 4 is a schematic representation of a simple cloud infrastructure. The diagram shows a VMware vCloud Director cluster of four server hosts. Each host runs a group of services called a VMware vCloud cell. All hosts in the cluster share a single database. The entire cluster is connected to three VMware vCenter instances and the VMware ESX hosts they manage. Each VMware vCenter instance is connected to a VMware vShield Manager host, which provides network services to the cloud. The VMware vCloud Director installation and configuration process establish an initial set of connections to a VMware vCenter Server, VMware ESX hosts, and VMware vShield Manager. Additional VMware vCenter, VMware vShield Manager, and VMware ESX hosts can be connected to the VMware vCloud Director cluster at any time.

Technical Review

Installation and Configuration

In the test bed, a single instance of VMware vCloud Director was configured to a single VMware vCenter installation with three hypervisor nodes. The sections that follow provide a brief overview of the above steps. Detailed instruction on the setup can be obtained from VMware's website, at http://www.vmware.com/pdf/vcd_10_install.pdf

VMware vSphere Hypervisor

VMware vCloud Director installation relies on the compute, storage, and network capacity provided by the underlying VMware ESX or VMware ESXi 4.0 Update 2 or 4.1 nodes. In the test bed installation, both types of VMware hypervisors co-existed without any issues. Refer to VMware vSphere Hardware Compatibility Guide, http://www.vmware.com/resources/compatibility, for the list of VMware certified hardware.

VMware vCenter* Server

Install VMware vCenter Server 4.0 Update 2 or 4.1 and VMware vSphere Client 4.1 Update 2 or higher on a Windows Server* 2008 R2 system. Create a cluster and add the VMware ESX/ESXi hosts created in the above step. Configure the VMware Distributed Resource Scheduler (DRS) setting based on the requirements, and setup "Enhanced vMotion Compatibility (EVC)" based on the processors in the VMware ESX hosts that will be added into the clusters. Ex: If your clusters will just contain Intel Xeon 5500 and 5600 series servers, you can choose "Intel® Xeon® Core™ i7" – this branding is not quite correct – appreciate you can double check on this – it's either Xeon or Core i7, but not both at same time as your EVC Mode configuration. This mode will support flex migration of VMs between the 5500 and 5600 systems. Ensure that all required configurations necessary for live VM migration of virtual machines between the hosts are completed.[4]

VMware vShield Manager

VMware vShield Manager provides the required network and security services to the VMware vCloud Director. A separate instance of VMware vShield Manager (version 4.1) is required for each VMware vCenter that is added to the VMware vCloud Director. VMware pre-bundles VMware vShield Manager as an OVF template, which can be imported into VMware vCenter. After network configuration, the VMware vShield Manager VM is up and running.

Oracle Database

VMware vCloud Director requires a database to store the information and share it with other VMware vCloud Director cells[5] within the VMware vCloud Director cluster. VMware supports both Oracle* 10g Standard/Enterprise Release 2 and Oracle* 11g Standard/Enterprise. In the test bed, we used the Oracle 11g Enterprise edition installed on a Windows 2008 R2 system. Ensure that all the required privileges are assigned to the new user created as per the installation document.6 This user will be employed during configuration of the VMware vCloud Director to establish the link with the Oracle database.

VMware vCloud* Director Installation and Configuration

Ideally a VMware vCloud Director cluster will have several hosts, each of which will run the VMware vCloud services and each of which is called a VMware vCloud Director cell. All these individual cells will be connected to the same Oracle database created in the above step. These individual hosts will run Red Hat* Enterprise Linux* (RHEL) 5 Update 4 or Update 5. After the installation of the VMware vCloud Director services, configure the network and database settings. To connect to the database, use the credentials of the new user created during the installation of the database. Do not use the SYSTEM account for this step.

Connecting VMware vCloud Director with VMware vCenter and VMware vShield Manager

Once the network and database configuration is completed successfully, login to the VMware vCloud Director with the credentials configured. Now we need to add VMware vCenter Server instance(s) to this VMware vCloud Director cell, which will provide the required compute, storage, and network resources, and to VMware vShield Manager for the network and security services. The following figures show the VMware vCloud Director's verification flow to configure VMware vCenter Server and VMware vShield Manager.

Once you are logged into the vCloud Director with an administrative account, you are able to attach the vSphere resources.

The welcome screen will guide you through the necessary steps to build up your own Cloud Service.

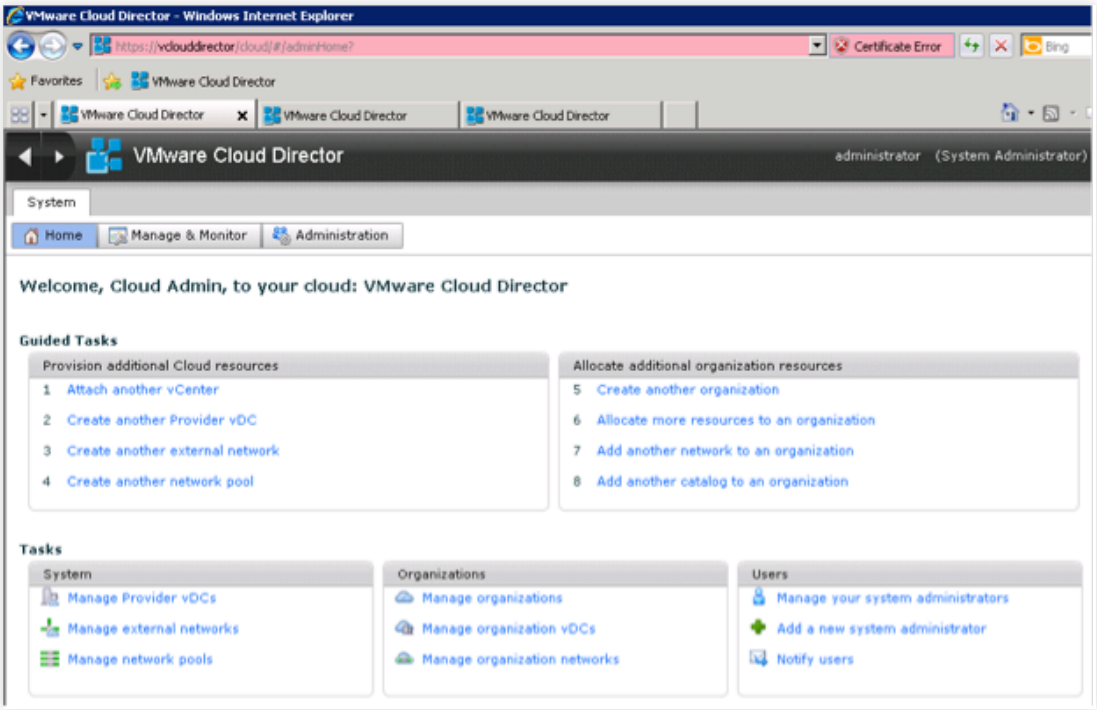
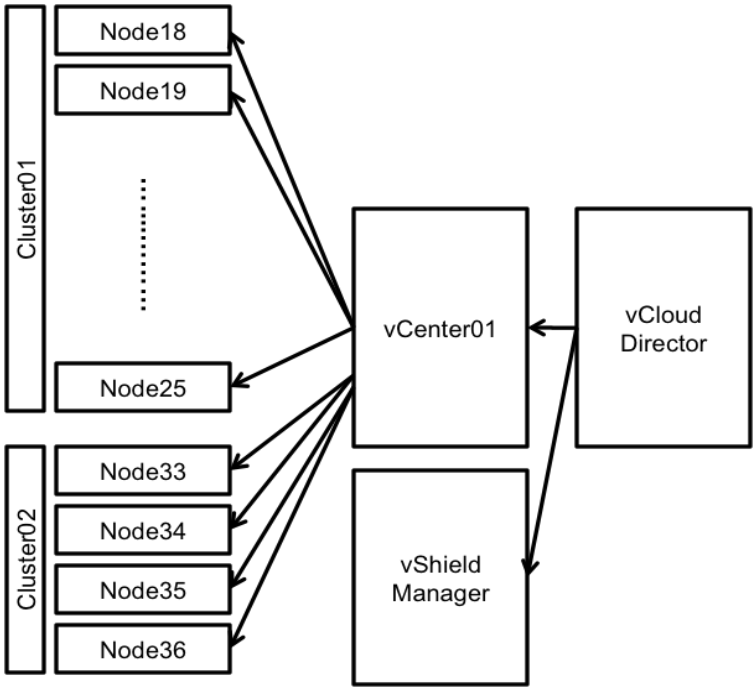
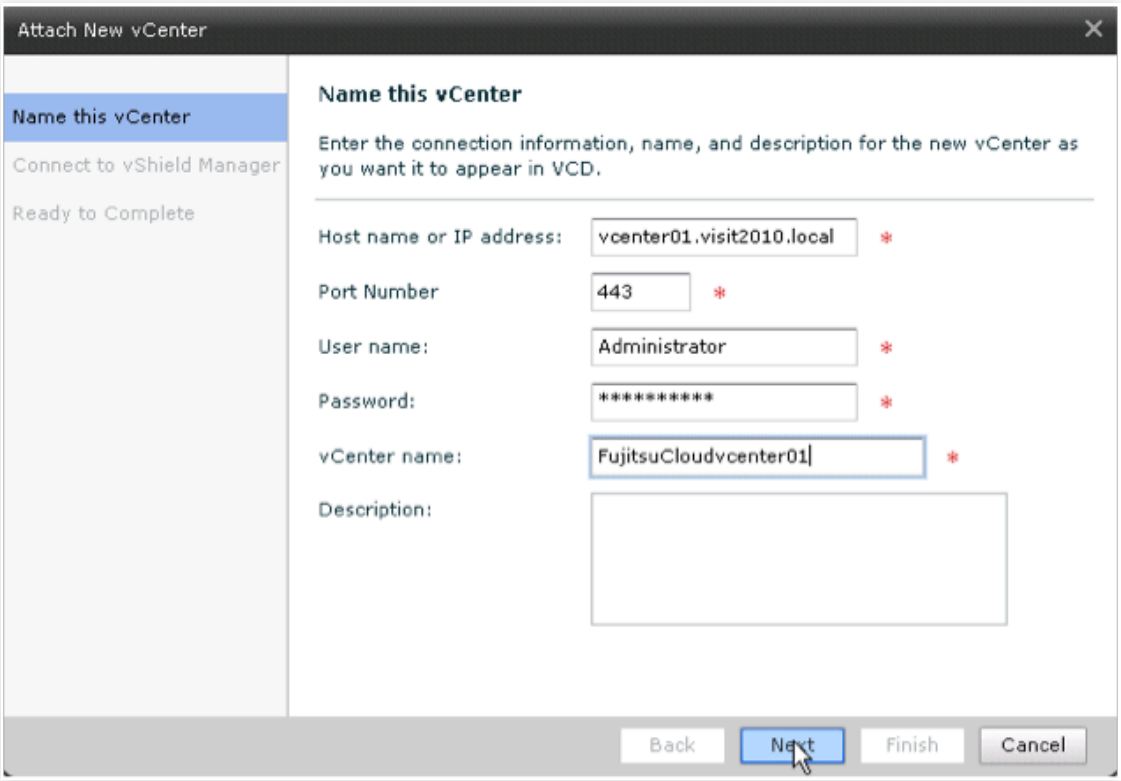


Figure 4: Welcome screen

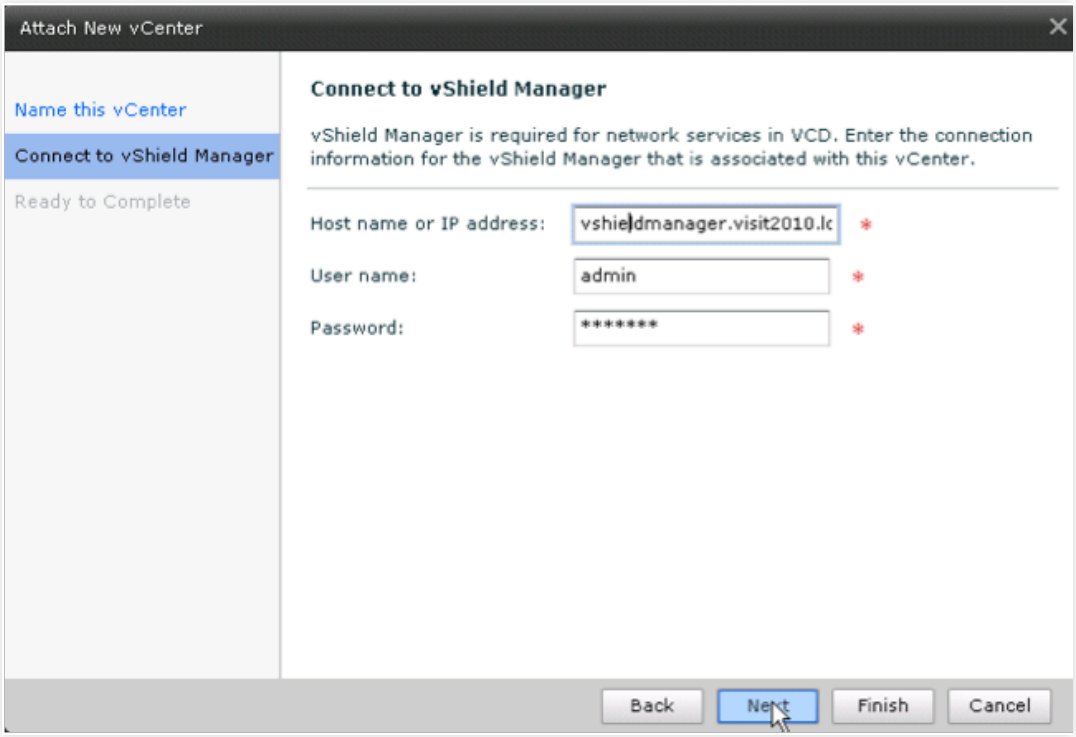
Attach vCenter Server

The first step is to attach a vCenter Server, this action allows the VCD (VMware vCloud Director) to control the vSphere resources allocated to it as well as automate the management of network provisioning and security tasks using vShield Manager and its built-in vShield Edge capabilities.

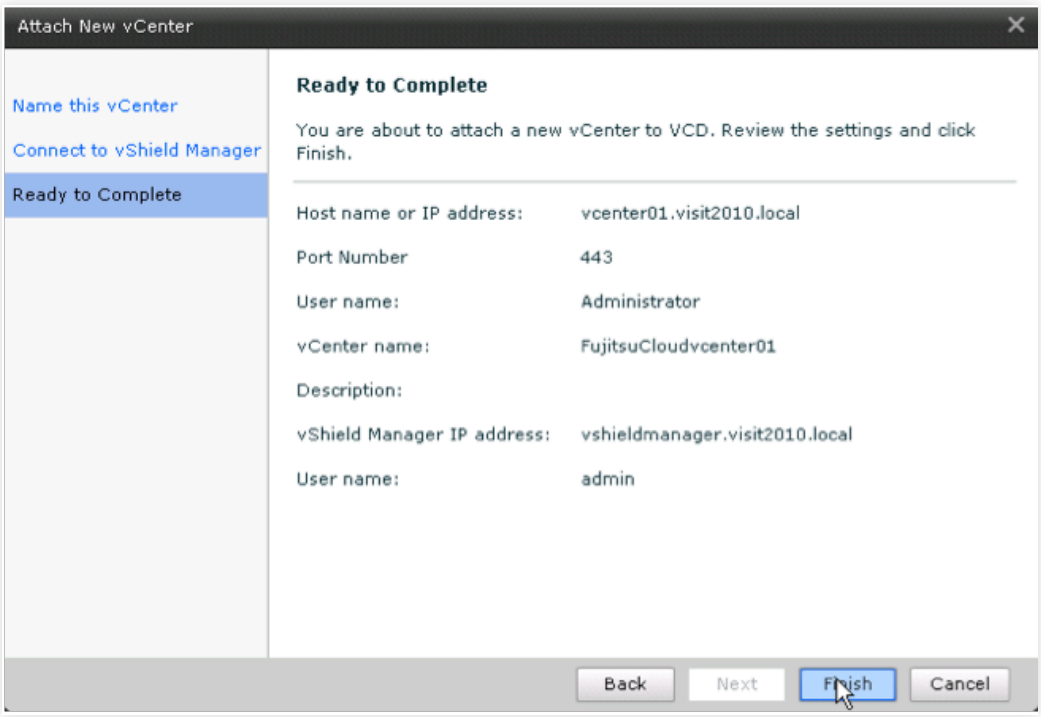




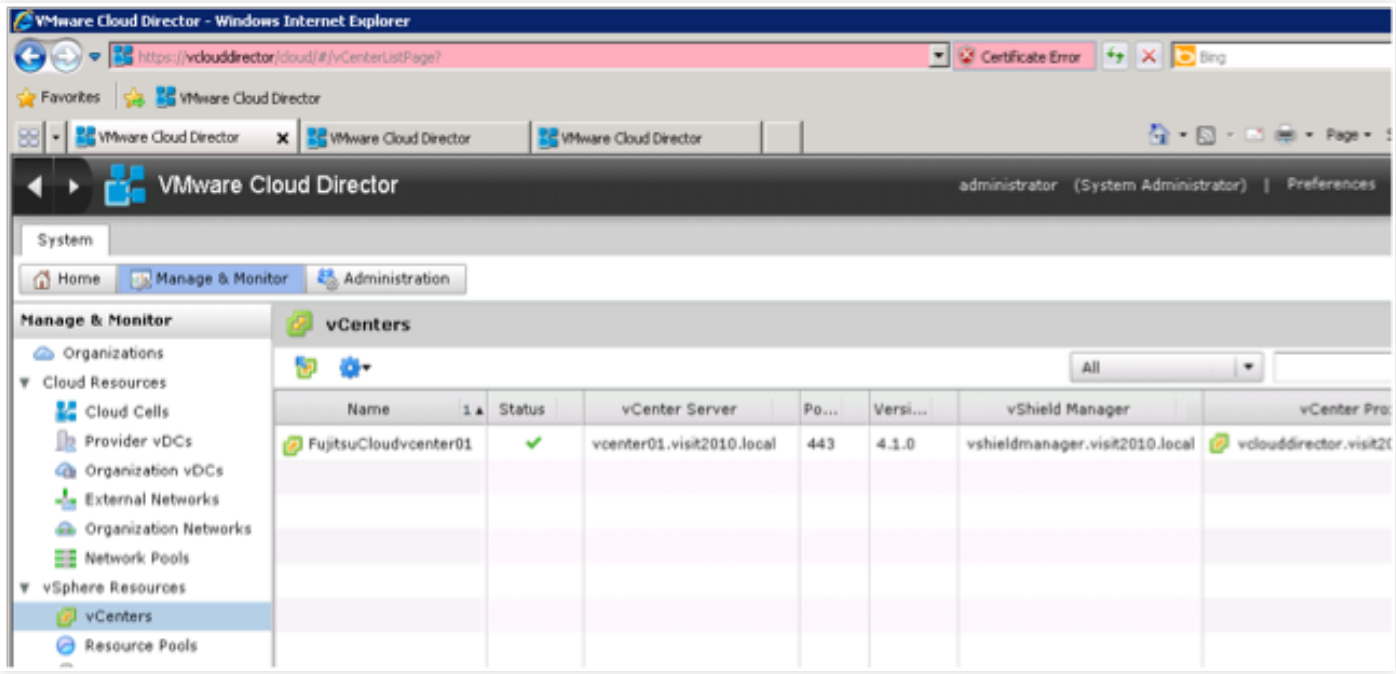
Connect to vShield Manager



VCD will now process the attachment of this vCenter and its companion vShield Manager



Verify vCenter Server has been successfully added.



Use Case Details

The following use cases describe brief scenarios what a cloud administrator has to do in order to set up the cloud services.

Preconfigured User Roles:

Cloud Administrator -> provides resources to the cloud

Organization Administrator -> can manage organizations and can create catalogs

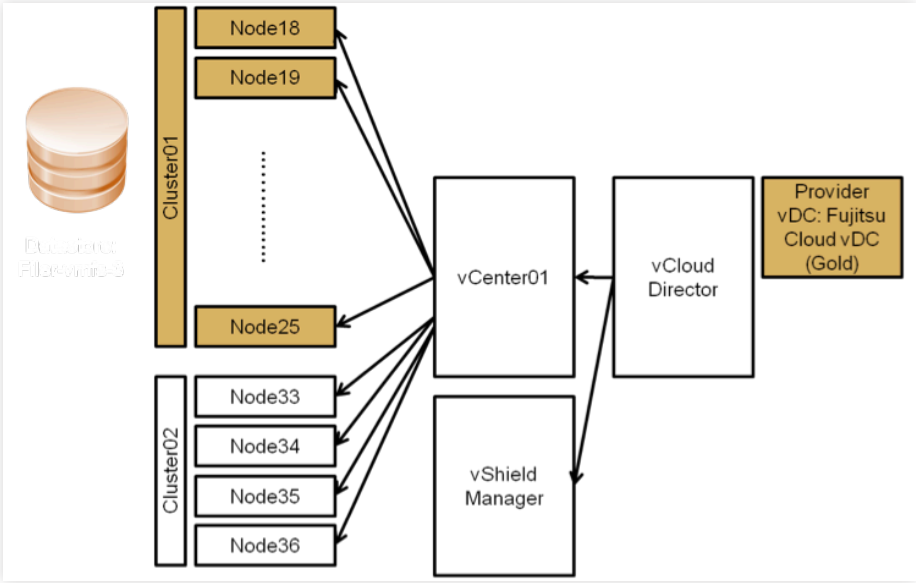
End User -> can browse the Catalog of vApps via a Web-browser portal and use IT as a service

Overview

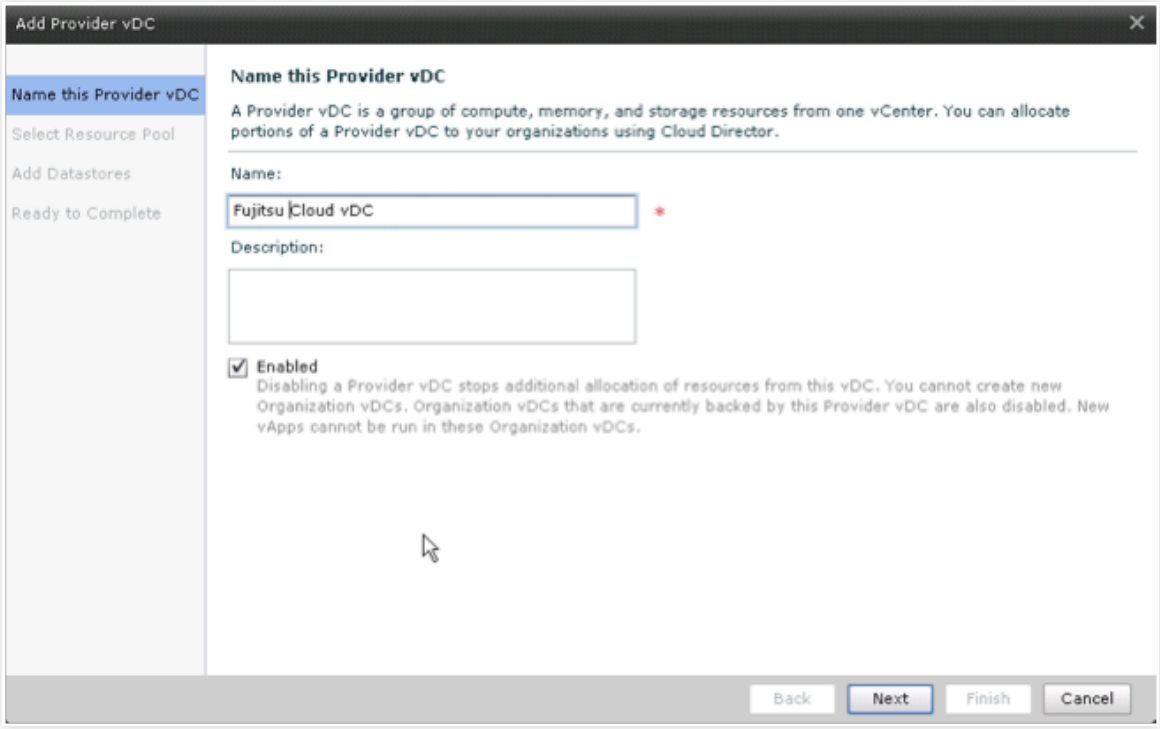
1. Provider vDC creation
2. External Network creation
3. Network pool creation
4. Organizations and Users
5. Organization vDCs
6. Organizational Networks
7. Create Catalogs
8. vAppTemplate creation
9. Use of Infrastructure as a Service (IaaS)
10. Dynamic Scaling of Compute Resources
11. Termination of vApp or Service
12. Separation of Duties
13. Notifications and Alerts

Use Case 1: Provider vDC creation

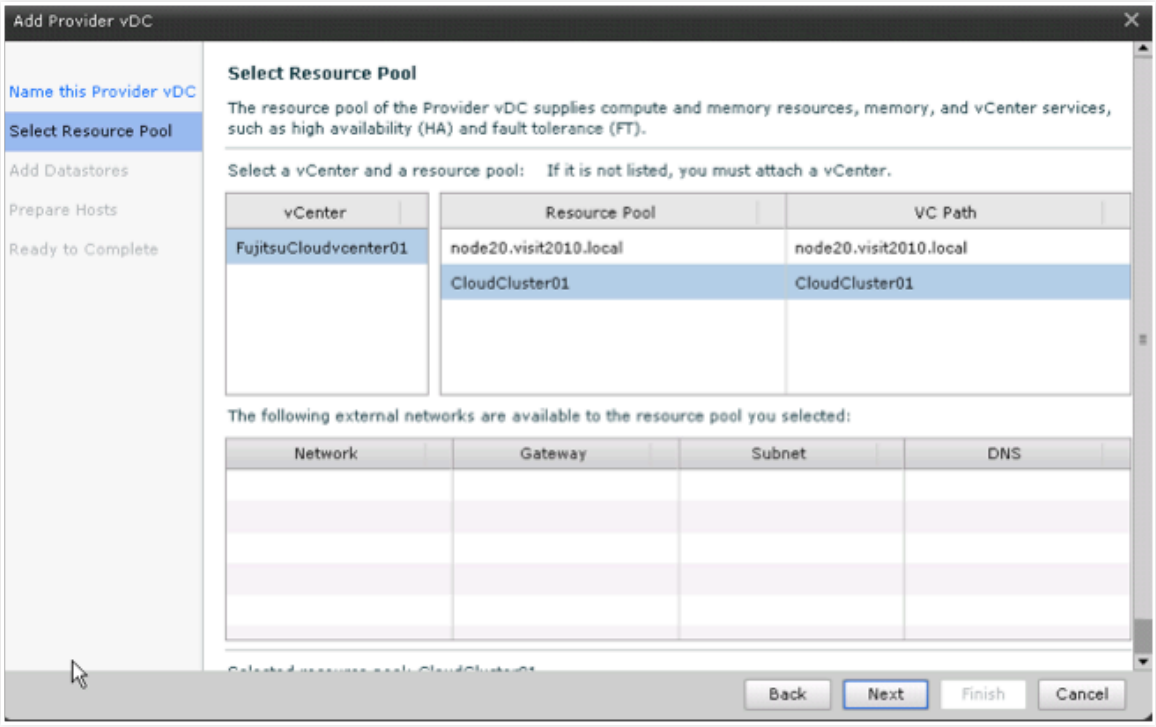
The first service offering will combine compute, storage and network resources together. This resource grouping is called a Provider Virtual Data Center (vDC).



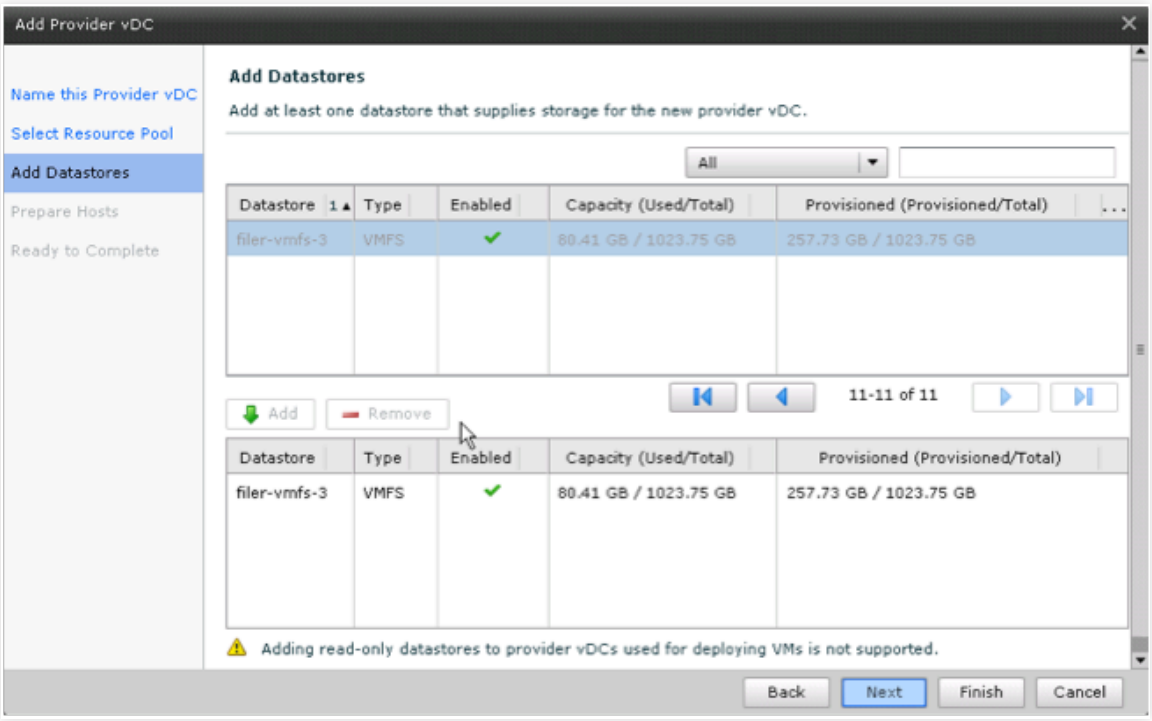
1. Create a Gold Provider vDC.



