vSphere Web Services SDK Programming Guide

17 APR 2018

VMware vSphere 6.7

vCenter Server 6.7

VMware ESXi 6.7

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VMware, Inc.
3401 Hillview Ave.
Palo Alto, CA 94304
www.vmware.com

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About This Book

The *vSphere Web Services SDK Programming Guide* provides information about developing applications using the VMware® vSphere Web Services SDK 6.7.

VMware provides different APIs and SDKs for various applications and goals. The vSphere Web Services SDK targets developers who create client applications for managing VMware® vSphere components available on VMware ESXi and VMware vCenter Server systems.

To view the current version of this book as well as all VMware API and SDK documentation, go to http://www.vmware.com/support/pubs/sdk_pubs.html.

Revision History

This book is revised with each release of the product or when necessary. A revised version can contain minor or major changes. The following table summarizes the significant changes in each version of this book.

Table 1. Revision History

Revision Date	Description
17APR2018	vSphere 6.7 - GA Added Instant Clone material to VM Management chapter. Minor updates elsewhere.
12APR2017	Removed appendix with list of permissions. Was not maintained.
15NOV2016	vSphere 6.5 - GA Added chapter about vSphere virtual machine encryption. Removed description of deprecated CIM Storage Management API. Updated information about session cookie management.
04SEP2015	Updated information about migrating VMs with VMotion across data centers.
12MAR2015	vSphere 6.0 - Rewrote “Exporting a Virtual Application” section in Virtual Applications chapter.
19SEP2013	vSphere 5.5 – Added a C# example of using LoginByToken; clarified limitation for HA clusters.
10SEP2012	vSphere 5.1 – Added information about using the SessionManager.LoginByToken method; added information about distributed virtual switches.

Table 1. Revision History (Continued)

Revision Date	Description
24AUG2011	vSphere 5.0 - Revised performance manager chapter. Added information about: unset properties, using vCenter to access host data, and using the QueryConfigOption to add devices; emphasized ListView instead of TaskManager; clarified limits and limitations of Linked Virtual Machines; updated samples in chapters 3,5,14, and 16; replaced information about Axis bindings with JAX-WS; and updated paths to samples supplied with SDK.
13JUL2010	Restructured manual and added chapters about host, storage, and networking. Revised property collector chapter and added appendix about HTTP access.
07MAY2009	vSphere Web Services SDK 4.0 Programming Guide.

Intended Audience

This book is intended for anyone who needs to develop applications using the vSphere Web Services SDK. Developers typically create client applications using Java or C# (in the Microsoft .NET environment) targeting VMware vSphere. An understanding of Web Services technology and some programming background in one of the stub languages (C# or Java) is required.

VMware Technical Publications Glossary

VMware Technical Publications provides a glossary of terms that might be unfamiliar to you. For definitions of terms as they are used in VMware technical documentation go to http://www.vmware.com/support/pubs.

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VMware vSphere and the vSphere Web Services SDK 1

VMware vSphere supports robust, fault-tolerant virtualized applications, networking, and storage. vSphere offers many optional components and modules such as VMware High Availability and VMware VMotion. The VMware vSphere Web Services SDK gives Web services developers programmatic access to vSphere components.

This chapter includes the following topics:

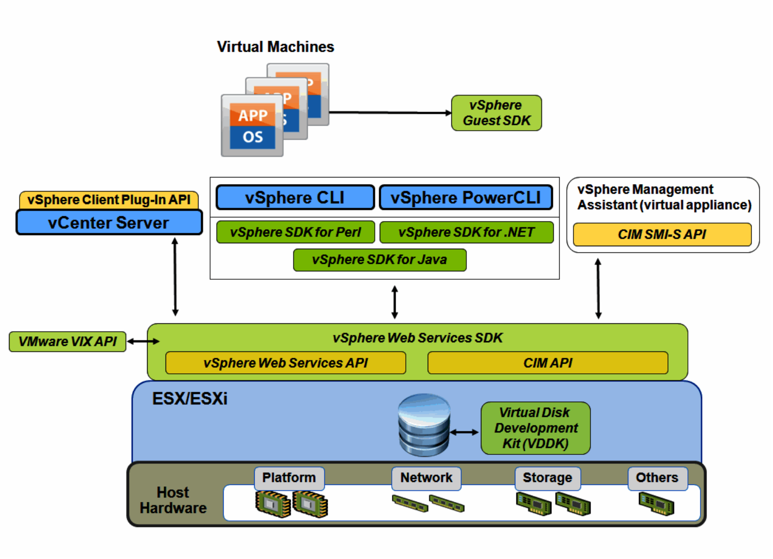
- vSphere Web Services SDK
- SDK Developer Setup for the Web Services SDK
- SDK Samples for the Web Services SDK
- UML Diagrams Used in the Web Services SDK Programming Guide

vSphere Web Services SDK

The vSphere Web Services SDK is the most comprehensive of the available management APIs. The SDK works against both ESXi and vCenter Server systems.

As a Web Services SDK, the SDK is language neutral. The SDK includes stubs and examples for Java and C# and a comprehensive documentation set including an *API Reference* generated from the source.

Figure 1-1. vSphere APIs and CLIs



SDK Developer Setup for the Web Services SDK

Before you can start developing applications with the vSphere Web Services SDK, you must download the software and set up your system. The *vSphere Web Services SDK Developers Setup Guide* has complete instructions for Java and C# development and discusses a simplified security configuration for development environments.

SDK Samples for the Web Services SDK

The SDK includes a set of samples that illustrate much of the SDK features. Two sample sets are available:

- Java samples use the generated Java stubs that are shipped with the SDK.
- C# samples use the generated C# stubs that are shipped with the SDK.

Both sample sets include a set of utility applications that are used by the sample code.

The code fragments in this guide are in part based on the Java sample applications, but present code that does not require utility applications to run.

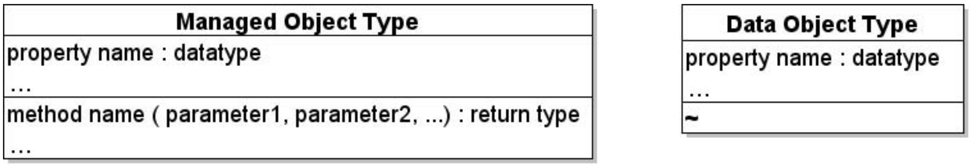
See #unique_7 for lists of samples for the two languages and a brief explanation of what each sample does.

UML Diagrams Used in the Web Services SDK Programming Guide

This guide uses UML (unified modeling language) diagrams to illustrate the API objects and their relationships.

The guide includes class diagrams and instance diagrams. Figure 1-2 shows the UML notation used for managed objects and data objects. The diagrams use a tilde (~) if an object has no properties or methods. Ellipses (...) means some properties or methods are omitted.

Figure 1-2. Legend for UML Class Diagrams



vSphere Web Services API Programming Model

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The vSphere Web Services API is implemented as a language-neutral Web service. The API is based on a remote procedure call mechanism that client applications use to access services and components on ESXi and vCenter Server systems.

This chapter includes the following topics:

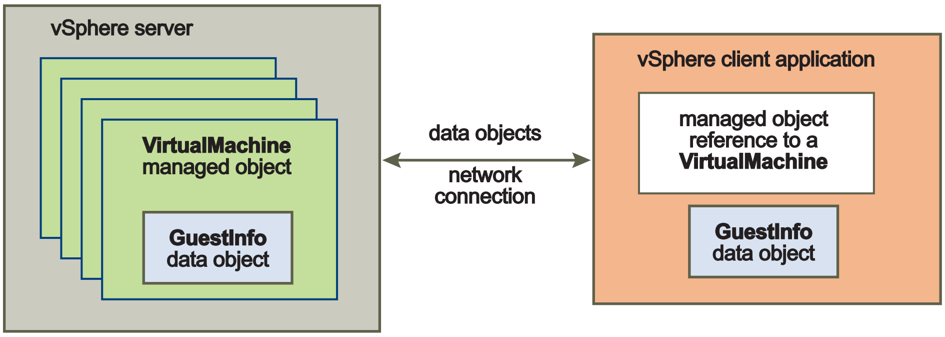
vSphere Client-Server Architecture

VMware vSphere client applications participate in a distributed architecture that uses an asynchronous communications model. This architecture is based on server-side managed objects, client-side managed object references, and data objects.

- Managed objects exist on a vSphere server (ESX/ESXi or vCenter Server system). They represent vSphere services and components. Services include `PropertyCollector`, `SearchIndex`, `PerformanceManager`, and `ViewManager`. Components include inventory objects such as `VirtualMachine`, `Datastore`, and `Folder`.
- Managed object references are client application references to server-side managed objects. Your client application uses `ManagedObjectReference` objects when it invokes operations on a server. A `ManagedObjectReference` is guaranteed to be unique and persistent during an object's lifetime. The reference persists after an object has moved within the inventory, across sessions, and across server restarts. If you remove an object, for example, a virtual machine, from the inventory, and then put it back, the reference changes.
- Data objects contain information about managed objects. Your client application sends data objects to and receives data objects from a vSphere server. Examples are the different specification and capability objects such as `VirtualMachineConfigSpec` and `HostCapability`.

Figure 2-1 shows a vSphere server and client application. The client has a managed object reference to a virtual machine on the server, and a copy of the `GuestInfo` data object for the virtual machine. A client must maintain its copy of a data object because, depending on the type of client request, a vSphere server might send property data for a data object as a set of name-value pairs associated with a managed object reference. See the description of the `ObjectContent` data object in the *vSphere API Reference*.

Figure 2-1. vSphere Server and Client


vSphere server
VirtualMachine managed object
GuestInfo data object
data objects
network connection
vSphere client application
managed object reference to a VirtualMachine
GuestInfo data object

The VMware vSphere application model uses an asynchronous client-server communication model in most cases. Methods are nonblocking and return a reference to a `Task` managed object. For more information about the `Task` managed object, see Tasks and Scheduled Tasks.

Web Services API as a Web Service

The vSphere Web Services API is a language-neutral Web service that runs on ESXi and vCenter Server systems.

The API complies with the Web Services Interoperability Organization (WS-I) Basic Profile 1.0. The WS-I Basic Profile 1.0 includes support for the following standards:

- XML Schema 1.0
- SOAP 1.1
- WSDL 1.1

For information about the WS-I Basic Profile 1.0, go to the Web Services Interoperability Organization (WS-I) Web site at http://www.ws-i.org.

Web services support operations, which are the same as methods in other programming languages. The vSphere API Web service provides access to all operations necessary for monitoring and managing vSphere components, such as compute resources, virtual machines, networks, storage, and so on.

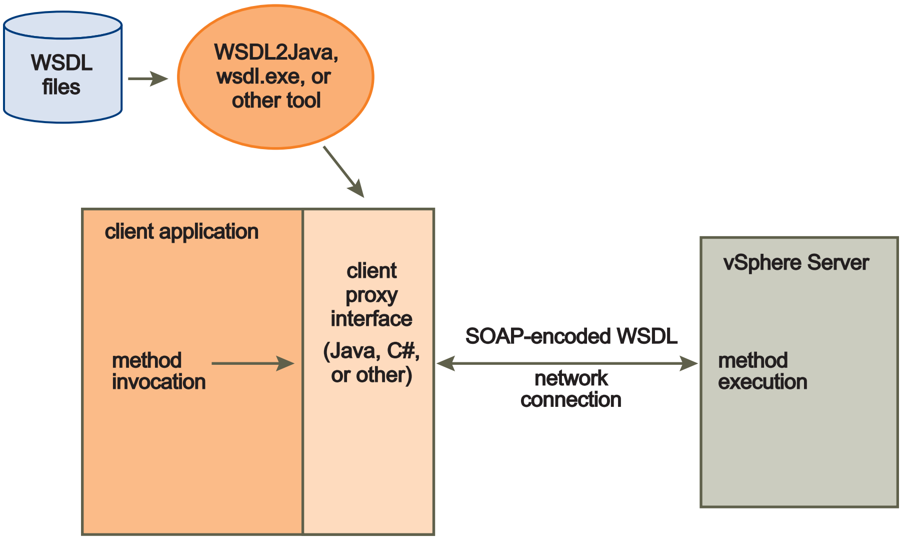
WSDL Files and the Client-Side Proxy Interface

The vSphere Web Services SDK provides a set of WSDL (Web Services Description Language) files that define the vSphere Web Services API. Web-services development tools such as JAX-WS `wsimport`, or Microsoft .NET `wsdl.exe` use these WSDL files to generate client-side proxy code (stubs).

The client proxy provides a language-specific interface proxy, for example, using Java or C#. The proxy facilitates remote method invocation, organization of object data, and other aspects of distributed, object-oriented, applications programming. Your client application calls proxy interface methods. The client proxy uses SOAP (Simple Object Access Protocol) to exchange WSDL messages with a vSphere server.

Figure 2-2 is a representation of a client application that uses the client proxy interface to call a method. The client proxy interface is based on the WSDL definitions.

Figure 2-2. Client-Server Communication Through a Client Proxy Interface



To use the VMware client proxy interface, you must import the vSphere Web Services API client libraries in to your client application using the following Java and C# statements.

C#	`using VimApi;`
Java	`import com.vmware.vim25.*;`

Important The vSphere Web Services SDK includes Java client-side proxy code that was generated using the JAX-WS toolkit. If the versions of Java and JAX-WS on your development platform are the same as those used to generate the proxy interface shipped in the SDK, you do not have to generate client-side proxy code from the WSDL. See the *Developer's Setup Guide* for information about how to configure a development environment for the vSphere Web Services SDK.

Network Access to the vSphere Web Service

Your client application can use the vSphere Web Services API to communicate with vSphere servers over HTTPS (HTTP over an encrypted Secure Sockets Layer connection) at port 443. HTTPS is the default protocol.

You can configure the server to support HTTP. Use HTTP access only for test or development environments, not for production. For information about how to configure the server to support HTTP access, see the *vSphere Web Services SDK Developer's Setup Guide*.

Language-Specific Classes and Methods

The SOAP tools generate language-specific classes and methods that match the WSDL definitions. The tools also produce objects and methods that are not in the WSDL files.

- Generated objects. The additional objects provide access to the vSphere Web Service to establish the client-server connection (`VimServiceLocator`, `AppUtil`) and declare the methods defined for the vSphere API (`VimPortType`, `VimService`).
- Generated methods. The additional methods are accessor (getter) and mutator (setter) methods for properties. For Java, the method names are constructed by adding `get` and `set` prefixes to a property name, and changing the first character of the property name to upper case.

The following table identifies client proxy definitions for the vSphere Web Services SDK WSDL.

Element Access	Java	C#
Access to vSphere Web service (HTTPS/HTTP)	`VimServiceLocator` class	`AppUtil` class
Access to vSphere API methods	`VimPortType` class	`VimService` class
Access to vSphere API properties	`get`*PropertyName* and `set`*PropertyName* methods defined for data objects	`get` and `set` methods defined for properties
vSphere API data objects	Data objects in the vSphere API (see the *vSphere API Reference*) defined as objects in the proxy interface	

The following code fragments show getter and setter method definitions for the `AfterStartupTaskScheduler.minute` property.

Java

```
public int getMinute() {
     return minute; }
public void setMinute(int minute) {
     this.minute = minute; }
```

C#

```
public int minute {
     set; get; }
```

You can extrapolate the getter and setter methods that are available in the client proxy interface from the *vSphere API Reference*. For example, the `ScsiLun` data object has a `displayName` property. For the Java API, you can use a `setDisplayName` method to assign a string value to the property, and obtain the string value by using the `getDisplayName` method. The vSphere Web Services SDK includes Java and C# sample code that illustrates how to use the proxy interfaces. See #unique_18.

Mapping XML Data Types to Java and C# Data Types

In this guide, the UML class and object diagrams use the primitive data type names such as string and integer, without the XML Schema definition namespace prefix (`xsd:`). The *vSphere API Reference* contains the complete data type name, such as `xsd:string`. The data types map to the primitive data types of the programming language used for the client application.

The following table lists some of the more common XML primitive data type mappings.

XML Schema	Java	.NET Data Type
xsd:base64binary	byte[]	Byte[]
xsd:boolean	boolean	Boolean
xsd:byte	byte	SByte
xsd:dateTime	java.util.Calendar	DateTime
xsd:decimal	java.math.BigDecimal	Decimal
xsd:double	double	Double
xsd:float	float	Single
xsd:int	int	Int32
xsd:string	java.lang.String	String

Access to Managed Objects

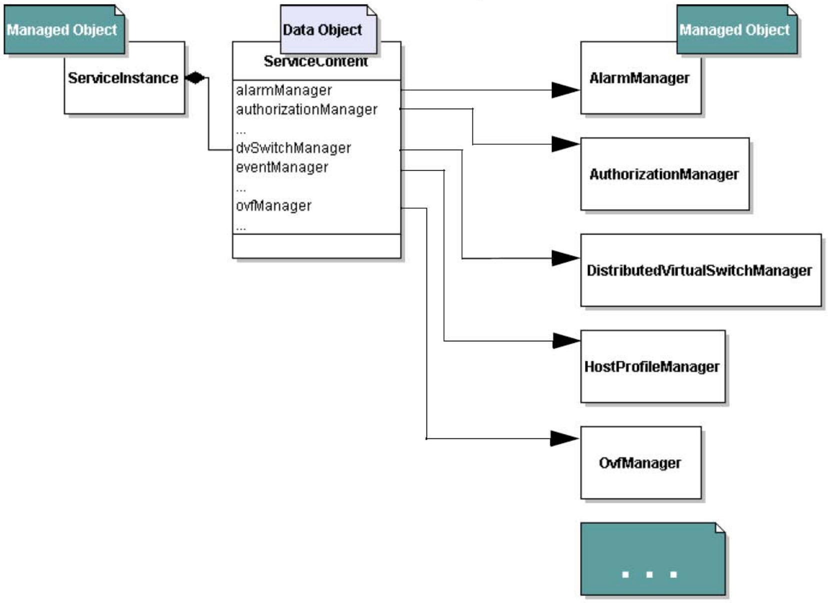
Your client application obtains access to managed objects through the `ServiceInstance` managed object and its associated `ServiceContent` data object. The `ServiceContent` data object contains managed object references to services and manager entities, and to the root folder of the inventory.

The `ServiceInstance` managed object is the root object of the inventory on both ESX/ESXi and vCenter Server systems. The server creates the `ServiceInstance`, and creates the manager entities that provide services in the virtual environment. Examples of manager entities are `LicenseManager`, `PerformanceManager`, and `ViewManager`.

The `ServiceInstance` is the primary point of access to the server inventory. Your client application starts by connecting to a server and creating a reference to the `ServiceInstance`. After you have connected to the server, you can call the `ServiceInstance.RetrieveServiceContent` method to a `ServiceContent` data object. `ServiceContent` provides access to the vSphere managed object services. See Overview of a Java Sample Application for the Web Services SDK for an example of connecting to a server and using the `ServiceInstance` reference to retrieve the `ServiceContent` object.

Figure 2-3 shows the object model for the `ServiceInstance` and `ServiceContent` objects. The figure shows some of the `ServiceContent` managed object references and the target objects of the references. Each managed object reference identifies a specific managed object on the server with its type and a value. (The `value` property is an opaque string.)

Figure 2-3. ManagedObjectReference Data Object



Access to vSphere Server Data

To obtain information about the virtual infrastructure, you retrieve managed object properties. Managed object properties can be simple data types, such as integer or string data, or they can be complex types such as data objects that contain sets of properties.

Obtaining Information from a Server

With a reference to a managed object, you can obtain information about the state of the server-side inventory objects and populate client-side data objects based on the values. You can use one of the following approaches:

- Use an accessor (getter) method. The client proxy interface provides accessor methods for each data object property. You can use these accessor methods to obtain the values of the object. See Language-Specific Classes and Methods for information about client proxy interface accessor methods.
- Use a `PropertyCollector` to navigate to a selected point on the server and obtain values from specific properties. See #unique_28 for more information about `PropertyCollector`.

- Use the `SearchIndex` managed object to obtain a managed object reference to the managed entity of interest. The `SearchIndex` can return managed object references to specific managed entities—`ComputeResource`, `Datacenter`, `Folder`, `HostSystem`, `ResourcePool`, `VirtualMachine`—given an inventory path, IP address, or DNS name.

Important You can use API methods to operate on managed objects in the vSphere inventory. A method that updates properties in one managed object may also update properties in other managed objects. The Server performs asynchronous updates to the inventory. There is no guarantee that the inventory will be completely updated when the method returns to the caller. Use the `PropertyCollector` method `WaitForUpdatesEx` to obtain property changes.

Working with Data Structures

Properties contain information about the server-side objects at a given point in time. The value of a property can be of one of the following types:

- Simple data types, such as a string, boolean, or integer (or other numeric) data type. For example, the `ManagedEntity` managed object has a `name` property that takes a string value.
- Arrays of simple data types or data objects. For example, a `HostSystem` managed object contains an array of managed object references (a type of data object) to virtual machines hosted by that physical machine. As another example, the `SessionManager` managed object has a `sessionList` property that is an array of `UserSession` data objects.
- Enumerated types (enumeration, enum) of predefined values. The values can be a collection of simple data types or data objects. For example, a virtual machine's power state can be one of three possible string values—`poweredOn`, `poweredOff`, or `suspended`.

  The type of a property is often a string, but the property actually expects one of the values an enumeration encapsulates. For example, when you set `VirtualMachineConfigSpec.guestid` you can specify one of the elements of the `VirtualMachineGuestOSIdentifier` as a string.
- Complex (or composite) data types. For example, the `HostProfileConfigInfo` object contains data objects, an array of data objects, and an array of strings.

Accessing Property Values

To use the composite data structures and arrays that contain Server data:

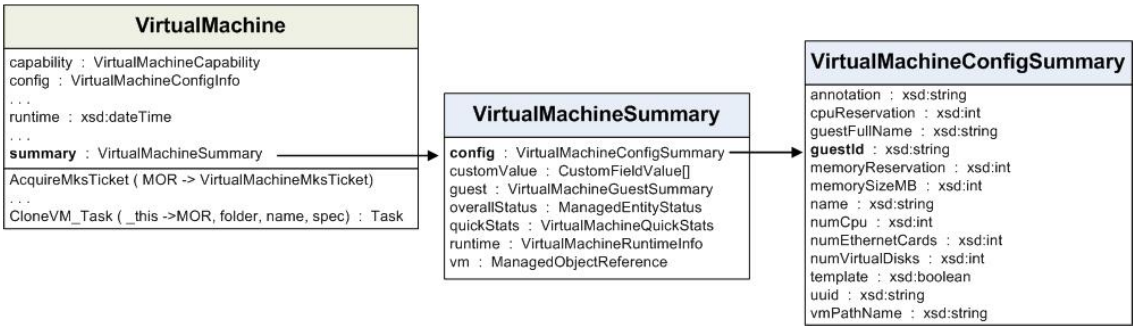
- Use dot notation to access nested properties in composite data structures.
- Cast unconstrained property values (`xsd:anyType`) to array types.
- Use keys or index values as appropriate to access array values.

Nested Properties and Property Paths in Composite Data Structures

vSphere Data objects can include properties that are defined as composite data types, such as data objects. The embedded data objects can also contain properties that are data objects. Properties can nest to several levels.

For example, the following figure shows a UML class diagram of the VirtualMachine managed object, which has a runtime property that is defined as an xsd:dateTime data type. VirtualMachine also has a summary property that is a VirtualMachineSummary data object. The VirtualMachineSummary data object contains a config property that is a VirtualMachineConfigSummary data object.

Figure 2-4. VirtualMachine Managed Object and Nested Properties


VirtualMachine
capability : VirtualMachineCapability
config : VirtualMachineConfigInfo
. . .
runtime : xsd:dateTime
. . .
summary : VirtualMachineSummary
AcquireMksTicket (MOR -> VirtualMachineMksTicket)
. . .
CloneVM_Task (_this ->MOR, folder, name, spec) : Task
VirtualMachineSummary
config : VirtualMachineConfigSummary
customValue : CustomFieldValue[]
guest : VirtualMachineGuestSummary
overallStatus : ManagedEntityStatus
quickStats : VirtualMachineQuickStats
runtime : VirtualMachineRuntimeInfo
vm : ManagedObjectReference
VirtualMachineConfigSummary
annotation : xsd:string
cpuReservation : xsd:int
guestFullName : xsd:string
guestId : xsd:string
memoryReservation : xsd:int
memorySizeMB : xsd:int
name : xsd:string
numCpu : xsd:int
numEthernetCards : xsd:int
numVirtualDisks : xsd:int
template : xsd:boolean
uuid : xsd:string
vmPathName : xsd:string

To refer to a nested property, use dot notation to separate the object names in the sequence that defines the path to the property. Your code must handle the type referenced at the end of the sequence.

For example, you can compare the property referenced by the path summary.config.guestId (a string value) to the property referenced in the path summary.config (the complete VirtualMachineSummary data object).

The following table shows examples of property references and the corresponding data types for some of the properties of the VirtualMachine managed object shown in Figure 2-4.

Reference	Data Type
summary	VirtualMachineSummary data object
summary.config	VirtualMachineConfigSummary data object
summary.config.guestID	string

xsd:anyType Arrays

The vSphere Web Services API uses xsd:anyType unconstrained type declarations. A vSphere client must map values of xsd:anyType to explicit data types. An xsd:anyType value can represent a single data value or it can represent an array. The WSDL for the vSphere Web Services API defines array types for all of the data values that a vSphere client can send or receive as arrays. The array types use the prefix “Array Of”. An example of an array type is ArrayOfString for string values.

When a client sends data to a vSphere Server, the client must use explicit datatypes. For example, a client can define a MethodAction for a ScheduledTask. The vSphere Web Services API defines arguments to the action (the MethodActionArgument.value property) as type xsd:anyType. If the action takes an array argument, the client must set the corresponding MethodAction.argument[].value to the appropriate ArrayOf... type.

When a client receives xsd:anyType data from a vSphere server, it must cast the data to an explicit type. For example, the PropertyCollector method RetrievePropertiesEx returns a set of ObjectContent data objects. The ObjectContent.propSet property is a list of DynamicProperty objects that contains the requested property values. Each DynamicProperty object contains a name-value pair. The value property (DynamicProperty.val) is of type xsd:anyType. It can represent a single object or an array of objects.

When the returned value is a single object such as an Event, ManagedObjectReference, or String, you can cast it directly to a variable of the appropriate type. However, when the value is an array of objects you cannot cast the anyType value directly to an array variable.

When the PropertyCollector returns array data, it sends it as an xsd:anyType value. The language-specific bindings contain definitions for array objects such as ArrayOfEvent, ArrayOfManagedObjectReference, and ArrayOfString, and corresponding “get” methods. To extract the actual array from a property of type xsd:anyType, cast DynamicProperty.val to the appropriate array type and use the matching get method – for example, getEvent(), getManagedObjectReference(), or getString().

The following sections provide some examples of how to cast returned values for a few of the array types.

Cast an xsd:anyType Array to an Event Array

When the PropertyCollector returns array data representing an array of Event objects, the array has the type xsd:anyType. To use the data in your application, you must first cast it to a specialized type for Event arrays.

This example code uses the JAX-WS-generated Java bindings for the VMware vSphere Web Services SDK WSDL.

Procedure

1 Use the DynamicProperty.getVal() method to retrieve the anyType property value.

2 Cast the anyType value to a value of type ArrayOfEvent.

3 Use the corresponding get method to assign the result of the cast operation to a list variable.

```
/*
* Handling arrays of Event objects.
* Cast the return value to ArrayOfEvent and use getEvent().
*/
List[] eventList = ((ArrayOfEvent) dynamicProp.getVal()).getEvent();
```

Cast an `xsd:anyType` Array to an Array of Managed Object References

When the `PropertyCollector` returns array data representing an array of managed objects, the array has the type `xsd:anyType`. To use the data in your application, you must first cast it to a specialized type for arrays of managed object references.

This example code uses the JAX-WS-generated Java bindings for the VMware vSphere Web Services SDK WSDL.

Procedure

1. Use the `DynamicProperty.getVal()` method to retrieve the `anyType` property value.
2. Cast the `anyType` value to a value of type `ArrayOfManagedObjectReference`.
3. Use the corresponding get method to assign the result of the cast operation to a list variable.

```
/*
* Handling arrays of ManagedObjectReference objects.
* Cast the return value to ArrayOfManagedObjectReference and use getManagedObjectReference().
*/
List[] morList =
     ((ArrayOfManagedObjectReference)dynamicProp.getVal()).getManagedObjectReference();
```

Cast an `xsd:anyType` Array to an Array of String

When the `PropertyCollector` returns array data representing an array of strings, the array has the type `xsd:anyType`. To use the data in your application, you must first cast it to a specialized type for arrays of strings.

This example code uses the JAX-WS-generated Java bindings for the VMware vSphere Web Services SDK WSDL.

Procedure

1. Use the `DynamicProperty.getVal()` method to retrieve the anyType property value.
2. Cast the `anyType` value to a value of type `ArrayOfString`.
3. Use the corresponding get method to assign the result of the cast operation to a list variable.

```
/*
* Handling arrays of strings.
* Cast the return value to ArrayOfString and use getString().
*/
List[] stringList = ((ArrayOfString) dynamicProp.getVal()).getString();
```

Indexed Array and Key-Based Array Properties

The VMware vSphere data structures include array properties, which can be indexed arrays or key-based arrays.

- **Indexed arrays** are accessed by using an index integer. Indexed arrays are used for arrays of data types whose positions in the array do not change. For example, the `roleList` property of the `AuthorizationManager` managed object is an array of authorization roles. Adding a new role to the array does not change the position of existing elements in the array.
- **Key-based arrays** are used for information whose position is subject to change. A key-based array (same basic concept as a Perl hash or a Python dictionary) uses a unique, unchanging value as a key to access an element's value.

  Typically, the key is a string, but integers can also be used. For example, `Event` arrays use integers as keys.

  The vSphere management object model uses key-based arrays to track managed object references. The contents of a key-based array property are accessed by the value of either the key property or, in the case of a managed object reference, its value property. The value of these fields is unique across all of the components of an array.

  Nested properties can also refer to entries in a key-based array. For example, `a.b.c["xyz"]` refers to the property `c` that has the key value of `xyz`.

Unset Optional Properties

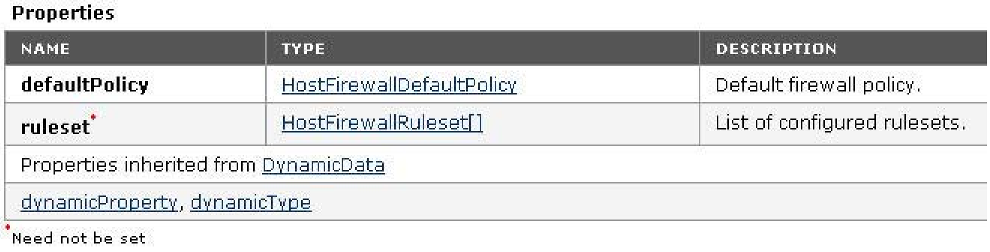
Many of the Data Objects in the vSphere Web Services SDK have optional properties that may be set by your client application or by a Server process or event. If you retrieve a data object that has an optional property that is unset, the Server will not return a value for the optional property. If you call an accessor function to retrieve the property value, the value returned by the function depends on the programming language that you are using.

For example, if you are programming in Java or C#, the value you will receive for an unset property is `null`.

Figure 2-5 shows part of the Properties table for the `HostFirewallInfo` data object in the *vSphere Web Services SDK API Reference*. When you look at properties in the *vSphere Web Services SDK API Reference*, you can see that optional properties are marked with a red asterisk.

In this example, that the `defaultPolicy` property is always returned, but the `ruleset` property will be returned as a `null` value if it has not been set.

Figure 2-5. Data Object - HostFirewallInfo Properties



Properties

NAME	TYPE	DESCRIPTION
defaultPolicy	HostFirewallDefaultPolicy	Default firewall policy.
ruleset*	HostFirewallRuleset[]	List of configured rulesets.
Properties inherited from DynamicData		
dynamicProperty, dynamicType		

*Need not be set

Since Data Objects are part of many different constructs, there is no standard scenario for when an optional property should be set, what will happen if an optional property is left unset, or what you should do if a null value is returned.

Escape Character in Name and Path Properties

The percent sign (%) is used as an escape character to embed special characters in strings. For example, %2f (or %2F) is interpreted as the slash (/) character. To include a percent sign as a literal in a string, use %%.The path to the inventory starts from the root folder (`ServiceContent.rootFolder` property), denoted by the slash character.

Character	Description	Representation in URL
%	Percent sign	%25
/	Slash	%2F, %2f
\	Backslash	%5C, %5c
-	Dash	%2D, %2d
.	Dot	%2E, %2e
“	Double quotation mark	%2B, %2b

Client Applications for the Web Services API

3

Any client application written for the Web Services API must perform certain basic functions. These include making a connection to the server, authenticating and creating a session, and closing the connection.

This chapter includes the following topics:

vCenter Server Connections

Every vCenter Server client application must connect to the server and pass user account credentials to authenticate to the server. After the connection has been established, the client application can use vSphere services to access the virtual environment.

vSphere uses SSL certificates, HTTP tokens, and vCenter Single Sign-On tokens to authenticate a client and support a persistent connection between the client and vCenter Server. The following table provides an overview of these elements.

Security Element	Description
SSL certificates	vSphere Servers use standard X.509 version 3 (X.509v3) certificates to encrypt session information sent over Secure Socket Layer (SSL) protocol connections. In a production environment, client applications verify the vSphere Server certificate during the connection sequence. The examples in this chapter and the examples in the vSphere Web Services SDK accept all certificates.
HTTP tokens	A vSphere Server uses an HTTP token to identify a client session. The Server provides the HTTP token in its response to a client connection request. Subsequent messages between the client and the Server include the HTTP token in the HTTP header.
Client authentication vCenter Single Sign On token	vSphere supports vCenter Single Sign-On. A vCenter client can obtain a vCenter Single Sign-On token from a vCenter Single Sign-On Server and use that token to login to a vCenter Server.
Client authentication username/password	Username/password authentication for client-server connections. A client can present user credentials either directly to vCenter Server to establish a session, or to the vCenter Single Sign-On Service in exchange for a SAML token.

Establishing a Single Sign-On Session with a vCenter Server

vSphere uses single sign-on to provide a single point of authentication for clients. vSphere includes the vCenter Single Sign-On Server. To use vCenter Single Sign-On, your client obtains a SAML token (Security Assertion Markup Language) from the vCenter Single Sign-On Server and passes the token to the vCenter Server in the login request. The token represents the client and contains claims that support client authentication. Components in the vSphere environment perform operations based on the original authentication. For information about obtaining a vCenter Single Sign-On token from the vCenter Single Sign-On Server, see *vCenter Single Sign On Programming Guide*.

To use single sign on, your client calls the `LoginByToken` method. Your client must send a SAML token to the vCenter Server by embedding the token in the SOAP header for the `LoginByToken` request. During the login sequence, your client must save and restore the HTTP session cookie. The vCenter Single Sign-On SDK contains sample code that demonstrates how to use the `LoginByToken` method.

The following sections describe examples of using the `LoginByToken` method to establish a vCenter Single Sign On session with a vCenter Server.

LoginByToken to vCenter Server By Using C#

The following sections describe a C# example of using the `LoginByToken` method.

vCenter Server Single Sign On Session Using C#

After you obtain a SAML token from the vCenter Single Sign On Server, you can use the vSphere API method `LoginByToken` to establish a single sign on session with a vCenter Server. To establish a vCenter Server session that is based on SAML token authentication, the client must embed the SAML token in the SOAP header of the `LoginByToken` request. The C# `LoginByToken` example uses the following .NET services to support a single sign on session.

.NET Element / Namespace	vCenter Single Sign On Usage
SecurityPolicyAssertion Microsoft.Web.Services3.Security	The sample creates a custom policy assertion derived from the SecurityPolicyAssertion class. The custom assertion contains the SAML token and X509 certificate.
SendSecurityFilter Microsoft.Web.Services3.Security	The sample defines a custom output filter derived from the SendSecurityFilter class. The custom filter adds the token and certificate to the outgoing SOAP message.
ServicePointManager System.net	The sample uses the ServicePointManager to specify SSL3 and HTTP 100-Continue behavior.
ConfigurationManager System.Configuration	The sample uses the ConfigurationManager to specify certificate metadata (password and certificate type).
CookieContainer System.Net	The sample uses the CookieContainer class to manage vCenter session cookies.

Persistent vCenter Server Sessions

A persistent vCenter Server session relies on a session cookie. When the vCenter Server receives a login request, the server creates a session cookie and returns it in the HTTP header of the response. The client-side .NET framework embeds the cookie in HTTP messages that the client sends to the Server.

The LoginByToken request includes the SAML token and client certificate security assertions for client authentication. After successful login, the authentication overhead is no longer needed. The client resets the VimService context to eliminate the security overhead. Subsequent client requests will contain the session cookie, which is enough to support the persistent, authenticated session.

Sample Code

The code examples in the following sections show how to use the LoginByToken method with a holder-of-key security token. The code examples are based on the LoginByTokenSample project contained in the vCenter Single Sign-On SDK. The project is located in the dotnet samples directory (SDK/ssoclient/dotnet/cs/samples/LoginByToken).

- Project file – LoginByToken.csproj
- Sample code – LoginByTokenSample.cs
- SOAP header manipulation code – CustomSecurityAssertionHok.cs

Using LoginByToken in C#

A Web Services API client can authenticate by using a token provided by the vCenter Single Sign-On Service. This example shows C# client code for dealing with token authentication.

The example program uses the following elements and general steps:

- LoginByTokenSample Constructor in a C# Web Services SDK Client
- Security Policies in a C# Web Services SDK Client

- Custom Security Assertion in a C# Web Services SDK Client
- Custom Output Filter for a C# Web Services SDK Client
- Login for a C# Web Services SDK Client
- Session Handling in C# Web Services Client

LoginByTokenSample Constructor in a C# Web Services SDK Client

The `LoginByTokenSample` class constructor creates the following elements to set up access to the vCenter Server.

- `VimService` object – Provides access to vSphere API methods and support for security policies and session cookie management. It also stores the vCenter Server URL.
- `CookieContainer` – Provides local storage for the vCenter Server session cookie.
- `ManagedObjectReference` – Manually created `ManagedObjectReference` to retrieve a `ServiceInstance` at the beginning of the session.

The following code fragment shows the `LoginByTokenSample` constructor.

Example: LoginByTokenSample Constructor

```
// Global variables
private VimService _service;
private ManagedObjectReference _svcRef;
private ServiceContent _sic;
private string _serverUrl;


public LoginByTokenSample(string serverUrl)
{
    _service = new VimService();
    _service.Url = serverUrl;
    _serverUrl = serverUrl;
    _service.CookieContainer = new System.Net.CookieContainer();
    _svcRef = new ManagedObjectReference();
    _svcRef.type = "ServiceInstance";
    _svcRef.Value = "ServiceInstance";
}
```

Security Policies in a C# Web Services SDK Client

The `LoginByToken` sample creates a custom policy assertion that is derived from the .NET class `SecurityPolicyAssertion`. The assertion class gives the .NET framework access to the SAML token and the X509 certificate.

The sample performs the following operations to set up the security policy and message handling.

1. Sets the ServicePointManager properties to specify SSL3 and HTTP 100-Continue response handling. 100-Continue response handling supports more efficient communication between the client and vCenter Server. When the client-side .NET framework sends a request to the Server, it sends the request header and waits for a 100-Continue response from the Server. After it receives that response, it sends the request body to the Server.

2. Creates an X509Certificate2 object, specifies the certificate file, and imports the certificate. The certificate file specification indicates a PKCS #12 format file (Public-Key Cryptography Standards) – PfxCertificateFile. The file contains the client’s private key and public certificate. The PfxCertificateFile setting is defined in the app.config file in the LoginByToken project. The definition specifies the location of the file.

3. Creates a custom security assertion to store the SAML token and the certificate. The token and certificate will be included in the policy data for the LoginByToken request.

4. Defines a custom output filter that is derived from the .NET class SendSecurityFilter.

Custom Security Assertion in a C# Web Services SDK Client

The following code fragment shows the LoginByTokenSample class method GetSecurityPolicyAssertionForHokToken. The method returns a CustomSecurityAssertionHok instance which overrides the .NET class SecurityPolicyAssertion. The security assertion contains the SAML token and the X509 certificate token. This code is taken from the LoginByToken project file samples/LoginByToken/CustomSecurityAssertionHok.cs.

Example: Setting Up Security Policies

```
private SecurityPolicyAssertion
GetSecurityPolicyAssertionForHokToken(XmlElement xmlToken)
{
    //When this property is set to true, client requests that use the POST method
    //expect to receive a 100-Continue response from the server to indicate that
    //the client should send the data to be posted. This mechanism allows clients
    //to avoid sending large amounts of data over the network when the server,
    //based on the request headers, intends to reject the request
    ServicePointManager.Expect100Continue = true;
    ServicePointManager.SecurityProtocol = SecurityProtocolType.Ssl3;

    X509Certificate2 certificateToBeAdded = new X509Certificate2();
    string certificateFile = ConfigurationManager.AppSettings["PfxCertificateFile"];
    string password = ConfigurationManager.AppSettings["PfxCertificateFilePassword"];
    certificateToBeAdded.Import(certificateFile,
                                password ?? string.Empty,
                                X509KeyStorageFlags.MachineKeySet);

    var customSecurityAssertion = new CustomSecurityAssertionHok();
    customSecurityAssertion.BinaryToken = xmlToken;
    customSecurityAssertion.TokenType = strSamlV2TokenType;
    customSecurityAssertion.SecurityToken = new X509SecurityToken(certificateToBeAdded);

    return customSecurityAssertion;
}
```

Custom Output Filter for a C# Web Services SDK Client

The following code fragment shows the custom output filter for the custom security assertion. The custom filter provides three methods:

`CustomSecurityClientOutputFilterHok`	Class constructor that creates token and message signature objects for the SOAP message.
`SecureMessage`	An override method for the .NET method `SendSecurityFilter.SecureMessage`. The override method adds the SAML token and message signature to the .NET Security element.
`CreateKeyInfoSignatureElement`	Creates an XML document that specifies the SAML token type and ID.

Example: Output Filter for the Custom SecurityPolicyAssertion

```
internal class CustomSecurityClientOutputFilterHok : SendSecurityFilter
{
  IssuedToken issuedToken = null;
  string samlAssertionId = null;
  MessageSignature messageSignature = null;

  /// Create a custom SOAP request filter.
  /// (Save the token and certificate.)
  public CustomSecurityClientOutputFilterHok(CustomSecurityAssertionHok parentAssertion)
        : base(parentAssertion.ServiceActor, true)
  {
    issuedToken = new IssuedToken(parentAssertion.BinaryToken, parentAssertion.TokenType);
    samlAssertionId = parentAssertion.BinaryToken.Attributes.GetNamedItem("ID").Value;
    messageSignature = new MessageSignature(parentAssertion.SecurityToken);
  }

  ///  Secure the SOAP message before its sent to the server.
  public override void SecureMessage(SoapEnvelope envelope, Security security)
  {
    //create KeyInfo XML element
    messageSignature.KeyInfo = new KeyInfo();
    messageSignature.KeyInfo.LoadXml(CreateKeyInfoSignatureElement());

    security.Tokens.Add(issuedToken);
    security.Elements.Add(messageSignature);
  }

  /// Helper method to create a custom key info signature element.
  /// Returns Key info XML element.
  private XmlElement CreateKeyInfoSignatureElement()
  {
    var xmlDocument = new XmlDocument();
    xmlDocument.LoadXml(@"<root><SecurityTokenReference
    xmlns=""http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd""
    xmlns:wsse=""http://docs.oasis-open.org/wss/oasis-wss-wssecurity-secext-1.1.xsd""
    wsse:TokenType=""http://docs.oasis-open.org/wss/oasis-wss-saml-token-profile-1.1#SAMLV2.0"">
    <KeyIdentifier
    xmlns=""http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd""
    ValueType=""http://docs.oasis-open.org/wss/oasis-wss-saml-token-profile-1.1#SAMLID"">"
    + samlAssertionId + @"</KeyIdentifier></SecurityTokenReference></root>");
    return xmlDocument.DocumentElement;
  }
```

Login for a C# Web Services SDK Client

The client must obtain a SAML token from a vCenter Single Sign-On Server. See the *vCenter Single Sign-On Programming Guide*. This code fragment performs the following actions:

Procedure

1. Calls the `LoginByTokenSample` class method `GetSecurityPolicyAssertionForHokToken` (see Security Policies in a C# Web Services SDK Client) and adds the security policy to the `VimService` object.

   The `VimService` object contains the following data:

   - vCenter Server URL.
   - SAML token (stored in the security policy assertion).
   - X509 certificate (stored in the security policy assertion).

2. Calls the `RetrieveServiceContent` method. The method establishes the connection with the vCenter Server and provides access to the `SessionManager` managed object.

3. Calls the `LoginByToken` method. The .NET framework uses the security policy assertion to construct the login request. The response includes a session cookie.

4. Calls the `LoginByTokenSample` class method `resetService` to create a new `VimService` object. The session cookie is stored in the cookie container in the `VimService` object.

Example: Connection and Login

```
// Construct the security policy assertion
SecurityPolicyAssertion securityPolicyAssertion = null;
securityPolicyAssertion = GetSecurityPolicyAssertionForHokToken(xmlToken);

// Setting up the security policy for the request
Policy policySAML = new Policy();
policySAML.Assertions.Add(securityPolicyAssertion);

// Setting policy of the service
_service.SetPolicy(policySAML);

_sic = _service.RetrieveServiceContent(_svcRef);
if (_sic.sessionManager != null)
```

```
{
    _service.LoginByToken(_sic.sessionManager, null);
}
resetService();
```

Session Handling in C# Web Services Client

The following code fragment shows the `resetService` method. The method creates a new `VimService` object and a new cookie container. The method also adds the session cookie to the cookie container.

The resetService method

```
/// Resetting the VimService without the security policies
/// as we need the policy only for the LoginByToken method
/// and not the other method calls. resetService also maintains the
/// authenticated session cookie post LoginByToken.
///
/// This method needs to be called only after successful
/// login
private void resetService()
{
    var _cookie = getCookie();
    _service = new VimService();
    _service.Url = _serverUrl;
    _service.CookieContainer = new CookieContainer();
    if (_cookie != null)
    {
        _service.CookieContainer.Add(_cookie);
    }
}


/// Method to save the session cookie
private Cookie getCookie()
{
    if (_service != null)
    {
        var container = _service.CookieContainer;
        if (container != null)
        {
            var _cookies = container.GetCookies(new Uri(_service.Url));
            if (_cookies.Count > 0)
            {
                return _cookies[0];
            }
        }
    }
    return null;
}
```

LoginByToken to vCenter Server By Using Java

The following example is based on the `LoginByTokenSample.java` file contained in the vCenter Single Sign On SDK. The SDK contains Java code that supports HTTP and SOAP header manipulation.

vCenter Server Single Sign-On Session Using Java

After you obtain a SAML token from the vCenter Single Sign-On Server, you can use the vSphere Web Services API method `LoginByToken` to establish a vCenter Single Sign-On session with a vCenter Server. At the beginning of the session, your client is responsible for the following tasks:

- Insert the vCenter Single Sign-On token and a timestamp into the SOAP header of the `LoginByToken` message.
- Maintain the vCenter session cookie. During the login sequence, the Server produces an HTTP session cookie to support the persistent connection. Your client must save this cookie and re-introduce it at the appropriate times.
- If at a later time your client invokes the `LoginByToken` method, or other login method, the Server issues a new session cookie in response. You must have a cookie handler in place to save the cookie for subsequent requests.

The example program uses these general steps:

Procedure

1. Call the `RetrieveServiceContent` method to establish an HTTP connection with the vCenter Server and get the Session Manager managed object reference.
2. Call the `LoginByToken` method to authenticate the vCenter session. To send the token to the vCenter Server, the client uses a handler to embed the token and a time stamp in the SOAP header for the message. The client uses an HTTP header handler method to extract the session cookie from the vCenter Server response.
3. Restore the session cookie for future requests. To identify the session started with the `LoginByToken` method, the client uses a handler to embed the session cookie in the HTTP header.

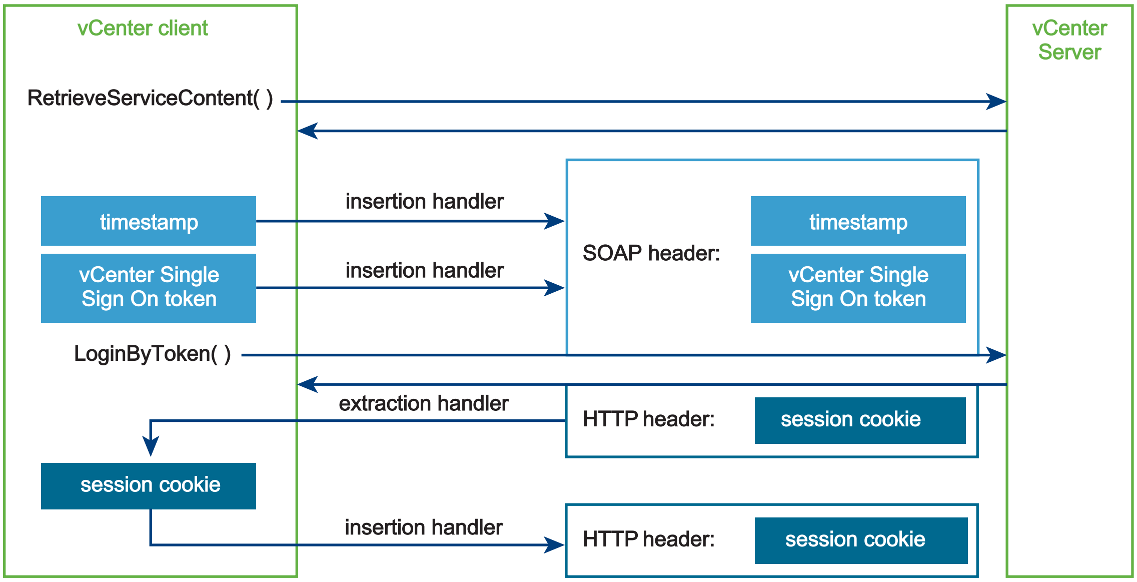
HTTP and SOAP Header Handlers in Java

To use a vCenter Single Sign On token to login to a vCenter Server, the example uses header handlers to manipulates the HTTP and SOAP header elements of the login request. After establishing a handler, subsequent requests automatically invoke the handler.

- Insertion handlers put the vCenter Single Sign On token and a timestamp into the SOAP header into the HTTP header of the login request.
- An extraction handler obtains the HTTP session cookie provided by the vCenter Server. After setting up the handler, a call to the `LoginByToken` method will invoke the handler to extract the cookie from the Server response.

The following figure shows the use of handlers to manipulate header elements when establishing a vCenter Single Sign On session with a vCenter Server.

Figure 3-1. Starting a vCenter Session



Important Every call to the vCenter Server will invoke any message handlers that have been established. The overhead involved in using the SOAP and HTTP message handlers is not necessary after the session has been established. The example saves the default message handler before setting up the SOAP and HTTP handlers. After establishing the session, the example will reset the handler chain and restore the default handler.

The example code also uses multiple calls to the `VimPortType.getVimPort method` to manage the request context. The `getVimPort` method clears the HTTP request context. After each call to the `getVimPort` method, the client resets the request context endpoint address to the vCenter Server URL. After the client has obtained the session cookie, it will restore the cookie in subsequent requests.

Sample Code for a Java Client to the Web Services SDK

The code examples in the following sections show how to use the `LoginByToken` method with a holder-of-key security token. The code examples are based on the sample code contained in the vCenter Single Sign On SDK. The files are located in the Java samples directory (`SDK/ssoclient/java/JAXWS/samples`):

- LoginByToken sample:

  `samples/com/vmware/vsphere/samples/LoginByTokenSample.java`

- Header cookie handlers:

  `samples/com/vmware/vsphere/soaphandlers/HeaderCookieHandler.java`

  `samples/com/vmware/vsphere/soaphandlers/HeaderCookieExtractionHandler.java`

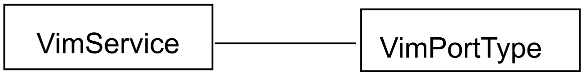
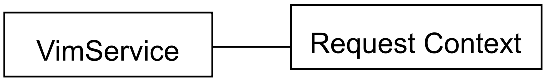
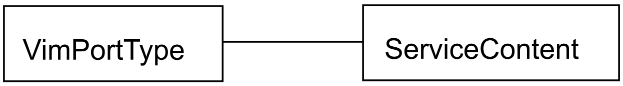
- SOAP header handlers. These are the same handlers that are used in the vCenter Single Sign-On example in *vCenter Single Sign On Programming Guide*. The SOAP handler files are contained in the vCenter Single Sign-On SDK and are located in the SSO client `soaphandlers` directory:

  `SDK/ssoclient/java/JAXWS/samples/com/vmware/sso/client/soaphandlers`

Creating the HTTP Connection in Java

The code fragment in this section establishes an HTTP session with the vCenter Server and saves the HTTP session cookie.

The following sequence describes these steps and shows the corresponding objects and methods.

1	Use the `getHandlerResolver` method to save the default message handler. To use the HTTP and SOAP message handlers, you must first save the default message handler so that you can restore it after login. The HTTP and SOAP message handlers impose overhead that is unnecessary after login.	`VimService.getHandlerResolver( )`
2	Get the VIM port. The VIM port provides access to the vSphere API methods, including the `LoginByToken` method.	
3	Set the request context endpoint address to the vCenter Server URL.	
4	Retrieve the ServiceContent. This method establishes the HTTP connection.	

The following example shows Java code that saves the session cookie.

Example: Saving the vCenter Server Session Cookie

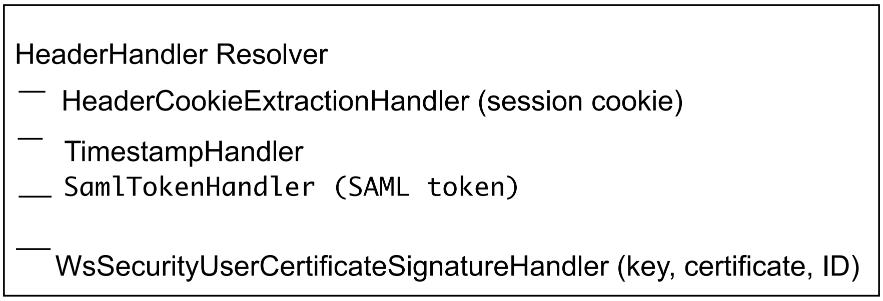
```
/*
 * The example uses a SAML token (obtained from a vCenter Single Sign On Server)
 * and the vCenter Server URL.
 * The following declarations indicate the datatypes; the token datatype (Element) corresponds
 * to the token datatype returned by the vCenter Single Sign On Server.
 *
 * Element token;       -- from vCenter Single Sign On Server
 * String vcServerUrl;  -- identifies vCenter Server
 *
 * First, save the default message handler.
 */

HandlerResolver defaultHandler = vimService.getHandlerResolver();
```

```
/*
 * Create a VIM service object.
 */
vimService = new VimService();

/*
 * Construct a managed object reference for the ServiceInstance.
 */
ManagedObjectReference SVC_INST_REF = new ManagedObjectReference();
SVC_INST_REF.setType("ServiceInstance");
SVC_INST_REF.setValue("ServiceInstance");

/*
 * Get the VIM port for access to vSphere API methods. This call clears the request context.
 */
vimPort = vimService.getVimPort();

/*
 * Get the request context and set the connection endpoint.
 */
Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();
ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, vcServerUrl);
ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);

/*
 * Retrieve the ServiceContent. This call establishes the HTTP connection.
 */
serviceContent = vimPort.retrieveServiceContent(SVC_INST_REF);
```

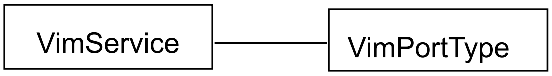
Using LoginByToken in Java

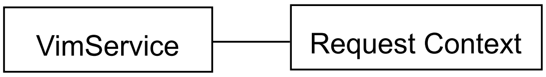
The code fragment in this section sets up the message handlers and calls the `LoginByToken` method to get the session cookie. The following sequence describes the steps and shows the corresponding objects and methods.

1 Create a new `HeaderHandlerResolver`. Then set the message security handlers for cookie extraction and for inserting the SAML token and credentials in the SOAP header.


HeaderHandler Resolver
HeaderCookieExtractionHandler (session cookie)
TimestampHandler
SamlTokenHandler (SAML token)
WsSecurityUserCertificateSignatureHandler (key, certificate, ID)

2 Get the VIM port.



3	Set the connection endpoint in the HTTP request context.	
4	Call the `LoginByToken()` method. The method invocation executes the handlers to insert the elements into the message headers. The method returns a session cookie that identifies the newly created session.	`VimPortType.LoginByToken()`
5	Extract the cookie and save it for later use.	`HeaderCookieExtractionHandler.getCookie()`

The following examples shows Java code that calls the `LoginByToken()` method.

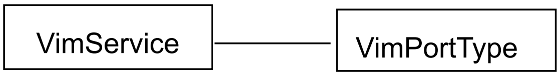
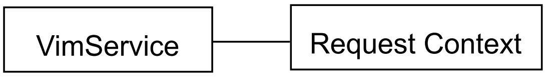
Example: Using LoginByToken

```
/*
 * Create a handler resolver and add the handlers.
 * Create a cookie extraction handler and add it to the handler resolver.
 */
HeaderHandlerResolver handlerResolver = new HeaderHandlerResolver();
HeaderCookieExtractionHandler cookieExtractor = new HeaderCookieExtractionHandler();
handlerResolver.addHandler(cookieExtractor);
handlerResolver.addHandler(new TimeStampHandler());
handlerResolver.addHandler(new SamlTokenHandler(token));
handlerResolver.addHandler(new WsSecuritySignatureAssertionHandler(
                                                 userCert.getPrivateKey(),
                                  userCert.getUserCert(),
                                  Utils.getNodeProperty(token, "ID")));
vimService.setHandlerResolver(handlerResolver);

/*
 * Create a handler resolver.
 * Set the VIM service handler resolver.
 */
vimService.setHandlerResolver(handlerResolver);
/*
 *  Get the Vim port; this call clears the request context.
 */
vimPort = vimService.getVimPort();

/*
 * Retrieve the request context and set the server URL.
 */
Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();
ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, vcServerUrl);
ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);

/*
```

```
 * Call LoginByToken.
 */
UserSession us = vimPort.loginByToken(serviceContent.getSessionManager(), null);

/*
 * Save the HTTP cookie.
 */
 String cookie = cookieExtractor.getCookie();
```

Restoring the vCenter Server Session Cookie in a Java Client

After you log in, you must restore the standard vCenter Server session context. The code fragment in this section restores the default message handler and the session cookie. As the cookie handler has been replaced by the default handler, the client resets the session cookie by calling request context methods to access the context fields directly. The following sequence describes these steps and shows the corresponding objects and methods.

1	Restore the default message handler. The handlers used for `LoginByToken()` are not used in subsequent calls to the vSphere API.	`VimService.setHandlerResolver()`
2	Get the VIM port.	
3	Set the connection endpoint in the HTTP request context.	

4	Set the HTTP request header (vCenter Server session cookie).	`RequestContext.get()`
		`RequestContext.put()`

The following example shows Java code that restores the vCenter Server session. This code requires the vCenter Server URL and the cookie and default handler that were retrieved before login. See Sample Code for a Java Client to the Web Services SDK.

Example: Restoring the vCenter Server Session

```
/*
 * Reset the default handler. This overwrites the existing handlers, effectively removing them.
 */
vimService.setHandlerResolver(defaultHandler);
vimPort = vimService.getVimPort();

/*
 * Restore the connection endpoint in the request context.
 */
// Set the validated session cookie and set it in the header for once,
// JAXWS will maintain that cookie for all the subsequent requests

Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();
```

```
ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, vcServerUrl);
ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);

/*
 * Reset the cookie in the request context.
 */
Map<String, List<String>> headers =
  (Map<String, List<String>>) ctxt.get(MessageContext.HTTP_REQUEST_HEADERS);
if (headers == null) {
   headers = new HashMap<String, List<String>>();
}
headers.put("Cookie", Arrays.asList(cookie));
ctxt.put(MessageContext.HTTP_REQUEST_HEADERS, headers);
```

Establishing a Session with Username and Password Credentials

You can specify username and password credentials to establish a session with a vCenter Server. The following steps describe how a client application specifies username and password credentials for access to a vCenter Server.

Procedure

1. Create a connection to the vSphere server Web service.
2. Instantiate a local proxy object for reference to `ServiceInstance`. Use this local proxy object to retrieve the `ServiceContent` object from the server. `ServiceContent` contains a reference to the root folder for the inventory and references to the managed objects that provide the vSphere services.
3. Instantiate a local proxy object for access to vSphere API methods.
4. Log in to the server using appropriate credentials (user account, password, and optionally the locale).
5. Access server-side objects to retrieve data and perform management operations.
6. Close the connection.

Overview of a Java Sample Application for the Web Services SDK

This section includes an example of a complete client application that demonstrates the basic client capability. The sample client application prints out the product name, server type, and product version to demonstrate that it is connected and able to retrieve information from the server.

While Example: Java Test Client Application is a complete client application that demonstrates the basic client capability, it uses a slightly different format than the Java sample files in the `SDK\` directory. This example, and the Java samples that are included with your vSphere Web Service SDK, have been compiled using JAX-WS bindings.

Most of the vSphere Web Services SDK samples do not handle exceptions, and they accept all security certificates. Use the samples as examples for extracting the types of data you want to view, but do not use these security or exception techniques in your production applications.

Build a Simple vSphere Client Application for the Web Services SDK

This simple client application accepts command-line arguments for the vSphere server name (DNS name or IP address), user name, and password.

To build a simple vSphere client application in Java, use the following steps.

Procedure

1 Import the vSphere Web Services API libraries:

```
import com.vmware.vim25.*;
```

2 Import the necessary Java (and JAX-WS connection, bindings, and SOAP) libraries:

```
import java.util.*;
import javax.net.ssl.HostnameVerifier;
import javax.net.ssl.HttpsURLConnection;
import javax.net.ssl.SSLSession;
import javax.xml.ws.BindingProvider;
import javax.xml.ws.soap.SOAPFaultException;
```

3 Create the `TestClient` class:

```
public class TestClient {
```

4 Include the class variable declarations/definitions. Use a `TrustManager` class to accept all certificates, as shown in Accessing the vSphere Web Services HTTP Endpoint with JAX-WS . This is not appropriate for a production environment. Production code should implement certificate support.

5 Use the vSphere Web Services APIs to create the connection, as shown in Accessing the vSphere Server from a Web Services Client.

6 Retrieve data from the vSphere or vCenter Server. In this example, we are just going to print out the product name, server type, and product version to prove that the client is connected and working correctly.

```
System.out.println(serviceContent.getAbout().getFullName());
System.out.println("Server type is " + serviceContent.getAbout().getApiType());
System.out.println("API version is " + serviceContent.getAbout().getVersion());
```

7 Use the `VimPort` object to close the connection, as shown in Closing the Connection from a Web Services Client. Always close your server connections to maintain security.

Java Client Example for the Web Services SDK

This example shows the complete sample client application code, without the explanatory steps. The example opens a connection with the server, retrieves the service content, uses the session manager managed object reference to log in, displays information about the server, and closes the connection.

Example: Java Test Client Application

```
import com.vmware.vim25.*;
import java.util.*;
import javax.net.ssl.HostnameVerifier;
import javax.net.ssl.HttpsURLConnection;
import javax.net.ssl.SSLSession;
import javax.xml.ws.BindingProvider;
import javax.xml.ws.soap.SOAPFaultException;

public class TestClient {

// Authentication is handled by using a TrustManager and supplying
// a host name verifier method. (The host name verifier is declared
// in the main function.)
private static class TrustAllTrustManager
   implements javax.net.ssl.TrustManager,
              javax.net.ssl.X509TrustManager {

   public java.security.cert.X509Certificate[] getAcceptedIssuers() {
      return null;
   }

   public boolean isServerTrusted(java.security.cert.X509Certificate[] certs) {
      return true;
   }

   public boolean isClientTrusted(java.security.cert.X509Certificate[] certs) {
      return true;
   }

   public void checkServerTrusted(java.security.cert.X509Certificate[] certs,
                                  String authType)
      throws java.security.cert.CertificateException {
         return;
   }

   public void checkClientTrusted(java.security.cert.X509Certificate[] certs,
                                  String authType)
      throws java.security.cert.CertificateException {
         return;
   }
}

public static void main(String[] args) {
  try {
     // Server URL and credentials.
     String serverName = args[0];
     String userName   = args[1];
     String password   = args[2];
     String url = "https://"+serverName+"/sdk/vimService";
     // Variables of the following types  for access to the API methods
     // and to the vSphere inventory.
     // -- ManagedObjectReference for the ServiceInstance on the Server
     // -- VimService for access to the vSphere Web service
     // -- VimPortType for access to methods
     // -- ServiceContent for access to managed object services
     ManagedObjectReference SVC_INST_REF = new ManagedObjectReference();
     VimService vimService;
     VimPortType vimPort;
     ServiceContent serviceContent;

     // Declare a host name verifier that will automatically enable
     // the connection. The host name verifier is invoked during
     // the SSL handshake.
     HostnameVerifier hv = new HostnameVerifier() {
        public boolean verify(String urlHostName, SSLSession session) {
           return true;
        }
      };
      // Create the trust manager.
      javax.net.ssl.TrustManager[] trustAllCerts = new javax.net.ssl.TrustManager[1];
      javax.net.ssl.TrustManager tm = new TrustAllTrustManager();
      trustAllCerts[0] = tm;

      // Create the SSL context
      javax.net.ssl.SSLContext sc = javax.net.ssl.SSLContext.getInstance("SSL");

      // Create the session context
      javax.net.ssl.SSLSessionContext sslsc = sc.getServerSessionContext();

      // Initialize the contexts; the session context takes the trust manager.
      sslsc.setSessionTimeout(0);
      sc.init(null, trustAllCerts, null);

      // Use the default socket factory to create the socket for the secure connection
      javax.net.ssl.HttpsURLConnection.setDefaultSSLSocketFactory(sc.getSocketFactory());
      // Set the default host name verifier to enable the connection.
      HttpsURLConnection.setDefaultHostnameVerifier(hv);

      // Set up the manufactured managed object reference for the ServiceInstance
      SVC_INST_REF.setType("ServiceInstance");
      SVC_INST_REF.setValue("ServiceInstance");

      // Create a VimService object to obtain a VimPort binding provider.
      // The BindingProvider provides access to the protocol fields
      // in request/response messages. Retrieve the request context
      // which will be used for processing message requests.
      vimService = new VimService();
      vimPort = vimService.getVimPort();
      Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();

      // Store the Server URL in the request context and specify true
      // to maintain the connection between the client and server.
      // The client API will include the Server's HTTP cookie in its
      // requests to maintain the session. If you do not set this to true,
      // the Server will start a new session with each request.
      ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, url);
      ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);

      // Retrieve the ServiceContent object and login
      serviceContent = vimPort.retrieveServiceContent(SVC_INST_REF);
      vimPort.login(serviceContent.getSessionManager(),
                    userName,
                    password,
                    null);

      // print out the product name, server type, and product version
      System.out.println(serviceContent.getAbout().getFullName());
      System.out.println("Server type is " + serviceContent.getAbout().getApiType());
      System.out.println("API version is " + serviceContent.getAbout().getVersion());

      // close the connection
      vimPort.logout(serviceContent.getSessionManager());
      } catch (Exception e) {
         System.out.println(" Connect Failed ");
         e.printStackTrace();
      }
   }//end main()
}// end class TestClient
```

// See Example: Obtaining a Session Token - Code Fragments from VMPromoteDisks.java for more details.

Compiling the Java Test Client in the Web Services SDK

Use the following command to compile the code for the Java Test Client Application, after you have saved it as a `.java` file:

```
c:>javac -classpath path-to-vim25.jar TestClient.java
```

Use the following command to execute the compiled class (binary) file:

```
c:>java -classpath path-to-vim25.jar TestClient web-service-url user-name user-password
```

Web Server Session Token

As with other Web services, the vSphere Web service maintains session state for each client connection by using a token in the HTTP header to identify the session. The vSphere server returns a session token to the client in its response to the client connection request. Subsequent messages between client and server automatically include the token.

Each of the stand-alone samples in the `SDK\vsphere-ws\java\JAX-WS\samples\com\vmware\` uses the JAX-WS TrustAllTrustCertificates class, as discussed in Example: Obtaining a Session Token - Code Fragments from VMPromoteDisks.java to ignore certificates, obtain a session token, and then connect to the server.