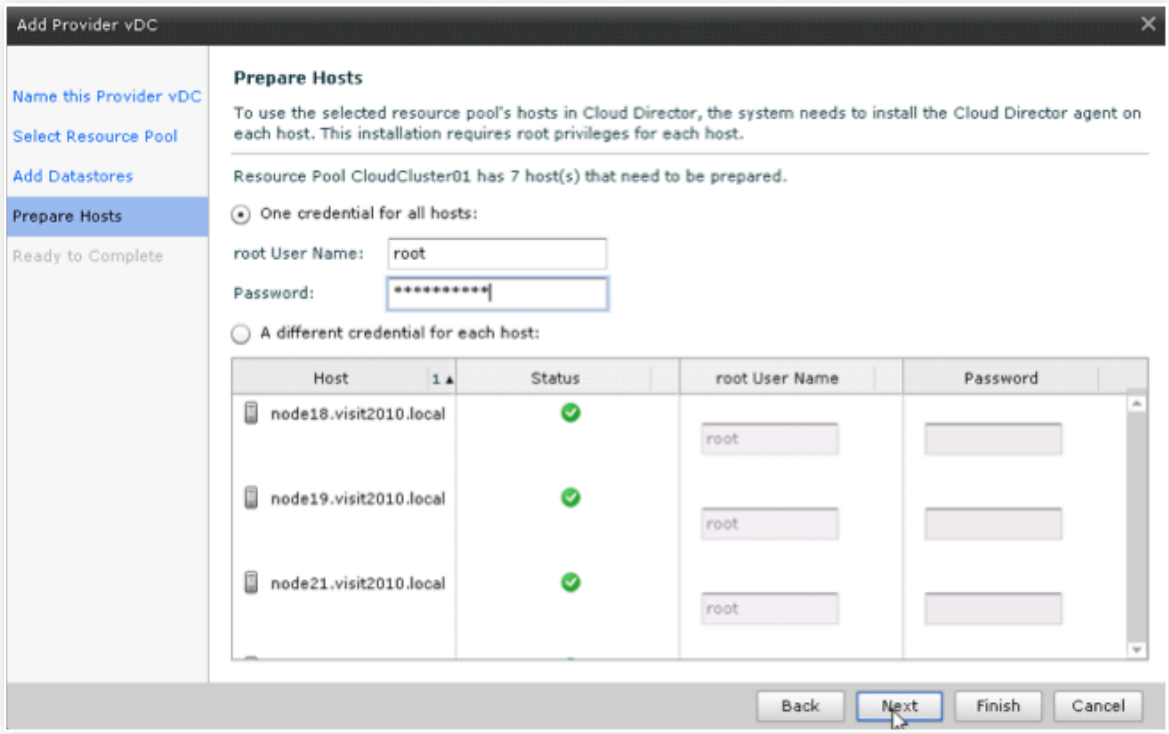
2. Select the vCenter Server and the appropriate resource pool for a Gold Service.

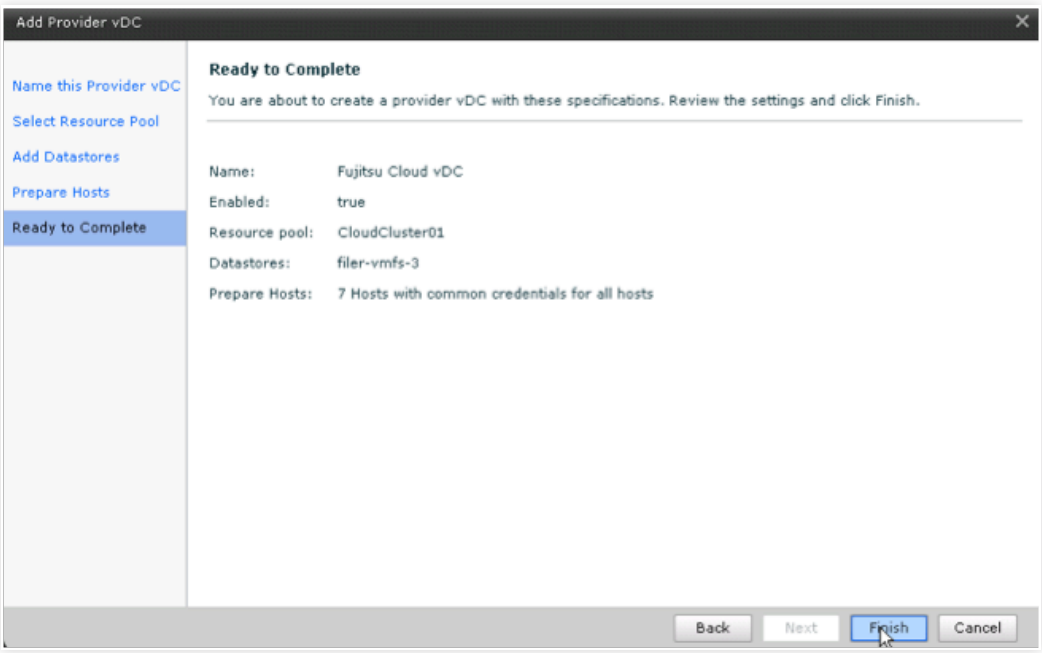


3. Select the datastore for the Gold vDC.

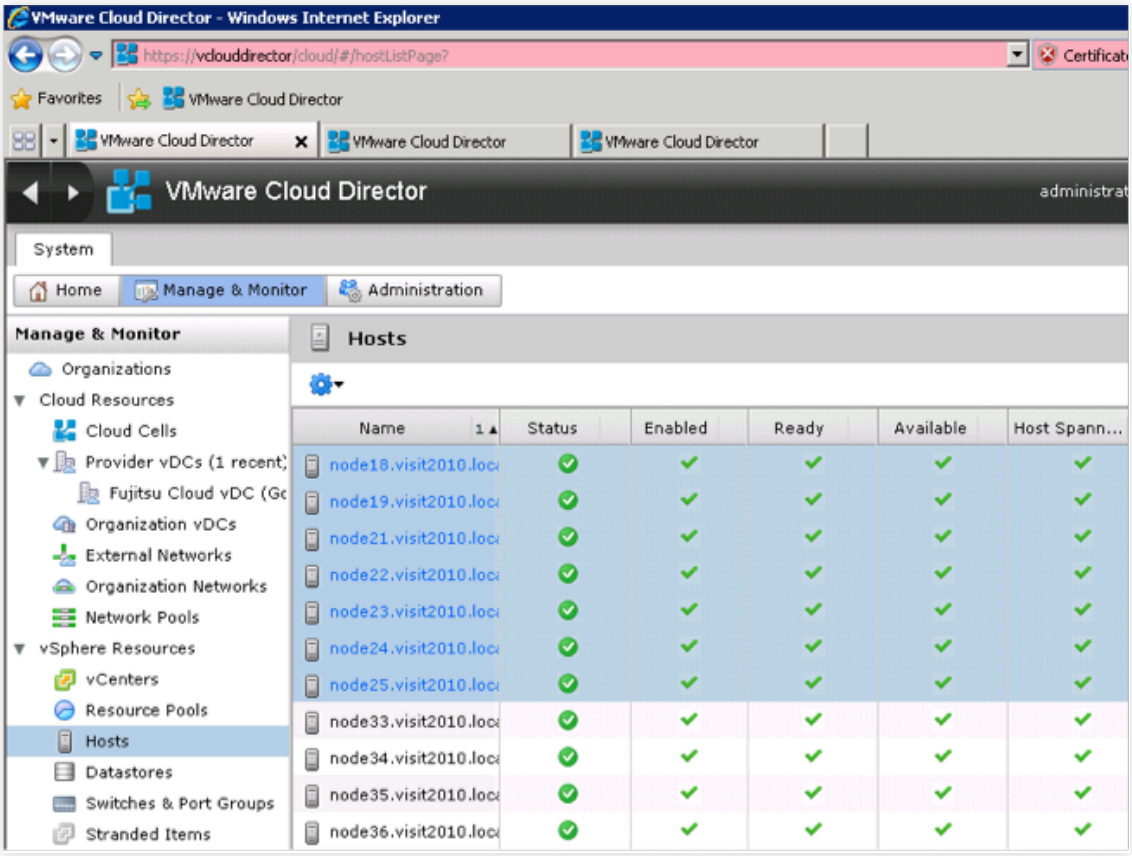


4. Finally prepare the ESXi hosts; the VCD will install an agent on the ESXi hosts.On this screen you can give a single set of credentials for all ESXi hosts or you can enter credentials for each host individually if they are unique.

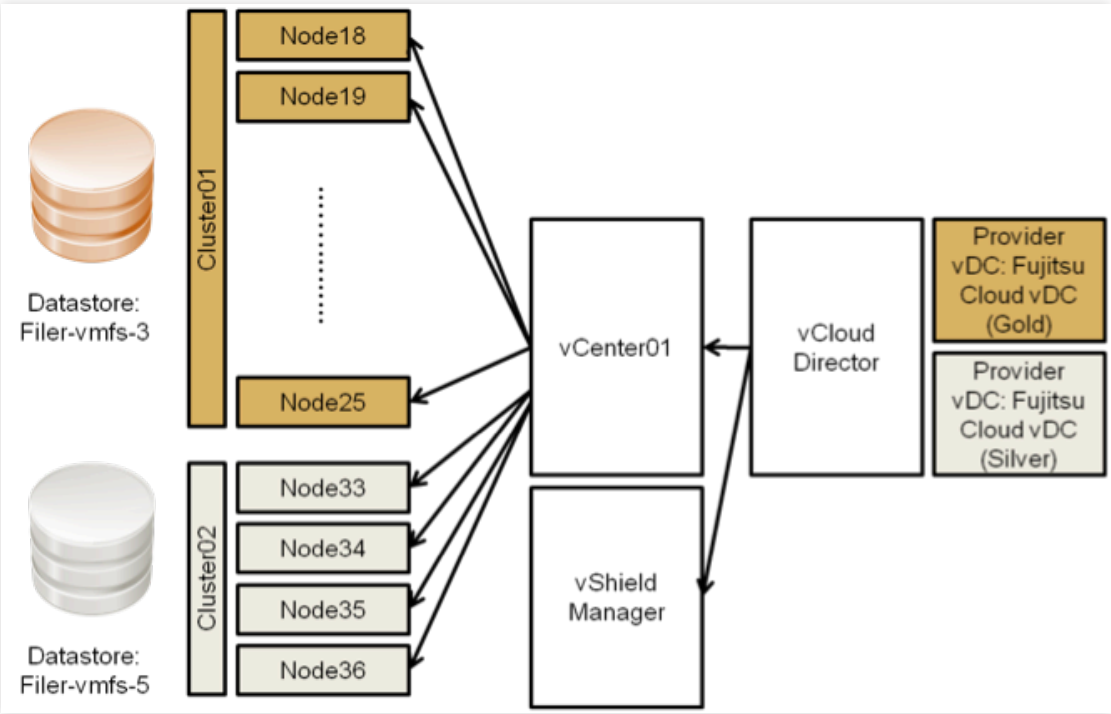




5. Verify that all nodes can now be seen within vCloud Director.



6. Optional: Feel free to repeat the above mentioned steps in order to create a "Silver" Provider vDC.

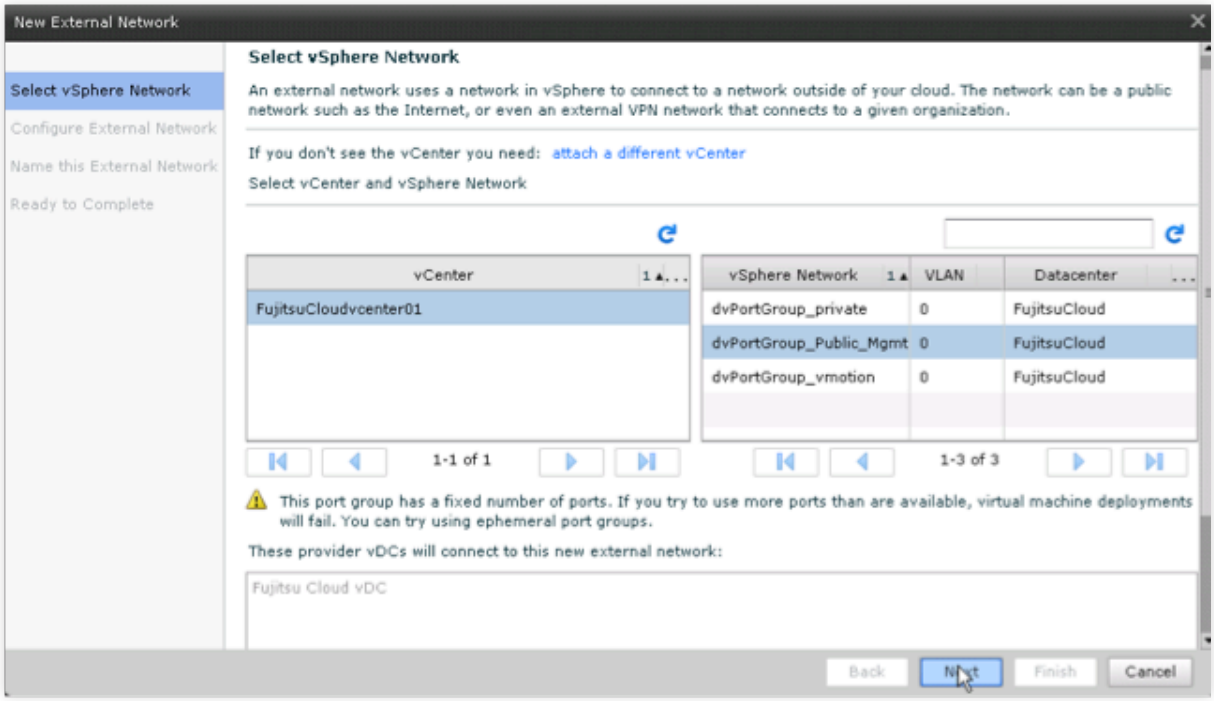


Use Case 2: External network creation

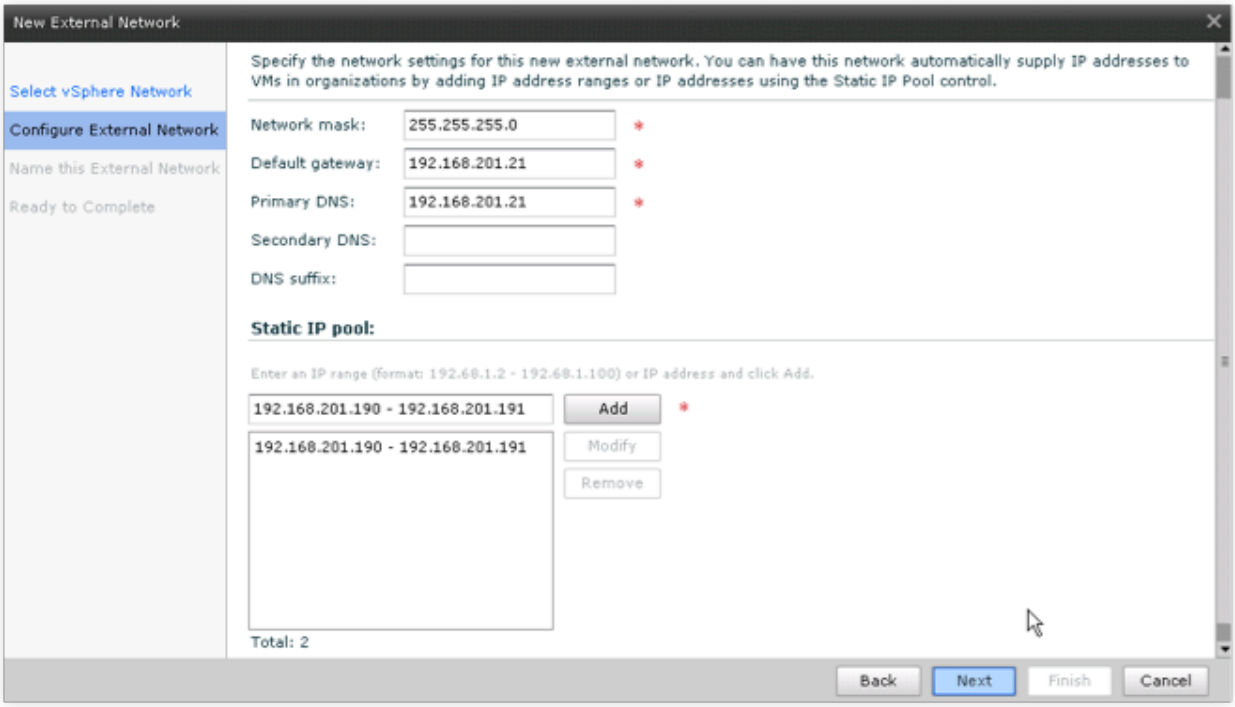
VMware vCloud Director is capable of supporting complex virtual networking scenarios within a hosted Organization, and ultimately most workloads will need to communicate with the outside world and so it is required to give the VCD the ability to connect to a physical network whether it is a public facing network to the internet or a private network within the same organization.

VCD makes it easy for organizations to consume and release resources and networking is no different, VCD uses Network Pools to dynamically create and release network resources to Organizations and their VMs. This removes the need for Network Admin intervention as new networks can be created when needed by the organization dynamically by VCD and when no longer being used they can be un-deployed and their resources will be returned to the network pool for re-use by other organizations.

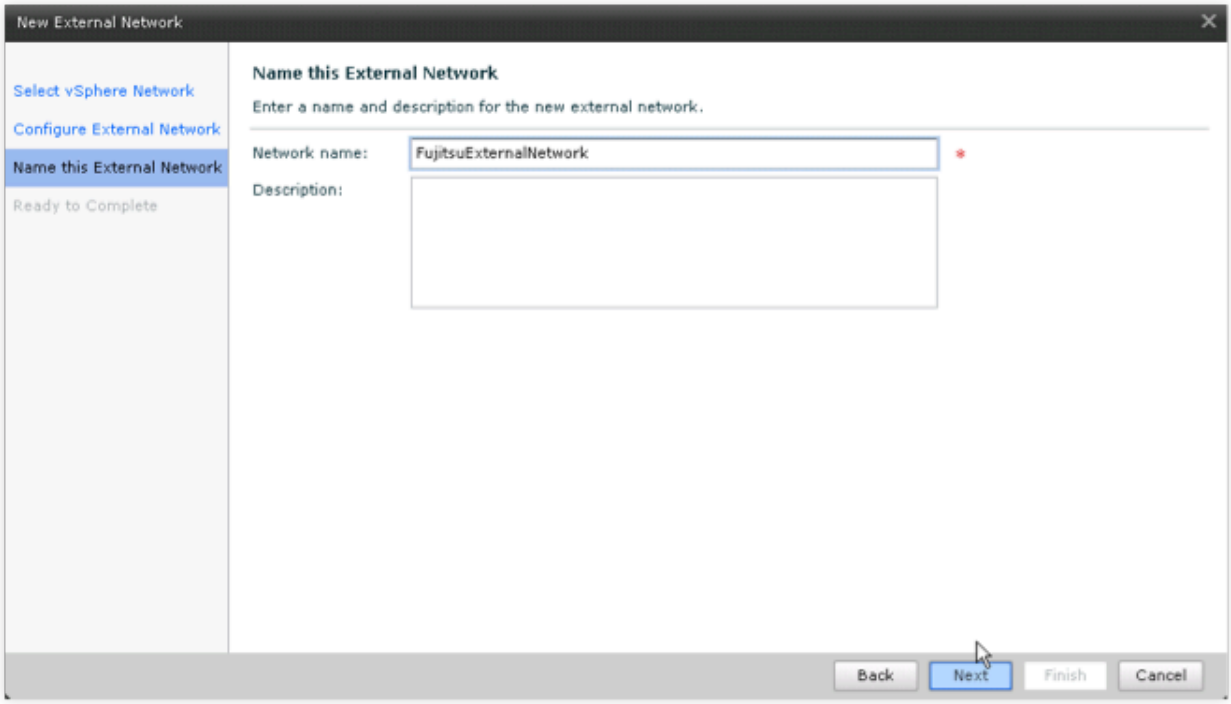
An External Network describes how an Organization network can be connected to the physical world.



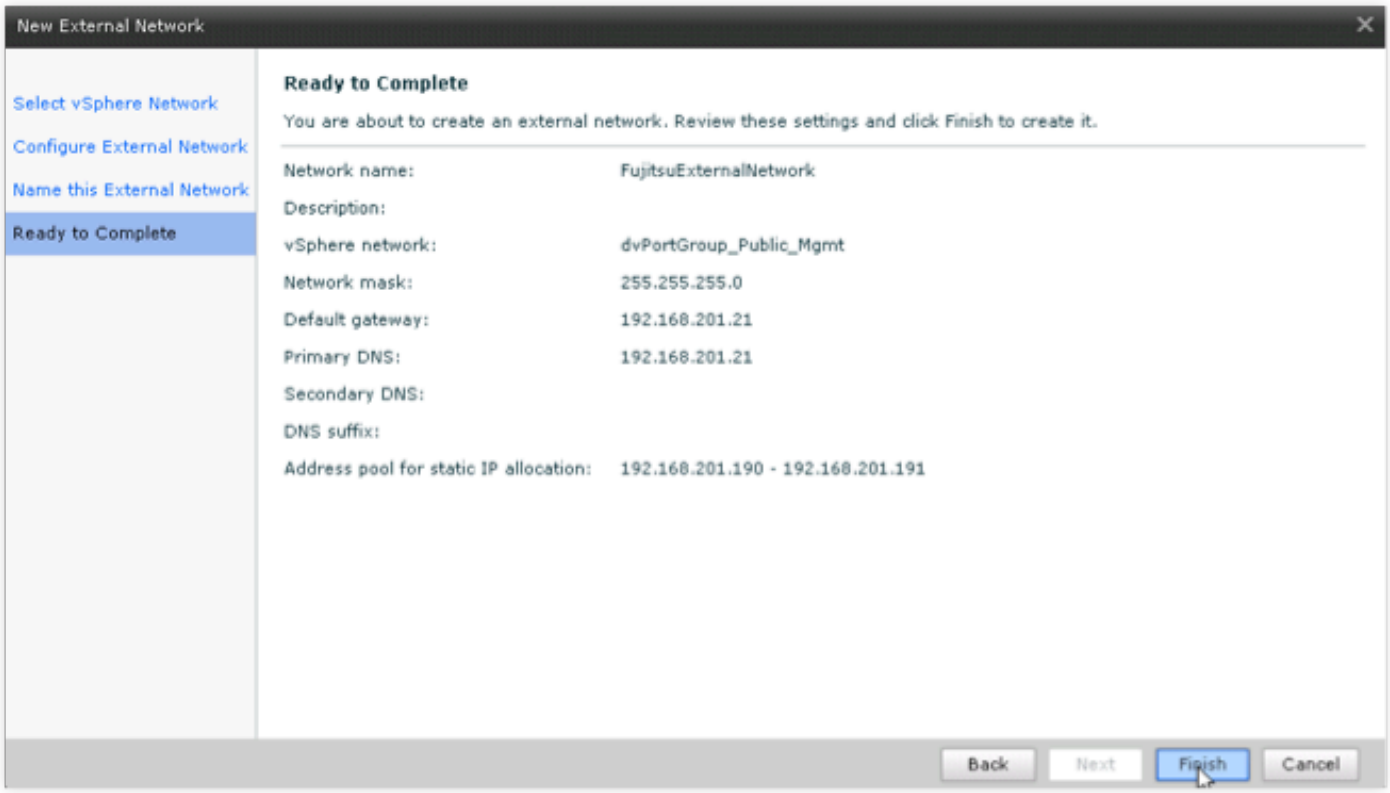
1. To connect a VM's vNIC to the External Network, VCD needs to assign a valid NAT IP address on the External Network; therefore it is required to define a pool of IP addresses that can be allocated to VMs.



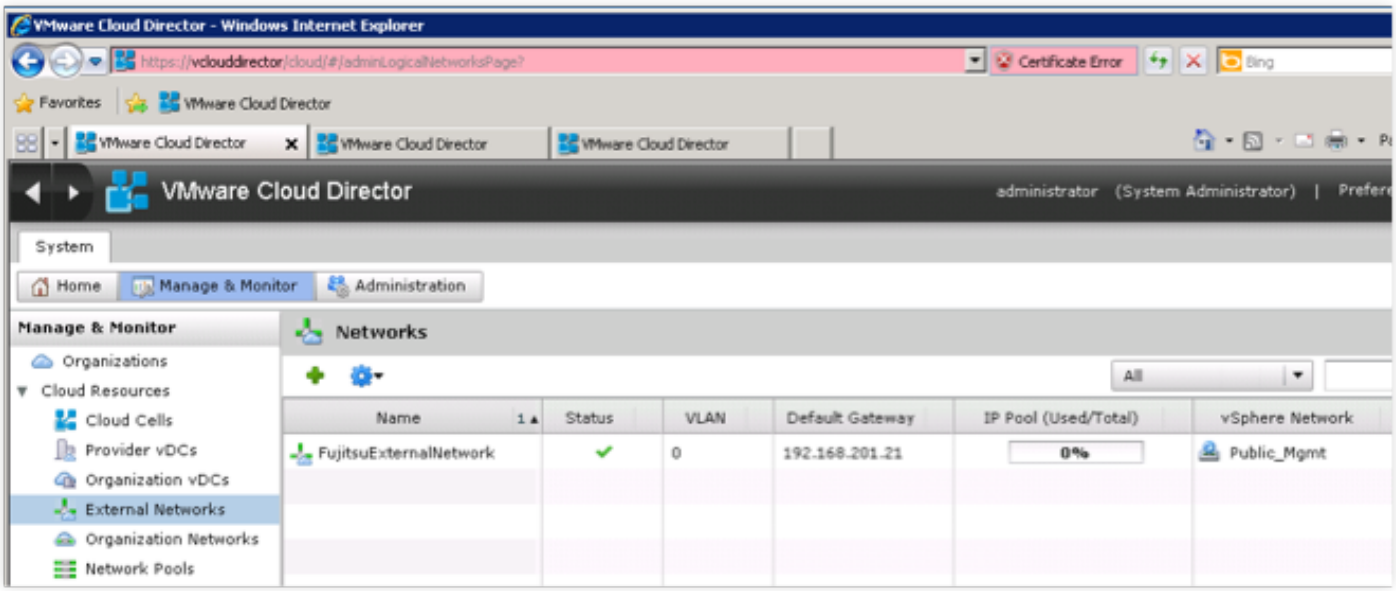
2. Define a meaningful name for the network.



3. Click Finish.



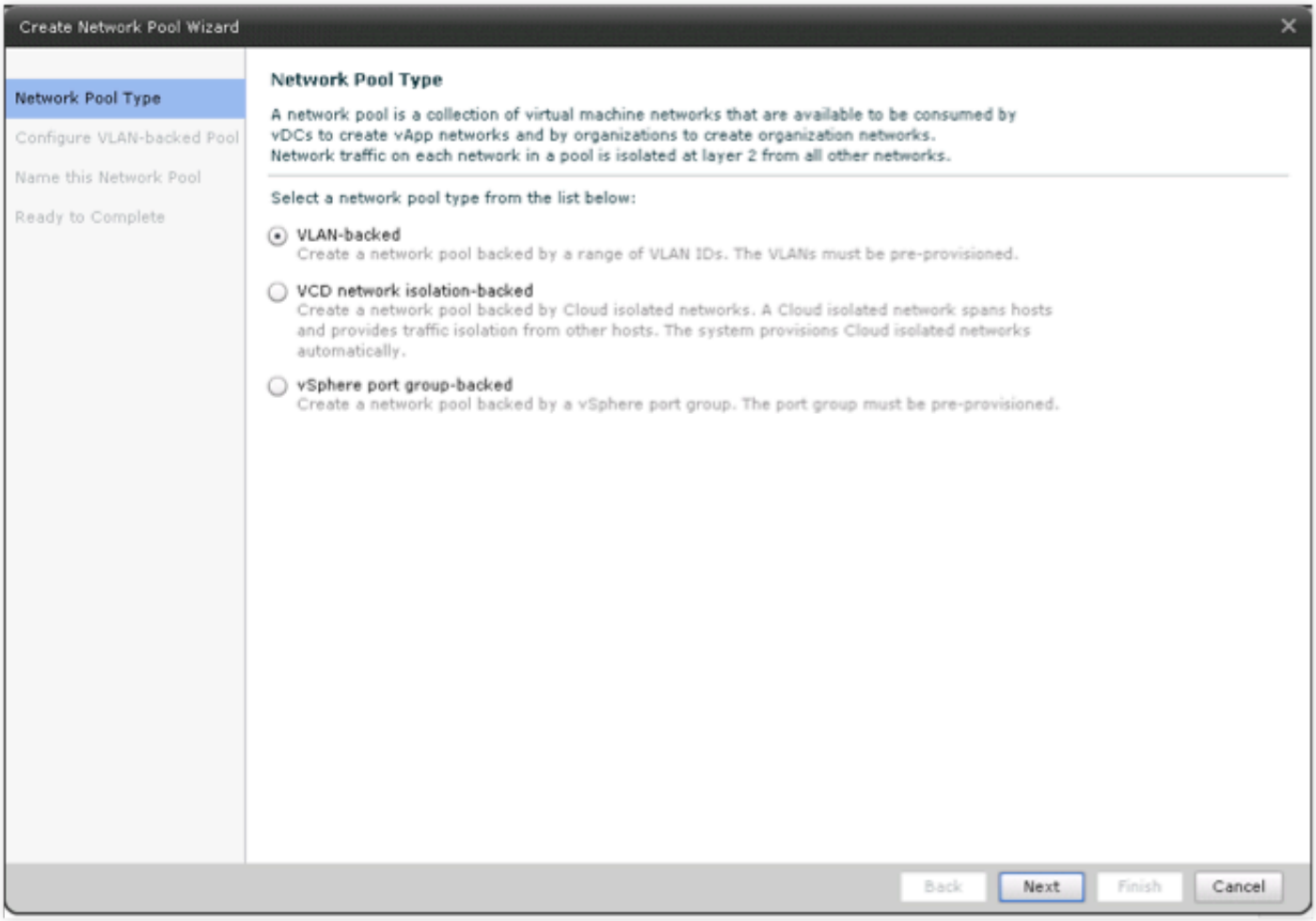
4. Finally verify the status of the created external network.



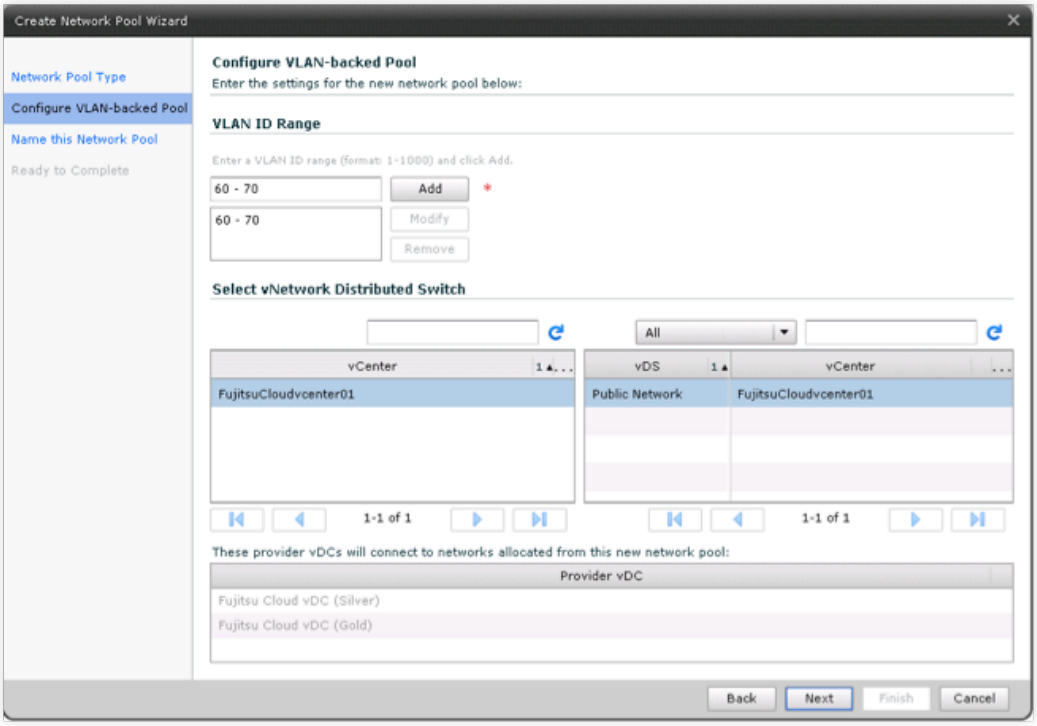
Use Case 3: Network pool creation

A Network Pool is a collection of Virtual Machine networks available to be con-sumed by virtual datacenters to create vApp networks and by organizations to create organization networks. Network traffic on each network of a network pool is isolated at layer 2 from all other networks

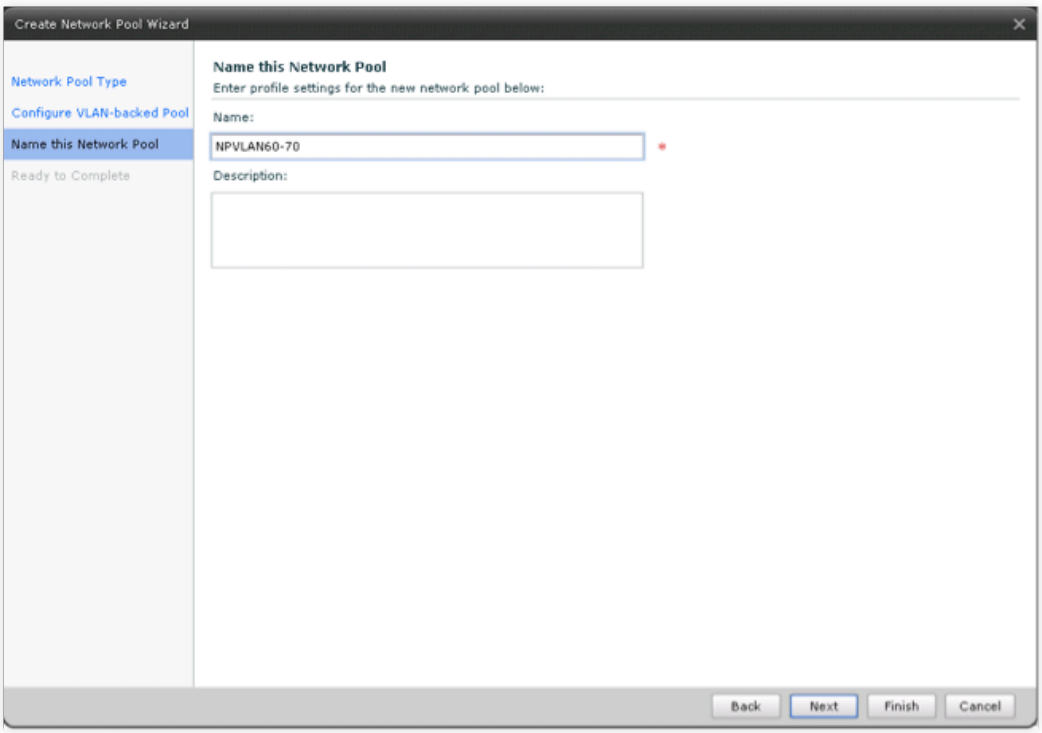
1. Configure a "VLAN-backed" network pool.

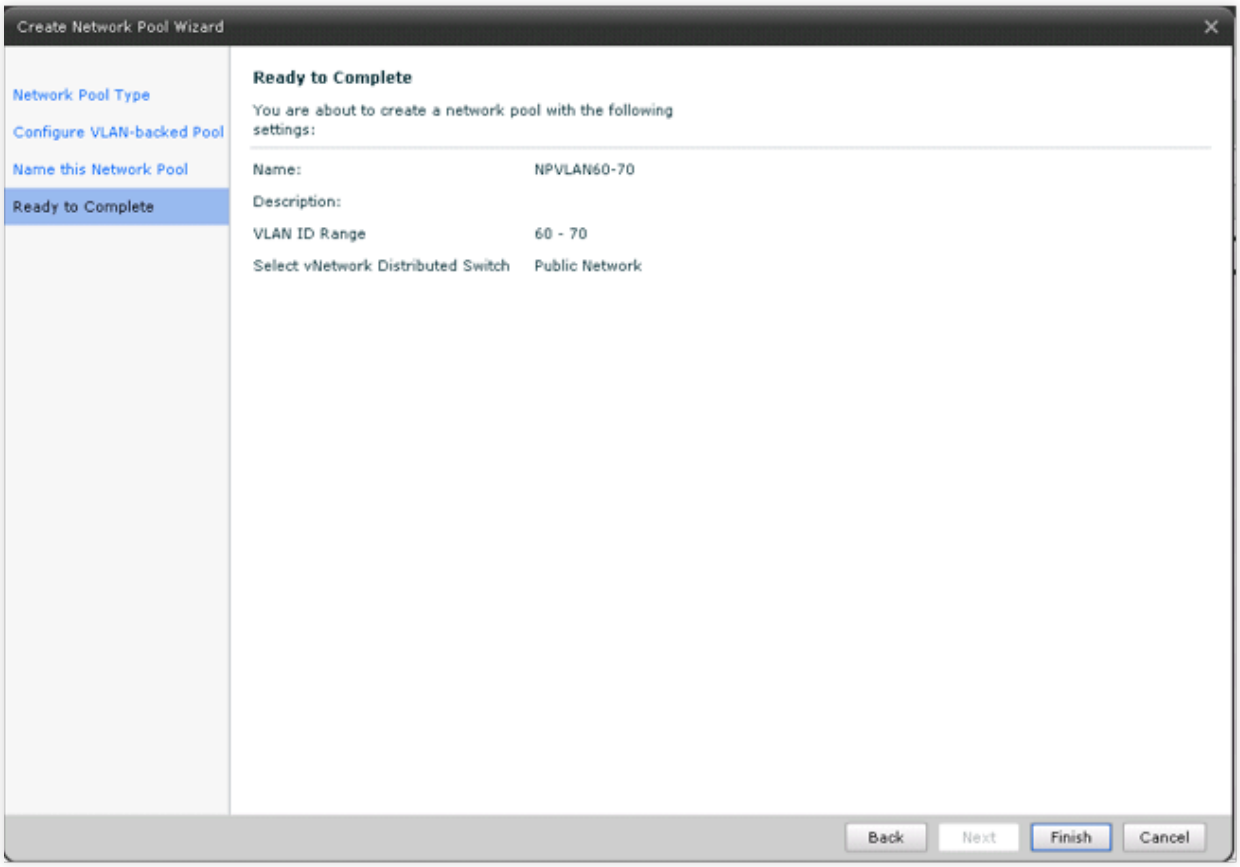


2. Add a valid range of VLANs and assign it to a distributed virtual switch.

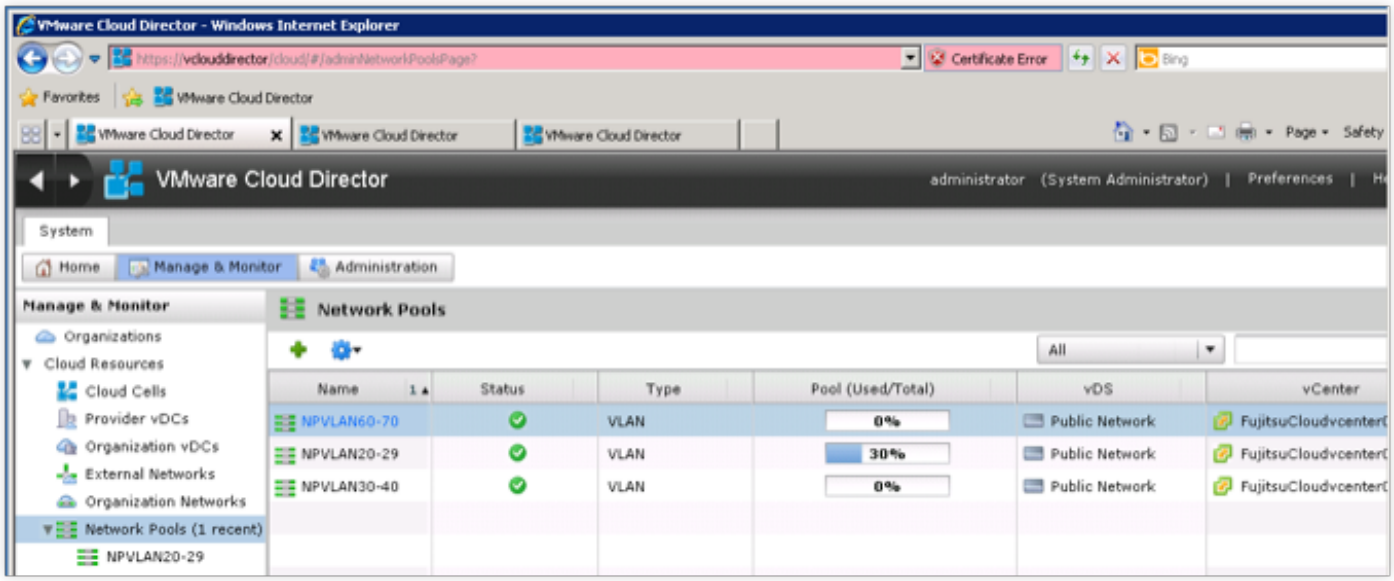


3. Use a meaningful name.





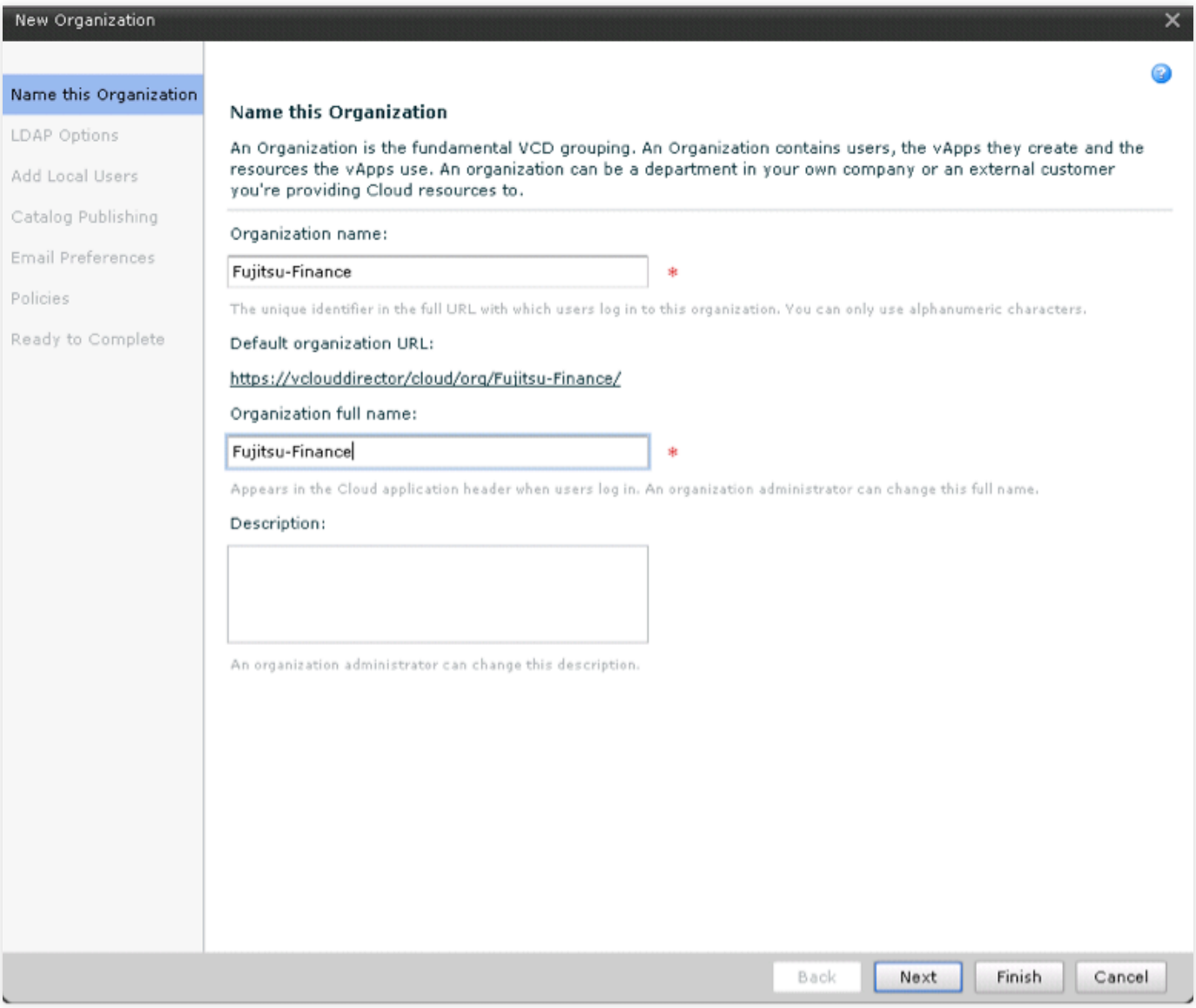
4. Finally verify the status of the created network pool.



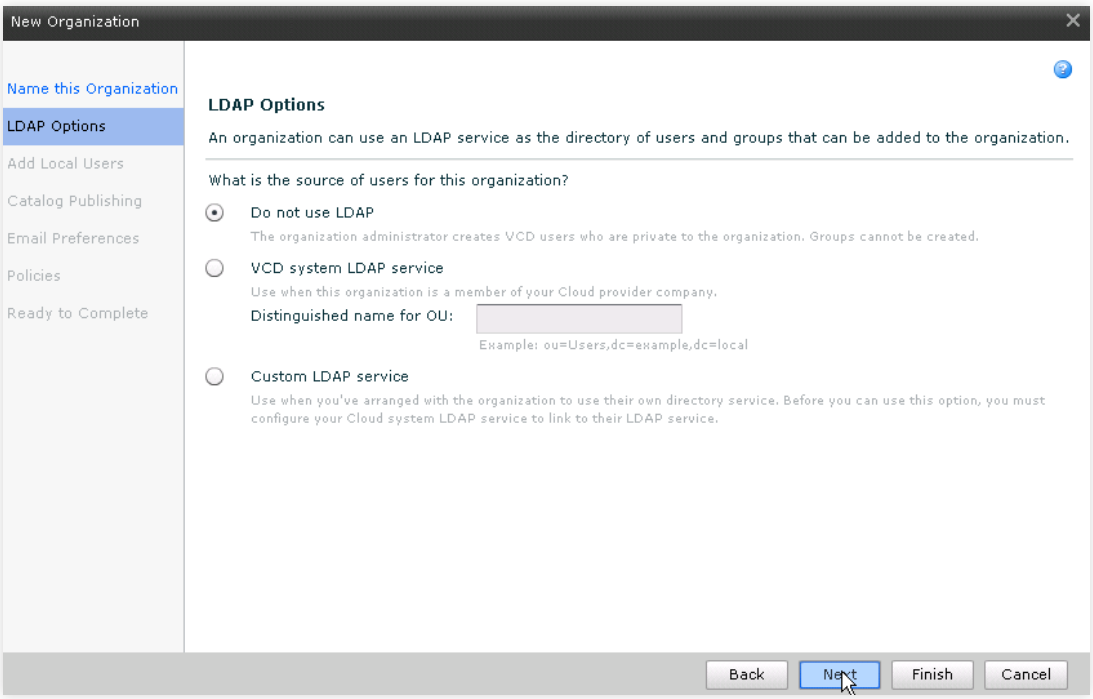
Use Case 4: Organizations and Users

VMware vCloud Director is now ready to start offering Cloud resources to Fujitsu Business units. For example the Fujitsu-Finance division has a new Finance application in development and the Project team wants to test out the flexibility that the Cloud will offer as they develop their new application. To do so create an organization for the Fujitsu-Finance division and build an Organization Virtual Datacenter using some resources from the Gold Service.

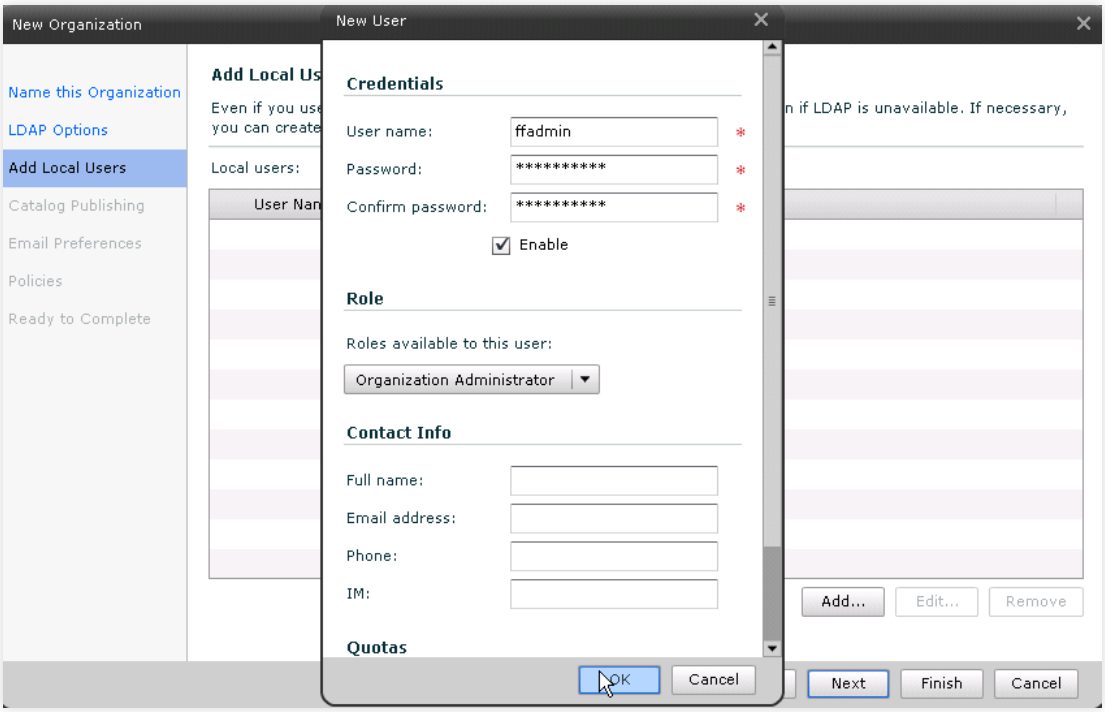
Organization's name is Fujitsu-Finance notice as you type in the Organization's URL dynamically changes to show what you're typing and will finish with http://vclouddirector/cloud/org/Fujitsu-Finance/ The Organization's Full name is Fujitsu-Finance as well.



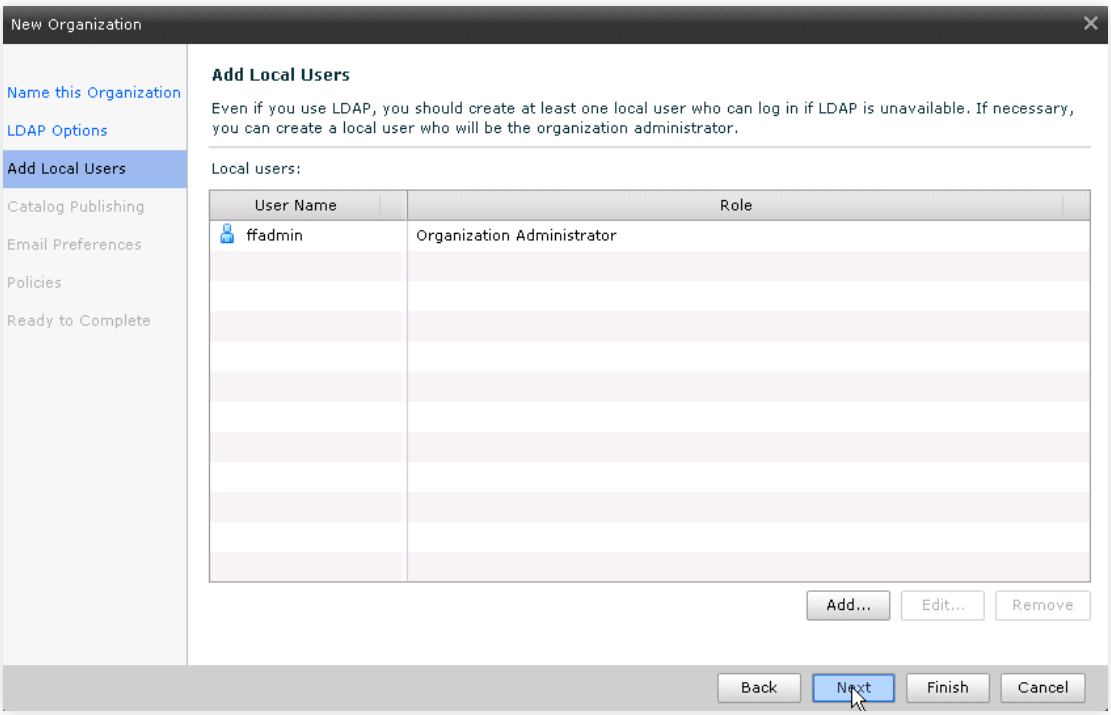
VCD can take identity and logon credentials from an existing LDAP or Active Directory source on a per Organization basis (VCD System LDAP Service). To keep the example simple LDAP services are not used.



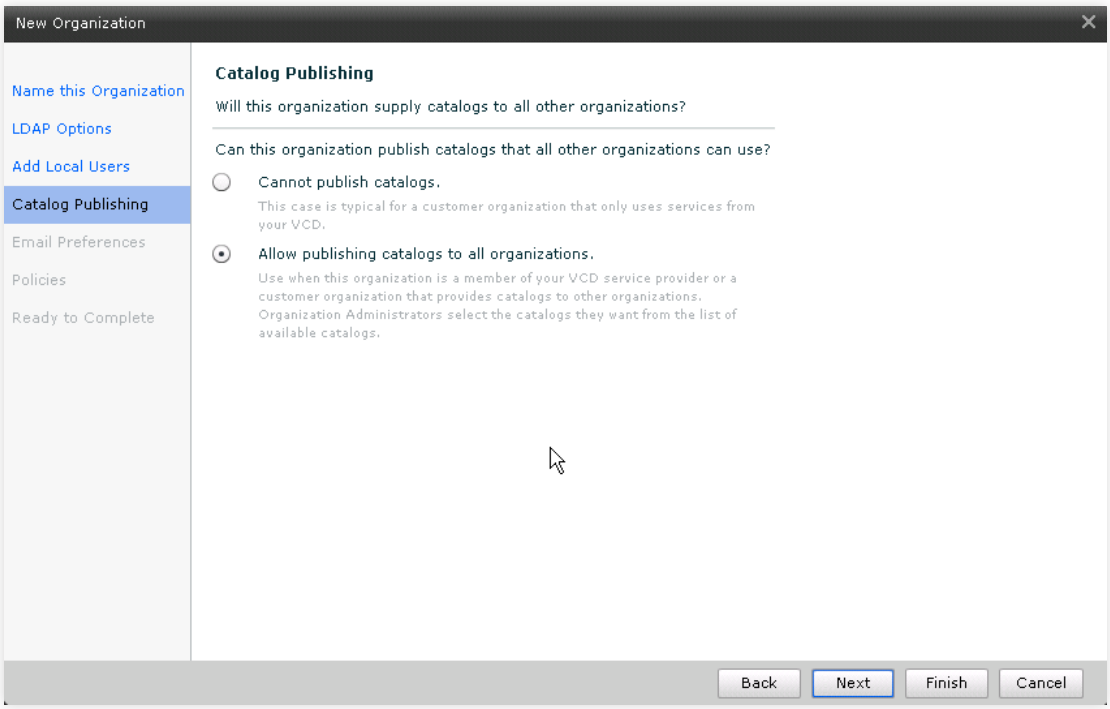
1. Add an organizational Administrator user for Fujitsu-Finance Organization.



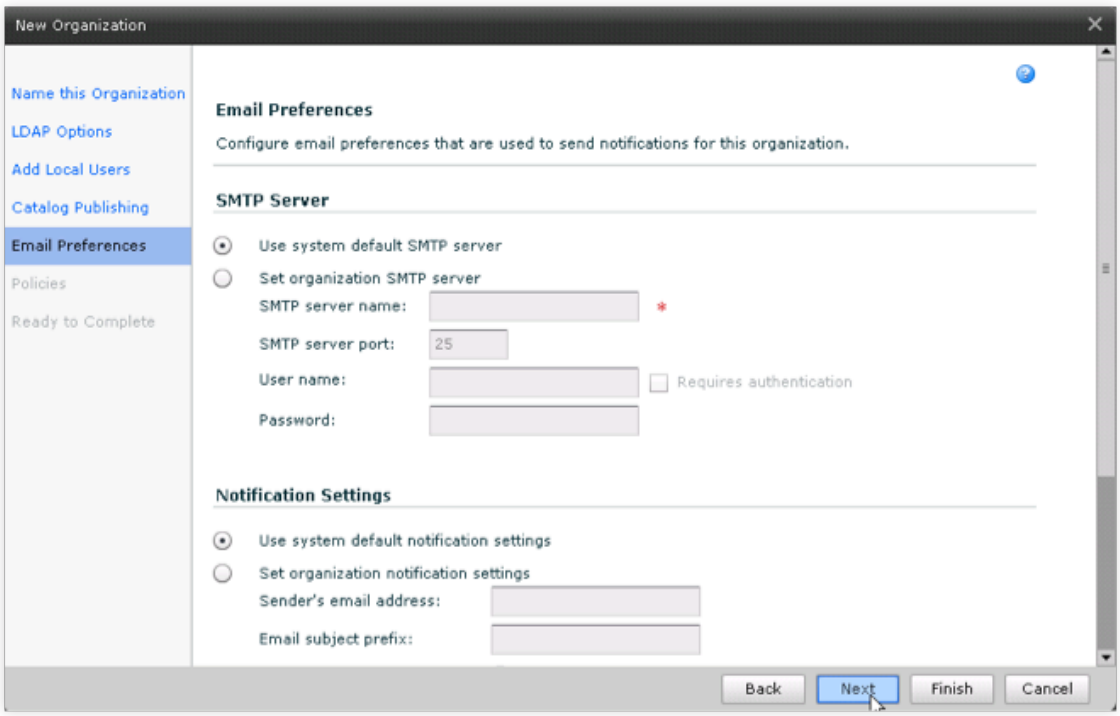
2. Done with adding administration users to the organization.