Caution We do not recommend that you trust all certificates in a production environment. Instead, you can look at the sample code to see how the JAX-WS libraries are used when making the connection, but set up an SSL policy that allows connection only with trusted certificates.

The logic for getting a cookie and putting it in the header looks like this:

```
//cookie logic
List cookies = (List) headers.get("Set-cookie");
cookieValue = (String) cookies.get(0);
StringTokenizer tokenizer = new StringTokenizer(cookieValue, ";");
cookieValue = tokenizer.nextToken();
String path = "$" + tokenizer.nextToken();
String cookie = "$Version=\"1\"; " + cookieValue + "; " + path;

// set the cookie in the new request header
Map map = new HashMap();
map.put("Cookie", Collections.singletonList(cookie));

((BindingProvider) vimPort).getRequestContext().put(
MessageContext.HTTP_REQUEST_HEADERS, map);
```

Accessing the vSphere Web Services HTTP Endpoint with JAX-WS

The steps for accessing any HTTP endpoint with JAX-WS bindings include the vSphere Web Services SDK Server URL, vSphere server object, and variables.

These steps are listed at the beginning of Example: Obtaining a Session Token - Code Fragments from VMPromoteDisks.java.

Procedure

1 Create a `TrustManager` class to handle certificate checking.

   In this example we use a `TrustManager` class to accept all certificates. This is not appropriate for a production environment. Production code should implement certificate support.

```
private static class TrustAllTrustManager
  implements javax.net.ssl.TrustManager,
  javax.net.ssl.X509TrustManager {

   public java.security.cert.X509Certificate[] getAcceptedIssuers() {
      return null;
   }

   public boolean isServerTrusted(
      java.security.cert.X509Certificate[] certs) {
      return true;
   }

   public boolean isClientTrusted(java.security.cert.X509Certificate[] certs) {
      return true;
   }

   public void checkServerTrusted(java.security.cert.X509Certificate[] certs,
                                  String authType)
         throws java.security.cert.CertificateException {
      return;
   }

   public void checkClientTrusted(java.security.cert.X509Certificate[] certs,
                                  String authType)
         throws java.security.cert.CertificateException {
      return;
   }
}
```

2 Include the Server URL and credentials as arguments in the main method:

```
public static void main(String[] args) {
  try {
     String serverName = args[0];
     String userName   = args[1];
     String password   = args[2];
     String url = "https://"+serverName+"/sdk/vimService";
```

3 Declare variables of the following types for access to vSphere server objects:

- `ManagedObjectReference` for the `ServiceInstance`.
- `VimService` object for access to the Web service.
- `VimPortType` object for access to all of the methods defined in the vSphere API.
- `ServiceContent` for access to the managed object services on the server.

  The following Java code fragment shows these variable declarations:

  ```
  ManagedObjectReference SVC_INST_REF
  VimService vimService;
  VimPortType vimPort;
  ServiceContent serviceContent;
  ```

4 Declare a host name verifier that will automatically enable the connection. The host name verifier is invoked during the SSL handshake.

```
HostnameVerifier hv = new HostnameVerifier() {
  public boolean verify(String urlHostName, SSLSession session) {
     return true;
  }
};
```

5 Instantiate the trust manager object.

```
// Create the trust manager.
javax.net.ssl.TrustManager[] trustAllCerts = new javax.net.ssl.TrustManager[1];
javax.net.ssl.TrustManager tm = new TrustAllTrustManager();
trustAllCerts[0] = tm;
```

6 Create the SSL context

```
javax.net.ssl.SSLContext sc = javax.net.ssl.SSLContext.getInstance("SSL");
```

7 Create the session context

```
javax.net.ssl.SSLSessionContext sslsc = sc.getServerSessionContext();
```

8 Initialize the contexts; the session context takes the trust manager.

```
sslsc.setSessionTimeout(0);
sc.init(null, trustAllCerts, null);
```

9 Use the default socket factory to create the socket for the secure connection

```
javax.net.ssl.HttpsURLConnection.setDefaultSSLSocketFactory(sc.getSocketFactory());
```

10 Set the default host name verifier to enable the connection.

```
HttpsURLConnection.setDefaultHostnameVerifier(hv);
```

Accessing the vSphere Server from a Web Services Client

The steps that use the vSphere Web Services API to create the connection are:

Procedure

1 Create a managed object reference for the `ServiceInstance` object on the server.

```
ManagedObjectReference SVC_INST_REF = new ManagedObjectReference();
SVC_INST_REF.setType("ServiceInstance");
SVC_INST_REF.setValue("ServiceInstance");
```

2. Create a VimService object to obtain a VimPort binding provider. The BindingProvider object provides access to the protocol fields in request/response messages. Retrieve the request context which will be used for processing message requests.

   The VimServiceLocator and VimPortType objects provide access to vSphere servers. The getVimPort method returns a VimPortType object that provides access to the vSphere API methods.

   ```
   vimService = new VimService();
   vimPort = vimService.getVimPort();
   Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();
   ```

3. Store the Server URL in the request context and specify true to maintain the connection between the client and server. The client API will include the server's HTTP cookie in its requests to maintain the session. If you do not set this to true, the server will start a new session with each request.

   ```
   ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, url);
   ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);
   ```

4. Retrieve the ServiceInstance content (the ServiceContent data object) and log in to the server.

   ```
   serviceContent = vimPort.retrieveServiceContent(SVC_INST_REF);
   vimPort.login(serviceContent.getSessionManager(),
                 userName,
                 password,
                 null);
   isConnected = true;
   ```

Closing the Connection from a Web Services Client

Use the VimPort object again to close the connection. Always close your server connections to maintain security.

```
        vimPort.logout(serviceContent.getSessionManager());
     } catch (Exception e) {
        System.out.println(" Connect Failed ");
        e.printStackTrace();
     }
  }//end main()
}// end class TestClient
```

Using the Java Samples as Reference

The following code fragment from the SDK\vsphere-ws\java\JAX-WS\samples\com\vmware\vm\VMPromoteDisks.java sample shows another implementation of the server connection. Review the stand-alone Java samples that are shipped with your *vSphere Web Services SDK*, and use similar code to get a session token for your client application.

Example: Obtaining a Session Token - Code Fragments from VMPromoteDisks.java

```
.
.
.
private static String cookieValue = "";
private static Map headers = new HashMap();
.
.
.
private static void trustAllHttpsCertificates()
   throws Exception {

   javax.net.ssl.TrustManager[] trustAllCerts = new javax.net.ssl.TrustManager[1];
   javax.net.ssl.TrustManager tm = new TrustAllTrustManager();
   trustAllCerts[0] = tm;
   javax.net.ssl.SSLContext sc = javax.net.ssl.SSLContext.getInstance("SSL");
   javax.net.ssl.SSLSessionContext sslsc = sc.getServerSessionContext();
   sslsc.setSessionTimeout(0);
   sc.init(null, trustAllCerts, null);
   javax.net.ssl.HttpsURLConnection.setDefaultSSLSocketFactory(sc.getSocketFactory());
}
...
private static void connect()
   throws Exception {

   HostnameVerifier hv = new HostnameVerifier() {
      public boolean verify(String urlHostName, SSLSession session) {
         return true;
      }
   };
   trustAllHttpsCertificates();
   HttpsURLConnection.setDefaultHostnameVerifier(hv);

   SVC_INST_REF.setType(SVC_INST_NAME);
   SVC_INST_REF.setValue(SVC_INST_NAME);

   vimService = new VimService();
   vimPort = vimService.getVimPort();
   Map<String, Object> ctxt =
      ((BindingProvider) vimPort).getRequestContext();

   ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, url);
   ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);

   serviceContent = vimPort.retrieveServiceContent(SVC_INST_REF);
   headers =
      (Map) ((BindingProvider) vimPort).getResponseContext().get(
              MessageContext.HTTP_RESPONSE_HEADERS);
   vimPort.login(serviceContent.getSessionManager(),
                 userName,
                 password, null);
```

```
        isConnected = true;

        propCollectorRef = serviceContent.getPropertyCollector();
        rootRef = serviceContent.getRootFolder();
     }
     ...
```

Multiple Versions of the vSphere API

When a client application connects to a Web service running on a vSphere server (ESXi or vCenter Server system), the server detects the version of the API that was used to develop the client and makes available only those operations supported by the client.

Client applications convey information about the API version used in the SOAP messages that they send to a vSphere server. These SOAP messages include a `versionID` in the `soapAction` attribute. The details are handled transparently by the SOAP toolkit and the client proxy code. The server adjusts its behavior based on the client's version information, exposing the API version that the client supports to the client.

Starting with vSphere 4.0, information about the supported API versions is contained in an XML file, `vimServiceVersions.xml`, located on the server (see Example: Service-Versions File (vimServiceVersions.xml)). You can access this file with the URL https://*server_hostname*/`sdk/vimServiceVersions.xml`.

Example: Service-Versions File (vimServiceVersions.xml)

```
<?xml version="1.0" encoding="UTF-8" ?>
- <!--    Copyright 2008-2010 VMware, Inc.  All rights reserved. -->
- <namespaces version="1.0">
     - <namespace>
            <name>urn:vim25</name>
            <version>5.0</version>
     - <priorVersions>
          <version>2.5u2</version>
          <version>2.5</version>
       </priorVersions>
     </namespace>
     - <namespace>
          <name>urn:vim2</name>
          <version>2.0</version>
       </namespace>
  </namespaces>
```

If you are developing a client application that must support multiple server versions at the same time (ESXi 5.0 and ESXi 5.5, for example), you must obtain information about the API versions that are supported on the server and provide logic in your code to use or not use features, based upon the version information.

One approach to targeting multiple versions of the API from the same client application code is to check for the existence of the server versions file on the server. If you do not find a `vimServiceVersions.xml` file on the server, the server is older than ESX/ESXi 4.x, vCenter Server 4.x.

Java and C# Sample Applications in the Web Services SDK

The vSphere Web Services SDK includes sample applications, written in Java and C#, that demonstrate features of the vSphere API and object model. Most of the samples do not handle exceptions, and they accept all security certificates. So use the applications as examples for extracting the types of data you want to view, but do not use the helper classes, trust store methods or exception handling techniques in your production environment.

Java Samples in the Web Services SDK

The Java samples in your vSphere Web Services SDK include `.java` files that you can compile and then run using any Java editor or IDE. The samples accept command-line arguments for the vSphere server name (DNS name or IP address), user name, and password.

C# Samples in the Web Services SDK

The C# samples in your vSphere Web Services SDK include a `.cs` file and three project files in each directory (`.proj`, `2008.proj`, and `2010.proj`) so you can run them using Microsoft's Visual Studio.

Like the Java samples, the C# samples also accept command-line arguments for the vSphere server name (DNS name or IP address), user name, and password, and they accept all certificates to establish the SSL handshake.

Unlike the Java samples, the C# samples use the helper classes discussed in Helper Classes for C# Sample Applications in the Web Services SDK.

Helper Classes for C# Sample Applications in the Web Services SDK

The C# sample applications included with the vSphere Web Services SDK include C# helper classes that handle the details of creating sessions, obtaining session tokens, saving the session token as a string to a file, and reusing the session. The Microsoft .NET Web services implementation uses the `Cookie` class to handle the session information from the server.

The helper classes (listed in the following table) handle command-line input such as common parameters, server name, and other details. These helper classes are located in the unpacked C# version of the SDK download, in this location:

C# Helper Classes

```
%SDKHOME%\vsphere-ws\dotnet\cs\samples\AppUtil
```

AppUtils	Functional Description
`AppUtil.cs`	Convenient methods you can use to handle user input from command line. Catches errors (faults). Logs output to console.
`AppUtil.csproj`	Convenient methods you can use to handle user input from command line., built to run on versions of Microsoft Visual Studio that were released before 2008.
`ArgumentHandlingException.cs`	Convenient methods you can use to handle exceptions.
`CertPolicy.cs`	Convenient methods you can use to customize certificate error messages.
`ClientUtil.cs`	Convenient methods you can use to handle user input from command line. Catches errors (faults). Logs output to console.
`CustomSecurity.cs`	Convenient methods you can use to override the SOAP security filter.
`CustomSecurityAssertionBearer.cs`	Convenient methods you can use to create a custom policy assertion that applies security to a SOAP message exchange.
`Log.cs`	Convenient methods you can use to create a log file or send log output to the console.
`OptionSpec.cs`	Helper class for handling default and custom command-line arguments.
`PropertyManager.cs`	Convenient methods you can use to listen for Property Manager updates.
`ServiceUtil.cs`	Wrapper methods for the `vimService` methods (the local proxy code methods) for API 2.0 and prior releases.
`SvcConnection.cs`	Convenient methods you can use to create a Web service connection handler.
`TrustAllCertificatePolicy.cs`	Creates an instance of local proxy for connecting to the server, and obtains managed object references to several needed managed objects—`ServiceInstance`, `ServiceContent`, `rootFolder`.
`VersionUtil.cs`	Convenient methods you can use to retrieve the namespace and API version.
`VMUtils.cs`	Convenient methods you can use to create a virtual machine configuration spec.

Datacenter Inventory 4

The vSphere inventory is a representation of the vSphere datacenter and the objects in the datacenter. Knowing how the objects in the datacenter relate to each other helps you traverse the inventory hierarchy and access the objects you want to manipulate.

This chapter includes the following topics:

Inventory Overview for the Web Services SDK

The vSphere inventory contains the following types of objects:

- Systems in the datacenter: `Host`, `VirtualMachine`, and `VirtualApp`.
- Support components: `ComputeResource`, `Datastore`, `Network`, and virtual devices.
- Organizational components: `Folder` and `Datacenter`

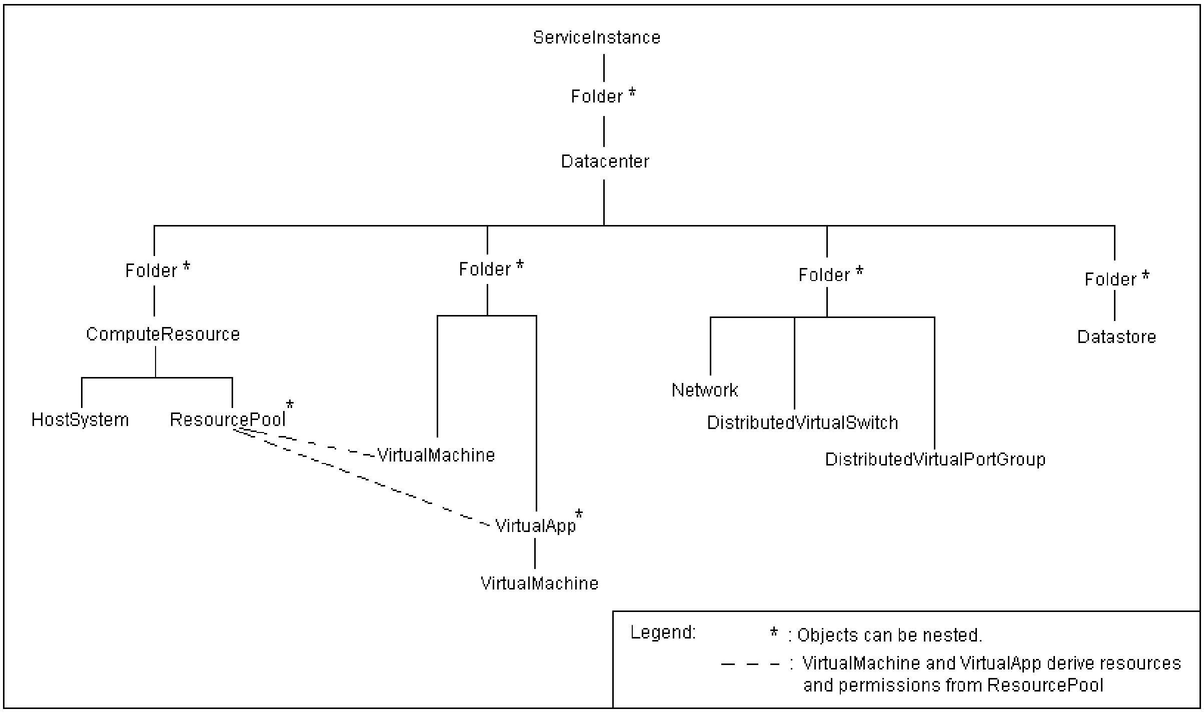
When you manage the virtual infrastructure, you access objects and their properties and methods based on their location in the inventory. Understanding the inventory structure is therefore critical for any programming task. You always start with the `ServiceInstance` associated with a session, which is the root object of the inventory, and traverse the inventory hierarchy from there. See Chapter 5 Property Collector. How you access objects depends on whether your client application is connected to a vCenter Server or an ESXi host.

Inventory Hierarchies and ServiceInstance

When you start a session, vSphere creates a `ServiceInstance` with one root folder, one `Datacenter`, and four folders that hold the different types of inventory objects.

When you access a vCenter Server System, the hierarchy shown in the illustration below allows you to traverse the inventory.

Figure 4-1. vCenter Server Inventory Hierarchy



Caution If your ESXi hosts are managed by vCenter Server, you must always access your hosts through vCenter Server. The vCenter service keeps track of all synchronous and asynchronous operations, and will have the latest status and inventory information about each ESXi host. Therefore, connecting directly to a managed host may give you incorrect or incomplete data.

When you have ESXi hosts that are not managed by vCenter Server, your application can connect to each host directly.

Folders in the Hierarchy

If your installation includes a vCenter Server system, you can create additional datacenters under the root folder. For every `Datacenter` object, the server automatically creates the following `Folder` objects:

- A folder for `VirtualMachine`, template, and `VirtualApp` objects.
- A folder for a `ComputeResource` hierarchy.
- A folder for `Network`, `DistributedVirtualSwitch`, and `DistributedVirtualPortgroup` objects.
- A folder for `Datastore` objects.

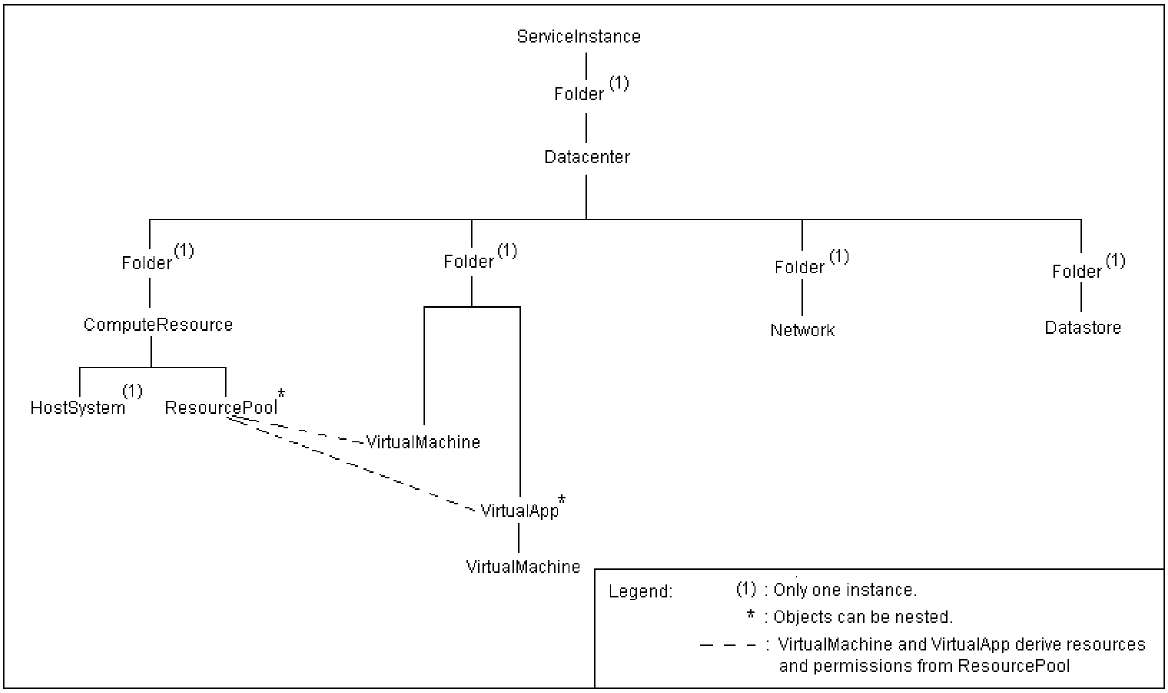
In a large deployment, the nested structure allows you to organize the objects in the datacenter into an easily manageable structure by using multiple folders and datacenters.

For a standalone ESXi system, only a single datacenter is supported, and the `Folder` managed entity does not support creating additional `Folder` objects or `Datacenter` objects.

ESXi Inventory Hierarchy

When you access an ESXi host directly, rather than accessing the host through a vCenter Server system, the hierarchy shown in the illustration below allows you to traverse the inventory.

Figure 4-2. ESXi Inventory Hierarchy



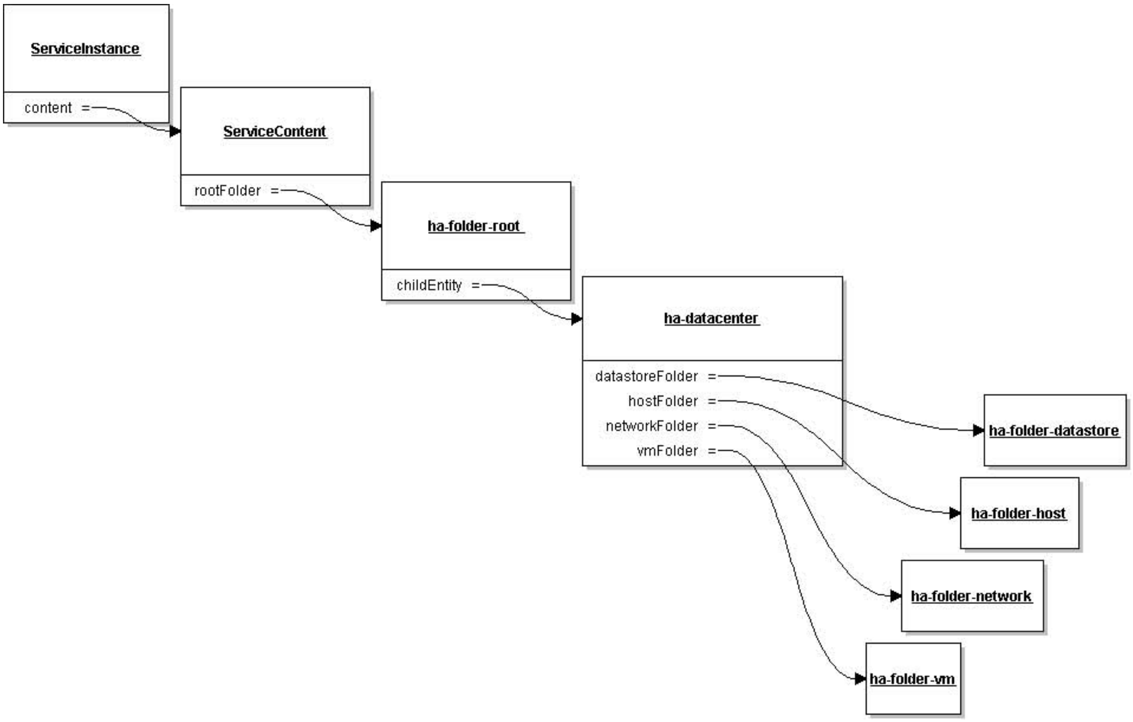
Accessing Inventory Objects

To retrieve information from an inventory object, you start with `ServiceInstance`, the root object of the inventory. You access an object using a `TraversalSpec` in conjunction with a property collector, using the properties that identify an object's position in the hierarchy.

- Every managed entity has a `parent` property that identifies its relative position in the inventory hierarchy.
- The `Folder` managed object has a `childEntity` property that identifies objects in a folder instance.

Figure 4-3 shows the `childEntity` and `folder` properties that define the default objects in the inventory of a standalone ESXi system. The inventory begins with the `ServiceContent.rootFolder` property. The `rootFolder` has a `childEntity` that consists of a managed object reference to a `Datacenter` managed object.

Figure 4-3. Instance Diagram of Root Folders in an Inventory



Creating Inventory Objects

The `Folder` managed entity provides methods for creating instances of the following managed entities.

- `Datacenter`
- `DistributedVirtualSwitch`
- `VirtualMachine`
- `Cluster`
- `Folder`

When you create these objects, they appear in the folder you invoked the creation method from.

While some managed entities are created through a method on the `Folder` managed entity, other managed entities are instantiated directly. For example, the `HostDatastoreSystem` has methods for creating datastores such as `CreateNasDatastore` and `CreateVmfsDatastore`.

Important When you create an inventory object, you must stay within the bounds of the host's capabilities, accessible through the `HostSystem.capability` property, which is a `HostCapability` data object. For example, a `HostCapability` object might have the `maxSupportedVMs` property specified.

Privileges Required for Inventory Management

Navigating the inventory requires a user account that can connect to the server and obtain a valid session. The user identity associated with the session is called a principal. When a client application attempts to access an object in the inventory, the server checks the permission object or objects and compares the permissions with the principal's privileges.

For example, creating a virtual machine requires that the principal associated with the session have the following privileges:

- The `VirtualMachine.Inventory.Create` privilege on the folder in which to create the virtual machine.
- The `Resource.AssignVMToPool` privilege on the resource pool from which the virtual machine obtains its allocation of CPU and memory resources.

Reading the `perfCounter` property of the `PerformanceManager` managed object requires the `System.View` privilege on the root folder.

Important Some privileges are specific to objects on vCenter Server or specific to ESXi. For example, the `Alarm.Create` privilege associated with `AlarmManager` is available only through vCenter Server systems.

See Chapter 6 Authentication and Authorization for more information on authentication, authorization, roles, and user identity.

Privileges

A privilege is a system-defined requirement associated with a VMware vSphere managed object. Privileges are static and do not change for a version of a product. Privileges for vSphere components are defined as follows:

```
<group>[.<group>].privilege
```

For example:

```
Datacenter.Create
Host.Config.Connection
Host.Config.Snmp
```

Permissions

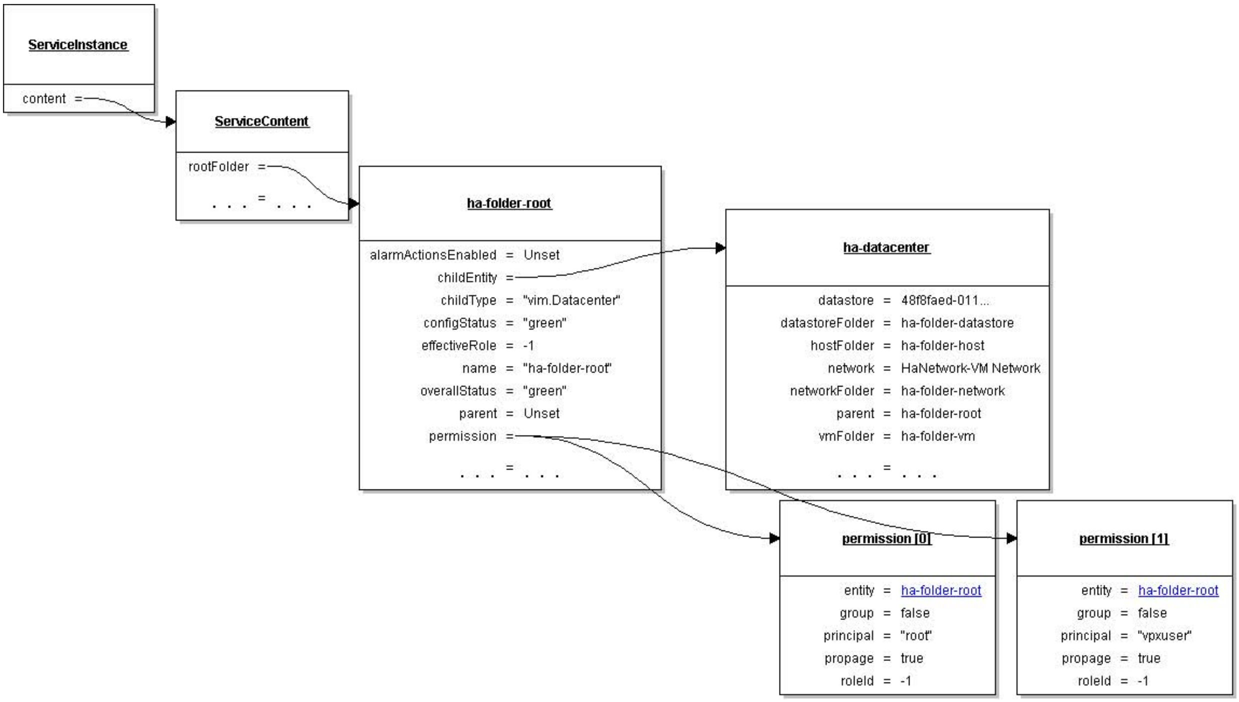
Permissions are the associations of roles with privileges on a specified managed entity. You use permissions to specify which users can access which managed entity.

A child entity inherits the permissions of its parent if the parent's `propagate` property is set to true. A permission that is set directly on a child overrides the permission in the parent. To grant permission to all child entities of a `Datacenter` object, assign permissions to the `Datacenter` object and set the `Permission` object's `propagate` property to `true`.

Figure 4-4 shows that users `root` and `vpxuser` both have permissions on the `rootFolder` of the inventory. The `vpxuser` is the account created on a host by the vCenter Server system when that host is added to the vCenter Server system. The vCenter Server system needs access to the inventory objects of the host systems that it manages, so the `vpxuser` account is granted privileges to the `rootFolder` of each host.

Important See Chapter 6 Authentication and Authorization for a detailed discussion of privileges, permissions, and user management.

Figure 4-4. Inventory and Permissions



Managed and Standalone ESXi Hosts

You can run ESXi as a managed or standalone ESXi host.

- Standalone ESXi hosts are standalone hosts with limited capabilities. The inventory of a standalone host can support multiple virtual machines and multiple resource pools, but it contains a single default datacenter and a single root folder. The default datacenter and root folder are not visible in the vSphere Client, but they exist in the inventory of a standalone host and they are visible in the MOB.
- Managed ESXi hosts have been added to the vCenter Server inventory. Available features depend on the licenses available for that host. For example, you can configure two or more hosts for VMware DRS resource management or VMware HA failover protection.

The following table summarizes the differences between the number of objects that an inventory can contain. See also Figure 4-2 and Figure 4-1.

ManagedEntity Subtype	ESX/ESXi Inventory	vCenter Server Inventory
`ClusterComputeResource`	None.	Multiple instances supported.
`ComputeResource`	Exactly one only.	Multiple instances supported.
`Datacenter`	Exactly one only. Cannot be destroyed. Transparent.	Multiple instances supported.
`Datastore`	Multiple instances supported.	Multiple instances supported.
`DistributedVirtualSwitch`	Multiple instances supported.	Multiple instances supported.
`Folder`	Exactly one only. Cannot be destroyed. Transparent.	Multiple instances supported.
`HostSystem`	Exactly one only.	Multiple instances supported.
`Network`	Multiple instances supported.	Multiple instances supported.
`ResourcePool`	Multiple instances supported.	Multiple instances supported.
`VirtualApp`	None.	Multiple instances supported.
`VirtualMachine`	Multiple instances supported.	Multiple instances supported.

Property Collector 5

vSphere servers provide the `PropertyCollector` service for accessing data and monitoring changes. Use the `PropertyCollector` to obtain references to managed objects, to obtain values of managed object properties, and to monitor and retrieve modified property values.

This chapter includes the following topics:

Introduction to the PropertyCollector

The `PropertyCollector` service interface provides a way to monitor and retrieve information about managed objects, such as whether a virtual machine is powered on or whether a host in a cluster is offline.

The `PropertyCollector` uses one or more filters to determine the scope of collection and it has methods to retrieve data. A filter uses a set of data objects that specify the following information:

- Starting point for inventory traversal during the collection operation.
- Inventory traversal path.
- Objects and properties from which data will be collected.

A vSphere server creates a default `PropertyCollector` for every session, and allows you to create multiple, additional `PropertyCollector` objects. Create additional `PropertyCollector` objects, using one per thread, to perform mutually independent collection operations.

Data Retrieval

There are two ways to retrieve data:

- Property retrieval as a single operation uses the RetrievePropertiesEx and ContinueRetrievePropertiesEx methods. These methods perform a single collection operation.
- Incremental property retrieval, also referred to as property monitoring, uses the WaitForUpdatesEx method. The initial call to this method retrieves a baseline set of managed object property values. Subsequent calls retrieve changes in property values since the last retrieval. Use WaitForUpdatesEx to monitor changes to the inventory or any managed object properties.

> **Note** The PropertyCollector does not guarantee the order of data that it returns in response to a request for data.

Inventory Traversal and Object Selection

PropertyCollector filter properties identify object properties and paths that define inventory traversal. For example, you can retrieve the properties for a VirtualMachine object and specify a traversal path using the VirtualMachine.network property to obtain the properties for the associated Network objects.

You can use vSphere view objects (for example, ContainerView) in filters to simplify traversal specification. A view maintains a subset of inventory objects, so if there is a change in the inventory hierarchy, you do not have to recreate the view. Use a view to specify a set of objects that the PropertyCollector can use for data collection.

For information about the vSphere inventory, see Inventory Traversal and Object Selection.

vSphere Data Objects for Property Collection

The following table provides an overview of the PropertyCollector data objects. For more detailed descriptions, see the *vSphere API Reference*.

Data Object	Description
PropertyFilterSpec	Provides access to object and property selection data. A PropertyFilterSpec must have at least one ObjectSpec and one PropertySpec.
ObjectSpec	Identifies the starting object for property collection. An ObjectSpec also identifies additional objects for collection.
TraversalSpec	Identifies the type of object for property collection. It also provides one or more paths for inventory traversal.
SelectionSpec	Acts as a placeholder reference to a TraversalSpec.
PropertySpec	Identifies properties for collection.
View objects	Identify a subset of the vSphere inventory objects.

vSphere Methods for Property Collection

The PropertyCollector supports the following approaches to obtaining objects and properties from the server:

- If your client application does not keep a synchronized representation of server state, use the RetrievePropertiesEx method. RetrievePropertiesEx instantiates a filter, collects the specified objects and properties, and returns the data to your client application as an ObjectContent data object. The server does not add the filter to the PropertyCollector.filter array. The server destroys the filter after returning the results to your client.
- If your application maintains a synchronized representation of server state, use the CreateFilter and WaitForUpdatesEx methods. WaitForUpdatesEx returns descriptions of property changes, organized by the filter that identified the properties.

In either case, you create a PropertyFilterSpec data object to specify the objects and properties you want to retrieve from the server.

The following table shows the PropertyCollector methods organized by the context in which you use them. For more information about these methods, see the *vSphere API Reference*.

Method Context	Method	Description
Monitor properties using different filters	CreatePropertyCollector	Creates a new PropertyCollector object to monitor properties using different filters. The vSphere server handles requests for a PropertyCollector instance independently of any other instances of the PropertyCollector on the server.
	DestroyPropertyCollector	Destroys an instance of a PropertyCollector that was created by a call to CreatePropertyCollector from your client application.
Single collection operation	RetrievePropertiesEx	Retrieves property data for the specified managed objects.
	ContinueRetrievePropertiesEx	Retrieves additional property data for an operation started by RetrievePropertiesEx.
	CancelRetrievePropertiesEx	Cancels a RetrievePropertiesEx or ContinueRetrievePropertiesEx operation.
Incremental collection or monitoring operation	WaitForUpdatesEx	Retrieves changes to property data since the last WaitForUpdatesEx cycle. WaitForUpdatesEx blocks until it can satisfy the request or until the request times out. WaitForUpdatesEx supports chunked data transmission (see Server Data Transmission).
	CancelWaitForUpdatesEx	Cancels a WaitForUpdatesEx operation.
General	CreateFilter	Creates a new instance of a PropertyFilter managed object.

Retrieve Properties with the PropertyCollector

The following procedure shows how to retrieve properties of managed objects by using the RetrievePropertiesEx method. The procedure steps are illustrated by code fragments.

This procedure shows only the task of using the PropertyCollector. For a description of server connection, see Build a Simple vSphere Client Application for the Web Services SDK. You can also see these code fragments in the context of an end-to-end example that includes connection and authentication logic, in Build a Simple vSphere Client Application for the Web Services SDK.

To do a single retrieval operation with the PropertyCollector, use the following steps.

Procedure

1. Get references to the ViewManager and the PropertyCollector.

   In the example, sContent is the variable for the ServiceContent data object. sContent provides the methods to retrieve the managed object references to the vSphere services.

   ```
   ManagedObjectReference viewMgrRef = sContent.getViewManager();
   ManagedObjectReference propColl = sContent.getPropertyCollector();
   ```

2. Create a container view for virtual machines.

   methods is the variable for the VimPortType object. VimPortType defines the Java methods that correspond to the vSphere API methods. The createContainerView parameters container (the inventory root folder, returned by the method sContent.getRootFolder) and type ("Virtual Machine") direct the ViewManager to select virtual machines, starting at the root folder. The value true for the recursive parameter extends the selection beyond the root folder so that the ViewManager will follow child folder paths to add virtual machines to the view. The container view provides references to all virtual machines in the inventory.

   ```
   List<String> vmList = new ArrayList<String>();
   vmList.add("VirtualMachine");

   ManagedObjectReference cViewRef = methods.createContainerView(viewMgrRef,
       sContent.getRootFolder(),
       vmList,
       true );
   ```

3. Create an object specification to define the starting point for inventory navigation.

   The ObjectSpec.obj property identifies the starting object (the container view). This example collects only virtual machine data, so the skip property is set to true to ignore the container view itself during collection.

   ```
   ObjectSpec oSpec = new ObjectSpec();
   oSpec.setObj(cViewRef);
   oSpec.setSkip(true);
   ```

4. Create a traversal specification to identify the path for collection.

   The TraversalSpec properties type and path determine path traversal. TraversalSpec.type identifies an object type. TraversalSpec.path identifies a property in the type object. The PropertyCollector uses the path object to select additional objects.

This example uses a single TraversalSpec to walk the list of virtual machines that are available through the container view. The following code fragment specifies the ContainerView object for the TraversalSpec.type property and the view property in the ContainerView for the TraversalSpec.path property. The skip property is set to false, so the PropertyCollector will collect data from the path objects (the virtual machines in the container view).

```
TraversalSpec tSpec = new TraversalSpec();
tSpec.setName("traverseEntities");
tSpec.setPath("view");
tSpec.setSkip(false);
tSpec.setType("ContainerView");
```

5 Add the TraversalSpec to the ObjectSpec.selectSet array.

```
oSpec.getSelectSet().add(tSpec);
```

6 Identify the properties to be retrieved.

The example program creates a PropertySpec data object to specify the properties to be collected. The type property is set to VirtualMachine to match the object selections in the container view. The pathSet property identifies one or more properties in the type object.

This example specifies the VirtualMachine.name property.

```
PropertySpec pSpec = new PropertySpec();
pSpec.setType("VirtualMachine");
pSpec.getPathSet().add("name");
```

7 Add the object and property specifications to the property filter specification.

A PropertyFilterSpec must have at least one ObjectSpec and one PropertySpec.

```
PropertyFilterSpec fSpec = new PropertyFilterSpec();
fSpec.getObjectSet().add(oSpec);
fSpec.getPropSet().add(pSpec);
```

8 Create a list for the filters and add the spec to it.

```
List<PropertyFilterSpec> fSpecList = new ArrayList<PropertyFilterSpec>();
fSpecList.add(fSpec);
```

9 Retrieve the data.

To invoke a single property collection operation, call the RetrievePropertiesEx method. The example application passes the populated PropertyFilterSpec and an empty options structure to the method. The default for the RetrieveOptions.maxObjects specifies that no maximum for the number of objects that can be returned is set. The PropertyCollector can impose a maximum. If the number of collected objects is greater than the maximum, the PropertyCollector returns a token value in the RetrieveResult data object and this token is used to retrieve the remaining properties using the ContinueRetrievePropertiesEx API method. For more information, see Server Data Transmission.

```
RetrieveOptions ro = new RetrieveOptions();
RetrieveResult props = methods.retrievePropertiesEx(propColl,fSpecList,ro);
```

10 Print the virtual machine names.

The following code fragment walks the list of ObjectContent objects returned in the RetrieveResult object. For each object (ObjectContent), the inner loop prints the name-value pairs.

```
if (props != null) {
   for (ObjectContent oc : props.getObjects()) {
   String vmName = null;
   String path = null;
   List<DynamicProperty> dps = oc.getPropSet();
   if (dps != null) {
      for (DynamicProperty dp : dps) {
         vmName = (String) dp.getVal();
         path = dp.getName();
         System.out.println(path + " = " + vmName);
      }
   }
}
```

Simple Property Collector Program in Java for Web Services SDK

The Property Collector provides a powerful, flexible, and efficient way to collect data from vCenter Server or ESXi.

Example: Simple PropertyCollector Example (Java) is a simple PropertyCollector example written in Java. The example uses a ContainerView for efficient access to the inventory and a PropertyFilterSpec that contains one ObjectSpec, one TraversalSpec, and one PropertySpec. The program performs the following tasks:

1 Accepts command line arguments for the vSphere server name (DNS name or IP address), user name, and password.

2 Connects to a vSphere server.

3 Uses a ContainerView to create a subset of the inventory; the subset contains only virtual machines.

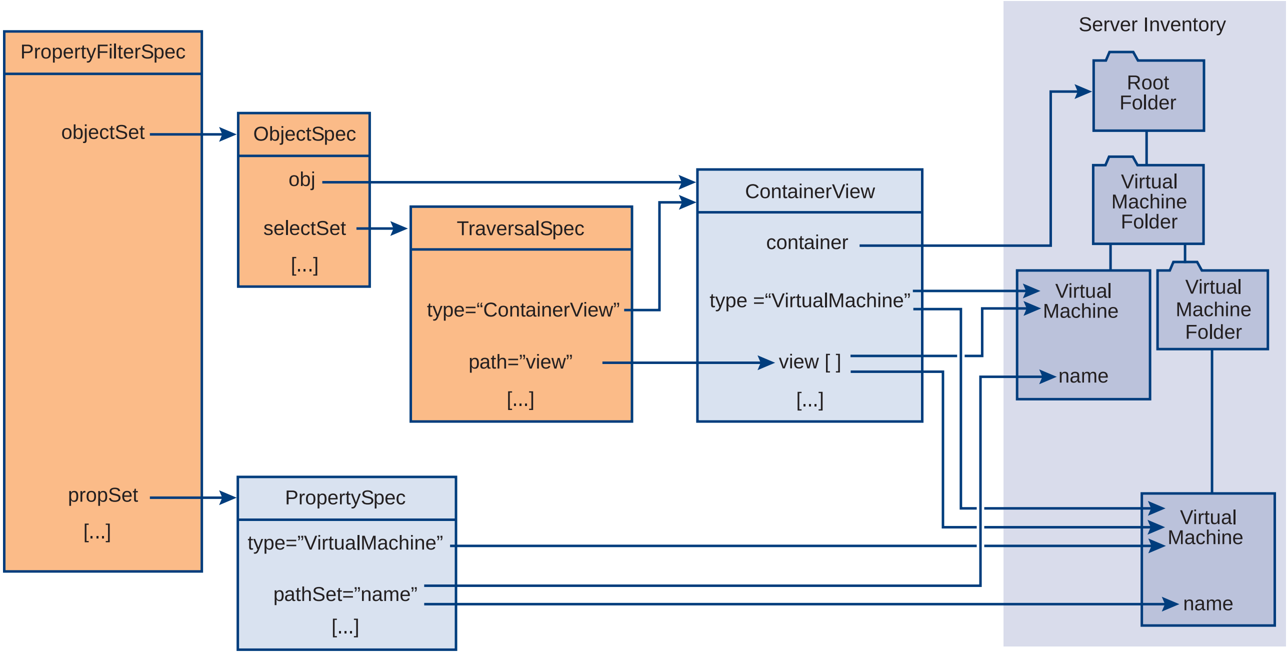
4 Uses the RetrievePropertiesEx method for a single retrieval operation.

5 Collects the names of all of the virtual machines in the inventory and prints the names using the standard output stream.

6 Closes the connection to the server.

Figure 5-1 shows the objects used in Example: Simple PropertyCollector Example (Java). The figure represents properties that identify inventory elements directly or indirectly. It does not show all the properties for the different objects.

Figure 5-1. Property Filter Specification



Example: Simple PropertyCollector Example (Java)

```
import com.vmware.vim25.*;

import java.util.*;
import javax.net.ssl.HostnameVerifier;
import javax.net.ssl.HttpsURLConnection;
import javax.net.ssl.SSLSession;
import javax.xml.ws.BindingProvider;
import javax.xml.ws.soap.SOAPFaultException;


// PropertyCollector example
// command line input: server name, user name, password

public class PCollector {

  private static void collectProperties(VimPortType methods,
                                        ServiceContent sContent) throws Exception {
    // Get references to the ViewManager and PropertyCollector
    ManagedObjectReference viewMgrRef = sContent.getViewManager();
    ManagedObjectReference propColl = sContent.getPropertyCollector();

    // use a container view for virtual machines to define the traversal
    // - invoke the VimPortType method createContainerView (corresponds
    //   to the ViewManager method) - pass the ViewManager MOR and
    //   the other parameters required for the method invocation
```

```
      // – createContainerView takes a string[] for the type parameter;
      //   declare an arraylist and add the type string to it
      List<String> vmList = new ArrayList<String>();
      vmList.add("VirtualMachine");

      ManagedObjectReference cViewRef = methods.createContainerView(viewMgrRef,
                                                                    sContent.getRootFolder(),
                                                                    vmList,
                                                                    true);

      // create an object spec to define the beginning of the traversal;
      // container view is the root object for this traversal
      ObjectSpec oSpec = new ObjectSpec();
      oSpec.setObj(cViewRef);
      oSpec.setSkip(true);

      // create a traversal spec to select all objects in the view
      TraversalSpec tSpec = new TraversalSpec();
      tSpec.setName("traverseEntities");
      tSpec.setPath("view");
      tSpec.setSkip(false);
      tSpec.setType("ContainerView");

      // add the traversal spec to the object spec;
      // the accessor method (getSelectSet) returns a reference
      // to the mapped XML representation of the list; using this
      // reference to add the spec will update the list
      oSpec.getSelectSet().add(tSpec);

      // specify the property for retrieval (virtual machine name)
      PropertySpec pSpec = new PropertySpec();
      pSpec.setType("VirtualMachine");
      pSpec.getPathSet().add("name");

      // create a PropertyFilterSpec and add the object and
      // property specs to it; use the getter method to reference
      // the mapped XML representation of the lists and add the specs
      // directly to the list
      PropertyFilterSpec fSpec = new PropertyFilterSpec();
      fSpec.getObjectSet().add(oSpec);
      fSpec.getPropSet().add(pSpec);

      // Create a list for the filters and add the spec to it
      List<PropertyFilterSpec> fSpecList = new ArrayList<PropertyFilterSpec>();
      fSpecList.add(fSpec);

      // get the data from the server
      RetrieveOptions ro = new RetrieveOptions();
      RetrieveResult props = methods.retrievePropertiesEx(propColl,fSpecList,ro);

      // go through the returned list and print out the data
      if (props != null) {
        for (ObjectContent oc : props.getObjects()) {
          String vmName = null;
          String path = null;
          List<DynamicProperty> dps = oc.getPropSet();
          if (dps != null) {
            for (DynamicProperty dp : dps) {
              vmName = (String) dp.getVal();
              path = dp.getName();
              System.out.println(path + " = " + vmName);
            }
          }
        }
      }
    }//end collectProperties()

    // Authentication is handled by using a TrustManager and supplying
    // a host name verifier method. (The host name verifier is declared
    // in the main function.)
    //
    // For the purposes of this example, this TrustManager implementation
    // will accept all certificates. This is only appropriate for
    // a development environment. Production code should implement certificate support.

    private static class TrustAllTrustManager
            implements javax.net.ssl.TrustManager,
                       javax.net.ssl.X509TrustManager {
      public java.security.cert.X509Certificate[] getAcceptedIssuers() {
        return null;
      }

      public boolean isServerTrusted(java.security.cert.X509Certificate[] certs) {
        return true;
      }

      public boolean isClientTrusted(java.security.cert.X509Certificate[] certs) {
        return true;
      }

      public void checkServerTrusted(java.security.cert.X509Certificate[] certs,
                                     String authType)
             throws java.security.cert.CertificateException {
        return;
      }

      public void checkClientTrusted(java.security.cert.X509Certificate[] certs,
                                     String authType)
             throws java.security.cert.CertificateException {
        return;
      }
    }

    public static void main(String [] args) throws Exception {

      // arglist variables
      String serverName = args[0];
      String userName = args[1];
      String password = args[2];
      String url = "https://"+serverName+"/sdk/vimService";
```

```
      // Variables of the following types  for access to the API methods
      // and to the vSphere inventory.
      // -- ManagedObjectReference for the ServiceInstance on the Server
      // -- VimService for access to the vSphere Web service
      // -- VimPortType for access to methods
      // -- ServiceContent for access to managed object services
      ManagedObjectReference SVC_INST_REF = new ManagedObjectReference();
      VimService vimService;
      VimPortType vimPort;
      ServiceContent serviceContent;

      // Declare a host name verifier that will automatically enable
      // the connection. The host name verifier is invoked during
      // the SSL handshake.
      HostnameVerifier hv = new HostnameVerifier() {
      public boolean verify(String urlHostName, SSLSession session) {
        return true;
      }
    };

    // Create the trust manager.
    javax.net.ssl.TrustManager[] trustAllCerts = new javax.net.ssl.TrustManager[1];
    javax.net.ssl.TrustManager tm = new TrustAllTrustManager();
    trustAllCerts[0] = tm;
    // Create the SSL context
    javax.net.ssl.SSLContext sc = javax.net.ssl.SSLContext.getInstance("SSL");

    // Create the session context
    javax.net.ssl.SSLSessionContext sslsc = sc.getServerSessionContext();

    // Initialize the contexts; the session context takes the trust manager.
    sslsc.setSessionTimeout(0);
    sc.init(null, trustAllCerts, null);

    // Use the default socket factory to create the socket for the secure connection
    javax.net.ssl.HttpsURLConnection.setDefaultSSLSocketFactory(sc.getSocketFactory());

    // Set the default host name verifier to enable the connection.
    HttpsURLConnection.setDefaultHostnameVerifier(hv);

    // Set up the manufactured managed object reference for the ServiceInstance
    SVC_INST_REF.setType("ServiceInstance");
    SVC_INST_REF.setValue("ServiceInstance");

    // Create a VimService object to obtain a VimPort binding provider.
    // The BindingProvider provides access to the protocol fields
    // in request/response messages. Retrieve the request context
    // which will be used for processing message requests.
    vimService = new VimService();
    vimPort = vimService.getVimPort();
    Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();

    // Store the Server URL in the request context and specify true
    // to maintain the connection between the client and server.
    // The client API will include the Server's HTTP cookie in its
```

```
  // requests to maintain the session. If you do not set this to true,
  // the Server will start a new session with each request.
  ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, url);
  ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);

  // Retrieve the ServiceContent object and login
  serviceContent = vimPort.retrieveServiceContent(SVC_INST_REF);
  vimPort.login(serviceContent.getSessionManager(),
                userName,
                password,
                null);

  // retrieve data
  collectProperties( vimPort, serviceContent );

  // close the connection
  vimPort.logout(serviceContent.getSessionManager());

  }
}
```

Inventory Traversal

The Property Collector provides a facility to traverse the inventory on the server in arbitrary ways, enabling you to follow links between related objects.

Example: Simple PropertyCollector Example (Java) uses a `ContainerView` to specify the objects that start the collection process. This is the simplest way to set up a filter, using a single reference to a view to provide the `PropertyCollector` with access to a set of objects. To select objects from the inventory, a filter includes `TraversalSpec` and possibly `SelectionSpec` objects. Use these objects to make object selections based on the references in a view, and to extend inventory traversal beyond those objects (or beyond the object specified in `ObjectSpec.obj`).

TraversalSpec Traversal

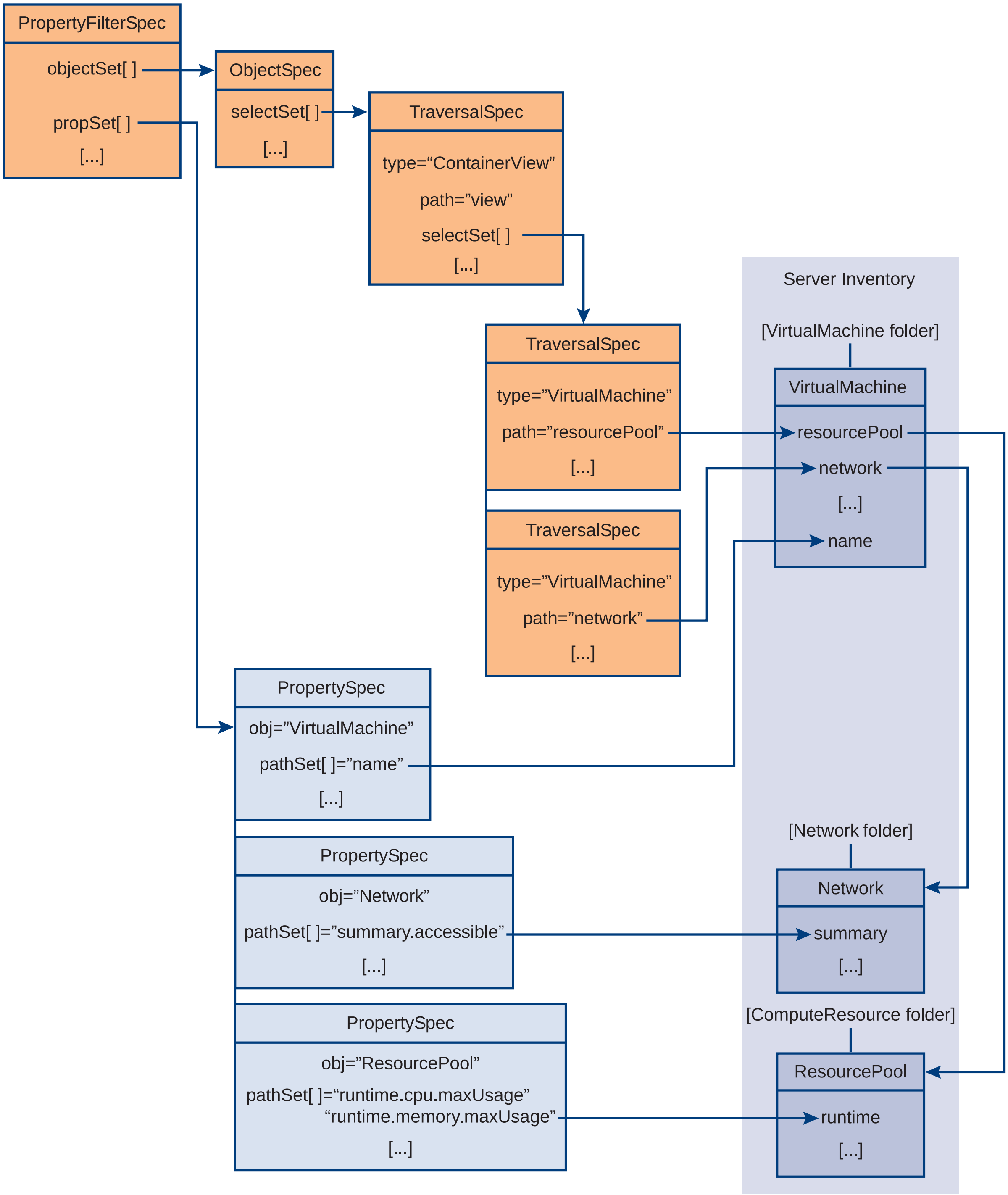
Use a `TraversalSpec` object to identify a managed object type and a traversal property in that type. `TraversalSpec` contains the following properties:

- `type` – identifies an inventory object type.
- `path` – specifies a managed object reference property in the `type` object. This property provides the traversal path extending from this object.
- `selectSet` – specifies an optional list of selection objects for additonal object traversal paths. The `PropertyCollector` applies the `TraversalSpec` objects in the `selectSet` array to the result of the traversal (the target of `TraversalSpec.path`). The `selectSet` array can also contain `SelectionSpec` objects; a `SelectionSpec` is a reference to a `TraversalSpec`. See SelectionSpec Traversal.
- `skip` – indicates whether to collect properties for the `path` object.

During inventory traversal, the PropertyCollector applies the PropertySpec object or objects (PropertyFilterSpec.propSet) to objects. Inventory traversal begins with the object identified by ObjectSpec.obj and continues by following TraversalSpec paths. If PropertySpec.type matches the current object type, and the skip property is false, the PropertyCollector sends the PropertySpec.pathSet properties to your client.

Figure 5-2 is a representation of a PropertyFilterSpec that defines traversal of VirtualMachine objects. The filter uses a ContainerView as a starting point. The TraversalSpec for the ContainerView specifies the view property for access to the view's virtual machines. The figure shows TraversalSpec objects that extend navigation from a VirtualMachine object to the associated Network and ResourcePool objects. The PropertyCollector applies these TraversalSpec objects to each of the VirtualMachine objects in the view list. The figure also shows the PropertySpec objects for collecting data from VirtualMachine, Network, and ResourcePool objects.

Figure 5-2. Inventory Navigation



Traverse the Inventory By Using the Property Collector

To traverse inventory objects, you define one or more `TraversalSpec` objects. In each `TraversalSpec` object, you specify a property of one managed object that holds a reference to another managed object. The `TraversalSpec` defines a path that the PropertyCollector can follow between objects.

To define inventory traversal, use the following steps.

Procedure

1. Create a `ContainerView` for virtual machines.
2. Create an `ObjectSpec` that uses the container view as the collection starting point.
3. Create a `TraversalSpec` to be applied to the `ContainerView` to select `VirtualMachine` objects.
4. Create additional `TraversalSpec` objects to select additional objects.

   The `SelectSet` list for the container view `TraversalSpec` has two `TraversalSpec` objects. Both specify a `VirtualMachine` object context. One object uses the `network` property to extend traversal to the `Network` managed object. The other uses the `resourcePool` property to extend traversal to the `ResourcePool` managed object.
5. Create `PropertySpec` objects to retrieve `VirtualMachine`, `Network`, and `ResourcePool` properties.

   To retrieve properties that are embedded in data objects, the `PropertySpec.PathSet` property uses dot notation to specify the property paths.

Inventory Traversal Example in Java

This example shows a complete Java program that collects and prints selected properties from the inventory, using traversal specs with a property collector. The example lists networks, resource pool status, and virtual machines.

Example: Inventory Traversal in Java

```
import com.vmware.vim25.*;

import java.util.*;
import javax.net.ssl.HostnameVerifier;
import javax.net.ssl.HttpsURLConnection;
import javax.net.ssl.SSLSession;
import javax.xml.ws.BindingProvider;
import javax.xml.ws.soap.SOAPFaultException;


// PropertyCollector example
// command line input: server name, user name, password

public class PCollector_traversal {

  private static void collectProperties(VimPortType methods,
                                        ServiceContent sContent) throws Exception {

    // Get references to the ViewManager and PropertyCollector
    ManagedObjectReference viewMgrRef = sContent.getViewManager();
    ManagedObjectReference propColl = sContent.getPropertyCollector();

    // use a container view for virtual machines to define the traversal
    // - invoke the VimPortType method createContainerView (corresponds
    //   to the ViewManager method) - pass the ViewManager MOR and
    //   the other parameters required for the method invocation
```

```
      //   (use a List<String> for the type parameter's string[])
      List<String> vmList = new ArrayList<String>();
      vmList.add("VirtualMachine");

      ManagedObjectReference cViewRef =
            methods.createContainerView(viewMgrRef,
                                        sContent.getRootFolder(),
                                        vmList,
                                        true);

      // create an object spec to define the beginning of the traversal;
      // container view is the root object for this traversal
      ObjectSpec oSpec = new ObjectSpec();
      oSpec.setObj(cViewRef);
      oSpec.setSkip(true);

      // create a traversal spec to select all objects in the view
      TraversalSpec tSpec = new TraversalSpec();
      tSpec.setName("traverseEntities");
      tSpec.setPath("view");
      tSpec.setSkip(false);
      tSpec.setType("ContainerView");

      // add the traversal spec to the object spec;
      // the accessor method (getSelectSet) returns a reference
      // to the mapped XML representation of the list; using this
      // reference to add the spec will update the selectSet list
      oSpec.getSelectSet().add(tSpec);

      // extend from virtual machine to network
      TraversalSpec tSpecVmN = new TraversalSpec();
      tSpecVmN.setType("VirtualMachine");
      tSpecVmN.setPath("network");
      tSpecVmN.setSkip(false);

      // extend from virtual machine to resourcepool
      TraversalSpec tSpecVmRp = new TraversalSpec();
      tSpecVmRp.setType("VirtualMachine");
      tSpecVmRp.setPath("resourcePool");
      tSpecVmRp.setSkip(false);

      // add the network and resource pool traversal specs
      // to the virtual machine traversal;
      // the accessor method (getSelectSet) returns a reference
      // to the mapped XML representation of the list; using this
      // reference to add the spec will update the selectSet list
      tSpec.getSelectSet().add(tSpecVmN);
      tSpec.getSelectSet().add(tSpecVmRp);

      // specify the properties for retrieval
      // (virtual machine name, network summary accessible, rp runtime props);
      // the accessor method (getPathSet) returns a reference to the mapped
      // XML representation of the list; using this reference to add the
      // property names will update the pathSet list
      PropertySpec pSpec = new PropertySpec();
      pSpec.setType("VirtualMachine");
      pSpec.getPathSet().add("name");

      PropertySpec pSpecNs = new PropertySpec();
      pSpecNs.setType("Network");
      pSpecNs.getPathSet().add("summary.accessible");

      PropertySpec pSpecRPr = new PropertySpec();
      pSpecRPr.setType("ResourcePool");
      pSpecRPr.getPathSet().add("runtime.cpu.maxUsage");
      pSpecRPr.getPathSet().add("runtime.memory.maxUsage");
      pSpecRPr.getPathSet().add("runtime.overallStatus");

      // create a PropertyFilterSpec and add the object and
      // property specs to it; use the getter methods to reference
      // the mapped XML representation of the lists and add the specs
      // directly to the objectSet and propSet lists
      PropertyFilterSpec fSpec = new PropertyFilterSpec();
      fSpec.getObjectSet().add(oSpec);
      fSpec.getPropSet().add(pSpec);
      fSpec.getPropSet().add(pSpecNs);
      fSpec.getPropSet().add(pSpecRPr);

      // Create a list for the filters and add the spec to it
      List<PropertyFilterSpec> fSpecList = new ArrayList<PropertyFilterSpec>();
      fSpecList.add(fSpec);

      // get the data from the server
      RetrieveOptions ro = new RetrieveOptions();
      RetrieveResult props = methods.retrievePropertiesEx(propColl,fSpecList,ro);

      // go through the returned list and print out the data
      if (props != null) {
        for (ObjectContent oc : props.getObjects()) {
          String value = null;
          String path = null;
          List<DynamicProperty> dps = oc.getPropSet();
          if (dps != null) {
            for (DynamicProperty dp : dps) {
              path = dp.getName();
              if (path.equals("name")) {
                value = (String) dp.getVal();
              }
              else if (path.equals("summary.accessible")) {
                // summary.accessible is a boolean
                value = String.valueOf( dp.getVal() );
              }
              else if (path.equals("runtime.cpu.maxUsage")) {
                // runtime.cpu.maxUsage is an xsd:long
                value = String.valueOf( dp.getVal() );
              }
              else if (path.equals("runtime.memory.maxUsage")) {
                // runtime.memory.maxUsage is an xsd:long
                value = String.valueOf( dp.getVal() );
              }
              else if (path.equals("runtime.overallStatus")) {
                // runtime.overallStatus is a ManagedEntityStatus enum
                value = String.valueOf( dp.getVal() );
              }

              System.out.println(path + " = " + value);
            }
          }
        }
      }
    }//end collectProperties()

    // Authentication is handled by using a TrustManager and supplying
    // a host name verifier method. (The host name verifier is declared
    // in the main function.)
    //
    // For the purposes of this example, this TrustManager implementation
    // will accept all certificates. This is only appropriate for
    // a development environment. Production code should implement certificate support.
    private static class TrustAllTrustManager
        implements javax.net.ssl.TrustManager,
                   javax.net.ssl.X509TrustManager {

      public java.security.cert.X509Certificate[] getAcceptedIssuers() {
        return null;
      }

      public boolean isServerTrusted(java.security.cert.X509Certificate[] certs) {
        return true;
      }

      public boolean isClientTrusted(java.security.cert.X509Certificate[] certs) {
        return true;
      }

      public void checkServerTrusted(java.security.cert.X509Certificate[] certs, String authType)
          throws java.security.cert.CertificateException {
        return;
      }

      public void checkClientTrusted(java.security.cert.X509Certificate[] certs, String authType)
          throws java.security.cert.CertificateException {
        return;
      }
    }

    public static void main(String [] args) throws Exception {

      // arglist variables
      String serverName = args[0];
      String userName = args[1];
      String password = args[2];
      String url = "https://"+serverName+"/sdk/vimService";

      // Variables of the following types  for access to the API methods
```

```
      // and to the vSphere inventory.
      // -- ManagedObjectReference for the ServiceInstance on the Server
      // -- VimService for access to the vSphere Web service
      // -- VimPortType for access to methods
      // -- ServiceContent for access to managed object services
      ManagedObjectReference SVC_INST_REF = new ManagedObjectReference();
      VimService vimService;
      VimPortType vimPort;
      ServiceContent serviceContent;

      // Declare a host name verifier that will automatically enable
      // the connection. The host name verifier is invoked during
      // the SSL handshake.
      HostnameVerifier hv = new HostnameVerifier() {
        public boolean verify(String urlHostName, SSLSession session) {
          return true;
        }
      };

      // Create the trust manager.
      javax.net.ssl.TrustManager[] trustAllCerts = new javax.net.ssl.TrustManager[1];
      javax.net.ssl.TrustManager tm = new TrustAllTrustManager();
      trustAllCerts[0] = tm;

      // Create the SSL context
      javax.net.ssl.SSLContext sc = javax.net.ssl.SSLContext.getInstance("SSL");

      // Create the session context
      javax.net.ssl.SSLSessionContext sslsc = sc.getServerSessionContext();

      // Initialize the contexts; the session context takes the trust manager.
      sslsc.setSessionTimeout(0);
      sc.init(null, trustAllCerts, null);

      // Use the default socket factory to create the socket for the secure connection
      javax.net.ssl.HttpsURLConnection.setDefaultSSLSocketFactory(sc.getSocketFactory());

      // Set the default host name verifier to enable the connection.
      HttpsURLConnection.setDefaultHostnameVerifier(hv);

      // Set up the manufactured managed object reference for the ServiceInstance
      SVC_INST_REF.setType("ServiceInstance");
      SVC_INST_REF.setValue("ServiceInstance");

      // Create a VimService object to obtain a VimPort binding provider.
      // The BindingProvider provides access to the protocol fields
      // in request/response messages. Retrieve the request context
      // which will be used for processing message requests.
      vimService = new VimService();
      vimPort = vimService.getVimPort();
      Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();

      // Store the Server URL in the request context and specify true
      // to maintain the connection between the client and server.
      // The client API will include the Server's HTTP cookie in its
```

```
    // requests to maintain the session. If you do not set this to true,
    // the Server will start a new session with each request.
    ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, url);
    ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);
    // Retrieve the ServiceContent object and login
    serviceContent = vimPort.retrieveServiceContent(SVC_INST_REF);
    vimPort.login(serviceContent.getSessionManager(),
                  userName,
                  password,
                  null);

    // retrieve data
    collectProperties( vimPort, serviceContent );

    // close the connection
    vimPort.logout(serviceContent.getSessionManager());

  }
}
```

SelectionSpec Traversal

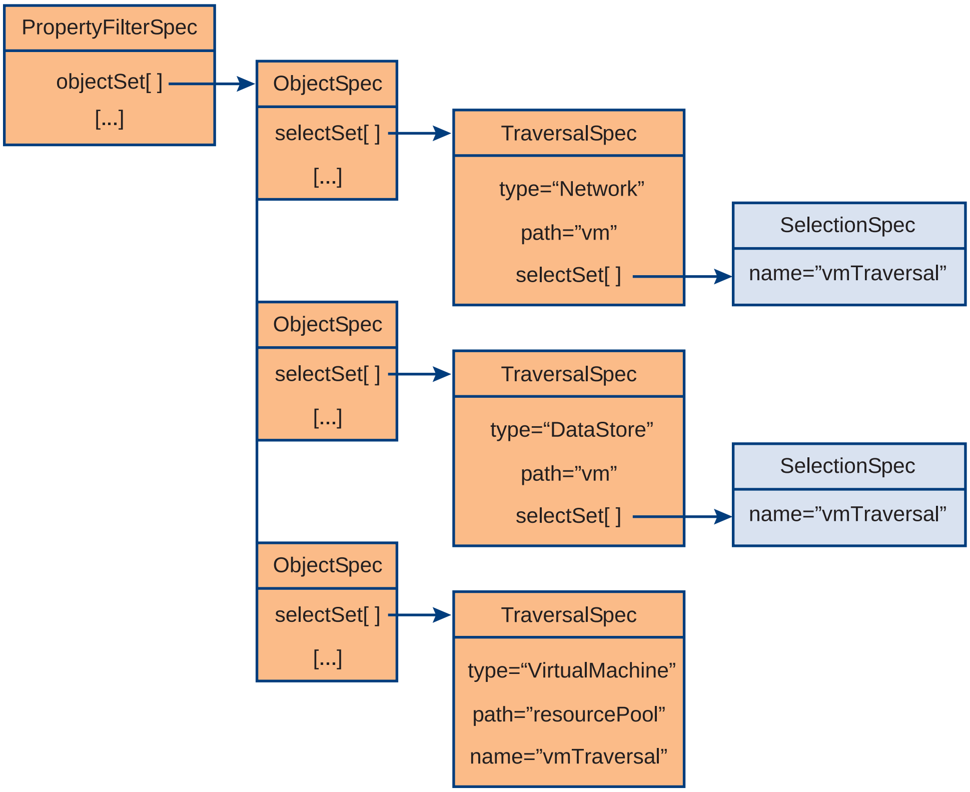
The selectSet array in ObjectSpec and TraversalSpec objects can include TraversalSpec objects and SelectionSpec objects. SelectionSpec is the base class for TraversalSpec objects. SelectionSpec defines the name property. You can use a SelectionSpec object in a selectSet array as a reference to a named TraversalSpec object. By using SelectionSpec references, you can reuse a TraversalSpec and you can define recursive traversal.

Simple Reference SelectionSpec

Use SelectionSpec references to avoid writing duplicate TraversalSpec declarations.

The TraversalSpec identified in a SelectionSpec reference must be within the same PropertyFilterSpec. Figure 5-3 shows the use of SelectionSpec references to a virtual machine TraversalSpec. The SelectionSpec references are associated with Network and Datastore traversals.

Figure 5-3. SelectionSpec Reference



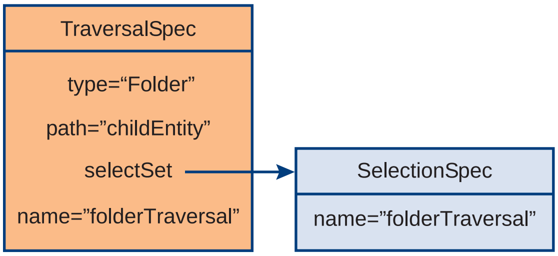
If the `ObjectSpec.selectSet` array contains a `SelectionSpec`, the referenced `TraversalSpec` must identify the same object type. `TraversalSpec.type` must match the type of the object specified in `ObjectSpec.obj`. The `PropertyCollector` applies the `TraversalSpec` to the object and uses the `TraversalSpec.path` property to extend its traversal.

Recursive Traversal

Use a `SelectionSpec` to apply a `TraversalSpec` to the results of its own traversal. To use a recursive filter construction, create a `SelectionSpec` that specifies the name of a `TraversalSpec` and add it to the named `TraversalSpec` selection set. The recursive construction extends inventory traversal beyond the paths directly represented by `TraversalSpec` objects.

You can use recursive traversal on any inventory objects that can be nested. See Inventory Hierarchies and ServiceInstance for a general representation of the structure of an inventory. For example, on a vCenter Server, folders can nest to arbitrary depths. To describe a traversal path through a succession of folders, you can add a `SelectionSpec` to the `Folder TraversalSpec`. The `SelectionSpec` must reference the `TraversalSpec`. Figure 5-4 shows a representation of a `TraversalSpec` and its associated `SelectionSpec` for nested folder traversal.

Figure 5-4. Recursive TraversalSpec and SelectionSpec



Use Recursive TraversalSpec to Traverse Nested Inventory Folders

To traverse inventory objects that are nested to a variable depth, define one or more recursive `TraversalSpec` objects. In each `TraversalSpec` object, you specify a property of one managed object that holds a reference to another managed object. The `TraversalSpec` defines a path that the property collector can follow between objects.

To define recursive inventory traversal, use the following steps.

Procedure

1. Use the `SearchIndex` managed object to retrieve the managed object reference for the top-level virtual machine folder.

   This folder is used as the beginning of the inventory traversal. For more information see SearchIndex.
2. Create an `ObjectSpec` object that references the top-level virtual machine folder.
3. Create a `SelectionSpec` object that references the `Folder TraversalSpec` by name.
4. Create a named `TraversalSpec` for `Folder` objects.

   The `TraversalSpec.path` property identifies the `Folder.childEntity` property for traversal to any child objects.
5. Add the `SelectionSpec` to the `TraversalSpec` to create the recursive filter.
6. Add the `TraversalSpec` to the `ObjectSpec`.
7. Create a `PropertySpec` for the `Folder` name.
8. Add the object and property specifications to the `PropertyFilterSpec`.
9. Call the `RetrievePropertiesEx` method.

Nested Folder Traversal in Java

This example shows the use of a recursive `TraversalSpec` with the property collector. The recursive traversal spec enables the property collector to navigate a chain of nested objects of the same type.

Example: Nested Folder Traversal

```
import com.vmware.vim25.*;

import java.util.*;
import javax.net.ssl.HostnameVerifier;
import javax.net.ssl.HttpsURLConnection;
import javax.net.ssl.SSLSession;
import javax.xml.ws.BindingProvider;
import javax.xml.ws.soap.SOAPFaultException;

// PropertyCollector example
// command line input: server name, user name, password

public class nestedTraversal {

  private static void collectProperties(VimPortType methods,
                                        ServiceContent sContent)
                      throws Exception {

    // Get reference to the PropertyCollector
    ManagedObjectReference propColl = sContent.getPropertyCollector();

    // get the top-level vm folder mor
    ManagedObjectReference sIndex = sContent.getSearchIndex();
    ManagedObjectReference rootVmFolder =
              methods.findByInventoryPath(sIndex,"datacenter1/vm");
    // create an object spec to define the beginning of the traversal;
    // root vm folder is the root object for this traversal
    ObjectSpec oSpec = new ObjectSpec();
    oSpec.setObj(rootVmFolder);
    oSpec.setSkip(true);

    // folder traversal reference
    SelectionSpec sSpecF = new SelectionSpec();
    sSpecF.setName("traverseFolder");

    // create a folder traversal spec to select childEntity
    TraversalSpec tSpecF = new TraversalSpec();
    tSpecF.setType("Folder");
    tSpecF.setPath("childEntity");
    tSpecF.setSkip(false);
    tSpecF.setName("traverseFolder");

    // use the SelectionSpec as a reflexive spec for the folder traversal;
    // the accessor method (getSelectSet) returns a reference to the
    // mapped XML representation of the list; using this reference
    // to add the spec will update the list
    tSpecF.getSelectSet().add(sSpecF);

    // add folder traversal to object spec
    oSpec.getSelectSet().add(tSpecF);

    // specify the property for retrieval (folder name)
    PropertySpec pSpec = new PropertySpec();
    pSpec.setType("Folder");
    pSpec.getPathSet().add("name");

    // create a PropertyFilterSpec and add the object and
    // property specs to it; use the getter method to reference
    // the mapped XML representation of the lists and add the specs
    // directly to the lists
    PropertyFilterSpec fSpec = new PropertyFilterSpec();
    fSpec.getObjectSet().add(oSpec);
    fSpec.getPropSet().add(pSpec);

    // Create a list for the filter and add the spec to it
    List<PropertyFilterSpec> fSpecList = new ArrayList<PropertyFilterSpec>();
    fSpecList.add(fSpec);

    // get the data from the server
    RetrieveOptions ro = new RetrieveOptions();
    RetrieveResult props = methods.retrievePropertiesEx(propColl,fSpecList,ro);

    // go through the returned list and print out the data
    if (props != null) {
      for (ObjectContent oc : props.getObjects()) {
        String folderName = null;
        String path = null;
        List<DynamicProperty> dps = oc.getPropSet();
        if (dps != null) {
          for (DynamicProperty dp : dps) {
            folderName = (String) dp.getVal();
            path = dp.getName();
            System.out.println(path + " = " + folderName);
          }
        }
      }
    }
  }//end collectProperties()

  // Authentication is handled by using a TrustManager and supplying
  // a host name verifier method. (The host name verifier is declared
  // in the main function.)
  //
  // For the purposes of this example, this TrustManager implementation
  // will accept all certificates. This is only appropriate for
  // a development environment. Production code should implement certificate support.
  private static class TrustAllTrustManager
                 implements javax.net.ssl.TrustManager,
                 javax.net.ssl.X509TrustManager {

    public java.security.cert.X509Certificate[] getAcceptedIssuers() {
      return null;
    }

    public boolean isServerTrusted(java.security.cert.X509Certificate[] certs) {
      return true;
    }
    public boolean isClientTrusted(java.security.cert.X509Certificate[] certs) {
      return true;
    }

    public void checkServerTrusted(java.security.cert.X509Certificate[] certs, String authType)
        throws java.security.cert.CertificateException {
      return;
    }

    public void checkClientTrusted(java.security.cert.X509Certificate[] certs, String authType)
        throws java.security.cert.CertificateException {
      return;
    }
  }

  public static void main(String [] args) throws Exception {

    // arglist variables
    String serverName = args[0];
    String userName = args[1];
    String password = args[2];
                String url = "https://"+serverName+"/sdk/vimService";
    // Variables of the following types  for access to the API methods
    // and to the vSphere inventory.
    // -- ManagedObjectReference for the ServiceInstance on the Server
    // -- VimService for access to the vSphere Web service
    // -- VimPortType for access to methods
    // -- ServiceContent for access to managed object services
    ManagedObjectReference SVC_INST_REF = new ManagedObjectReference();
    VimService vimService;
    VimPortType vimPort;
    ServiceContent serviceContent;

    // Declare a host name verifier that will automatically enable
    // the connection. The host name verifier is invoked during
    // the SSL handshake.
    HostnameVerifier hv = new HostnameVerifier() {
      public boolean verify(String urlHostName, SSLSession session) {
        return true;
      }
    };

    // Create the trust manager.
    javax.net.ssl.TrustManager[] trustAllCerts = new javax.net.ssl.TrustManager[1];
    javax.net.ssl.TrustManager tm = new TrustAllTrustManager();
    trustAllCerts[0] = tm;

    // Create the SSL context
    javax.net.ssl.SSLContext sc = javax.net.ssl.SSLContext.getInstance("SSL");

    // Create the session context
    javax.net.ssl.SSLSessionContext sslsc = sc.getServerSessionContext();

    // Initialize the contexts; the session context takes the trust manager.
    sslsc.setSessionTimeout(0);
    sc.init(null, trustAllCerts, null);

    // Use the default socket factory to create the socket for the secure connection
    javax.net.ssl.HttpsURLConnection.setDefaultSSLSocketFactory(sc.getSocketFactory());

    // Set the default host name verifier to enable the connection.
    HttpsURLConnection.setDefaultHostnameVerifier(hv);

    // Set up the manufactured managed object reference for the ServiceInstance
    SVC_INST_REF.setType("ServiceInstance");
    SVC_INST_REF.setValue("ServiceInstance");

    // Create a VimService object to obtain a VimPort binding provider.
    // The BindingProvider provides access to the protocol fields
    // in request/response messages. Retrieve the request context
    // which will be used for processing message requests.
    vimService = new VimService();
    vimPort = vimService.getVimPort();
    Map<String, Object> ctxt = ((BindingProvider) vimPort).getRequestContext();

    // Store the Server URL in the request context and specify true
    // to maintain the connection between the client and server.
    // The client API will include the Server's HTTP cookie in its
    // requests to maintain the session. If you do not set this to true,
    // the Server will start a new session with each request.
    ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, url);
    ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);

    // Retrieve the ServiceContent object and login
    serviceContent = vimPort.retrieveServiceContent(SVC_INST_REF);
    vimPort.login(serviceContent.getSessionManager(),
                  userName,
                  password,
                  null);

    // retrieve data
    collectProperties( vimPort, serviceContent );

    // close the connection
    vimPort.logout(serviceContent.getSessionManager());

  }
}
```

Client Data Synchronization (WaitForUpdatesEx)

To maintain a client-side representation of server object state (by monitoring the properties for the inventory), use the `CreateFilter` and `WaitForUpdatesEx` methods. The `WaitForUpdatesEx` method supports an incremental retrieval model.

Important The filters you use for incremental retrieval persist for the duration of the session or until you destroy them.

Property Filters

A PropertyCollector can have one or more associated PropertyFilter objects. A PropertyFilter has one or more associated PropertyFilterSpec objects. A PropertyFilterSpec that is used with the RetrievePropertiesEx method has a limited lifespan; the server destroys the filter after returning results to your client. For a sequence of incremental property collection operations, the WaitForUpdatesEx method relies on PropertyFilterSpec objects that are available for multiple calls to the method.

To create persistent property filter specifications, use the CreateFilter method. When you call CreateFilter, you pass a PropertyFilterSpec object to the method. The method adds the new filter to the PropertyCollector associated with the method invocation and returns a reference to the new filter. After you have created the filter, you can add additional PropertyFilterSpec objects. You cannot share a filter with a PropertyCollector in another session.

WaitForUpdatesEx

The WaitForUpdatesEx method supports a polling mechanism for property collection that is based on a specified wait time.

Specify the following parameters when you call WaitForUpdatesEx:

- Managed object reference to a PropertyCollector instance.
- version value that identifies a sequence value. The first time you call WaitForUpdatesEx, specify an empty string (““) to retrieve a complete set of results for the specified properties. Your subsequent calls should use the version value returned in the previous call. If you don’t include the version value, the server returns everything. For more information about data versions, see Server Data Transmission.
- options specifying the amount of data to transmit in a single response (the WaitOptions.maxObjectUpdates property) and the number of seconds the PropertyCollector should wait for updates (the WaitOptions.maxWaitSeconds property).

The value of the WaitOptions.maxWaitSeconds property determines whether the PropertyCollector uses an instant retrieval or a polling model. When you call WaitForUpdatesEx with a wait time of 0, it checks for updates and returns immediately. When you call WaitForUpdatesEx with a wait time greater than 0, the method waits until the specified time or until a change. WaitForUpdatesEx blocks your process until updates occur or until it times out. The time-out is affected by the maxWaitSeconds value, the amount of time it takes to collect updated property values, and PropertyCollector policy.

If the property collection operation times out, and there are no updates to the requested properties, the PropertyCollector returns null for the WaitForUpdatesEx response.

- maxWaitSeconds is an optional property. If you do not specify a value, the PropertyCollector waits as long as possible for updates. Therefore, if maxWaitSeconds is unset, the waitForUpdatesEx method will block the thread after all of the data has been retrieved, waiting for the TCP connection with the vSphere server to timeout. Your code can handle this in one of the following ways: call waitForUpdatesEx from a separate thread; look for specific updates and then stop calling the method; or change the TCP connection timeout, BindingProviderProperties.CONNECT_TIMEOUT.
- maxWaitSeconds set to zero specifies an immediate call and response. The PropertyCollector checks for updates for all properties specified by the union of all filters associated with that instance of the PropertyCollector. The PropertyCollector returns any results, or null if there have been no updates.
- maxWaitSeconds greater than zero specifies a wait followed by polling. The PropertyCollector returns null if no updates are available within maxWaitSeconds.

Comparing Usage of MaxWaitSeconds

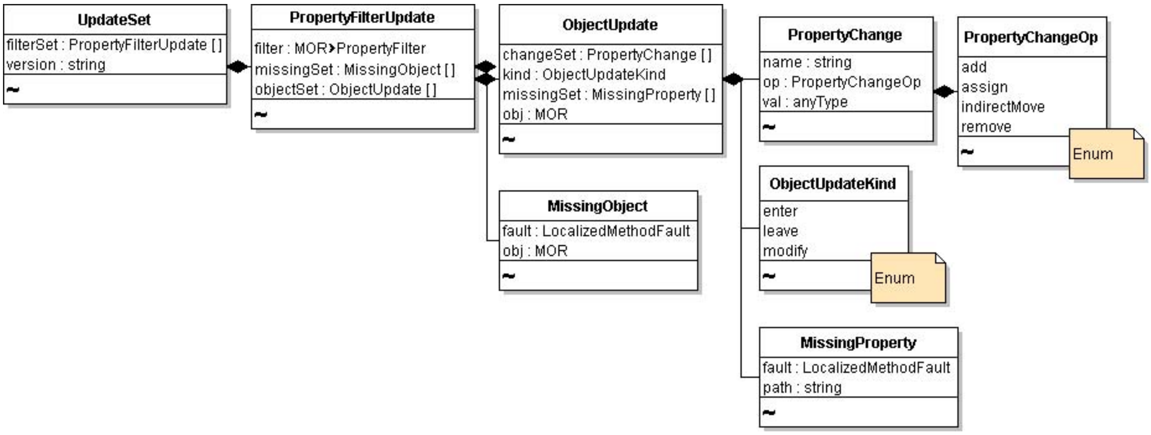
The following table lists some of the advantages and disadvantages of these two operations.

Operation	Advantages	Disadvantages
MaxWaitSeconds=0	Returns only properties that have changed since the version specified. Returns changed data only, providing better network utilization than RetrieveProperties.	Returns an empty set even when nothing has changed on the server. Depending on your client application, this might be inefficient.
MaxWaitSeconds>0	Blocks thread until an update occurs. Efficient use of network resources. The only operation that you can cancel.	Blocks processing thread until updates occur. However, this call can be cancelled so you can monitor the time the operation is taking and cancel if necessary.

UpdateSet Data Object from the Property Collector

The WaitForUpdatesEx method returns an UpdateSet data object, the composite data structure shown in the following figure.

Figure 5-5. UpdateSet Data Object Returned by WaitForUpdates Operations



Server Data Transmission

Property collection can involve the retrieval of large amounts of data, depending on the number of properties implied in the collection request. The vSphere server supports segmented data transmission, or chunking, when it sends collected data to a client. If the amount of collected data exceeds the chunk size, the server returns a chunk of data in a single response, and indicates additional data can be retrieved. For information about chunk size, see the description of the `RetrieveOptions.maxObjects` and `WaitOptions.maxObjectUpdates` properties in the *vSphere API Reference*.

- The `WaitForUpdatesEx` method returns an `UpdateSet` data object. The `UpdateSet.truncated` property indicates whether you must call `WaitForUpdatesEx` again to retrieve additional data. If `truncated` is `true`, the `WaitForUpdatesEx` method returns a version string to identify chunked data. When your client application receives an indication that additional data are available, it must send the returned `UpdateSet.version` string in the subsequent call to `WaitForUpdatesEx` to retrieve the next chunk of data.
- The `RetrievePropertiesEx` method returns a `RetrieveResult` data object. The `RetrieveResult.token` property indicates whether you must call the `ContinueRetrievePropertiesEx` method to retrieve additional data. If the `token` property has a value, it identifies chunked data. When your client application receives an indication that additional data are available, it must send the returned token in the subsequent call to `ContinueRetrievePropertiexEx` to retrieve the next chunk of data.

Version strings and tokens are sequenced. Your client application must keep track of the sequence of values. If an error interrupts the collection operation, resume the operation by using the version string or token that was submitted before the interruption.

PropertyCollector Performance

These factors can affect the performance of a `PropertyCollector` for any given session:

- Number of objects
- Number of properties

- Density of property data (composite, nested data objects)
- Frequency of changes to the objects and properties on the server
- Depth of traversal (number of properties traversed)

In addition, a vSphere server is affected by the number of PropertyCollector instances and the number of filters each instance is supporting across all sessions on the server.

To minimize PropertyCollector overhead and the amount of network traffic for your client application, use View objects with the PropertyCollector. Example: Simple PropertyCollector Example (Java) illustrates using views with the PropertyCollector.

SearchIndex

The SearchIndex managed object provides a set of methods to retrieve references to managed objects in the vSphere inventory. You can search by managed objects inventory path, IP address, datastore path, DNS name, and various other identifying attributes.

For example, if you know the IP address of a virtual machine, you can obtain its managed object reference by using the SearchIndex.FindByIp method. You can use SearchIndex to obtain the reference to a server object, and then use that reference as the starting object for property collection. See the sample applications SearchIndex.java and SearchIndex.cs for more information about using SearchIndex. See the *vSphere API Reference* for more information about SearchIndex methods.

Authentication and Authorization 6

VMware vSphere implements mechanisms to ensure that only valid users can access virtual infrastructure components.Each property and method in the API has an associated privilege requirement, and only uses with corresponding privileges can access the entities. This chapter discusses approaches to securing the system and the related service interfaces. The chapter also discusses the user model, which is different in ESXi systems and vCenter Server systems.

See the *vSphere Datacenter Administration Guide* for a list of required privileges for common tasks and best practices for roles and permissions.

This chapter includes the following topics:

Objects for Authentication and Authorization Management

VMware vSphere includes the following interfaces for authenticating users and protecting virtual infrastructure components from unauthorized access:

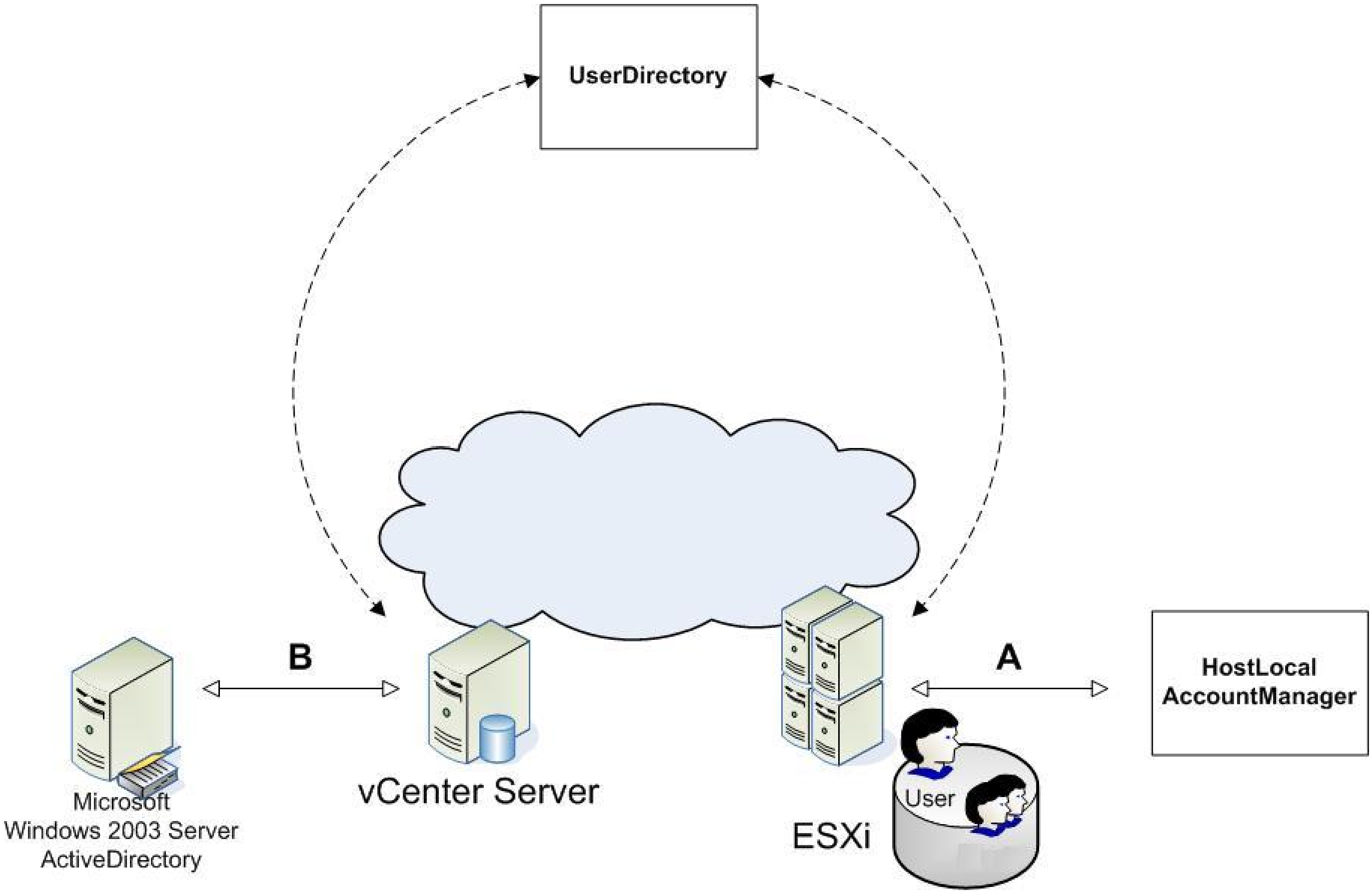
- `HostLocalAccountManager` is used to create and manage user accounts on ESXi systems. Authenticated users can view objects or invoke operations on the server depending on the permissions associated with their account. See Managing ESXi Users with HostLocalAccountManager.

- AuthorizationManager protects vSphere components from unauthorized access. Access to components is role-based: Users are assigned roles that encompass the privileges needed to view and perform operations on vSphere objects. AuthorizationManager has operations for creating new roles, modifying roles, setting permissions on entities, and handling the relationship between managed objects and permissions.
- UserDirectory provides a look-up mechanism that returns user-account information to AuthorizationManager or to another requestor, such as a client application. See Obtaining User and Group Information from UserDirectory.
- SessionManager provides an interface to the authentication infrastructure on the target server system (see Authenticating Users Through SessionManager).
  - For vCenter Server systems, SessionManager supports single sign-on based on SSO tokens obtained from a VMware SSO Server. See Establishing a Single Sign-On Session with a vCenter Server.
  - For ESXi systems, SessionManager supports authenticating user accounts as defined on the host system, such as accounts created using vSphere Client or accounts created programmatically through the HostLocalAccountManager API.
- Even if a user is authorized to perform operations on a vSphere object, the operation fails if the licenses for the host or the feature have not been assigned. You use LicenseManager and LicenseAssignmentManager to manage the licenses. See Managing Licenses with LicenseManager.

Authentication and Authorization for ESXi and vCenter Server

Several server-side mechanisms authenticate a human user when a client application, such as the vSphere Client or a vSphere Web Services SDK application, connects to the server. Because ESXi uses Linux-based authentication, and vCenter Server is a Windows service, the two systems use different approaches for handling user accounts. The following illustration shows the two different user management mechanisms associated with the VMware vSphere server.

Figure 6-1. Managed Objects for Handling User Accounts



These services work together to ensure that only authenticated users can connect to ESXi or vCenter Server systems, and that they can access only those objects—folders, virtual machines, datacenters, virtual services, and so on—for which they have the required privileges and which they are authorized to use or to view.

In addition, the vSphere Web Services SDK supports automated login through a credential store. See Using the Credential Store for Automated Login.

ESXi User Model

When users enter their user account and credential from a client application, the server consults the appropriate user account store and validates the authenticity of the user account and the associated credential. Currently, the credential consists of a password, but vSphere also supports certificates, such as X.509 certificates. Authenticated users can then access objects they are authorized to use. Authentication succeeds if a user identity exists as a user account on the target system or in a supported directory service.

ESXi leverages standard Linux infrastructure, including the Linux pluggable authentication module (PAM) mechanism for user account creation and management. The VMware authentication daemon (`vmware–authd`) is implemented as a PAM module. You can create and manage user accounts on an ESXi system by using `HostLocalAccountManager`.

vCenter Server User Model

vCenter Server is a Windows-based service that uses native Windows facilities and the Windows user model for identification and authentication. The vCenter Server Web service is associated with the Windows user account that was logged in to the machine for the vCenter Server installation process. This vCenter Server administrator account must be a member of the local Windows Administrator group on the machine. VMware recommends creating a dedicated Windows user account for installing and managing the vCenter Server system.

Other vCenter Server users who connect to the Web service must also have a Windows account on the local Administrator group.

Important Even if a user with the same name exists on an ESXi host and a vCenter Server system, the two users have different accounts.

For details, see the *Datacenter Administration Guide* in the VMware vSphere documentation set.

Organizations that are using Microsoft Active Directory can use the user identities contained in a Windows 2003 Server domain controller or Active Directory service across their virtual infrastructure. Microsoft Active Directory identities are supported for all clients that run vSphere Web Services SDK applications from Windows-based systems.

A vCenter Server client uses a SAML token to establish a single sign on session with the Server. See Establishing a Single Sign-On Session with a vCenter Server.

vSphere Security Model

Although the details of authentication and authorization differ between ESXi and vCenter Server, the model itself is the same for both systems. It relies on privileges, roles, and permissions.

Privileges

A privilege is a system-defined requirement associated with a VMware vSphere object. Privileges are defined by VMware. Privileges are static, and do not change for a single version of a product. Each managed object has one or more privileges that a principal (user, group member) must have to invoke an operation or to view a property. For example, managed entities such as `Folder` and `VirtualMachine` require the principal to have the `System.Read` privilege on the entity to view the values of its properties.

The *vSphere API Reference* includes information about privileges required to invoke operations and to view properties on the **Required Privileges** labels on the documentation page for each managed object. Privileges for vSphere components are defined as follows:

```
<group>[.<group>].privilege
```

For example:

```
Datacenter.Create
Host.Config.Connection
Host.Config.Snmp
```

A privilege might be specific to vCenter Server or to ESXi systems. For example, the `Alarm.Create` privilege is defined on vCenter Server. Setting alarms is done through the `AlarmManager` service interface, which requires a running vCenter Server system.

Privilege requirements apply to system objects regardless of how a given client application attempts to access server content (vSphere Client, CLI, or SDK). For example, you can use the following URL to access virtual machine datastore files:

```
https://<hostname>/folder[/<path>]/?dcPath=<datacenter_path>[&dsName=<datastore_name>]
```

The URL accesses a `Datastore` object in the inventory. You must have privileges to access each object in the hierarchy, corresponding to the elements of the URL.

Privileges for Datastore Objects in the Web Services API

The following table shows the privileges needed by methods that access datastore objects..

Object Associated with File	URL Element	Required Privileges
Root folder	`/folder`	`System.View`
Datacenter	`?dcPath`	`Datastore.Browse`
		`Datastore.FileManagement`
Datastore	`&dsName`	`Datastore.Browse`
		`Datastore.FileManagement`
Host	`/host`	`Host.Config.AdvancedConfig`
	`/tmp/`	`Host.Config.SystemManagement`

Roles

A role is a predefined set of privileges. Users are granted privileges to objects through roles.

When you assign user or group permissions, you pair the user or group with a role and associate that pairing with an inventory object. A single user might have different roles for different objects in the inventory.

For example, if you have two resource pools in your inventory, Pool A and Pool B, you might assign a particular user the role Virtual Machine User on Pool A and the role `ReadOnly` on Pool B. These assignments allow that user to turn on virtual machines in Pool A. In Pool B, the user can view the status of virtual machines, but cannot turn on virtual machines.

Permissions

In vSphere, a permission consists of a user or group and an assigned role for an inventory object, such as a virtual machine or ESXi host. Permissions grant users the right to perform the activities specified by the role on the object to which the role is assigned.

For example, to configure memory for an ESXi host, a user must be granted a role that includes the `Host.Configuration.Memory` privilege. By assigning different roles to users or groups for different objects, you can control the tasks that users can perform in your vSphere environment.

Many tasks require permissions on more than one object.

Setting Up Users, Groups, and Permissions

Setting up users, groups, and permissions consists of these tasks:

1. Get information about privilege requirements and privileges associated with system and sample roles.
   - Find out which operations on vSphere objects require which privileges. See the *API Reference*.
   - Find out which operations the system roles and sample roles can perform. See Description of Roles on vSphere Servers.
2. If necessary, create additional roles (sets of privileges). See Modifying Sample Roles to Create New Roles.
3. Retrieve information about existing users and groups (see Obtaining User and Group Information from UserDirectory) and create additional groups if needed.
4. Associate users or groups with roles using permissions. See Managing Roles and Permissions with AuthorizationManager.

At runtime, use `SessionManager` to log in to the server. vCenter Servers support single sign-on sessions. To establish a single sign-on session, use the `SessionManager.LoginByToken` method. To establish a session with a standalone ESXi host, use the `SessionManager.Login` method.

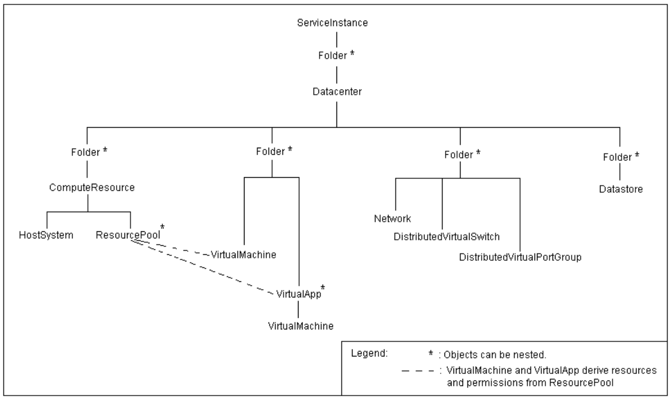
Obtaining User and Group Information from UserDirectory

The `UserDirectory` managed object allows a client application to obtain information about users and groups on a VMware vSphere server. Properties and results vary, depending on whether the server is a vCenter Server or an ESXi system.

- vCenter Server system. Domain controller, Active Directory, or local Windows account repository.
- ESXi host. Linux password file in `/etc/passwd` on the host.

For example, vCenter Server user accounts can be managed in a Windows Active Directory server or domain controller from which the `domainList` property of `UserDirectory` is derived. For ESXi systems, the `domainList` property is empty.

Figure 6-2. UserDirectory Managed Object



`RetrieveUserGroups` Method

`UserDirectory` allows you to obtain information about users and groups using the `RetrieveUserGroups` method. The method can obtain a list of all user accounts from the host, and can search for specific users or groups based on specific criteria to filter the results. You can search by user name, by group name, for an exact match, or for a partial string (substring).

- ESXi does not support local user groups, so this method will not return group information for a host. This method will return information about Active Directory groups.
- For ESXi systems, search returns all users from the `passwd` file. If this file contains Network Information System (NIS) or NIS+ users, `RetrieveUserGroups` returns these accounts as well.
- For vCenter Server, search is limited to the specified Windows domain. If the domain is omitted, the search is performed on local users and groups.

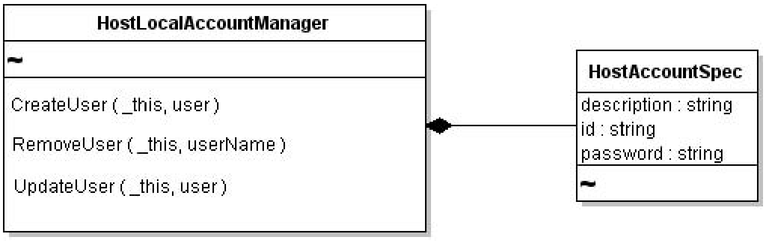
Important Do not configure an ESXi system to use NIS or NIS+, unless it is acceptable to have NIS (or NIS+) user information available through the `UserDirectory.RetrieveUserGroups` API.

Managing ESXi Users with HostLocalAccountManager

The `HostLocalAccountManager` managed object supports user administration tasks. `HostLocalAccountManager` is available only on ESXi system.

Important vCenter Server systems use the Microsoft Windows user management facilities. See vCenter Server User Model.

Figure 6-3. HostLocalAccountManager Managed Object



Methods Available for Local Account Management

HostLocalAccountManager provides the following methods for local user account management:

- CreateUser
- RemoveUser
- UpdateUser

These methods accept a HostAccountSpec data object. Specify the object properties according to the requirements on the target system. Examples of user account requirements are password length requirements and restricted use of dictionary words.

Create a Local User Account on an ESXi System

You can use the API to create a user account on an ESXi system.

Procedure

1. Obtain a managed object reference to the HostLocalAccountManager of the target system.
2. Create a HostAccountSpec data object that defines the properties of the user account, including description and password.

   Define account names and passwords according to the configuration required by your ESXi system for user account naming conventions and password requirements, such as minimum length, character set, and other requirements.
3. Call the HostLocalAccountManager.CreateUserAccount method, passing in the managed object reference (from step 1) and the HostAccountSpec data object (step 2).

   After creating user accounts on the ESXi system, you can grant these users access to virtual components by using AuthorizationManager methods. See Managing Roles and Permissions with AuthorizationManager.

Managing Roles and Permissions with AuthorizationManager

AuthorizationManager is the service interface for handling permissions and roles assigned to the users and groups you define with HostLocalAccountManager. AuthorizationManager methods allow you to create, modify, and manage roles and permissions, and to obtain information about the roles and permissions defined in the system. If a predefined role does not meet your needs, define a new one that contains only the minimum set of required privileges.

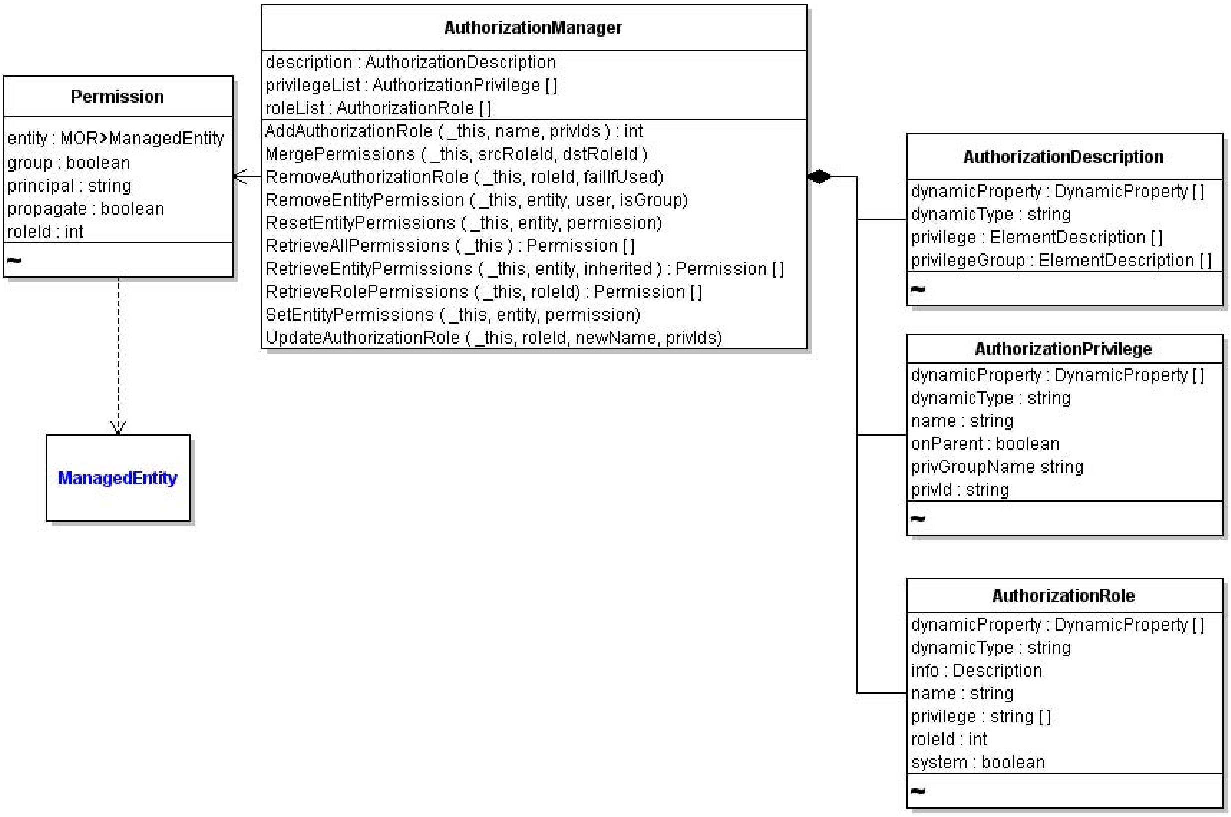
The AuthorizationManager also allows access and prevents access to specific server objects based on the permissions associated with the object.

AuthorizationManager includes methods for managing roles and for managing permissions:

- Roles Management. AddAuthorizationRole, RemoveAuthorizationRole, and UpdateAuthorizationRole. See Using Roles to Consolidate Sets of Privileges and Modifying Sample Roles to Create New Roles.
- Permissions Management. MergePermissions, RemoveEntityPermission, ResetEntityPermissions, RetrieveAllPermissions, RetrieveEntityPermissions, RetrieveRolePermissions, and SetEntityPermissions. See Granting Privileges Through Permissions.

The following diagram shows these methods in a UML diagram for AuthorizationManager and some of its associated data objects.

Figure 6-4. AuthorizationManager Managed Object


AuthorizationManager
description : AuthorizationDescription
privilegeList : AuthorizationPrivilege [ ]
roleList : AuthorizationRole [ ]
AddAuthorizationRole (_this, name, privIds) : int
MergePermissions (_this, srcRoleId, dstRoleId)
RemoveAuthorizationRole (_this, roleId, failIfUsed)
RemoveEntityPermission (_this, entity, user, isGroup)
ResetEntityPermissions (_this, entity, permission)
RetrieveAllPermissions (_this) : Permission [ ]
RetrieveEntityPermissions (_this, entity, inherited) : Permission [ ]
RetrieveRolePermissions (_this, roleId) : Permission [ ]
SetEntityPermissions (_this, entity, permission)
UpdateAuthorizationRole (_this, roleId, newName, privIds)
Permission
entity : MOR>ManagedEntity
group : boolean
principal : string
propagate : boolean
roleId : int
~
ManagedEntity
AuthorizationDescription
dynamicProperty : DynamicProperty [ ]
dynamicType : string
privilege : ElementDescription [ ]
privilegeGroup : ElementDescription [ ]
~
AuthorizationPrivilege
dynamicProperty : DynamicProperty [ ]
dynamicType : string
name : string
onParent : boolean
privGroupName string
privId : string
~
AuthorizationRole
dynamicProperty : DynamicProperty [ ]
dynamicType : string
info : Description
name : string
privilege : string [ ]
roleId : int
system : boolean
~

`AuthorizationManager` properties allow access to information. For example:

- The `privilegeList` property returns a list of all privileges defined on the system, as an array of `AuthorizationPrivilege` data objects. Privileges are defined by VMware, on the objects and properties contained in the system. These privileges are fixed and cannot be changed by client applications.
- The `roleList` property returns a list of all currently defined roles, including the system-defined roles, as an array of `AuthorizationRole` data objects.

Using Roles to Consolidate Sets of Privileges

A role is a named set of one or more privileges. A role is normally defined for a group of people who have common responsibilities in the system, for example, administrators. Each role can have zero to multiple privileges. ESXi defines system roles and user roles.

- System roles. Cannot be modified or deleted.
- User roles. Apply to different user communities or restrict access for add-on tools. Several predefined user roles are included with vCenter Server and with ESXi systems. You can create new roles using these predefined user roles as a starting point.

Description of Roles on vSphere Servers

The following table describes system roles and user roles in more detail and lists currently available roles as examples.

Type	Role name	Role ID	Description
System Roles	Administrator	-1	Superuser access. Encompasses the set of all defined privileges. This role cannot be deleted. By default, the Administrator role is granted to the user or group that owns the root node.
	Anonymous	-4	Cannot be granted. Default access role associated with any user account that has logged in.
	No Access	-5	No access. Explicitly denies access to the user or group with this role. Assigning this role to a user account prevents the user from seeing any objects. Use the `No Access` role to mask subobjects under a higher-level object that has propagated permissions defined.
	Read-Only	-2	Read-only access. Encompasses the set of all nonmutable privileges. (`System.Anonymous`, `System.Read`, and `System.View`). Equivalent to a user role with no permissions. Users with this role can read data or properties and call query methods, but cannot make changes to the system.
	View	-3	Visibility access consisting of `System.Anonymous` and `System.View` privileges. Cannot be granted.
Sample Roles	Virtual Machine Administrator	1	Set of privileges necessary to manage virtual machines and hosts within the system.
	Datacenter Administrator	2	Set of privileges necessary to manage resources, but not interact with virtual machines.
	Virtual Machine Provider	3	Set of privileges necessary to provision resources.
	Virtual Machine Power User	4	Set of privileges for a virtual machine user that can also make configuration changes and create new virtual machines.
	Virtual Machine User	5	Set of privileges necessary to use virtual machines only. Cannot reconfigure virtual machines.
	ResourcePool Administrator	6	Available on vCenter Server systems only.
	VMware Consolidated Backup Utility	7	Available on vCenter Server systems only. Set of privileges necessary to run the Consolidated Backup Utility.

Modifying Sample Roles to Create New Roles

The system roles cannot be modified or deleted. However, you can create new roles, or modify the sample roles.

To create new roles using the API, use the following steps.

Procedure

1 Starting with the `ServiceContent` object in `ServiceInstance.content`, obtain a managed object reference to the `AuthorizationManager` for the server.

2 Invoke the `AddAuthorizationRole` method. Parameters are a reference to `AuthorizationManager`, a name for the role (as a string), and an array of privileges (array of strings) that should be assigned to the role.

   `AddAuthorizationRole` returns an integer (`xsd:int`) value for the `roleId` that the system assigns to the newly defined role.

3 In subsequent code, use the `roleID` to assign the role to specific users or groups.

Granting Privileges Through Permissions

When you use one of the `AuthorizationManager` objects to assign or modify permissions, you use a `Permission` data object. `Permission` associates a principal with a set of privileges. A permission identifies:

- The user or group (`principal`) to which the permission applies.
- The role containing the privileges that should be granted to the user or group.
- The managed object reference to the entity to which the permission applies.

Every managed entity has at least one `Permission` object associated with it. A managed entity can have more than one `Permission` assigned to it, effectively granting different privileges to different users or groups. Permissions are defined for managed entities either explicitly or through inheritance.

Obtaining Information About Permissions

Users with the Administrator role can obtain information about `Permission` objects at different levels of detail.

- For an array of `Permission` objects, call the `AuthorizationManager.RetrieveAllPermissions` method.
- For specific inventory objects, such as managed entities, folders, datacenters, or virtual services, call the `AuthorizationManager.RetrieveEntityPermissions` method.
- For a role defined in the system, call the `AuthorizationManager.RetrieveRolePermissions` method.

See the *vSphere API Reference*.

Setting, Changing, or Deleting Permissions

The `Permission` data object associates the privileges required to perform an action on an object with the principals (user, group). Principals have privileges through their role. To set or update permissions on an object, use the `AuthorizationManager.SetEntityPermissions` method.

To set permissions on an entity, use the following steps.

Procedure

1. Obtain a reference to the `AuthorizationManager` for the server from the `ServiceContent` object associated with the `ServiceInstance`. For example:

   ```
   ManagedObjectReference hostAuthorizationManager = service.getAuthorizationManager();
   ```

2. Create a `Permission` data object that identifies the user (or group) name, the role, the entity to which the permission should apply, and whether the permission should be applied to the entity's children.

   For example, the following code fragment creates a permission on the root folder of the inventory granting a user Administrator role to the root folder and all its children.

   ```
   Permission per = new Permission();
   per.setGroup(false);
   per.setPrincipal(“new_user_name”);
   per.setRoleId(-1);
   per.setPropagate(true);
   per.setEntity(rootFolder);
   ```

   Permissions cannot be set directly on children in a complex entity. For complex entities, set permissions on the parent entity and set the `propagate` flag to true to apply permissions to the child entities.

   To replace existing permissions with a new set of permissions, use the `AuthorizationManager.ResetEntityPermissions` method.

Impact of Group Membership on Permissions

Users can be members of multiple groups. The system handles multigroup membership as follows:

- Permissions are applied to inventory objects from the containing object to each of its child entities.
- If a user has no explicit user-level permissions, group-level permissions apply as if granted to the user directly.
- Membership in multiple groups with permissions on the same object results in a union of permissions.
- User-level permissions always take precedence over group-level permissions.

Applying Permission to a Managed Entity

The following example shows some of the code required to create a user account and apply a permission to an entity that grants access to the user account based on a role.

The role with role ID 4, assigned in this example, is defined as a “Virtual Machine Power User.” The sample uses `AuthorizationManager` to grant permissions to the user and to associate the permission with the managed entity in the inventory—in this example, the `rootFolder`. The example uses the `apputil` helper classes to access the objects.

Example: Creating a User Account

```
...
ManagedObjectReference _authManRef = _sic.getAuthorizationManager();
public class CreateUser {
private static AppUtil appUtil= null;
private void createUser() throws Exception {
ManagedObjectReference hostLocalAccountManager =
appUtil.getConnection().getServiceContent().getAccountManager();
ManagedObjectReference hostAuthorizationManager =
     appUtil.getConnection().getServiceContent().getAuthorizationManager();

// Create a user
HostAccountSpec hostAccountSpec = new HostAccountSpec();
hostAccountSpec.setId(userName);
hostAccountSpec.setPassword(password);
hostAccountSpec.setDescription("my delegated admin auto-agent software");
appUtil.getConnection().getService().createUser(hostLocalAccountManager, hostAccountSpec);
ManagedObjectReference rootFolder = appUtil.getConnection().getServiceContent().getRootFolder();
Permission permission = new Permission();
permission.setGroup(false);
permission.setPrincipal(userName);

// Assign the Virtual Machine Power User role
permission.setRoleId(4);
permission.setPropagate(true);
permission.setEntity(rootFolder);
appUtil.getConnection().getService().setEntityPermissions(hostAuthorizationManager, rootFolder,
     new Permission [] {permission});
...
```

Authenticating Users Through SessionManager

The `SessionManager` managed object controls user access to the server. `SessionManager` includes methods for logging in to the server, obtaining a session, and logging out. The `SessionManager` defines the lifetime and visibility of many objects. Session-specific objects are not visible outside the session in which they are created.

Important Each user session uses system resources and creates locks on the server side. Too many concurrent sessions can slow down the server. By default, vCenter Server terminates a session after 30 minutes.

Upon successful authentication of a user account, `SessionManager` returns a `UserSession` data object to the client application. The session is associated with that user account for the duration of the session. The client application can save the session locally, to a secure file, and reuse the session later to reconnect to the server. You can also configure an ESXi or vCenter Server system to support local sessions, which enable users with credentials on the host to log in based on those privileges.

The SessionManager provides these capabilities:

- Log in and log out. Basic operations to log in to ESXi or vCenter Server system, obtain a session, and log out. When a session terminates, all session-specific objects are destroyed.
- Impersonation. One user session adopts the authorization level of another user session. Impersonation is common in Web based scenarios in which a middle-tier application functions as a central account that interacts with other back-end servers or processes. Windows services impersonate a client when accessing resources on behalf of the client. SesssionManager supports impersonation through its ImpersonateUser method.
- Delegation. A client application that is running on behalf of a local user can call the SessionManager.AcquireLocalTicket method to obtain a one-time user name and password for logging in. Delegation is useful for host-based utilities that run in the local console.

If the user account associated with the session does not have the permissions required to perform an action, the AuthorizationManager returns a NoPermission fault to the client application.

Using VMware Single Sign On for vCenter Server Sessions

vSphere supports single sign on for a single point of authentication for vCenter Server clients. To use VMware Single Sign On, your vSphere Web Services SDK client connects to the VMware SSO Server to obtain an SSO token. Your client includes the token in the SessionManager.LoginByToken request to start a vSphere session.

For more information about creating a session, see Establishing a Single Sign-On Session with a vCenter Server.

Using the Credential Store for Automated Login

To facilitate automated login for unattended applications, the vSphere Web Services SDK includes client-side credential store libraries and tools for automating the login process in a more secure manner. The libraries eliminate the need for system administrators to keep passwords in local scripts.

Important These libraries are built on top of the vSphere Web Services SDK.

The credential store has the following components:

- A persistence file (credential store backing file) that stores authentication credentials. Currently, only passwords are supported. The persistence file maps a remote user account from an ESXi host to the password for that user on the server.
- C#, Java, and Perl libraries for managing the credential store programmatically. See Credential Store Methods for available methods.
- Java and Microsoft PowerShell-based command-line utilities for managing the credential store.

In addition to the libraries listed in Credential Store Libraries, the vSphere Web Services SDK includes the `CredentialStoreAdmin` tool for creating, examining, and managing the credential store. You can use the tool to examine the contents of the credential store, for example, the generated user accounts and passwords.

If you use these credential store client libraries in an application, you must set up the credential store on all client machines that run your application.

Credential Store Libraries

The following table shows the credential management libraries for Java and C#.

Package com.vmware.security.credstore (Java)	Namespace VMware.Security.CredentialStore(C#)
CredentialStore.java	CredentialStoreFactory.cs
CredentialStoreFactory.java	CredentialStore.cs

Several of the helper classes provided with the sample applications use the credential store mechanism.

Credential Store Methods

The following table shows the methods used in Java and C# clients for managing credentials.

Java	C#	Description
`addPassword(hostname, username, password)`	`AddPassword(hostname, username, password)`	Stores the password for the specified host and user. Overwrites any existing password for that user in the credential store. Creates the default credential store backing file in the default location (if it does not exist).
`removePassword(hostname, username)`	`RemovePassword(hostname, username)`	Deletes the password for the specified user from the credential store.
`clearPasswords()`	`ClearPasswords()`	Deletes all passwords from the credential store.
`getPassword(hostname, username)`	`GetPassword(hostname, username)`	Returns the password for the specified host and user from the credential store.
`getHosts()`	`GetHosts()`	Returns the set of hosts contained in the credential store.
`getUsernames(hostname)`	`GetUsernames(hostname)`	Returns the collection of all user names that have passwords stored for the specified `hostname`.
`close()`	`Close()`	Closes the credential store, preventing further method invocations. Releases associated resources.

Credential Store Backing File

The credential store backing file is an XML file that is saved locally on the client machine for access at runtime. Unless otherwise specified, the backing file is located in the following location:

- Linux. `$HOME/.vmware/credstore/vicredentials.xml`
- Windows Vista. `C:\Users\[user_name]\AppData\Roaming\VMware\credstore\vicredentials.xml`
- Windows XP and Windows 2000. `C:\Documents and Settings\[user_name]\Application Data\VMware\credstore\vicredentials.xml`

The credential store persists locally on a per-user basis—each user has his or her own credential store backing file.

Caution The credential store backing files use filesystem-level permissions to ensure that passwords remain confidential. Protect the credential store backing file with appropriate file permissions.

Example: Credential Store File Format shows the XML elements that are read and written to the file.

Example: Credential Store File Format

```
<?xml version="1.0" encoding="UTF-8"?>
     <viCredentials>
          <version>1.0</version>
          <passwordEntry>
              <host>mi6.vmware.com</host>
              <username>agent007</username>
              <password>IhWS1saIhtsw2FbIh0w2F2...</password>
          </passwordEntry>
          <passwordEntry>
              ...
          </passwordEntry>
          ...
     </viCredentials>
```

Credential Store Samples

The `CreateUser` and `SimpleAgent` sample applications demonstrate how to use the credential store client libraries.

- The `CreateUser` sample creates a user account and password for the server based on random-number-generation scheme. The sample populates the local credential store backing file with this information. If the backing file does not exist, it is created in the default location.

When you run `CreateUser`, specify the name of an ESXi system, and an administrator user name and password. A user account name and password are created on the server. Specify `--ignorecert` unless your system has a secure connection to the target. Do not use `--ignorecert` in a production environment.

```
java com.vmware.samples.simpleagent.CreateUser --server <servername> --url
https://<servername>/sdk --username <adminuser> --password <pwd> --ignorecert ignorecert
```

Caution The `CreateUser` sample application is for demonstration purposes only and should not be used as a model for production code. The sample breaks the principle of least privilege by granting the user account the Administrator role (-1). Never do this in a production environment.

- The `SimpleAgent` sample application demonstrates how to use credential store libraries to extract the user account and password at runtime to authenticate a user noninteractively.

```
java com.vmware.samples.simpleagent.SimpleAgent <servername>
```

Specifying Roles and Users with the Credential Store

VMware recommends that you apply the principle of least privilege to any agent-like software or automated application that uses the credential store in a production environment. Give user accounts the minimal number of privileges on the system that they require to do their jobs.

Specify roles and users as follows:

Procedure

1 For each SDK-based application, use one specific role, newly created or predefined, that has appropriate privileges.

   For example, if you are developing an agent-like application to automatically start the VMware Consolidated Backup utility, you might use the “VMware Consolidated Backup Utility” role (roleID 7).

   If no predefined user role that meets the needs of your application exists, create a role with only those privileges needed for the application. See Using Roles to Consolidate Sets of Privileges for more information about roles.

2 Create a user account for use with the agent or application.

3 Apply the role created in Step 1 to the user account created in Step 2.

4 Store the user account and password in the credential store, using the `CredentialStoreAdministration` tool.

   Never grant administrator privileges to a user account associated with an automated script or software agent, especially one that uses the credential store.

Managing Licenses with LicenseManager

When you want to perform tasks in the vSphere environment, you must have licenses to do so. Licensing applies to ESXi hosts, vCenter Server, and special features such as VMware HA or VMware vMotion.

The *vSphere Datacenter Administration Guide* explains how to manage ESXi and vCenter Server licenses using the vSphere Client, and gives background information about license keys, license inventory, and related topics.

You can also manage licenses using the `LicenseManager` and `LicenseAssignmentManager` managed objects. You use `LicenseManager` to explicitly manage the pool of available licenses on ESXi systems released before vSphere 4.0. You use `LicenseAssignmentManager`, available through the `LicenseManager.licenseAssignmentManager` property, to manage assignment of licenses to entities in the vCenter Server inventory. You can retrieve information, add licenses, and remove licenses.

Retrieve Information

- Retrieve the `LicenseManager.evaluation` and `LicenseManager.licenses` properties to obtain information on evaluation licenses and full licenses.
- Call `LicenseManager.DecodeLicense` to decode license information. The call returns a `LicenseManagerLicenseInfo` data object, which encapsulates information about the license.
- Call `LicenseAssignmentManager.QueryAssignedLicenses` for information about assigned licenses.

Add Licenses

- Call `LicenseManager.AddLicense`, passing in a license key, to add a license to the inventory of available licenses.
- Call `LicenseAssignmentManager.UpdateAssignedLicense`, passing in a license key, to update the licenses for an entity, for example, a host system.

Remove Licenses

- Call `LicenseAssignmentManager.RemoveAssignedLicense` to remove all licenses from an entity, passing in an entity to remove licenses from. You can then assign those licenses to other entities.
- Call `LicenseManager.RemoveLicense`, passing in a license key, to remove a license from the inventory of available licenses.

Hosts

7

Many of the operations in your vSphere environment involve setting up the ESXi hosts on which the virtualization layer runs. You can set up storage and networking, and those settings directly affect the virtual machine. You must also manage other aspects of the host, as discussed in this chapter.

Important See the *ESX Configuration Guide* and the *ESXi Configuration Guide* for important information on security considerations, not included here.

This chapter includes the following topics:

Host Management Objects

The vSphere Web Services SDK includes several objects for host management.

The central object is `HostSystem`. Each property of `HostSystem` is a data object that encapsulates some information about the host. For example, the `capability` property is a `HostCapability` object, the `runtime` property is a `HostRuntimeInfo` object. See the *API Reference* for a list of the properties and the corresponding data objects.

`HostSystem` methods allow you to perform certain tasks on ESX/ESXi hosts. However, many tasks are not performed through `HostSystem` methods, but through methods in managed objects related to `HostSystem`. For example, you manage the host time using the `HostDateTimeSystem` and you manage kernel modules using `HostKernelModuleSystem`.

Retrieving Host Information

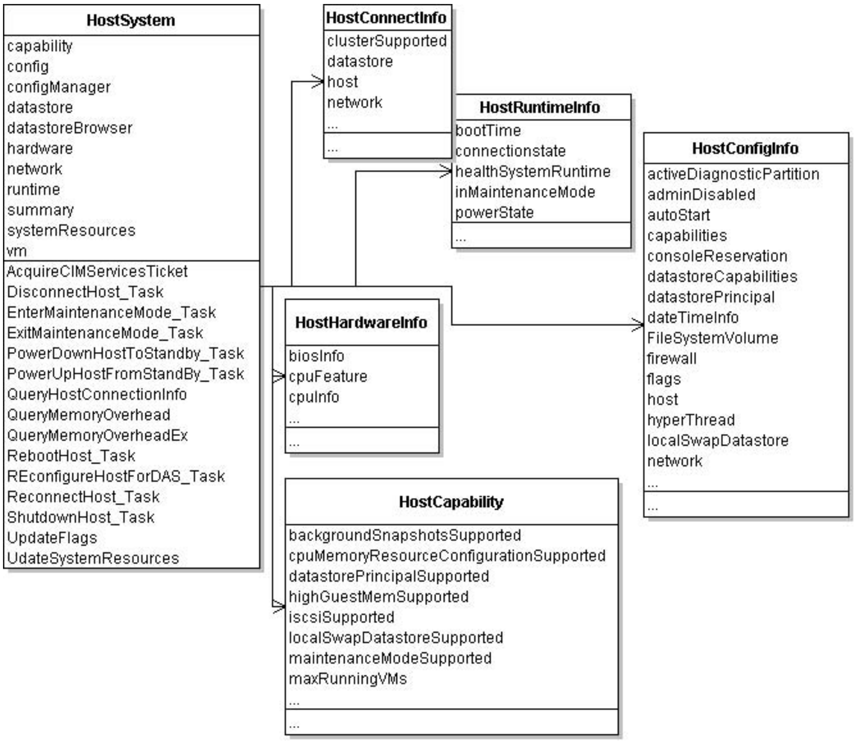
You retrieve information about the host by accessing data objects defined for the `HostSystem`.

- `HostSystem.capability` is a `HostCapability` object. The `HostCapability` properties indicate the features that are supported by the host, for example, `maintenanceModeSupported` or `recursiveResourcePoolsSupported`.
- `HostSystem.runtimeInfo` is a `HostRuntimeInfo` object that contains several data objects with detailed information about the current state of the host. You can, for example, extract the health status as a `HealthSystemRuntime` object or the power state as a `HostPowerState` object.
- `HostSystem.hardware` is a `HostHardwareInfo` object that allows you to retrieve the host's hardware configuration including CPU and NUMA information and memory size.
- `HostSystem.config` is a `HostConfigInfo` object. This data object type encapsulates a typical set of host configuration information that is useful for displaying and configuring a host. You can access the `HostConfigInfo` object only on managed hosts, and only if the host is connected.

`HostSystem` has several additional properties that allow you to directly access the virtual machines, datastores, and networks associated with that system.

The `QueryHostConnectionInfo`, `QueryMemoryOverhead`, and `QueryMemoryOverheadEx` methods are available for information retrieval.

Figure 7-1. HostSystem and Information Properties



Configuring and Reconfiguring Hosts

When you configure or reconfigure an ESX/ESXi host, you usually do not use the methods in HostSystem directly, but work with managed objects available for configuration of that part of the system. For example, HostNetworkSystem allows you to configure the network, and HostAuthorizationManager is for managing users, groups, and permissions on a host. The objects and related methods are discussed in the corresponding chapters of this guide.

Some methods are defined locally in HostSystem. See the *vSphere API Reference* for details on each method.

- CIM Management – AcquireCimServicesTicket. For additional information on using vSphere with CIM, see the VMware CIM APIs documentation.
- Host Lifecycle – RebootHost_Task, ShutdownHost_Task, PowerDownHostToStandBy_Task, PowerUpHostFromStandBy_Task, DisconnectHost_Task, ReconnectHost_Task. See Managing the Host Lifecycle.
- Maintenance Mode – EnterMaintenanceMode_Task, ExitMaintenanceMode_Task.
- Updates – UpdateFlags, UpdateIpmi, UpdateSystemResources.

Managing the Host Lifecycle

A host's lifecycle depends in part on whether the host is a standalone host or managed by a vCenter Server system.

Reboot and Shutdown

You can reboot and shut down managed and standalone hosts. The ShutdownHost_Task method is not supported on all hosts. Check the host capability shutdownSupported.

You can call both methods with a force parameter, which specifies whether to reboot hosts even when virtual machines are running or other operations are in progress on the host. If you set the parameter to false, hosts are rebooted only when they are in maintenance mode.

- ShutdownHost_Task – Shuts down a host. If connected directly to the host, the client never receives an indicator of success in the returned task, but temporarily loses connection to the host. If the method does not succeed, an error is returned.
- RebootHost_Task – Reboots a host. If the command is successful, then the host has been rebooted. Clients connected directly to the host do not receive an indication of success in the returned task, but temporarily lose connection to the host. If the method does not succeed, an error is returned.

Using Standby Mode

Standby is a power state in which the host does not support provisioning or power on of virtual machines. VMware power management module might evacuate and put a host in standby mode to save power. The host can be powered up remotely by using PowerUpHostFromStandBy_Task.

The following methods support standby mode. Both methods are cancelable.

- PowerDownHostToStandBy_Task – Puts the host in standby mode, a mode in which the host is in a standby state from which it can be powered up remotely. The command is only supported on hosts on which the host capability standbySupported is true.

  While this task is running, no virtual machines can be powered on and no provisioning operations can be performed on the host.

  Calling this method does not directly initiate any operations to evacuate or power down powered-on virtual machines. However, if VMware DRS is enabled, the vCenter Server migrates powered-off virtual machines or recommends migration to a different host, depending on the automation level. If the host is part of a cluster and the task is issued with a vCenter Server target with the method's evacuatePoweredOffVms parameter set to true, the task does not succeed unless all the powered-off virtual machines are reregistered to other hosts.
- PowerUpHostFromStandBy_Task – Takes the host out of standby mode. If the command is successful, the host wakes up and starts sending heartbeats. This method might be called automatically by VMware DRS to add capacity to a cluster, if the host is not in maintenance mode.

Disconnecting and Reconnecting Hosts

You can make a host a managed host by adding it to the vCenter Server system. You can later disconnect and reconnect the host, for example, to refresh the agents.

You can use the following methods, which are only supported if you access the host through a vCenter Server system.

- QueryHostConnectionInfo – Returns a HostConnectInfo object, which is the same object that the Datacenter.QueryConnectionInfo returns. The information in this object can be used by a connection wizard, like the wizard used in the vSphere Client.
- DisconnectHost_Task – Disconnects from a host and instructs the vCenter Server system to stop sending heartbeats to the host.
- ReconnectHost_Task – Reconnects a host to the vCenter Server system. This process reinstalls agents and reconfigures the host, if it has gotten out of sync with the server. The reconnection process checks for the correct set of licenses and for the number of CPUs on the host, ensures the correct set of agents is installed, and ensures that networks and datastores are discovered and registered with the vCenter Server system.

  Client applications can change the IP address and port of the host when doing a reconnect operation. This can be useful if the client wants to preserve existing metadata, such as statistics, alarms, and privileges, even though the host is changing its IP address.

Querying and Changing the Host Time

The HostDateTimeSystem supports date and time related configuration on a host and supports NTP configuration.

The `HostDateTimeSystem.dateTimeInfo` property allows you to retrieve and set date and time information. The `HostDateTimeInfo` data object's properties contain two data object for date time management:

- `HostNTPConfig` contains a list of NTP servers for use by the host.
- `HostDateTimeSystemTimeZone` specifies the time zone including the GMT offset, identifier for the time zone, and name.

You can also query the host's time information by calling one of the `HostDateTimeSystem` methods.

- `QueryAvailableTimeZones` – Retrieves the list of available timezones on the host. The method uses the public domain `tz` timezone database. The method returns an array of `HostDateTimeSystemTimeZone` objects.
- `QueryDateTime` – Returns the current date and time on the host.

You can modify the host's date time information by calling one of the following `HostDateTimeSystem` methods:

- `RefreshDateTimeSystem` – Refreshes the date and time related settings to pick up any changes that might have occurred.
- `UpdateDateTime` – Updates the date and time on the host using the date and time passed into the method. Use with caution. Network delays or execution delays can result in time skews.
- `UpdateDateTimeConfig` – Updates the date and time configuration of the host. You call this method with a `HostDateTimeConfig` parameter, which allows you to specify both the NTP configuration and the time zone.