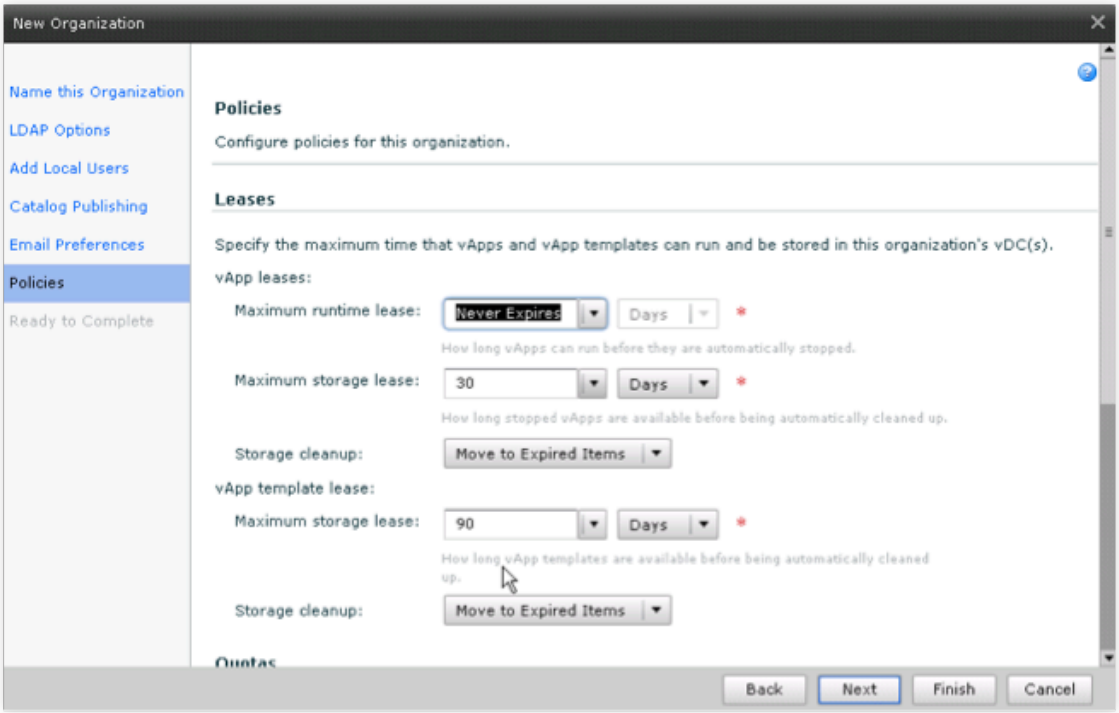
3. Allow publishing catalogs to all organizations,

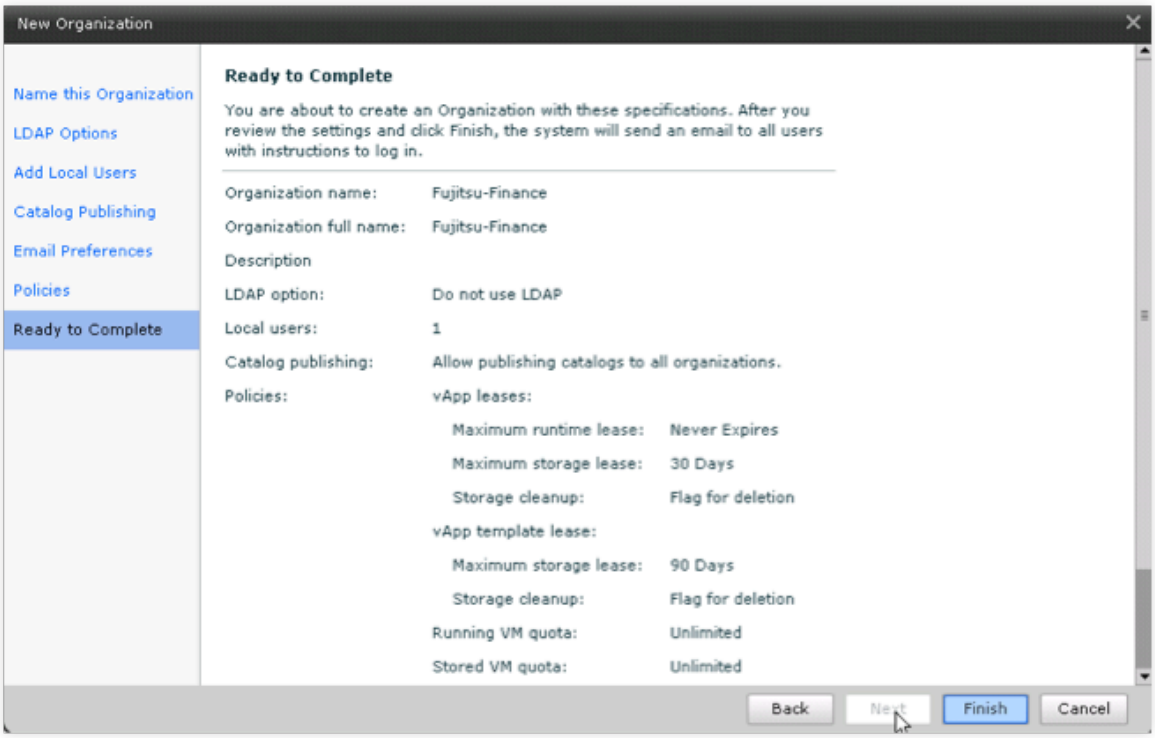


4. Stay with the defaults concerning notifications (email).

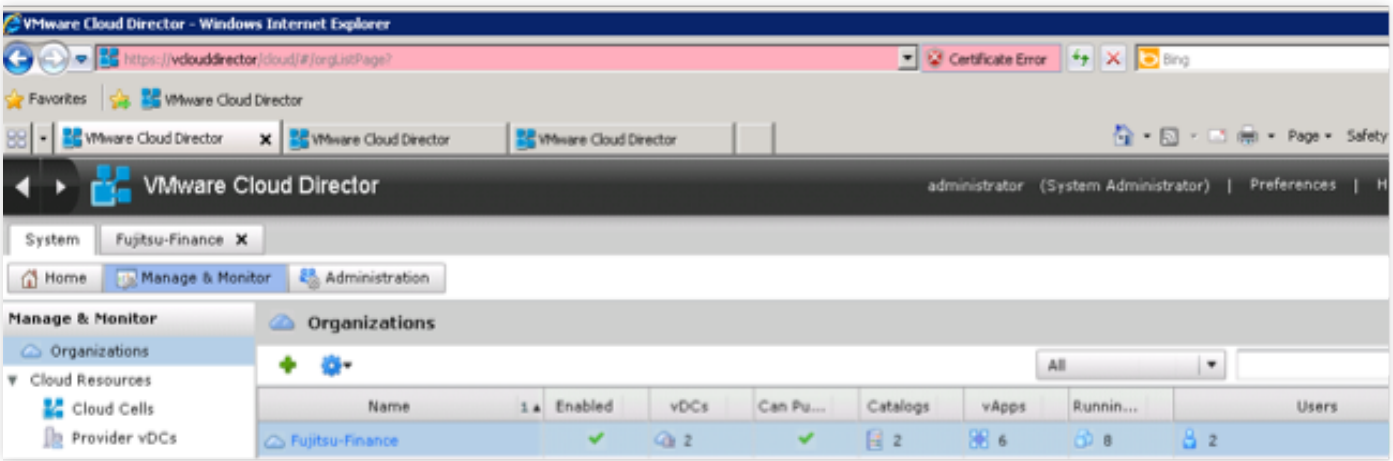


5. Stay with the defaults concerning policies.





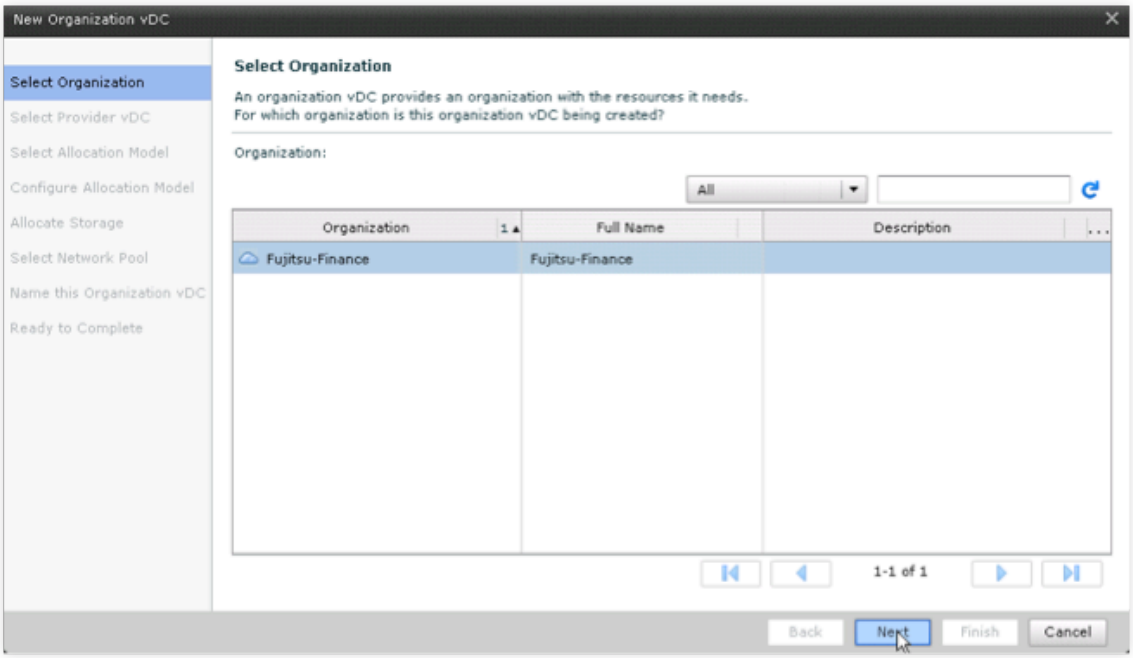
6. Finally verify the status of the newly created organization.



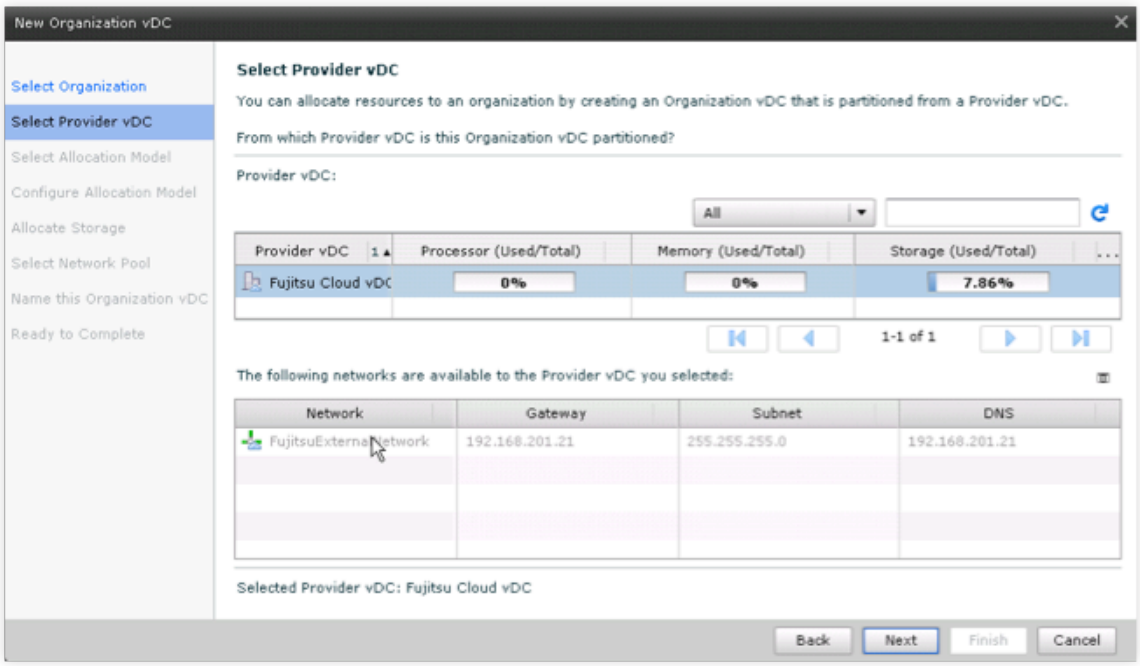
Use Case 5: Organization vDCs

The Organization for the Fujitsu-Finance division was created. You can now take some of the resources from the Fujitsu Cloud Gold Service (Provider VDC) and allocate them to the Fujitsu-Finance organization.

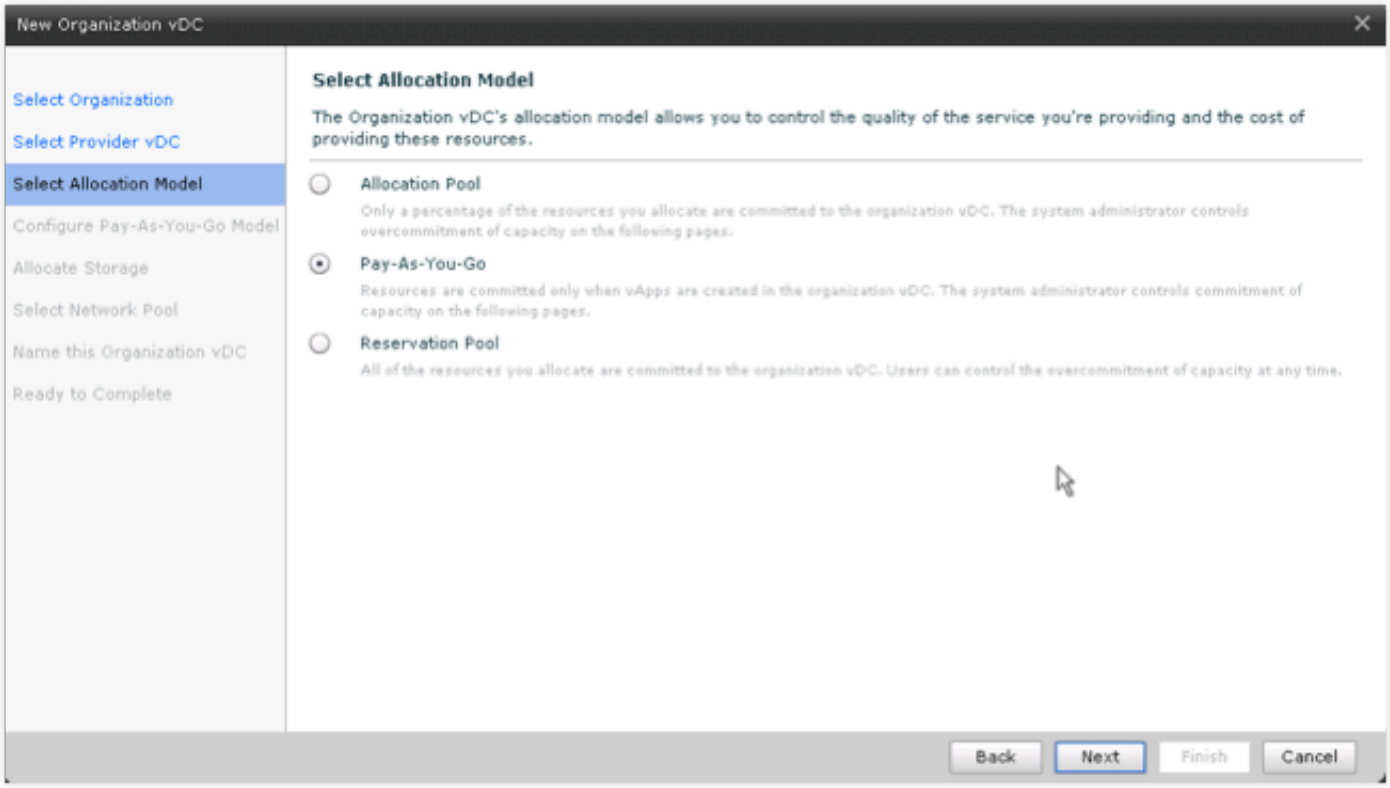
1. Select the organization.



2. Select the appropriate Provider vDC (Gold).

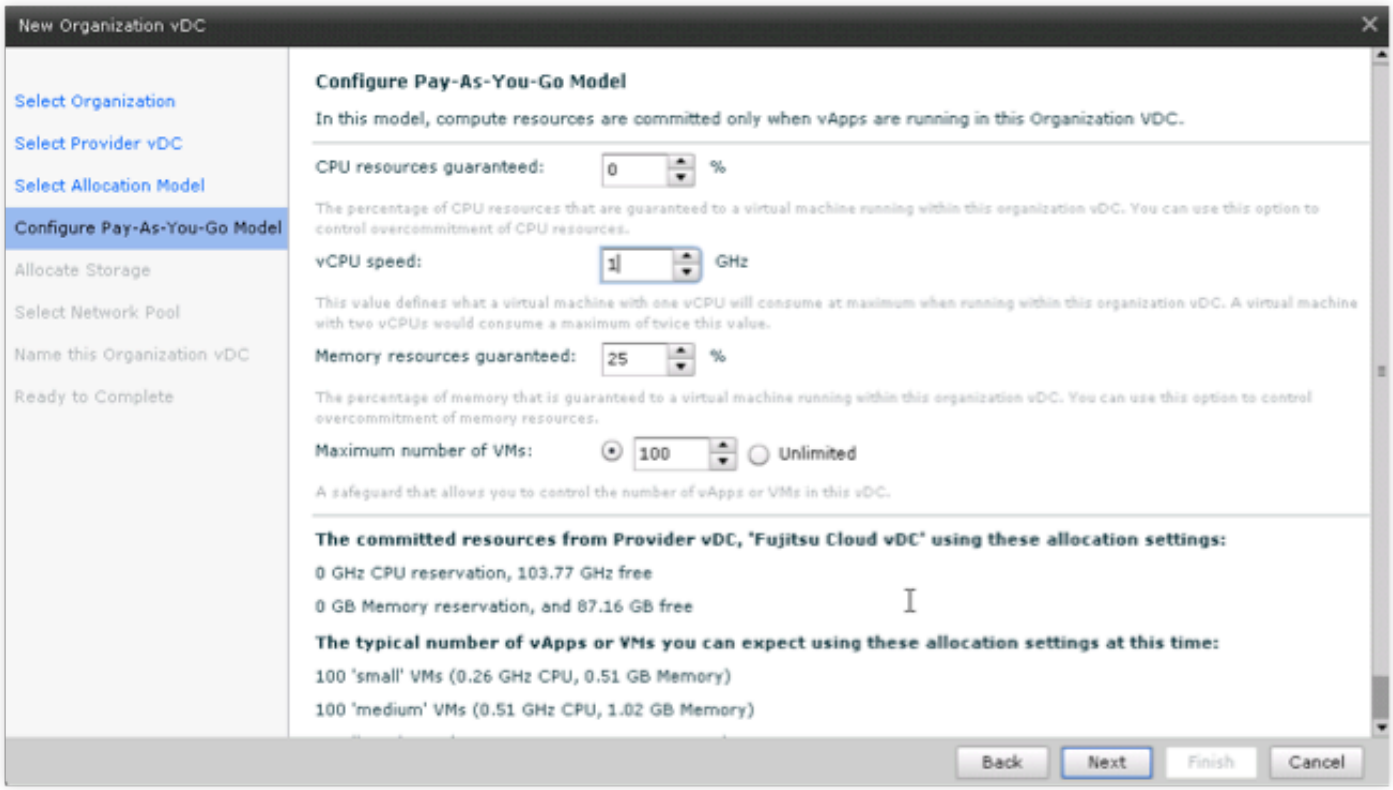


3. On the allocation model page, you can select how resources are allocated to Fujitsu-Finance. This will have an impact on how resources are allocated, reserved and charged back to the Fujitsu-Finance organization division. Select the pay-as-you-go allocation model. Resources will be added or removed dynamically on a per VM basis and Fujitsu-Finance will only be charged for the actual resources used.



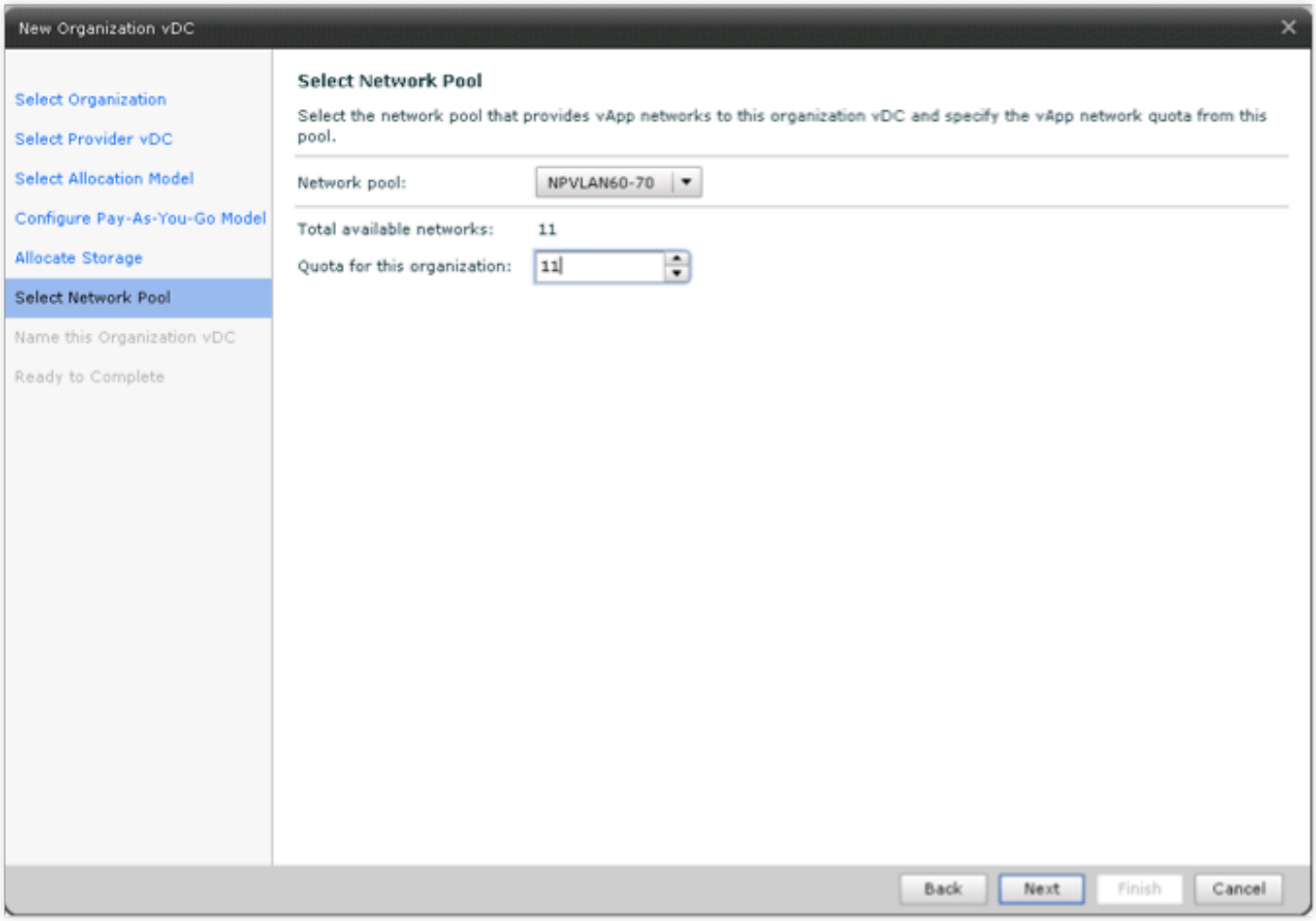
4. With the use of the Pay-As-You-Go model you can specify how much of a VM resource is reserved, whether there should be caps on CPU or Memory and how many VMs can be deploy in this Org vDC. Leave CPU resource guaranteed at 0%.

   Set the vCPU speed to 1 GHz, this sets a defined performance characteristic on any VM created in this Org vDC, so ensuring a consistent performance profile, regardless of the Cloud's load. Set memory resources guaranteed to 25 %, this ensures we have at least a 1/4th of the VM's memory allocation guaranteed to it. The VM can burst into the additional capacity up to 100 % of its defined memory allocation, but the additional 75 % of memory is not guaranteed to be there when the VM needs it. Finally set the Maximum number of VM's to 100 to limit the number of VM's that can be deployed in this Org vDC.

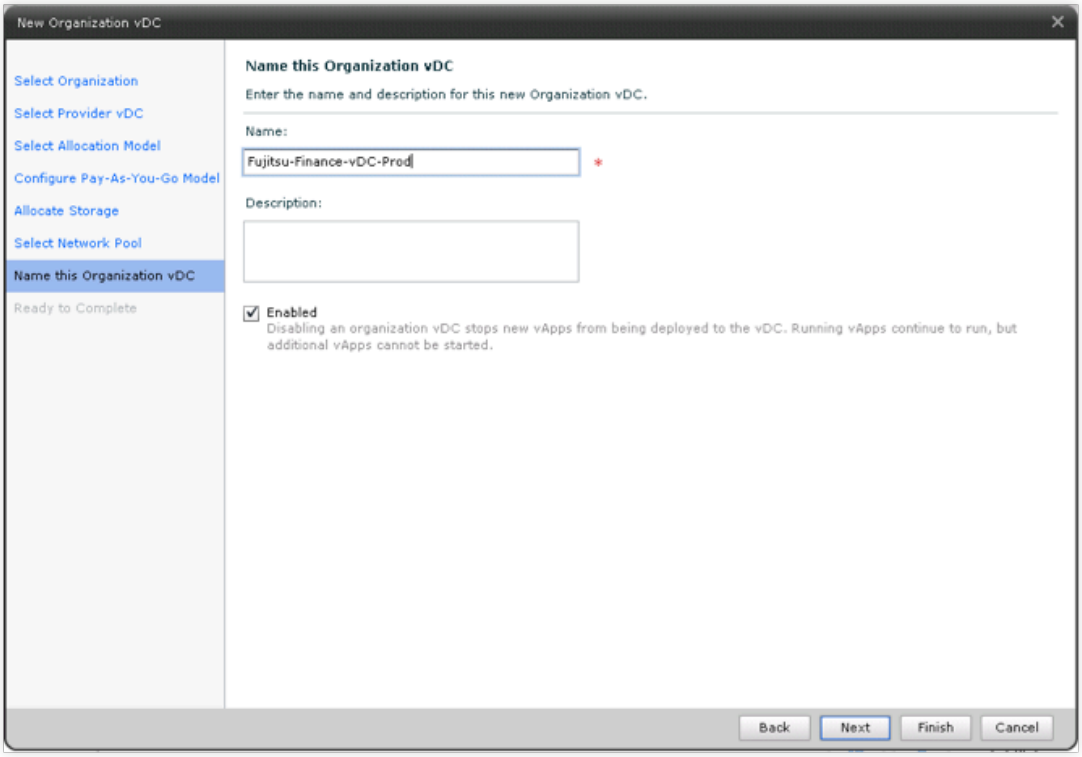


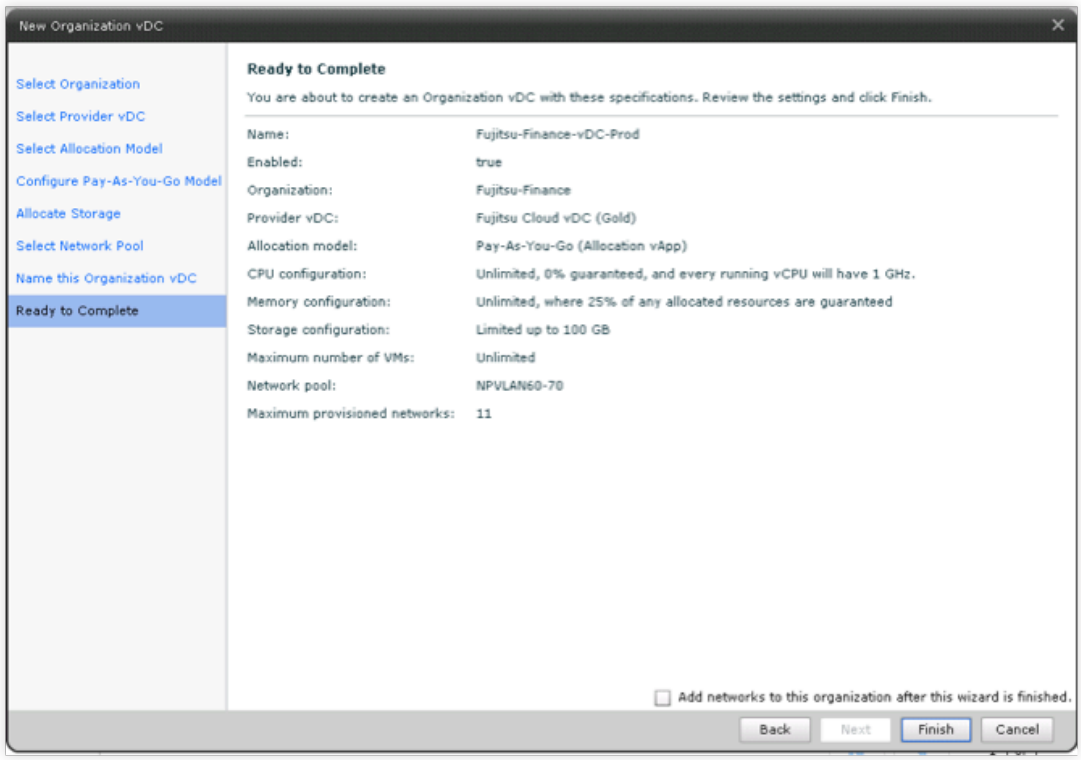
5. Storage allocation is simple, please limit the amount of storage and and enable "thin provisioned" virtual disks.

6. On the Select Network Pool screen, select the Network Pool created earlier during VLAN Network Pool creation and change the quota for this organization to 11 and press TAB to clear the warning message. This means that the Fujitsu-Finance department has a self-service capability to create 11 Layer 2 isolated networks based on VLANs without having to raise a change request.