Querying Virtual Machine Memory Overhead

Each virtual machine you power on requires a certain amount of memory for its use. In addition, the host must have some memory overhead available for each virtual machine. To find out about memory overheat, call the `HostSystem.QueryMemoryOverheadEx` method. The method takes a `virtualMachineConfigInfo` data object as an argument, and determines the amount of overhead necessary to power on a virtual machine with those characteristics.

The methods returns the amount of memory required, in bytes.

Storage 8

A virtual machine uses a virtual disk to store its operating system, program files, and other data. A virtual disk is a large physical file, or a set of files, that can be copied, moved, archived, and backed up like other files. To store and manipulate virtual disk files, a host requires dedicated storage space. ESX/ESXi supports storage in multiple ways. Hosts that are managed by a vCenter Server system can share storage.

Any type of network-attached storage requires complete configuration of networking in the VMkernel to support network-based access to the storage media. The VMkernel requires its own IP address. See #unique_148.

This chapter includes the following topics:

Storage Management Objects

You can access the objects that support storage management through the `HostSystem` managed object.

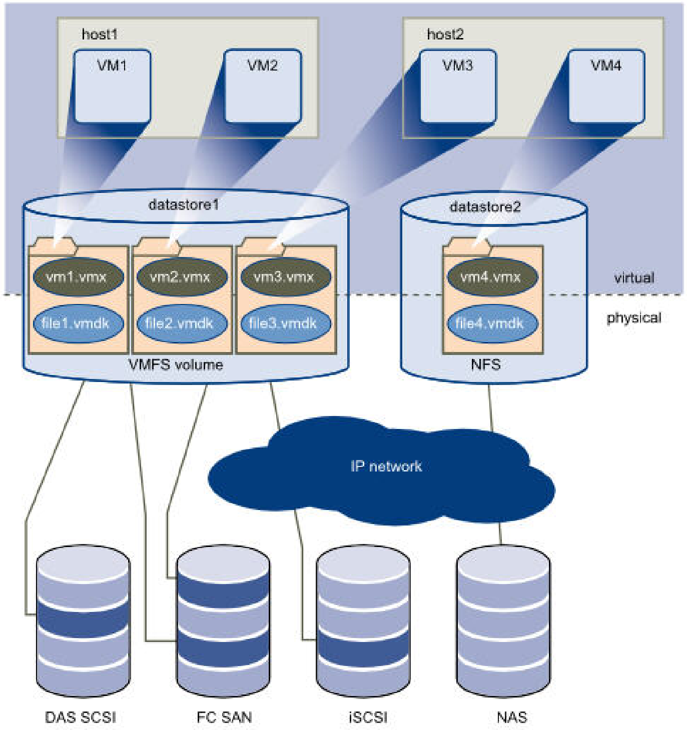
- `HostStorageSystem` – The `HostSystem.storageSystem` property is a managed object reference to the `HostStorageSystem` of the ESX/ESXi system. `HostStorageSystem` is a low-level interface that is used mainly for configuring the physical storage. See Configuring Disk Partitions.

- `HostDatastoreSystem` – The `HostSystem.datastoreSystem` property is a managed object reference to a `HostDatastoreSystem` managed object. `HostDatastoreSystem` methods allow you to create, configure, extend, and remove datastores. While `HostStorageSystem` supports access and configuration of physical storage, `HostDatastoreSystem` supports access and configuration of logical storage through the volumes (`Datastore` managed objects) the host can use for virtual machines. See Creating and Managing Datastores.
- `HostDatastoreBrowser` – Provides access to the contents of one or more datastores. The items in a datastore are files that contain configuration, virtual disk, and other data associated with a virtual machine.
- `Datastore` – The `Datastore` managed entity provides methods for mounting datastores, browsing datastores, and obtaining information about the datastores associated with a virtual machine. See Creating and Managing Datastores.
- `HostDiagnosticPartition` – Supports creating and querying diagnostic partitions for your ESX/ESXi host. See Managing Diagnostic Partitions.

Introduction to Storage

The VMware vSphere storage architecture consists of layers of abstraction that hide and manage the complexity and differences of physical storage subsystems, shown in the following illustration.

Figure 8-1. Storage Architecture



How Virtual Machines Access Storage

Virtual machines use virtual disks for their operating system, application software, and other data files. A virtual disk is stored as a VMDK file on a datastore. The virtual disk hides the physical storage layer from the virtual machine's operating system. Regardless of the type of storage device that your host uses, the virtual disk always appears to the virtual machine as a local SCSI device. As a result, you can run operating systems that are not certified for specific storage equipment, such as SAN, in the virtual machine.

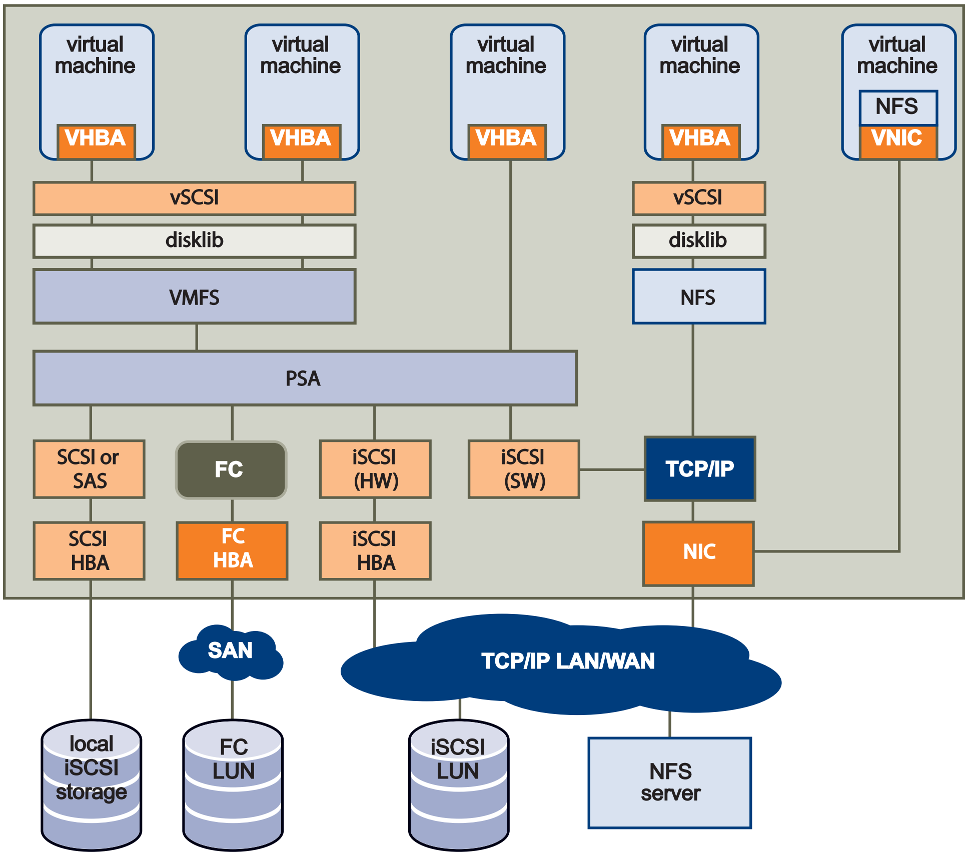
When a virtual machine communicates with its virtual disk stored on a datastore, it issues SCSI commands. Because datastores can exist on different types of physical storage, these commands are encapsulated into other forms, depending on the protocol that the ESX/ESXi host uses to connect to the physical storage device.

To the applications and guest operating systems running on each virtual machine, the storage subsystem appears as a virtual SCSI controller connected to one or more virtual SCSI disks as shown in the top half of Figure 8-1. These controllers are the only types of SCSI controllers that a virtual machine can see and access, and include the objects that extend `VirtualSCSIController`:

- `ParaVirtualSCSIController`
- `VirtualBusLogicController`
- `VirtualLsiLogicController`
- `VirtualLsiLogicSASController`

How precisely a virtual machine accesses storage depends on the setup of the host. Figure 8-2 gives an overview of the different possibilities.

Figure 8-2. Storage API Architecture



Datastores

A datastore is a manageable storage entity, usually used as a repository for virtual machine files including log files, scripts, configuration files, virtual disks, and so on. vSphere supports two types of datastores, VMFS and NAS.

- If you want to use a NAS volume, mount it using `CreateNasDatastore` and unmount it using `RemoveDatastore`. The two commands are host specific, you must invoke the create and remove methods on each host on which you want to mount or unmount the datastore.
- To create a VMFS datastore, call `CreateVmfsDatastore`, passing in any existing disk. As a result of the call, the disk is formatted with VMFS and the datastore is automounted on all ESX/ESXi hosts on which the disk is visible the next time you perform a rescan. When you call `RemoveDatastore` on a VMFS datastore, the datastore is destroyed. After a rescan, the datastore is no longer available to any ESX/ESXi systems. In contrast to NAS datastores, you do not have to invoke methods for creation and removal of the datastore on each host.

An ESX/ESXi host automatically discovers the VMFS volume on attached Logical Unit Numbers (LUNs) on startup and after re-scanning the host bus adapter. When you create a VMFS datastore, the datastore label is based on the VMFS volume label. If there is a conflict with an existing datastore, the label is made unique by appending a suffix. The VMFS volume label remains unchanged.

Destroying a VMFS datastore removes the partitions that compose the VMFS volume.

Datastores can span multiple physical storage devices. A single VMFS volume can contain one or more LUNs from a local SCSI disk array on a physical host, a Fibre Channel SAN disk farm, or iSCSI SAN disk farm. The ESX/ESXi system detects new LUNS that are added to any of the physical storage subsystems. When the user queries for a list of available devices, the newly discovered devices are included. You can extend storage capacity on an existing VMFS volume without powering down physical hosts or storage subsystems.

If any of the LUNs within a VMFS volume fails or becomes unavailable, only virtual machines with data on that LUN are affected. An exception is the LUN that has the first extent of the spanned volume (multi-extent volume). All other virtual machines with virtual disks residing on other LUNs continue to function normally.

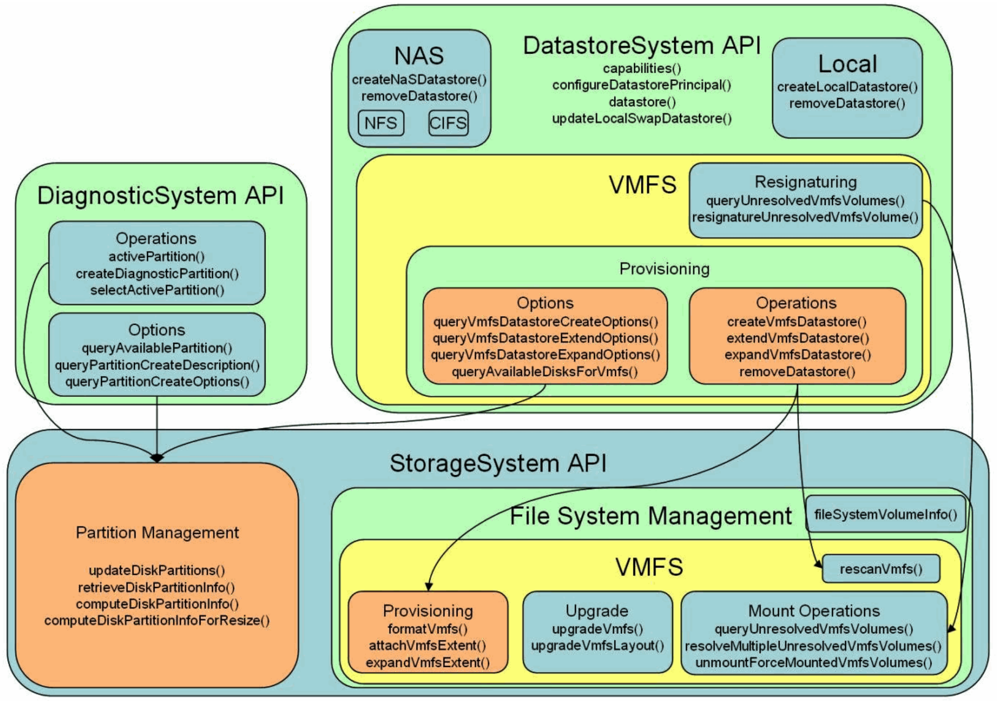
Choosing the Storage API to Use

The `HostStorageSystem` APIs are low-level enough for performing VMFS provisioning operations. They require a knowledge of partitioning details and VMFS extent composition. They do not enforce VMFS best practices like partition alignment and optimum VMFS block sizes, and they allow you to mix extents from different datastores on the same LUN and to add extents even though expansion is preferable in most cases.

The `HostDatastoreSystem` APIs are primarily used for managing VMFS volumes. They don't require an in-depth knowledge of storage systems, and do enforce best practices.

Figure 8-3 gives an overview of the different APIs. See Managed Objects for Working with Storage to determine which tasks are commonly performed with which API.

Figure 8-3. Storage APIs



Managed Objects for Working with Storage

The Web Services API provides several managed objects that are designed to work with ESXi storage devices.

Managed Object	Task	See
HostStorageSystem	Low-level operations associated with individual hosts, such as resizing or updating disk partitions.	Configuring Disk Partitions
HostStorageSystem	Multipath management.	Multipath Management
HostStorageSystem	iSCSI Storage setup and configuration.	Configuring iSCSI Storage
HostDatastoreSystem	Creating and managing VMFS datastores and remote datastores.	Creating and Managing Datastores
HostDatastoreSystem HostStorageSystem	Managing VMFS volume copies (resignature or force mount).	Managing VMFS Volume Copies (Resignaturing)
HostDiagnosticSystem	Creating and managing diagnostic partitions.	Managing Diagnostic Partitions

Configuring Disk Partitions

HostStorageSystem manages low-level storage components including HBAs, SCSI LUNs, file system volumes, and so on. You can use this API to set up the partitions before creating, extending, or expanding a VMFS file system.

- ComputeDiskPartitionInfo – Computes the disk partition information based on the specified disk layout. The server computes a new HostDiskPartitionInfo object for a specific disk using the layout that is specified by the HostDiskPartitionLayout object. Inside the HostDiskPartitionLayout object, you specify the list of block ranges for that partition, and optionally the total number and size of the blocks. You can then use that information inside the HostDiskPartitionSpec when updating a disk partition.

- ComputeDiskPartitionInfoForResize – Computes the disk partition information to support resizing a given partition. Returns the resized disk partition information as a HostDiskPartitionInfo object. You can then use that information inside the HostDiskPartitionSpec when resizing the disk partition.

- RetrieveDiskPartitionInfo – Allows you to specify an array of device path names that identify disks and returns an array of HostPartitionInfo objects for each of those disks.

- UpdateDiskPartitions – Changes the partitions on a disk by supplying a partition specification (HostDiskPartitionSpec) and device name.

After you have updated the disk partitions for the host, you must perform a rescan by using one of the following methods. Complete rescans might take a long time.

- RefreshStorageSystem – Refreshes the storage information and settings to pick up changes, but does not explicitly issue commands to discover new devices.
- RescanAllHba – Rescans all host bus adapters for new storage devices. This method might take a long time.
- RescanHba – Rescans a specific host bus adapter for new devices.

HostStorageSystem methods are also used for setting up iSCSI storage. See Configuring iSCSI Storage.

Multipath Management

The *vSphere Storage* documentation includes information about using multipathing for failover and load balancing. You can manage multipathing using the vSphere Client, the esxcli command, or using the following commands. Use the HostStorageSystem.multipathStateInfo property to access the HostMultipathStateInfo data object that describes runtime information about the state of multipathing on a given host.

- EnableMultipathPath – Enables a disabled path for a device. Use the pathname from HostMultipathStateInfoPath or HostMultipathInfoPath.
- QueryPathSelectionPolicyOptions – Obtains the set of path-selection-policy options. These options determine the path that can be used by a device that is managed by native multipathing. A HostMultipathInfo data object identifies the devices that are managed through native multipathing.
- QueryStorageArrayTypePolicyOptions – Obtains the set of storage-array-type policy options. These options determine the storage-array-type policies that a device that is managed by native multipathing might use. A HostMultipathInfo data object identifies the devices that are managed through native multipathing.
- SetMultipathLunPolicy – Updates the path selection policy for a LUN. Specify the LUN using the LUN UUID from the HostMultipathInfoLogicalUnit object.
- DisableMultipathPath – Disables an enabled path for a device. Use the pathname from HostMultipathStateInfoPath or HostMultipathInfoPath.

Configuring iSCSI Storage

vSphere supports software iSCSI, dependent hardware iSCSI, and independent hardware iSCSI. See *Configuring iSCSI Adapters and Storage* in the *vSphere Storage* documentation for a detailed discussion.

The following HostStorageSystem methods are available for iSCSI storage management.

- Add a dynamic or static target.
  - AddInternetScsiSendTarget – Adds send target entries to the host bus adapter discovery list if the DiscoveryProperties.sendTargetsDiscoveryEnabled flag is set to true.

  - AddInternetScsiStaticTargets – Adds static target entries to the host bus adapter discovery list. The DiscoveryProperty.staticTargetDiscoveryEnabled flag must be set to true.
- Configure targets.
  - UpdateInternetScsiAdvancedOptions – Updates the advanced options that the iSCSI host bus adapter or the discovery addresses and targets associated with it.
  - UpdateInternetScsiAlias – Updates the alias of an iSCSI host bus adapter.
  - UpdateInternetScsiAuthenticationProperties – Updates the authentication properties for one or more targets or discovery addresses associated with an iSCSI host bus adapter.
  - UpdateInternetScsiDigestProperties – Updates the digest properties for the iSCSI host bus adapter or the discovery addresses and targets associated with it.
  - UpdateInternetScsiDiscoveryProperties – Updates the discovery properties for an iSCSI host bus adapter.
  - UpdateInternetScsiIPProperties – Updates the IP properties for an iSCSI host bus adapter.
  - UpdateInternetScsiName – Updates the name of an iSCSI host bus adapter.
  - UpdateSoftwareInternetScsiEnabled – Enables and disables software iSCSI in the VMkernel.
- Remove a dynamic or static target.
  - RemoveInternetScsiSendTargets – Removes send target entries from the host bus adapter discovery list. The DiscoveryProperty.sendTargetsDiscoveryEnabled must be set to true. If any of the targets provided as parameters are not found in the existing list, the other targets are removed and an exception is thrown.
  - RemoveInternetScsiStaticTargets – Remove static target entries from the host bus adapter discovery list. The DiscoveryProperty.staticTargetDiscoveryEnabled must be set to true. If any of the targets provided as parameters are not found in the existing list, the other targets are removed and an exception is thrown.

iSCSI initiators and targets have unique, permanent iSCSI names and addresses. An iSCSI name correctly identifies a specific iSCSI initiator or target, regardless of physical location. Names must be in EUI or IQN format, as specified by the storage vendor’s hardware.

Configure the VMkernel To Support Software iSCSI

Before you can set up iSCSI on a system, you must create a dedicated VMkernel network interface. See. You can then enable the VMkernel to support iSCSI and configure the initiator.

To enable the VMkernel to support software iSCSI, use the following steps.

Procedure

1. Obtain a managed object reference to the host system’s HostStorageSystem.
2. Invoke the UpdateSoftwareInternetScsiEnabled method, passing the reference to the HostStorageSystem and the value true.

Configure iSCSI Initiators

After you have configured the VMkernel to support software iSCSI, you can configure the storage initiators for iSCSI.

To configure iSCSI initiators, use the following steps.

Procedure

1. Access the list of available HBAs on the host system.

   You can do this by creating a property collector with `HostSystem` as the starting point. See #unique_28. From the `HostSystem.config` property, you can obtain the list (array) of host bus adapters by specifying this property path:

   ```
   config.storageDevice.hostBusAdapter
   ```

   The property path returns an array of host bus adapters. For example:

   ```
   hostBusAdapter["key-vim.host.BlockHba-vmhba32"]
   hostBusAdapter["key-vim.host.BlockHba-vmhba33"]
   hostBusAdapter["key-vim.host.BlockHba-vmhba34"]
   hostBusAdapter["key-vim.host.BlockHba-vmhba35"]
   hostBusAdapter["key-vim.host.BlockHba-vmhba1"]
   ...
   ```

2. From the array, select the host bus adapter (instance of `HostHostBusAdapter`) that you want to configure and obtain its `key` property, which is the device name of the host bus adapter as a string.

3. Determine the capabilities of the adapter by retrieving the properties of the `HostHostBusAdapter` object.

4. Configure the initiator.

   - For an independent hardware initiator, configure the IP address.
   - For a software initiator, enable the software initiator in the VMkernel.

5. Configure the iSCSI name by calling `HostStorageSystem.UpdateInternetScisiName` and the alias by running `HostStorageSystem.UpdateInternetScisiAlias`.

6. Configure target discovery by calling `HostStorageSystem.UpdateInternetScisiHbaDiscoveryProperties`.

   The method takes a `HostInternetScisiHbaDiscoveryProperties` data object that you can configure.

7 (Optional) Set the authentication information by calling `HostStorageSystem.UpdateInternetScisiAuthenticationProperties`.

   The `HostInternetScsiHbaAuthenticationProperties` object you pass into that method includes properties for configuring CHAP and Mutual CHAP. See the *vSphere Storage* documentation for information about securing your iSCSI storage array.

8 Configure access to the targets.

9 Rescan the HBAs.

   Rescan enables the HBAs to discover the new storage devices. You can either rescan a single HBA with `HostStorageSystem.RescanHba`, specifying the HBA ID as a parameter, or rescan all HBAs using `HostStorageSystem.RescanAllHba`.

Creating and Managing Datastores

Each datastore is a logical container, analogous to a file system on a logical volume, where the host places virtual disk files and other virtual machine files. Datastores hide specifics of the physical storage device and provide a uniform model for storing virtual machine files.

The `HostDatastoreSystem` managed object provides methods for creating and managing datastores. All `HostDatastoreSystem` methods require a managed object reference to `HostDatastoreSystem`, and return a reference to the `Datastore` object after it is created.

`HostDatastoreSystem` allows you to create and expand, query, and remove or update datastores. `HostDatastoreSystem` also allows you to configure a datastore principal for a host by calling `ConfigureDatastorePrincipal.` All virtual machine-related file I/O is performed under this user.

VMFS provisioning tasks are often performed as follows:

1 Call `QueryAvailableDisksForVmfs` to get the subset of disks that are well suited for holding VMFS datastores.

   `QueryAvailableDisksForVmfs` obtains a list of disks that can be used to contain VMFS datastore extents. You can provide a datastore name to obtain the list of disks that can contain extents for the specified VMFS datastore. The operation does not return disks currently used by the VMFS datastore, nor does it return management LUNs and disks that are referenced by RDMs. RDM disks are not usable for VMFS datastores.

2 Get information about provisioning options by calling one of the following methods, passing in the selected disk:

   - `QueryVmfsDatastoreCreateOptions` – Obtains information about options for creating a new VMFS datastore on a disk. The method returns an array of `VmfsDatastoreOption` data objects.
   - `QueryVmfsDatastoreExpandOptions` – Obtains information about options for expanding the extents of an existing VMFS datastore.
   - `QueryVmfsDatastoreExtendOptions` – Obtains information about options for extending an existing VMFS datastore for a disk.

3 If required, change the layout by calling `HostStorageSystem.ComputeDiskPartitionInfo` and then `HostStorageSystem.UpdateDiskPartition` to resize the partition.

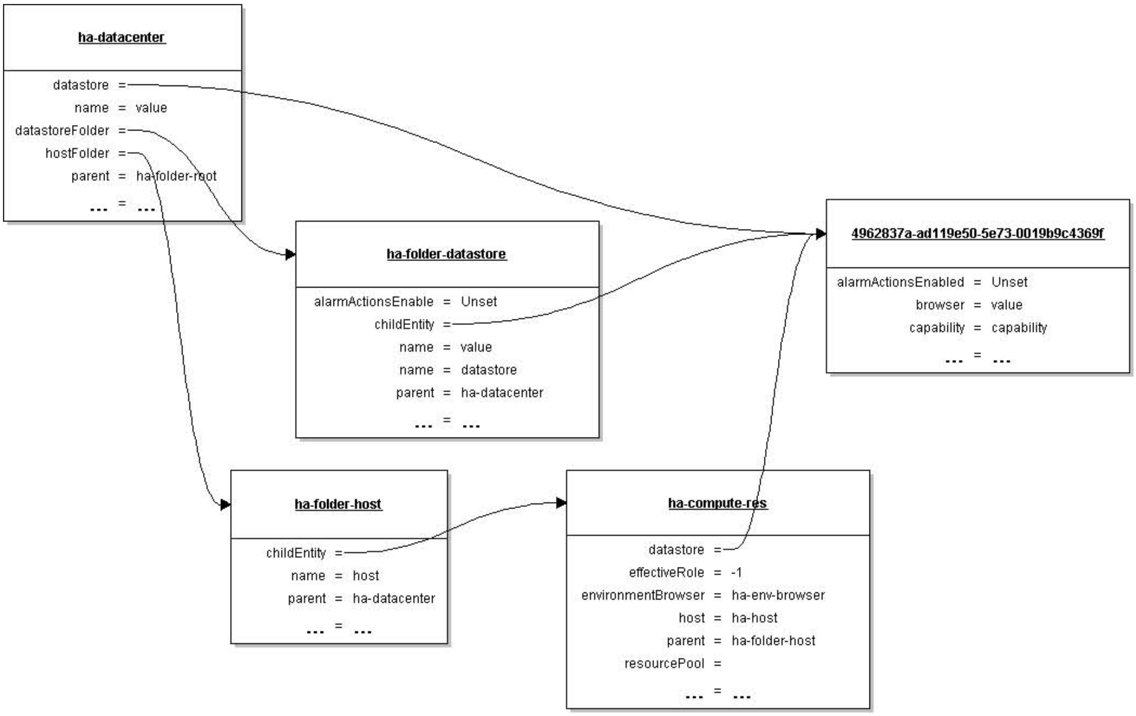
4 Call `CreateVmfsDatastore`, `ExtendVmfsDatastore`, or `ExpandVmfsDatastore` to complete the VMFS provisioning operation.

Accessing Datastores

The following diagram illustrates how you can access or specify datastores.

- Each `Datacenter` managed object has a `datastore` property that contains an array of datastores.
- Each `Datacenter` managed object has a `datastoreFolder` property that is a reference to the folder (or folder hierarchy) that contains the datastores for this datacenter.
- Each `Datacenter` managed object has a `hostFolder` property that is a reference to the folder (or folder hierarchy) that contains the compute resources, including hosts and clusters, for this datacenter. Each `HostSystem` or `ComputeResource` has a `datastore` property that is an array of `Datastore` managed objects.

Figure 8-4. Datastore Managed Object



For more information about the hierarchy of managed objects, see Chapter 4 Datacenter Inventory.

Creating and Modifying a VMFS Datastore

A datastore is a manageable storage entity, usually used as a repository for virtual machine files including log files, scripts, configuration files, virtual disks, and so on.

VMFS is a proprietary file system VMware designed for virtual machines. VMFS is well suited for storing a small number of large data files like virtual disks. These files are mostly used by a single host. VMFS differs from other filesystem formats like FAT16/FAT32 and so on in that it can be accessed by multiple hosts connected to the same SAN LUN.

You can set up a VMFS datastore on any SCSI-based storage device that the host can access. VMFS volume creation, extension, and expansion requires first partitioning operations and the VMFS volume operations.

Set Up Disk Partitions

The Web Services API enables you to manage disk partitions on ESXi host storage devices.

To set up the disk partitions, use the following steps.

Procedure

1. Call `HostStorageSystem.RetrieveDiskPartitionInfo` to retrieve information about existing partitions.

2. Call `HostStorageSystem.ComputeDiskPartition`, passing in the desired disk layout. The server computes a new partition information object for a specific disk representing the desired layout and returns a `HostDiskPartitionInfo` object that you can use in the `HostDiskPartitionSpec` you pass into `UpdateDiskPartitions`.

3. Call `HostStorageSystem.UpdateDiskPartitions` to update partitions by passing in a `HostDiskPartitionSpec`.

Create the VMFS Datastore

After you create disk partitions on host storage, you can configure VMFS datastores.

To create a VMFS datastore, use the following steps.

Procedure

1. Configure and install any third-party adapter your storage requires and rescan the adapters by calling `HostStorageSystem.RescanAllHba`.

2. Call `HostDatastoreSystem.QueryAvailableDisksForVmfs` for information about disks that can be used to contain VMFS datastore.

   This method filters out disks that are currently in use by an existing VMFS unless the VMFS using the disk is one being extended. It will also filter out management LUNs and disks that are referenced by RDMs. These disk LUNs are also unsuited for use by a VMFS. The method returns an array of `HostScisiDisk` objects.

3. Call `HostDatastoreSystem.QueryVmfsDatastoreCreateOptions` for information about options for for creating a new VMFS datastore. The call returns an array of `VmfsDatastoreCreateOption` data objects that allow you to access the UUIDs of suitable data stores.

4. (Optional) If no suitable partitions for your VMFS volume exist, you might have to create them. Use the `ComputeDiskPartitionInfo` and `UpdateDiskPartitions` methods in `HostStorageSystem`.

5 Create the datastore.

- Call HostDatastoreSystem.CreateVmfsDatastore to create a VMFS datastore. The method takes a VmfsDatastoreCreateSpec data object that consists of a a partition, a HostVmfsSpec, and an optional extent. The HostVmfsSpec allows you to specify the block size, extent, major version, and volume name for the VMFS.
- Call HostDatastoreSystem.CreateNasDatastore to create a network-attached storage based datastore.

You can later expand and extend the VMFS datastore by calling one of the following methods.

- Call first QueryVmfsDatastoreExpandOptions and then ExpandVmfsDatastore to expand an existing VMFS datastore using the specification provided in the VmfsDatastoreExpandSpec data object (which contains the name of the extent and partition information). ExpandVmfsDatastore increases the size of the datastore up to the full size provisioned for the datastore, if necessary.
- Call first QueryVmfsDatastoreExtendOptions and then ExtendVmfsDatastore to extend an existing VMFS datastore using the specification provided in the VmfsDatastoreExtendSpec data object.

Removing and Updating Datastores

The Web Services API has methods to update and remove datastores.

- RemoveDatastore – Removes a datastore from a host.
- UpdateLocalSwapDatastore - Choose the localSwapDatastore for this host. Any change to this setting affects virtual machines that subsequently power on or resume from a suspended state at this host, or that migrate to this host while powered on. Virtual machines that are currently powered on at this host are not affected.

See the *vSphere API Reference* for more information about the HostDatastoreSystem operations, including constraints and limitations.

Managing VMFS Datastores with HostStorageSystem

In most cases, the Datastore methods are appropriate for creating and managing VMFS datastores. However, in some cases the following HostStorageSystem commands are used instead:

- AttachVmfsExtent – Extends a VMFS by attaching a disk partition as an extent.
- ExpandVmfsExtent – Expands a VMFS extent as specified by the disk partition specification.
- FormatVmfs – Formats a new VMFS on a disk partition based on the HostVmfsSpec that you pass in. Returns a HostVmfsVolume that represents the new VMFS file system. The HostVmfsVolume includes the block size, list of partition names of the disk’s VMFS extents, and other information including the UUID.

  This command is a low-level API you can use to partition disks explicitly. In most cases, the Datastore VMFS commands are more suitable.

- `RescanVmfs` – Rescans for new VMFS instances.
- `UpgradeVmfs` – Upgrades the VMFS to the current VMFS version.

Update and Upgrade with HostStorageSystem

You can use the HostStorageSystem managed object to alter characteristics of storage units.

- `HostStorageSystem.UpdateScsiLunDisplayName` – Update the mutable display name associated with a SCSI LUN. The SCSI LUN to be updated is identified using the LUN UUID.
- `HostStorageSystem.UpgradeVmLayout` – Iterates over all registered virtual machines. For each virtual machine, upgrades the layout and logs an event. After the method has been called, the information in the `VirtualMachineFileLayout` data object data object is correct.

Managing VMFS Volume Copies (Resignaturing)

By default, ESX/ESXi hosts mount all VMFS datastores. Each VMFS datastore that is created in a partition on a LUN has a unique UUID that is stored in the file system superblock. In addition, the LUN ID of the source LUN is unique and is stored in the VMFS metadata.

When a LUN is replicated or a copy is made, the resulting LUN copy is identical, byte-for-byte, with the original LUN. As a result, if the original LUN contains a VMFS datastore with UUID X, the LUN copy appears to contain an identical VMFS datastore, or a VMFS datastore copy, with exactly the same UUID X. ESX/ESXi can determine whether a LUN contains the VMFS datastore copy, and considers the copy unresolved and does not mount it automatically.

To make the data on the LUN copy available, you can either force mount the copy if you are sure the original is not in use, or you can resignature the copy. When you perform datastore resignaturing, consider the following points:

- Datastore resignaturing is irreversible because it overwrites the original VMFS UUID.
- The LUN copy that contains the VMFS datastore that you resignature is no longer treated as a LUN copy, but instead appears as an independent datastore with no relation to the source of the copy.
- A spanned datastore can be resignatured only if all its extents are online.
- The resignaturing process is crash and fault tolerant. If the process is interrupted, you can resume it later.
- You can mount the new VMFS datastore without a risk of its UUID colliding with UUIDs of any other datastore, such as an ancestor or child in a hierarchy of LUN snapshots.

See the *vSphere Storage* documentation for additional information.

Resignaturing Volumes with ResignatureUnresolvedVmfsVolume_Task

The easiest way to resignature unresolved volumes is by using the HostDatastoreSystem.ResignatureUnresolvedVmfsVolume_Task method. The method assigns a new DiskUuid to a VMFS volume, but keep its contents intact. The method supports safe volume sharing across hosts and is appropriate in most cases.

You can instead use the low-level HostStorageSystem methods to find, force mount, or unmount unresolved volumes:

- HostStorageSystem.QueryUnresolvedVmfsVolume – Obtains the list of unbound VMFS volumes. For sharing a volume across hosts, a VMFS volume is bound to its underlying block device storage. When a low-level block copy is performed to copy or move the VMFS volume, the copied volume is unbound.
- HostStorageSystem.ResolveMultipleUnresolvedVmfsVolumes – Resignatures or force mounts unbound VMFS volumes. This method takes a HostUnresolvedVmfsResolutionSpec data object as input. The HostUnresolvedVmfsResolutionSpec.resolutionSpec property is an array of HostUnresolvedVmfsResolutionSpec data objects that contain a HostUnresolvedVmfsResolutionSpecVmfsUuidResolution enumeration. The enumeration is either forceMount or resignature.
- UnmountForceMountedVmfsVolume – Unmounts a force mounted VMFS volume. When a low-level block copy is performed to copy or move the VMFS volume, the copied volume is unresolved. For the VMFS volume to be usable, a resolution operation is applied. As part of resolution operation, you might decide to keep the original VMFS UUID. Once the resolution is applied, the VMFS volume is mounted on the host for its use. This method allows you to unmount the VMFS volume if it is not used by any registered virtual machines.

Managing Diagnostic Partitions

Your host must have a diagnostic partition (dump partition) to store core dumps for debugging and for use by VMware technical support.

For more information about diagnostic bundles, see Generating Diagnostic Bundles. For information about how to collect diagnostic partitions for a purple screen fault in ESXi, see the VMware knowledge base article at http://kb.vmware.com/kb/1004128.http://kb.vmware.com/kb/1004128.

A 100MB diagnostic partition for each host is recommended. If more than one ESX/ESXi host uses the same LUN as the diagnostic partition, that LUN must be zoned so that all the ESX/ESXi host can access it. Each host needs 100MB of space, so the size of the LUN determines how many servers can share it. Each ESX/ESXi host is mapped to a diagnostic slot. VMware recommends at least 16 slots (1600MB) of disk space if servers share a diagnostic partition. You can set up a SAN LUN with FibreChannel or hardware iSCSI. SAN LUNs accessed through a software iSCSI initiator are not supported.

Caution If two hosts that share a diagnostic partition fail and save core dumps to the same slot, the core dumps might be lost. To collect core dump data, reboot a host and extract log files immediately after the host fails. If another host fails before you collect the diagnostic data of the first host, the second host does not save the core dump.

Retrieving Diagnostic Partition Information

The `HostDiagnosticSystem` managed object allows you to retrieve information in several ways.

- Retrieve the `HostDiagnosticPartition` object from the `HostDiagnosticSystem.activePartition` property to examine the properties of the active partition.
- Call the `HostDiagnosticPartition.QueryAvailablePartition` method to retrieve a list of available diagnostic partitions, in order of suitability.
- Call the `HostDiagnosticPartition.QueryPartitionCreateOptions` method to retrieve a list of disks with sufficient space to contain a diagnostic partition of the specified type. The choices are returned in order of suitability.

Create a Diagnostic Partition

Creating a diagnostic partition requires that you find a suitable partition using one of the query methods. You can then retrieve a creation specification, and perform the actual creation.

To create a diagnostic partition, use the following steps.

Procedure

1. Find a suitable partition by calling `HostDiagnosticPartition.QueryAvailablePartition` or `HostDiagnosticPartition.QueryPartitionCreateOptions`.
2. Call `HostDiagnosticPartition.CreateDiagnosticPartition`, passing in a `HostDiagnosticPartitionCreateSpec`, which includes information about the diagnostic type, id, storage type, and so on.

On success, this method creates the partition and makes the partition the active partition if specified in the `active` parameter. On failure, the diagnostic partition might exist, but will not be active even if the partition was supposed to be made active.

Sample Code Reference

The following table lists the sample applications included with the vSphere Web Services SDK that demonstrate some of the topics discussed in this chapter.

Java (SDK\vsphere-ws\java\JAXWS\samples\com\vmware\)	**C# (SDK\vsphere-ws\dotnet\cs\samples\)**
scsilun\SCSILunName.java	SCSILunName\SCSILunName.cs
--	SCSILunName\SCSILunName.csproj
--	SCSILunName\SCSILunName2008.csproj
--	SCSILunName\SCSILunName2010.csproj
httpfileaccess\GetVMFiles.java	GetVirtualDiskFiles\GetVirtualDiskFiles.cs

vSphere Networks

9

Before you add storage and virtual machines to an ESXi system, you should have completed networking setup. This chapter describes how to set up virtual switches in the vSphere environment.

This chapter includes the following topics:

Virtual Switches

vSphere supports the use of virtual switches to manage network traffic to and from virtual machines.

- vCenter Server supports a distributed network model in which a distributed virtual switch manages ESXi host proxy switch configuration. In the distributed network model, a host proxy switch reflects the distributed virtual switch port settings, describes how physical network adapters are bridged to the switch, and performs network I/O.
- On a standalone ESXi host, you can use a VMware standard virtual switch to support network traffic to and from virtual machines on the host.

To configure a vSphere network you perform the following operations:

- Set up virtual switches
- Define portgroups
- Configure physical network adapters

Port Groups

Port groups aggregate multiple ports under a common configuration. Each port can connect to a network adapter of a virtual machine, or an uplink adapter on the physical machine.

Each port group is identified by a network label, which is unique to the current host. Network labels make virtual machine configuration portable across hosts. All port groups in a datacenter that are physically connected to the same network (in the sense that each can receive broadcasts from the others) are given the same label. Conversely, if two port groups cannot receive broadcasts from each other, they have distinct labels.

You can use a VLAN ID to restrict port group traffic to a logical Ethernet segment within the physical network. For a port group to reach port groups located on other VLANs, the VLAN ID must be set to 4095. If you use VLAN IDs, you must change the port group labels and VLAN IDs together so that the labels properly represent connectivity.

Virtual Machine Network Interfaces

When you create a virtual machine, you include a `VirtualMachineConfigSpec`, which, in turn, includes a `VirtualDeviceConfigSpec`. The `device` property of `VirtualDeviceConfigSpec` is a `VirtualDevice` data object.

One of the available virtual devices is `VirtualEthernetCard`. You can use one of the subtypes of `VirtualEthernetCard` to specify the virtual card to use and to specify the MAC address and whether wake-on-LAN is enabled for this virtual card. See Adding Devices to Virtual Machines. A limited number of adapters is supported. KB article 1001805 (http://kb.vmware.com/kb/1001805) discusses available network adapters and which adapter is appropriate in which situation.

VMkernel Network Interfaces

The network services that the VMkernel provides (iSCSI, NFS, and VMotion) use a TCP/IP stack in the VMkernel. This stack accesses various networks by attaching to one or more port groups on one or more virtual switches.

The VMware VMkernel TCP/IP networking stack handles iSCSI, NFS, and VMotion in the following ways.

- iSCSI as a virtual machine datastore
- iSCSI for the direct mounting of ISO files, which are presented as CD-ROMs to virtual machines
- NFS as a virtual machine datastore
- NFS for the direct mounting of ISO files, which are presented as CD-ROMs to virtual machines
- Migration with VMotion

If you have two or more physical NICs for iSCSI, you can create multiple paths for the software iSCSI by using port binding. For more information on port binding, see the *iSCSI SAN Configuration Guide*.

A freshly installed ESX/ESXi system does not include VMkernel network interfaces. When you wish to migrate a virtual machine with VMotion, your VMkernel networking stack must be set up properly. When you want to use storage types that use TCP/IP network communications, such as iSCSI, you must provide a separate VMkernel network interface for that storage device. You must create any VMkernel ports you might need (see Adding a VMkernel Network Interface).

Physical Network Adapter (pnic)

The term pnic refers to the physical network adapters as seen by the primary operating system. When using the vSphere Web Services SDK, you can manipulate the adapter directly. When using the vSphere Client GUI, you manipulate instead the uplink adapter. On an ESXi host, each pnic has one associated uplink adapter.

In a vDS environment, you use a DVS uplink instead of an uplink adapter.

Using a Distributed Virtual Switch

A `DistributedVirtualSwitch` managed object is a virtual network switch that is located on a vCenter Server. A distributed virtual switch manages configuration for proxy switches (`HostProxySwitch`). A proxy switch is located on an ESXi host that is managed by the vCenter Server and is a member of the switch. A distributed switch also provides virtual port state management so that port state is maintained when vCenter Server operations move a virtual machine from one host to another.

A proxy switch performs network I/O to support the following network traffic and operations:

- Network traffic between virtual machines on any hosts that are members of the distributed virtual switch.
- Network traffic between a virtual machine that uses a distributed virtual switch and a virtual machine that uses a VMware standard virtual switch.
- Network traffic between a virtual machine and a remote system on a physical network connected to the ESXi host.
- vSphere system operations to support capabilities such as VMotion or High Availability.

A `DistributedVirtualSwitch` is the base distributed switch implementation. It supports a VMware distributed virtual switch implementation and it supports third party distributed switch implementations. The base implementation provides the following capabilities (defined in the `DVSFeatureCapability` object):

- NIC teaming
- Network I/O control
- Network resource allocation
- Quality of service tag support
- User-defined resource pools
- I/O passthrough (VMDirectPath Gen2)

A `VmwareDistributedVirtualSwitch` supports the following additional capabilities (defined in the `DVSFeatureCapability` and `VMwareDVSFeatureCapability` objects):

- Backup, restore, and rollback for a VMware distributed virtual switch and its associated portgroups.
- Maximum Transmission Unit (MTU) configuration.

- Health check operations for NIC teaming and VLAN/MTU support.
- Monitoring switch traffic using Internet Protocol Flow Information Export (IPFIX).
- Link Layer Discovery Protocol (LLDP).
- Virtual network segmentation using a Private VLAN (PVLAN).
- VLAN-based SPAN (VSPAN) for virtual distributed port mirroring.
- Link Aggregation Control Protocol (LACP) defined for uplink portgroups.

Distributed Virtual Switch Configuration

To use a distributed virtual switch, you create a switch and portgroups on a vCenter Server, and add hosts as members of the switch.

Procedure

1. Use the `Folder.CreateDVS_Task` method to create a distributed virtual switch. Use a `DVSConfigSpec` to create a switch for a third-party implementation. Use a `VMwareDVSConfigSpec` to create a VMware distributed virtual switch.
2. Use the `CreateDVPortgroup_Task` method to create portgroups for host and virtual machine network connections and for the connection between proxy switches and physical NICs. A `DistributedVirtualPortgroup` specifies how virtual ports (`DistributedVirtualPort`) will be used. When you create a distributed virtual switch, the vCenter Server automatically creates one uplink portgroup (`config.uplinkPortgroup`). Uplink portgroups are distributed virtual portgroups that support the connection between proxy switches and physical NICs.

   Port creation on a distributed switch is determined by the portgroup type (`DVPortgroupConfigSpec.type`):

   - If a portgroup is early binding (static), then `DVPortgroupConfigSpec.numPorts` determines the number of ports that get created when the portgroup is created. This number can be increased if `DVPortgroupConfigSpec.autoExpand` is true.
   - If a portgroup is ephemeral (dynamic), then `numPorts` is ignored and ports are created as needed.

     You can also specify standalone ports that are not associated with a port group and uplink ports that are created on ESXi hosts (`DVSConfigSpec.numStandalonePorts`).

     The `DVPortgroupConfigInfo.numPorts` property is the total number of ports for a distributed virtual switch. This total includes the ports generated by the static and dynamic portgroups and the standalone ports.
3. If you have created additional uplink portgroups, use the `ReconfigureDvs_Task` method to add the portgroup(s) to the `DVSConfigSpec.uplinkPortgroup` array.
4. Retrieve physical NIC device names from the host (`HostSystem.config.network.pnic[].device`).

5 Add host member(s) to the distributed virtual switch. To configure host members:

- Specify hosts (`DVSConfigSpec.host[]`).
- For each host, specify one or more physical NIC device names to identify the pNIC(s) for the host proxy connection to the network (`DistributedVirtualSwitchHostMemberConfigSpec.backing.pnicSpec[].pnicDevice`)
- Use the `DistributedVirtualSwitch.ReconfigureDvs_Task` method to update the switch configuration.

  When you add a host to a distributed virtual switch (`DistributedVirtualSwitch.config.host`), the host automatically creates a proxy switch. The proxy switch is removed automatically when the host is removed from the distributed virtual switch.

6 Connect hosts and virtual machines to the distributed virtual switch.

Host connection	Specify port or portgroup connections in the host virtual NIC spec (`HostVirtualNicSpec.distributedVirtualPort` or `HostVirtualNicSpec.portgroup`).
Virtual machine connection	Specify port or portgroup connections in the distributed virtual port backing (`VirtualEthernetCardDistributedVirtualPortBackingInfo`) for the virtual Ethernet cards on the virtual machine (`VirtualEthernetCard.backing`).

Backup, Rollback, and Query Operations

If you are using a `VmwareDistributedVirtualSwitch`, you can perform backup and rollback operations on the switch and its associated distributed virtual portgroups.

When you reconfigure a VMware distributed virtual switch (`ReconfigureDvs_Task`), the server saves the current switch configuration before applying the configuration updates. The saved switch configuration includes portgroup configuration data. The server uses the saved switch configuration as a checkpoint for rollback operations. You can rollback the switch or portgroup configuration to the saved configuration, or you can rollback to a backup configuration (`EntityBackupConfig`).

- To backup the switch and portgroup configuration, use the `DistributedVirtualSwitchManager.DVSManagerExportEntity_Task` method. The export method produces a `EntityBackupConfig` object. The backup configuration contains the switch and/or portgroups specified in the `SelectionSet` parameter. To backup the complete configuration you must select the distributed virtual switch and all of its portgroups.
- To rollback the switch configuration, use the `DVSRollback_Task` method to determine if the switch configuration has changed. If it has changed, use the `ReconfigureDvs_Task` method to complete the rollback operation.

- To rollback the portgroup configuration, use the DistributedVirtualPortgroup.DVPortgroupRollback_Task method to determine if the portgroup configuration has changed. If it has changed, use the ReconfigureDVPortgroup_Task method to complete the rollback operation.

To perform query operations on a distributed virtual switch, use the DistributedVirtualSwitchManager methods.

VMware Standard Virtual Switch

Network setup for ESXi hosts can consist of several parts:

- Setting up one or more virtual switches. Virtual switches provide the connectivity between virtual machines on the same host or on different hosts. Virtual switches also support VMkernel network access for VMotion, iSCSI, and NFS. You set up virtual switches independently on each host. See Adding a Standard Virtual Switch.
- Adding virtual machine port groups. A virtual machine always accesses the network through a port group. See Adding a Virtual Port Group.
- Specifying the adapter for the virtual machine. This adapter is specified as a virtual device, configured as part of virtual machine setup, and discussed in Configuring a Virtual Machine.
- Adding VMkernel network interfaces, for example, to support iSCSI storage or VMotion. See Adding a VMkernel Network Interface.
- Configuring a physical adapter (pnic), the actual connection from the host to the network. You can configure the pnic through the HostNetworkSystem.pnic property, which is a PhysicalNic data object. You can specify the set of pnics associated with a virtual switch through the VirtualSwitch.pnic property, which takes an array of physical network adapters.
- Network configuration for the host (IP routing, DNS, SNMP). See Adding Networking Services.

Configuring a Standard Virtual Switch

To use a VMware standard virtual switch, you use the following elements to configure the switch on an ESXi host.

- HostNetworkSystem – Managed object that represents the host’s networking configuration. This object’s properties point to the networking data objects you can use for network management, including HostDnsConfig and HostIpRouteConfig.

  HostNetworkSystem properties allow you to access HostNetCapabilities and HostNetworkInfo data objects, and access and modify the HostNetworkConfig data object.

  HostNetworkSystem includes methods for retrieving and changing the network configuration. See the *API Reference* for a complete list of methods and the permissions required to run them.
- HostNetworkConfig – Allows you to specify the network configuration for the host. You can apply the configuration by running the HostNetworkSystem.UpdateNetworkConfig method.

- Network – Represents a network accessible by either hosts or virtual machines. This can be a physical network or a logical network, such as a VLAN.

  When you add a host to a vCenter Server system, or when you add a virtual machine to an ESX/ESXi host, a Network is added automatically.

- HostSystem.QueryHostConnectionInfo and Datacenter.QueryConnectionInfo both return a HostConnectInfo data object, which describes the current network configuration.

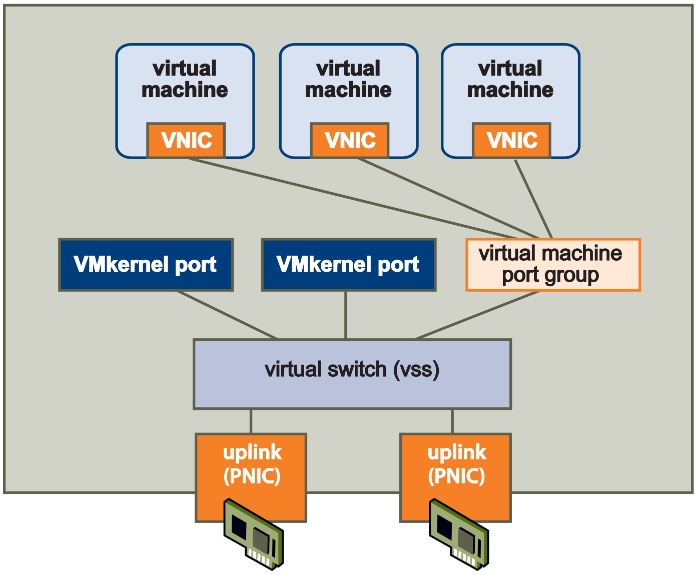
HostSNMPSystem – Supports SNMP setup. See Setting Up SNMP.

vNetwork Standard Switch Environment

A vNetwork Standard Switch (vSS) can route traffic internally between virtual machines and can link virtual machines to external networks.

The following diagram shows the elements of a vSS environment.

Figure 9-1. vSS Environment



Virtual Switches

At the center of networking with vSS is the virtual switch itself. The vSS can send network traffic between virtual machines on the same host (private network) or network traffic to an external network (public network). The public network uses the Ethernet adapter associated with the physical host (uplink adapter).

When two or more virtual machines are connected to the same vSS, network traffic between them is routed locally. If an uplink adapter is attached to the vSS, each virtual machine can access the external network that the adapter is connected to.

Setting Up Networking with vSS

You can use the HostNetworkSystem managed object to access and manipulate the elements of an ESXi network.

Retrieving Information About the Network Configuration

You can retrieve information about the network configuration as follows:

- The properties of the HostNetworkConfig object, which you access through HostNetworkSystem.networkConfig, allow you to retrieve configuration information. This information is comprehensive and includes the physical adapters, virtual switches, virtual network interfaces, and so on.

  You can also use HostNetworkConfig to make changes to the configuration.

- The properties of the HostNetworkInfo object, which you access through HostNetworkSystem.networkInfo, allow you to retrieve runtime information.

Adding a Standard Virtual Switch

You call the HostNetworkSystem.AddVirtualSwitch method to add one or more virtual switches. Pass in the name of the virtual switch and a HostVirtualSwitchSpec data object as parameters.

Inside HostVirtualSwitchSpec you can specify the MTU, number of ports, network policy, and bridge specification. The bridge specifies how the virtual switch connects to the physical adapter. The currently supported bond bridge provides network adapter (NIC) teaming capabilities through the use of a list of physical devices and, optionally, a beacon probe to test connectivity with physical adapters.

After you have created the virtual switch, you can connect it to a pnic for connection to the outside, and to a VMkernel port or a port group.

To add a virtual switch, use the following steps.

Procedure

1 Obtain information about the current networking configuration.

  You can use a property collector to retrieve the HostNetworkSystem managed object and several of its properties, such as networkInfo.

2 Define a HostVirtualSwitchSpec that specifies the attributes of the virtual switch. You can specify the number of ports (56 to 4088 on ESXi systems) and the HostNetworkPolicy. See “Defining the Host Network Policies” on page 122.

3 Call HostNetworkSystem.AddVirtualSwitch to add a virtual switch. Specify a unique name and a HostVirtualSwitchSpec that defines the switch attributes.

  The following fragment from AddVirtualSwitch.java illustrates this.

Example: Adding a Virtual Switch

```
vswitchId = vSwitch42;
...
ManagedObjectReference nwSystem = configMgr.getNetworkSystem();
HostVirtualSwitchSpec spec = new HostVirtualSwitchSpec();
spec.setNumPorts(8);
service.addVirtualSwitch(nwSystem, vswitchId, spec);
System.out.println( " : Successful creating : " + vswitchId);
```

Adding a Virtual Port Group

Port groups allow you to differentiate between different kinds of traffic passing through a virtual switch. You can also use port groups as a boundary for communication or for security policy configuration. The default port groups for ESXi systems are `Management Network` and `VM Network`.

When you create a port group, you can specify a VLAN ID for it. VLANs are an important part of ESXi networking because they allow you to group traffic. For example, you could create separate network segments for VMotion, for management and for development. Using VLANS, you only need to have a separate uplink adapter for each network segment and a single virtual switch connecting to that adapter. That setup can greatly reduce the number of switches you need.

To add a virtual port group, use the following steps.

Procedure

1. Define a `HostPortgroupSpec`. For each port group, you can specify the network policy, the VLAN ID, and the virtual switch to which the port group belongs.
2. Call `HostNetworkSystem.AddPortGroup`, passing in the `PortGroupSpec`.

Adding a VMkernel Network Interface

VMkernel network interfaces provide the network access for the VMkernel TCP/IP stack. You must create new VMkernel ports for your ESXi system if you plan on using VMotion, VMware FT, or iSCSI and NAS storage. A VMkernel port consists of a port on the virtual switch and a VMkernel interface.

To add a VMkernel Network Interface to your ESXi system, use the following steps.

Procedure

1. Create a `HostVirtualNicSpec` data object. Inside the object, you can specify the IP configuration in a `HostIpConfig` data object. For vSS, specify the `portgroup` property. For vDS, specify the `distributedVirtualPort` property.
2. Call `HostNetworkSystem.AddVirtualNic`, passing in the `HostVirtualNicSpec`.

3. You can then use the VMkernel network interface for software iSCSI or NAS, or call the `HostVmotionSystem.SelectVnic` method to use this VMkernel NIC for VMotion.

   Example: Adding a VMkernel Network Interface, a code fragment from the `AddVirtualNic` example, illustrates this. The sample retrieves the IP address from the command line using the `cb.get_option` call.

Example: Adding a VMkernel Network Interface

```
private HostVirtualNicSpec createVNicSpecification() {
     HostVirtualNicSpec vNicSpec = new HostVirtualNicSpec();
     HostIpConfig ipConfig = new HostIpConfig();
     ipConfig.setDhcp(false);
     ipAddr = cb.get_option("ipaddress");
     ipConfig.setIpAddress(ipAddr);
     ipConfig.setSubnetMask("255.255.255.0");
     vNicSpec.setIp(ipConfig);
     return vNicSpec;
}
     ....

HostVirtualNicSpec vNicSpec = createVNicSpecification();
service.addVirtualNic(nwSystem, portGroup, vNicSpec);
```

Defining the Host Network Policies

When you configure host networks, you can define specific policies for the network. The `HostNetworkPolicy` data object type describes network policies for both virtual switches and port groups. If the settings are not specified for the port group explicitly, the port group inherits policy settings from the virtual switch with which it is associated.

The policies are defined by the following data objects available as properties of `HostNetworkPolicy`.

- `HostNicTeamingPolicy` – Defines the connection to the physical network. This includes failure criteria, active and standby NICs, and failover and load balancing information. See NIC Teaming.
- `HostNetworkSecurityPolicy` – Defines the security policies for the network. See the *ESXi Configuration Guide*.
- `HostNetworkTrafficShapingPolicy` – Establishes parameters for three traffic characteristics: average bandwidth, peak bandwidth, and maximum burst size.

You can also specify the VLAN policy by assigning an integer to the `HostPortgroupSpec.vlanid` property. The VMkernel takes care of tagging and untagging the packets as they pass through the virtual switch. See the `HostPortgroupSpec` and `HostNetworkPolicy` data objects in the *API Reference*.

NIC Teaming

Virtual machines connect to the public network through a virtual switch, which, in turn, connects to the physical network interface (pnic). When the physical adapter or the adapter's network connection fails, connectivity for the associated virtual switch and all port groups and virtual machines is lost.

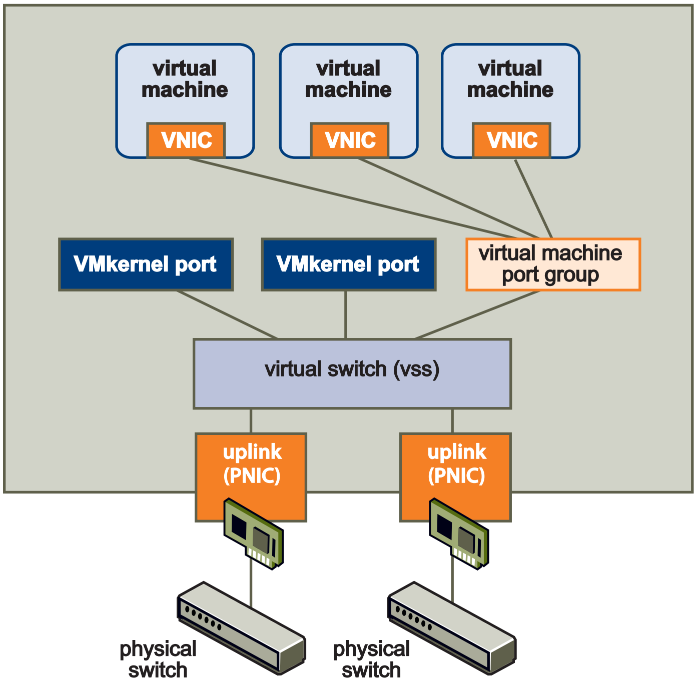
To resolve this issue, you can set up your environment so each virtual switch connects to two uplink adapters. Each uplink adapter connects to two different physical switches. The teams can then either share the load of traffic between physical and virtual networks among some or all of its members, or provide passive failover in the event of a hardware failure or a network outage.

You set up NIC teaming by setting the `HostNetworkPolicy`. The path to the `HostNicTeamingPolicy` is:

`HostConfigSpec.network.vswitch[].spec.policy.nicTeaming`

If you specify NIC teaming for a virtual switch, the `HostVirtualSwitchSpec.bridge` property must be set to `HostVirtualSwitchBondBridge`.

Figure 9-2. NIC Teaming



Setting Up IPv6 Networking

vSphere supports both Internet Protocol version 4 (IPv4) and Internet Protocol version 6 (IPv6) environments. With IPv6, you can use vSphere features such as NFS in an IPv6 environment.

An IPv6-specific configuration in vSphere involves providing IPv6 addresses, either by entering static addresses or by using DHCP for all relevant vSphere networking interfaces. IPv6 addresses can also be configured using stateless autoconfiguration sent by router advertisement.

You can set up IPv6 networking for a host by changing the `HostIpConfig.ipV6Config` property, which is a `HostIpConfigIpV6AddressConfiguration` data object. `HostIpConfigIpV6AddressConfiguration` allows you to specify whether auto-configuration is enabled, whether DHCP for ipV6 addresses is enabled, and an array of IPv6 addresses (`HostIpConfigIpV6Address` data objects).

HostIpConfigIpV6Address allows you to specify all aspects of the IPv6 address including the state of the address, the address (unless DHCP is enabled), life time, operation, origin, and prefix length. See the *API Reference*. The following code fragment illustrates setting the VMkernel NIC to get an automatic IPv6 address from router advertisements and through DHCP. The user provides the IP address on the command line when calling the program from which the fragment is taken. The sample retrieves the address using the cb.get_option utility applications call.

Example: IPv6 Setup

```
private HostVirtualNicSpec createVNicSpecification() {
     HostVirtualNicSpec vNicSpec = new HostVirtualNicSpec();
     HostIpConfig ipConfig = new HostIpConfig();

     //setting the vnic to get an automatic ipv6 address from router advertisements
     // and through dhcp

     ipV6Config = new HostIpConfigIpV6AddressConfiguration();
     ipV6Config.setAutoConfigurationEnabled(true);
     ipV6Config.setDhcpV6Enabled(true);
     ipConfig.setIpV6Config(ipV6Config);
     vNicSpec.setIp(ipConfig);
     return vNicSpec;
....
```

Adding Networking Services

You can set up network services for your ESXi system by using HostConfigManager properties and methods.

Adding an NTP Service

The HostConfigManager.dateTimeSystem property contains a HostDateTimeSystem data object. This object allows you to perform NTP and date and time related configuration.

- Query and update the date and time information by using one of the methods defined in HostDateTimeSystem.
- Modify the HostDateTimeSystem.dateTimeInfo property, which contains a HostDateTimeInfo object, to set up NTP. The NTP information is stored in the HostDateTimeInfo.ntpConfig property, which is a HostNtpConfig object. The HostNtpConfig objects's server property contains a list of time servers, specified by IP address or fully qualified domain name.

  Important You can start and stop the NTP daemon and retrieve information about it by using the HostServiceSystem object.

Setting Up the IP Route Configuration

You can use the `HostNetworkSystem.UpdateIPRouteConfig` method to specify the IP route configuration for an ESXi system. The method takes a `HostIPRouteConfig` data object as an argument. In this object, you can specify the default gateway address and the IPv6 gateway address.

Setting Up SNMP

Simple Network Management Protocol (SNMP) allows management programs to monitor and control networked devices. vCenter Server and ESXi systems include different SNMP agents:

- The SNMP agent included with vCenter Server can send traps when the vCenter Server system is started or when an alarm is triggered on vCenter Server. The vCenter Server SNMP agent functions only as a trap emitter and does not support other SNMP operations such as `GET`.
- ESXi 4.0 includes an SNMP agent embedded in the host daemon (`hostd`) that can send traps and receive polling requests such as `GET` requests.

Versions of ESX released before ESX/ESXi 4.0 included a Net-SNMP-based agent. You can continue to use this Net-SNMP-based agent in ESX 4.x with MIBs supplied by your hardware vendor and other third-party management applications. However, to use the VMware MIB files, you must use the embedded SNMP agent. To use the NET-SNMP based agent and embedded SNMP agent at the same time, make one of the agents listen on a nondefault port. By default, both agents use the same port.

The SDK supports SNMP agent configuration through the `HostSnmpSystem` managed object. This object includes two methods, `ReconfigureSnmpAgent` and `SendTestNotification`.

- `HostSnmpSystem.ReconfigureSnmpAgent` allows you to specify agent properties through a `HostSnmpConfigSpec`. That data object allows you to specify the SNMP port, read only communities, and the trap targets in an `HostSnmpDestination` object. The `HostSnmpDestination` object allows you to specify the community, and a host and port listening for notification.
- `HostSnmpSystem.SendTestNotification` allows you to test your configuration.

A `HostSnmpSystemAgentLimits` data object in the `HostSnmpSystem.limits` property specifies limits of the agent.

Sample Code Reference

The following table lists the sample applications included with the vSphere SDK that demonstrate how to use some of the managed objects discussed in this chapter.

Java	C#
(SDK\vsphere-ws\java\JAXWS\samples\com\vmware\host)	(SDK\vsphere-ws\dotnet\cs\samples\)
`AddVirtualNic.java`	`AddVirtualNic\AddVirtualNic.cs`
	`AddVirtualNic\AddVirtualNic.csproj`
	`AddVirtualNic\AddVirtualNic2008.csproj`

Java	C#
	AddVirtualNic\AddVirtualNic2010.csproj
AddVirtualSwitch.java	AddVirtualSwitch\AddVirtualSwitch.cs
	AddVirtualSwitch\AddVirtualSwitch.csproj
	AddVirtualSwitch\AddVirtualSwitch2008.csproj
	AddVirtualSwitch\AddVirtualSwitch2010.csproj
AddVirtualSwitchPortGroup.java	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup.cs
	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup.csproj
	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup2008.csproj
	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup2010.csproj
RemoveVirtualNic.java	RemoveVirtualNic\RemoveVirtualNic.cs
	RemoveVirtualNic\RemoveVirtualNic.csproj
	RemoveVirtualNic\RemoveVirtualNic2008.csproj
	RemoveVirtualNic\RemoveVirtualNic2010.csproj
RemoveVirtualSwitch.java	RemoveVirtualSwitch\RemoveVirtualSwitch.cs
	RemoveVirtualSwitch\RemoveVirtualSwitch.csproj
	RemoveVirtualSwitch\RemoveVirtualSwitch2008.csproj
	RemoveVirtualSwitch\RemoveVirtualSwitch2010.csproj
RemoveVirtualSwitchPortGroup.java	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup.cs
	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup.csproj
	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup2008.csproj
	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup2010.csproj

Virtual Machine Configuration 10

A virtual machine is a software computer that, like a physical computer, runs an operating system and applications. Virtual machines are compatible with all standard x86 computers. Each virtual machine encapsulates a complete computing environment and runs independently of underlying hardware.

This chapter includes the following topics:

VirtualMachine Management Objects and Methods

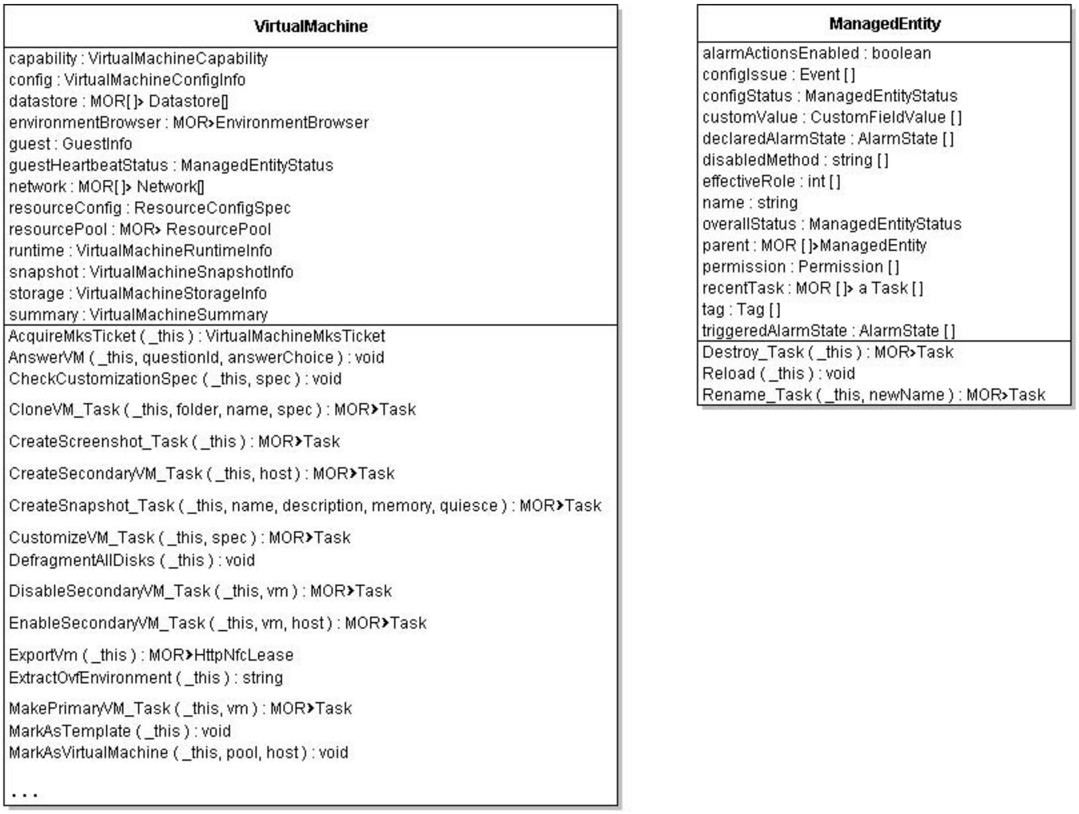
Virtual machines are the central elements of your vSphere environment.

You create a virtual machine by calling `Folder.CreateVM_Task`, and configure the virtual machine by using properties and methods of the `VirtualMachine` managed object. Most of the properties point to data objects that the methods use as input. Figure 10-1 shows some of the properties and methods.

Client applications commonly access and manipulate the following virtual machine related objects:

- `VirtualMachine` – Managed object used for most virtual machine manipulation. Includes methods that create templates, clones, or snapshots of a virtual machine, perform power operations and guest OS management, and install VMware Tools.
- `VirtualMachineConfigInfo` – Data object which allows you to retrieve configuration-specific information from a virtual machine.
- `VirtualMachineCloneSpec` – Data object which allows you to specify virtual machine properties for a clone operation. Argument to `VirtualMachine.CloneVM_Task`.

Figure 10-1. VirtualMachine Managed Object with Some Properties and Methods



VirtualMachine

capability : VirtualMachineCapability
config : VirtualMachineConfigInfo
datastore : MOR[ ]> Datastore[]
environmentBrowser : MOR>EnvironmentBrowser
guest : GuestInfo
guestHeartbeatStatus : ManagedEntityStatus
network : MOR[ ]> Network[]
resourceConfig : ResourceConfigSpec
resourcePool : MOR> ResourcePool
runtime : VirtualMachineRuntimeInfo
snapshot : VirtualMachineSnapshotInfo
storage : VirtualMachineStorageInfo
summary : VirtualMachineSummary

AcquireMksTicket (_this) : VirtualMachineMksTicket
AnswerVM (_this, questionId, answerChoice) : void
CheckCustomizationSpec (_this, spec) : void
CloneVM_Task (_this, folder, name, spec) : MOR>Task
CreateScreenshot_Task (_this) : MOR>Task
CreateSecondaryVM_Task (_this, host) : MOR>Task
CreateSnapshot_Task (_this, name, description, memory, quiesce) : MOR>Task
CustomizeVM_Task (_this, spec) : MOR>Task
DefragmentAllDisks (_this) : void
DisableSecondaryVM_Task (_this, vm) : MOR>Task
EnableSecondaryVM_Task (_this, vm, host) : MOR>Task
ExportVm (_this) : MOR>HttpNfcLease
ExtractOvfEnvironment (_this) : string
MakePrimaryVM_Task (_this, vm) : MOR>Task
MarkAsTemplate (_this) : void
MarkAsVirtualMachine (_this, pool, host) : void
. . .

ManagedEntity

alarmActionsEnabled : boolean
configIssue : Event [ ]
configStatus : ManagedEntityStatus
customValue : CustomFieldValue [ ]
declaredAlarmState : AlarmState [ ]
disabledMethod : string [ ]
effectiveRole : int [ ]
name : string
overallStatus : ManagedEntityStatus
parent : MOR [ ]>ManagedEntity
permission : Permission [ ]
recentTask : MOR [ ]> a Task [ ]
tag : Tag [ ]
triggeredAlarmState : AlarmState [ ]

Destroy_Task (_this) : MOR>Task
Reload (_this) : void
Rename_Task (_this, newName) : MOR>Task

Creating Virtual Machines and Virtual Machine Templates

To create a virtual machine, you use the `Folder.CreateVM_Task` method. The method takes a `VirtualMachineConfigSpec` data object as input argument. `VirtualMachineConfigSpec` allows you to specify the attributes of the virtual machine you are creating.

If you need several identical virtual machines, you can convert an existing virtual machine to a template and create multiple copies (clones) from the template. You can also create multiple virtual machines by cloning an existing virtual machine directly.

Creating a Virtual Machine Using VirtualMachineConfigSpec

Use the `Folder.CreateVM_Task` method to create a virtual machine by specifying its attributes. You must specify either a host or a resource pool (or both). The virtual machine uses the CPU and memory resources from the host or resource pool.

Calling the CreateVM_Task Method

Create a virtual machine by calling the `Folder.CreateVM_Task` method with the following arguments:

- `_this` —Folder where you want to place the virtual machine.
- `config`— `VirtualMachineConfigSpec` data object that specifies CPU, memory, networking, and so on. See Specifying Virtual Machine Attributes with VirtualMachineConfigSpec)

- pool— Resource pool for the virtual machine to draw resources from.
- host— HostSystem managed object that represents the target host on which to run the virtual machine. If you invoke this method on a standalone host, omit this parameter. If the target host is part of a VMware DRS cluster, this parameter is optional; if no host is specified, the system selects one.

Important All objects must be located in the same datacenter.

Specifying Virtual Machine Attributes with VirtualMachineConfigSpec

The actual customization of the virtual machine happens through the properties of the VirtualMachineConfigSpec that is passed in as an argument to Folder.CreateVM_Task. For example, you can specify the name, boot options, number of CPUs, and memory for the virtual machine. All properties of VirtualMachineConfigSpec are optional to support incremental changes. See the *API Reference*.

The following example fragment from the VMCreate sample program illustrates how to define a VirtualMachineConfigSpec.

Example: Defining a VirtualMachineConfigSpec Data Object

```
VirtualMachineConfigSpec vmConfigSpec = new VirtualMachineConfigSpec();
     ...
     vmConfigSpec.setName(“MyVM”);
     vmConfigSpec.setMemoryMB(new Long(Integer.parseInt 500));
     vmConfigSpec.setNumCPUs(Integer.parseInt 4);
     vmConfigSpec.setGuestId(cb.get_option("guestosid"));
     ...
```

The VMware SDK SDK/samples/Axis/java/com/vmware/apputils/vim/VMUtils.java sample defines a more comprehensive virtual machine that also includes a Floppy, CD-ROM, disk, and virtual NIC. See Configuring a Virtual Machine for a discussion of commonly set properties.

When you create a virtual machine, the virtual machine files are added at the virtual machine’s storage location. See Table 10-1.

Additional Configuration Information

The VirtualMachineConfigInfo and VirtualMachineConfigSpec objects provide the extraConfig property for additional configuration information. The extraConfig property is an array of key/value pairs that identify configuration options. The Server stores the extraConfig options in the .vmx file for the virtual machine. As the vSphere API evolves from version to version, an extraConfig option may become a standard configuration property that is part of the defined inventory data model. In this case, you must use the standard data model property for access; you cannot use the extraConfig property.

Creating Virtual Machine Templates

Templates allow you to create multiple virtual machines with the same characteristics, such as resources allocated to CPU and memory, or type of virtual hardware. A virtual machine template is a virtual machine that cannot be powered on and that is not associated with a resource pool.

You can convert any powered off virtual machine to a template by calling `VirtualMachine.MarkAsTemplate`. After the conversion, the original virtual machine no longer exists. You can use the template to create multiple clones of the same configuration.

Cloning a Virtual Machine

A clone is a copy of a virtual machine. The main difference between a virtual machine and a clone is that the `VirtualMachine.config.template` property is set to `true`.

You can create a clone in one of the following ways:

- If you no longer need a specific instance of a virtual machine, but you want to use the virtual machine's configuration as a template, use the `VirtualMachine.MarkAsTemplate` method. This method sets the `config.template` property to `true`, and disables the virtual machine.
- If you want to use an existing virtual machine as a template, but keep the virtual machine, call the `VirtualMachine.CloneVM_Task` method to create a duplicate of the virtual machine.

If you use the `VirtualMachine.CloneVM_Task` method, you can customize certain attributes of the clone by specifying them in the `VirtualMachineCloneSpec` data object you pass in when you call the method.

The following code fragment from `VMClone.java` illustrates how you can customize a clone and specify a new location for it.

Example: Cloning a Virtual Machine

```
VirtualMachineCloneSpec cloneSpec = new VirtualMachineCloneSpec();
VirtualMachineRelocateSpec relocSpec = new VirtualMachineRelocateSpec();
cloneSpec.setLocation(relocSpec);
cloneSpec.setPowerOn(false);
cloneSpec.setTemplate(false);

String clonedName = cloneName;

ManagedObjectReference cloneTask
            = service.cloneVM_Task(vmRef, vmFolderRef, clonedName, cloneSpec);
```

The `VirtualMachine.CloneVM_Task` method takes the source virtual machine, target folder, name, and `VirtualMachineCloneSpec` as arguments.

The VirtualMachineCloneSpec data object includes the location, power state, and whether the clone should be a template. The location, in turn, is a VirtualMachineRelocateSpec data object that specifies the target location (datastore, disk, and host or resource pool) and any transformation to be performed on the disk.

Converting a Template to a Virtual Machine

You can change a template back to an operational virtual machine.

- To convert the template to a virtual machine, call the MarkAsVirtualMachine method on the template. You must specify a resource pool and, optionally, a host for the virtual machine. Host and resource pool must be under the same ComputeResource. When the operation completes, the template no longer exists.
- To keep the template, clone the template by calling the CloneVM_Task method on the template. In the VirtualMachineCloneSpec (the spec parameter), set the template property to false.

Accessing Information About a Virtual Machine

After you have created a virtual machine, you can retrieve information about the virtual machine through the VirtualMachineConfigInfo properties. See the *API Reference* for a complete list.

Checking Default Files

After you have created a virtual machine, several files are generated and placed in the directory specified in the VirtualMachineConfigSpec.files property.

Table 10-1. Default Files

File	Usage	File Description	File Format
.vmx	.*vmname*.vmx	Virtual machine configuration file.	ASCII
.vmxf	*vmname*.vmxf	Additional virtual machine configuration files, available, for example, with teamed virtual machines.	ASCII
.vmdk	*vmname*.vmdk	Virtual disk file.	ASCII
.flat.vmdk	*vmname*.flat.vmdk	Preallocated virtual disk in binary format.	Binary
.vswp	*vmname*.vswp	Swap file.	
.nvram	*vmname*.nvram or nvram	Non-volatile RAM. Stores virtual machine BIOS information.	
.vmss	*vmname*.vmss	Virtual machine suspend file.	
.log	vmware.log	Virtual machine log file.	ASCII
#.log	vmware-#.log	Old virtual machine log files. # is a number starting with 1.	ASCII
.vmtx	*vmname*.vmtx	Virtual machine template file.	ASCII

If you are using snapshots, the following additional files might be available. See Snapshots.

File Extension	Usage	File Description
.vmsd	*vmname*.vmsd	Virtual machine snapshot file.
.vmsn	*vmname*.vmsn	Virtual machine snapshot data file.
**.delta.vmdk		Snapshot difference file. A number preceding the extension increases with more snapshots.
**.vmdk		Metadata about a snapshot.
-Snapshot#.vmsn		Snapshot of virtual machine memory. Snapshot size is equal to the size of you virtual machine's maximum memory.

Checking Default Devices

When you create a virtual machine, you are also creating a set of default devices, based on the hardware version associated with your SDK. You can see these devices using the EnvironmentBrowser.QueryConfigOption method. For example, the IDE controllers are created by default. Many of these default devices contain properties that you cannot change.

However, you can add the following optional devices to the default set: VirtualSerialPort, VirtualParallelPort, VirtualFloppy, VirtualCdrom, VirtualUSB, VirtualEthernetCard, VirtualDisk, and VirtualSCSIPassthrough. See the VirtualDevice Data Object in the *API Reference* for more information about each of these optional devices.

Caution Do not try to change default device properties using the VirtualMachineConfigSpec.deviceChange method discussed in Adding Devices to Virtual Machines, because the deviceChange method is not applicable to default device properties.

Configuring a Virtual Machine

You can configure a virtual machine during creation (Folder.CreateVM_Task) or cloning (VirtualMachine.CloneVM_Task). You can also reconfigure a virtual machine using VirtualMachine.ReconfigVM_Task. However, do not use the VirtualMachine.ReconfigVM_Task call to create or add a disk.

In vSphere 5.5 and later, the ReconfigVM_Task method will throw an error when it attempts to change certain virtual machine properties while the virtual machine is powered on. In previous releases, the server would modify the properties in the configuration specification and the changes would take effect after the virtual machine resets, reboots, or performs a fast suspend and resume.

Since vSphere 5.5, a reconfigure operation modifies the virtual machine in real time, so that the virtual machine properties have been changed by the time the method returns control to the client.

You cannot reconfigure a virtual machine successfully if you specify any of the following properties in the VirtualMachineConfigSpec when you call the ReconfigVM_Task method.

Property	VirtualMachineConfigSpec Path
VirtualDevice.unitNumber	deviceChange.device.unitNumber
VirtualDevicePciBusISlotInfo.pciSlotNumber	deviceChange.device.slotInfo.pciSlotNumber

Property	VirtualMachineConfigSpec Path
VirtualDiskFlatVer1BackingInfo.diskMode VirtualDiskFlatVer2BackingInfo.diskMode VirtualDiskRawDiskMappingVer1BackingInfo.diskMode VirtualDiskSeSparseBackingInfo.diskMode VirtualDiskSparseVer1BackingInfo.diskMode VirtualDiskSparseVer2BackingInfo.diskMode	deviceChange.device.backing.diskMode
VirtualDiskFlatVer2BackingInfo.digestEnabled VirtualDiskSeSparseBackingInfo.digestEnabled	deviceChange.device.backing.digestEnabled
VirtualMachineConfigSpec.changeTrackingEnabled	changeTrackingEnabled
VirtualEthernetCard.addressType	deviceChange.device.addressType
VirtualEthernetCard.macAddress	deviceChange.device.macAddress
VirtualEthernetCard.wakeOnLanEnabled	deviceChange.device.wakeOnLanEnabled
VirtualSCSIController.sharedBus	deviceChange.device.sharedBus
VirtualSerialPort.yieldOnPoll	deviceChange.device.yieldOnPoll
VirtualUSBController.autoConnectDevices VirtualUSBXHCIController.autoConnectDevices	deviceChange.device.autoConnectDevices
VirtualUSBController.ehciEnabled	deviceChange.device.ehciEnabled
VirtualMachineVideoCard.useAutoDetect	deviceChange.device.useAutoDetect
VirtualMachineVideoCard.videoRamSizeInKB	deviceChange.device.videoRamSizeInKB
VirtualMachineVideoCard.numDisplays	deviceChange.device.numDisplays
VirtualMachineVideoCard.use3dRendererSupported	deviceChange.device.use3dRendererSupported

The *API Reference* lists all properties and includes information about required permissions for these configuration methods. The following sections describe some commonly specified attributes.

Name and Location

You can specify the display name for the virtual machine by setting the `VirtualMachineConfigSpec.name` property. Any % (percent) character used in this `name` parameter must be escaped, unless it is used to start an escape sequence. Clients can also escape any other characters in this name parameter.

Use the `annotation` field to provide a description of the virtual machine. To remove an existing description, specify the empty string as the value of `annotation`.

The location of the virtual machine is determined implicitly during creation because you call a `Folder.CreateVM_Task` method and specify resource pool and optional target host the virtual machine should belong to. See #unique_230 for a discussion of resource pools and virtual machine location.

Hardware Version

The hardware version of a virtual machine indicates the lower-level virtual hardware features a virtual machine supports, such as BIOS, number of virtual slots, maximum number of CPUs, maximum memory configuration, and other hardware characteristics.

For a newly created virtual machine, the default hardware version is the most recent version available on the host where the virtual machine is created. To increase compatibility, you might want to create a virtual machine with a hardware version older than the highest supported version. You can do so by specifying the `VirtualMachineConfigSpec.version` property during virtual machine creation. For existing virtual machines, call the `VirtualMachine.UpgradeVM_Task` method.

The hardware version of a virtual machine can be lower than the highest version supported by the ESXi host it is running on under the following conditions:

- You migrate a virtual machine to a newer version of ESXi after it was created on a host that was running an earlier version of ESXi.
- You create a virtual machine on a newer version of ESXi by using an existing virtual disk that was created on a host that was running an earlier version of ESXi.
- You add a virtual disk created on a host that was running an earlier version of ESXi to a virtual machine created on a newer version of ESXi.

Virtual machines with hardware versions lower than 4 can run on ESX/ESXi 4.x hosts but have reduced performance and capabilities. In particular, you cannot add or remove virtual devices on virtual machines with hardware versions lower than 4 when they reside on an ESX/ESXi 4.x host. To make full use of these virtual machines, upgrade the virtual hardware.

Boot Options

You can control a virtual machine's boot behavior by setting the `VirtualMachineConfigSpec.bootOptions` property. The `VirtualMachineBootOptions` data object in that property allows you to specify the following properties:

- `bootDelay` – Delay before starting the boot sequence, in milliseconds.
- `bootRetryDelay` – Delay before a boot retry, in milliseconds. This property is only considered if the `bootRetryEnabled` property is set to `true`.
- `bootRetryEnabled` – If set to `true`, a virtual machine that fails to boot tries again after the `bootRetryDelay` time period has elapsed.
- `enterBIOSSetup` – If set to `true`, the virtual machine enters BIOS setup the next time it boots. The virtual machine resets this flag to `false` so subsequent boots proceed normally.

Operating System

The guest operating system that you specify affects the supported devices and available number of virtual CPUs. You specify the guest operating system in the following two properties:

- `guestosid` – Specify one of the constants in the `VirtualMachineGuestOsIdentifier` as a string.
- `alternateGuestName` – Full name for the guest operating system. Use this property if `guestosid` is one of the values of `VirtualMachineGuestOsIdentifier` starting with `other*`.

CPU and Memory Information

The `VirtualMachineConfigSpec` data object allows you to specify CPU and memory configuration.

CPU and Memory Resource Allocation

To allocate resources, use the `cpuAllocation` and `memoryAllocation` properties of `VirtualMachineConfigSpec`. Both properties contain `ResourceAllocationInfo` objects with the following properties:

- `reservation` – Amount of resources that is guaranteed to be available to the virtual machine. If resource utilization is less than the reservation, other running virtual machines can use the resources.
- `limit` – Upper limit for CPU or memory resources assigned to this virtual machine. The virtual machine does not exceed this limit, even if resources are available. This property is typically used to ensure consistent performance. If end users are used to work on a virtual machine that uses extra resources, and additional virtual machines are added to the host or resource pool, the virtual machine might slow down noticably. If set to -1, no fixed upper limit on resource usage has been set.
- `shares` – Metric for allocating memory or processing capacity among multiple virtual machines. The `SharesInfo` data object has two properties, `level` and `shares`.
  - `level` – Choose `high`, `low`, or `normal` to map to a predetermined set of numeric values for shares. See the *API Reference Guide* for the numbers for CPU, memory, and disk shares. Set this property to `custom` to specify an explicit number of shares instead.
  - `shares` – Allows you to specify the number of shares you want to allocate to the resource pool. The allocation is divided evenly between resource pools with the same level.

Resource Allocation discusses resource allocation in the context of resource pool hierarchies. The *Resource Management Guide* includes a detailed discussion of resource allocation in the vSphere environment.

CPU and Memory Modification for Running Virtual Machines

Set `CpuHotAddEnabled` and `CpuHotRemoveEnabled` to specify whether virtual processors can be added to or removed from a virtual machine while the virtual machine is running. Set `MemoryHotAddEnabled` to specify whether memory can be added while the virtual machine is running.

Number of CPUs

You can set the number of virtual processors for the virtual machine with the VirtualMachineConfigSpec.numCPUs property. Legal values for this property change depending on the guestosid value you specify.

CPU Processors and Memory Affinity

If your virtual machine is on an ESXi system, and if you have a license that supports Symmetric Multiprocessors (SMP), you can configure the virtual machine to have multiple virtual CPUs by setting cpuAffinity and memoryAffinity. You define a set of integers that represents the processors (for CPU) and NUMA nodes (for memory). If you are reconfiguring the affinity setting and leave the array empty, any existing affinity is removed. See the *Resource Management Guide* for a discussion of NUMA nodes and affinity.

CPU Features

You can use the VirtualMachineConfigSpec.cpuFeatureMask[].info property to represent the CPU features requirements for a virtual machine or guest operating system. See the HostCpuIdInfo data object discussion in the *API Reference* for a detailed discussion.

Networks

You configure network settings so that a virtual machine can communicate with the host and with other virtual machines.

Virtual Network Interfaces

You can add a virtual network interface to a virtual machine using a subclass of VirtualEthernetCard, you can set the addressType to Manual, Generated, or Assigned. If you choose Assigned, you can specify a MAC address explicitly.

For more information about virtual devices in general, see Adding Devices to Virtual Machines.

The number of virtual network interfaces depends on the hardware version you specify for a virtual machine. Hardware version 7 virtual machines support up to ten virtual NICs. Hardware version 4 virtual machines support up to four virtual NICs.

Virtual Machine MAC Address

Upon virtual machine creation, ESXi or vCenter Server systems assign each virtual network interface its own unique MAC address. The first three bytes of the MAC address that is generated for each virtual network adapter consists of a manufacturer-specific Organizationally Unique Identifier (OUI). The MAC address-generation algorithm produces the other three bytes. vSphere generates MAC addresses that are checked for conflicts. After the MAC address has been generated, it does not change unless the virtual machine is moved to a different location.

All MAC addresses that have been assigned to virtual network interfaces of running and suspended virtual machines on a given physical machine are tracked. The MAC address of a powered off virtual machine is not checked against those of running or suspended virtual machines. It is possible that a virtual machine acquires a different MAC address after a move.

The *ESXi Configuration Guide* discusses virtual machine MAC addresses in detail.

Fibre Channel NPIV Settings

N-port ID virtualization (NPIV) supports sharing a single physical FC HBA port among multiple virtual ports, each with unique identifiers. This capability lets you control virtual machine access to LUNs on a per-virtual machine basis.

Each virtual port is identified by a pair of world wide names (WWNs): a world wide port name (WWPN) and a world wide node name (WWNN). These WWNs are assigned by vCenter Server. For detailed information on how to configure NPIV for a virtual machine, see the *Fibre Channel SAN Configuration Guide*.

NPIV support is subject to the following limitations:

- NPIV must be enabled on the SAN switch. Contact switch vendors for information about enabling NPIV on their devices.
- NPIV is supported only for virtual machines with RDM disks. Virtual machines with regular virtual disks continue to use the WWNs of the host’s physical HBAs.
- Virtual machines on a host have access to a LUN using their NPIV WWNs if the physical HBAs on the ESXi host have access to a LUN using its WWNs. Ensure that access is provided to both the host and the virtual machines

You can set up NPIV with the `VirtualMachineConfigSpec` properties that start with `npiv`.

File Locations

File locations for a virtual machine are specified in the following properties:

- `VirtualMachineConfigSpec.files` is a `VirtualMachineFileInfo` data object that allows you to specify the log directory, snapshot directory, suspend directory, and configuration file location. Most locations have a default that you can change as needed.
- `VirtualMachineConfigSpec.locationID` is a 128-bit hash based on the virtual machine’s configuration file location and the UUID of the host the virtual machine is assigned to. This property is not usually set by developers; however, clearing this property by setting it to an empty string is recommended if you move the virtual machine.

If a virtual machine’s `VirtualMachineCapability.swapPlacementSupported` property is `true` for a virtual machine, you can specify a value for the `VirtualMachineConfigSpec.swapPlacement` property. The value must be one of the values of the `VirtualMachineConfigInfoSwapPlacementType` enumeration, as a string.

Adding Devices to Virtual Machines

You can add devices to a virtual machine during creation using the `VirtualMachineConfigSpec.deviceChange` property, which is a `VirtualDeviceSpec`. You specify the host device that the virtual device should map to by using a backing object. A backing object represents the host device associated with a virtual device.

- Backing option objects – You can find out which devices the host supports by extracting the relevant backing option object.
- Backing information object – The backing information object allows you to supply data for virtual device configuration. You access a `VirtualDeviceBackinInfo` object as follows:

  ```
  VirtualMachineConfigSpec.deviceChange[].device.backing
  ```

To add a device to a virtual machine, you must first find out which devices are supported on the corresponding ESXi host, and then specify a `VirtualDevice` object. Perform these tasks to add a device to a virtual machine:

Procedure

1 Find out which devices your ESXi system supports by calling the `QueryConfigOption` method, which you can access through the `VirtualMachine.environmentBrowser` property. The method returns a `VirtualMachineConfigOption` data object that specifies what the ESXi supports. For example, `VirtualMachineConfigOption.hardwareOptions` includes information about supported CPU and memory and an array of `VirtualDeviceOption` data objects.

Note You cannot use the `QueryConfigOption` method to create another instance of a default device. If you attempt to add a default device, such as an IDE controller, the server ignores the operation.

2 Specify the backing information object for the device. The actual process for defining the object differs for different objects. For example, for a CD-ROM passthrough device, you use a `VirtualCdromPassthroughBackingInfo` device. The `VirtualDevice.backing` property is a `VirtualDeviceBackingInfo` object which is extended by devices.

The following code fragment adds a CD-ROM passthrough device:

```
VirtualCdromPassthroughBackingInfo vcpbi = new VirtualCdromPassthroughBackingInfo();
// Does the virtual device have exclusive access to the CD-ROM device?
vcpbi.setExclusive(false);
// Specifies the device name.
vcpbi.setDeviceName('cdrom0');
```

3. Specify connection information for the device.

   The `VirtualDevice.connectable` property is a `VirtualDeviceConnectInfo` data object. This object provides information about restrictions on removing the device while a virtual machine is running. This property is `null` if the device is not removable.

   ```
   VirtualDeviceConnectInfo vdci = new VirtualDeviceConnectInfo();
   // Allow the guest to control whether the virtual device is connected?
   vdci.setAllowGuestControl(false);
   // Is the device currently connected?
   vdci.setConnected(true);
   // Connect the device when the virtual machine starts?
   vdci.setStartConnected(true);
   ```

4. Define the controller key, the virtual device key, and the unit number.

   You define these items with the integer properties: `controllerKey`, `key`, and `unitNumber`. See the `VirtualDevice` data object in the *API Reference*.

5. Specify device Information.

   The `deviceInfo` property is a `Description` data object that has a `name` property and a `summary` property. You can supply a string value for each, describing the device.

   ```
   Description vddesc = new Description();
   vddesc.setLabel('CD-ROM Device cdrom0');
   vddesc.setSummary('The CD-ROM device for this virtual machine.');
   ```

6. Specify the virtual device as the `device` property of a `VirtualDeviceConfigSpec.`

7. Specify the `VirtualDeviceConfigSpec` as the `deviceChange` property to the `VirtualMachineConfigSpec` that you pass in to a `Folder.CreateVM_Task` or `VirtualMachine.ReconfigVM_Task` method.

Here’s the complete code fragment for a CD-ROM passthrough device:

```
VirtualDevice vd = new VirtualDevice();
vd.setBacking(vcpbi);
vd.setConnectable(vdci);
vd.setControllerKey(257);
vd.setDeviceInfo(vddesc);
vd.setKey(2);
vd.setUnitNumber(25);
```

Performing Virtual Machine Power Operations

Just like physical machines, virtual machines have power states.

- Powered on – The virtual machine is running. If no OS has been installed, you can perform OS installation as you would for a physical machine.

- Powered off – The virtual machine is not running. You can still update the software on the virtual machine's physical disk, which is impossible for physical machines.
- Suspended – The virtual machine is paused and can be resumed; like a physical machine in standby or hibernate state.

  Important Before you power on a virtual machine, you must make sure that the host has sufficient resources. You must have enough memory for the virtual machine, and some memory overhead. See Querying Virtual Machine Memory Overhead.

`VirtualMachine` power operations allow you to change the power state. Each operation is sensitive to the current power state, for example, powering on a powered off virtual machine has the desired result while powering on a powered on virtual machine results in an error. You must check the current state before you run one of these tasks.

- `PowerOnVM_Task` – Powers on a virtual machine. If the virtual machine is suspended, this method resumes execution from the suspend point.
- `PowerOffVM_Task` – Powers off a virtual machine.
- `ResetVM_Task` – Resets power on this virtual machine. If the current state is `poweredOn`, `ResetVM_Task` first performs a hard `powerOff` operation. After the power state is poweredOff, `ResetVM_Task` performs a `powerOn` operation.

  Although this method functions as a `powerOff` followed by a `powerOn`, the two operations are atomic with respect to other clients, meaning that other power operations cannot be performed until the reset method completes.
- `SuspendVM_Task` – Suspends the virtual machine. You can later power on the suspended virtual machine to the same state.

Virtual machines are often configured to start up the guest operating system when they are started, and try to shut down the guest operating system when being shut down. However, starting and stopping a virtual machine differs from starting and stopping the guest operating system (see Customizing the Guest Operating System).

Important Power operations might affect other virtual machines that are participating in a DRS cluster or VMware HA. See #unique_230 for information about DRS clusters and VMware HA.

You can use the `Datacenter.PowerOnMultiVM_Task` to power on multiple virtual machines in a datacenter. Pass an array of `VirtualMachine` managed object references and an array of option values to the method. If any of the virtual machines in the list is manually managed by VMware DRS, the system generates a DRS recommendation that the user needs to apply manually. Standalone or DRS disabled virtual machines are powered on for the current host. Virtual machines managed by DRS, to be placed by DRS, are powered on for the recommended host.

Registering and Unregistering Virtual Machines

When you create a virtual machine, it becomes part of the inventory (inside the folder from which you called the creation method by default), and it is registered. If you copy virtual machine files to relocate the virtual machine, or if you remove the files from the inventory using the vSphere Client, it becomes unregistered and unusable. You cannot power on a virtual machine that is not part of the inventory.

To restore the virtual machine to the inventory, and make it usable again, you can use the `RegisterVM_Task` method, defined in the `Folder` managed object. You can register the virtual machine to a host or to a resource pool. You can register the virtual machine as a template if you want to use it to clone other virtual machines from.

The `ColdMigration.java` sample illustrates both registering and reconfiguring a virtual machine. At the heart of the sample is the following call, which registers the virtual machine. Arguments include the virtual machine's current folder, datastore path, and name, whether to register as a template, and the resource pool or host to register the machine in.

```
ManagedObjectReference taskmor = cb.getConnection().getService().registerVM_Task(
                 vmFolderMor,vmxPath,getVmName(),false,resourcePool,host);
```

After registration, the virtual machine takes its resources (CPU, memory, and so on) from the resource pool or host to which it is registered.

The `RemoveManagedObject.java` sample illustrates unregistering a virtual machine.

Customizing the Guest Operating System

You install the guest operating system on the virtual machine just as you would install it on a physical machine. Afterwards, you can use the Web Services API to retrieve information and perform some customization if VMware Tools is installed on top of the guest operating system.

`VirtualMachine` includes the following methods for managing the guest operating system:

- `ShutdownGuest` and `RebootGuest` shut down and reboot the guest OS, and `StandbyGuest` puts the guest in hybernate mode. In each case, you perform the action on the guest OS. For example, you might shut down Windows but leave the virtual machine running.
- `ResetGuestInformation` clears cached guest information. Guest information can be cleared only if the virtual machine is powered off. Use this method if stale information is cached, preventing reuse of an IP address or MAC address.
- `SetScreenResolution` sets the console screen size of the guest operating system. When you call this method, the change is reflected immediately the virtual machine console you can access in the vSphere Client.

You can customize the identity and network settings of the guest OS with the `CustomizationSpec` data object that is a parameter to `VirtualMachine.CustomizeVM_Task`. The `CustomizationSpec` is also a property of the `VirtualMachineCloneSpec` you pass in when cloning a virtual machine.

The settings you customize with this method are primarily virtual machine settings, but because the virtual machine and the guest OS share the information, you are also customizing the guest OS with this method.

The `CustomizationSpec` allows you to set the following properties:

- `encryptionKey` – Array of bytes that can be used as the public key for encrypting passwords of administrators.
- `globalIPSettings` – Contains a `CustomizationGlobalIPSettings` data object which specifies a list of DNS servers and a list of name resolution suffixes for the virtual network adapter.
- `identity` – Allows you to specify the network identity and settings, similar to the Microsoft Sysprep tool.
- `nicSettingMap` – Custom IP settings that are specific to a particular virtual network adapter.
- `options` – Optional operations (either LinuxOptions or WinOptions).

Installing VMware Tools

VMware Tools is a suite of utilities that enhances the performance of a virtual machine's guest operating system and improves virtual machine management. For each guest OS, VMware provides a specific binary-compatible version of VMware Tools. The SDK requires that you install VMware Tools, or some operations related to the guest operating system fail.

Important You must install the guest operating system before you install VMware Tools.

With VMware Tools installed on the guest OS, the virtual machine obtains its DNS (domain name server) name and an IP address and is therefore reachable over the network.

`VirtualMachine` includes three methods for automating installation and upgrade of VMware Tools.

- `MountToolsInstaller` – Mounts the VMware Tools CD installer as a CD-ROM for the guest operating system. To monitor the status of the tools installallation, check `GuestInfo.toolsStatus`. Check `GuestInfo.toolsVersionStatus` and `GuestInfo.toolsRunningStatus` for related information.
- `UnmountToolsInstaller` – Unmounts the VMware Tools installer CD.
- `UpgradeToolsTask` – Performs an upgrade of VMware Tools. This method assumes VMware Tools has been installed and is running. The method takes one argument, `InstallerOptions`, which allows you to specify command-line options passed to the installer to modify the installation procedure for tools.

Use the`ToolsConfigInfo` data object in `VirtualMachineConfigSpec.toolsInfo` property to specify the settings for the VMware Tools software running on the guest operating system.

Upgrading a Virtual Machine

You can upgrade virtual machine hardware by running the `VirtualMachine.UpgradeVM_Task` method. The method upgrades this virtual machine's virtual hardware to the latest revision that is supported by the virtual machine's current host. You can specify the version number as an argument. This method is useful if you want to run your virtual machine on a newer hypervisor that supports newer versions of the hardware.

Virtual Machine Management 11

Virtual machines can perform like physical computers and can be configured like physical computers. Virtual machines also support special features that physical computers do not support. This chapter discusses some of these features: migrating virtual machines, using snapshots, and using linked virtual machines.

For more information about configuring virtual machines, see the chapter Configuring a Virtual Machine.

This chapter includes the following topics:

- Virtual Machine Migration
- Snapshots
- Linked Virtual Machines

Virtual Machine Migration

Migration is the process of moving a virtual machine from one host or storage location to another. Copying a virtual machine creates a new virtual machine. It is not a form of migration. vSphere supports the following migration types:

Migration Type	Description
Cold migration	Moves a powered-off virtual machine to a new host. Optionally, you can relocate configuration and disk files to new storage locations.
Migration of a suspended virtual machine	Moves a suspended virtual machine to a new host. Optionally, you can relocate configuration and disk files to new storage location.
Migration with VMotion	Moves a powered-on virtual machine to a new host. Migration with VMotion allows you to move a virtual machine to a new host without interruption in the availability of the virtual machine.
Migration with Storage VMotion	Moves the virtual disks or configuration file of a powered-on virtual machine to a new datastore. Migration with Storage VMotion allows you to move a virtual machine’s storage without interruption in the availability of the virtual machine.

Migration of a suspended virtual machine and migration with VMotion are both sometimes called hot migration, because they allow migration of a virtual machine without powering it off.

You can move virtual machines manually or set up a scheduled task to perform the cold migration.

Cold Migration

If a virtual machine is shut down, you can move it to a different cluster, resource pool, or host by copying all virtual machine files to a different directory. The `ColdMigration` example illustrates this.

Migration with VMotion

VMware VMotion support the live migration of running virtual machines from one physical server to another with no downtime. The source and destination physical servers can be in the same datacenter or in different datacenters.

When you call the `VirtualMachine` object's `MigrateVM_Task` method, you can specify either a host or resource pool to migrate to. You can optionally specify the task priority and the power state of the virtual machine. The `VMotion` example performs the following tasks:

- Uses `QueryVMotionCompatibility_Task` to check two hosts are compatible.
- Uses `CheckMigrate_Task` to check whether migration is feasible. For example, if two hosts are not compatible, virtual machines cannot be migrated from one to the other.
- Uses `CheckRelocation_Task` to check whether relocation is possible.

The sample performs the migration if the hosts are compatible.

Using Storage VMotion

Storage VMotion allows you to move a running virtual machine from one VMFS volume to another. Taking the virtual machine or its associated storage offline is not required. All datastore types are supported, including local storage, VMFS, and NAS (network attached storage).

You can place the virtual machine and all its disks in a single location, or select separate locations for the virtual machine configuration file and each virtual disk. The virtual machine remains on the same host during Storage VMotion.

To perform storage VMotion, you use the `VirtualMachine.RelocateVM_Task` method. The `RelocateVMSpec` passed in to the method allows you to specify the target datastore and target host or resource pool.

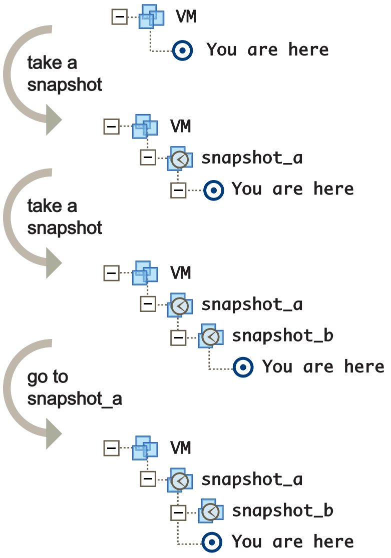
Snapshots

A snapshot is reproduction of the virtual machine just as it was when you took the snapshot. The snapshot includes the state of the data on all virtual machine disks and the virtual machine power state (on, off, or suspended). You can take a snapshot when a virtual machine is powered on, powered off, or suspended.

When you create a snapshot, the system creates a delta disk file for that snapshot in the datastore and writes any changes to that delta disk. You can later revert to the previous state of the virtual machine.

The `VirtualMachine` object has methods for creating snapshots, reverting to any snapshot in the tree, and removing snapshots.

Figure 11-1. Virtual Machine Snapshots



Virtual machine with no snapshots

The new snapshot (snapshot_a) is now the parent snapshot of the You are here state. The parent snapshot of the You are here state is the parent snapshot of the virtual machine.

When you take a snapshot from the snapshot_a state, snapshot_a becomes the parent of the new snapshot (snapshot_b) and snapshot_b is the parent snapshot of the You are here state.
If you take a snapshot now, the new snapshot will be based on the snapshot_b state, whose parent snapshot is the snapshot_b state.

When you go to snapshot_a, snapshot_a becomes the parent of the You are here state.
If you take a snapshot now, the new snapshot will be based on the snapshot_a state.

When you revert a virtual machine, the virtual machine returns to the parent snapshot of the virtual machine (that is, the parent of the current You are here state).

Snapshot hierarchies can become fairly complex. For example, assume that, in the example in Figure 11-1, you revert to `snapshot_a`. You might then work with and make changes to the `snapshot_a` virtual machine, and create a new snapshot, creating, in effect, a branching tree.

Creating a Snapshot

The `VirtualMachine.CreateSnapshot_Task` method creates a new snapshot of a virtual machine. As a side effect, the current snapshot becomes the parent of the new snapshot.

The method allows you to specify a name for the snapshot and also requires you set the `memory` and `quiesce` properties:

- `memory` – If `true`, a dump of the internal state of the virtual machine (basically a memory dump) is included in the snapshot. Memory snapshots consume time and resources, and take a while to create. When set to `false`, the power state of the snapshot is set to powered off.
- `quiesce` – If `true` and the virtual machine is powered on when the snapshot is taken, VMware Tools is used to quiesce the file system in the virtual machine. This ensures that a disk snapshot represents a consistent state of the guest file systems. If the virtual machine is powered off or VMware Tools is not available, the quiesce flag is ignored.

The `VMSnapshot.java` example calls this method as follows:

```
ManagedObjectReference taskMor = service.createSnapshot_Task(
                                     vmMor, snapshotName, desc, false, false);
```

The method returns MOR to a `Task` object with which to monitor the operation. The `info.result` property in the `Task` contains the newly created `VirtualMachineSnapshot` upon success.

Reverting to a Snapshot

When you revert to a snapshot, you restore a virtual machine to the state it was in when the snapshot was taken. The `VirtualMachine.RevertToSnapshot_Task` allows you to specify a target host and whether the virtual machine should be powered on.

If the virtual machine was running when the snapshot was taken, and you restore it, you must either specify the host to restore the snapshot to, or set the `SupressPowerOn` flag to `true`.

Deleting a Snapshot

You can delete all snapshots by calling `VirtualMachine.RemoveAllSnapshots` or by calling the `VirtualMachineSnapshot.RemoveSnapshot_Task` method. The `VirtualMachineSnapshot` object was previously returned in the task returned by the `CreateSnapshot_Task` method.

Linked Virtual Machines

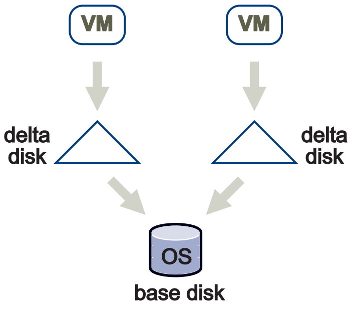
Linked virtual machines are two or more virtual machines that share storage and support efficient sharing of duplicated data.

Linked Virtual Machines and Disk Backings

In its simplest form, shared storage is achieved through the use of delta disk backings. A delta disk backing is a virtual disk file that sits on top of a standard virtual disk backing file. Each time the guest operating system on a virtual machine writes to disk, the data is written to the delta disk. Each time the guest operating system on a virtual machine reads from disk, the virtual machine first targets the disk block in the delta disk. If the data is not on the delta disk, the virtual machine looks for it on the base disk.

Linked virtual machines can be created from a snapshot or from the current running point. After you create a set of linked virtual machines, they share the base disk backing and each virtual machine has its own delta disk backing, as shown in Figure 11-2.

Figure 11-2. Linked Virtual Machines with Shared Base Disk Backing and Separate Delta Disk Backing



Caution We recommend a limit of up to eight host virtual machines accessing the same base disk in a linked virtual machine group. However, you can have an unlimited number of linked virtual machines within each host virtual machine in the group.

Limitation for HA Clusters

Virtual machines in a linked clone group can be part of a VMware HA (high availability) cluster. The number of hosts in a cluster might affect HA's ability to restart a failed virtual machine.

- Clusters that contain ESXi 5.0 or earlier hosts – If a cluster has eight or fewer hosts, then linked virtual machines restart properly. However, if the cluster has more than eight hosts and any of the hosts are ESXi 5.0 or earlier, HA might not be able to restart a virtual machine after it fails. HA is not aware that virtual machines in the linked clone group are subject to the eight host limit. In this case, when HA responds to a failure, it might try to restart the virtual machine on a host that cannot participate in the group due to the maximum host limit. HA will attempt failover five times to different hosts. Thus, in clusters with 13 or more hosts, it is possible that HA will never try a host that is associated with the linked clone group.
- Clusters that contain only ESXi 5.1 or later hosts – The maximum host limit for a linked clone group is the maximum number of hosts allowed in a cluster. In this case, the number of hosts in the cluster does not affect the ability to restart failed virtual machines.

Creating a Linked Virtual Machine

You can create linked virtual machines in one of two ways:

- Clone the virtual machine from a snapshot.
- Clone the virtual machine from the current virtual machine state. This state might differ from the snapshot point.

Creating a Linked Virtual Machine From a Snapshot

You first create a snapshot, and then create the linked virtual machine from the snapshot.

Procedure

1. To create the snapshot, call the `CreateSnapshot_Task` method for the virtual machine. The virtual machine can be in any power state. The following pseudo code creates a snapshot named `snap1`. The code does not include a memory dump. VMware Tools is used to quiesce the file system in the virtual machine if the virtual machine is powered on.

   ```
   myVm.CreateSnapshot("snap1", "snapshot for creating linked virtual machines", False, True)
   ```

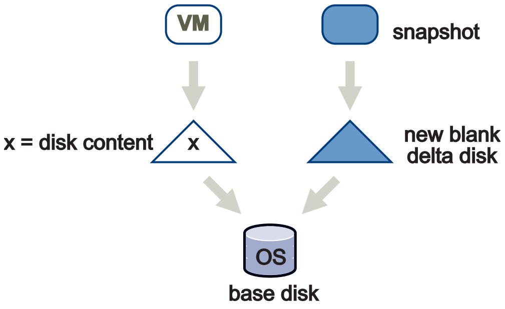
2. To create the linked virtual machine, specify the snapshot you created and use a `VirtualMachineRelocateDiskMoveOptions.diskMoveType` of `createNewDeltaDiskBacking`, as illustrated in Example: Creating a Linked Virtual Machine from a Snapshot. Creating linked virtual machines from a snapshot works with virtual machines in any power state.

Example: Creating a Linked Virtual Machine from a Snapshot

```
relSpec = new VirtualMachineRelocateSpec()
relSpec.diskMoveType = VirtualMachineRelocateDiskMoveOptions.createNewChildDiskBacking

cloneSpec = new VirtualMachineCloneSpec()
cloneSpec.powerOn = False
cloneSpec.template = False
cloneSpec.location = relSpec
cloneSpec.snapshot = myVm.snapshot.currentSnapshot

myVm.Clone(myVm.parent, myVm.name + "-clone", cloneSpec)
```

The result is a virtual machine with the same base disk as the original, but a new delta disk backing.

Figure 11-3. Creating a Linked Virtual Machine from a Snapshot



Creating a Linked Virtual Machine From the Current Running Point

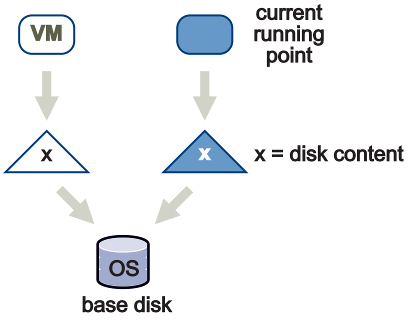
To create a virtual machine from the current running point, clone the virtual machine, as in , but use a `diskMoveType` of `moveChildMostDiskBacking`. The virtual machine can be in any power state.

For more information about cloning a virtual machine, see Example: Creating a Linked Virtual Machine from a Snapshot.

Example: Creating a Linked Virtual Machine from the Current Running Point

```
relSpec = new VirtualMachineRelocateSpec()
relSpec.diskMoveType = VirtualMachineRelocateDiskMoveOptions.moveChildMostDiskBacking

cloneSpec = new VirtualMachineCloneSpec()
cloneSpec.powerOn = False
cloneSpec.template = False
cloneSpec.location = relSpec

myVm.Clone(myVm.parent, myVm.name + "-clone", cloneSpec)
```

Figure 11-4. Creating a Linked Virtual Machine from the Current Running Point



Instant Clone Virtual Machines

The instant clone operation creates a running virtual machine that continues running from the current state of the source virtual machine. There is no delay to power on the cloned virtual machine.

An instant clone virtual machine is a kind of linked clone with these characteristics:

- The clone starts out powered on and running.
- The clone replicates the memory of the source virtual machine.
- The clone shares memory pages with the source virtual machine as long as they remain unmodified.

The instant clone operation facilitates rapid deployment of virtual machines for low-latency response to peak computing demand. It also uses memory and disk space as efficiently as possible.

Because the clone replicates the running state of the source virtual machine, it usually requires customization of some network properties in the guest operating system to eliminate conflicts with the source. An instant clone virtual machine may also require new backings for some dedicated virtual devices, such as serial ports, parallel ports, or optical drives.

Instant Clone Terminology

The instant clone feature has its own set of terminology, which uses some terms in ways specific to the feature.

stun To stop the clock of a virtual machine temporarily, preventing guest operations during an instant clone operation.

freeze To stop the clock of a virtual machine indefinitely, allowing a series of instant clone operations that reproduce the exact process state of the source virtual machine.

suspend Save the state of a virtual machine so applications can resume, and put it to sleep.

resume Continue running the virtual machine that was suspended, including its applications.

unstun

To release a stunned source virtual machine, allowing I/O operations to proceed.

source

A virtual machine that is cloned during an instant clone operation.

instant clone

1. An operation that quickly creates a new virtual machine that is an exact copy of a source virtual machine.
2. A new virtual machine created by an instant clone operation.

Run State of the Instant Clone Source

An instant clone can be created either from a source virtual machine in a frozen state, or from the current running point of a source virtual machine. Certain characteristics of the process and of the result can affect your choice of frozen virtual machine or current running point for the source virtual machine.

Advantages of Cloning from the Current Running Point

An instant Clone created from the current running point of a source virtual machine does not require an agent running in the guest operating system to invoke the frozen state.

If you create an instant clone from the current running point, the source virtual machine continues running from that point after a very brief delay, whereas a frozen source virtual machine requires intervention by the host to thaw it.

Advantages of Cloning from a Frozen Virtual Machine

A source virtual machine in the frozen state allows you to deploy any number of instant clones in exactly the same state, because the guest operating system retains its state after the clone operation.

When you create instant clones from the current running point of a source virtual machine, each cloning operation adds another delta disk to the source virtual machine. Each delta disk adds a small performance penalty, but a long chain of delta disks causes a noticeable performance penalty for virtual disk accesses.

The Instant Clone Process from a Frozen Source

The process to create an instant clone from a frozen source virtual machine requires one-time initial preparation, but after that it proceeds faster than creating an instant clone from the current running point. The source virtual machine must be booted and running, in a state that you want to replicate to other virtual machines. VMware Tools must be installed and running in the guest operating system.

Freezing the Source Virtual Machine for an Instant Clone Operation

Before you start the instant clone operation, you issue a VMware Tools command in the guest operating system, which freezes the source virtual machine. This is only needed one time, prior to the first instant clone operation. After that, the source virtual machine remains frozen. When VMware Tools receives the command to freeze the virtual machine, it passes the command through a back door to the host hypervisor.

The command to freeze the virtual machine depends on the guest operating system.

- For a Linux guest operating system, either of the following commands will freeze the virtual machine:
  - `vmware-rpctool "instantclone.freeze"`
  - `vmtoolsd -cmd "instantclone.freeze"`
- For a Windows guest operating system, the following command will freeze the virtual machine:
  - `C:\Program Files\VMware\VMware Tools\vmtoolsd.exe --cmd "instantclone.freeze"`

When a virtual machine is frozen, the hypervisor prevents future context switches to the guest operating system, which in effect stops the virtual machine's clock, although the virtual machine status continues to indicate that it is running. You can determine whether the virtual machine is frozen by examining the `runtimeinfo.InstantCloneFrozen` flag.

How the Instant Clone Operation Works

The instant clone operation involves the following sequence of steps.

Stunning the Instant Clone Source Virtual Machine

When you issue an API command to initiate an instant clone operation, the host begins by doing a stun operation on the source virtual machine. The stunned condition lasts a very short time, and is not directly visible to the API user.

The stunned condition blocks all I/O operations of the source virtual machine while the instant clone is created. The stun is redundant in the case of a frozen virtual machine. During the time the source virtual machine is stunned, the host creates a delta disk for the source virtual machine, which remains empty as long as the source virtual machine is stunned or frozen.

Copying Virtual Disks During the Instant Clone Operation

Then the host creates an empty delta disk for the instant clone virtual machine. This delta disk links to the base disk of the source virtual machine. More precisely, if the source virtual machine already had one or more delta disks, the instant clone delta disk links to the second delta disk in the disk chain of the source. The second delta disk is the delta disk that was the topmost delta disk when the stun operation was invoked.

Copying Memory During the Instant Clone Operation

The host creates a new virtual memory paging file for the instant clone virtual machine, whose page tables link to the paging file of the source virtual machine. When the instant clone virtual machine is complete and is allowed to run instructions, all its memory pages will be shared with the source virtual machine until either virtual machine does a write to memory.

Configuring the Instant Clone Virtual Machine

Then the host creates a virtual machine configuration file for the instant clone, which links to its delta disk and memory paging file. At this point, the instant clone virtual machine is capable of running instructions, and the host unstuns it. Both the memory and the virtual disks are shared with the source virtual machine, so the instant clone is identical to the source virtual machine, from the guest operating system point of view.

When you create virtual machines with identical guest operating systems, the network settings conflict. Usually you will want to customize these settings for each instance of the guest operating system.

Limitations of Instant Clones

The instant clone feature provides good performance and scalability, but it has a few limitations:

- The instant clone feature is not available when you connect directly to ESXi. Instant clone depends on functionality available only in vCenter Server.
- Delta disks created during the instant clone operation are not visible in the snapshot trees of the virtual machines. They cannot be managed with the VirtualMachineSnapshot managed object. Instead, you must manage the delta disks using the `VirtualMachine.Reconfigure()` method.
- The instant clone operation is partly parallel and partly serialized. You can start several operations concurrently, but part of the process is exclusive and requires serialization of requests.
- The instant clone operation responds to errors by backing out changes, such as delta disks, to restore the previous state of the file system and the source virtual machine. However, there is a small window of failure at the end of the operation where the cloned virtual machine is independent and cannot be backed out to recover from an error. This is a low risk situation.

Guest Customization of Instant Clone Virtual Machines

The instant clone operation produces a virtual machine whose memory is exactly the same as the source virtual machine. This can cause conflicts in network addressing, if two different virtual machines respond concurrently with the same network identity. The conflicting network attributes are usually the host name, IP address, and MAC address.

In the case of an instant clone derived from a frozen source virtual machine, a conflict might not immediately arise, because the source virtual machine is not active on the network. The instant clone simply assumes the identity of the source virtual machine. However, a second clone derived from the same frozen virtual machine could create a network conflict by duplicating the same identity as the first instant clone.

For an instant clone derived from the current running point of the source virtual machine, the problem is more acute because the source virtual machine resumes operation simultaneously with the instant clone.

To avoid network conflicts, you customize the instant clone to adopt a new identity, before allowing both the source virtual machine and the instant clone to run concurrently. In a situation where temporary network disruption is tolerable, you can ignore the conflict while you customize the network settings in the guest operating system of the instant clone.

Otherwise, you have two options to avoid the race condition that results when both virtual machines resume running from the same point. You can either disable the virtual NIC before the instant clone operation, or else you can specify that the virtual NIC in the instant clone will be disabled at the time when it resumes running after the operation.

Avoiding Network Identity Collisions after Instant Clone Operations

To avoid a network conflict between a source virtual machine and its instant clone, you must disable at least one of the two conflicting virtual NICs until you complete network customization in the guest operating system of the instant clone. Here are some common approaches:

If the source virtual machine is frozen, its virtual NIC is effectively disabled, and you can reconfigure the guest network settings of the instant clone at any time before the source virtual machine is thawed.

If you derive the instant clone from the current running point of the source virtual machine, you can set the `connected` property of the virtual NIC backing to `false`, which disables it in the source before you start the instant clone operation. Then you re-enable the virtual NIC after the instant clone operation completes. After you customize the network settings in the guest operating system of the instant clone, you must re-enable the virtual NIC in the instant clone as well. This approach requires that you tolerate a network interruption until the instant clone operation is complete.

To avoid a network interruption, you can issue the instant clone operation with an `InstantCloneSpec` that specifies that the virtual NIC in the instant clone will be disconnected. The virtual NIC in the source virtual machine is not affected. After you complete guest operating system customization in the instant clone, you set the `connected` property of its virtual NIC back to `true`, and the instant clone operates under its new network identity.

In any case where you change the network identity settings in the guest operating system of the instant clone, you must reset the network stack for the virtual NIC to cause it to adopt the new settings. You do the reset from the guest operating system, as with a physical machine. The way to reset a NIC differs, depending on the operating system.

Resetting the Network Stack in a Linux Virtual Machine

When you change network settings in an instant clone, you must reset the network stack of the virtual NIC to adopt the new settings. For a Linux guest operating system, you must unbind and rebind the network driver so it adopts a new MAC address.

The following shell script rebinds all network drivers:

```
#!/bin/bash
for NETDEV in /sys/class/net/*
do
  DEV_LABEL=`basename \`readlink -f $NETDEV/device\``
  DEV_DRIVR=`basename \`readlink -f $NETDEV/device/driver\``
  echo $DEV_LABEL > /sys/bus/pci/drivers/$DEV_DRIVR/unbind
  echo $DEV_LABEL > /sys/bus/pci/drivers/$DEV_DRIVR/bind
done
```

If the guest operating system was configured to use DHCP, you must also force a DHCP refresh after the MAC addresses refresh has completed.

Tip: Avoid resetting the network stack in the guest operating system while you are working over a network connection, such as SSH. You can run the shell commands to reset the stack as part of a customization script installed in the guest operating system of the source virtual machine before running the instant clone operation.

Resetting the Network Stack in a Windows Virtual Machine

When you change network settings in a Windows virtual machine, you must disable and re-enable the network object. There are several ways to do that in Windows.

Reset the Network Stack in a Windows Virtual Machine Using the Control Panel

When you change network settings in a Windows virtual machine, you must reset the network stack of the virtual NIC to adopt the new settings. For a Windows guest operating system, you must disable and re-enable the network connection so it adopts a new MAC address. You can do this using the Control Panel.

Procedure

1. In the Control Panel, navigate to **Control Panel > Networks and Internet > Network Connections**.
2. Right-click the network adapter icon and choose **disable**.
3. Right-click the network adapter icon and choose **enable**.
4. Repeat these steps for each network adapter.

Reset the Network Stack in a Windows Virtual Machine Using PowerShell

When you change network settings in a Windows virtual machine, you must reset the network stack of the virtual NIC to adopt the new settings. For a Windows guest operating system, you must disable and re-enable the network connection so it adopts a new MAC address. To perform this task with PowerShell, use the `Restart-NetAdapter` cmdlet.

The cmdlet is described in more detail at https://technet.microsoft.com/en-us/itpro/powershell/windows/netadapter/restart-netadapter.

Procedure

1. List the virtual network adapters in the guest operating system.

   ```
   Get-NetAdapter
   ```

   The names of the virtual network adapters appear in the first column of output.
2. Restart the network adapter representing the external interface.

   ```
   Restart-NetAdapter -Name "Ethernet0"
   ```
3. If you have more than one virtual interface, repeat the previous step for each one.

Reset the Network Stack in a Windows Virtual Machine Using netsh

When you change network settings in a Windows virtual machine, you must reset the network stack of the virtual NIC to adopt the new settings. For a Windows guest operating system, you must disable and re-enable the network connection so it adopts a new MAC address. To perform this task with `netsh`, use the `interface` command.

Run the following commands in a DOS shell.

Procedure

1. List the network interfaces.

   ```
   netsh interface show interface
   ```

2. Choose the interface that represents the external network connection and disable it with a `netsh` command.

   ```
   netsh interface set interface name="Ethernet0" admin=DISABLED
   ```

3. Re-enable the interface with a `netsh` command.

   ```
   netsh interface set interface name="Ethernet0" admin=ENABLED
   ```

4. Repeat the previous two commands if you have more than one NIC that needs to be reset.

Removing Snapshots and Deleting Linked Virtual Machines

After you have created a group of linked virtual machines, you can remove a snapshot that was the basis for a linked virtual machine, or delete a virtual machine. Those actions affect disks in the linked virtual machine group. Perform the actions when connected to a vCenter Server system for disk consolidation or deletion.

- Snapshot removal – During snapshot removal, the snapshot metadata is also removed, and the virtual machine from which the snapshot was taken is no longer shown as having snapshots. If you remove a snapshot while connected to the ESXi host directly, shared disks are not consolidated and unnecessary levels of delta disks might result. If you remove a snapshot while connected to a vCenter Server system, shared disks are not consolidated, but unshared disks are consolidated.
- Virtual machine deletion – When you delete a virtual machine by directly connecting to the ESXi host, shared disks are not deleted. When you delete a virtual machine by connecting to a vCenter Server system, shared disks are not deleted, but unshared disks are deleted.

  Caution Delete all linked virtual machines before deleting the master from which they were created, so that you don't have orphaned or corrupt disk files on your file system.

Relocating a Virtual Machine in a Linked Virtual Machine Group

You can move the virtual machines in a linked virtual machine group between datastores and save storage. he contents of the delta disk might not be as important as the contents of the base, and you can save storage by removing the delta disk.

For more information, see Figure 11-3.

Example: Relocating a Linked Virtual Machine

```
relSpec = new VirtualMachineRelocateSpec()
relSpec.diskMoveType = VirtualMachineRelocateDiskMoveOptions.moveChildMostDiskBacking
relSpec.datastore = localDatastore
myVm.Relocate(relSpec)
```

You can relocate multiple linked virtual machines to a new datastore, but keep all shared storage during the relocation. To achieve the relocation, relocate the desired virtual machines one by one, giving the option to allow reattaching to an existing disk, as shown in Example: Relocating Multiple Linked Virtual Machines.

Example: Relocating Multiple Linked Virtual Machines

```
relSpec = new VirtualMachineRelocateSpec()
relSpec.diskMoveType = VirtualMachineRelocateDiskMoveOptions.moveAllDiskBackingsAndAllowSharing
relSpec.datastore = targetDatastore
myVm.Relocate(relSpec)
```

Promoting a Virtual Machine's Disk

Promoting a virtual machine’s disk improves performance.

Important You can use the `PromoteDisks` API only when connected to a vCenter Server system.

You can use `PromoteDisks` to copy disk backings or to consolidate disk backings.

- Copy – If the `unlink` parameter is `true`, any disk backing that is shared by multiple virtual machines is copied so that this virtual machine has its own unshared version. Files are copied into the home directory of the virtual machine. This setting results in improved read performance, but higher space requirements. The following call copies and shares disks, and then collapses all unnecessary disks.

  ```
  myVm.PromoteDisks(True, [])
  ```

- Consolidate – If the `unlink` parameter is `false`, any disk backing that is not shared between multiple virtual machines and not associated with a snapshot is consolidated with its child backing. The net effect is improved read performance at the cost of inhibiting future sharing. The following call eliminates any unnecessary disks:

  ```
  myVm.PromoteDisks(False, [])
  ```

Promoting a virtual machine’s disk might also be useful if you end up with disk backings that are not needed for snapshots or for sharing with other virtual machines.

Both uses of PromoteDisks take an optional second argument, which allows you to apply the method to only a subset of disks. For example, you can unshare and consolidate only the virtual disk with key 2001 as follows:

```
for any of my VMs in dev
   if (dev.key == 2001)
      disk2001 = dev

myVm.PromoteDisks(True, [disk2001])
```

Performing Advanced Manipulation of Delta Disks

For advanced manipulation of delta disks, you can use VirtualDeviceConfigSpec methods such as VirtualDeviceConfigSpec.create and VirtualDeviceConfigSpec.add.

Together add and create allow you to create a blank delta disk on top of an existing disk. For the VirtualDeviceConfigSpec you specify add to prepare the VM for a new delta disk, then create to initiate the file operation for the delta disk whose parent property is an existing disk. These methods create a new delta disk whose parent is the pre-existing disk.

One use case is adding a delta disk on top of an existing virtual disk in a virtual machine without creating a snapshot. Example: Adding a Delta Disk Backing illustrates how to add the delta disk for the first virtual disk in the virtual machine.

Example: Adding a Delta Disk Backing

```
disk = None
for any of my VMs in dev
   if (VirtualDisk.isinstance == dev):
      disk = dev

# Remove the disk
removeDev = new VirtualDeviceConfigSpec()
removeDev.operation = "remove"
removeDev.device = disk

# Create a new delta disk which has the
# original disk as its parent disk
addDev = new VirtualDeviceConfigSpec()
addDev.operation = "add"
addDev.fileOperation = "create"
addDev.device = copy.copy(disk)
addDev.device.backing = copy.copy(disk.backing)
addDev.device.backing.fileName = "[" + disk.backing.datastore.name + "]"
addDev.device.backing.parent = disk.backing

spec = new VirtualMachineConfigSpec()
spec.deviceChange = [removeDev, addDev]
```

For working code with a similar use case, see the JAXWS sample program VMDeltaDisk.java in the SDK under vsphere-ws/java.

Virtual Machine Encryption APIs 12

vSphere virtual machine encryption protects virtual machines, virtual disks, and related files. First you set up a trusted connection between vCenter Server and a key management server (KMS), then vCenter Server can retrieve keys from the KMS as needed.

Various aspects of virtual machine encryption are handled differently. You manage setup of the KMS trusted connection and perform most encryption workflows from the vSphere Web Client. You manage automation of some advanced features using the vSphere Web Services SDK, as discussed in this chapter. You use the `crypto-util` command-line tool directly on ESXi hosts for some special cases, for example, to decrypt the core dumps in a vm-support bundle.

This chapter includes the following topics:

- How Virtual Machine Encryption Protects a Datacenter
- vSphere Virtual Machine Encryption Components
- Prerequisites and Required Privileges for Encryption Tasks
- API Methods for vSphere Virtual Machine Encryption
- Workflows for vSphere Virtual Machine Encryption
- Best Practices

How Virtual Machine Encryption Protects a Datacenter

With vSphere virtual machine encryption, you can create encrypted virtual machines and encrypt existing ones. Because all virtual machine files with sensitive information are encrypted, the virtual machine is protected. Only administrators with encryption privileges can perform encryption and decryption tasks.

What Keys are Used

Two types of keys are used for encryption.

- The ESXi host generates and uses internal keys to encrypt virtual machines and disks. These keys are used as the disk encryption key (DEK) and are XTS-AES-256 keys.
- The key management server (KMS) sends keys to the vCenter Server upon request. These keys are used as the key encryption key (KEK) and are AES-256 keys. vCenter Server stores only the ID of each KEK, but not the key itself.

- ESXi hosts use the KEK to encrypt their internal keys, and store only the encrypted internal keys on disk, but not the KEK itself. When an ESXi host reboots, vCenter Server requests the necessary KEKs by sending the corresponding IDs to the KMS, and upon receipt, make the KEKs available to the ESXi host, which can then decrypt its internal keys as needed.

What Is Encrypted

Virtual machine encryption supports encrypting virtual machine files, virtual disk files, and core dump files.

Virtual Machine Files

Most virtual machine files, in particular guest data that are not stored in the VMDK file, are encrypted. This set of files includes but is not limited to the NVRAM (memory), VSWP (swap), and VMSN (snapshot) files. The key that vCenter Server retrieves from the KMS unlocks an encrypted bundle in the VMX file that contains internal keys and other secrets.

If you use the vSphere Web Client to create an encrypted virtual machine, all virtual disks are encrypted by default. For other encryption tasks, such as encrypting an existing virtual machine, you can encrypt and decrypt virtual disks separate from virtual machine files.

Note You cannot associate an encrypted virtual disk with an unencrypted virtual machine.

Virtual Disk Files

Data in an encrypted virtual disk (VMDK) file are never written in cleartext to storage or physical disk, and is never transmitted over the network in cleartext. The VMDK descriptor file is mostly cleartext, but contains a key ID for the KEK and the internal key (DEK) in the encrypted bundle.

You can use the vSphere API to perform either a shallow recrypt operation with a new KEK, or a deep recrypt operation with new internal keys.

Core Dump Files

Core dumps on an ESXi host that has encryption mode enabled are always encrypted. You can decrypt and password protect ESXi core dumps using the `crypto-util` command-line tool on the ESXi host.

Note Core dumps on the vCenter Server (Appliance) are not encrypted. Be sure to protect access to all vCenter Server systems.

What Is Not Encrypted

Some files that are associated with a virtual machine are not encrypted or partially encrypted.

Log Files

Log files are not encrypted because they should not contain sensitive data.

Virtual Machine Configuration Files

Most of the virtual machine configuration information, stored in the VMX and VMSD files, is not encrypted. Information about the KMS and the key ID is visible in those files.

Virtual Disk Descriptor File

To support disk management without a key, most of the virtual disk descriptor file is not encrypted.

Who Can Perform Cryptographic Operations

Only users who are assigned the Cryptographic Operations privileges can perform cryptographic operations. The privilege set is fine grained; see the *vSphere Security* guide. The default Administrator system role includes all Cryptographic Operations privileges. A new system role, No Cryptography Administrator, supports all Administrator privileges except for the Cryptographic Operations privileges.

You can create additional custom roles, for example, to allow a group of users to encrypt virtual machines but to prevent them from decrypting virtual machines.

For a full list of privileges, see the section “Cryptographic Operations Privileges” in the *vSphere Security* manual.

How Can I Perform Cryptographic Operations

The vSphere Web Client supports many cryptographic operations. For other tasks, you must use the API.