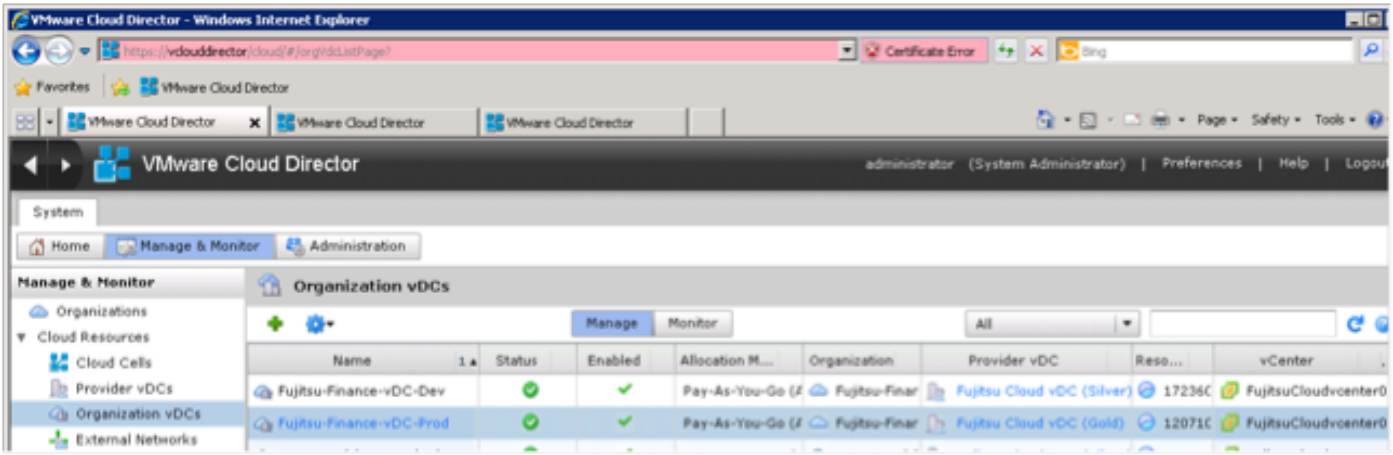


7. Define a meaningful name.





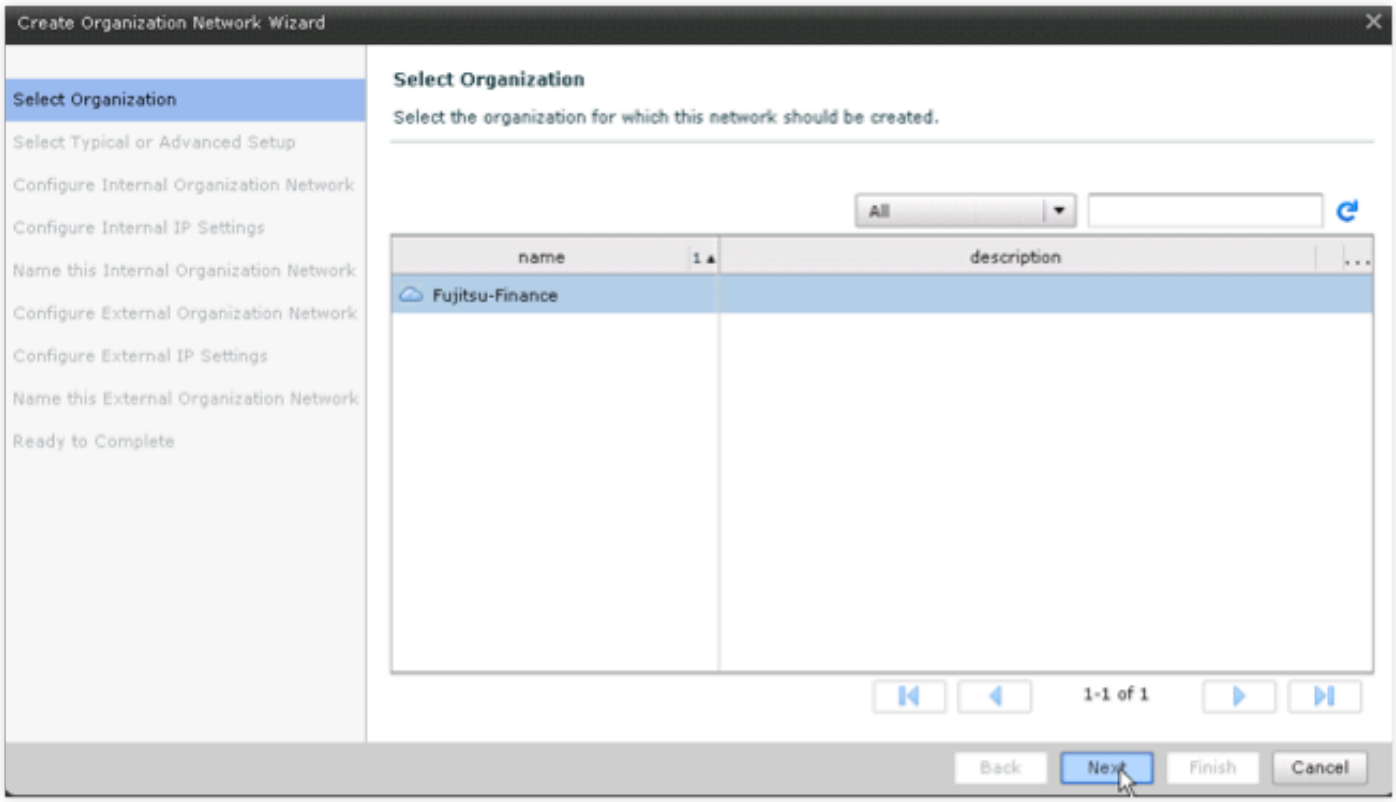
8. Finally verify the status of the newly created organization vDC



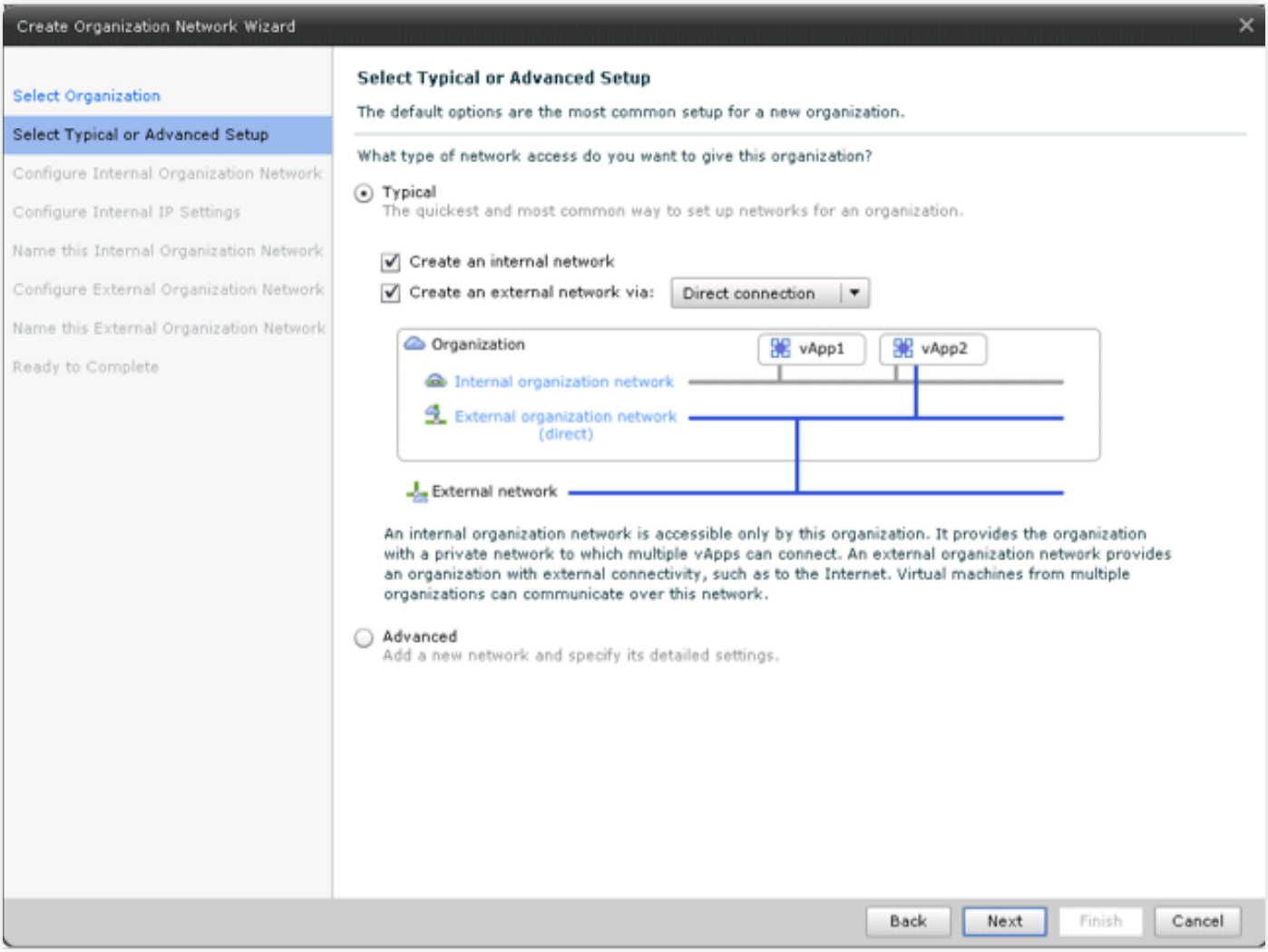
Use Case 6: Organizational Networks

The next task is to give the Fujitsu-Finance organization's VMs the ability to communicate with the outside world. Adding the External Network created earlier to the Fujitsu-Finance organization does this.

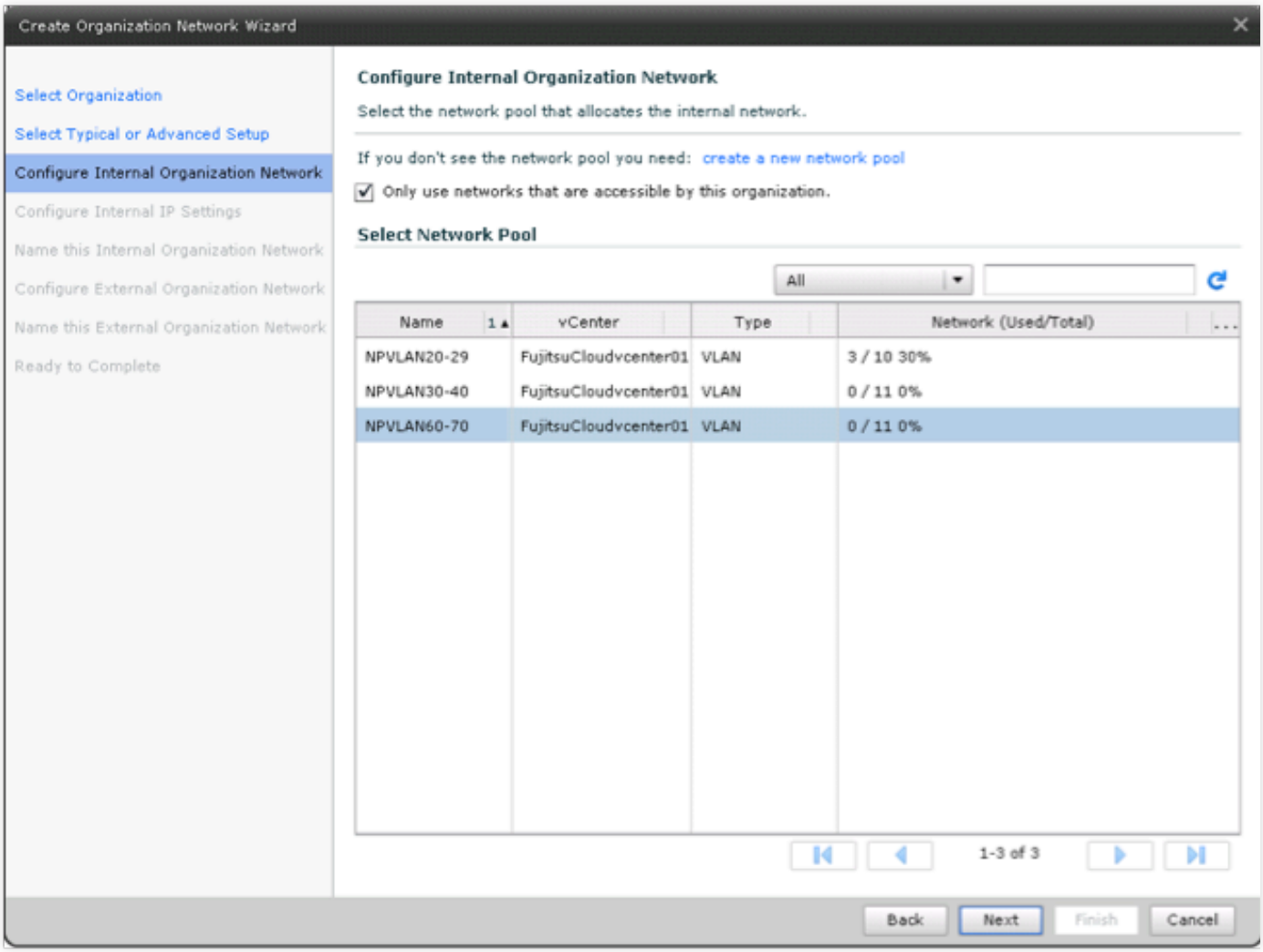
1. Decide how VMs within the organization will connect to the physical network. VCD helpfully provides a diagram on the Create Organization Network dialog to show how vApps will connect to the External Network. The default shows how VCD will create internal organization networks, external organization networks and how they each can connect to an external physical network. An internal organization network is accessible only by the Finance organization. It provides the Finance organization with a private network to which multiple vApps can connect to.



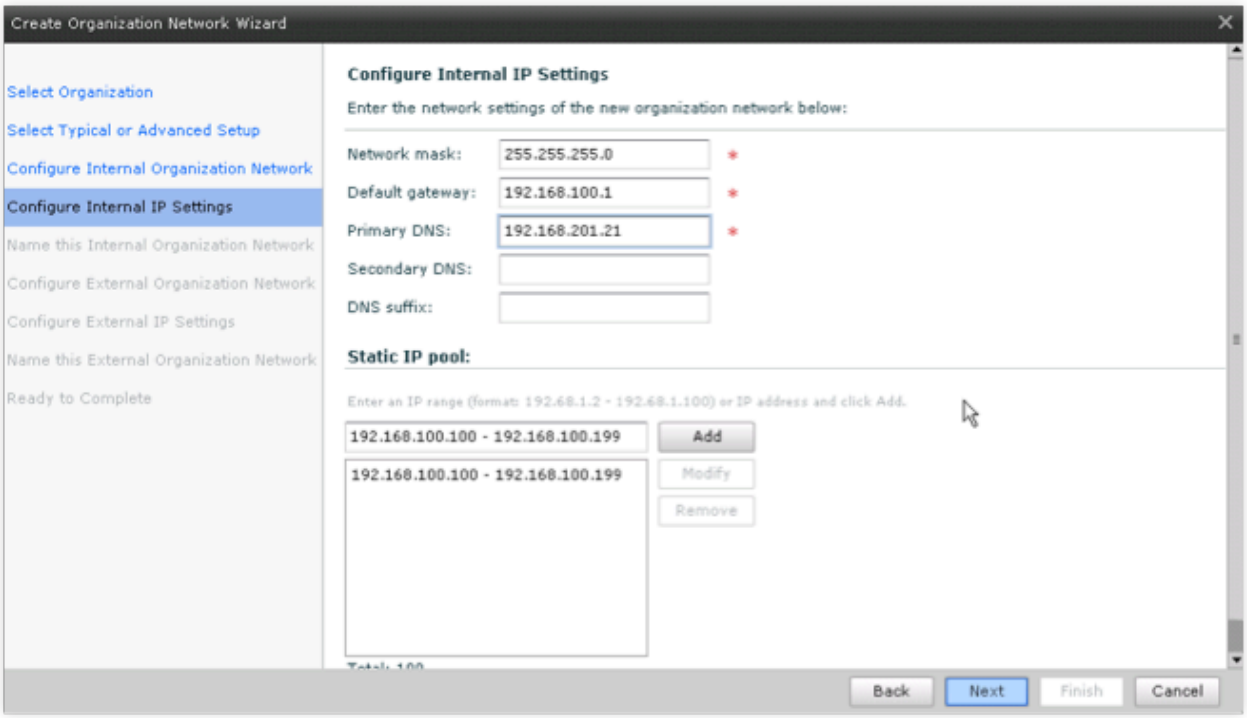
2. An external organization network provides Fujitsu-Finance with external connectivity, such as to the Internet or a physical internal network within Fujitsu's Data Center. Virtual machines from multiple organizations or business units can communicate over this network.



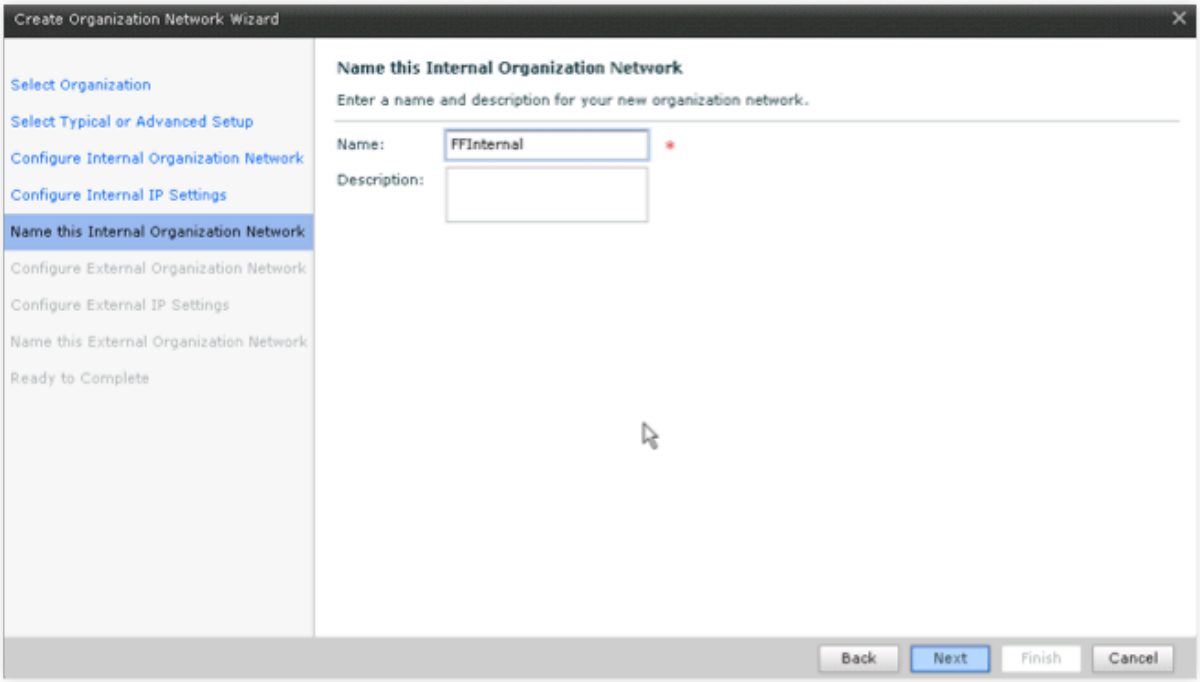
3. Set up the Internal Organization Network, think of this as a private network that allows multiple applications to communicate with each other securely. You can use a Network Pool to create this network. Remember, the Network Pool is to be backed by a pool of VLANs, so one of these VLANs will now be allocated automatically to host this Internal Network for the Fujitsu-Finance Organization.



4. The Network Spec for this Internal Network needs to be defined to create a Static IP Pool which is used to allocate IPs to VM vNICs that need to connect to the Internal Network.

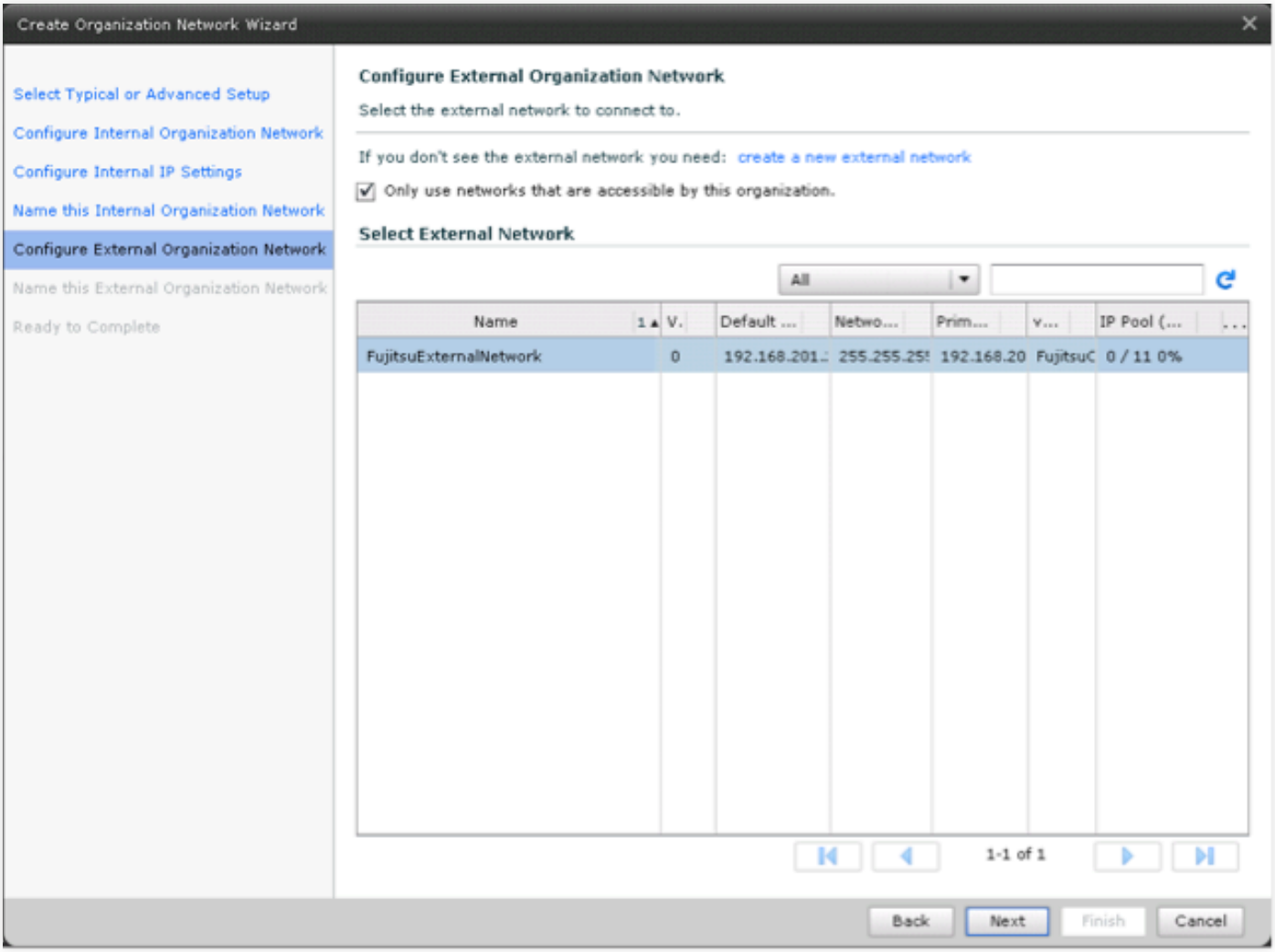


5. Use a meaningful name for the internal organization network.

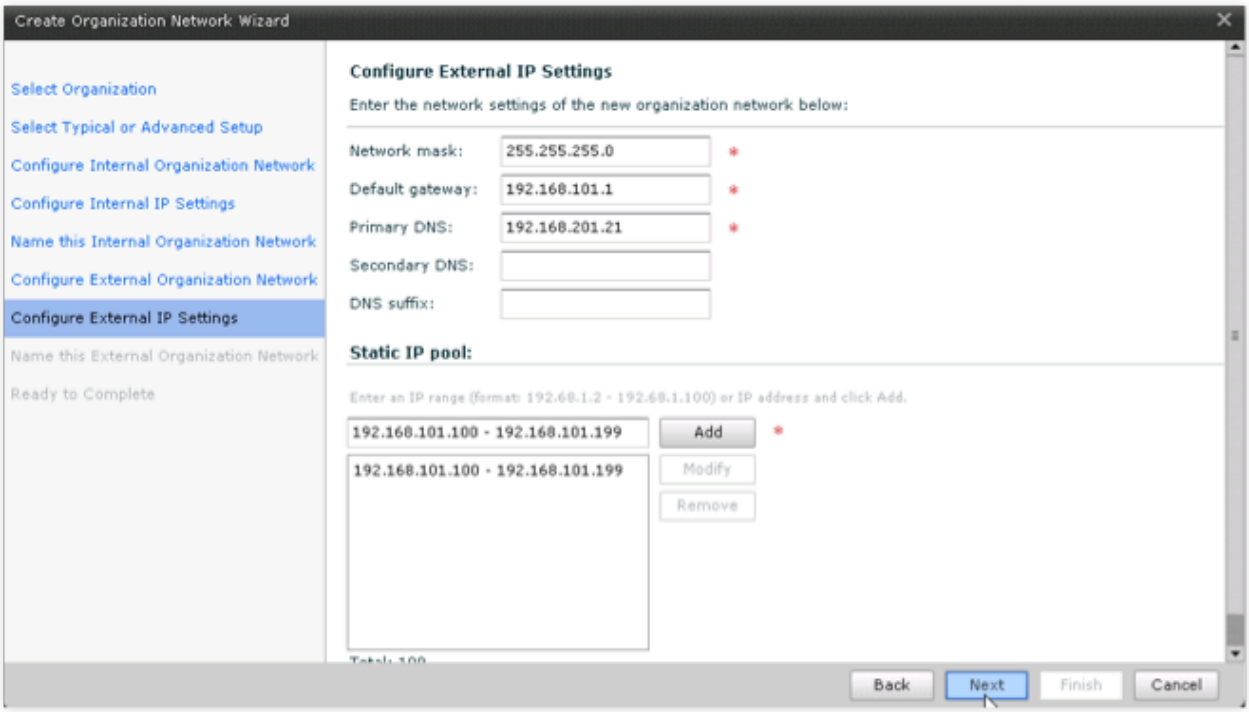


6. Now configure the External Organization Network, this Network is still a virtual network within vSphere, but allows the VM's to have either direct or NAT routed access to the physical network.

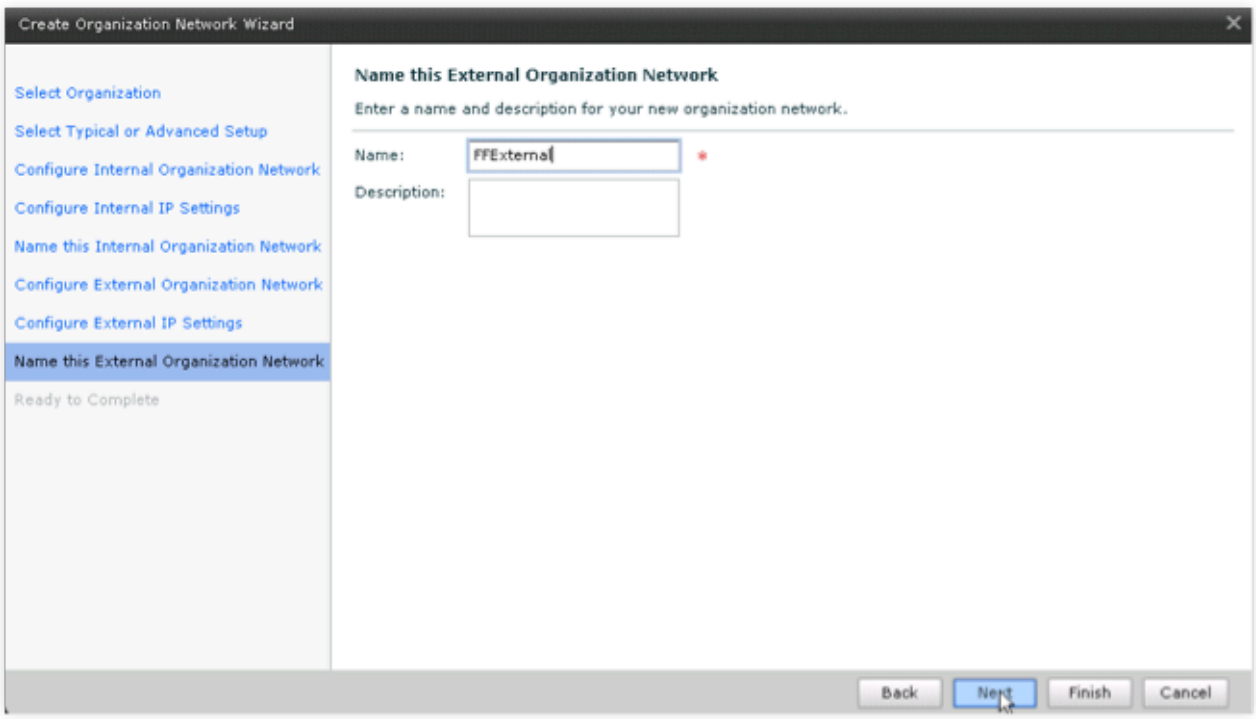
Select the External Physical Network you want to connect to.



7. Define external IP settings for this external organization network

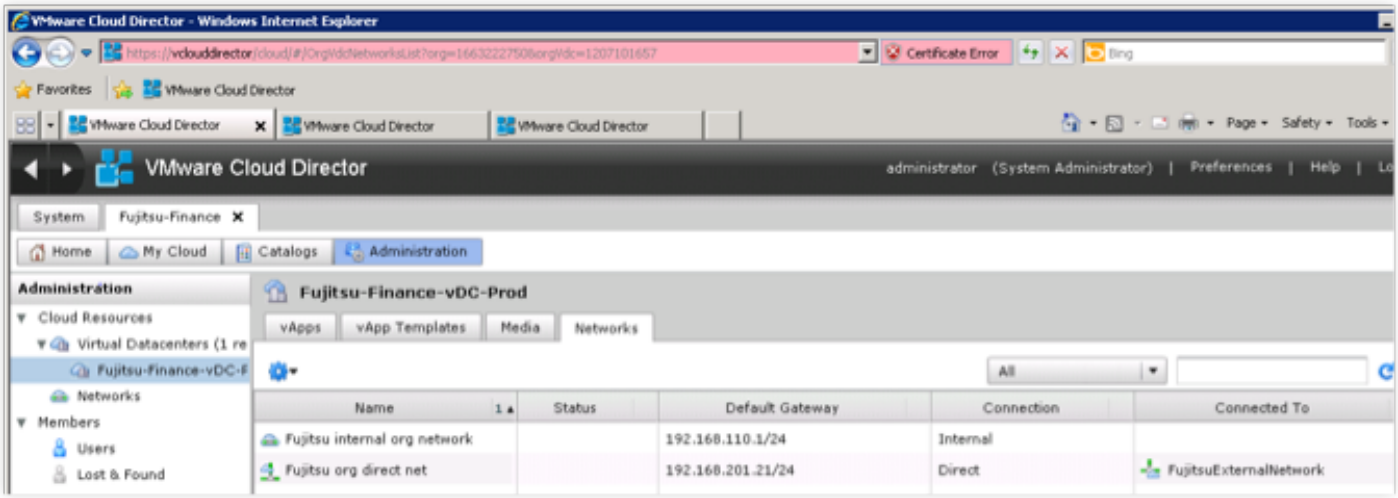


8. Use a meaningful name for the external organization network



Two networks are created for the Fujitsu-Finance Organization. An Internal Network where Finance applications can talk securely to each other and an External Network direct routed to the physical world so Fujitsu-Finance applications can interact with other business units, as well as access the external network.

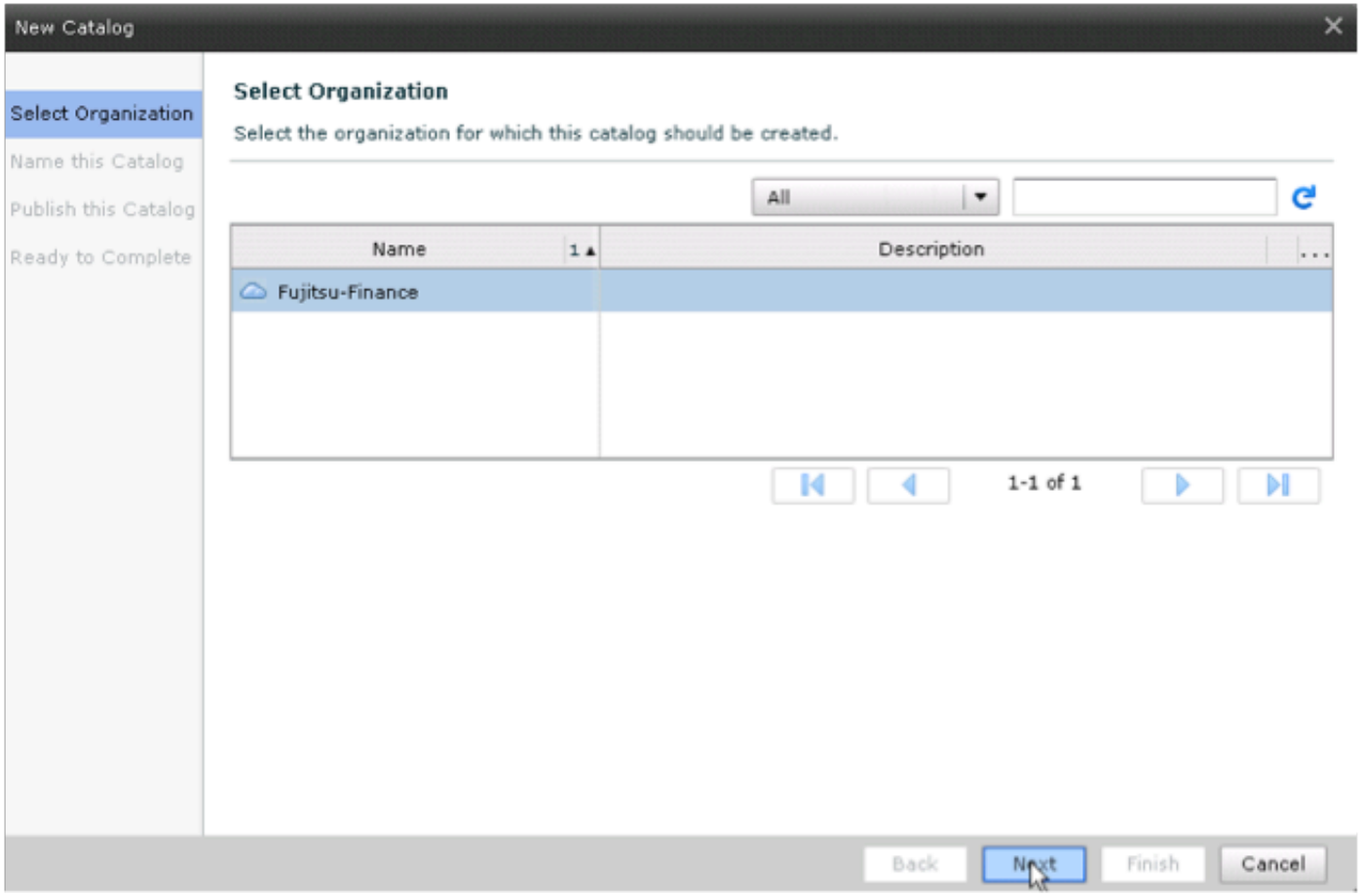
9. Finally verify the status of the newly networks for this vDC.



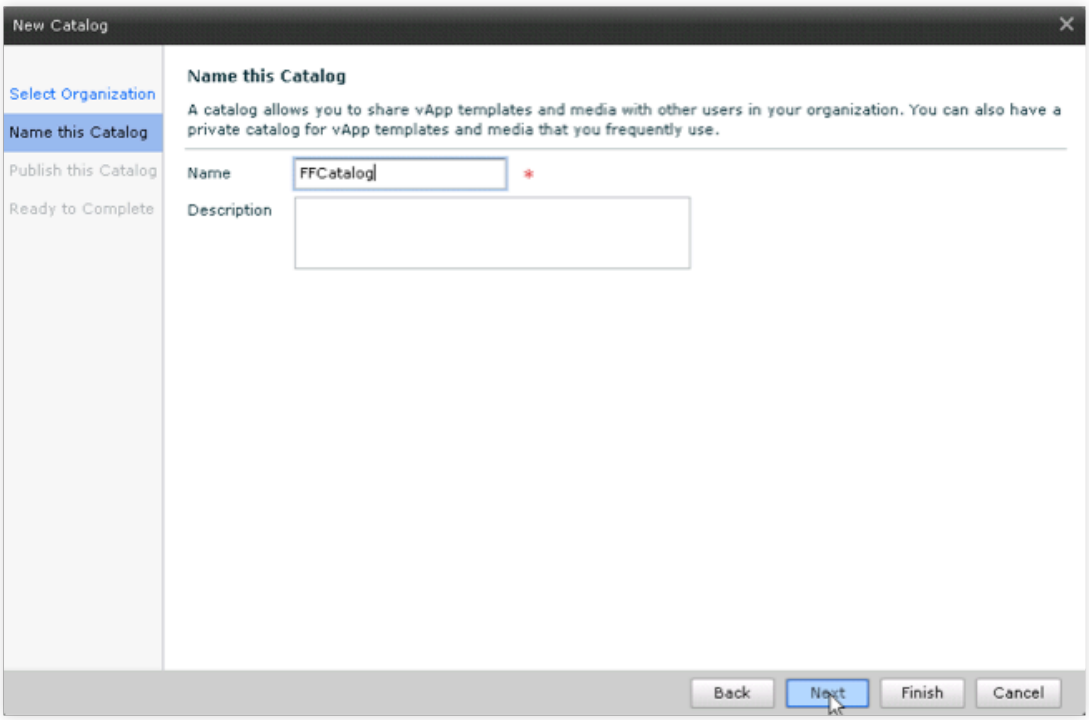
Use Case 7: Catalogs

Catalogs are used to offer vApps and media to end users for self-service. IT can build standardized offerings of VM and application environments and upload them to the catalog. Catalogs are created by organization administrators or catalog authors, and can be shared or published. When a catalog is shared, it can be setup to be accessible by one or more members of an organization. When a catalog is published, it can be accessed by other authorized organizations in the private cloud.

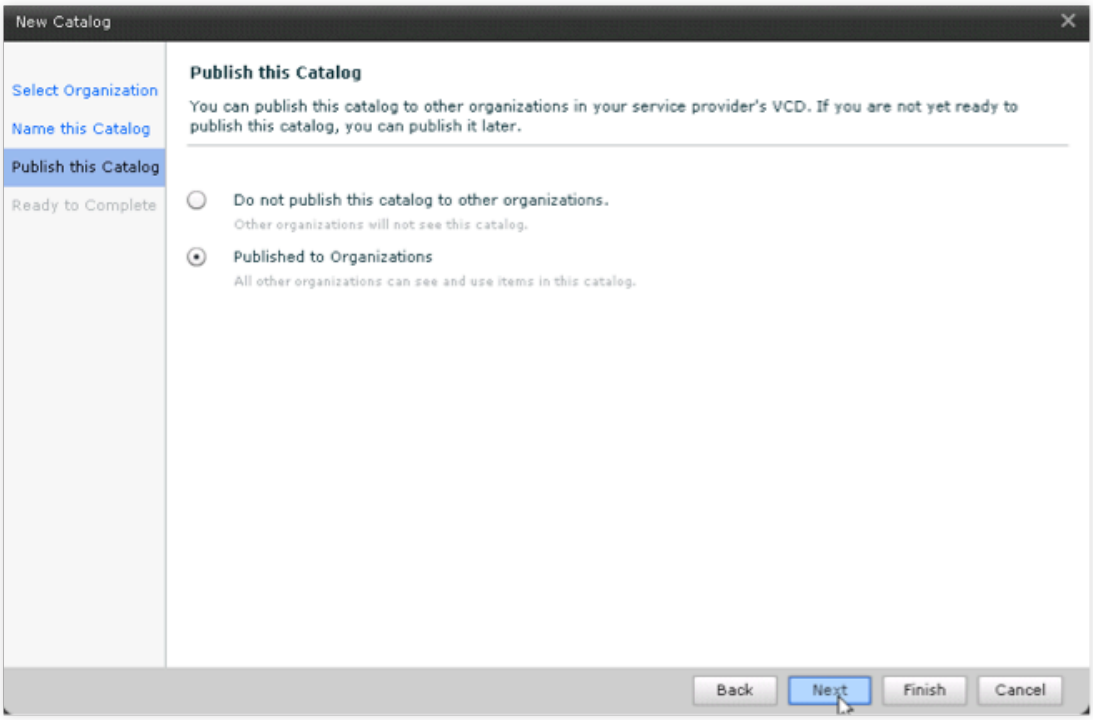
1. Select an organization.

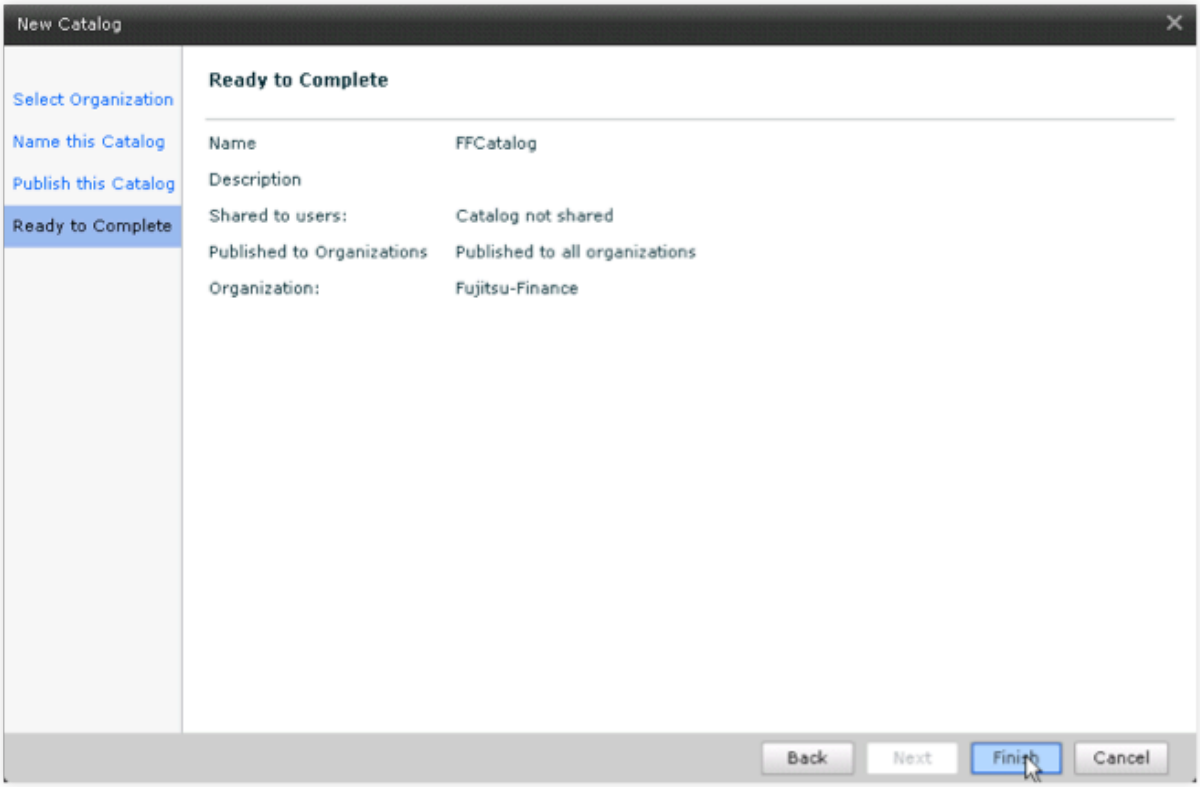


2. Use a meaningful name.

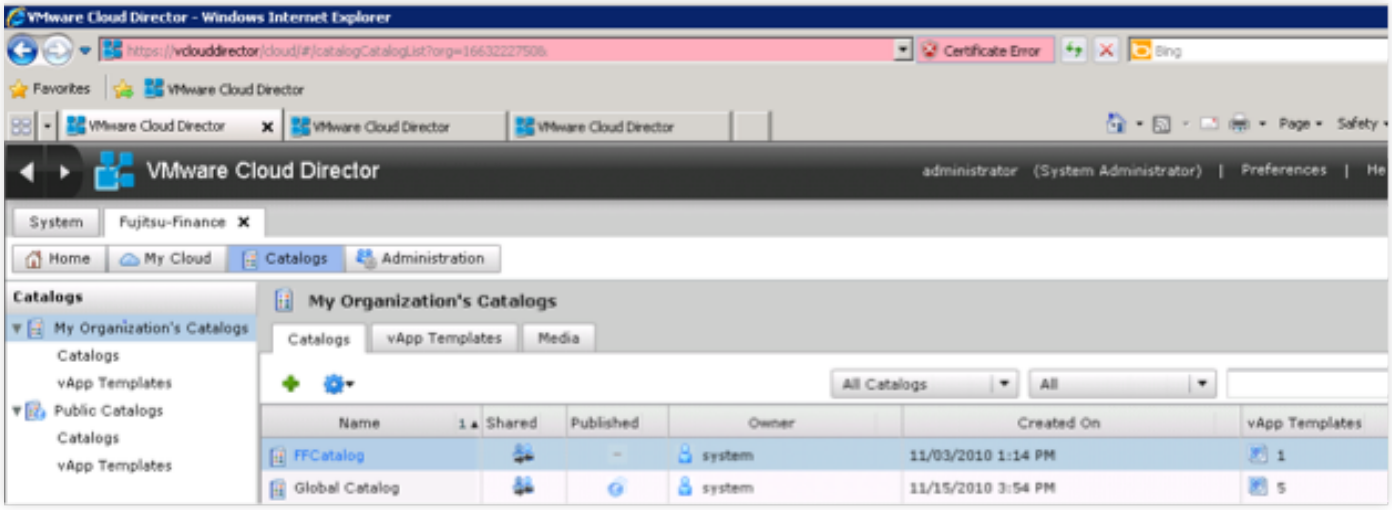


3. Allow to publish this catalog to other organizations.





4. Verify the successful deployed catalog.

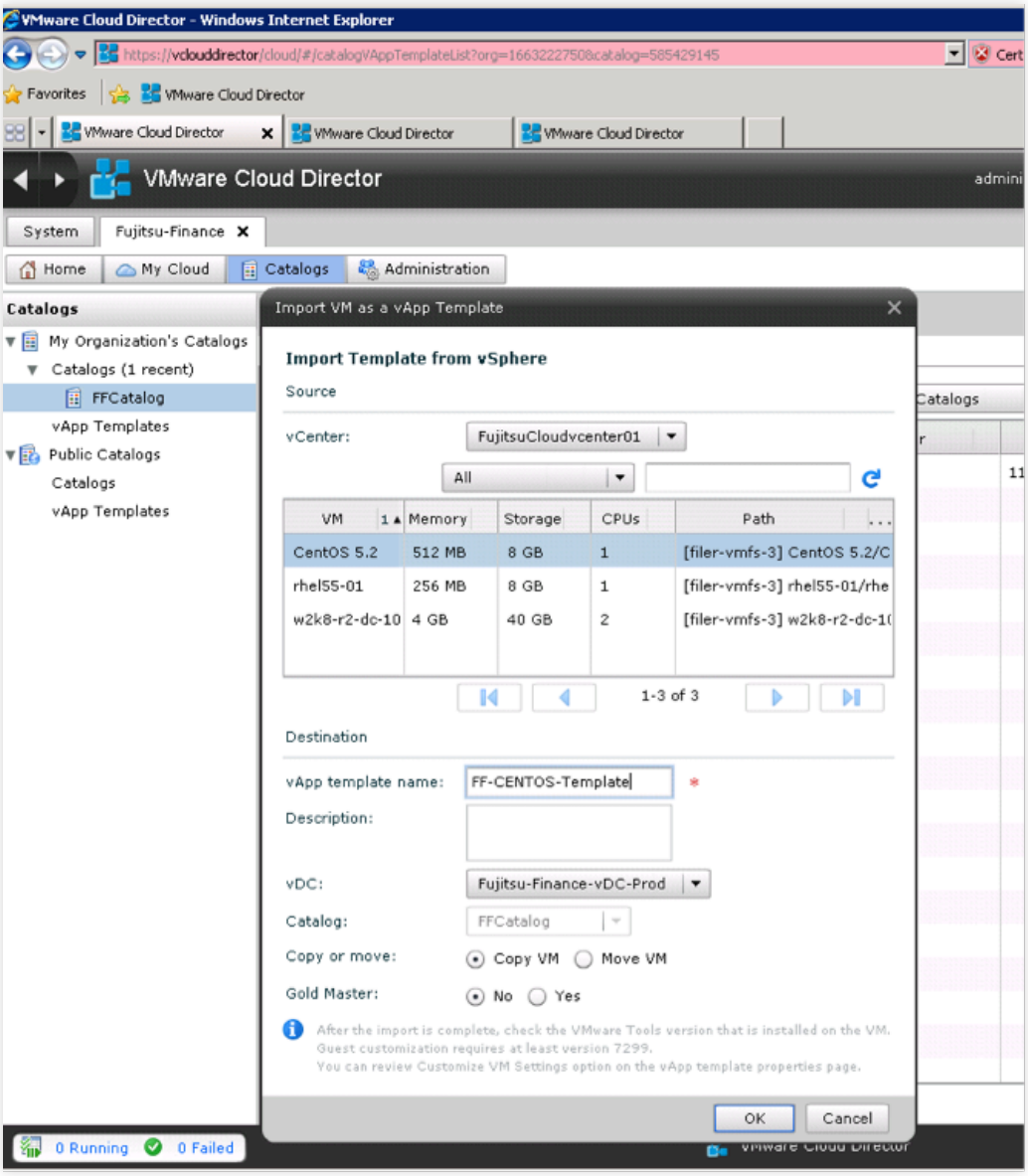


Use Case 8: vApp Template creation

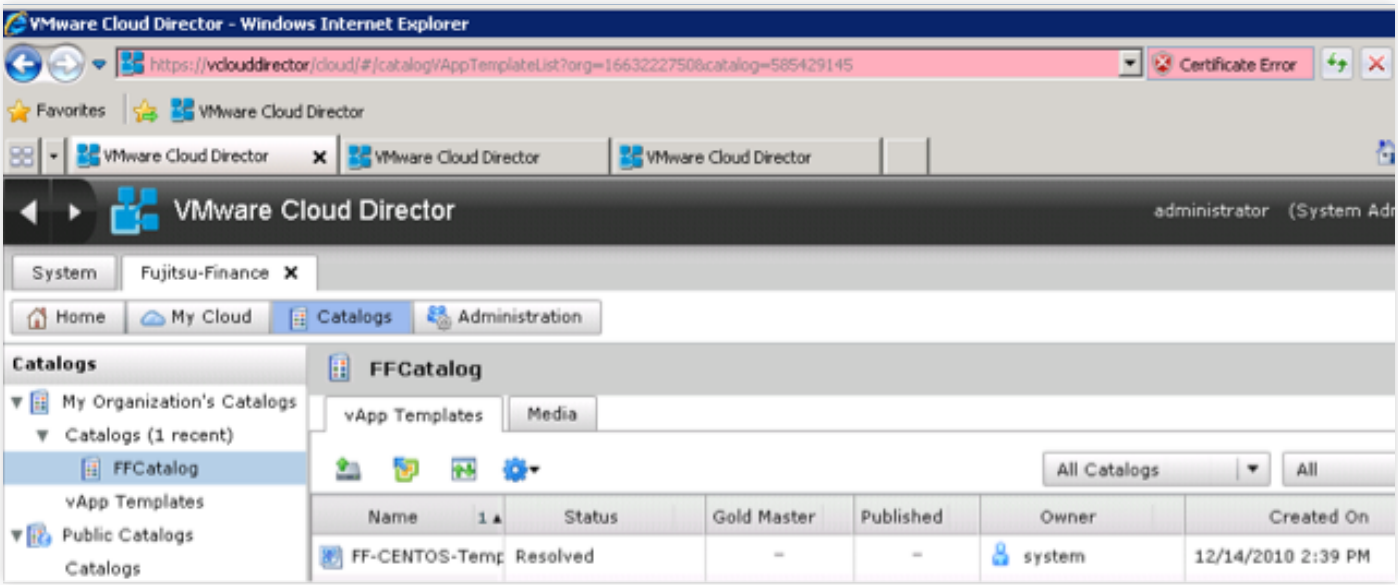
vApps can be created in organization catalogs using three methods:

1. A cloud administrator can copy VMs and templates from the underlying VMware vSphere infrastructure.
2. An organization administrator can copy a vApp in OVF format from local disk to the private cloud.
3. An organization administrator, catalog author, or vApp author can create vApps from scratch in the private cloud. They can create VMs and install the guest operating system (GOS) and application. Only organization administrators and catalog authors can add items to the catalog.

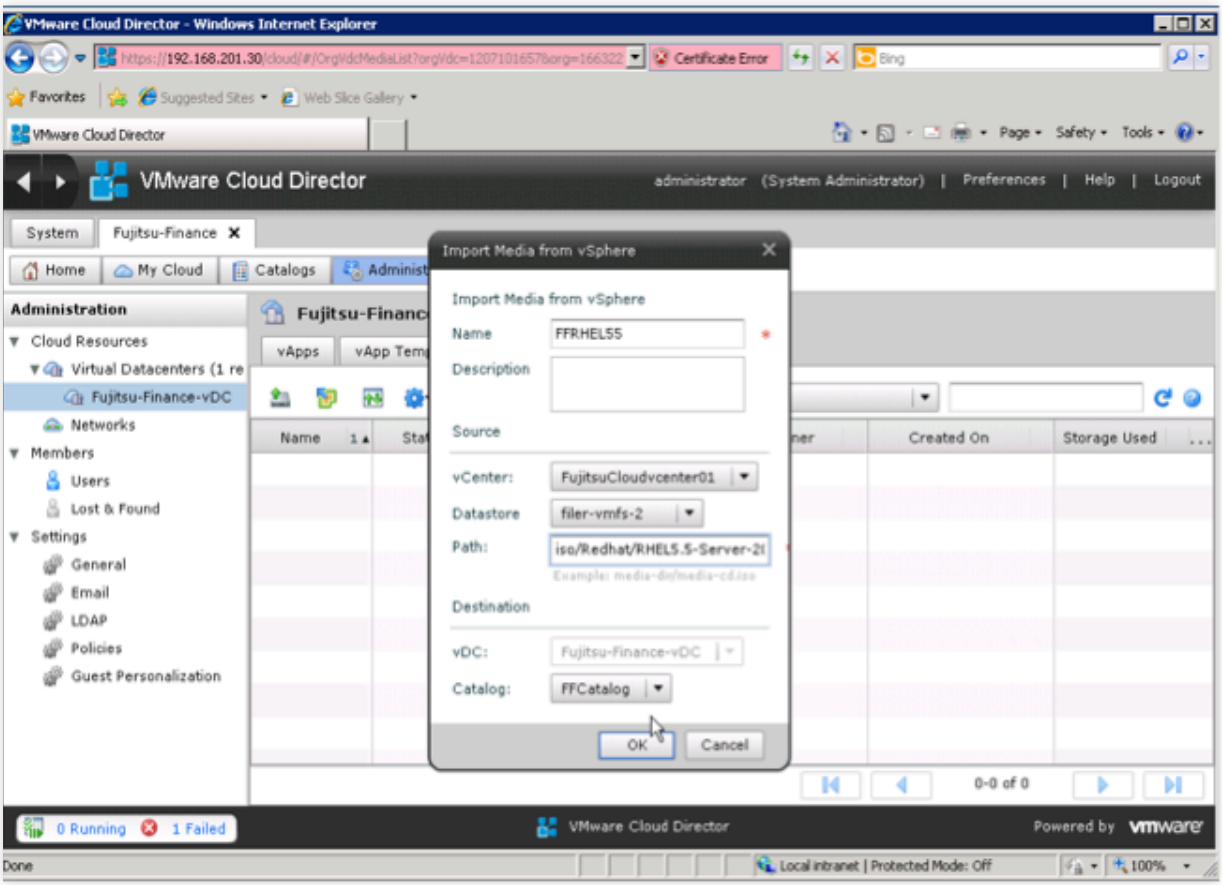
You can import VMs (Sample: CentOS 5.2) from VMware vSphere. This assumes that you have prepared a template available in your VMware vSphere environment to import into VMware vCloud Director.



Verify the successful deployment of the template.



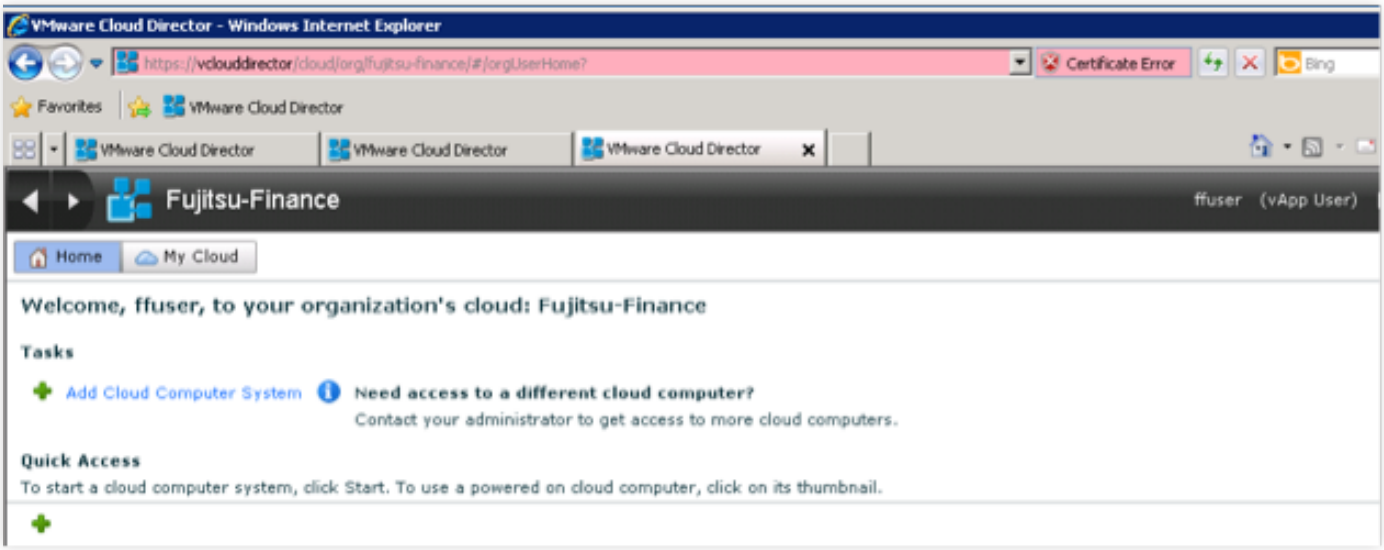
Optional: Import media from vSphere



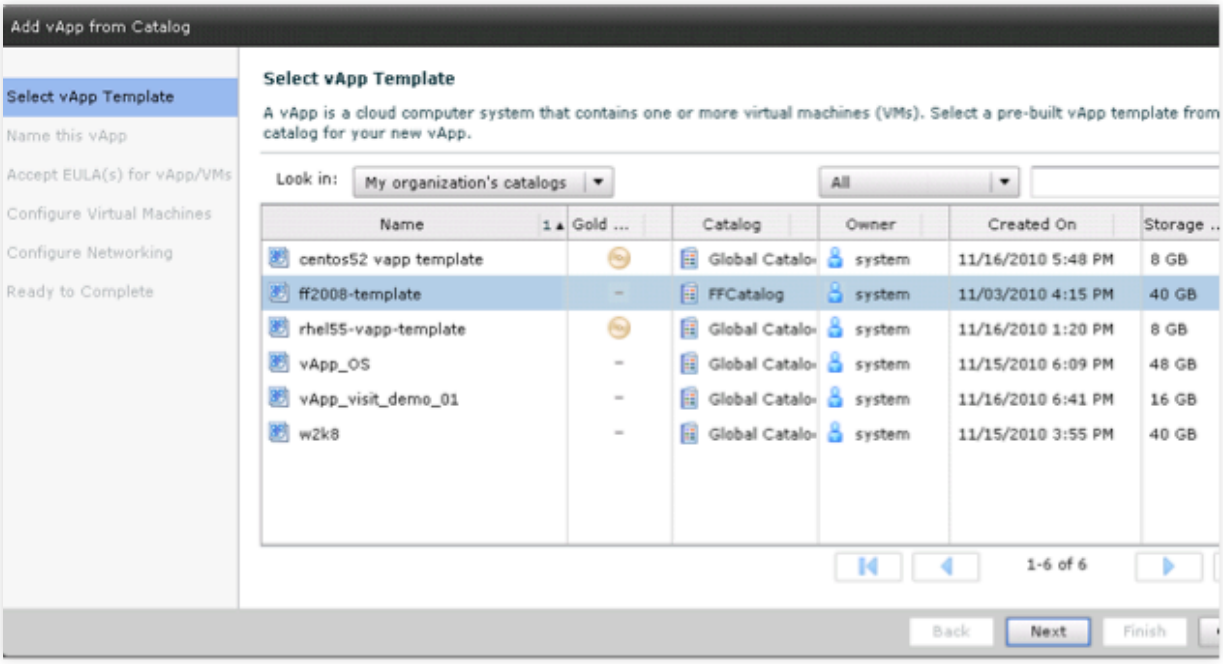
Use Case 9: Use Infrastructure as a Service (IAAS)

In this use case please login as a user to the Fujitsu-Finance organization, browse the catalog, adding vApp template from the catalog to the user's cloud (self-service), and connect the vApp to an Fujitsu external network.