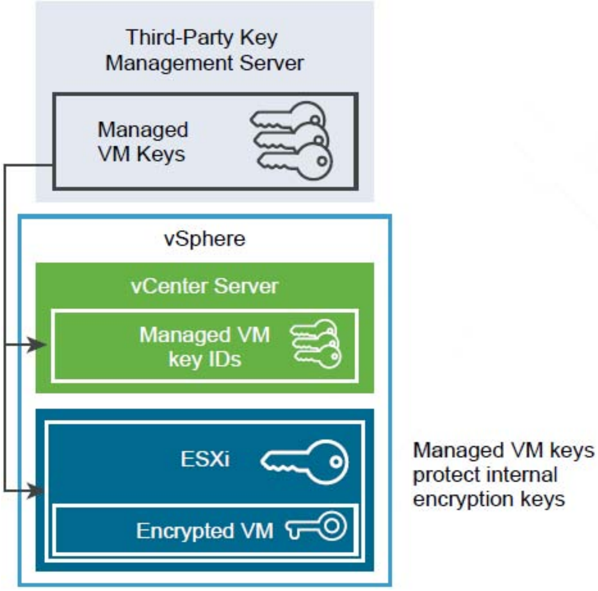
Table 12-1. Interfaces for performing cryptographic operations

Interface	Operations	Information
vSphere Web Client	Create encrypted virtual machines Encrypt and decrypt virtual machines	The *vSphere Security* guide.
vSphere Web Services SDK	Create encrypted virtual machines Encrypt and decrypt virtual machines Perform a deep recrypt of virtual machines (use a different KEK and DEK). Perform a shallow recrypt of virtual machines (use a different KEK).	This chapter.
`crypto-util`	Decrypt encrypted core dumps, check whether files are encrypted, and perform other management tasks directly on the ESXi host,	Command-line help and the *vSphere Security* guide.

vSphere Virtual Machine Encryption Components

An external key management server (KMS), the vCenter Server system, and ESXi hosts all contribute to the vSphere virtual machine encryption solution.

Figure 12-1. vSphere Virtual Machine Encryption Architecture


Third-Party Key Management Server
Managed VM Keys
vSphere
vCenter Server
Managed VM key IDs
ESXi
Encrypted VM
Managed VM keys protect internal encryption keys

Key Management Server

The vCenter Server requests keys from an external KMS. The KMS generates and stores the keys, and passes them to vCenter Server for distribution.

You can use the vSphere Web Client or the vSphere API to add a cluster of KMS instances to the vCenter Server system. If you use multiple KMS instances in a cluster, all instances must be from the same vendor and must replicate keys.

If your environment uses different KMS vendors in different environments, you can add a KMS cluster for each KMS and specify a default KMS cluster. The first cluster that you add becomes the default cluster. You can explicitly change the default later.

As a KMS client, vCenter Server uses the Key Management Interoperability Protocol (KMIP) and makes it easy to use the KMS of your choice.

vCenter Server

Only vCenter Server has credentials for logging in to the KMS. The ESXi hosts do not have those credentials. The vCenter Server obtains keys from the KMS and pushes them to the ESXi hosts. The vCenter Server does not store the KMS keys, it merely keeps a list of key IDs.

The vCenter Server checks the privileges of users who perform cryptographic operations. You can use the vSphere Web Client to assign cryptographic privileges or to assign the No cryptography administrator custom role to groups of users. See Prerequisites and Required Privileges for Encryption Tasks.

The vCenter Server adds cryptography events to the list of events that you can view and export from the vSphere Web Client Event Console. Each event includes the user, time, key ID, and cryptographic operation.

ESXi Hosts

ESXi hosts are responsible for several aspects of the encryption workflow.

- Accepting keys and storing them in memory (never on disk). If a host has encryption mode enabled, and the current user's role includes cryptographic operations privileges, vCenter Server pushes keys to the ESXi host upon request. See Prerequisites and Required Privileges for Encryption Tasks.
- Ensuring that guest data for encrypted virtual machines are encrypted when stored on disk.
- Ensuring that guest data for encrypted virtual machines are never sent unencrypted over the network.

The keys that the ESXi host generates are called internal keys in this document. These keys are typically act as data encryption keys (DEKs).

Encryption Process Flow

After vCenter Server is connected to the KMS, users with the required privileges can create encrypted virtual machines and disks. Those users can also perform other encryption tasks such as encrypting existing virtual machines and decrypting encrypted virtual machines. During the encryption process, different components interact as follows.

1. When the user performs an encryption task, for example, creating an encrypted virtual machine, vCenter Server requests a new key from the default KMS. This key will be used as the KEK.
2. The vCenter Server stores the key ID and passes the key to an ESXi host. If the ESXi host is part of a cluster, vCenter Server sends the KEK to each host in the cluster. The key itself is not stored on the vCenter Server system. Only the key ID is stored.
3. The ESXi host generates internal keys (DEKs) for the virtual machine and its disks, using the KEK that it received from vCenter Server to encrypt the internal keys. The the internal keys are kept in memory only. Only the encrypted data are stored on disk.
4. The ESXi host encrypts the virtual machine and its disks with the encrypted internal key.

ESXi hosts that have the KEK and can access the encrypted key file can perform operations on an encrypted virtual machine or disk. Because they come from the KMS, ESXi hosts can use the same KEK across reboots.

If you later want to decrypt a virtual machine, you change its storage policy either for the virtual machine or for its disks. If you want to decrypt individual components, first decrypt selected disks, then decrypt the virtual machine by changing the storage policy for VM Home. Both keys are required for decryption of each component, virtual disks or VM Home.

When you encrypt an existing virtual machine, you need at least twice the space that the virtual machine is currently using, in most cases.

Prerequisites and Required Privileges for Encryption Tasks

Users who perform encryption related tasks must have the appropriate privileges. Additional privileges are required if virtual machine encryption tasks require changing the host encryption mode. An extensive number of Cryptographic Operations privileges allow fine-grained control.

Encryption tasks are possibly only in environments that include a vCenter Server. Additionally, the ESXi host must have encryption mode enabled for most encryption tasks. The user who performs an encryption task must have the appropriate privileges. Additional privileges are required if virtual machine encryption tasks require changing the host encryption mode. An extensive number of Cryptographic Operations privileges allow fine-grained control.

Cryptography Privileges and Roles

By default, the user with the vCenter Server Administrator role has all Cryptographic Operations privileges. You can assign the No cryptography administrator role to all vCenter Server administrators who do not need cryptographic privileges.

The user with the vCenter Server Administrator role has all privileges by default. You can assign the No cryptography administrator role to vCenter Server users who do not need Cryptographic Operations privileges. The No cryptography administrator lacks the following privileges for cryptographic operations:

- Add Cryptographic Operations privileges
- Global.Diagnostics
- Host.Inventory.Add host to cluster
- Host.Inventory.Add standalone host
- Host.Local operations.Manage user groups

To further limit what users can do, you can clone the No cryptography administrator role and create a custom role with only some of the Cryptographic Operations privileges. For example, you can create a role that allows users to encrypt but not to decrypt virtual machines, or that does grant privileges for management operations. See the *vSphere Security* manual for details.

Host Encryption Mode

You can encrypt virtual machines only if host encryption mode is enabled for the ESXi host. Host encryption mode is often enabled automatically, but it can be enabled explicitly.

You can check and explicitly set the current host encryption mode from the vSphere Web Client or by using the vSphere API; see API Methods to Prepare an ESXi Host.

After host encryption mode is enabled, it cannot be disabled easily. See the *vSphere Security* guide for details.

Automatic changes occur when encryption operations attempt to enable host encryption mode. For example, suppose that you add an encrypted virtual machine to an ESXi host, and host encryption mode is not enabled. If you have the required privileges on the host, encryption mode automatically changes to enabled.

Assume a cluster that includes three ESXi hosts, host A, B, and C. You add an encrypted virtual machine to host A. What happens depends on several factors. If all three hosts have encryption enabled, you can create an encrypted virtual machine if you have `Encrypt new` privileges. If none of the hosts has encryption enabled, and you have `Register host` privileges on host A, then the virtual machine creation process enables host encryption on that host; otherwise an error results. The scenario is more complicated if host B or C is not enabled for encryption; see the *vSphere Security* guide for details.

Encrypted vSphere vMotion

vSphere vMotion always tries to use encryption when migrating encrypted virtual machines. You cannot disable encrypted vMotion for encrypted virtual machines in a cluster.

For virtual machines that are not encrypted, you can set encrypted vMotion to `Opportunistic` (use encrypted vMotion if supported) or `Required` (do not migrate if unsupported). See Encrypted vSphere vMotion.

API Methods for vSphere Virtual Machine Encryption

Methods for managing vSphere virtual machine encryption are in the vSphere API, part of the Web Services SDK. In addition, you need a few Storage Policy APIs to create and assign encryption storage policies.

vSphere API Methods for KMS Management

Cryptographic key management interfaces are defined in the following hierarchy.

- CryptoManager – managed object, parent of CryptoManagerKmip.

  CryptoManager defines methods that are covered in vSphere API Methods for Cryptographic Operations.

  - CryptoManagerKmip – managed object for handing the cryptographic keys.

    - CertificateInfo – basic information of a certificate.
    - ClusterStatus – status of a KMS cluster.
    - ServerCertInfo – information about the KMS certificate.
    - ServerStatus – status of a KMS.

    CryptoManagerKmip defines the following methods:

  - `String` **`generateClientCsr`**`(cluster)` – generate a certificate signing request with its private key.

- String **generateSelfSignedClientCert**(cluster) – generate self-signed client certificate with its private key.
- KmipClusterInfo[] **kmipServers**() – get a list of registered KMS, grouped by clusters.
- KmipClusterInfo[] **listKmipServers**(limit) – get a list of registered KMS.
- void **markDefault**(clusterId) – set the default KMS cluster.
- void **registerKmipServer**(server) – register a KMS.
- void **removeKmipServer**(clusterId, serverName) – remove a KMS, even if in use.
- String **retrieveClientCert**(cluster) – get the client certificate of the KMS cluster.
- String **retrieveClientCsr**(cluster) – get the generated client certificate signing request.
- ServerCertInfo **retrieveKmipServerCert**(keyProvider, server) – get the server certificate.
- ClusterStatus[] **retrieveKmipServersStatus**(clusters[]) – get status of the KMS instances.
- String **retrieveSelfSignedClientCert**(cluster) – get generated self signed client certificate.
- void **updateKmipServer**(server) – update a KMS.
- void **updateKmsSignedCsrClientCert**(cluster, certificate) – Set KMS signed certificate as the client certificate for a KMS cluster.
- void **updateSelfSignedClientCert**(cluster, certificate) – set a self-signed certificate as the client certificate for the KMS cluster.
- void **uploadClientCert**(cluster, certificate, privateKey) – set a client certificate with private key for the KMS cluster.
- void **uploadKmipServerCert**(cluster, certificate) – upload a server certificate.
- CryptoKeyResult **generateKey**(keyProvider) – generate a new encryption key.

  The generateKey method is out of alphabetic order because it is called after the others.

API Methods to Prepare an ESXi Host

Encryption interfaces for ESXi hosts are additions to a previously existing managed object, HostSystem.

- HostSystem – managed object providing access to the ESXi host, including these additions:
  - HostCryptoState – enumeration indicating whether the ESXi host is incapable of, prepared for encryption mode, or cryptography safe with its host key already set. Safe means that the ESXi host can encrypt virtual machines and will not leak keys.
  - ConfigureCryptoKey – vCenter Server calls this method to set or change the key used for core dump encryption, and to place the host in safe mode. It is like calling PrepareCrypto and EnableCrypto in quick succession. Not supported if called on an ESXi host.

  - `PrepareCrypto` – this method puts the ESXi host in prepared mode so it can receive sensitive data.
  - `EnableCrypto` – this method sets or changes the key for core dump encryption and puts the ESXi host in safe mode. It must be called in sequence after `PrepareCrypto`.

  The following data objects are used by the `ConfigureCryptoKey` and `EnableCrypto` methods above, and by the CryptoManager methods below in vSphere API Methods for Cryptographic Operations.

  - `CryptoKeyPlain` – data object representing a plain text cryptographic key.
  - `CryptoKeyId` – data object representing a cryptographic key.
  - `CryptoKeyResult` – data object representing the result of a cryptographic key operation.

vSphere API Methods for Cryptographic Operations

Cryptographic operations are defined in the following hierarchy.

- `CryptoManager` – managed object for handling cryptographic keys.

  `CryptoManager` defines the following methods:

  - `void` **`addKey`**`(CryptoKeyPlain key)` – add plain key to the vCenter Server.
  - `CryptoKeyResult[]` **`addKeys`**`(CryptoKeyPlain[] keys)` – add multiple plain keys to vCenter.
  - `boolean` **`enabled`**`()` – indicate if the encryption feature is enabled.
  - `CryptoKeyId[]` **`listKeys`**`(int limit)` – list keys.
  - `void` **`removeKey`**`(CryptoKeyId key, boolean force)` – remove a key (only its ID is needed).
  - `CryptoKeyResult[]` **`removeKeys`**`(CryptoKeyId[] keys, boolean force)` – multiple keys.
- `VirtualMachineConfigSpec` – previously existing data object passed as parameter to `CreateVM_Task` and `ReconfigVM_Task`. One of its newly added properties is crypto, a CryptoSpec with one of the following options, which is inherited by all virtual disks and virtual machine configuration files (VM home).
  - `CryptoSpecEncrypt` – indicates that the virtual machine should be encrypted.
  - `CryptoSpecDecrypt` – indicates that the virtual machine should be decrypted.
  - `CryptoSpecDeepRecrypt` – indicates that all KEKs and DEKs should be replaced.
  - `CryptoSpecShallowRecrypt` – indicates that only KEKs should be replaced.
  - `CryptoSpecNoOp` – indicates that encryption settings should not be changed.
  - `CryptoSpecRegister` – indicates that the operation should send keys but should not modify the encryption settings of the virtual machine or virtual disk. When an encrypted disk is hot attached, the program must pass `CryptoSpecRegister` with the key ID that encrypted the disk. The key can be obtained from the Datastore Browser.

These data objects are informational properties of `VMConfigFileInfo` and `VMDiskFileInfo`, respectively. They can be used to check whether the VM home and its virtual disks are encrypted.

- `VmConfigFileEncryptionInfo` – the encryption information of a virtual machine configuration.
- `VmDiskFileEncryptionInfo` – the encryption information of a virtual disk.

The enumeration `EncryptedVMotionModes` controls whether encrypted vMotion is `disabled`, `required`, or `opportunistic` (fall back to unencrypted vMotion if necessary, the default option).

More information about the encryption interfaces is available in vSphere Management SDK Documentation under vSphere Web Services SDK, in the *vSphere API Reference*.

SPBM API Methods for Encryption

The managed object PbmProfileProfileManager (`pbm.profile.ProfileManager`) provides methods to set encryption related storage policies, including create and update.

- `PbmCreate(createSpec)` – create a capability-based storage profile defining storage requirements.
- `PbmUpdate(profileId, createSpec)` – update a storage profile with new capability requirements.

Workflows for vSphere Virtual Machine Encryption

The sections below present vSphere API methods for key acquisition and encryption.

Set Up the Key Management Server Cluster

Before you can start encrypting virtual machines, you must set up the Key Management Server (KMS) cluster. This includes adding the KMS, establishing trust with the KMS, and setting the default KMS cluster. The KMS must support the KMIP (Key Management Interoperability Protocol) 1.1 standard, and it must be capable of acting as a symmetric key foundry and server.

Add Key Management Server(s) to Your Datacenter

Your organization’s security administrator may be responsible for this task. This person will need to provide the cluster name (if it already exists), the KMS server name, its IP address, its connection port number, and possibly a proxy address, proxy port number, KMS user name, and corresponding password.

The `CryptoManager.java` code to add a KMS and set the default KMS cluster appears in Example: CryptoManager Java program to add KMS and set default cluster. The user running this program must have Cryptographic operations.Manage key servers privileges.

Establish a Trusted Connection by Exchanging Certificates

There are four ways to establish trust between a KMS and vCenter Server. Different KMS vendors require different ways.

Java examples for these four ways follow.

1 Upload your Root CA Certificate to the KMS. Obtain it manually and upload with the self-signed call.

2 Upload a self-signed vCenter Certificate to the KMS.

3 Have vCenter Server generate a certificate signing request (CSR), which the KMS signs and returns.

4 Download a security certificate and private key generated by the KMS to vCenter Server.

Example: CryptoManager Java program to add KMS and set default cluster

```
package com.vmware.general;
import com.vmware.common.annotations.Action;
import com.vmware.common.annotations.Option;
import com.vmware.common.annotations.Sample;
import com.vmware.connection.ConnectedVimServiceBase;
import com.vmware.vim25.CryptoKeyId;
import com.vmware.vim25.CryptoKeyResult;
import com.vmware.vim25.CryptoManagerKmipServerCertInfo;
import com.vmware.vim25.KeyProviderId;
import com.vmware.vim25.KmipServerInfo;
import com.vmware.vim25.KmipServerSpec;
import com.vmware.vim25.ManagedObjectReference;
import com.vmware.vim25.RuntimeFaultFaultMsg;
/**
 * CryptoManager. Demonstrates uses of the CryptoManager API. Parameters:
 * url      [required] : web service url, for example https://10.9.8.7/sdk
 * username [required] : username for the authentication
 * password [required] : corresponding password
 * Command line to run CryptoManager code:
 * run.bat com.vmware.general.CryptoManager ^
 *         --url webserviceurl --username name --password pass ^
 *         --kmsname kms --kmsip ipaddr --kmsclusterid providerId
 */
@Sample(name = "CryptoManager", description = "Demonstrates uses of the CryptoManager API")
public class CryptoManager extends ConnectedVimServiceBase {
  private ManagedObjectReference cryptoManager = null;
  private KmipServerSpec kmipSpec = null;
  private String kmsName;
  private String kmsIp;
  private int kmsPort = 5696; // default
  private String kmsClusterId;

   public void initCryptoManager() throws RuntimeFaultFaultMsg {
      if (serviceContent != null) {
         cryptoManager = serviceContent.getCryptoManager();
         if (cryptoManager == null) {
            throw new RuntimeFaultFaultMsg("CryptoManager could not be obtained", null);
         }
      } else {
         throw new RuntimeFaultFaultMsg("ServiceContent could not be obtained", null);
      }
   }
   public void registerKmipServer() throws RuntimeFaultFaultMsg {
      KmipServerInfo serverInfo = new KmipServerInfo(); // Create KMS info
      serverInfo.setName(kmsName); // Set the name of your KMS here
      serverInfo.setAddress(kmsIp); // Set the IP addr of your KMS
      serverInfo.setPort(kmsPort); // Set KMS port, if different from default
      KeyProviderId providerId = new KeyProviderId(); // Set the name of KMS cluster here
      providerId.setId("KMScluster");
      kmipSpec = new KmipServerSpec();
      kmipSpec.setInfo(serverInfo); // KMS spec with server and cluster ID
      kmipSpec.setClusterId(providerId);
      vimPort.registerKmipServer(cryptoManager, kmipSpec); // Register server
   }
   public void trustKmip() throws RuntimeFaultFaultMsg { // Get KMS certificate
      CryptoManagerKmipServerCertInfo certInfo = vimPort.retrieveKmipServerCert(
            cryptoManager, kmipSpec.getClusterId(), kmipSpec.getInfo());
      // Upload retrieved certificate to vCenter Server and trust it
      vimPort.uploadKmipServerCert(
            cryptoManager, kmipSpec.getClusterId(), certInfo.getCertificate());
   }
   public void establishTrust() throws RuntimeFaultFaultMsg {
      // Make KMS trust vCenter Server by uncommenting and calling one of these lines
      // - establishTrustUsingSelfSignedCert() - see Example 12-2 for source code
      // - establishTrustUsingSignedCsr() - see Example 12-3 for source code
      // - establishTrustUsingCertAndKey() - see Example 12-4 for source code
      trustKmip(); // Now make the vCenter Server trust KMS
   }
   public void setDefaultKmipCluster() throws RuntimeFaultFaultMsg {
      vimPort.markDefault(cryptoManager, kmipSpec.getClusterId()); // Mark cluster as default
   }
   public void generateNewKey() throws RuntimeFaultFaultMsg {
      CryptoKeyResult keyResult = vimPort.generateKey(cryptoManager, kmipSpec.getClusterId());
      CryptoKeyId keyId = keyResult.getKeyId(); // Generate new key for encryption
   }
   @Action
   public void action() throws RuntimeFaultFaultMsg {
      initCryptoManager();
      registerKmipServer();
      establishTrust();
      setDefaultKmipCluster();
      generateNewKey();
   }
   @Option(name = "kmsname", description = "Name of the KMS", required = true)
   public void setKMSName(String name) {
      this.kmsName = name;
   }
   @Option(name = "kmsip", description = "IP address of the KMS", required = true)
   public void setKMSIp(String ip) {
      this.kmsIp = ip;
   }
   @Option(name = "kmsport", description = "KMS port", required = false)
   public void setKMSPort(String port) {
      this.kmsPort = Integer.parseInt(port);
   }
   @Option(name = "kmsclusterid", description = "KMS cluster Id", required = true)
   public void setKMSClusterId(String clusterId) {
      this.kmsClusterId = clusterId;
   }
}
```

Example: Trust with self-signed certificate or Root CA certificate

This example method uploads a self-signed vCenter certificate, or the Root CA certificate, to the KMS.

```
public void establishTrustUsingSelfSignedCert() throws RuntimeFaultFaultMsg {
   // Generate self-signed cert, or obtain the Root CA certificate
   String selfSignedCert = vimPort.generateSelfSignedClientCert(
         cryptoManager, kmipSpec.getClusterId());
   // Follow steps for KMS to trust self-signed or Root CA cert, update vCenter to use it
   vimPort.updateSelfSignedClientCert(
         cryptoManager, kmipSpec.getClusterId(), selfSignedCert);
}
```

Example: Trust with CSR then downloading KMS signed certificate

This example method generates a CSR and downloads the KMS signed certificate onto vCenter Server.

```
public void establishTrustUsingSignedCsr() throws RuntimeFaultFaultMsg {
   // Generate a Certificate Signing Request
   String csr = vimPort.generateClientCsr(cryptoManager, kmipSpec.getClusterId());
   String signedCert = null;
   // Follow steps for your KMS to sign CSR and get the signedCert to update on vCenter
   vimPort.updateKmsSignedCsrClientCert(
         cryptoManager, kmipSpec.getClusterId(), signedCert);
}
```

Example: Trust by downloading KMS certificate and private key

This example method downloads a certificate and private key generated by the KMS to vCenter Server.

```
public void establishTrustUsingCertAndKey() throws RuntimeFaultFaultMsg {
   String certFromKms = null;
   String privateKeyKms = null;
   // Follow steps for KMS to generate certificate and private key (certFromKms, privateKeyKms)
   vimPort.uploadClientCert(
         cryptoManager, kmipSpec.getClusterId(), certFromKms, privateKeyKms);
}
```

Create an Encryption Storage Policy

Before any virtual machines can be encrypted, vCenter Server must contain an encryption storage policy. The policy only needs to be created once; it can be assigned to any virtual machines that you want to encrypt.

Example: Java program to set storage policy for encryption

```
package com.vmware.spbm.samples;
import java.util.ArrayList;
import java.util.List;
import com.vmware.common.annotations.Action;
import com.vmware.common.annotations.Option;
import com.vmware.common.annotations.Sample;
import com.vmware.pbm.InvalidArgumentFaultMsg;
import com.vmware.pbm.PbmCapabilityConstraintInstance;
import com.vmware.pbm.PbmCapabilityInstance;
import com.vmware.pbm.PbmCapabilityMetadata;
import com.vmware.pbm.PbmCapabilityMetadataPerCategory;
import com.vmware.pbm.PbmCapabilityProfileCreateSpec;
import com.vmware.pbm.PbmCapabilityPropertyInstance;
import com.vmware.pbm.PbmCapabilityPropertyMetadata;
import com.vmware.pbm.PbmCapabilitySubProfile;
import com.vmware.pbm.PbmCapabilitySubProfileConstraints;
import com.vmware.pbm.PbmCapabilityVendorNamespaceInfo;
import com.vmware.pbm.PbmCapabilityVendorResourceTypeInfo;
import com.vmware.pbm.PbmDuplicateNameFaultMsg;
import com.vmware.pbm.PbmFaultProfileStorageFaultFaultMsg;
import com.vmware.pbm.PbmProfileId;
import com.vmware.pbm.PbmServiceInstanceContent;
import com.vmware.spbm.connection.ConnectedServiceBase;
import com.vmware.spbm.connection.helpers.PbmUtil;
import com.vmware.vim25.ManagedObjectReference;
import com.vmware.vim25.RuntimeFaultFaultMsg;
/**
 * CreateVMEncryptionProfile
 * Create new Storage Profile with one rule-set based on vmwarevmcrypt capabilities.
 *  Parameters:
 * vcurl       [required] : web service url, for example https://10.9.8.7/sdk
 * username    [required] : username for the authentication
 * password    [required] : corresponding password
 * profilename [required] : name of the storage profile
 * Command Line:
 * run.bat com.vmware.spbm.samples.CreateVMEncryptionProfile --vcurl [webserviceurl] ^
 *         --username [username] --password [password] --profilename [Storage Profile Name]
 */
@Sample(name = "CreateVMEncryptionProfile",
 description = "Create a new storage profile with "
             + "one rule-set based on vmwarevmcrypt capabilities.")
public class CreateVMEncryptionProfile extends ConnectedServiceBase {
   private PbmServiceInstanceContent spbmsc;
   private String profileName;

   // Build capability instance based on capability name associated with vmwarevmcrypt provider
   PbmCapabilityInstance buildCapability(String capabilityName,
                                         List<PbmCapabilityMetadataPerCategory> metadata)
   throws InvalidArgumentFaultMsg {
      // Create Property Instance with capability vmwarevmcrypt
      PbmCapabilityMetadata capabilityMeta =
            PbmUtil.getCapabilityMeta(capabilityName,metadata);
      if (capabilityMeta == null)
         throw new InvalidArgumentFaultMsg("Specified Capability does not exist", null);
      // Create and associate Property Instances with a Rule
      PbmCapabilityConstraintInstance rule = new PbmCapabilityConstraintInstance();
      for (PbmCapabilityPropertyMetadata propMeta : capabilityMeta.getPropertyMetadata()) {
         PbmCapabilityPropertyInstance prop = new PbmCapabilityPropertyInstance();
         prop.setId(propMeta.getId());
         prop.setValue(propMeta.getDefaultValue());
         rule.getPropertyInstance().add(prop);
      }
      // Associate Rule with a Capability Instance
      PbmCapabilityInstance capability = new PbmCapabilityInstance();
      capability.setId(capabilityMeta.getId());
      capability.getConstraint().add(rule);
      return capability;
   }
   @Action
   public void createProfile() throws RuntimeFaultFaultMsg,
         com.vmware.pbm.RuntimeFaultFaultMsg, InvalidArgumentFaultMsg,
         PbmDuplicateNameFaultMsg, PbmFaultProfileStorageFaultFaultMsg {
      // Get PBM Profile Manager & Associated Capability Metadata
      spbmsc = connection.getPbmServiceContent();
      ManagedObjectReference profileMgr = spbmsc.getProfileManager();
      // Step 1: Check if there is a vmwarevmcrypt Provider
      Boolean encryptionCapable = false;
      List<PbmCapabilityVendorResourceTypeInfo> vendorInfo =
         connection.getPbmPort().pbmFetchVendorInfo(profileMgr, null);
      for (PbmCapabilityVendorResourceTypeInfo vendor : vendorInfo)
         for (PbmCapabilityVendorNamespaceInfo vnsi : vendor .getVendorNamespaceInfo())
            if (vnsi.getNamespaceInfo().getNamespace().equals("vmwarevmcrypt")) {
               encryptionCapable = true;
               break;
            }
      if (!encryptionCapable)
         throw new RuntimeFaultFaultMsg(
               "Cannot create storage profile. 'vmwarevmcrypt' Provider not found.",  null);
      // Step 2: Get PBM Supported Capability Metadata
      List<PbmCapabilityMetadataPerCategory> metadata =
        connection .getPbmPort().pbmFetchCapabilityMetadata(profileMgr,
                                                            PbmUtil.getStorageResourceType(),
                                                            "com.vmware.iofilters");
      // Step 3: Add Provider Specific Capabilities
      List<PbmCapabilityInstance> capabilities = new ArrayList<PbmCapabilityInstance>();
      capabilities.add(buildCapability("vmwarevmcrypt@ENCRYPTION", metadata));
      // Step 4: Add Capabilities to a RuleSet
      PbmCapabilitySubProfile ruleSet = new PbmCapabilitySubProfile();
      ruleSet.getCapability().addAll(capabilities);
      // Step 5: Add Rule-Set to Capability Constraints
      PbmCapabilitySubProfileConstraints constraints = new PbmCapabilitySubProfileConstraints();
      ruleSet.setName("Rule-Set " + (constraints.getSubProfiles().size() + 1));
      constraints.getSubProfiles().add(ruleSet);
      // Step 6: Build Capability-Based Profile
      PbmCapabilityProfileCreateSpec spec = new PbmCapabilityProfileCreateSpec();
      spec.setName(profileName);
      spec.setDescription("Storage Profile in SDK. Rule based on Encryption capability");
      spec.setResourceType(PbmUtil.getStorageResourceType());
      spec.setConstraints(constraints);
      // Step 7: Create Storage Profile
      PbmProfileId profile = connection.getPbmPort().pbmCreate(profileMgr, spec);
      System.out.println("Profile " + profileName + " with ID: " + profile.getUniqueId());
   }
   @Option(name = "profilename", description = "Name of the storage profile", required = true)
   public void setProfileName(String profileName) {
      this.profileName = profileName;
   }
}
```

Create an Encrypted Virtual Machine

The Web Services SDK provides Java and C# code to create a virtual machine. The Java code can be modified to create an encrypted virtual machine. Steps below show how to implement virtual machine encryption in the `VMCreate.java` sample program. The `crypto` property in `VirtualMachineConfigSpec` should be set to `CryptoSpecEncrypt`, and an encryption key provided. The storage profile must have been previously set to specify encryption. If the `CryptoSpec` is unset, but a storage profile with encryption is set, vCenter Server automatically generates new keys and sets `CryptoSpec`, if a default KMS has been configured.

To enhance the `com.vmware.spbm.samples.VMCreate` program for encryption, follow these steps:

1 Import the following classes:

```
import com.vmware.vim25.CryptoKeyId;
import com.vmware.vim25.CryptoSpecEncrypt;
import com.vmware.vim25.KeyProviderId;
import com.vmware.vim25.VirtualDeviceConfigSpecBackingSpec;
```

2 Declare the following variables:

```
private CryptoKeyId cryptoKeyId;
private String keyId;
private String providerId;
```

3 In the `createVirtualDisk()` function, find the following line:

```
diskSpec.setOperation(VirtualDeviceConfigSpecOperation.ADD);
```

4 In the `createVirtualDisk()` function, add the following code after the line you found in the previous step:

```
if ((keyId != null) && (providerId != null)) {
   CryptoSpecEncrypt cSpec = new CryptoSpecEncrypt();
   VirtualDeviceConfigSpecBackingSpec backingSpec =
         new VirtualDeviceConfigSpecBackingSpec();
   cSpec.setCryptoKeyId(buildCryptoKeyId());
   backingSpec.setCrypto(cSpec);
   diskSpec.setBacking(backingSpec);
}
```

5 In the `createVmConfigSpec()` function, find the following line:

```
VirtualMachineConfigSpec configSpec = new VirtualMachineConfigSpec();
```

6 In the `createVmConfigSpec()` function, add the following code after the line you found in the previous step:

```
if ((keyId != null) && (providerId != null)) {
   CryptoSpecEncrypt cryptoSpecForVMHome = new CryptoSpecEncrypt();
   cryptoSpecForVMHome.setCryptoKeyId(buildCryptoKeyId());
   configSpec.setCrypto(cryptoSpecForVMHome);
}
```

7 Add the following options toward the end of file:

```
@Option(name = "keyid", description = "Key Id", required = false)
public void setKeyId(String kid) {
   this.keyId = kid;
}
@Option(name = "providerid", description = "Cluster/Provider Id", required = false)
public void setProviderId(String pid) {
   this.providerId = pid;
}
```

The SPBM sample code is in the Storage Policy SDK, not in the vSphere Web Services SDK.

Clone an Encrypted Virtual Machine

Set the `crypto` property in `RelocateSpec` at `cloneSpec.location`. The virtual machine must be powered off, with no existing snapshots. The encrypted virtual machine will be cloned, still encrypted.

Example: Clone an encrypted virtual machine

```
// Step 5: Create Specs
VirtualMachineRelocateSpec relocSpec = new VirtualMachineRelocateSpec();
VirtualMachineCloneSpec cloneSpec = new VirtualMachineCloneSpec();
VirtualMachineConfigSpec configSpec = new VirtualMachineConfigSpec();
// Step 6: Associate Storage Profile
relocSpec.getProfile().add(getVMDefinedProfileSpec(profileName));
cloneSpec.setConfig(configSpec);
cloneSpec.setLocation(relocSpec);
cloneSpec.setPowerOn(false);
cloneSpec.setTemplate(false);
// Step 7: Clone VM
ManagedObjectReference
     cloneTask = connection.getVimPort().cloneVMTask(vmRef, vmFolderRef, cloneName, cloneSpec);
```

Encrypt an Existing Virtual Machine or Disk

First set the `crypto` property in the `VirtualMachineConfigSpec` to `CryptoSpecEncrypt` and provide a key. The virtual machine must be powered off, with no existing snapshots.

Storage profiles must also be set to specify encryption. If the `CryptoSpec` is unset, but a storage profile with encryption is set, the vCenter Server automatically generates new keys and sets `CryptoSpec`, if the default KMS cluster has been configured.

Example: Encrypt a virtual machine based on storage profile

```
void Encrypt() throws Exception {
   // Create VirtualMachineConfigSpec
   VirtualMachineConfigSpec vmConfigSpec = new VirtualMachineConfigSpec();
   // Create VirtualDeviceConfigSpec
   VirtualDeviceConfigSpec diskSpec = new VirtualDeviceConfigSpec();
   // Get VirtualMachineProfileSpec for new encryption profile and name it encryptionProfile
   VirtualMachineProfileSpec encryptionProfile = new VirtualMachineDefinedProfileSpec();
   // Get VirtualDisk for disk to be reconfigured as in com.vmware.vm.VMReconfig, name it disk
   diskSpec.setDevice(disk);
   diskSpec.setOperation(VirtualDeviceConfigSpecOperation.EDIT);
   // Add encryption profile to VirtualDeviceConfigSpec
   diskSpec.getProfile().add(encryptionProfile);
   // Create CryptoSpec for encryption
   // Get Key Id from CryptoManager as keyId
   // See CryptoManager for details on generating or retrieving CryptoKeyId
   CryptoSpecEncrypt cryptoSpec = new CryptoSpecEncrypt();
   cryptoSpec.setCryptoKeyId(keyId);
   // Add CryptoSpecEncrypt to diskSpec backing
   VirtualDeviceConfigSpecBackingSpec backingSpec = new VirtualDeviceConfigSpecBackingSpec();
   backingSpec.setCrypto(cryptoSpec);
   diskSpec.setBacking(backingSpec);
   // When encrypting a VirtualDisk, the VM home needs to be encrypted also.
   // You can choose the same key to encrypt VM home and virtual disk, or use different keys.
   // Set cryptoSpec and profile for encrypting virtual machine home.
   vmConfigSpec.setCrypto(cryptoSpec);
   vmConfigSpec.getVmProfile().add(encryptionProfile);
   // Set the device changes
   vmConfigSpec.getDeviceChange().add(diskSpec);
   // Issue reconfigure – See reConfig() in com.vmware.vm.VMReconfig for how to reconfigure VM
}
```

Decrypt an Encrypted Virtual Machine or Disk

This is similar to encrypting an existing virtual machine, but with a different `CryptoSpec`. First set the `crypto` property in the `VirtualMachineConfigSpec` to `CryptoSpecDecrypt`. The virtual machine must be powered off, and the storage profiles must be set not to specify encryption.

If the `CryptoSpec` is unset, but a storage profile without encryption is set, the vCenter Server sets `CryptoSpecDecrypt`. The `ConfigSpec.crypto` parameter must be set explicitly. Only encryption is deduced from the storage profile.

Example: Decrypt a virtual machine based on storage profile

```
void Decrypt() throws Exception {
   // Create VirtualMachineConfigSpec
   VirtualMachineConfigSpec vmConfigSpec = new VirtualMachineConfigSpec();
   // Create VirtualDeviceConfigSpec
   VirtualDeviceConfigSpec diskSpec = new VirtualDeviceConfigSpec();
   // Create Empty VirtualMachineProfileSpec for decryption
   VirtualMachineProfileSpec emptyProfile = new VirtualMachineEmptyProfileSpec();
   // Get VirtualDisk for disk to be reconfigured as in com.vmware.vm.VMReconfig, name it disk.
   diskSpec.setDevice(disk);
   diskSpec.setOperation(VirtualDeviceConfigSpecOperation.EDIT);
   // Remove any encryption profile set for the disk
   diskSpec.getProfile().add(emptyProfile);
   // Create CryptoSpec for decryption
   CryptoSpecDecrypt cryptoSpec = new CryptoSpecDecrypt();
   // Add CryptoSpecEncrypt to diskSpec backing
   VirtualDeviceConfigSpecBackingSpec backingSpec = new VirtualDeviceConfigSpecBackingSpec();
   backingSpec.setCrypto(cryptoSpec);
   diskSpec.setBacking(backingSpec);
   // Decrypting virtual machine home is not necessary when decrypting a virtual disk.
   // If no encrypted disk is present on the virtual machine after the above disk is decrypted,
   // you can choose to decrypt virtual machine home.
   // Set cryptoSpec and profile for decrypting virtual machine home
   vmConfigSpec.setCrypto(cryptoSpec);
   vmConfigSpec.getVmProfile().add(emptyProfile);
   // Set the device changes
   vmConfigSpec.getDeviceChange().add(diskSpec);
   // Issue reconfigure – See reConfig() in com.vmware.vm.VMReconfig for how to reconfigure VM
}
```

Encrypt Using Different Keys

This method shows how to use two different keys to encrypt the virtual machine (VM home) and its disk.

Example: Different encryption keys for VM home and virtual disk

```
void EncryptUsingDifferentKeys() throws Exception {
   // Create VirtualMachineConfigSpec and VirtualDeviceConfigSpec
   VirtualMachineConfigSpec vmConfigSpec = new VirtualMachineConfigSpec();
   VirtualDeviceConfigSpec diskSpec = new VirtualDeviceConfigSpec();
   // Get VirtualMachineProfileSpec for encryption profile you created and name it
   VirtualMachineProfileSpec encryptionProfile = new VirtualMachineDefinedProfileSpec();
   // Get VirtualDisk for disk to be reconfigured as shown in VMReconfig and name it
   diskSpec.setDevice(disk);
   diskSpec.setOperation(VirtualDeviceConfigSpecOperation.EDIT);
   // Add encryption profile to VirtualDeviceConfigSpec
   diskSpec.getProfile().add(encryptionProfile);
   // Create CryptoSpec for disk encryption and get KeyId from from CryptoManager
   // See CryptoManager for details on generating or retrieving CryptoKeyId
   CryptoSpecEncrypt cryptoSpecForDisk = new CryptoSpecEncrypt();
   cryptoSpecForDisk.setCryptoKeyId(keyIdForDiskEncryption);
   // Add CryptoSpecEncrypt to diskSpec backing
   VirtualDeviceConfigSpecBackingSpec backingSpec = new VirtualDeviceConfigSpecBackingSpec();
   backingSpec.setCrypto(cryptoSpecForDisk);
   diskSpec.setBacking(backingSpec);
   // When encrypting a VirtualDisk, the virtual machine home must also be encrypted.
   // You can choose the same key to encrypt VM home and disk, or use different keys.
   // Create CryptoSpec for VM Home encryption and get KeyId from CryptoManager.
   CryptoSpecEncrypt cryptoSpecForVMHome = new CryptoSpecEncrypt();
   cryptoSpecForVMHome.setCryptoKeyId(keyIdForVMHomeEncryption);
   // Set cryptoSpec and profile for encrypting virtual machine home
   vmConfigSpec.setCrypto(cryptoSpecForVMHome);
   vmConfigSpec.getVmProfile().add(encryptionProfile);
   // Set the device changes
   vmConfigSpec.getDeviceChange().add(diskSpec);
}
```

Recrypting Encrypted Virtual Machines

Currently it is not possible to recrypt virtual machines using the vSphere Web Client. Only the vSphere API can accomplish this task.

There are two kinds of recryption operations. Deep recrypt replaces all keys, rewriting encrypted data in a powered-off virtual machine and its disks. Shallow recrypt replaces only top-level keys and is comparatively fast.

For details on generating or retrieving the CryptoKeyId, see CryptoManager code in Example: CryptoManager Java program to add KMS and set default cluster.

Recrypt Only Key Encryption Keys

For shallow recrypt, which affects only the key encryption keys (KEKs), set the `crypto` property in the `VirtualMachineConfigSpec` to `CryptoSpecShallowRecrypt` and call the `Reconfigure` method.

Example: Shallow Recrypt

```
void ShallowRecrypt() throws Exception {
    // Shallow recrypt follows the same flow as encrypt. The two differences are:
    // - Instead of using a new encryption profile, just get the previously
    //   applied profile from the virtual machine to be reconfigured and use it.
    // - The type of CryptoSpec object created is CryptoSpecShallowRecrypt()
    // Create CryptoSpec for shallow recrypt
    // Get Key Id from CryptoManager as newKeyId
    CryptoSpecShallowRecrypt cryptoSpec = new CryptoSpecShallowRecrypt();
    cryptoSpec.setNewKeyId(newKeyId);
    // Follow steps from Encrypt()
}
```

Shallow recrypt can be done with the virtual machine powered on. Deep recrypt requires power off.

Recrypt Both Key and Disk Encryption Keys

For deep recrypt, which affects both KEKs and disk encryption keys (DEKs), set the `crypto` property in the `VirtualMachineConfigSpec` to `CryptoSpecDeepRecrypt` and call the `Reconfigure` method.

Example: Deep Recrypt

```
void DeepRecrypt() throws Exception {
    // Deep recrypt follows the same flow as encrypt. The two differences are:
    // - Instead of using a new encryption profile, just get the previously
    //   applied profile from the virtual machine to be reconfigured and use it.
    // - The type of CryptoSpec object created is CryptoSpecDeepRecrypt()
    // Create CryptoSpec for deep recrypt
    // Get Key Id from CryptoManager as newKeyId
    CryptoSpecDeepRecrypt cryptoSpec = new CryptoSpecDeepRecrypt();
    cryptoSpec.setNewKeyId(newKeyId);
    // Follow steps from Encrypt()
}
```

Encrypted vSphere vMotion

When virtual machines and data move across the network, all sensitive data remain encrypted.

Enable Encrypted vMotion

The enumeration VirtualMachineConfigSpecEncryptedVMotionModes controls whether encrypted vMotion is disabled, opportunistic (fall back to unencrypted vMotion if necessary, the default option), or required.
If encrypted vMotion is required, or opportunistic and available, the vCenter Server can migrate either encrypted or unencrypted virtual machines within a disk cluster, or from one disk cluster to another using Storage vMotion.

In this release, vMotion across vCenter Servers is not supported for encrypted virtual machines.

Virtual Disk Manager

The following methods in managed object `VirtualDiskManager` are affected by encryption:

`copyVirtualDisk` – If the source disk is encrypted, its copied disk is encrypted with the same key, regardless of the `crypto` spec. When calling `copyVirtualDisk_Task` on vCenter Server, do not specify the `destSpec` parameter, which throws a Not Implemented fault; `destSpec` is supported only on ESXi hosts.

`createVirtualDisk` – Given a valid `crypto` spec, this task directly creates an encrypted virtual disk.

`moveVirtualDisk` – An encrypted virtual disk cannot be moved to an unencrypted virtual machine.

`createChildDisk` – The child disk of an encrypted disk remains encrypted with the same key.

`reparentDisks` – Encrypted child disk cannot be reparented to a new disk that is not in the same disk chain.

Best Practices

This section gives tips for optimum use of keys and virtual machine encryption.

Key Lifecycle and Removal

The `removeKey` and `removeKeys` methods delete key(s) from vCenter Server, but they do not delete keys from the KMS. Key lifecycle is managed entirely from the KMS, where stale keys persist. You can invoke the `listKeys` method to show keys in use on the vCenter Server, but there is currently no method to query whether a specific key is in use.

Be Careful with Force Remove

The `force` parameter of `removeKey` and `removeKeys` should be used judiciously. With the `force` option, the `removeKey` and `removeKeys` methods delete key(s) from both the vCenter Server and ESXi hosts, even if the key is currently in use. The result can leave virtual machines in a locked state until the key is replaced. The use case for the force option is for customers to prevent a key from being used anywhere, after it was compromised or expired.

Remove Keys on ESXi host

If you call `removeKey` on an ESXi host, even without the `force` option, the key gets deleted from the host’s key cache, and the encrypted virtual machine becomes unusable. ESXi hosts do not track which keys are in use. Rebooting the ESXi host causes vCenter Server to push all keys to the host again, but the virtual machine may not be fully recoverable from its failed state.

Carefully Manage Differential Keys

When you encrypt both a virtual machine and its virtual disks from the vSphere Web Client, the same key is used for both. When you encrypt a virtual machine and its disks using the API, you can set different encryption keys for the virtual machine and each virtual disk. If one of the disk keys is missing, the power on operation may fail. If the missing key is for a non-boot virtual disk, you can remove that disk from the virtual machine and retry the power on operation. Take care when managing the lifecycle of different keys for a virtual machine and its disks.

Rename During Registration

The `registerVM_Task` method can rename a virtual machine at registration time. In vSphere 6.5 this required a two-step workaround for encrypted virtual machines, but in vSphere 6.7, this operation is supported with encryption. Also in vSphere 6.7, the `reloadVirtualMachineFromPath_Task` is supported for encrypted virtual machines. The reload API is equivalent to unregistering and registering a virtual machine on a different configuration path.

Encryption on vSAN Datastores

For security on vSAN datastores, you should use vSAN encryption instead of virtual machine encryption. This is because vSAN encryption is designed to be compatible with deduplication and compression. Whereas virtual machine encryption causes vSAN deduplication and compression to become less effective.

Unlocking Encrypted Virtual Machines

There are many reasons why an encrypted virtual machine could be, in effect, locked. For solutions, see section “Resolve Missing Key Issues” in the *vSphere Security* manual.

In vSphere 6.7 and later you can unlock locked virtual machines with the `cryptoUnlock_Task` method. A vCenter Server alarm notifies you when an encrypted virtual machine is in a locked state. To unlock it you must have **Cryptographic operations.RegisterVM** privilege. Before unlocking, it is a good idea to troubleshoot and attempt to fix the cause of the locked virtual machine. The `cryptoUnlock_Task` method takes one parameter, the `MoRef` of a virtual machine.

Virtual Applications 13

A virtual application consists of one or more virtual machines, which are deployed, managed, and maintained as a single unit. This chapter explains how to use the vSphere Web Services SDK for building and managing a virtual application.

This chapter includes the following topics:

About Virtual Applications

A virtual application specifies and encapsulates the components of virtual machines and applications, and the operational policies and service levels associated with those components. A virtual application can be as simple as an individual virtual machine with a specific operating system (virtual appliance), or as complex as a complete corporate Web site. Each virtual machine in a virtual application contains a preinstalled, preconfigured operating system and might contain an application stack optimized to provide a specific set of services.

In the vSphere Web Services SDK, the `VirtualApp` managed object represents a virtual application. A `VirtualApp` object extends `ResourcePool` with the following capabilities:

- Store product information such as product name, vendor, properties, and licenses in `vAppConfigInfo`.
- Specify power-on and power-off sequence specification.
- Import and export of `VirtualApp` objects as OVF packages.
- Perform application-level customization using the OVF environment.

Management Overview

You can use the Web Services SDK to create and manage virtual applications by following these steps:

Procedure

1. Call the CreateVApp method to create a virtual application without children. See Creating a VirtualApp.
2. Add child objects. See Managing VirtualApp Children.
3. Export the VirtualApp to OVF (ExportVApp method) See Exporting a Virtual Application.

   You can then import the OVF to create and customize the virtual application.

Direct and Linked Children

A virtual application consists of one or more child virtual machines or virtual applications. VirtualApp children have the following characteristics:

- Each child has exactly one parent VirtualApp.
- Each child can participate in power-on and power-off sequences.
- The lifetime of each child is determined by the parent VirtualApp object.

VirtualApp children are either direct or linked, based on where a child derives its resources.

- Direct Children. A direct child of a virtual application is a virtual machine or virtual application object that you add explicitly. See Managing VirtualApp Children for a list of methods. Direct children share resources with the parent VirtualApp object. Both virtual machines and virtual application can be direct children.
- Linked Children. A linked child of a virtual application is a virtual machine or virtual application that you add by calling the UpdateLinkedChildren method. Linked children increase the flexibility of the VirtualApp by allowing child entities to use different resources from the parent VirtualApp object. Linked children can be part of a different clusters, but a virtual application and its children must be in the same Datacenter. Both virtual machines and virtual applications can be linked children.

Linked children gives better flexibility. In particular, you can create virtual applications that span clusters. The vSphere Client does not support adding or removing links, though it does show links.

When you add a linked child to a virtual application, the following rules apply:

- An InvalidArgument fault is thrown if the UpdateLinkedChildren method is called on a link target that is a direct child of another virtual application.
- When you add a virtual machine or virtual application that is already a linked child of another virtual application, the existing link is removed and replaced with the new link.
- The life-time of a linked child is determined by the destroyWithParent property on the VAppEntityConfigInfo data object. If set to true, the child is destroyed when the parent VirtualApp is destroyed. Otherwise, the link is removed when the VirtualApp is destroyed.

If you add a virtual application that consists of multiple entities, for example multiple virtual machines, the entities are moved sequentially and committed one at a time, as specified in the list. If a failure is detected, the method terminates with an exception.

OVF Packages

Open Virtualization Format (OVF) is a distribution format for virtual applications. vSphere uses the OVF package as a unit of distribution and storage for virtual applications. Because these entities are uploaded, downloaded, and stored in OVF package format, vSphere supports access to and deployment of a wide variety of virtual applications.

A virtual application typically consists of one or more virtual disk files and a configuration file.

- The virtual disk files contain the operating systems and applications that run on the virtual machines in the virtual application.
- The configuration file contains metadata that describes how the virtual application is configured and deployed.

An OVF package might also include certificate and manifest files.

The OVF package contains metadata that describes the capabilities and infrastructure requirements of the virtual application, and contains references to the virtual disks and other files that store the virtual machine state. Most of this information is stored in an XML document called the OVF envelope. When an OVF package is instantiated into either a `VirtualApp` or a `VirtualMachine` object (which depends on metadata in the envelope), then the configuration stored in the OVF envelope is applied to the `VirtualVApp` and the `VirtualMachine` objects.

Some of the information in the OVF file is used unaltered, with entire `ovf:Section_Type` elements included in the `VirtualApp` object body. Other sections are transformed or extended by instantiation. You do not need detailed knowledge of all OVF package elements, but a basic understanding of key parts of the package and how they relate to virtual applications is useful.

See the OVF specification at the DMTF Web site for additional information.

Creating a VirtualApp

You always create a `VirtualApp` without children. The `CreateVApp` method includes the following parameters:

- `resSpec` – Properties you would specify for a `ResourcePool`.
- `configSpec` – `VAppConfigSpec` data object for specifying virtual-application specific information.
- `vmFolder` – Depends on the `VirtualApp` structure:
  - When creating top-level virtual applications, that is, virtual applications with no ancestor virtual applications, you must specify a folder.
  - If the `VirtualApp` has another virtual application in the ancestry chain, the `folder` parameter must be `NULL` when you create the `VirtualApp`.

Managing VirtualApp Children

You can add virtual machines and virtual applications to your virtual application as direct or linked children.

You use different methods for adding or removing direct or linked children, as follows:

- Direct children. Use one of the following methods:
  - `CreateChildVMTask` adds a new virtual machine.
  - `CreateVApp` adds a new virtual application.
  - `MoveIntoResourcePool` adds or removes an existing virtual machine or virtual application
- Linked children. `Use UpdateLinkedChildren` to add or remove virtual machines or virtual applications.

You can call the `UpdateVappConfig` method to specify how each virtual machine fits into the virtual application.

Property	Enumeration
`destroyWithParent`	True if the entity should be removed when the `VirtualApp` is removed.
`key`	Key for the virtual machine or virtual application, a managed object reference to the child.
`startAction`	One of the strings in the `VAppAutoStartAction` enumeration.
`startDelay`	Delay, in seconds, before continuing with the next entity.
`startOrder`	Specifies the start order for this entity. Entities are started from lower numbers to higher-numbers and reverse on shutdown. Multiple entities with the same start order are started in parallel and the order is unspecified. This value must be 0 or higher.
`stopAction`	Defines the stop action for the entity. Can be set to `none`, `powerOff`, `guestShutdown`, or `suspend`. If set to `none`, then the entity does not participate in auto-stop.
`stopDelay`	Delay, in seconds, before continuing with the next entity.
`tag`	Tag for the entity.
`waitingForGuest`	Determines if the virtual machine should start after receiving a heartbeat, from the guest.

For more information about direct children and linked children, see Direct and Linked Children.

Exporting a Virtual Application

To export a virtual application, you must generate an OVF package. The Web Services API supports the generation of OVF packages. It does not support the generation of OVA files. An OVA file is a tar file that contains an OVF package. The OVF package consists of one of more images and an OVF file descriptor. You can create an OVA file by creating a tar file out of the OVF package for your exported virtual application.

The following steps describe how to use the vSphere VirtualApp and OvfManager API to generate an OVF package for a virtual application. The steps assume the simplest scenario: downloading one image from one device URL. You use the same steps to download many images from many device URLs. You can also export a VirtualMachine with the same steps, but use VirtualMachine.ExportVm rather than VirtualApp.ExportVApp.

Procedure

1 Call the VirtualApp.ExportVApp method, which returns HttpNfcLease. The deviceURL is stored in the info property of HttpNfcLease.

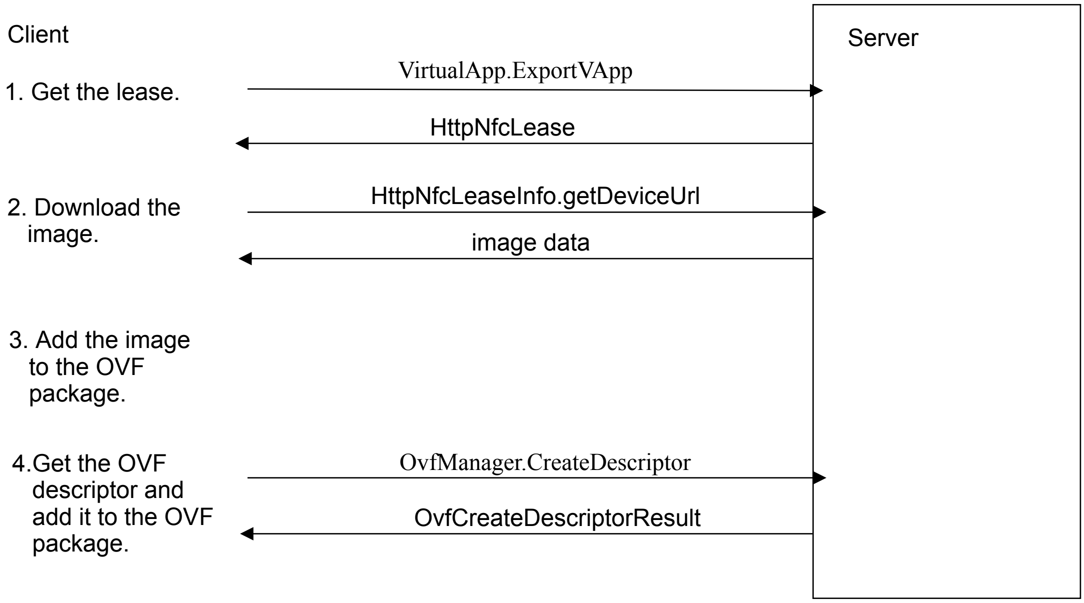
2 Call the HttpNfcLeaseInfo.getDeviceUrl method to access the device URL and download the image data from the device URL.

3 Add the image to the OVF package.

4 Call the OvfManager.CreateDescriptor method, which returns OvfCreateDescriptorResult. Write the file descriptor to a file with the file extension .ovf. Add the .ovf file to the OVF package.

Figure 13-1 shows the major steps.

Figure 13-1. Generating an OVF Package


Client
Server
1. Get the lease.
VirtualApp.ExportVApp
HttpNfcLease
2. Download the image.
HttpNfcLeaseInfo.getDeviceUrl
image data
3. Add the image to the OVF package.
4.Get the OVF descriptor and add it to the OVF package.
OvfManager.CreateDescriptor
OvfCreateDescriptorResult

VirtualApp and OvfManager Methods

The following table describes the methods used by the VirtualApp and the OvfManager API:

Method	Description
CreateDescriptor	Creates an OVF descriptor for the specified `ManagedEntity`, which may be a `VirtualMachine` or a `VirtualApp`. `CreateDescriptor` is a method in the `OvfManager` managed object.
ExportVApp	Obtains an export lease on the virtual application. The export lease contains a list of URLs for the disks of the virtual machines in this virtual application. `ExportVApp` is a method in the `VirtualApp` managed object.
getDeviceUrl	Retrieves the device IDs and URLs from the server. `getDeviceUrl` is an accessor method provided in the generated JAX-WS bindings. It does not appear in the class diagram in VirtualApp Data Structures.

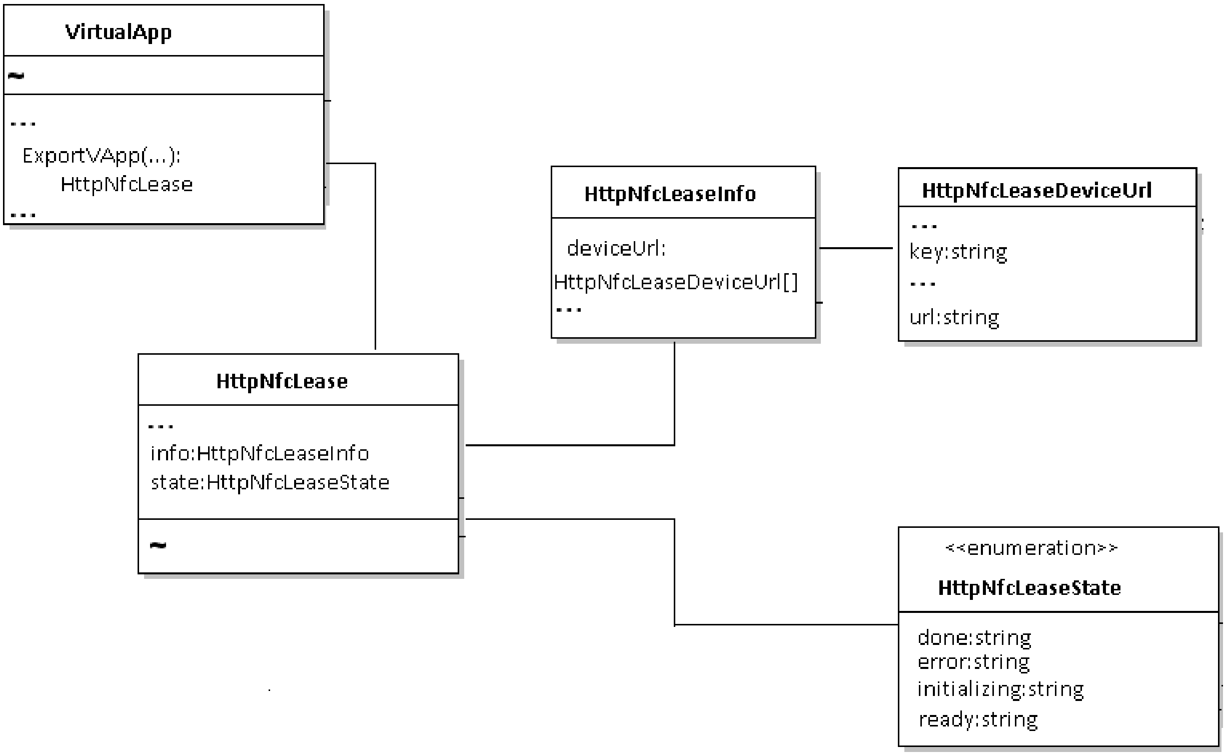
The next two sections deal with the `VirtualApp` and `OvfManager` data structures.

VirtualApp Data Structures

The `VirtualApp` managed object contains the `ExportVApp` method, which returns an `HttpNfcLease`. The `HttpNfcLease` contains the info and state properties, where info is of type `HttpNfcLeaseInfo` and state is of type `HttpNfcLeaseState`. The `HttpNfcLeaseInfo` data object has several properties, one of which is the `deviceUrl` of type `HttpNfcLeaseDeviceUrl[]`. The `HttpNfcLeaseState` has four different states—done, `error`, `initializing` and `ready`.

The following class diagram shows the UML representation of the data structures used in the VirtualApp API.

Figure 13-2. VirtualApp Class Diagram



The VirtualApp API data structures are the following:

- VirtualApp—A managed object that is a collection of virtual machines (and potentially other VirtualApp containers) that are operated and monitored as a unit.
- HttpNfcLease—A managed object returned when you call VirtualApp.ExportVApp. It represents a lease on the virtual application. While you hold the lease, you block the operations that alter the state of the virtual application.
- HttpNfcLeaseInfo—A data object that holds information about the lease, such as the virtual application covered by the lease, and the device URLs for up/downloading images.
- HttpNfcLeaseState—An enumeration that is a list of possible states of a lease.

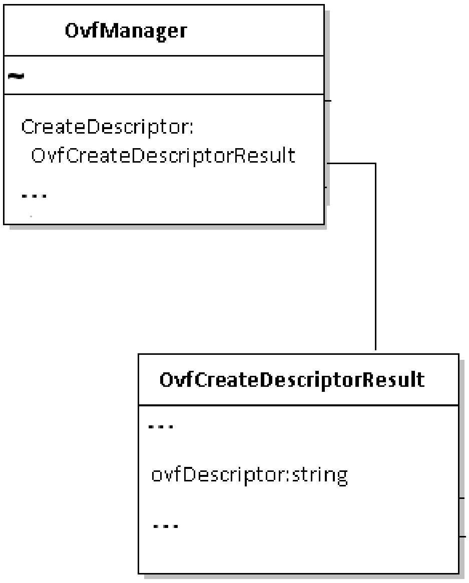
HttpNfcLeaseDeviceUrl—A data object that provides a mapping from logical device IDs to upload/download URLs.

OvfManager Data Structures

The OvfManager managed object has a CreateDescriptor method that returns an OvfCreateDescriptorResult. The OvfCreateDescriptorResult has the ovfDescriptor string.

Figure 13-3 shows the UML representation of the data structures used in the OvfManager API.

Figure 13-3. OvfManager Class Diagram



The OvfManager data structures are the following:

- OvfManager—A managed object that provides a service interface to parse and generate OVF descriptors.

- OvfCreateDescriptorResult—A data object that contains the result of creating the OVF descriptor for the virtual application.

Example of Generating an OVF Package

In summary, the steps in generating an OVF package are the following:

Procedure

1 Get the managed object reference to the VirtualApp object. Call the ExportVApp method, which returns an HttpNfcLease data object. Wait for the state of the lease to turn to READY. Get the list of device URLs from the lease and store them in an array.

2 For each of the URLs in the list of device URLs, download the images from that URL to the client.

3 Save the image to the OVF package (directory/folder). Create an OvfFile object using the deviceID, absolute path of the downloaded image, and the size of the image on the local disk.

4 Call the OvfManager.CreateDescriptor method by passing the managed object reference to the VirtualApp and the OvfFile object wrapped in an OvfCreateDescriptorParams object. This method returns OvfCreateDescriptorResult, which contains the file descriptor. Write the file descriptor to a file with the file extension .ovf. Add the .ovf file to the OVF package.

The following is an example of how to generate an OVF package. The example assumes a more complex scenario: downloading more than one image from more than one device URL. The example is based on the OVFManagerExportVAAP.java sample, which is located in the SDK/vsphere-ws/java/JAXWS/samples/com/vmware/vapp/ directory.

You can use the ExportVM method instead of the ExportVapp method when exporting a VirtualMachine.

```
package com.vmware.vapp;

import java.io.*;
import java.net.URL;
import java.util.*;

...
  /** 1. Get the MOR of the VirtualApp.
  ManagedObjectReference vAppMoRef = getVAPPByName(vApp);
...
  /**    Call the ExportVApp method, which returns an HttpNfcLease data object. */
  ManagedObjectReference httpNfcLease = vimPort.exportVApp(vAppMoRef);

...
  /**    Wait for the state of the lease to turn to READY. */
  Object[] result = waitForValues.wait(httpNfcLease,
                                      new String[]{"state"},
                                      new String[]{"state"},
                                      new Object[][]{new Object[]{
                                         HttpNfcLeaseState.READY,
                                         HttpNfcLeaseState.ERROR}});
  if (result[0].equals(HttpNfcLeaseState.READY)) {
```

```
...
  /**    Get the list of device URLs from the lease. */
     List<HttpNfcLeaseDeviceUrl> deviceUrlArr = httpNfcLeaseInfo.getDeviceUrl();
     if (deviceUrlArr != null) {
...
  /** 2. For each of the URLs in the list of device URLs,
   *     download the images from that URL to the client. */
        for (int i = 0; i < deviceUrlArr.size(); i++) {
           String deviceId = deviceUrlArr.get(i).getKey();
           String deviceUrlStr = deviceUrlArr.get(i).getUrl();
           String absoluteFile = deviceUrlStr.substring(deviceUrlStr.lastIndexOf("/") + 1);

  /** 3. Save the image to the OVF package (directory/folder). Create an OvfFile object using
   * the deviceID, absolute path of the downloaded image, and the size of the image on the
   * local disk.
   */
           long writtenSize = writeVMDKFile(absoluteFile, deviceUrlStr.replace("*", host));
           OvfFile ovfFile = new OvfFile();
           ovfFile.setPath(absoluteFile);
           ovfFile.setDeviceId(deviceId);
           ovfFile.setSize(writtenSize);
           ovfFiles.add(ovfFile);
        }

  /** 4. Call the OvfManager.CreateDescriptor method by passing the managed object reference
   * to the VirtualApp and the OvfFile object wrapped in an OvfCreateDescriptorParams object.
   * This method returns OvfCreateDescriptorResult, which contains the file descriptor.
   * Write the file descriptor to a file with the file extension .ovf. Add the .ovf file to
   * the OVF package.
   */
        ovfCreateDescriptorParams.getOvfFiles().addAll(ovfFiles);
        OvfCreateDescriptorResult ovfCreateDescriptorResult =
              vimPort.createDescriptor( serviceContent.getOvfManager(),
                                        vAppMoRef,
                                        ovfCreateDescriptorParams);

        String outOVF = localpath + "/" + vApp + ".ovf";
        File outFile = new File(outOVF);
        FileWriter out = new FileWriter(outFile);

        out.write(ovfCreateDescriptorResult.getOvfDescriptor());
        out.close();
```

Importing an OVF Package

To import the virtual application OVF template, you follow a few basic steps. The steps are the same for an OVF package that contains a single virtual machines or an OVF package that contains a more complex virtual application.

Procedure

1 Parse the OVF descriptor by calling `OvfManager.parseDescriptor`.

2 Validate the target ESX/ESXi host by calling `OvfManager.validateHost`.

3 Create the `VirtualAppImportSpec` by calling `OvfManager.createImportSpec`.

   This structure contains all the information needed to create the entities on the vCenter Server, including children. Clients do not have to read or modify `VirtualAppImportSpec` to perform basic OVF operations.

4 Create the vCenter Server entities by calling `ResourcePool.importVApp`.

   The method uses a parsed OVF descriptor to create `VirtualApp` and `VirtualMachine` objects in the vSphere environment.

The import process itself consists of two steps:

- The server creates the virtual machines and virtual applications.

  You must wait for the server to create all inventory objects. During object creation, the server monitors the `state` property on the `HttpNfcLease` object returned from the `ImportVApp` call. When the server completes object creation, the server changes the lease to `ready` state and you can begin uploading virtual disk contents. If an error occurs while the server is creating inventory objects, the lease changes to the error state, and the import process is aborted.

- The client application uploads virtual disk contents do an HTTP POST request with the content of the disk to the provided URLs. The disk is in the stream-optimized VMDK format (http://www.vmware.com/technical-resources/interfaces/vmdk.html). As an alternative, you can use the OVF tool, available at http://communities.vmware.com/community/developer/forums/ovf at VMware Communities.