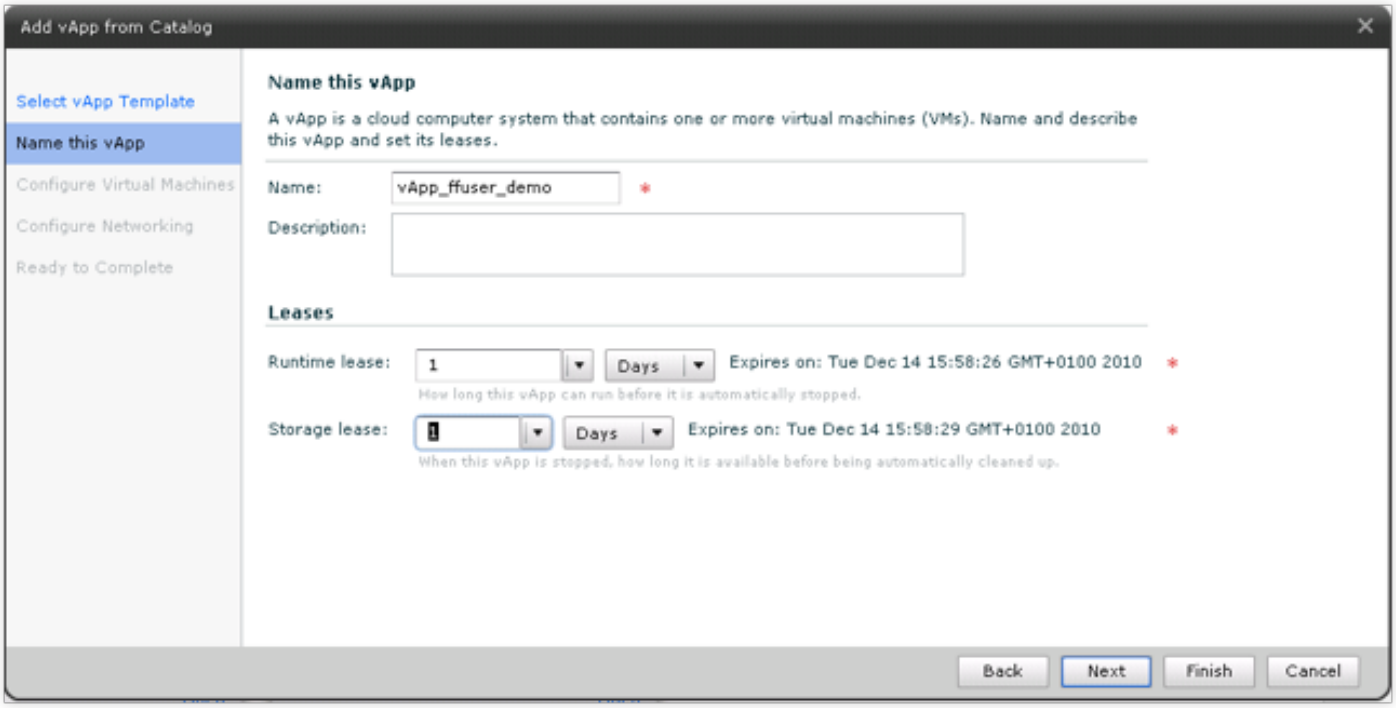
1. Logon to the home URL of the Fujitsu-Finance organization in order to "Add Cloud Computer System."



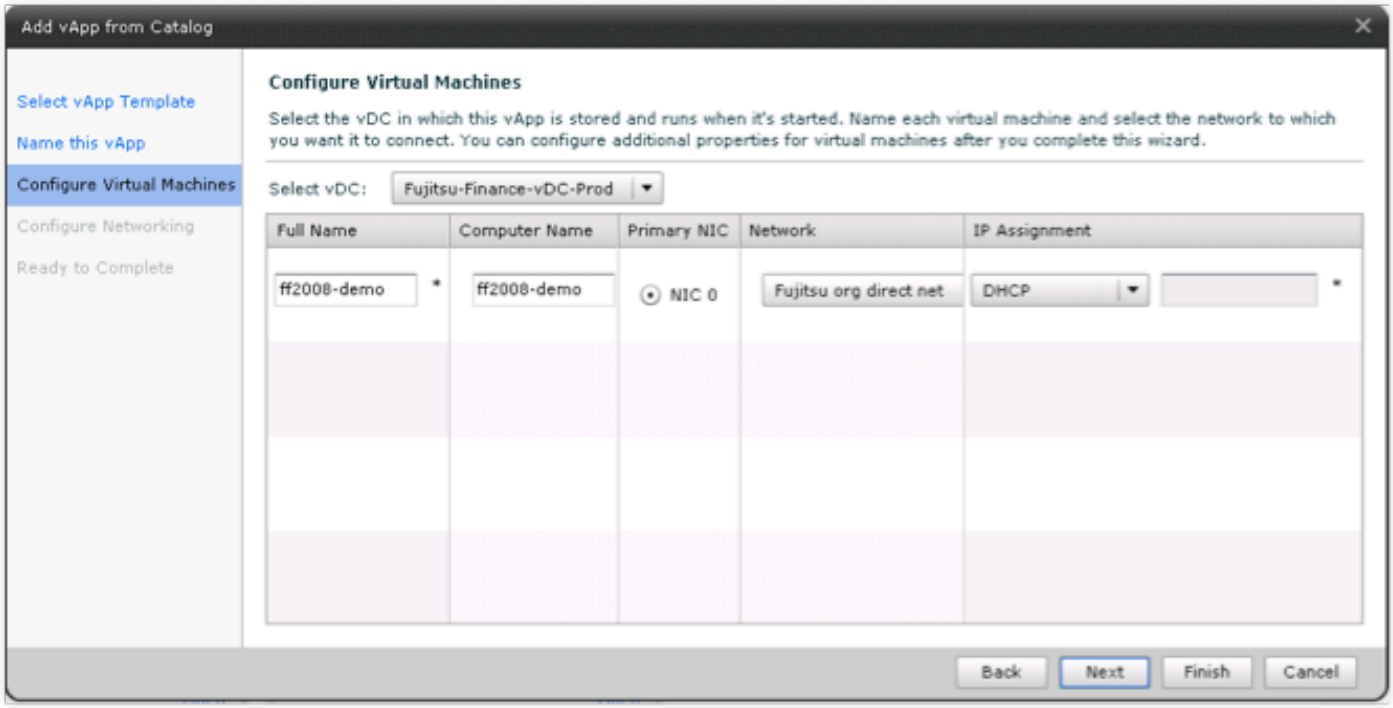
2. Select an appropriate template.



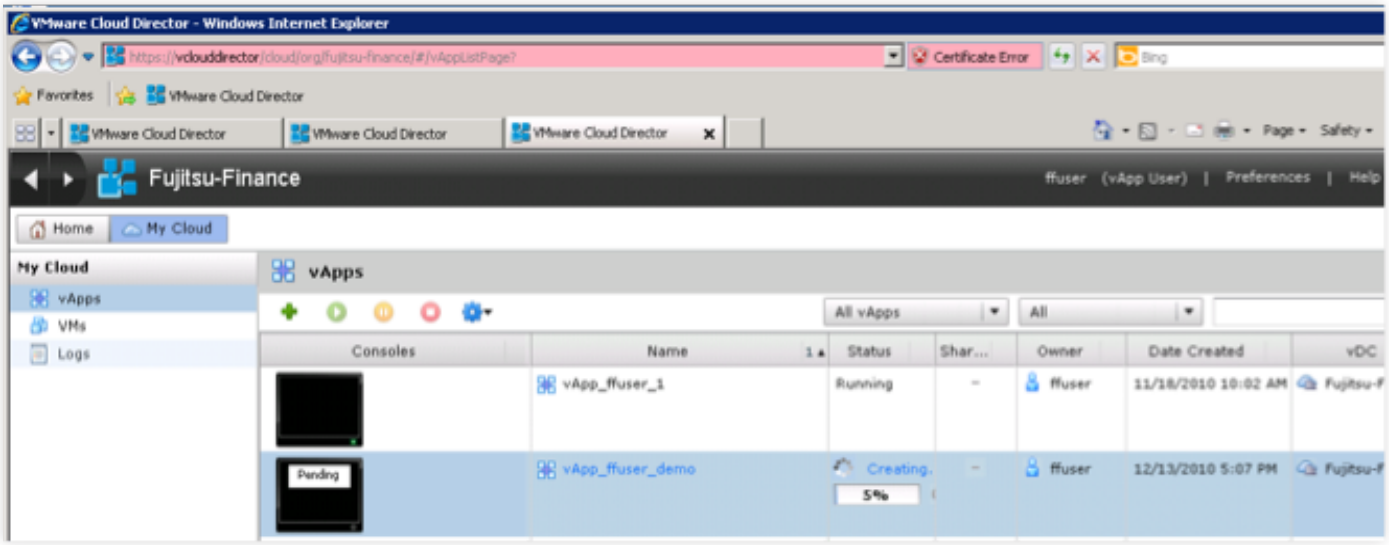
3. A wizard kicks off to guide you through the deployment process. Define a meaningful name and provide valid leases.



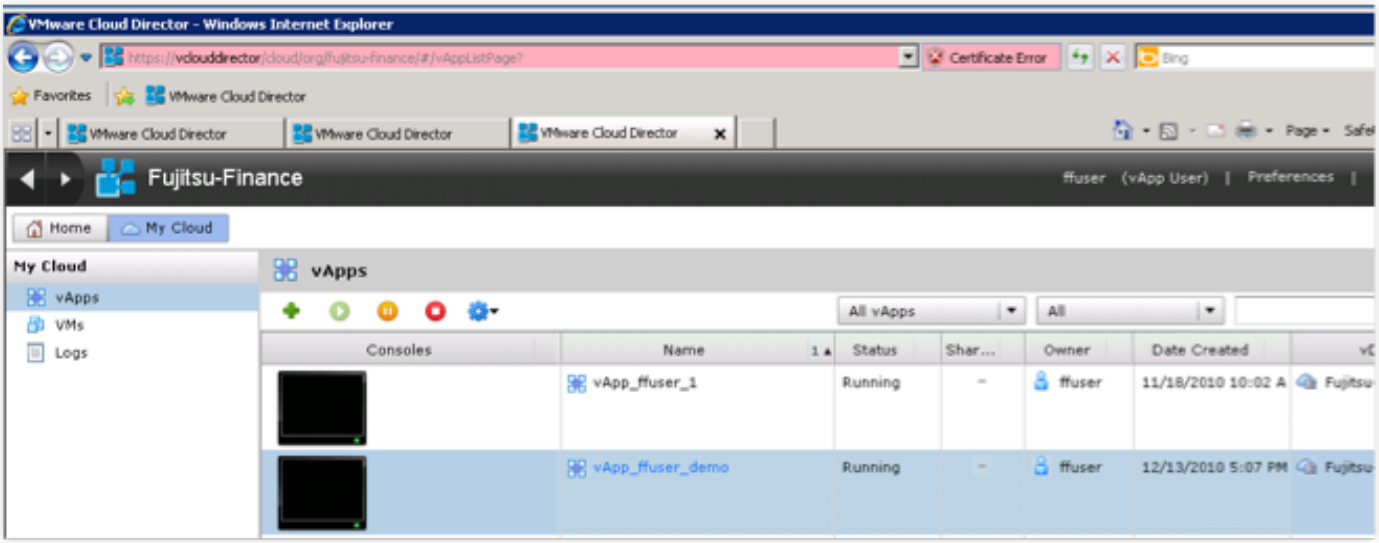
4. Configure the VMs itself and provide valid network settings.



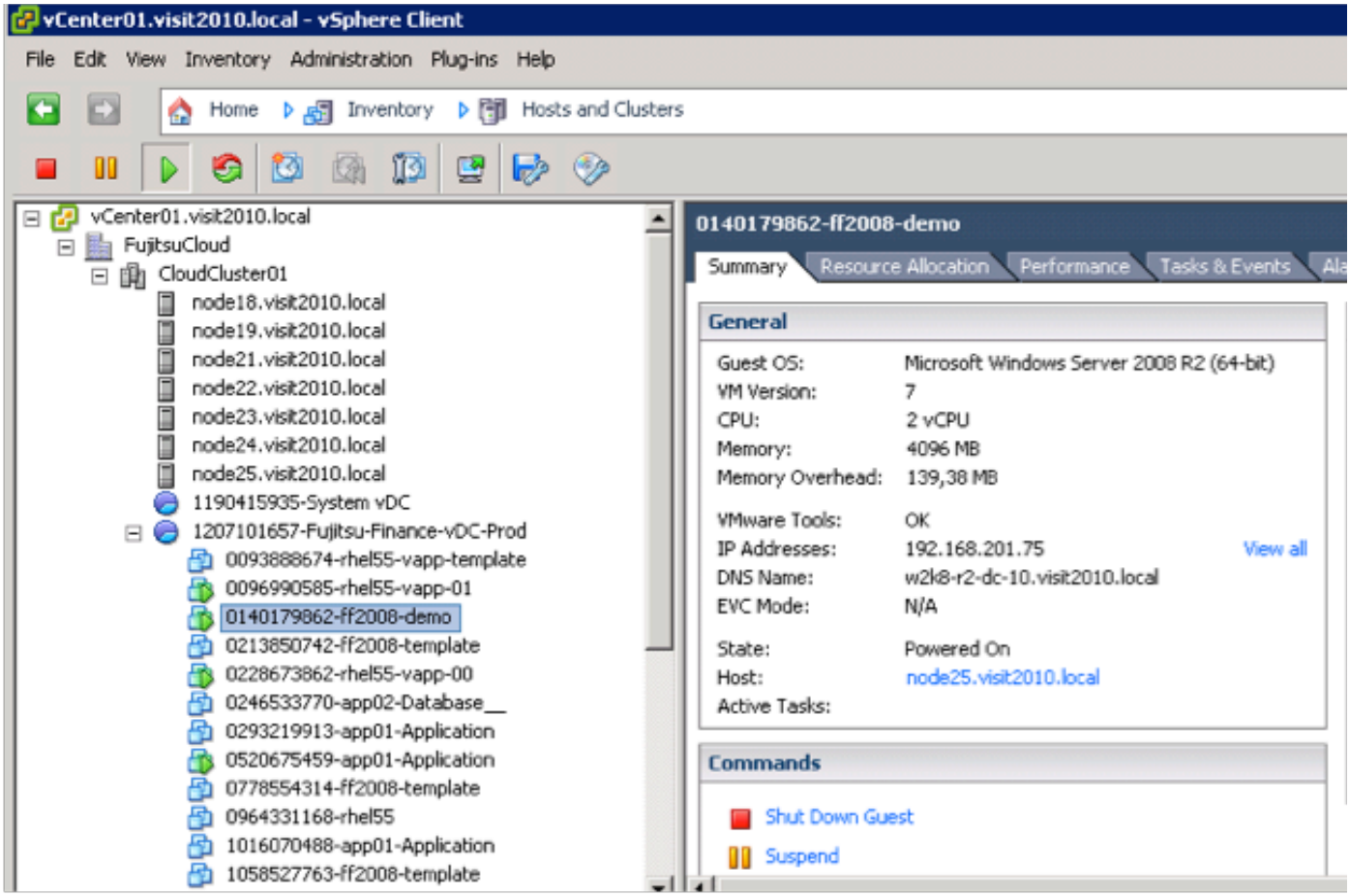
5. Wait until the deployment process finishes.



6. Now you can power on the vApp and click the thumbnail, if you like to get access to the console.



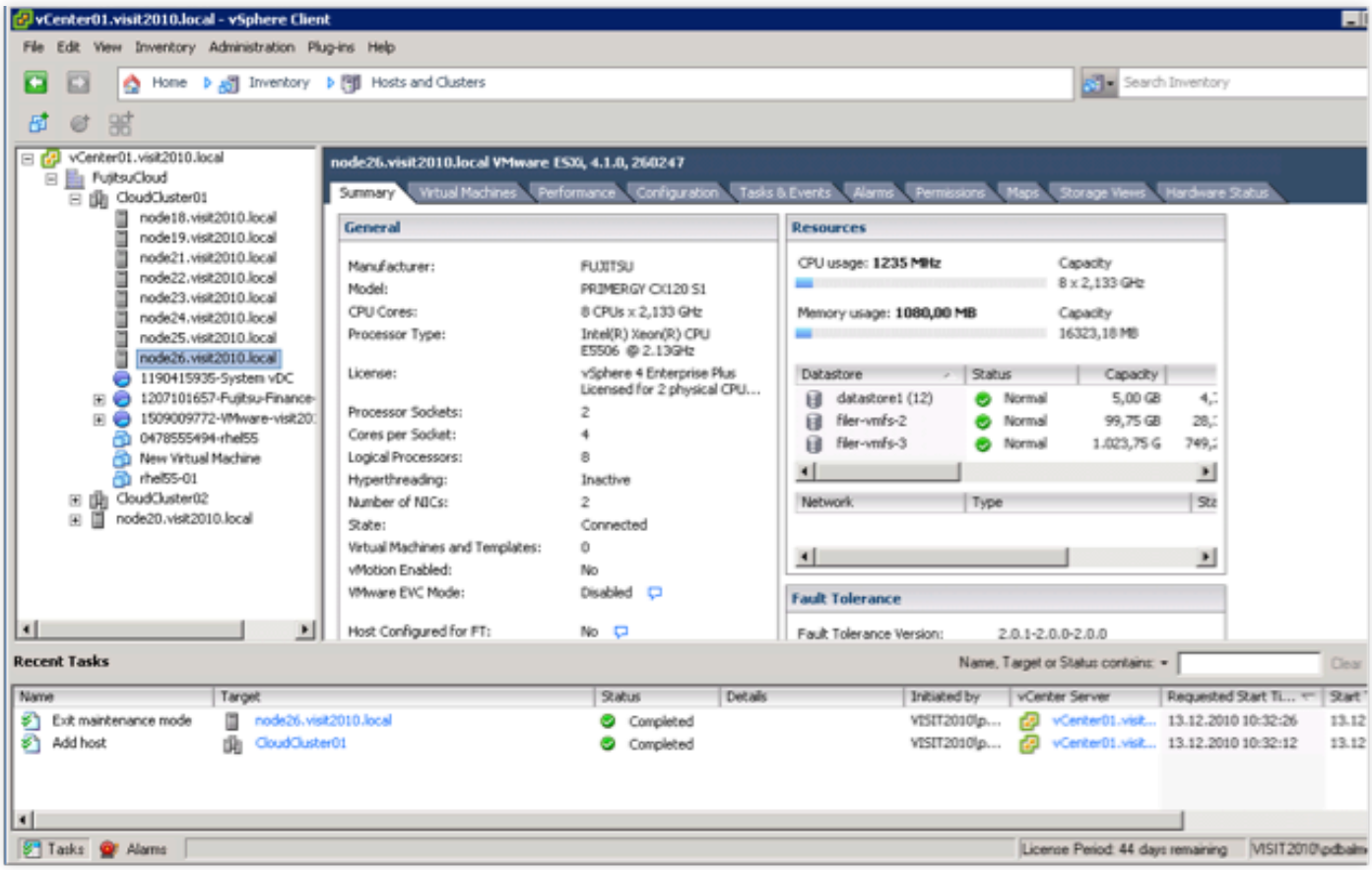
7. Option: Have a look into vSphere to verify the successful deployment process.



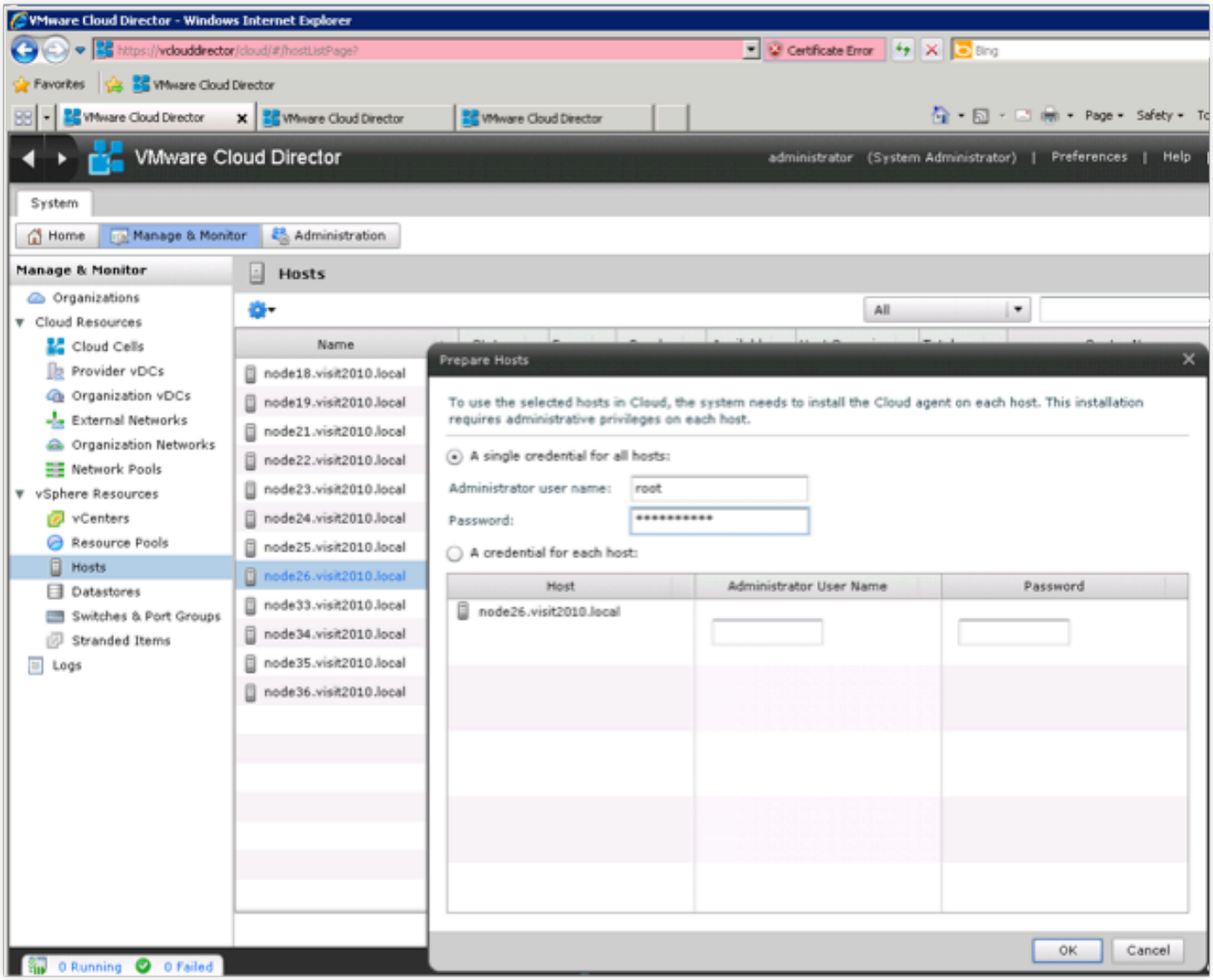
Use Case 10: Dynamic Scaling of Compute Resources

This use case illustrates the option to extend the compute resources within a vSphere cluster.

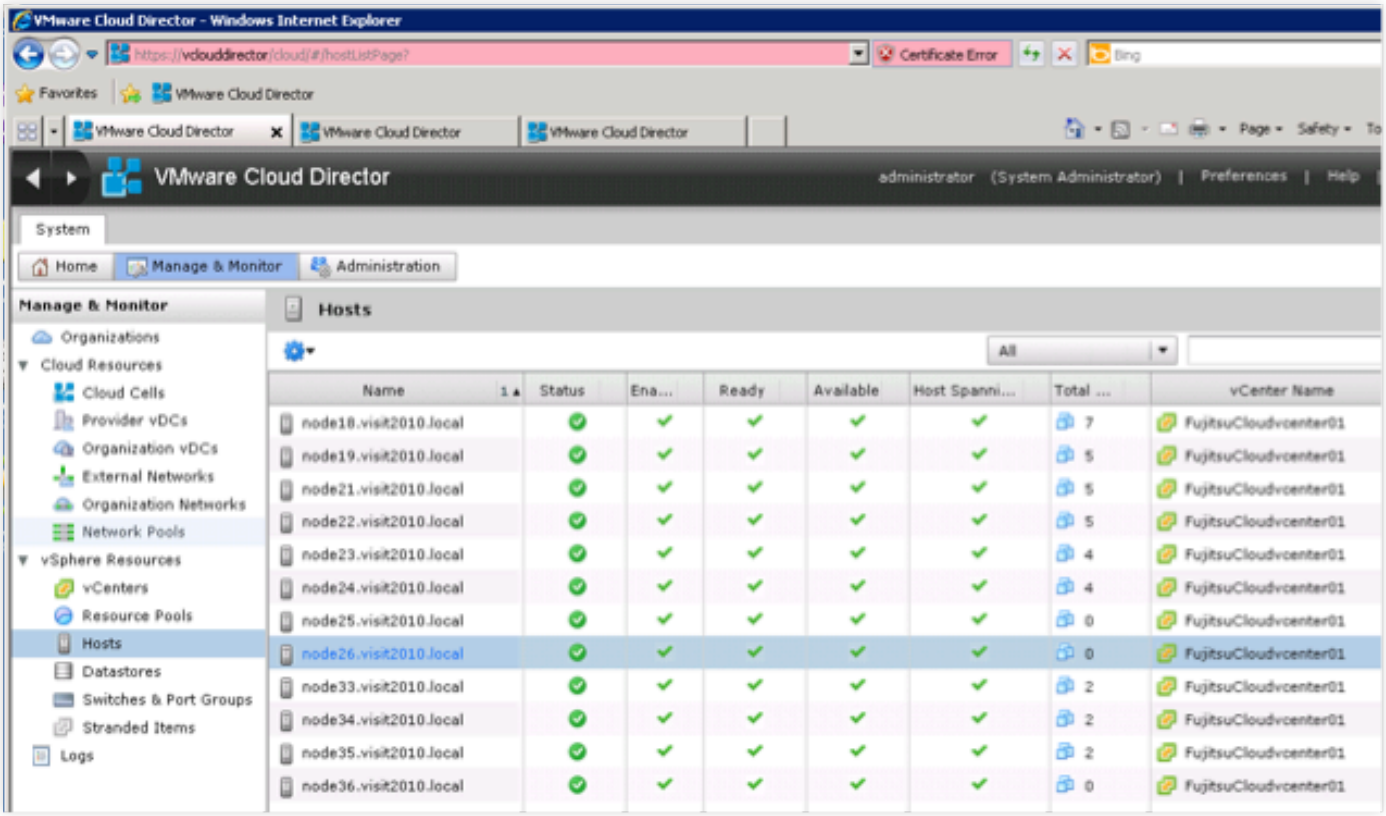
1. Add a new node to the existing cluster and ensure that the node has been joined the cluster without any warnings or error messages.



2. vCloud Director recognizes the new host and the node is seen as "available." In order to utilize this new resource it is required to "prepare" the newly added host.