  When all inventory objects have been created and the `HttpNfcLease` has changed to ready state, you can upload disk contents by using the URLs provided in the `info` property of the `HttpNfcLease` object. You must call the `HttpNfcLeaseProgress` method on the lease periodically to keep the lease alive and report progress to the server. Failure to do so causes the lease to time out, aborting the import process.

When you are done uploading disks, complete the lease by calling the `HttpNfcLeaseComplete` method. You can terminate the import process by calling the `HttpNfcLeaseAbort` method.

If the import process fails, is terminated, or times out, all created inventory objects are removed, including all virtual disks.

Virtual Application Life Cycle

You can power a virtual application on or off and perform other lifecycle operations.

Powering a Virtual Application On or Off

You can use the `PowerOnVApp_Task` method to power on a `VirtualApp` object. This method starts the virtual machines or child virtual applications in the order specified in the virtual application configuration.

While a virtual application is starting, all power operations performed on subentities are disabled.

If a virtual machine in a virtual application fails to start, an exception is returned and the power-on sequence terminates. In case of a failure, virtual machines that are already started remain powered on.

You can use the PowerOffVApp_Task method to power off a virtual application. This method stops the virtual machines or child virtual applications in the order specified in the VirtualApp object configuration if force is false. If force is set to true, this method stops all virtual machines (in no specific order and possibly in parallel) regardless of the VirtualApp object auto-start configuration.

While a virtual application is stopping, all power operations performed on subentities are disabled.

Unregistering a Virtual Application

You can call the UnregisterVApp_Task method to remove a VirtualApp object from the inventory without removing any of the component virtual machine files on disk. All high-level information stored with the management server (ESXi or vCenter Server system) is removed, including information about VirtualApp object configuration, statistics, permissions, and alarms.

Suspending a Virtual Application

You can call the SuspendVApp_Task method to suspend all running virtual machines in a virtual application, including virtual machines running in child virtual application. The virtual machines are suspended in the order that is used for a power off operation, which is the reverse of a power on sequence.

While a virtual application is being suspended, all power operations performed on subentities are disabled. If you attempt to perform a power operation, a TaskInProgress error results.

Destroying a Virtual Application

When a VirtualApp object is destroyed, all of its virtual machines and any child virtual applications are destroyed.

The VirtualAppVAppState type defines the set of states a VirtualApp object can be in. The transitory state between started and stopped is modeled explicitly, since the starting or stopping of a virtual application might take minutes to complete.

The life-time of a linked child is determined by the destroyWithParent property on the VAppEntityConfigInfo data object. If set to true, the child is destroyed when the parent virtual application is destroyed. Otherwise, only the link is removed when the virtual application is destroyed.

Resource Management 14

Underlying all virtual components are the actual physical resources of the host system, such as CPU, RAM, storage, network infrastructure, and so on. vSphere supports sharing of resources on an individual host or across hosts using resource pools. vSphere also supports clusters for failover or load balancing.

This chapter includes the following topics:

Resource Management Objects

Central to resource management for all environments is either a `ComputeResource` or a `ClusterComputeResource` managed object.

- The `ComputeResource` managed object represents the set of resources for a set of virtual machines. A `ComputeResource` is always associated with a root `ResourcePool` object.
- The `ResourcePool` managed object represents a set of physical resources of a single host, a subset of a host's resources, or resources spanning multiple hosts. Resource pools can be subdivided by creating child resource pools. Only virtual machines associated with a resource pool can be powered on.

- The ClusterComputeResource data object aggregates the compute resources of multiple associated HostSystem objects into a single compute resource for use by virtual machines. If you plan on using VMware cluster services such as HA (High Availability), DRS (Distributed Resource Scheduling), or on using EVC (Enhanced vMotion Compatibility), use ClusterComputeResource.

  Important HA, DRS, and EVC require licenses. If any clustering functionality does not work properly, check whether you have licenses for it.

Introduction to Resource Management

An ESXi host allocates each virtual machine a portion of the underlying hardware resources based on several factors:

- Total available resources for the ESXi host, resource pool, or cluster to which the virtual machine belongs.
- Number of virtual machines powered on and resource usage by those virtual machines.
- Overhead required to manage the virtualization.
- Limits defined by the user.

Resource management allows you to dynamically allocate resources to virtual machines so that you can more efficiently use available capacity. You can change resource allocation in the following ways.

- Specify resource allocation for individual virtual machines. See CPU and Memory Resource Allocation.
- Create a hierarchy of resource pools and add the virtual machine to a resource pool with characteristics appropriate for its use. See Resource Pool Hierarchies.
- Add hosts and virtual machines to a cluster so you can take advantage of VMware DRS for recommendations or automatic resource redistribution. See Creating and Configuring Clusters.

Resource Allocation

When you create a virtual machine, you always specify the resource pool that the virtual machine can draw resources from and optionally a host on which the virtual machine should run. You can access the resource pool as follows:

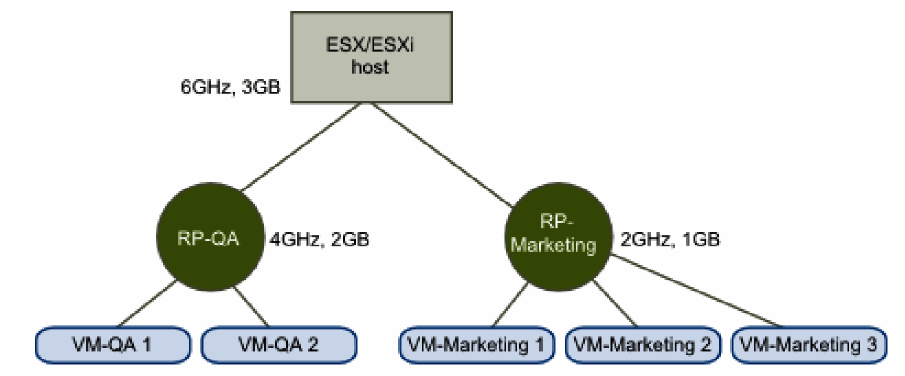
- Standalone host – When you call Folder.AddStandaloneHost_Task, the call returns a Task object that contains the ComputeResource. The ComputeResource.resourcePool property is the root resource pool associated with the compute resource (and with the host).
- Cluster – When you call Folder.CreateClusterEx, the method returns a managed object reference to a ClusterComputeResource instance. Because ClusterComputeResource inherits all properties of ComputeResource, you can access the root folder through the ClusterComputeResource.resourcePool property.

Resource Pool Hierarchies

Resource pool hierarchies allow detailed control over which virtual machines are allowed how many resources.

For example, assume a standalone host has several virtual machines. The marketing department uses three of the virtual machines and the QA department uses two virtual machines. Because the QA department needs larger amounts of CPU and memory, the administrator creates one resource pool for each group. The administrator sets CPU Shares to High for the QA department pool and to Normal for the Marketing department pool so that the QA department users can run automated tests. The second resource pool with fewer CPU and memory resources is sufficient for the lighter load of the marketing staff. Whenever the QA department is not fully using its allocation, the marketing department can use the available resources.

Figure 14-1. Allocating Resources to Resource Pools



Resource Pool Management Guidelines

The following rules govern resource pool creation.

- A root resource pool must always have at least as many resources as all its immediate children.
- Do not overcommit resource pool resources. The sum of all child pools should always be less than (not equal to or more than) the parent. For example, if four child resource pool reservations total 40 gigabytes and the parent resource pool has a reservation of 60 gigabytes, you have some room to create another resource pool. However, if the four child resource pool reservations total 60 gigabytes, you do not. For virtual machine, some overcommitment of resources is supported. See the technical white papers on the VMware web site.
- Before creating new child resource pools, check available resources in the parent pool. The `ResourcePool.runtimeInfo` property is a `ResourcePoolRuntimeInfo` data object. `ResourcePoolRuntimeInfo.cpu` and `ResourcePoolRuntimeInfo.memory` properties are `ResourcePoolResourceUsage` objects with resource usage information, including an `unreservedForPool` property. If the parent resource pool does not have enough available resources, reconfigure the reservation values of child pools before adding the new pool.

- Reconfigure child resource pools first, to ensure that the reservation properties of each child do not absorb all the resources of the parent.

Cluster Overview

vSphere supports grouping ESXi hosts that are managed by the same vCenter Server system into clusters. Clusters take advantage of features such as VMware DRS and VMware HA.

- VMware HA (VMware High Availability) migrates virtual machine from one host in a cluster to another host, in the event of host failure.
- VMware DRS (VMware Distributed Resource Scheduler, provides dynamic redistribution of resources. DRS also includes support for Distributed Power Management (DPM), which makes recommendations or decisions to power off hosts and power them on again as needed, to save energy.

  You can set up VMware DRS to automatically migrate virtual machines, or to display recommendations if resources are not used efficiently across the datacenter.

See Creating and Configuring Clusters and Managing DRS Clusters.

Creating and Configuring Resource Pools

A root resource pool is associated with each `ComputeResource` and with each `ClusterComputeResource`.

You can create a hierarchy of resource pools by calling the `ResourcePool.CreateResourcePool` method passing in a `ResourceConfig` method as an argument. The `ResourceConfig.cpuAllocation` and `ResourceConfig.memoryAllocation` properties point to a `ResourceAllocationInfo` object that allows you to specify the information.

- `reservation` – Amount of CPU or memory that is guaranteed available to the resource pool. Reserved resources are not wasted if they are not used. If the utilization is less than the reservation, the resources can be utilized by other resource pools or running virtual machines.
- `expandableReservation` – In a resource pool with an expandable reservation, the reservation on a resource pool can expand beyond the specified value, if the parent resource pool has unreserved resources. A non-expandable reservation is called a fixed reservation. See Understanding Expandable Reservation. This property is ignored for virtual machines.
- `limit` – Upper limit for CPU or memory resources assigned to this resource pool. The virtual machine or resource pool does not exceed this limit, even if resources are available. This property is typically used to ensure consistent performance. Set this property to -1 to indicate no fixed upper limit on resource usage.

- `shares` – Relative metric for allocating memory or processing capacity among multiple resource pools. The `SharesInfo` data object has two properties, `level` and `shares`, that allow you to specify resource allocation.
  - `level` – Choose `high`, `low`, or `normal` to map to a predetermined set of numeric values for shares. See the *API Reference Guide* for the numbers for CPU, memory, and disk shares. Set this property to `custom` to specify an explicit number of shares instead.
  - `shares` – Allows you to specify the number of shares you want to allocate to the resource pool. The allocation is divided evenly between resource pools with the same level.

Calling the `ResourcePool.UpdateConfig` or `ResourcePool.UpdateChildResourceConfiguration` method allows you to change the configuration.

Understanding Expandable Reservation

Expandable reservations are best illustrated with examples.

Expandable Reservation Example 1

Assume an administrator manages pool P, and defines two child resource pools, S1 and S2, for two different users (or groups).

The administrator knows that users want to power on virtual machines with reservations, but does not know how much each user will reserve. Making the reservations for S1 and S2 expandable allows the administrator to more flexibly share and inherit the common reservation for pool P.

Without expandable reservations, the administrator needs to explicitly allocate S1 and S2 a specific amount. Such specific allocations can be inflexible, especially in deep resource pool hierarchies and can complicate setting reservations in the resource pool hierarchy.

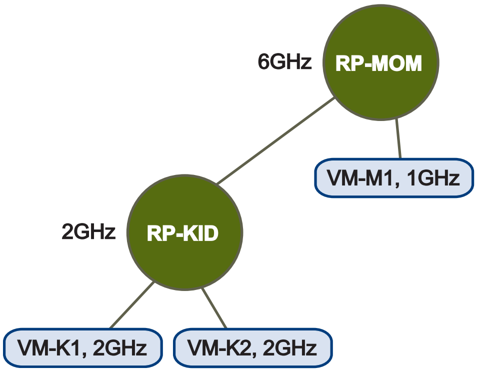
Expandable reservations cause a loss of strict isolation; that is, S1 can start using all of P's reservation, so that no memory or CPU is directly available to S2.

Expandable Reservation Example 2

Assume the following scenario:

- Parent pool RP-MOM has a reservation of 6GHz and one running virtual machine VM-M1 that reserves 1GHz.
- You create a child resource pool RP-KID with a reservation of 2GHz and with **Expandable Reservation** selected.
- You add two virtual machines, VM-K1 and VM-K2, with reservations of 2GHz each to the child resource pool and try to power them on.
- VM-K1 can reserve the resources directly from RP-KID (which has 2GHz).
- No local resources are available for VM-K2, so it borrows resources from the parent resource pool, RP-MOM. RP-MOM has 6GHz minus 1GHz (reserved by the virtual machine) minus 2GHz (reserved by RP-KID), which leaves 3GHz unreserved. With 3GHz available, you can power on the 2GHz virtual machine.

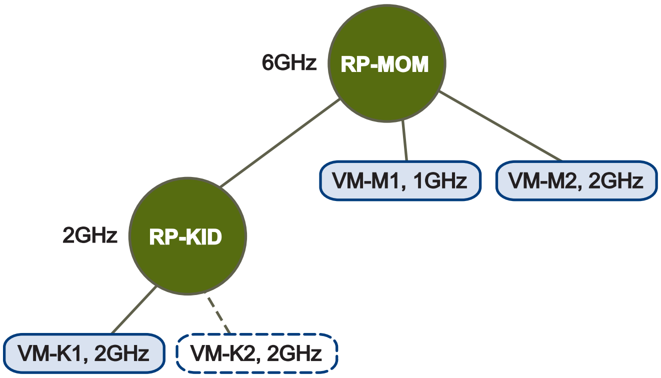
Figure 14-2. Admission Control with Expandable Resource Pools, Scenario 1



Now, consider another scenario with VM-M1 and VM-M2, shown in Figure 14-3.

- Power on two virtual machines in RP-MOM with a total reservation of 3GHz.
- You can still power on VM-K1 in RP-KID because 2GHz are available locally.
- When you try to power on VM-K2, RP-KID has no unreserved CPU capacity so it checks its parent. RP-MOM has only 1GHz of unreserved capacity available (5GHz of RP-MOM are already in use—3GHz reserved by the local virtual machines and 2GHz reserved by RP-KID). As a result, you cannot power on VM-K2, which requires a 2GHz reservation.

Figure 14-3. Admission Control with Expandable Resource Pools, Scenario 2



Deleting Child Resource Pools

The `ResourcePool.DestroyChildren` method recursively deletes all the child resource pools of a resource pool. The operation takes a single parameter, a reference to the parent `ResourcePool` managed object. Any virtual machines associated with the child resource pool are reassigned to the parent resource pool.

Moving Resource Pools or Virtual Machines Into a Resource Pool

You can move a resource pool and its children within a resource pool hierarchy.

The ResourcePool.MoveIntoResourcePool method lets you move virtual machines, virtual applications, or resource pool hierarchies into a new resource pool. You call the method with an array of ResourcePool or VirtualMachine managed object references that you want to move. The whole resource pool hierarchy, including child resource pools and virtual machines, is moved when you move a resource pool.

Minimum available resources of the immediate children must always be less than or equal to the resources of the immediate parent. The root resource pool cannot be moved.

Introduction to VMware DRS and VMware HA Clusters

Clusters are useful primarily with VMware DRS and VMware HA. This guide only gives a brief introduction. See the following manuals for details:

- VMware DRS. *vSphere Resource Management Guide*
- VMware HA. *vSphere Availability Guide*

VMware DRS

A VMware DRS cluster is a collection of ESXi hosts and associated virtual machines with shared resources and a shared management interface. Before you can obtain the benefits of cluster-level resource management you must create a DRS cluster.

When you add a host to a DRS cluster, the host’s resources become part of the cluster’s resources. In addition to this aggregation of resources, a DRS cluster supports cluster-wide resource pools and enforces cluster-level resource allocation policies. The following cluster-level resource management capabilities are available.

- Load Balancing. The vCenter Server system monitors distribution and usage of CPU and memory resources for all hosts and virtual machines in the cluster. DRS compares these metrics to an ideal resource utilization given the attributes of the cluster’s resource pools and virtual machines, the current demand, and the imbalance target. DRS then performs (or recommends) virtual machine migrations. When you first power on a virtual machine in the cluster, DRS attempts to maintain proper load balancing either by placing the virtual machine on an appropriate host or by making a recommendation.
- Power Management. When the VMware DPM (Distributed Power Management) feature is enabled, DRS compares cluster- and host-level capacity to the demands of the cluster’s virtual machines, including recent historical demand. DPM places (or recommends placing) hosts in standby power mode if sufficient excess capacity is found. DPM powers on (or recommends powering on) hosts if capacity is needed. Depending on the resulting host power state recommendations, virtual machines might need to be migrated to and from the hosts.
- Virtual Machine Placement. You can control the placement of virtual machines on hosts within a cluster, by assigning DRS affinity or antiaffinity rules.

See Managing DRS Clusters.

VMware HA

VMware HA supports high availability for virtual machines by pooling them and the hosts they reside on into a cluster. VMware HA monitors the hosts. In the event of host failure, VMware HA migrates virtual machines to hosts with capacity. When you add new virtual machines to a VMware HA cluster, VMware HA checks whether enough capacity to power on that virtual machine on a different host in case of host failure is available.

See Managing HA Clusters.

Creating and Configuring Clusters

The vSphere Web Services SDK includes objects and methods for all cluster management tasks. Some documentation is available in the *API Reference*. For additional background and details about the failover and load balancing behavior, see the *Resource Management Guide* and the *High Availability Guide.*

Creating a Cluster

If your environment includes a vCenter Server system and multiple ESXi hosts, you can create a cluster by calling the `Folder.CreateCluster` method. You pass in a name for the new cluster and a `ClusterConfigSpec` data object. In the data object, you can specify the following properties:

- VMware HA
  - `dasConfig` – `ClusterDasConfigInfo` data object that specifies the HA service on the cluster. Properties on this object determine whether strict admission control is enabled, what the default virtual machine settings in this cluster are, whether VMware HA restarts virtual machines after host failure, and so on. See the *API Reference*.
  - `dasVMConfigSpec` – `ClusterDasVMConfigSpec` object. `ClusterDasVMConfigSpec.info` is a `ClusterDasVmConfigInfo` data object that specifies the HA configuration for a single virtual machine. You can apply different settings to different virtual machines, or use the default specified in the `dasConfig` property.
- VMware DRS
  - `drsConfig` – `ClusterDrsConfigInfo` data object that contains configuration information for the VMware DRS service. Properties in this object specify the cluster-wide (default) behavior for virtual machine and the threshold for generating cluster recommendations. You can enable and disable VMware DRS with the `ClusterDrsConfigInfo.enabled` property.
  - `drsVmConfigSpec` – `ClusterDrsVMConfigSpec` data object that points to a `ClusterDrsVmConfigInfo` data object which specifies the DRS configuration for a single virtual machine. `ClusterDrsVmConfigInfo` overrides the default DRS configuration for an individual virtual machine and allows you to specify the DRS behavior and whether DRS can perform migration or recommend initial placement for a virtual machine.

When you update a DRS configuration, you call ComputeResource.ReconfigurComputeResource_Task and pass in a ClusterConfigSpecEx object. In the ClusterConfigSpecEx.drsVmConfigSpec property, you can specify an array of ClusterDrsVMConfigSpec objects that define the configuration for individual virtual machines.

- rulesSpec – ClusterDrsRuleSpec data object that points a ClusterRuleInfo data object which specifies the affinity and antiaffinity rules DRS should use. See the *API Reference* entry for ClusterRuleInfo.

Adding a Host to a Cluster

The methods available for adding hosts to a cluster are useful under different circumstances. Each method returns a managed object reference to a task.

- ClusterComputeResource.AddHost_Task – Adds a host to a cluster. The host name must be either an IP address, such as 192.168.0.1, or a DNS resolvable name. If the cluster supports nested resource pools and you specify the optional resourcePool argument, the host's root resource pool becomes the specified resource pool, and that resource pool and the associated hierarchy is added to the cluster.

  If a cluster does not support nested resource pools and you add a host to the cluster, the standalone host resource pool hierarchy is discarded and all virtual machines on the host are added to the cluster's root resource pool.

- ClusterComputeResource.moveHostInto_Task moves a host that is in the same datacenter as the cluster into the cluster. If the host is already part of a different cluster, the host must be in maintenance mode.

- ClusterComputeResource.moveInto_Task works like moveHostInto_Task, but supports an array of hosts at a time. When using this method, you cannot preserve the original resource pool hierarchy of the hosts.

Reconfiguring a Cluster

You can reconfigure a cluster by calling the ClusterComputeResource.ReconfigureCluster_Task method.

The method allows you to enable or disable VMware DRS or VMware HA and to define attributes. See Creating a Cluster.

To remove hosts from a cluster, you can use one of the following methods:

- ClusterComputeResource.MoveHostInto_Task or MoveInto_Task—Removes a host from a cluster and moves the host into another cluster. See Adding a Host to a Cluster.

- Folder.MoveIntoFolder_Task—Removes a host from a cluster and make it a standalone host.

- Host.Destroy_Task—Removes a host from inventory.

Managing DRS Clusters

The vSphere Client UI allows you to explore DRS cluster behavior, which is also described in the *Resource Management Guide*. When DRS is running, it generates recommendations and associated information that result in a well balanced cluster.

- Initial placement of virtual machines
- Virtual machine migration for load balancing. Each migration recommendation has a rating, which you can find in the `ClusterRecommendation.rating` property. Client applications can choose to consider only high-priority migrations are considered or migrations with multiple priority levels.
- Checks whether DRS clusters are valid — enough resources are available to start additional virtual machines — or not valid.

DRS recommendations are stored in the `ClusterComputeResource.recommendation` property, which is an array of `ClusterRecommendation` data objects. Each `ClusterRecommendation` includes information about the action to perform and information you can use to display information to end users or for logging.

- Client applications can call `ClusterComputeResource.ApplyRecommendation` to apply one or more recommendations.
- For more fine-grained control, client applications can perform individual actions only. The `ClusterRecommendation.action` property is an array of `ClusterAction` objects. Each `ClusterAction` includes a target for the action and the type, which is a string that is one of the values of the `ActionType` enum (`HostPowerV1`, `MigrationV1`, `VmPowerV1`). Client applications can use the `ActionType` information to act on DRS recommendations by powering on hosts, migrating virtual machines, or powering on virtual machines by calling `Datacenter.PowerOnMultiVM_Task`.

Managing HA Clusters

You can add a host to an HA cluster by calling one of the methods for moving hosts into a cluster.

You might have to call `HostSystem.ReconfigureHostForDAS_Task` to reconfigure the host for HA if the automatic HA configuration fails. See Adding a Host to a Cluster.

Primary and Secondary Hosts

You can add a host to a cluster by calling the `ClusterComputeResource.AddHost_Task` method, which requires that you specify the host name, port, and password for the host to be added as a `HostConnectSpec`.

When you add a host to a VMware HA cluster, an agent is uploaded to the host and configured to communicate with other agents in the cluster. The first five hosts added to the cluster are designated as primary hosts, and all subsequent hosts are designated as secondary hosts. The primary hosts maintain and replicate all cluster state and are used to initiate failover actions. If a primary host is removed from the cluster, VMware HA promotes another host to primary status.

Any host that joins the cluster must communicate with an existing primary host to complete its configuration (except when you are adding the first host to the cluster). At least one primary host must be functional for VMware HA to operate correctly. If all primary hosts are unavailable (not responding), no hosts can be successfully configured for VMware HA.

One of the primary hosts is also designated as the active primary host and its responsibilities include:

- Deciding where to restart virtual machines.
- Keeping track of failed restart attempts.
- Determining when it is appropriate to keep trying to restart a virtual machine.

Failure Detection and Host Network Isolation

Agents on the different hosts contact and monitor each other through the exchange of heartbeats, by default every second. If a 15-second period elapses without the receipt of heartbeats from a host, and the host cannot be pinged, the host is declared as failed. The virtual machines running on the failed host are restarted on the alternate hosts with the most available unreserved capacity (CPU and memory.)

Host network isolation occurs when a host is still running, but it can no longer communicate with other hosts in the cluster. With default settings, if a host stops receiving heartbeats from all other hosts in the cluster for more than 12 seconds, it attempts to ping its isolation addresses. If this also fails, the host declares itself isolated from the network.

When the isolated host's network connection is not restored for 15 seconds or longer, the other hosts in the cluster treat that host as failed and try to fail over its virtual machines. However, when an isolated host retains access to the shared storage it also retains the disk lock on virtual machine files. To avoid potential data corruption, VMFS disk locking prevents simultaneous write operations to the virtual machine disk files and attempts to fail over the isolated host's virtual machines fail. By default, the isolated host leaves its virtual machines powered on, but you can change the host isolation response.

Using VMware HA and DRS Together

Using VMware HA with VMware DRS combines automatic failover with load balancing. This combination can result in faster rebalancing of virtual machines after VMware HA has moved virtual machines to different hosts.

When VMware HA performs failover and restarts virtual machines on different hosts, its first priority is the immediate availability of all virtual machines. After the virtual machines have been restarted, those hosts on which they were powered on might be heavily loaded, while other hosts are comparatively lightly loaded. VMware HA uses the CPU and memory reservation to determine failover, while the actual usage might be higher.

In a cluster using DRS and VMware HA with admission control turned on, virtual machines might not be evacuated from hosts entering maintenance mode because of resources reserved to maintain the failover level. You must manually migrate the virtual machines off of the hosts using VMotion.

When VMware HA admission control is disabled, failover resource constraints are not passed on to DRS and VMware Distributed Power Management (DPM). The constraints are not enforced.

- DRS evacuates virtual machines from hosts and place the hosts in maintenance mode or standby mode regardless of the effect this might have on failover requirements.
- VMware DPM powers off hosts (place them in standby mode) even if doing so violates failover requirements.

Tasks and Scheduled Tasks 15

VMware vSphere uses an asynchronous client-server communication model. Methods that end with _Task are non-blocking, returning a reference to a Task managed object. You can use Task and ViewManager managed objects to monitor tasks, cancel certain tasks, and create custom tasks.

If you are using a vCenter Server system, the ScheduledTaskManager allows you to schedule your own tasks for a one-time run or for repeated runs.

This chapter includes the following topics:

Creating Tasks

Each time a vSphere server runs a method, it creates a Task and a corresponding TaskInfo data object. Some methods run synchronously and return data as the Task completes. But methods that end with _Task run asynchronously, and return a reference to a Task that will be created and completed as a processor becomes available. They are created to perform the functions in a non-blocking manner. Therefore, you must use the reference to the Task to monitor the status and results of the Task. vSphere operations that include the suffix _Task in their names are asynchronous and return Task references.

The Task object provides information about the status of the invoked operation through its TaskInfo data object. An instance of TaskInfo populates the info property of the Task managed object at runtime. By monitoring properties of the TaskInfo object, a client application can take appropriate action when the Task completes, or can handle errors if the Task does not complete successfully.

When a vSphere server creates a Task, it also creates a TaskEvent object. The TaskEvent object contains a copy of the TaskInfo object (TaskEvent.info). The TaskEvent copy of the TaskInfo object is a snapshot of the Task state at the time of its creation. It does not change after it is created. To find the current status of the task, use the Task.info.eventChainId property.

Session Persistence

A Task and its associated objects are session specific, so they will not persist after the session is closed. When your client opens a session, you can only obtain information about the Task objects that your client is authorized to view.

Cancelling a Task

To cancel a Task that is still running, call the Task.CancelTask method, passing in the managed object reference to the Task you want to cancel, as shown in this example:

```
my_conn.cancelTask(taskMoRef);
```

You can only cancel a Task that has its cancelable property set to true and its state property set to running. The operation that initiates the Task sets the value of cancelable when it creates the Task. For example, a CreateVM_Task cannot be cancelled. Before attempting to cancel a running Task, you can check the values of the cancelable property and the state property of the TaskInfo data object associated with the Task.

Using TaskInfo to Determine Task Status

A Task object provides information about the status of the invoked operation through its TaskInfo data object. An instance of TaskInfo populates the info property of the Task managed object at runtime. By monitoring properties of the TaskInfo object, a client application can take appropriate action when the Task completes, or can handle errors if the Task does not complete successfully.

The Task.info property contains a TaskInfo data object that contains information about the Task the server returns to your client application.

When a Task is instantiated by the server, the TaskInfo.result property is initialized to Unset. Upon successful completion of an operation, the result property is populated with the return type specific to the operation. The result might be a data object, a reference to a managed object, or any other data structure as defined by the operation.

For example:

1. The ClusterComputeResource.AddHost_Task method returns a Task object whose info property contains a TaskInfo data object.
2. At the start of the operation, the result property is Unset.
3. Upon successful completion of the operation, the result property of TaskInfo contains the managed object reference of the newly added HostSystem.

TaskInfo Values

The following table lists some of the values obtained from a TaskInfo data object at the beginning and the end of the Task instantiated by the CreateVM_Task method.

Property	Datatype	Start of Task Sample Values	End of Task Sample Values
cancelable	boolean	false	false
...			
completeTime	dateTime	Unset	"2009-02-19T22:53:35.015338Z"
progress	int	36	100
queueTime	dateTime	"2009-02-19T22:50:39.111604Z"	"2009-02-19T22:50:39.111604Z"
reason	TaskReason	reason	reason
result	anyType	Unset	64
....			
state	TaskInfoState	"running"	"success"

Monitoring TaskInfo Properties

To monitor the state of a Task, use the PropertyCollector.WaitForUpdatesEx method.

You can monitor the values of TaskInfo properties, which change as the Task runs to completion. For example, you can check the values of startTime, queueTime, completeTime, progress, result, and state as the operation progresses. Monitor these properties in your code in a separate thread until the Task completes, while the main line of your code continues with other activities.

For more information about monitoring properties, see Client Data Synchronization (WaitForUpdatesEx).

Your code must handle the datatype returned when the Task completes (managed object reference, data object, and so on). In addition to success, queued, and running, an operation can enter an error state, which your code must handle.

A Task object has a lifecycle that is independent of the TaskManager that creates it and independent of the entity with which it is associated. It exists to convey status about an operation. You can discard the reference to it when your application no longer needs the information.

The following example shows a code fragment that obtains values for the info property from each Task object in the array.

Example: Displaying TaskInfoState Values for Tasks in recentTask Array

```
...
private void displayTasks(ObjectContent[] oContents) {
      for(int oci=0; oci<oContents.length; ++oci) {
         System.out.println("Task");
         DynamicProperty[] dps = oContents[oci].getPropSet();
         if(dps!=null) {
            String op="", name="", type="", state="", error="";
            for(int dpi=0; dpi<dps.length; ++dpi) {
               DynamicProperty dp = dps[dpi];
               if("info.entity".equals(dp.getName())) {
                  type = ((ManagedObjectReference)dp.getVal()).getType();
               } else if ("info.entityName".equals(dp.getName())) {
                  name = ((String)dp.getVal());
               } else if ("info.name".equals(dp.getName())) {
                  op = ((String)dp.getVal());
               } else if ("info.state".equals(dp.getName())) {
                  TaskInfoState tis = (TaskInfoState)dp.getVal();
                  if(TaskInfoState.error.equals(tis)) {
                     state = "-Error";
                  } else if(TaskInfoState.queued.equals(tis)) {
                     state = "-Queued";
                  } else if(TaskInfoState.running.equals(tis)) {
                     state = "-Running";
                  } else if(TaskInfoState.success.equals(tis)) {
                     state = "-Success";
                  }
               } else if ("info.cancelled".equals(dp.getName())) {
                  Boolean b = (Boolean)dp.getVal();
                  if(b != null && b.booleanValue()) {
                     state += "-Cancelled";
                  }
              }...
```

Example: Sample Run of the TaskList Java Application shows output from a run of the program. See the source code listing for `TaskList.java` or for `TaskList.cs` in the vSphere Web Services SDK package for details.

Example: Sample Run of the TaskList Java Application

```
java com.vmware.samples.general.TaskList --url https://srv/sdk --username root --password *******

Started
Task
Operation AcquireCimServicesTicket
Name srv
Type HostSystem
State -Success
Error
======================
Ended TaskList
```

Accessing and Manipulating Multiple Tasks

Use the `ViewManager`'s `ListView` method to identify the set of Tasks you want to monitor.

You can specify a smaller and more efficient data set using one of the `ViewManager` views with the Property Collector. Each view represents objects you have selected on the server. Views are more efficient because you only need a single instance of a `PropertyCollector` object, instead of multiple instances with multiple filter specifications.

Gathering Data with a ViewManager Object

Use one of the `ViewManager` methods to obtain information about `Task` objects and references while the session is running. The `ViewManager`'s `ListView method` allows you to customize your view with an input object list, the `ContainerView method` lets you view all objects in a folder, datacenter, resource pool, or other data container, and the `InventoryView` method lets you monitor the entire inventory. The smallest view you can create will be the most efficient way to retrieve task data.

The `ViewManager` has the following property:

`viewList` – An array of view references. Each array entry is a managed object reference to a view created by this View Manager.

See Retrieve Properties with the PropertyCollector for an example that uses the `ContainerView` method to access Inventory data.

Task Monitoring Example Using the ListView Object

Use the ViewManager's `ListView` method to specify the set of tasks that you want to monitor.

The following example uses the `ViewManager` service interface with a `ListView` method to access and manipulate `Task` objects. This example uses the property collector to monitor tasks that are created in the process of virtual machine cloning. This program creates two clones of the specified virtual machine and then monitors the tasks and prints out status and reference values when the tasks have completed.

The following steps describe the procedure for creating a program that uses the ListView managed object.

You can run the example below as a stand-alone program against your own server by copying the code sections into a .java file, compiling it, and then using the following command line syntax:

>cloneVMTask server-name username password vm-name

Procedure

1 Import the vSphere Web Services API libraries:

```
import com.vmware.vim25.*;
```

2 Import the necessary Java (and JAX-WS connection, bindings, and SOAP) libraries:

```
import java.util.*;
import javax.net.ssl.HostnameVerifier;
import javax.net.ssl.HttpsURLConnection;
import javax.net.ssl.SSLSession;
import javax.xml.ws.BindingProvider;
import javax.xml.ws.soap.SOAPFaultException;
```

3. Create the cloneVMTask class to create cloned virtual machine Tasks on a host, so we can demonstrate how to monitor these Tasks.

```
public class cloneVMTask {
```

4. Declare variables for the service instance objects and methods:

```
// Services and methods
static ManagedObjectReference pCollector;
static ManagedObjectReference viewMgr;
static ServiceContent serviceContent;
static VimPortType methods;

/**
* getVmRef() retrieves a reference to the specified virtual machine.
*
* vmName – name of the virtual machine specified on the command line
*
* This function retrieves references to all of the virtual machines
* in the datacenter and looks for a match to the specified name.
*/
```

5. Create a function that retrieves references to all of the virtual machines in the datacenter and looks for a match to the specified name. The function in this example uses `getVMRef(String, vmName)`, which retrieves a reference to the virtual machine that you specify on the command line (`vmName`) when you run this sample. The function also initializes the vmRef variable to null.

```
private static ManagedObjectReference getVmRef( String vmName )
throws Exception
{
  ManagedObjectReference vmRef = null;
```

6. Use a container view to collect references to all virtual machines in the datacenter.

```
  List<String> vmList = new ArrayList<String>();
  vmList.add("VirtualMachine");
  ManagedObjectReference cViewRef =
     methods.createContainerView(viewMgr,
                                 serviceContent.getRootFolder(),
                                 vmList,
                                 true);
```

7. Create an `ObjectSpec` to define the beginning of the traversal. Use the `setObj` method to specify that the container view is the root object for this traversal. Set the `setSkip` method to true to indicate that you don't want to include the container in the results.

```
  ObjectSpec oSpec = new ObjectSpec();
  oSpec.setObj(cViewRef);
  oSpec.setSkip(true);
```

8 Create a traversal spec to select all objects in the view.

```
TraversalSpec tSpec = new TraversalSpec();
tSpec.setName("traverseEntities");
tSpec.setPath("view");
tSpec.setSkip(false);
tSpec.setType("ContainerView");
```

9 Add the traversal spec to the object spec.

```
oSpec.getSelectSet().add(tSpec);
```

10 Specify the property for retrieval (virtual machine name).

```
PropertySpec pSpec = new PropertySpec();
pSpec.setType("VirtualMachine");
pSpec.getPathSet().add("name");
```

11 Create a PropertyFilterSpec and add the object and property specs to it.

```
PropertyFilterSpec fSpec = new PropertyFilterSpec();
fSpec.getObjectSet().add(oSpec);
fSpec.getPropSet().add(pSpec);
```

12 Create a list for the filters and add the spec to it.

```
List<PropertyFilterSpec> fSpecList = new ArrayList<PropertyFilterSpec>();
fSpecList.add(fSpec);
```

13 Get the data from the server.

```
RetrieveOptions ro = new RetrieveOptions();
RetrieveResult props = methods.retrievePropertiesEx(pCollector,fSpecList,ro);
```

14 Go through the returned list and look for a match to the specified `vmName`.

```
if (props != null) {
  for (ObjectContent oc : props.getObjects()) {
    String vmname = null;
    List<DynamicProperty> dps = oc.getPropSet();
    if (dps != null) {
      for (DynamicProperty dp : dps) {
        vmname = (String) dp.getVal();
        // If the name of this virtual machine matches
        // the specified name, save the managed object reference.
        if (vmname.equals(vmName)) {
          vmRef = oc.getObj();
          break;
        }
      }
      if (vmRef != null) { break; }
      }
    }
  }
  if (vmRef == null) {
    System.out.println("Specified Virtual Machine not found.");
    throw new Exception();
  }
  return vmRef;

}
```

15. Get the folder that contains the specified virtual machine (`VirtualMachine.parent`)

```
private static ManagedObjectReference getVMParent(ManagedObjectReference vmRef)
throws Exception {
```

16. Create an `Object Spec` to define the property collection. Use the `setObj` method to specify that the vmRef is the root object for this traversal. Set the `setSkip` method to true to indicate that you don't want to include the virtual machine in the results.

```
  // don't include the virtual machine in the results
  ObjectSpec oSpec = new ObjectSpec();
  oSpec.setObj(vmRef);
  oSpec.setSkip(false);
```

17. Specify the property for retrieval (virtual machine parent).

```
  PropertySpec pSpec = new PropertySpec();
  pSpec.setType("VirtualMachine");
  pSpec.getPathSet().add("parent");
```

18. Create a PropertyFilterSpec and add the object and property specs to it.

```
  PropertyFilterSpec fSpec = new PropertyFilterSpec();
  fSpec.getObjectSet().add(oSpec);
  fSpec.getPropSet().add(pSpec);
```

19. Create a list for the filters and add the property filter spec to it.

```
  List<PropertyFilterSpec> fSpecList = new ArrayList<PropertyFilterSpec>();
  fSpecList.add(fSpec);
```

20. Get the data from the server.

```
  RetrieveOptions ro = new RetrieveOptions();
  RetrieveResult props = methods.retrievePropertiesEx(pCollector,fSpecList,ro);
```

21 Get the parent folder reference.

```
  ManagedObjectReference folderRef = null;
  if (props != null) {
    for (ObjectContent oc : props.getObjects()) {
      List<DynamicProperty> dps = oc.getPropSet();
      if (dps != null) {
        for (DynamicProperty dp : dps) {
          folderRef = (ManagedObjectReference) dp.getVal();
        }
      }
    }
  }

  if (folderRef == null) {
    System.out.println("Folder not found.");
    throw new Exception();
  }
  return folderRef;
}
```

Now that we have the reference information for the virtual machine that you specified on the command line (`vmRef`) and a reference for the parent directory (`folderRef`), we are ready to create the clone virtual machines.

22 To create clones, use the `cloneVM` method and pass in the `vmRef` that we retrieved previously.

```
private static void cloneVM(ManagedObjectReference vmRef) throws Exception {
```

23 After you have created the clone managed object, create a clone specification. Use default values whenever possible.

```
  VirtualMachineCloneSpec cloneSpec = new VirtualMachineCloneSpec();
  VirtualMachineRelocateSpec vmrs = new VirtualMachineRelocateSpec();
  cloneSpec.setLocation(vmrs);
  cloneSpec.setPowerOn(true);
  cloneSpec.setTemplate(false);
```

24 Get the destination folder for the clone virtual machines (VirtualMachine.parent). The clones will be created in the same folder that contains the specified virtual machine (vmName).

```
  ManagedObjectReference folder = getVMParent( vmRef );
```

25 Create two clone virtual machines.

```
  ManagedObjectReference cloneTask = methods.cloneVMTask( vmRef,
                                                          folder,
                                                          "clone__1",
                                                          cloneSpec);
```

```
ManagedObjectReference cloneTask2 = methods.cloneVMTask( vmRef,
                                                         folder,
                                                         "clone__2",
                                                         cloneSpec);
```

26 Create a list view for the clone tasks.

```
List<ManagedObjectReference> taskList = new ArrayList<ManagedObjectReference>();
taskList.add(cloneTask);
taskList.add(cloneTask2);
ManagedObjectReference cloneTaskList = methods.createListView(viewMgr,
                                                              taskList);
```

Next we will set up a property filter for WaitForUpdatesEx. This includes creating an object spec, a traversal spec, a property spec, a filter spec, and finally a property filter. The next six steps will describe these procedures.

27 Create an object spec to start the traversal.

```
ObjectSpec oSpec = new ObjectSpec();
oSpec.setObj(cloneTaskList);
oSpec.setSkip(true);
```

28 Create a traversal spec to select the list of tasks in the view.

```
TraversalSpec tSpec = new TraversalSpec();
tSpec.setName("traverseTasks");
tSpec.setPath("view");
tSpec.setSkip(false);
tSpec.setType("ListView");
```

29 Add the traversal spec to the object spec.

```
oSpec.getSelectSet().add(tSpec);
```

30 Create property spec for Task.info.state and Task.info.result.

```
PropertySpec pSpec = new PropertySpec();
pSpec.setType("Task");
pSpec.setAll(false);
pSpec.getPathSet().add("info.state");
pSpec.getPathSet().add("info.result");
```

31 Create a filter spec.

```
PropertyFilterSpec fSpec = new PropertyFilterSpec();
fSpec.getObjectSet().add(oSpec);
fSpec.getPropSet().add(pSpec);
```

32 Create the filter.

```
ManagedObjectReference pFilter = methods.createFilter(pCollector,
                                                      fSpec,
                                                      true);
```

In the next section, we use the `waitForUpdatesEx` method to look for a change in `cloneTask.info.state` and `cloneTask.info.result`. When the state is “success”, `cloneTask.info.result` is the managed object reference of the clone. Note that the order of property retrieval is not guaranteed, and it may take more than one call to `waitForUpdatesEx` to retrieve both properties for a task.

This code does not set a time-out (`WaitOptions.maxWaitSeconds` is unset), so after it has retrieved all of the property values, `waitForUpdatesEx` will block the thread, waiting for the TCP connection with the vSphere Server to time-out.

How a client application handles the session depends on the particular context. (The client can call `WaitForUpdatesEx` from its own thread, look for specific updates and then stop calling the method.)

For more information about `WaitOptions` and the `waitForUpdatesEx` method, see Client Data Synchronization (WaitForUpdatesEx).

33 Initialize wait loop (?)

```
String version = "";
Boolean wait = true;
WaitOptions waitOptions = new WaitOptions();

while ( wait ) {
```

34 Call WaitForUpdatesEx.

```
  UpdateSet uSet = methods.waitForUpdatesEx(pCollector,
                                            version,
                                            waitOptions);


  if (uSet == null) {
    wait = false;
  } else {
```

35 Get the version for subsequent calls to WaitForUpdatesEx.

```
    version = uSet.getVersion();
```

36 Get the list of property updates.

```
    List<PropertyFilterUpdate> pfUpdates = uSet.getFilterSet();
    for (PropertyFilterUpdate pfu : pfUpdates) {
```

37 Get the list of object updates produced by the filter.

```
    List<ObjectUpdate> oUpdates = pfu.getObjectSet();
    for (ObjectUpdate ou : oUpdates) {
```

38 Look for ObjectUpdate.kind=MODIFY (property modified).

```
      if (ou.getKind() == ObjectUpdateKind.MODIFY) {

        String name = "";
        TaskInfoState state;
        ManagedObjectReference cloneRef = new ManagedObjectReference();
```

39 Get the changed data.

```
        List<PropertyChange> pChanges = ou.getChangeSet();
```

40 Retrieve the name of the property

```
        for (PropertyChange pc : pChanges) {
          name = pc.getName();

          //The task property names are info.state or info.result;
          //pc.val is an xsd:anyType:
          //-- for info.state, it is the state value
          //-- for info.result, it is the clone reference
          if (name.equals("info.state")) {
            state = (TaskInfoState)pc.getVal();
            System.out.println("State is "+state.value());
          } else if (name.equals("info.result")) {
            cloneRef = (ManagedObjectReference)pc.getVal();
            System.out.println("Clone reference is "+cloneRef.getValue());
          }
        }
```

Authentication is handled using a TrustManager and supplying a host name verifier method. (The host name verifier is declared in the main function.)

For the purposes of this example, this TrustManager implementation will accept all certificates. This is only appropriate for a development environment. Production code should implement certificate support.

```
private static class TrustAllTrustManager implements javax.net.ssl.TrustManager,
   javax.net.ssl.X509TrustManager {
       public java.security.cert.X509Certificate[] getAcceptedIssuers() {
           return null;
       }

       public boolean isServerTrusted(
           java.security.cert.X509Certificate[] certs) {
           return true;
       }
```

```
        public boolean isClientTrusted(
            java.security.cert.X509Certificate[] certs) {
            return true;
        }

        public void checkServerTrusted(java.security.cert.X509Certificate[] certs,
            String authType)
            throws java.security.cert.CertificateException {
            return;
        }
        public void checkClientTrusted(java.security.cert.X509Certificate[] certs,
            String authType)
            throws java.security.cert.CertificateException {
            return;
        }
    }
```

Now we are set to retrieve the task information, so we implement the main method.

```
// cloneVMTask( server, user, password, virtual-machine )
public static void main(String [] args) throws Exception {
```

41 We create variables to hold the values passed in from the command line.

```
  String serverName = args[0];
  String userName = args[1];
  String password = args[2];
  String vmName = args[3];
  String url = "https://"+serverName+"/sdk/vimService";
```

42 Add variables for access to the API methods and services.

```
  // -- ManagedObjectReference for the ServiceInstance on the Server
  // -- VimService for access to the vSphere Web service
  // -- VimPortType for access to methods
  // -- ServiceContent for access to managed object services
  ManagedObjectReference SVC_INST_REF = new ManagedObjectReference();
  VimService vimService;
```

43 Declare a host name verifier that will automatically enable the connection. The host name verifier is invoked during the SSL handshake.

```
  HostnameVerifier hv = new HostnameVerifier() {
    public boolean verify(String urlHostName, SSLSession session) {
      return true;
    }
  };
```

44 Create the trust manager.

```
javax.net.ssl.TrustManager[] trustAllCerts = new javax.net.ssl.TrustManager[1];
javax.net.ssl.TrustManager tm = new TrustAllTrustManager();
trustAllCerts[0] = tm;
// Create the SSL context
javax.net.ssl.SSLContext sc = javax.net.ssl.SSLContext.getInstance("SSL");
// Create the session context
javax.net.ssl.SSLSessionContext sslsc = sc.getServerSessionContext();
// Initialize the contexts; the session context takes the trust manager.
sslsc.setSessionTimeout(0);
sc.init(null, trustAllCerts, null);
// Use the default socket factory to create the socket for the secure connection
javax.net.ssl.HttpsURLConnection.setDefaultSSLSocketFactory(sc.getSocketFactory());
```

45 Set the default host name verifier to enable the connection.

```
HttpsURLConnection.setDefaultHostnameVerifier(hv);
```

46 Set up the manufactured managed object reference for the ServiceInstance

```
SVC_INST_REF.setType("ServiceInstance");
SVC_INST_REF.setValue("ServiceInstance");
```

47 Create a VimService object to obtain a VimPort binding provider. The BindingProvider provides access to the protocol fields in request/response messages. Retrieve the request context which will be used for processing message requests.

```
vimService = new VimService();
methods = vimService.getVimPort();
Map<String, Object> ctxt = ((BindingProvider) methods).getRequestContext();
```

48 Store the Server URL in the request context and specify `true` to maintain the connection between the client and server. The client API will include the Server's HTTP cookie in its requests to maintain the session. If you do not set this to true, the Server will start a new session with each request.

```
ctxt.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY, url);
ctxt.put(BindingProvider.SESSION_MAINTAIN_PROPERTY, true);
```

49 Retrieve the ServiceContent object and login.

```
serviceContent = methods.retrieveServiceContent(SVC_INST_REF);
methods.login(serviceContent.getSessionManager(),
              userName,
              password,
              null);
```

50 Get references to the property collector and the view manager.

```
    pCollector = serviceContent.getPropertyCollector();
    viewMgr = serviceContent.getViewManager();
```

51 Get a reference to the specified virtual machine.

```
    ManagedObjectReference vmRef = getVmRef( vmName );
```

52 Clone the virtual machine and wait for the result.

```
    cloneVM( vmRef );
```

53 Close the connection.

```
    methods.logout(serviceContent.getSessionManager());
  }
}
```

Note For general task monitoring, it is a best practice to use a `ViewManager` to monitor specific tasks. See the *API Reference* for more information about using views.

Gathering Data with a TaskManager Interface

`TaskManager` is a service interface that you can also use for accessing and manipulating `Task` objects. This approach uses a `PropertyCollector` that includes the `recentTask` property of the `TaskManager` managed object that corresponds to the Recent Tasks pane at the bottom of the vSphere client User Interface.

You can use the following `TaskManager` properties in your client application.

- `description` – `TaskDescription` object that includes a `methodInfo` property. `methodInfo` contains a key-based array that `TaskManager` uses to populate the value of a `TaskInfo` data object's `descriptionId` property with the name of the operation. Examples of two elements from this key-based array are `methodInfo["Folder.createVm"]` and `methodInfo["Folder.createClusterEx"]`.
- `recentTask` – Array of `Task` managed object references that are queued to run, running, or completed within the past 10 minutes. On ESX/ESXi hosts that are managed by a vCenter Server, a completed task must also be one of the 200 most recent tasks to be included in the array. A vSphere Client connected to a vSphere Server displays queued, running, and completed tasks in the Recent Tasks pane.

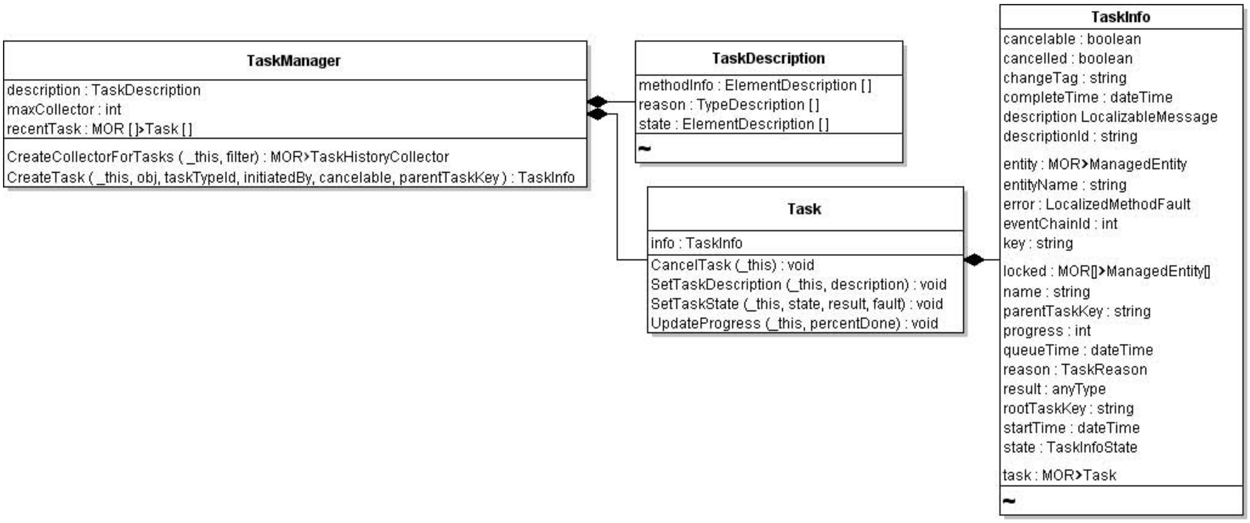
In addition to these properties, `TaskManager` has the following methods:

- `CreateTask` – Used by other methods to create a custom `Task` object. Developers creating extensions can use this method to create custom `Task` objects.

- CreateCollectorForTasks – Creates an object that contains all tasks from the vCenter Server database that meet specific criteria. You cannot run this method against an ESX/ESXi system. See Using a TaskHistoryCollector.

Figure 15-1 shows a UML class diagram for TaskManager and associated objects.

Figure 15-1. TaskManager and Task Managed Objects


TaskManager
description : TaskDescription
maxCollector : int
recentTask : MOR [ ]>Task [ ]
CreateCollectorForTasks (_this, filter) : MOR>TaskHistoryCollector
CreateTask (_this, obj, taskTypeId, initiatedBy, cancelable, parentTaskKey) : TaskInfo
TaskDescription
methodInfo : ElementDescription [ ]
reason : TypeDescription [ ]
state : ElementDescription [ ]
~
Task
info : TaskInfo
CancelTask (_this) : void
SetTaskDescription (_this, description) : void
SetTaskState (_this, state, result, fault) : void
UpdateProgress (_this, percentDone) : void
TaskInfo
cancelable : boolean
cancelled : boolean
changeTag : string
completeTime : dateTime
description LocalizableMessage
descriptionId : string
entity : MOR>ManagedEntity
entityName : string
error : LocalizedMethodFault
eventChainId : int
key : string
locked : MOR[]>ManagedEntity[]
name : string
parentTaskKey : string
progress : int
queueTime : dateTime
reason : TaskReason
result : anyType
rootTaskKey : string
startTime : dateTime
state : TaskInfoState
task : MOR>Task
~

Examining Recent Tasks with TaskManager

To obtain the list of recent tasks, use a PropertyCollector to obtain references to the TaskManager and to all Task objects from the recentTask property of the TaskManager.

The following example shows an excerpt from the TaskList.java sample that creates the ObjectSpec, PropertySpec, and a TraversalSpec to obtain references to all Task objects on the server from the TaskList. See also Chapter 5 Property Collector.

Example: PropertyFilterSpec Definition to Obtain recentTask Property Values

```
private PropertyFilterSpec[] createPFSForRecentTasks(ManagedObjectReference taskManagerRef) {
     PropertySpec pSpec = new PropertySpec();
          pSpec.setAll(Boolean.FALSE);
          pSpec.setType("Task");
          pSpec.setPathSet(new String[] {"info.entity", "info.entityName", "info.name",
              "info.state", "info.cancelled", "info.error"});
     ObjectSpec oSpec = new ObjectSpec();
          oSpec.setObj(taskManagerRef);
          oSpec.setSkip(Boolean.FALSE);
     TraversalSpec tSpec = new TraversalSpec();
          tSpec.setType("TaskManager");
          tSpec.setPath("recentTask");
          tSpec.setSkip(Boolean.FALSE);
     oSpec.setSelectSet(new SelectionSpec[]{tSpec});
     PropertyFilterSpec pfSpec = new PropertyFilterSpec();
```

```
            pfSpec.setPropSet(new PropertySpec[]{pSpec});
            pfSpec.setObjectSet(new ObjectSpec[]{oSpec});
       return new PropertyFilterSpec[]{pfSpec};
  }
```

For ESXi hosts managed by vCenter Server, use a TaskHistoryCollector. See Using a TaskHistoryCollector.

Understanding the ScheduledTaskManager Interface

You can use the ScheduledTaskManager to schedule tasks. In the vSphere Client, scheduled tasks display in the Task & Events tab.

You can define actions to occur on vCenter Server at different times:

- When a vCenter Server system starts up operations, such as after a reboot
- At a specific time and day
- At hourly, daily, weekly, or monthly intervals

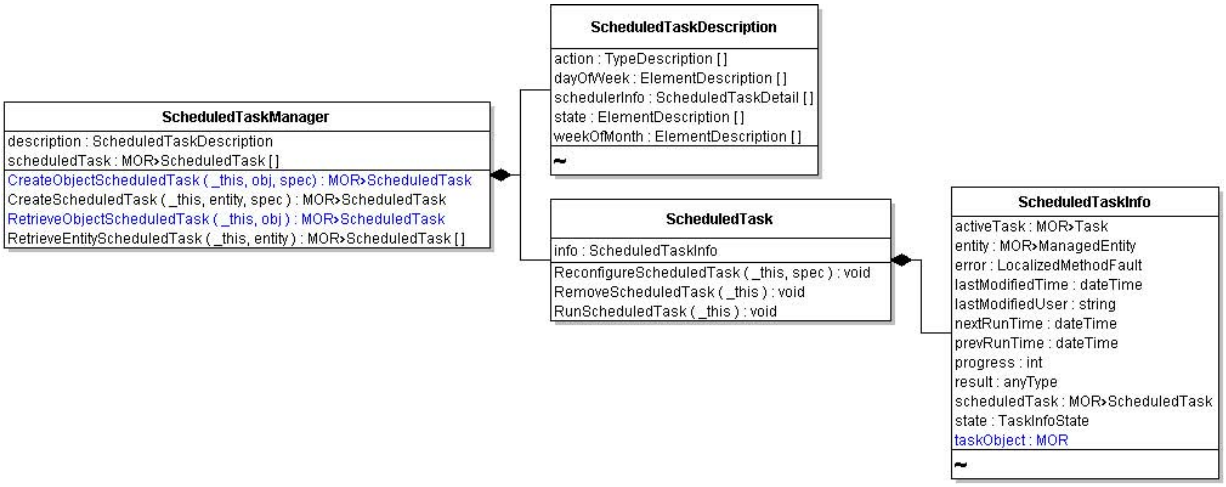
You can schedule scripts to be run or methods to be invoked on the server. You apply the action to an entity in the inventory, such as a virtual machine or a host.

You can perform the following actions with ScheduledTaskManager.

- Retrieve scheduled tasks for a specific managed entity by calling the ScheduledTaskManager.RetrieveEntityScheduledTask method.
- Create a scheduled task by calling the ScheduledTaskManager.CreateScheduledTask method. See Scheduling Tasks.

Figure 15-2 shows the ScheduledTaskManager service interface and associated data objects.

Figure 15-2. ScheduledTaskManager and ScheduledTask Managed Objects


ScheduledTaskManager
description : ScheduledTaskDescription
scheduledTask : MOR>ScheduledTask [ ]
CreateObjectScheduledTask (_this, obj, spec) : MOR>ScheduledTask
CreateScheduledTask (_this, entity, spec) : MOR>ScheduledTask
RetrieveObjectScheduledTask (_this, obj) : MOR>ScheduledTask
RetrieveEntityScheduledTask (_this, entity) : MOR>ScheduledTask [ ]
ScheduledTaskDescription
action : TypeDescription [ ]
dayOfWeek : ElementDescription [ ]
schedulerInfo : ScheduledTaskDetail [ ]
state : ElementDescription [ ]
weekOfMonth : ElementDescription [ ]
~
ScheduledTask
info : ScheduledTaskInfo
ReconfigureScheduledTask (_this, spec) : void
RemoveScheduledTask (_this) : void
RunScheduledTask (_this) : void
ScheduledTaskInfo
activeTask : MOR>Task
entity : MOR>ManagedEntity
error : LocalizedMethodFault
lastModifiedTime : dateTime
lastModifiedUser : string
nextRunTime : dateTime
prevRunTime : dateTime
progress : int
result : anyType
scheduledTask : MOR>ScheduledTask
state : TaskInfoState
taskObject : MOR
~

The ScheduledTaskManager.scheduledTask property contains an array of the ScheduledTask objects configured for the server. If you have no actions scheduled, this property is empty. For any ScheduledTask objects in this array, you can use the info property of the ScheduledTask object to obtain information about the status of the scheduled action. Information includes the task's progress, state, previous and next runtimes, and other details contained in the ScheduledTaskInfo data object.

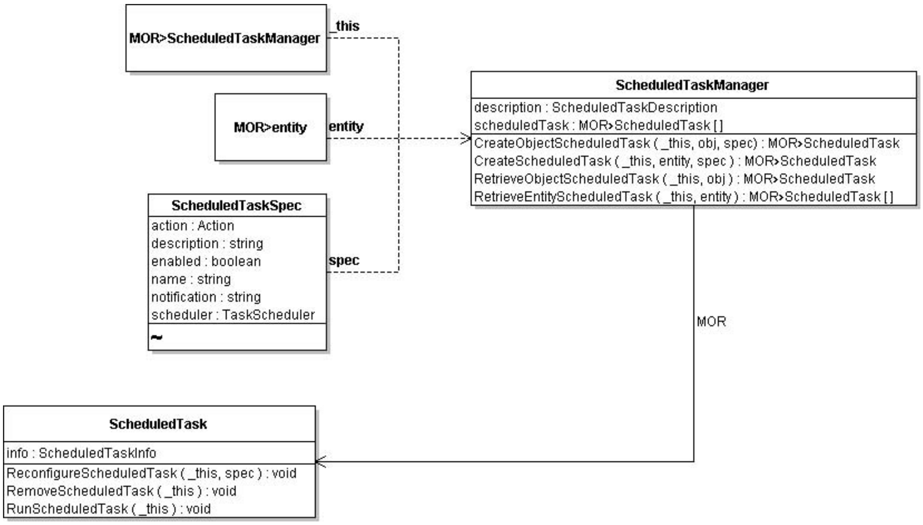
If the action specified for a ScheduledTask creates its own Task (such as with any of the asynchronous operations), the managed object reference to the Task populates the activeTask property of ScheduledTaskInfo.

Scheduling Tasks

You create a ScheduledTask by invoking the ScheduledTaskManager.CreateScheduledTask method. When you invoke the method, you include a ScheduledTaskSpec object that defines the schedule and specifies the action to take at the specified time. A scheduled action applies to an object based on these rules:

- If you specify a container object as the entity for the scheduled action, the schedule applies to all entities that are direct descendants of the container. You can set a ScheduledTask at the Folder, Datacenter, or VirtualApp level and have the scheduled action apply to all entities associated with the Folder, Datacenter, or VirtualApp.
- If you specify a node object in the inventory, such as a virtual machine, the action applies only to the virtual machine.

Figure 15-3. Using ScheduledTaskManager to Create a ScheduledTask


MOR>ScheduledTaskManager
_this
MOR>entity
entity
ScheduledTaskSpec
action : Action
description : string
enabled : boolean
name : string
notification : string
scheduler : TaskScheduler
~
spec
ScheduledTaskManager
description : ScheduledTaskDescription
scheduledTask : MOR>ScheduledTask [ ]
CreateObjectScheduledTask (_this, obj, spec) : MOR>ScheduledTask
CreateScheduledTask (_this, entity, spec) : MOR>ScheduledTask
RetrieveObjectScheduledTask (_this, obj) : MOR>ScheduledTask
RetrieveEntityScheduledTask (_this, entity) : MOR>ScheduledTask [ ]
MOR
ScheduledTask
info : ScheduledTaskInfo
ReconfigureScheduledTask (_this, spec) : void
RemoveScheduledTask (_this) : void
RunScheduledTask (_this) : void

Defining the Schedule and Action

The ScheduledTaskSpec data object contains all the information to create a ScheduledTask.

- action – Action to take when the ScheduledTask runs. Specify an Action data object, which is an abstract type that is extended by several specific action types. The Action data objects are also used by the Alarm infrastructure. See Specifying Alarm Actions.

- `notification` – Specifies the email address for sending notification messages about the `ScheduledTask`. To use notifications, the vCenter Server system must have an SMTP email gateway configured. By default, `notification` is set to an empty string.
- `scheduler` – Specifies the time, frequency, and other details of the schedule. The `TaskScheduler` data object is the base type for several specific schedule objects. See Scheduling Recurring Operations.

Scheduling Recurring Operations

You can specify the times, days, or frequency of scheduled tasks by creating the appropriate instances of `TaskScheduler` subtypes and setting the `scheduler` property of the `ScheduledTaskSpec`.

The `TaskScheduler` base type has two properties:

- `activeTime` is the time at which the action should occur. If you leave this property unset, it defaults to the time when that specification for the scheduled task was submitted to the server.
- `expireTime` is the time after which the scheduled action should not occur. By default, this property is unset, so the scheduled task does not expire.

The following table provides some usage information about the `TaskScheduler` subtypes. The examples in the table are Java code fragments.

TaskScheduler Subtype	Usage

`AfterStartupTaskScheduler`	Schedule a task to start as soon as the vCenter Server system is started, or at a defined time after startup. The value must be zero (task triggered at startup) or higher.
	Example: Schedule a task to run 10 minutes after vCenter Server startup.
	`AfterStartupTaskScheduler asts =`
	`    new    AfterStartupTaskScheduler();`
	`asts.setMinute(10);`

`OnceTaskScheduler`	Schedule an action to run once only at the specified date and time.
	Example: Schedule a task to run 30 minutes after the schedule is submitted to the server.
	`Calendar runTime = Calendar.getInstance();`
	`runtime.add(Calendar.MINUTE, 30);`
	`OnceTaskScheduler ots = new OnceTaskScheduler();`
	`ots.setRunAt(runTime);`

`RecurrentTaskScheduler`	Base type for `HourlyTaskScheduler`, `DailyTaskScheduler`, `WeeklyTaskScheduler`, and `MonthlyTaskScheduler` objects. Set the interval property to define how frequently a task should run. For example, setting the interval property of an hourly task to 4 causes the task to run every 4 hours.
`HourlyTaskScheduler`	Schedule a task to run once every hour (or every specified number of hours) at a specified time. Set the interval property to run the task after a specified number of hours. Example: Schedule a task to run every 4 hours at half-past the hour.

TaskScheduler Subtype	Usage

	`HourlyTaskScheduler hts =`
	`    new HourlyTaskScheduler();`
	`hts.setMinute(30);`
	`hts.setInterval(4);`

`DailyTaskScheduler`	Schedule a task to run daily or a specified number of days at a specified time (hour and minutes). Use in conjunction with the interval property to run the task after a specified number of days. Example: Schedule a task to run daily at 9:30 am (EST).

	`DailyTaskScheduler dts =`
	`    new DailyTaskScheduler();`
	`dts.setMinute(30);`
	`dts.setHour(14);`

`WeeklyTaskScheduler`	Schedule a task to run every week (or every specified number of weeks) on a specified day (or days) at a specific time. The hours and minutes are set as UTC values. At least one of the boolean values must be set to `true`. You can also set the interval property to run the task after a specified number of weeks. Example: Schedule a task to run every Tuesday and Sunday at 30 minutes past midnight.

	`WeeklyTaskScheduler wts =`
	`   new WeeklyTaskScheduler();`
	`wts.setMonday(true);`
	`wts.setTuesday(true);`
	`...`
	`wts.setSaturday(false);`
	`wts.setSunday(true);`
	`dts.setMinute(30);`
	`dts.setHour(4);`

`MonthlyByDayTaskScheduler`	Schedule a task to run every month (or every specified number of months) on a specified day at a specified time (hour and minutes). You can also set the interval property to run the task after a specified number of months. Example: Schedule a task to run every 3 months (on the last day of the month) at 12:30 p.m.

	`MonthlyByDayTaskScheduler mbdts =`
	`   new MonthlyByDayTaskScheduler();`
	`mbdts.setDay(31);`
	`mbdts.setInterval(3);`
	`mbdts.setMinute(30);`
	`mbdts.setHour(14);`

TaskScheduler Subtype	Usage

MonthlyByWeekdayTaskScheduler	Schedule a task to run every month (or every specified number of months) on a specified week, weekday, and time (hour: minutes). You can also set the interval property to run the task after a specified number of months.
	Example: Schedule a task to run on the last Wednesday of each month at 12:30 a.m.
	`MonthlyByWeekdayTaskScheduler mbwts =`
	`   new MonthlyByWeekdayTaskScheduler();`
	`mbwts.setOffset(WeekOfMonth.last);`
	`mbwts.setWeekday(DayOfWeek.wednesday);`
	`mbwts.setHour(4);`
	`mbwts.setMinute(30);`

The hour and minute properties of all objects that extend the RecurrentTaskSchedule data object are specified in Coordinated Universal Time (UTC) values rather than the local time of the server. When you define the schedule, convert your local time to a UTC value.

The following code fragment defines a ScheduledTask that powers on virtual machines daily at 4:15 a.m., if the server local time is in the Pacific Standard Time (PST) time zone. For a server in the Eastern European Summer Time (EEST) zone, the setting is read by the system as 3:15 pm.