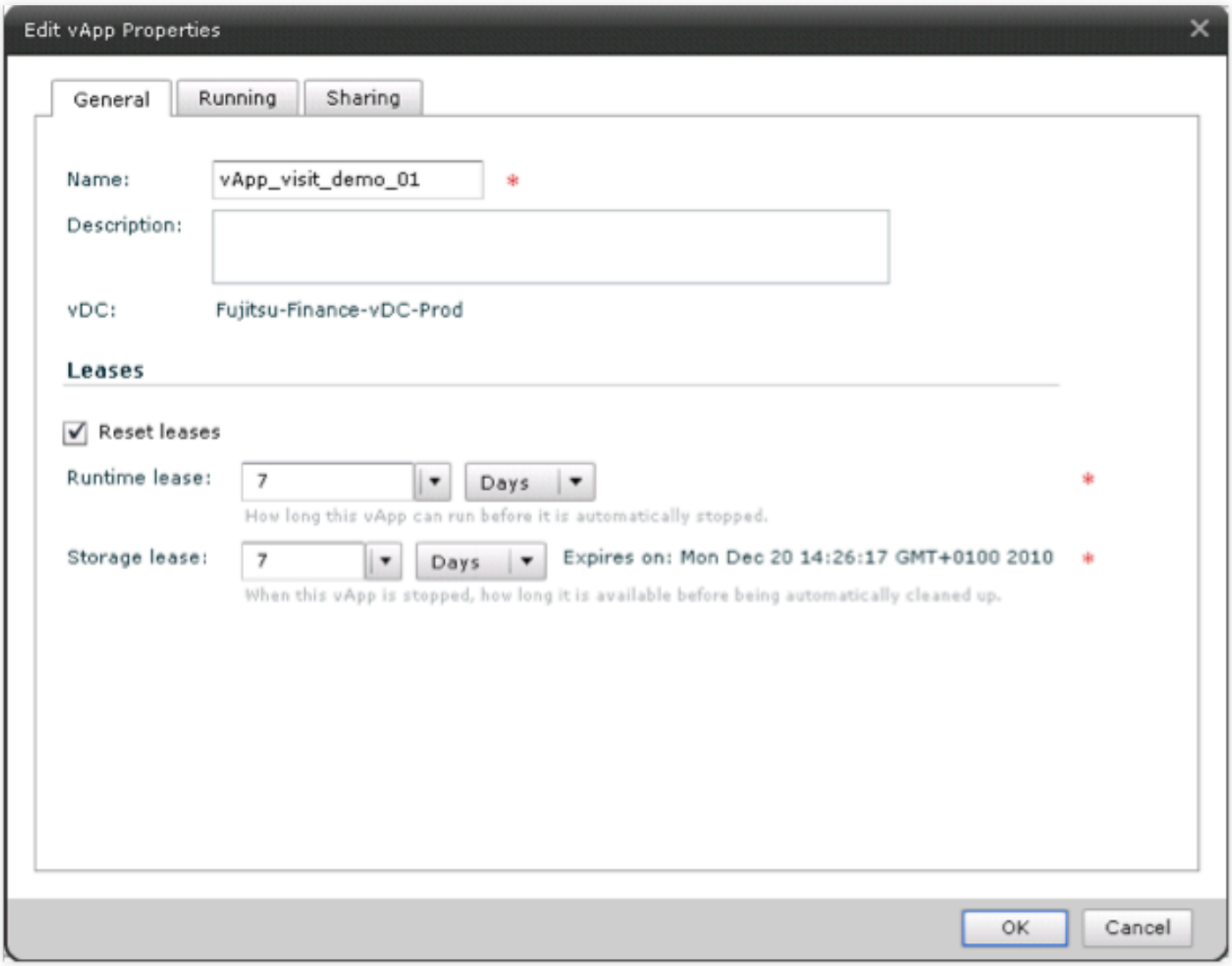


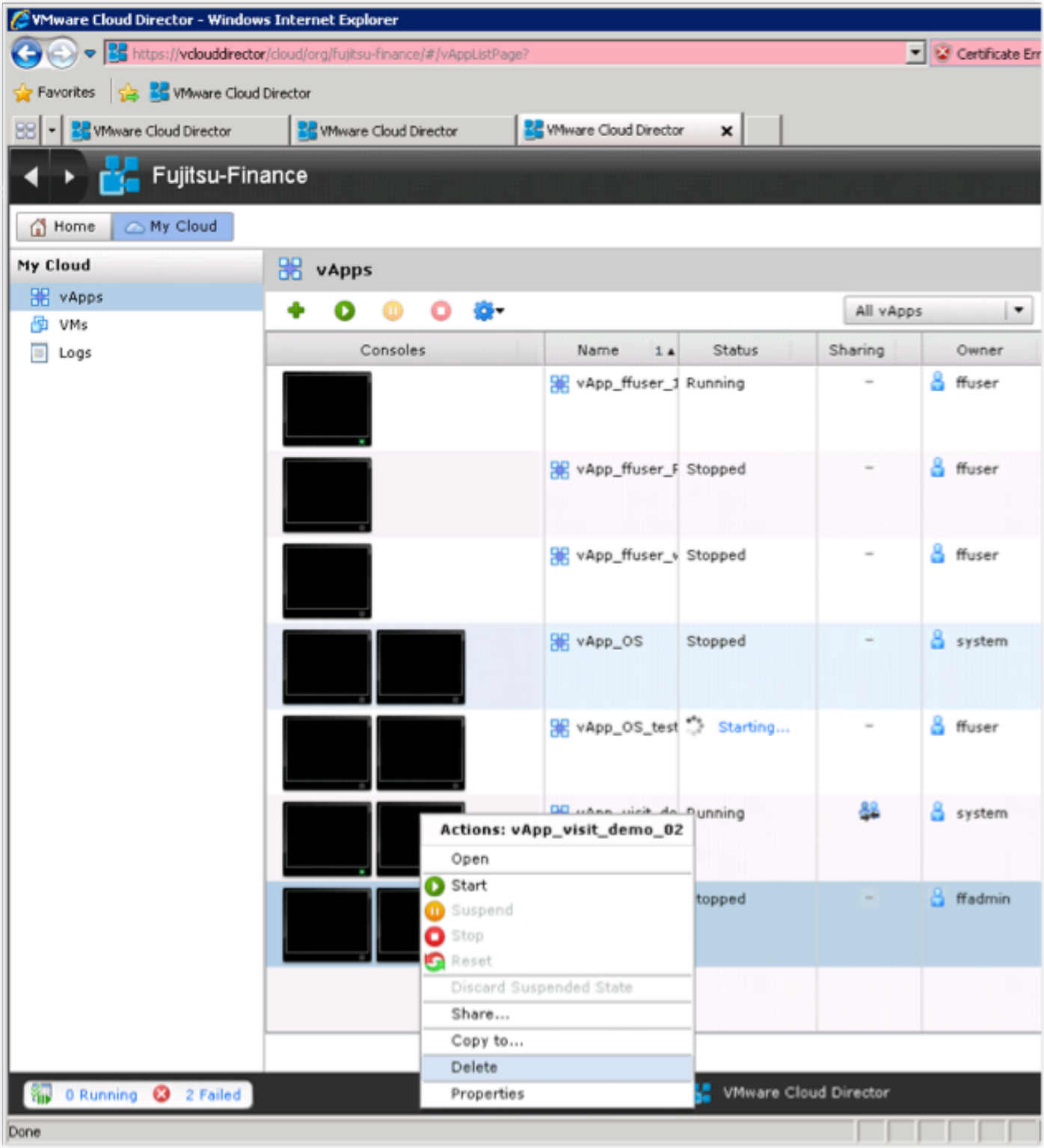
3. Now the vCloud Director can leverage the new compute resources.



Use Case 11: Termination of vApp or Service

The deployed vApps within an organization could be terminated either automatically or manually. When the vApp is initially deployed, the lease period for the vApp could be defined. After the lease period is completed, the vApp is automatically stopped and the resources are freed up. The administrator or the vApp user also has privileges to delete the vApp at any point in time.



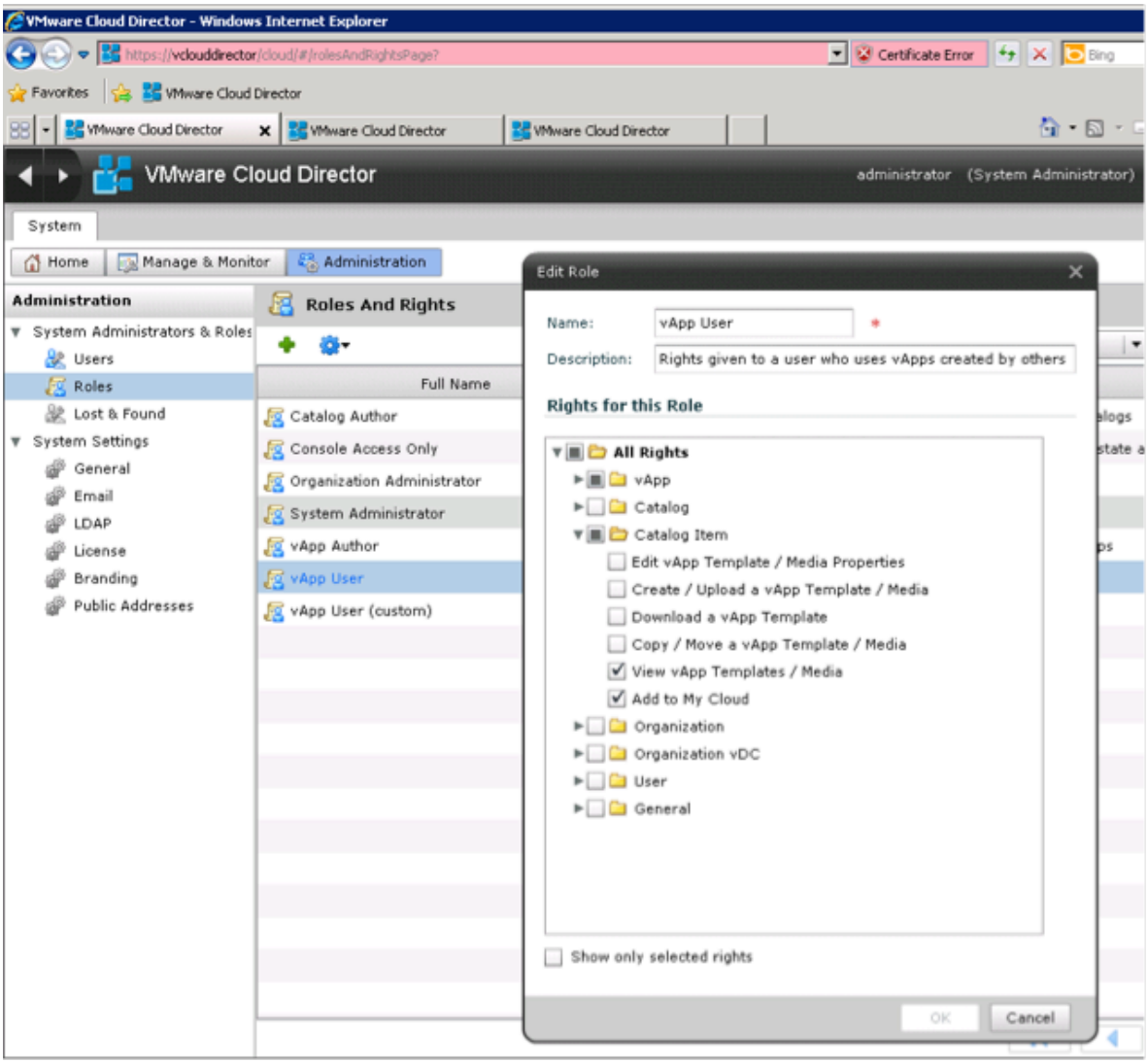

VMware Cloud Director - Windows Internet Explorer
https://vclouddirector/cloud/org/fujitsu-finance/#/vAppListPage?
Certificate Err
Favorites
VMware Cloud Director
VMware Cloud Director
VMware Cloud Director
VMware Cloud Director
Fujitsu-Finance
Home
My Cloud
My Cloud
vApps
VMs
Logs
vApps
All vApps
Consoles
Name
Status
Sharing
Owner
vApp_ffuser_1
Running
ffuser
vApp_ffuser_F
Stopped
ffuser
vApp_ffuser_v
Stopped
ffuser
vApp_OS
Stopped
system
vApp_OS_test
Starting...
ffuser
Running
system
topped
ffadmin
Actions: vApp_visit_demo_02
Open
Start
Suspend
Stop
Reset
Discard Suspended State
Share...
Copy to...
Delete
Properties
0 Running
2 Failed
VMware Cloud Director
Done

Use Case 12: Separation of Duties

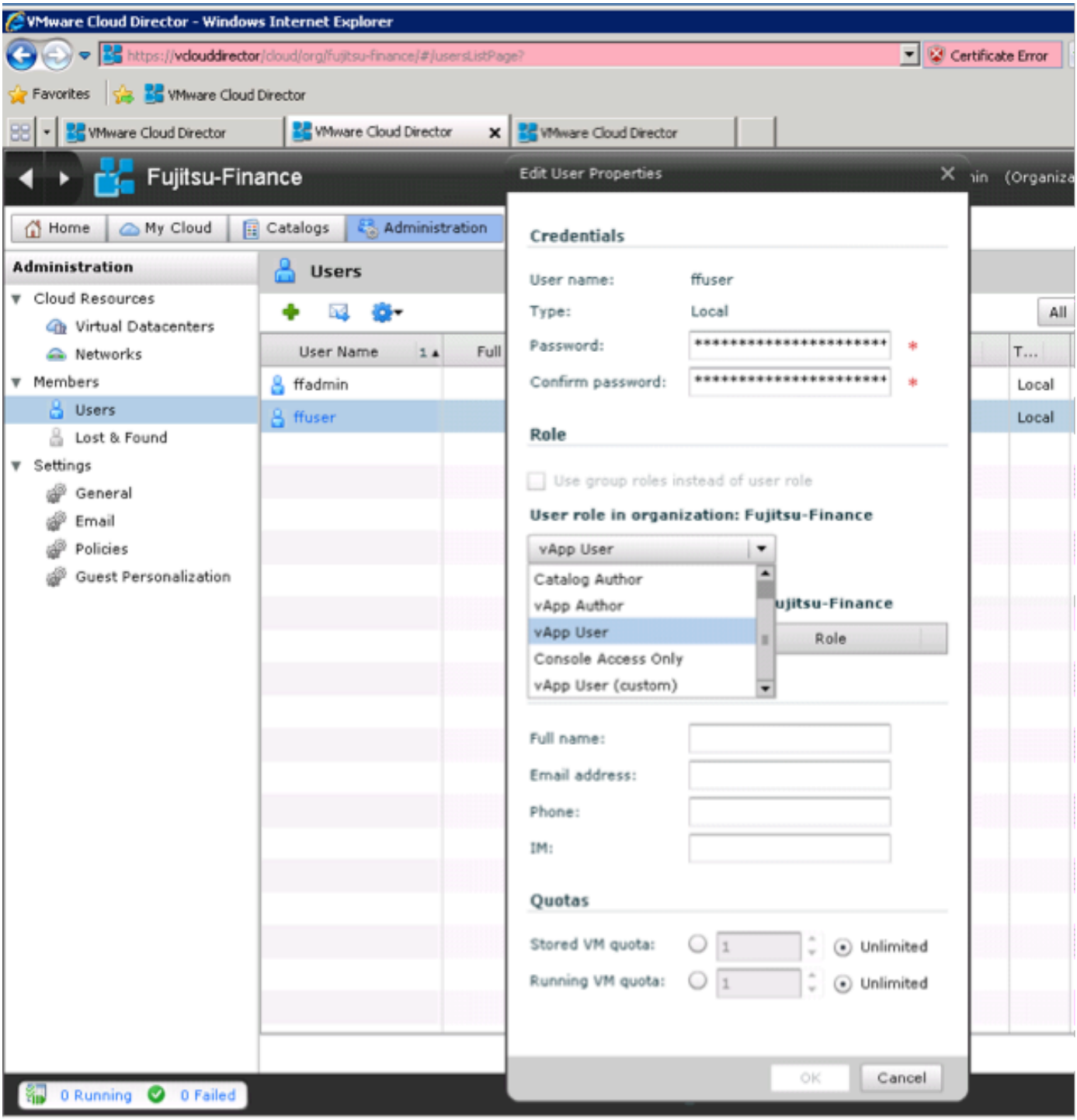
There are three main types of roles in the cloud:

1. Cloud administrators set up the cloud infrastructure and organizations. They access the underlying vSphere infrastructure during initial cloud setup and on an ongoing basis to manage the cloud infrastructure. They are root users of the cloud.
2. Each organization has an organization administrator. Organization administrators manage their own organizations in the cloud. They set up users and permissions and manage catalogs. They are root users for an organization. They cannot access or modify cloud infrastructure. They do not access underlying vSphere infrastructure.
3. End users are basic users in the cloud. They use the workloads that are made available to them in their organization via catalogs. They cannot make modifications to organizations or cloud infrastructures. They do not have access to underlying vSphere infrastructure.

Five default roles exist in Cloud Director. Each role represents "rights", giving the administrator the option to adjust specific rights to user roles.

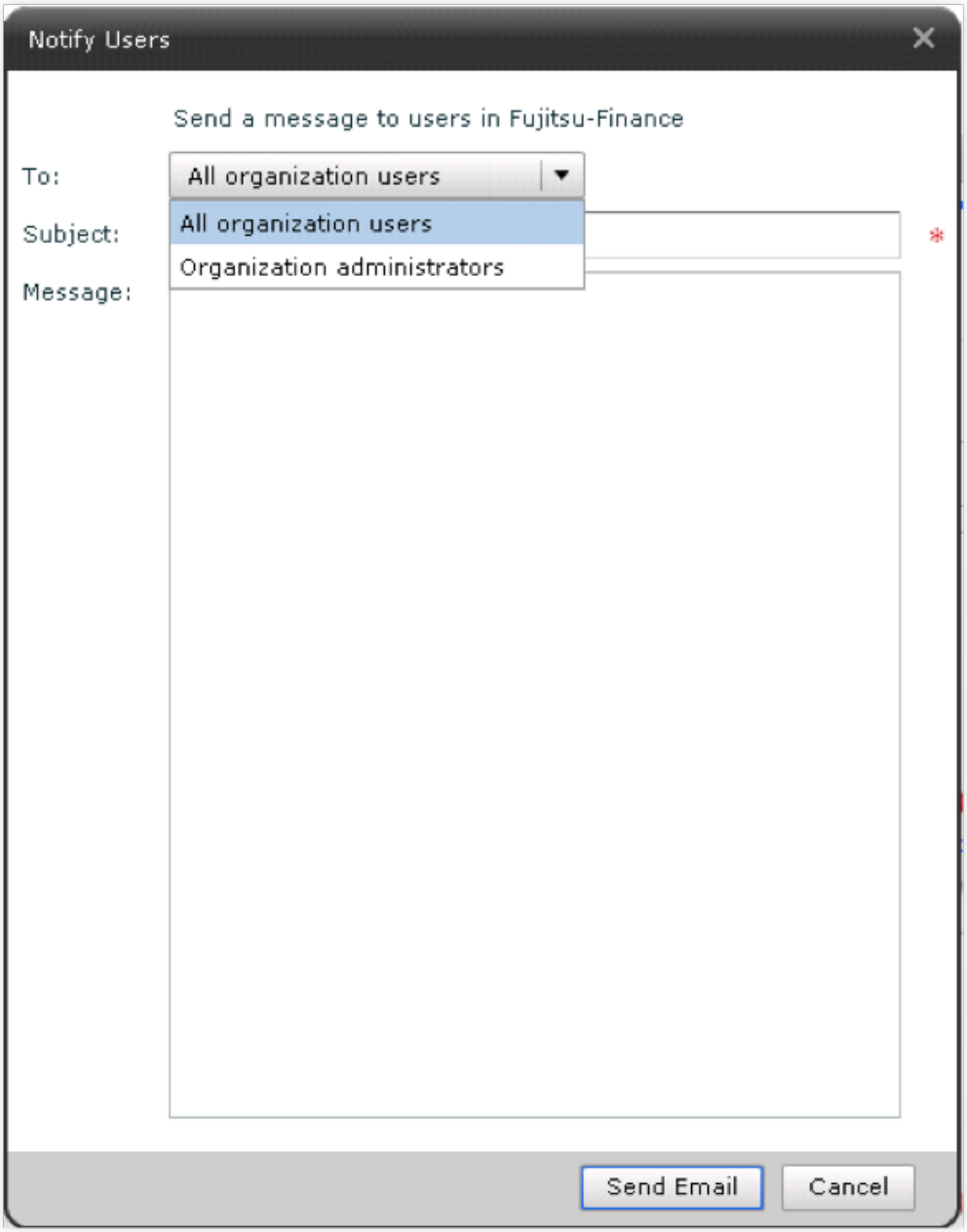


Users are going to be assigned to "roles" in order to give human beings the requested number of rights



Use Case 13: Notification

Cloud Director requires an SMTP server to send user notification and system alert emails. You can send an email notification to all the users in the entire installation, all system administrators, or all Organization administrators. You can send an email notification to let users know about upcoming system maintenance, for example. Cloud Director sends system alert emails when it has important information to report. For example, Cloud Director sends an alert when a datastore is running out of space. Organizations can use the system notification settings, or use custom notification settings. Users can configure email notification to receive a message before a runtime or storage lease expires.



Planning Considerations

Hardware

A full discussion of processor and overall server performance considerations is beyond the scope of this paper. However, it is important to note that the performance of virtual machines that use a virtualized platform is heavily influenced by factors of processor architecture and specific feature sets available in the processor. The use of high performance server processors equipped with virtualization and IO support feature sets, such as the Intel Xeon processor 5600 series, which also supports Intel® Intelligent Node Manager, Intel AES-NI and Intel Trusted Execution Technology (Intel TXT), is recommended. For more details on Intel Virtualization technologies, Intel Node

Manager, Intel AES-NI and Intel TXT please refer to http://download.intel.com/business/resources/briefs/xeon5500/xeon_5500_virtualization.pdf

Network Technology Architecture

For the infrastructure test bed, 1 GbE connections were used for service console/virtual machine and storage. Depending on the customer requirements and usage, production environments might benefit from using 10 GbE for virtual machine networks.

Storage Architecture

For the sake of cost effectiveness and simplicity, a NFS store was used as a shared storage to store virtual machine images. For production deployments, other alternatives might need to be chosen based on the performance, cost, and other factors. The performance of the storage nodes and hypervisor nodes (when local storage is utilized), as well as the overall power consumption of the cloud deployment, may be favorably impacted by the use of SSDs. This was not specifically tested.

Security

Security is one of the key considerations in today's virtualized or bare-metal server deployments. In a cloud deployment scenario, from the perspective of both service provider and service consumer, recommendations include systems that support Intel Advanced Encryption Standard-New Instructions (AES-NI) for faster encryption and Intel TXT (available with Intel Xeon Processor 5600 series) and software like VMware vSphere Hypervisor (VMware ESXi 4.1) to ensure protection against hacking and unauthorized access.

Software

This guide is not meant to substitute for product documentation. For detailed information regarding installation, configuration, administration, and usage of VMware products, please refer to the online documentation. You may also consult the online Knowledge Base if you have any additional questions. Should you require further assistance, please contact a VMware sales representative or channel partner. Below are some links to online resources, documentation and self-help tools:

VMware vSphere and VMware vCenter Server Resources:

Product Overview: http://www.vmware.com/products/vSphere

Product Documentation: http://www.vmware.com/support/pubs/vs_pubs.html

VMware vSphere Documentation (including hardware compatibility guides): http://www.vmware.com/support/pubs/vs_pages/vsp_pubs_esx40_vc40.html

Whitepapers and Technical Papers VMware VMware vSphere Evaluator guide: http://www.vmware.com/resources/techresources/10020

VMware vCloud Director Resources: Product Overview: http://www.vmware.com/products/cloud-director

Product Documentation: http://www.vmware.com/support/pubs/vcd_pubs.html

Installation and Configuration Guide: http://www.vmware.com/support/pdf/vcd_10_install.pdf

Administrator's Guide: http://www.vmware.com/support/pdf/vcd_10_admin_guide.pdf

User's Guide: http://www.vmware.com/support/pdf/vcd_10_users_guide.pdf

VMware vCloud Director Community: http://communities.vmware.com/community/vmtn/vcd

Support Knowledge Base: http://kb.vmware.com

VMware vCenter Server, VMware vShield Manager and VMware vCloud Director

This guide assumes that you have the following software. You have at least one evaluation or licensed VMware vCenter Server Standard. You have at least two VMware vSphere Enterprise Plus evaluations or licensed VMware ESXi/ESX Servers. You have one or more VMs in your VMware vSphere environment with guest operating system (GOS) installed which will be imported into VMware vCloud Director.

For details on installation and configuration of VMware vCenter Server and VMware ESXi/ESX Servers and creation of VMs, please refer to VMware vSphere documentation.

You have VMware vShield Manager 4.1 deployed, licensed, and configured in your VMware vCenter Server. A license for the VMware vShield Edge components of VMware vCloud Director is included with your VMware vCloud Director evaluation. For details on installation of VMware vShield Manager, please refer to the

VMware vCloud Director Installation and Configuration Guide.

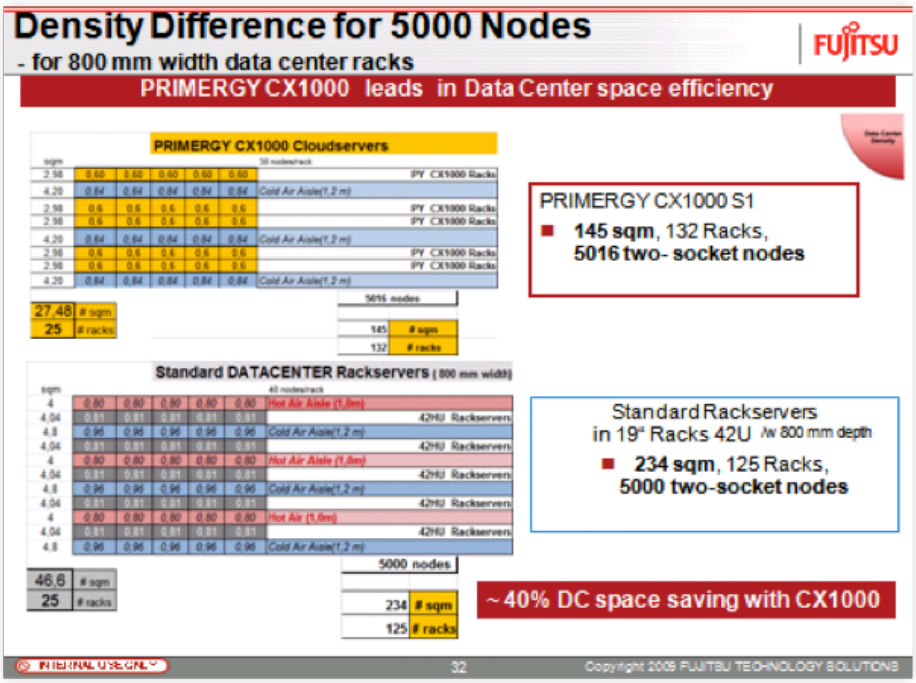
You have VMware vCloud Director installed and running in a VM or physical machine. For details, refer to the VMware vCloud Director Installation and Configuration Guide.

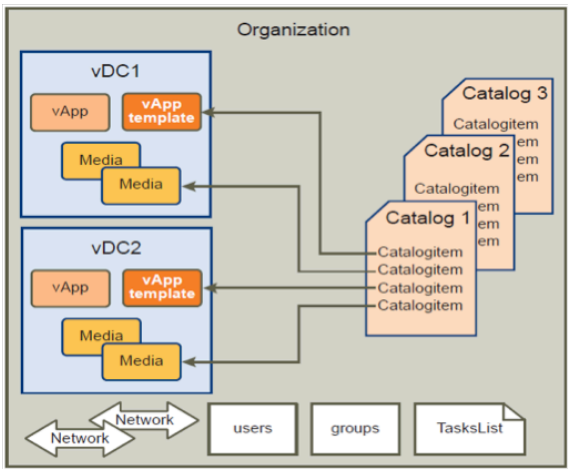
Additional Info

Intel Cloud Builders: http://www.intel.com/cloudbuilders

Intel Xeon processors: http://www.intel.com/xeon

Appendix: PRIMERGY CX1000 Datacenter Space Comparison





Logical Definition Map.

Glossary

To avoid ambiguity about the terms used, here are the definitions for some of the specific concepts used in this paper[7]:

Organization: An organization in VMware vCloud Director is a unit of administration for a collection of users, groups, computing resources, and deployment
of service.

VMware vCloud Users and Groups: An organization can contain an arbitrary number of users and groups. Users can be created by the organization administrator or imported from a directory service such as LDAP. Groups must be imported from the directory service. Permissions within an organization are controlled through the assignment of rights and roles to users and groups.

VMware vCloud Networks:
An organization can be provisioned with one or more networks. These organization networks can be configured to provide services such as DHCP, NAT, and firewalls.

VMware vCloud VDC: A VMware vCloud VDC is an allocation mechanism for resources such as storage, processors, and memory. In a VDC, computing resources are fully virtualized, and can be allocated based on demand, service level requirements, or a combination of the two. There are two kinds of VDCs:

- Provider VDCs: These VDCs contain all the resources available from the VMware vCloud service provider. Provider VDCs are created and managed by VMware vCloud system administrators.
- Organization VDCs: These VDCs provide an environment where virtual systems can be stored, deployed, and operated. They also provide storage for virtual media, such as floppy disks and CD ROMs.

VMware vCloud Catalogs: Catalogs contain references to virtual systems and media images. A catalog can be shared to make it visible to other members of an organization, and can be published to make it visible to other organizations.

vApp: A vApp contains one or more individual virtual machines, along with parameters that define operational details such as:

- How the contained virtual machines are connected to each other and to external networks.
- The order in which individual virtual machines are powered on or off.
- End-user license agreement terms for each virtual machine.
- Deployment lease terms (typically inherited from the containing organization) that constrain the vApp's consumption of VDC resources.
- Access control information which specifies which users and groups can perform operations such as deploy, power on, modify, and suspend on the vApp and the virtual machines it contains.

Endnotes

1. Intel® Xeon® Processor 5500 series Software Industry Testimonials, http://www.intel.com/business/software/testimonials/xeon5500.htm
2. Intel Virtualization Technology, http://www.intel.com/technology/virtualization/ and http://download.intel.com/business/resources/briefs/xeon5500/xeon_5500_virtualization.pdf
3. Intel® Xeon® Processor 5000 series product support: http://www.intel.com/support/processors/xeon5k/. Intel® Xeon® Processor 5600 series product information: http://ark.intel.com/ProductCollection.aspx?series=47915
4. VMware vMotion* Requirements: http://pubs.vmware.com/vi3/resmgmt/wwhelp/wwhimpl/common/html/wwhelp.htm?context=resmgmt&file=vc_create_cluster.7.4.html
5. VMware vCloud Director Product Page: http://www.vmware.com/products/vcloud-director/
6. VMware vCloud™ Director Installation and Configuration Guide: http://www.vmware.com/pdf/VMware_vCloud™ Director_10_install.pdf
7. VMware vCloud API Programming Guide: http://www.vmware.com/pdf/VMware vCloud* Director_10_api_guide.

Disclaimers

Δ Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. See www.intel.com/products/processor_number for details.

Hyper-Threading Technology requires a computer system with an Intel processor supporting Hyper-Threading Technology and an HT Technology enabled chipset, BIOS and operating system. Performance will vary depending on the specific hardware and software you use. See http://www.intel.com/info/hyperthreading/ for more information including details on which processors support HT Technology.

◊ Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

No computer system can provide absolute security under all conditions. Intel® Trusted Execution Technology (Intel® TXT) requires a computer system with Intel® Virtualization Technology, an Intel TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). The MLE could consist of a virtual machine monitor, an OS or an application. In addition, Intel TXT requires the system to contain a TPM v1.2, as defined by the Trusted Computing Group and specific software for some uses. For more information, see http://www.intel.com/technology/security/

Intel® Turbo Boost Technology requires a PC with a processor with Intel Turbo Boost Technology capability. Intel Turbo Boost Technology performance varies depending on hardware, software and overall system configuration. Check with your PC manufacturer on whether your system delivers Intel Turbo Boost Technology.For more information, see http://www.intel.com/technology/turboboost.

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