Example: Scheduled Task for Powering-on Virtual Machines

```
...
// Set the schedule using the DailyTaskScheduler subtype.
DailyTaskScheduler dTScheduler = new DailyTaskScheduler();
dTScheduler.setHour(12);
dTScheduler.setMinute(15);
ScheduledTaskSpec tSpec = new ScheduledTaskSpec();
tSpec.setDescription("Start virtual machine as per schedule.");
tSpec.setEnabled(Boolean=TRUE);
tSpec.setName("Power On Virtual Machine");
tSpec.setAction(ma);
tSpec.setScheduler(dTScheduler);
tSpec.setNotification("admin@vmware.com");
my_conn.createScheduledTask(_sic.getScheduledTaskManager, vmRef, tSpec);
...
```

Cancelling a Scheduled Task

You can cancel a scheduled task in several ways.

- To cancel the current run of a scheduled task, call ScheduledTask.RemoveScheduledTask. This method does not cancel subsequent runs of the ScheduledTask.
- To cancel an upcoming run of a ScheduledTask, call ScheduledTask.ReconfigureScheduledTask with a new ScheduledTaskSpec data object containing the new specifications for the schedule.
- To cancel a ScheduledTask that spawns a second task, create a PropertyCollector to obtain the reference to the Tasks and call its CancelTask method. The task must be cancellable.

Using a TaskHistoryCollector

A TaskHistoryCollector lets you gather information about tasks. You create a TaskHistoryCollector using the TaskManager.CreateCollectorForTasks method.

To create a TaskHistoryCollector

1 Identify the type of Task objects that you want to collect, and create an instance of a TaskFilterSpec data object that specifies your filter criteria.

  The TaskFilterSpec includes an taskTypeId property, which you use to limit the set of collected task objects to specific types. You can also provide a time range in the TaskFilterSpec by defining an TaskFilterSpecByTime data object for its time property. See the *vSphere API Reference*.

2 Obtain the managed object reference to the TaskManager on your server instance.

3 Submit the filter and the reference to the server in the CreateTaskHistoryCollector method. The server returns a reference to a TaskHistoryCollector object.

After a HistoryCollector has been created, the server appends new objects that meet the filter criteria to the collection as they occur. The system appends the new object to the collection by placing it in the first position of the latestPage and removes the oldest object from the collection. The latestPage property of the TaskHistoryCollector object has a property that consists of the 1000 most recent objects in the collection. Use a PropertyCollector to obtain the items from the latestPage property.

A HistoryCollector exists only for the duration of the session that instantiated it. Call the HistoryCollector.DestroyCollector method to delete the collector before the session ends.

Creating a TaskHistoryCollector Filter

When you create a TaskHistoryCollector, you can define filters. For example, rather than returning all Task objects associated with virtual machines, you might create a filter to collect only Task objects associated with virtual machines that were executed by the backup-administrator between 2:00 and 4:00 a.m. on a specific date.

The TaskFilterSpec object allows you to specify the collection criteria. Most of the properties are optional and can be submitted as null values. The TaskFilterSpec lets you collect tasks based on user name, entity type, time, and state of the Task.

Managing the HistoryCollector

The HistoryCollector managed object provides operations for managing the life-cycle and scrollable view of a collection.

- DestroyCollector – A HistoryCollector exists only for the current session. Invoke the DestroyCollector operation to explicitly destroy the collector before the session ends.
- ResetCollector – Adjusts the starting position for the subset of objects from the collector to the object immediately preceding the current latestPage.

- `RewindCollector` – Positions the `latestPage` to the oldest item in the array. When a `HistoryCollector` is created, this is the default location.
- `SetCollectorPageSize` – Accepts an integer parameter to set the size of the `latestPage` property of a `HistoryCollector`. The default size of a `HistoryCollector` is an array that consists of at most 1000 objects of the appropriate type (`Task`, `Event`). The array is sorted by creation date and time of the objects.

Sample Code Reference

The following table lists the sample applications included with the vSphere SDK that demonstrate how to use some of the managed objects discussed in this chapter.

Java	C#
(SDK\vsphere-ws\java\JAXWS\samples\com\vmware\host)	(SDK\vsphere-ws\dotnet\cs\samples\)
AddVirtualNic.java	AddVirtualNic\AddVirtualNic.cs
	AddVirtualNic\AddVirtualNic.csproj
	AddVirtualNic\AddVirtualNic2008.csproj
	AddVirtualNic\AddVirtualNic2010.csproj
AddVirtualSwitch.java	AddVirtualSwitch\AddVirtualSwitch.cs
	AddVirtualSwitch\AddVirtualSwitch.csproj
	AddVirtualSwitch\AddVirtualSwitch2008.csproj
	AddVirtualSwitch\AddVirtualSwitch2010.csproj
AddVirtualSwitchPortGroup.java	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup.cs
	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup.csproj
	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup2008.csproj
	AddVirtualSwitchPortGroup\AddVirtualSwitchPortGroup2010.csproj
RemoveVirtualNic.java	RemoveVirtualNic\RemoveVirtualNic.cs
	RemoveVirtualNic\RemoveVirtualNic.csproj
	RemoveVirtualNic\RemoveVirtualNic2008.csproj
	RemoveVirtualNic\RemoveVirtualNic2010.csproj
RemoveVirtualSwitch.java	RemoveVirtualSwitch\RemoveVirtualSwitch.cs
	RemoveVirtualSwitch\RemoveVirtualSwitch.csproj
	RemoveVirtualSwitch\RemoveVirtualSwitch2008.csproj
	RemoveVirtualSwitch\RemoveVirtualSwitch2010.csproj
RemoveVirtualSwitchPortGroup.java	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup.cs
	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup.csproj

Java	C#
	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup2008.csproj
	RemoveVirtualSwitchPortGroup\RemoveVirtualSwitchPortGroup2010.csproj

Events and Alarms

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Events are sent by vSphere to convey information about things that happen in the system. You can monitor events directly or use an EventHistoryCollector to retrieve events from a certain period.

Alarms are sent by vSphere to alert users to problems. You can also create your own alarm to monitor the system and set up follow-up actions. Alarm setup includes specifying the trigger condition and defining the action that should result.

This chapter includes the following topics:

Event and Alarm Management Objects

EventManager is the service interface for working with the event infrastructure.

Event subtypes define the events that the system generates. See Event Data Objects and Creating Custom Events.

EventHistoryCollector allows you to monitor events. You can create a filter to limit the number of events your code retrieves. You can monitor both system events and your own events. See Using an EventHistoryCollector.

The AlarmManager is the service interface for creating, setting, and managing alarms. You create an alarm, specifying trigger conditions and the action to take. When the conditions defined for the Alarm occur on the system, the Action specified for the alarm starts. The alarm also generates an Event that you can retrieve with an EventHistoryCollector.

Understanding Events

An Event is a data object type that contains information about state changes of managed entities and other objects on the server. Events include user actions and system actions that occur on datacenters, datastores, clusters, hosts, resource pools, virtual machines, networks, and distributed virtual switches. For example, these common system activities generate one or more Event data objects:

- Powering a virtual machine on or off
- Creating a virtual machine
- Installing VMware Tools on the guest OS of a virtual machine
- Reconfiguring a compute resource
- Adding a newly configured ESXi system to a vCenter Server system

In the vSphere Client, information from Event objects generated on a standalone ESXi hosts displays in the Events tab. For managed hosts, information from Event objects displays in the Tasks & Events tab.

Persistence of Event objects depends on the system setup.

- Standalone ESXi hosts – Event objects are not persistent. Events are retained only for as long as the host system’s local memory can contain them. Rebooting a standalone ESXi host or powering off a virtual machine removes Event objects from local memory.

  A standalone ESXi host might keep about 15 minutes worth of Event data, but this can vary depending on the processing load of the host, the number of virtual machines, and other factors.

- Managed ESXi systems. Event objects are persistent. Managed ESXi systems send Event data to the vCenter Server system that manages them, and the vCenter Server system stores the information its database.

You can use the event sample applications included in the SDK package with either managed or standalone ESXi systems and with vCenter Server systems.

Using an EventHistoryCollector, you can obtain information about these objects as they are being collected on a specific ESXi system, or from a specific historical period from the database. See Using an EventHistoryCollector.

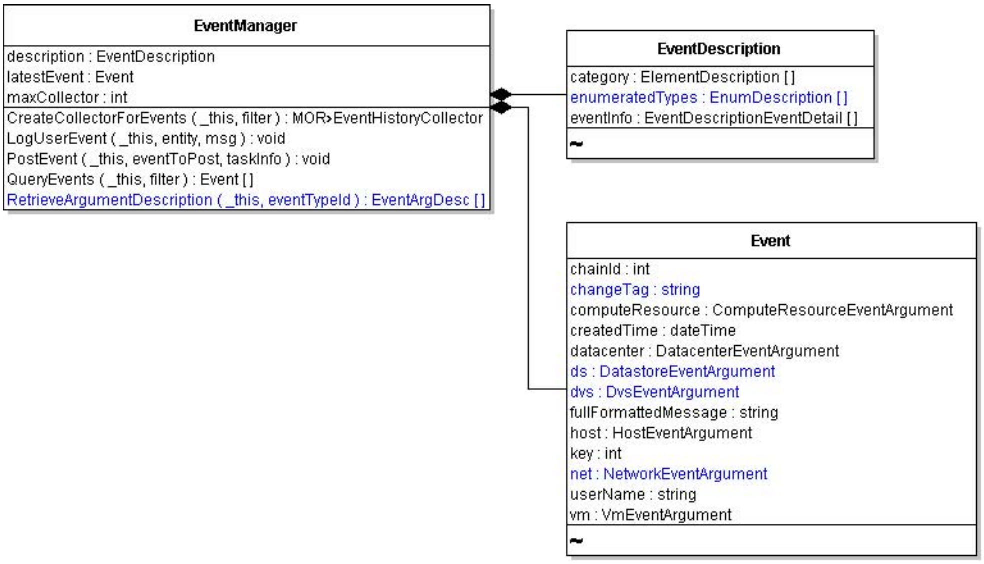
Managing Events with EventManager

EventManager is the service interface for working with the event infrastructure.

Figure 16-1 shows EventManager and related objects. An EventManager has these properties:

- A description property, defined as an instance of an EventDescription data object, which contains an event category and other information.
- A latestEvent property that contains the most recent Event data object in memory.
- A maxCollector property that specifies the number of EventHistoryCollector objects per client session that can be created. This value is set by the vCenter Server system.

Figure 16-1. EventManager Managed Object and Associated Objects


EventManager
description : EventDescription
latestEvent : Event
maxCollector : int
CreateCollectorForEvents (_this, filter) : MOR>EventHistoryCollector
LogUserEvent (_this, entity, msg) : void
PostEvent (_this, eventToPost, taskInfo) : void
QueryEvents (_this, filter) : Event [ ]
RetrieveArgumentDescription (_this, eventTypeId) : EventArgDesc [ ]
EventDescription
category : ElementDescription [ ]
enumeratedTypes : EnumDescription [ ]
eventInfo : EventDescriptionEventDetail [ ]
~
Event
chainId : int
changeTag : string
computeResource : ComputeResourceEventArgument
createdTime : dateTime
datacenter : DatacenterEventArgument
ds : DatastoreEventArgument
dvs : DvsEventArgument
fullFormattedMessage : string
host : HostEventArgument
key : int
net : NetworkEventArgument
userName : string
vm : VmEventArgument
~

Event Data Objects

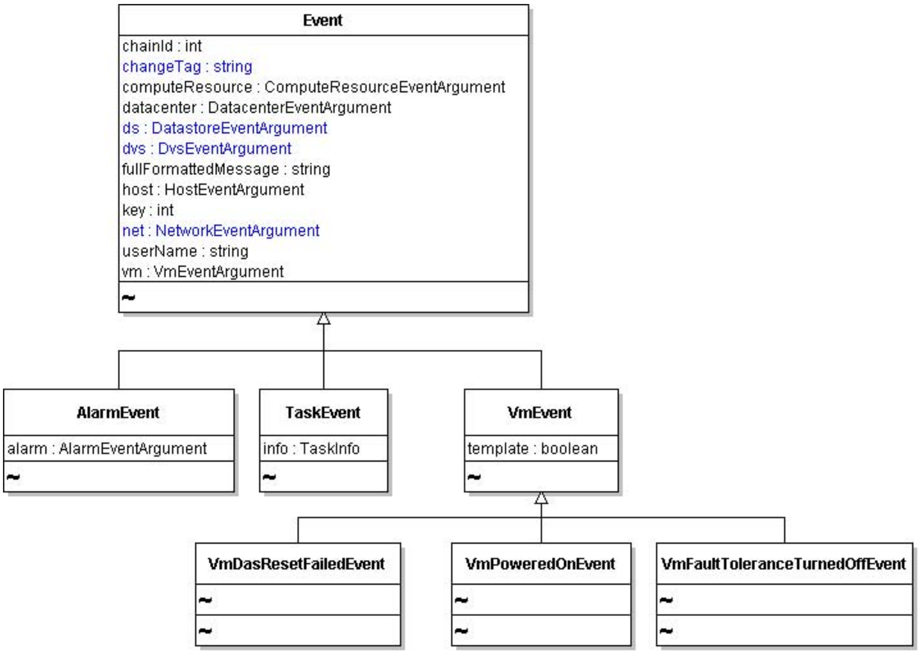
`Event` subtypes define the events that the system generates.

Figure 16-2 shows only a few of the subtypes that extend the `Event` data object. For example, `TaskEvent` inherits all `Event` properties and includes an `info` property that is an instance of a `TaskInfo` object (see Monitoring TaskInfo Properties).

The following event objects are commonly generated by a console-style client application:

```
com.vmware.vim.VmPoweredOnEvent
com.vmware.vim.VmStartingEvent
com.vmware.vim.VmReconfiguredEvent
com.vmware.vim.VmCreatedEvent
com.vmware.vim.VmBeingCreatedEvent
```

Figure 16-2. Event Data Object and Sample Subtypes



Formatting Event Message Content

When displayed at the console, `Event` data objects are not formatted and do not provide context information. You can format an `Event` message using the predefined string in the `Event.fullFormattedMessage` property.

You can also format an `Event` message based on contextual information. At runtime, the `Event` data object is populated with values that contain information associated with the source of an event, for example, the `Event` data object's `computeResource`, `datacenter`, `ds`, `dvs`, `host`, `net`, and `vm` properties.

You can use the properties of an `Event` object with the information in the `EventDescriptionEventDetail` in `EventManager.description.eventInfo` to format event messages.

Creating Custom Events

The Web Services API allows you to create custom Event objects that convey information specific to your application. There are two types of custom events, the user log event and the extended event.

Creating User Log Events

The `EventManager.LogUserEvent` method allows you to create user log `Event` objects. You can associate your custom `Event` with any managed entity. User log events are useful for marking actions or status associated with the objects your application deals with.

The following steps show how to create a user log Event.

Procedure

1 Obtain the managed object reference to the `EventManager`.

```
..
ManagedObjectReference _svcRef = new ManagedObjectReference();
ServiceContent _sic = my_conn.retrieveServiceContent(_svcRef);
ManagedObjectReference eMgrRef = _sic.getEventManager();
...
```

2 Obtain the managed object reference to the entity with which you are associating the `Event`.

For example, suppose you have a reference to a virtual machine (`myVMRef`) and you want to log a message to record the fact that a virus check completed. You want to use `myVMRef` as a parameter to the `LogUserEvent` method in the next step.

3 Call the `LogUserEvent` method, passing in the `EventManager` and the `Event` reference and a string consisting of the Event message for the `msg` parameter of the operation.

```
LogUserEvent(eMgrRef, myVMRef, "Completed virus check at 1:05 AM on Sunday December 21.");
```

User-defined Event objects display in the vSphere Client among the other events on the system, with the prefix User logged event: followed by the text submitted in your `msg` parameter. In other client applications, such as in the console-based Event sample applications, custom events display as `com.vmware.vim.GeneralUserEvent` objects.

Creating Extended Events

The `EventManager.EventEx` method allows you to create an event that contains an arbitrary dictionary of key-value pairs. This kind of custom event allows greater flexibility to store application data that is not associated with a managed entity, and is not limited to a single string value. The custom event structure also contains more sophisticated metadata than user log events.

The following steps show pseudocode examples of the operations you need to do in your client code.

Procedure

1 Obtain the managed object reference to the `EventManager`.

```
si = connection.retrieveServiceContent(svc_ref);
em = si.eventManager;
```

2 Choose a severity for the custom event.

```
severity = EventEventSeverity.warning;
```

3. Create a local copy of an extended event with metadata.

   ```
   e = vim.event.EventEx(severity,
                         eventTypeId=”com.example.events.Total_System_Backup”,
                         createdTime = si.CurrentTime(),
                         chainId=0,
                         key=0,
                         userName=local_account_name);
   ```

4. Create a set of key-value pairs to store the information you want to associate with the event.

   ```
   arg_list = {};
   arg1 = vmodl.KeyAnyValue(key=”reason”, value=”Upcoming governance audit”);
   arg2 = vmodl.KeyAnyValue(key=”datacenter”, value=”Washington South”);
   arg3 = vmodl.KeyAnyValue(key=”organization”, value=”IT Cloud Services”);
   arg_list.append(arg1, arg2, arg3);
   ```

5. Add the set of key-value pairs to the event object.

   ```
   e.arguments = arg_list;
   ```

6. Use the Event Manager to post the event to the server.

   ```
   em.PostEvent(e);
   ```

Using an EventHistoryCollector

An `EventHistoryCollector` lets you gather information about events that the server has generated. You create an `EventHistoryCollector` using the `EventManager.CreateCollectorForEvents` method.

The following steps show how to create an `EventHistoryCollector`.

Procedure

1. Identify the type of `Event` objects that you want to collect, and create an instance of an `EventFilterSpec` data object that specifies your filter criteria. See Creating an EventHistoryCollector Filter.

   The `EventFilterSpec` includes an `eventTypeId` property, which you use to limit the set of collected event objects to specific types. You can also provide a time range in the `EventFilterSpec`, by defining an `EventFilterSpecByTime` data object for its `time` property. See the *vSphere API Reference* for details.

2. Obtain the managed object reference to the `EventManager` on your server instance.

3. Submit the `filter` and the reference to the server in the `CreateEventHistoryCollector` operation. The server returns a reference to an `EventHistoryCollector` object.

After you have created the HistoryCollector, the server appends new objects that meet the filter criteria to the collection as they occur. The system appends the new object to the collection by placing it in the first position of the latestPage and it removes the oldest object from the collection. The latestPage property of the EventHistoryCollector object has a property that consists of the 1000 most recent objects in the collection. Use a PropertyCollector to obtain the items from the latestPage property.

A HistoryCollector exists only for the duration of the session that instantiated it. You invoke the DestroyCollector operation to explicitly eliminate the collector before the session ends.

Creating an EventHistoryCollector Filter

When you create an EventHistoryCollector, you can define filters. For example, rather than returning all Event objects associated with virtual machines, you might create a filter to collect only those Event objects associated with virtual machines that were executed by the backup-administrator between 2:00 and 4:00 a.m. on a specific date.

The EventFilterSpec object allows you to specify the collection criteria. Most of the properties are optional and can be submitted as null values. The EventFilterSpec lets you collect events based on user name, entity type, time, and state of the Event.

Managing the HistoryCollector

The HistoryCollector managed object provides operations for managing the life-cycle and scrollable view of a collection.

- DestroyCollector – A HistoryCollector exists only for the current session. Invoke the DestroyCollector operation to explicitly destroy the collector before the session ends.
- ResetCollector – Adjusts the starting position for the subset of objects from the collector to the object immediately preceding the current latestPage.
- RewindCollector – Positions the latestPage to the oldest item in the array. When a HistoryCollector is created, this is the default location.
- SetCollectorPageSize – Accepts an integer parameter to set the size of the latestPage property of a HistoryCollector. The default size of a HistoryCollector is an array that consists of at most 1000 objects of the appropriate type (Task, Event). The array is sorted by creation date and time of the objects.

Using Alarms

The vSphere alarm infrastructure supports automating actions and sending different types of notification in response to certain server conditions. Many Alarms exist by default on vCenter Server systems. You can also create alarms yourself. For example, an Alarm can send an alert email message when CPU usage on a specific virtual machine exceeds 99% for more than 30 minutes.

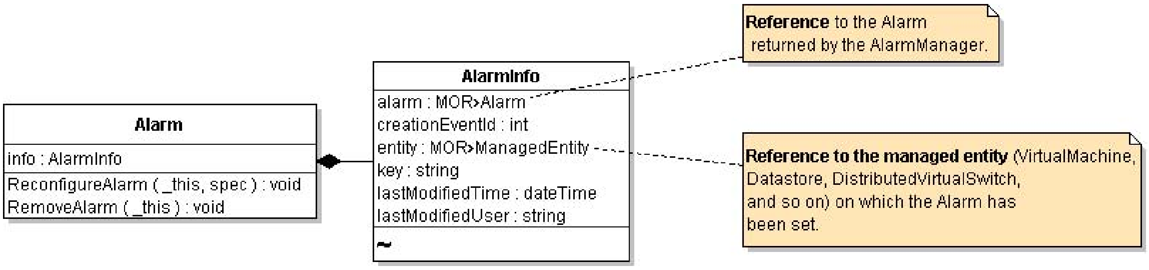
The alarm infrastructure integrates with other server components, such as events and performance counters.

The AlarmManager is the service interface for creating, setting, and managing alarms. You create an alarm, specifying trigger conditions and the action to take. When the conditions defined for the Alarm occur on the system, the Action specified for the alarm starts. The alarm also generates an Event that is posted to the Event history database. In addition, the action initiated by the Alarm might also post a second Event to the database, depending on the Action type.

Obtaining a List of Alarms

Use the AlarmManager.GetAlarm method to obtain an array of references to all Alarm managed objects defined for a specific managed entity. When you call the method, you can pass in an optional reference to a managed entity. Without a reference to a managed entity, the GetAlarm operation returns all Alarm objects for all entities that are visible to the principal associated with the session invoking the operation.

Figure 16-3. Alarm Managed Object


Alarm
info : AlarmInfo
ReconfigureAlarm (_this, spec) : void
RemoveAlarm (_this) : void
AlarmInfo
alarm : MOR>Alarm
creationEventId : int
entity : MOR>ManagedEntity
key : string
lastModifiedTime : dateTime
lastModifiedUser : string
~
Reference to the Alarm returned by the AlarmManager.
Reference to the managed entity (VirtualMachine, Datastore, DistributedVirtualSwitch, and so on) on which the Alarm has been set.

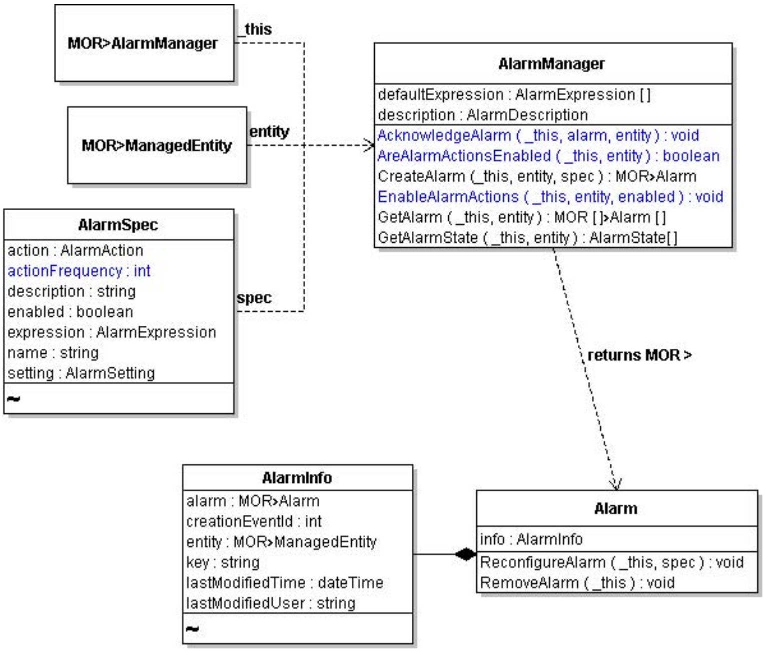
The Alarm.info property is an AlarmInfo data object. You can obtain information about active Alarms by collecting the properties of the AlarmInfo data object.

Creating an Alarm

You create an alarm with the AlarmManager.CreateAlarm method. In the simplest case, you specify the trigger condition in the AlarmSpec.expression property and the action to perform in the AlarmSpec.action property. When the expression evaluates to true, the alarm performs the action.

Figure 16-4 shows the CreateAlarm method.

Figure 16-4. CreateAlarm Method Inputs and Outputs


MOR>AlarmManager
_this
MOR>ManagedEntity
entity
AlarmSpec
action : AlarmAction
actionFrequency : int
description : string
enabled : boolean
expression : AlarmExpression
name : string
setting : AlarmSetting
~
spec
AlarmManager
defaultExpression : AlarmExpression [ ]
description : AlarmDescription
AcknowledgeAlarm (_this, alarm, entity) : void
AreAlarmActionsEnabled (_this, entity) : boolean
CreateAlarm (_this, entity, spec) : MOR>Alarm
EnableAlarmActions (_this, entity, enabled) : void
GetAlarm (_this, entity) : MOR [ ]>Alarm [ ]
GetAlarmState (_this, entity) : AlarmState[ ]
returns MOR >
AlarmInfo
alarm : MOR>Alarm
creationEventId : int
entity : MOR>ManagedEntity
key : string
lastModifiedTime : dateTime
lastModifiedUser : string
~
Alarm
info : AlarmInfo
ReconfigureAlarm (_this, spec) : void
RemoveAlarm (_this) : void

The following steps show how to create an alarm.

Procedure

1 Obtain a managed object reference to the `AlarmManager` associated with the vCenter Server.

2 Obtain a managed object reference of the entity on which you want to set the `Alarm`.

3 Create an `AlarmSpec` data object and specify the alarm details in its properties. See Defining Alarms Using the AlarmSpec Data Object.

4 Call `AlarmManager.CreateAlarm`, passing in the references and the `AlarmSpec` data object. The system returns a managed object reference to the `Alarm` (see Figure 16-4).

The state of an alarm is contained in an `AlarmState` data object.

Defining Alarms Using the AlarmSpec Data Object

The `AlarmSpec` data object has properties for all aspects of an `Alarm`, including its expression and the action to take when the expression evaluates to true. The following properties define the alarm; see the *API Reference* for a complete list.

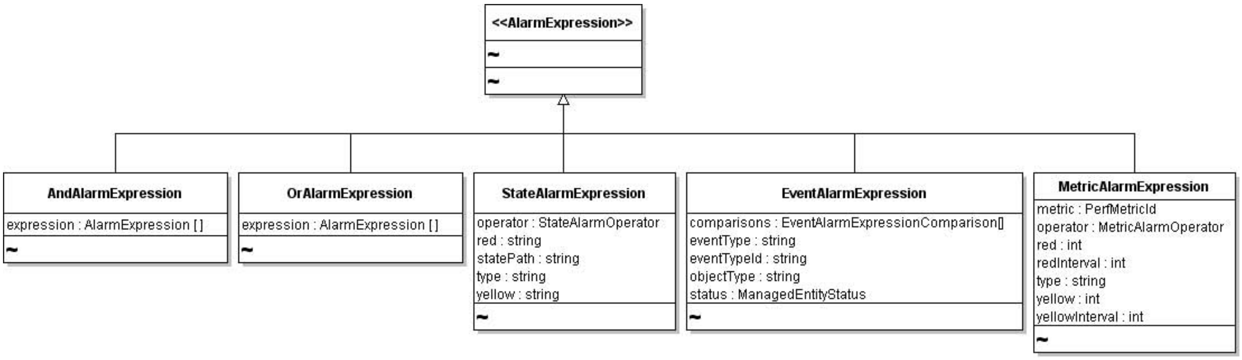
- `action` – Action to initiate when the `Alarm` becomes active. Specify one of the `Action` subtypes. See Specifying Alarm Actions.
- `actionFrequency` – Number of seconds that the `Alarm` remains in the state required to initiate the specified action.
- `expression` – One or more `AlarmExpression` data objects combined in a way that evaluates to a true-false expression. See Specifying Alarm Trigger Conditions with AlarmExpression.

- setting – Tolerance and frequency limits for the Alarm defined in the AlarmSetting data object. AlarmSetting contains two integer properties:
  - reportingFrequency, which specifies the number of seconds between activation of an alarm. Use 0 to specify that the alarm can activate as frequently as required.
  - toleranceRange, which specifies the acceptable range (measured in hundredth percentage) above and below the specified value defined in a MetricAlarmExpression.

Specifying Alarm Trigger Conditions with AlarmExpression

You use the AlarmExpression data object to specify the conditions under which you want the Alarm to become active. The AlarmExpression data object is an abstract type with several subtypes, which allow you to specify thresholds on objects, state of objects, or specify specific events to monitor.

Figure 16-5. AlarmExpression and Its Subtypes



AlarmExpression Types

By using the appropriate type of AlarmExpression, you can set alarms for different conditions, states, or events.

AlarmExpression	Description	Example
StateAlarmExpression	Specifies thresholds that trigger the alarm.	Triggered by a power state change of a virtual machine or state change of a distributed virtual switch.
MetricAlarmExpression	Specifies levels at which the alarm changes state. See Using MetricAlarmExpression.	Triggered when resource utilization metrics exceed a specified limit.
EventAlarmExpression	Specifies a type of event as the basis for the alarm.	Triggered by power on or power off events of primary or secondary virtual machines in a fault-tolerant cluster.
EventAlarmComparison	Specifies the property of the Event that should trigger the alarm and the operator to use as the basis for comparison.	
AndAlarmExpression OrAlarmExpression	Combines one or more instances of the AndAlarmExpression and the OrAlarmExpression data objects into an expression that evaluates to true or false.	

Using MetricAlarmExpression

The MetricAlarmExpression data object lets you set an alarm to monitor performance metrics. The vSphere Client uses the data object to indicate when hosts or clusters do not have sufficient resources in a DAS or DRS cluster environment. See the *Resource Management Guide.*

You set the metric property to the PerfMetricId of a performance metric that you want to monitor on the system. Set the red or yellow properties to identify the level at which the metric value moves from green, to yellow, to red. You must define red, yellow, or both properties. Use each of these properties with the isAbove or isBelow MetricAlarmOperator enumerations to complete the definition of the threshold.

In conjunction with red and yellow properties, you can use the redInterval or yellowInterval properties. These properties enable you to set the number of seconds that the performance metric must be in red or yellow state before the expression becomes true and triggers the defined action.

Specifying Alarm Actions

You specify the actions that the system should take by setting the action property of the AlarmSpec data object to the AlarmAction data object defined for the purpose.

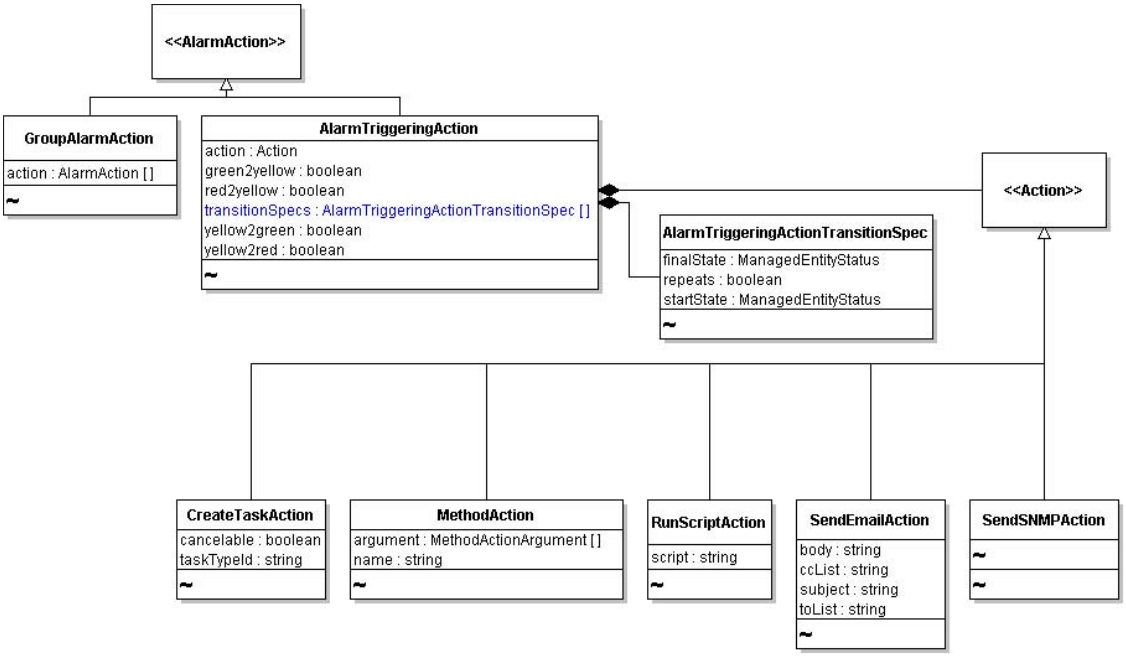
The AlarmAction data object is an abstract type that has two descendent objects.

- The AlarmTriggeringAction data object has an action property and a transitionSpecs property. AlarmTriggeringActionTransitionSpec allows you to define a starting state and a final state for the Alarm. You can limit the number of Alarm objects actually triggered to a single Alarm by specifying false for the repeats property of the AlarmTriggeringActionTransitionSpec.
- The GroupAlarmAction data object is an array version of the AlarmAction base type. You can create a single AlarmAction instance or an array of AlarmAction instances to take effect when the conditions specified for your alarm are met on the system.

The system can respond to an alarm in several ways:

- Invoking an operation. To invoke an operation, create a MethodAction data object.
- Running a Script. To run a script, create an instance of the RunScriptAction data object that specifies the fully qualified path to the shell script on the vCenter Server.
- Send an email message. To send an email message to a system administrator, use the SendEmailAction data object.

Figure 16-6. AlarmAction and Related Objects



For example, you can use the `MethodAction` data object type to invoke an operation on the server. The `MethodAction` data object contains the following properties:

- `name`—Name of the operation that you want to invoke at the scheduled time.
- `argument`—Specifies required parameters, if any, as an array of `MethodArgumentAction` data objects.

  Depending on the entity associated with the alarm, the `MethodAction.argument` property might not be needed.

Deleting or Disabling an Alarm

An `Alarm` remains active until you delete it or disable it. To delete the alarm, obtain a managed object reference to the `Alarm` and invoke its `RemoveAlarm` operation.

To disable the `Alarm`, obtain managed object references to the `AlarmManager` and to the entity on which the `Alarm` is set. Call `AlarmManager.EnableAlarmActions` operation, passing the value `false` for the `enabled` parameter.

Sample Code Reference

The following table lists the sample applications included with the vSphere Web Services SDK that demonstrate some of the topics discussed in this chapter.

Java	C#
\samples\alarms\MPowerStateAlarm.java	VMPowerStateAlarm
\samples\events\EventFormat.java	EventFormat

Java	C#
`\samples\events\EventHistoryCollectorMonitor.java`	`EventHistoryCollectorMonitor`
`\samples\events\VMEventHistoryCollectorMonitor.java`	`VMEventHistoryCollectorMonitor`

17 vSphere Performance

VMware vSphere servers use performance counters to track resource use. At runtime, vSphere components generate performance data which the vSphere servers store in performance counters. You can use the `PerformanceManager` interface to retrieve the data.

This chapter includes the following topics:

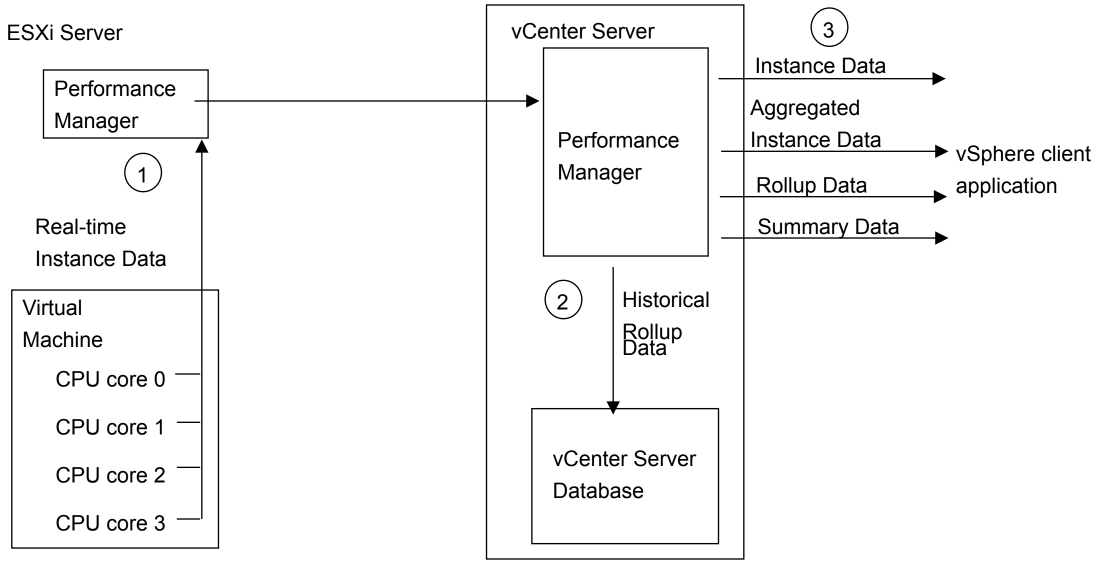
vSphere Performance Data Collection

In a vSphere environment, virtual and physical components generate performance data. To track the use of resources, ESXi Servers perform real-time data collection and vCenter Servers store the data in the vCenter database. vCenter Servers also store a historical rollup of the data according to defined performance intervals.

- Real-time data collection – An ESXi Server collects data for each performance counter every 20 seconds and maintains that data for one hour.
- Historical data rollup – A vCenter Server collects data from all of the hosts that the vCenter Server manages. The `PerformanceManager` defines performance intervals that specify time periods for performance data rollup, a methodology for combining data values. The server stores the rolled up performance counter data in the vCenter database.

The following figure represents vSphere performance data collection and retrieval.

Figure 17-1. vSphere Performance Data Collection and Retrieval



1 ESXi Servers sample performance counter instances every 20 seconds and maintain the real-time instance data for one hour. For example, the figure shows collection of CPU statistics for four CPU cores.

2 The vCenter Server retrieves and stores data from the servers that it manages. The Server produces rollup data according to the settings of the historical intervals.

3 vSphere client applications can retrieve real-time instance data, aggregated instance data, historical rollup data, and summary data.

The following table defines terms that are used to describe vSphere performance management.

Term	Definition
performance providers	Performance providers include managed entities, such as hosts, virtual machines, compute resources, resource pools, datastores, and networks.
performance counter	Unit of statistical data collected on a vSphere server. For example, a vCenter server collects the average CPU utilization for hosts, virtual machines and clusters (the counter `cpu.usage.average`).
counter ID	System-generated identifier for a performance counter.
instance	An identifier derived from device configuration names. Examples of counter instances are the name of a virtual Ethernet adapter such as “vmnic0:”, or a number that identifies a CPU core, such as 0, 1, 2, or 3. Performance data is retrieved as specific instances of performance counters.
instance data	Performance data collected at 20-second intervals.

Term	Definition
metric ID	Combination of a counter ID and an instance. You use metric IDs – `PerfMetricId` objects – when you construct a performance query specification to identify the data to be collected. There are two system-defined instances that you can use to specify aggregate retrieval. See the description of aggregate performance data below. ■ "*" – An asterisk directs the vSphere Server to return all instances plus rollup data. This is not supported for some disk-related counters. ■ "" – A string of length zero directs the vSphere Server to return only aggregated instance data or rollup type data. The vSphere Server returns metric IDs embedded in the data objects that it returns as a response to performance queries.
performance interval	Data object (`PerfInterval`) which defines the time interval between collection events, the collection level, and the time period that the data will be stored on the Server. ■ ESXi Servers define a built-in performance interval that specifies data collection every 20 seconds for each performance counter. ESXi Servers also define a single historical interval (`PerformanceManager.historicalInterval`) that defines aggregate performance data. This system-defined performance interval specifies aggregate data collection every 300 seconds for each counter. You cannot modify the performance intervals on an ESXi Server. ■ vCenter Servers define four performance intervals that determine how collected instance data is aggregated and stored. You can modify the system-defined intervals on a vCenter Server to a limited extent.
collection level	Number between one and four that is assigned to a performance interval (`PerformanceManager.historicalInterval[].level`). The interval collection level corresponds to the level specified for individual performance counters (`PerfCounterInfo.level`). A vCenter Server uses a performance interval to perform performance data aggregation, using data for the counters with levels that match the performance interval collection level.
rollup type	Methodology for producing a single value from a set of statistical values (`PerformanceManager.perfCounter[].rollupType`). Examples of rollup types are average, latest, and summation.
aggregate performance data	A single value that represents a set of instance data values collected for a performance counter. The single value is derived using one of the rollup types.

PerformanceManager Objects and Methods

`PerformanceManager` provides methods for obtaining statistical data about various aspects of system performance, as generated and maintained by the performance providers. It also defines historical performance intervals and it identifies the set of performance counters that you can use to obtain performance data. The following table shows the `PerformanceManager` properties.

Property	Description
description	Composite object that includes information about the types of counters (`counterType`) and statistics (`statsType`) available on the system.
historicalInterval	Array of system-defined performance intervals (`PerfInterval` data objects). Each object defines the interval between rollup events, the collection level, and the time period that the data is stored on the system. ■ For an ESXi system, the array contains a single performance interval. You cannot modify the ESXi performance interval. ■ For vCenter Server systems, the `PerfInterval` objects control how ESXi performance data are rolled up and stored in the database. You can modify some of the `PerfInterval` properties on a vCenter Server.
perfCounter	Array of `PerfCounterInfo` data objects. The array identifies all of the performance counters known to the vCenter Server at the time a client accesses the array. The set of counters may change as ESXi hosts are added or removed from vCenter management. Each `PerfCounterInfo` object contains metadata associated with a performance counter.

The `PerformanceManager` methods allow you to retrieve performance statistics and to retrieve metadata that defines the statistics. The following table classifies the methods and describes their purposes.

Method Type	Method	Purpose
Performance data availability	QueryAvailablePerfMetric	Returns `PerfMetricId` objects which identify the counter data available on the specified entity. For example, a virtual machine provides the memory counter `granted`, which indicates the amount of physical memory that is mapped for the virtual machine. The `PerfMetricId` object for the `mem.granted.average` counter specifies the system-defined counter ID. Since this is a memory counter, the `PerfMetricId.instance` property is empty.
Performance data retrieval	QueryPerf	Returns statistics for a specific list of managed entities that provide performance data.
	QueryPerfComposite	Returns statistics for a host and its virtual machines. This method accepts the `refreshRate` for current statistics or the `intervalId` of one of the historical intervals as a parameter. Supported for the `HostSystem` managed entity only.
Performance counter metadata retrieval	QueryPerfCounter	Returns `PerfCounterInfo` data objects for the specified list of counter IDs.
	QueryPerfCounterByLevel	Returns `PerfCounterInfo` data objects for the specified collection level.
Performance provider information	QueryPerfProviderSummary	Returns the `PerfProviderSummary` data object for the specified managed object.
Collection parameters	ResetCounterLevelMapping	Restores a set of performance counters to their default collection levels.

Method Type	Method	Purpose
	UpdateCounterLevelMapping	Changes the collection level for a set of performance counters.
	UpdatePerfInterval	Modifies the system-defined performance intervals.

Retrieving vSphere Performance Data

To retrieve collected data, your client application creates a query specification and passes the specification to a performance query method. The query specification is composed of one or more `PerfQuerySpec` objects. Each object identifies the following:

- Performance provider – managed entity for which the Server will return performance data (`PerfQuerySpec.entity`).
- Performance counters – `PerfMetricId` objects that identify performance counter instances (`PerfQuerySpec.metricId`).
- Performance interval – the sampling period that defines the data rollup (`PerfQuerySpec.intervalId`).
- Amount of data to be returned – start and end times (`PerfQuerySpec.startTime`, `PerfQuerySpec.endTime`) and maximum number of values (`PerfQuerySpec.maxSample`) to limit the amount of data to be returned.
- Output data format (`PerfQuerySpec.format`) – one of two kinds:
  - Normal output returned as values contained in data objects.
  - Formatted output returned as strings containing comma-separated values.

The combination of the `entity` and `metricID` properties determine the set of counters for which the server will return performance data. The combination of the `interval`, `startTime`, `endTime` properties produce instance, aggregated instance, rollup, or summarized data. The following table summarizes the different classifications of performance data that you can retrieve from a vCenter Server.

Performance Data	Description
Instance	ESXi Servers sample performance data every 20 seconds. 20-second interval data is called instance data or real-time data. To retrieve instance data, specify a value of 20 seconds for the `PerfQuerySpec.intervalId` property.
Aggregated Instance	A vSphere client can retrieve aggregated instance data. To obtain aggregated instance data, specify the following `PerfQuerySpec` properties. ■ `intervalId` – Specify 20 seconds to indicate instance data. ■ `metricId[].instance` – specify a zero-length string ("") for aggregated instance data.

Performance Data	Description
Rollup	The vCenter Server uses the historical intervals to rollup performance data from the servers that it manages. To retrieve historical performance data, specify the following PerfQuerySpec properties. ■ intervalId – Specify a value that corresponds to one of the historical intervals (PerformanceManager.historicalInterval[].samplingPeriod) . ■ startTime/endTime – If specified, use time values that are not within the last 30 minutes of the current time. If you do not specify a starting time, the Server will return values starting with the earliest data. If you do not specify an end time, the Server will return values that include the latest data.
Summary	When you call the QueryPerf method and specify a performance interval (PerfQuerySpec.intervalId) that does not match one of the historical intervals (PerformanceManager.historicalInterval[].samplingPeriod), the Server will attempt to summarize the stored data for the specified interval. In this case, the Server may return values that are different from the values that were stored for the historical intervals.

Performance Counter Example (QueryPerf)

The following code fragments are part of an example that uses the PerformanceManager.QueryPerf method to obtain performance statistics for a virtual machine.

The example code in this section does not include server connection code and it does not show the code for obtaining the managed object reference for the virtual machine. See Chapter 3 Client Applications for the Web Services API for an example of server connection code.

This example retrieves the following statistics:

- disk.provisioned.LATEST – virtual machine storage capacity.
- mem.granted.AVERAGE – amount of physical memory mapped for the virtual machine.
- power.power.AVERAGE – current power usage.

The example creates a query specification (PerfQuerySpec) to identify the data to be retrieved, calls the QueryPerf method, and prints out the retrieved performance data and corresponding performance counter metadata. The following sections describe the basic steps involved in retrieving performance statistics.

- Map the performance counters – Mapping Performance Counters (Counter Ids and Metadata).
- Create a performance query specification and call the QueryPerf method – Retrieving Statistics.
- Process the returned data – Handling Returned Performance Data.

Mapping Performance Counters (Counter Ids and Metadata)

Performance counters are represented by string names, for example disk.provisioned.LATEST or mem.granted.AVERAGE. A vSphere server tracks performance counters by using system-generated counter IDs. When you create a performance query, you use counter IDs to specify the statistics to be retrieved, so it is useful to map the names to IDs.

The example must specify counter IDs in the calls to `QueryPerf`, and it will use performance counter metadata when it prints information about the returned data. To obtain performance counter IDs and the corresponding performance counter metadata, the example creates two hash maps. This example maps the entire set of performance counters to support retrieval of any counter.

HashMap Declarations

The following code fragment declares two hash maps.

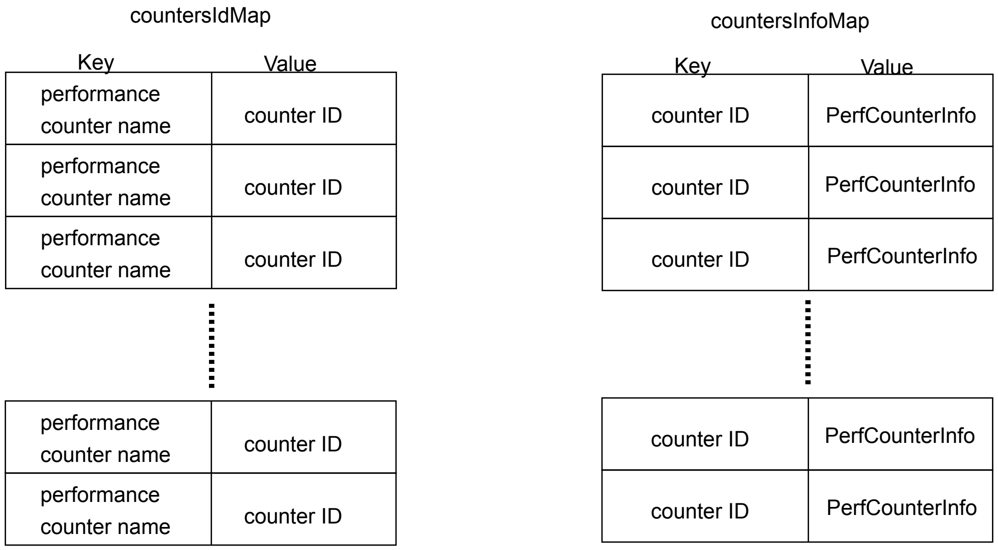
- `countersIdMap` – Uses full counter names to index performance counter IDs. A full counter name is the combination of counter group, name, and rollup type. The example uses this map to obtain counter IDs when it builds the performance query specification.
- `countersInfoMap` – Uses performance counter IDs to index `PerformanceCounterInfo` data objects. The example uses this map to obtain metadata when it prints the returned performance data.

```
/*
 * Map of counter IDs indexed by counter name.
 * The full counter name is the hash key – group.name.ROLLUP–TYPE.
 */
private static HashMap<String, Integer> countersIdMap = new HashMap<String, Integer>();

/*
 * Map of performance counter data (PerfCounterInfo) indexed by counter ID
 * (PerfCounterInfo.key property).
 */
private static HashMap<Integer, PerfCounterInfo> countersInfoMap =
    new HashMap<Integer, PerfCounterInfo>();
```

The following figure shows a representation of the hash maps.

Figure 17-2. Performance Counter Hash Maps



Creating the Map

The example uses the Property Collector to retrieve the array of performance counters (`PerfCounterInfo`) known to the vCenter Server (`PerformanceManager.perfCounter[]`). It then uses the data to create the maps. The code fragment uses the variable `apiMethods`, which is a `VimPortType` object that provides access to the vSphere API methods. For information about the `VimPortType` object, see Overview of a Java Sample Application for the Web Services SDK.

The following code fragment performs these steps:

1. Create an `ObjectSpec` to define the property collector context. This example specifies the Performance Manager.
2. Create a `PropertySpec` to identify the property to be retrieved. This example retrieves the `perfCounter` property, which is an array of `PerfCounterInfo` objects.
3. Create a `PropertyFilterSpec` for the call to the `PropertyCollector`. The `PropertyFilterSpec` creates the association between the `ObjectSpec` and `PropertySpec` for the operation.
4. Call the `PropertyCollector.RetrievePropertiesEx` method. This method blocks until the server returns the requested property data.
5. Cast the returned `xsd:anyType` value into the array of `PerfCounterInfo` objects.
6. Cycle through the returned array and load the maps. The counter-name to counter-ID map uses a fully qualified counter name. The qualified name is a path consisting of counter group, counter name, and rollup type – *group.counter.ROLLUP-TYPE* The rollup type must be coded in uppercase letters. Examples of qualified names are `disk.provisioned.LATEST` and `mem.granted.AVERAGE`.

```
/*
 * Create an object spec to define the context to retrieve the PerformanceManager property.
 */
ObjectSpec oSpec = new ObjectSpec();
oSpec.setObj(performanceMgrRef);

/*
 * Specify the property for retrieval
 * (PerformanceManager.perfCounter is the list of counters the vCenter Server is aware of.)
 */
PropertySpec pSpec = new PropertySpec();
pSpec.setType("PerformanceManager");
pSpec.getPathSet().add("perfCounter");

/*
 * Create a PropertyFilterSpec and add the object and property specs to it.
 */
PropertyFilterSpec fSpec = new PropertyFilterSpec();
fSpec.getObjectSet().add(oSpec);
fSpec.getPropSet().add(pSpec);

/*
 * Create a list for the filter and add the spec to it.
 */
List<PropertyFilterSpec> fSpecList = new ArrayList<PropertyFilterSpec>();
```

```
fSpecList.add(fSpec);

/*
 * Get the performance counters from the server.
 */
RetrieveOptions ro = new RetrieveOptions();
RetrieveResult props = apiMethods.retrievePropertiesEx(pCollectorRef,fSpecList,ro);

/*
 * Turn the retrieved results into an array of PerfCounterInfo.
 */
List<PerfCounterInfo> perfCounters = new ArrayList<PerfCounterInfo>();
if (props != null) {
   for (ObjectContent oc : props.getObjects()) {
      List<DynamicProperty> dps = oc.getPropSet();
      if (dps != null) {
         for (DynamicProperty dp : dps) {
            /*

/*
 * Cycle through the PerfCounterInfo objects and load the maps.
 */
             *  DynamicProperty.val is an xsd:anyType value to be cast
             *  to an ArrayOfPerfCounterInfo and assigned to a List<PerfCounterInfo>.
             */
            perfCounters = ((ArrayOfPerfCounterInfo)dp.getVal()).getPerfCounterInfo();
         }
      }
   }
}
for(PerfCounterInfo perfCounter : perfCounters) {
   Integer counterId = new Integer(perfCounter.getKey());

   /*
    * This map uses the counter ID to index performance counter metadata.
    */
   countersInfoMap.put(counterId, perfCounter);

   /*
    * Obtain the name components and construct the full counter name,
    * for example – power.power.AVERAGE.
    * This map uses the full counter name to index counter IDs.
    */
   String counterGroup = perfCounter.getGroupInfo().getKey();
   String counterName = perfCounter.getNameInfo().getKey();
   String counterRollupType = perfCounter.getRollupType().toString();
   String fullCounterName = counterGroup + "." + counterName + "." + counterRollupType;

   /*
    * Store the counter ID in a map indexed by the full counter name.
    */
   countersIdMap.put(fullCounterName, counterId);

}
```

Retrieving Statistics

The following code fragment calls the `QueryPerf` method to retrieve statistics. It performs these tasks:

Procedure

1. Create a list of qualified performance counter names for retrieval. The name is a path consisting of *group-name.counter-name.ROLLUP-TYPE*, for example `mem.granted.AVERAGE`. The rollup type must be coded in uppercase letters to match the character case of the rollup type in the performance counter metadata (`PerfCounterInfo.rollupType`). See the *vSphere API Reference* for tables of available counters. The *vSphere API Reference* page for the `PerformanceManager` managed object contains links to the tables.
2. Create a list of `PerfMetricId` objects, one for each counter to be retrieved. The metric ID is a combination of the counter ID and the instance. To fill in the `PerfMetricId` properties, the example does the following:
   - Use the `countersIdMap` to translate a full counter name into a counter ID.
   - Specify an asterisk (*) for the `PerfMetricId.instance` property. The asterisk is the system-defined instance specification for combined instance and rollup retrieval.
3. Build a query specification for the method call. This query specifies the following:
   - Virtual machine for which performance data is being retrieved (`entityMor`);
   - Interval ID of 300 to collect 5-minute rollup data.
   - Comma-separated value (CSV) format for the retrieved data.
4. Call the `QueryPerf` method.

```
/*
 * Use <group>.<name>.<ROLLUP-TYPE> path specification to identify counters.
 */
String[] counterNames = new String[] {"disk.provisioned.LATEST",
                                      "mem.granted.AVERAGE",
                                      "power.power.AVERAGE"};

/*
 * Create the list of PerfMetricIds, one for each counter.
 */
List<PerfMetricId> perfMetricIds = new ArrayList<PerfMetricId>();
for(int i = 0; i < counterNames.length; i++) {
   /*
    * Create the PerfMetricId object for the counterName.
    * Use an asterisk to select all metrics associated with counterId (instances and rollup).
    */
   PerfMetricId metricId = new PerfMetricId();
   /* Get the ID for this counter. */
   metricId.setCounterId(countersIdMap.get(counterNames[i]));
   metricId.setInstance("*");
   perfMetricIds.add(metricId);
}
```

```
/*
 * Create the query specification for queryPerf().
 * Specify 5 minute rollup interval and CSV output format.
 */
int intervalId = 300;
PerfQuerySpec querySpecification = new PerfQuerySpec();
querySpecification.setEntity(
querySpecification.setIntervalId(intervalId);
querySpecification.setFormat("csv");
querySpecification.getMetricId().addAll(perfMetricIds);

List<PerfQuerySpec> pqsList = new ArrayList<PerfQuerySpec>();
pqsList.add(querySpecification);

/*
 * Call queryPerf()
 *
 * QueryPerf() returns the statistics specified by the provided
 * PerfQuerySpec objects. When specified statistics are unavailable –
 * for example, when the counter doesn't exist on the target
 * ManagedEntity – QueryPerf() returns null for that counter.
 */
List<PerfEntityMetricBase> retrievedStats = apiMethods.queryPerf(performanceMgrRef, pqsList);
```

Performance Data Returned by a vSphere Server

The query methods return sampling information and performance data. The sampling information indicates the collection interval in seconds and the time that the data was collected. When you call performance query methods, you pass in query specifications (`PerfQuerySpec`) to identify the performance data to be retrieved. To indicate the format of the output data, specify either "`normal`" or "`csv`" for the `PerfQuerySpec.format` property.

The query methods return `PerfEntityMetricBase` objects which you must cast into the appropriate type that corresponds to the `PerfQuerySpec.format` value specified in the call to the method.

- The `QueryPerf` method returns a list of `PerfEntityMetricBase` objects.
- The `QueryPerfComposite` method returns a `PerfCompositeMetric` object, which contains `PerfEntityMetricBase` objects.

Normal Output Format

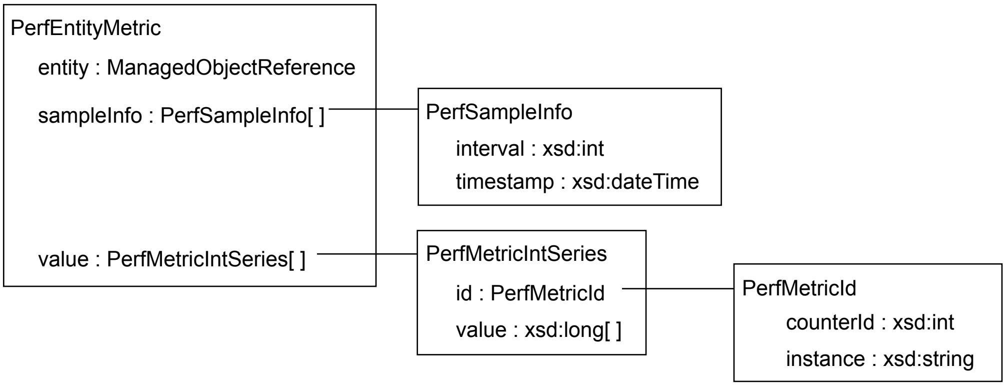
When you specify "`normal`" format, you must cast the returned `PerfEntityMetricBase` objects into `PerfEntityMetric` objects. Each `PerfEntityMetric` object contains the following properties:

- `entity` – Reference to the performance provider.
- `sampleInfo` – Array of sample information (`PerfSampleInfo` data objects), encoded as `xsd:int` and `xsd:dateTime` values.

- value – Array of data values (PerfMetricIntSeries data objects). Each object in the array contains the following properties:
  - id – Performance metric ID that identifies the counter instance.
  - value – Array of integers that corresponds to the array of sample information (PerfEntityMetric.sampleInfo).

The following figure shows a representation of the data object hierarchy returned by the query methods for normal format.

Figure 17-3. PerfEntityMetric Object Hierarchy



CSV Output Format

When you specify "csv" format, you must cast the returned PerfEntityMetricBase objects into PerfEntityMetricCSV objects. Both the sampling information and the collected data are encoded as comma-separated values suitable for display in tabular format.

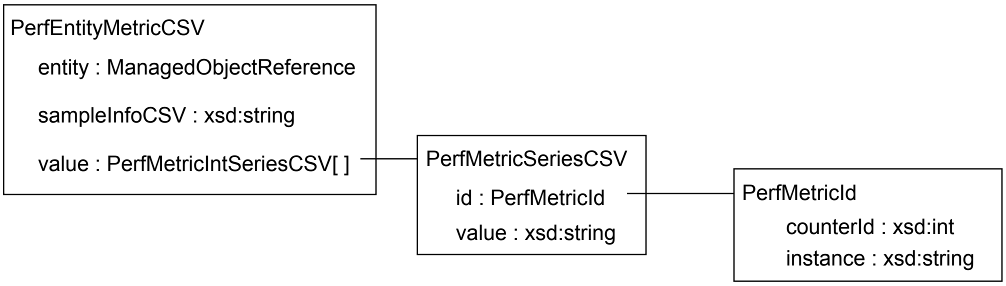
The PerfEntityMetricCSV object contains the following properties:

- entity – Reference to the performance provider.
- sampleInfoCSV – String containing a set of interval and date-time values. The property contains string representations of PerfSampleInfo xsd:int and xsd:dateTime values. The string values are encoded in the following CSV format:

  interval1, *date1*, *interval2*, *date2*
- value – Array of data values (PerfMetricSeriesCSV data objects). Each object in the array contains the following properties:
  - id – Performance metric ID that identifies the counter instance.
  - value – Set of sample values in CSV format, corresponding to the list of sample information (PerfEntityMetricCSV.sampleInfoCSV).

The following figure shows a representation of the data object hierarchy returned by the query methods for CSV format.

Figure 17-4. PerfEntityMetricCSV Object Hierarchy



Handling Returned Performance Data

The following code fragment prints out the returned performance data. This example uses CSV formatted data. The code fragment performs these tasks:

- Loop through the list of `PerfEntityMetricBase` objects returned by the `QueryPerf` method (`retrievedStats`).
  - Cast the `PerfEntityMetricBase` object to a `PerfEntityMetricCSV` object to handle the CSV output specified in the `PerfQuerySpec`.
  - Retrieve the sampled values.
  - Retrieve the interval information (`csvTimeInfoAboutStats`). The `sampleInfoCSV` string (`PerfEntityMetricCSV.sampleInfoCSV`) is `PerfSampleInfo` data formatted as interval,time pairs separated by commas – `interval-1,time-1,interval-2,time-2`. The list of pairs embedded in the string corresponds to the list of sampled values (`PerfEntityMetricCSV.value[]`).
  - Print the time and interval information.
  - Loop through the sampled values (`metricsValues`).
    - Use the counter metadata to print out identifying information about the counter along with the returned sampled value for the counter.
    - Use the `countersInfoMap` to translate the counter ID returned in the `PerfMetricSeriesCSV` object into the corresponding `PerfCounterInfo` object.

```
/*
 * Cycle through the PerfEntityMetricBase objects. Each object contains
 * a set of statistics for a single ManagedEntity.
 */
for(PerfEntityMetricBase singleEntityPerfStats : retrievedStats) {

  /*
   * Cast the base type (PerfEntityMetricBase) to the csv-specific sub-class.
   */
  PerfEntityMetricCSV entityStatsCsv = (PerfEntityMetricCSV)singleEntityPerfStats;

  /* Retrieve the list of sampled values. */
  List<PerfMetricSeriesCSV> metricsValues = entityStatsCsv.getValue();
  if(metricsValues.isEmpty()) {
    System.out.println("No stats retrieved. " +
                       "Check whether the virtual machine is powered on.");
          throw new Exception();
  }

  /*
   * Retrieve time interval information (PerfEntityMetricCSV.sampleInfoCSV).
   */
  String csvTimeInfoAboutStats = entityStatsCsv.getSampleInfoCSV();

  /* Print the time and interval information. */
  System.out.println("Collection: interval (seconds),time (yyyy-mm-ddThh:mm:ssZ)");
  System.out.println(csvTimeInfoAboutStats);

  /*
   * Cycle through the PerfMetricSeriesCSV objects. Each object contains
   * statistics for a single counter on the ManagedEntity.
   */
  for(PerfMetricSeriesCSV csv : metricsValues) {
    /*
     * Use the counterId to obtain the associated PerfCounterInfo object
     */
    PerfCounterInfo pci = countersInfoMap.get(csv.getId().getCounterId());

    /* Print out the metadata for the counter. */
    System.out.println("----------------------------------------");
    System.out.println(pci.getGroupInfo().getKey() + "."
                       + pci.getNameInfo().getKey() + "."
                       + pci.getRollupType() + " - "
                       + pci.getUnitInfo().getKey());
    System.out.println("Instance: "+csv.getId().getInstance());
    System.out.println("Values: " + csv.getValue());
  }
}
```

Large-Scale Performance Data Retrieval

The example described in the previous sections shows how to retrieve performance data for a single entity. When you design your application to retrieve performance data on a large scale, take the following information into consideration for more efficient processing.

- Use CSV formatted output. CSV format provides a more compact representation of the output data which can save on meta-data overhead.
- Create query specifications to reference a set of vSphere entities.
  - Using one QueryPerf method call per entity is not efficient.
  - Using a single call to QueryPerf to retrieve all of the performance data is not efficient.
  - As a general rule, specify between 10 and 50 entities in a single call to the QueryPerf method. This is a general recommendation because your system configuration may impose different constraints.

- Do not retrieve statistics more frequently than they are refreshed. For example, when you retrieve 20-second interval data, the data will not change until the next 20-second data collection event.
- Use QueryAvailablePerfMetric only when you intend to send a query for a specific counter using a specific performance interval. The method will return PerfMetricId objects that you can use for the query.

  In all other cases, create the PerfMetricId objects for the query.

  - For the counterId property, use the counter IDs from the PerformanceManager counter list (PerformanceManager.perfCounter[].key).
  - For the instance property, specify an asterisk ("*") to retrieve instance and aggregate data or a zero-length string ("") to retrieve aggregate data only.

Using the QueryPerf Method as a Raw Data Feed

The QueryPerf method can operate as a raw data feed that bypasses the vCenter database and instead retrieves performance data from an ESXi host. You can use a raw data feed to obtain real-time instance data associated with 20-second interval collection and aggregate data associated with the 5-minute intervals.

You can use a raw data feed on vCenter Server 2.5 and later.

Performance Interval	Description
20-second	ESXi servers collect data for each performance counter every 20 seconds and maintain that data for an hour. When you specify a 20-second interval in the query specification for the QueryPerf method (PerfQuerySpec.intervalId), the method operates as a raw data feed. The Server ignores the historical interval collection levels and retrieves data for all of the requested counters from the ESXi servers. When you send a query for 20-second instance data, the server returns the most recent data collected for the 20-second interval. The server does not perform additional, unscheduled data collection to satisfy the query.
5-minute	ESXi servers aggregate performance data according to the system-defined performance interval which specifies data collection every 300 seconds. To use a raw data feed for this data, specify the following PerfQuerySpec properties in the call to the QueryPerf method. ■ intervalId – Specify 300 seconds to match the system-defined performance interval. ■ startTime/endTime – Specify time values within the last 30 minutes of the current time. The QueryPerf method checks the performance interval collection level on the vCenter Server. The method returns aggregated statistics for performance counters that specify a collection level (PerfCounterInfo.level) at or below the vCenter Server performance interval for the 300 second sampling period (PerfInterval.level). For example, if the vCenter Server performance interval is set to level one, and your query specification requests only performance counters that specify level four, the QueryPerf method will not return any data.

Comparison of Query Methods

The following table presents a comparison of performance query methods.

Method	Notes
QueryPerf	- Specify an array of PerfQuerySpec objects. - An unset PerfQuerySpec.metricId property produces results for all counters defined for PerfQuerySpec.entity. - PerfQuerySpec.maxSample is ignored for historical statistics. You can use this method to retrieve historical statistics; you can also use it as a raw data feed. For information about retrieving the raw data collected on ESXi servers, see Using the QueryPerf Method as a Raw Data Feed.
QueryPerfComposite	- Method works only at the host level. You can use a single call to the QueryPerfComposite method to retrieve performance data for a host and its virtual machines. - Specify a single PerfQuerySpec object. - You must specify a list of performance metrics to identify the data to be retrieved (PerfQuerySpec.metricId). - You cannot specify PerfQuerySpec.maxSample. This method is designed for efficient client-server communications. QueryPerfComposite usually generates less network traffic than QueryPerf because it returns a large-grained object, a PerfCompositeMetric data object, that contains all the data.

Retrieving Summary Performance Data

You can obtain near real-time summary information about performance or utilization without using the PerformanceManager methods. vSphere servers maintain "quick stats" data objects for hosts (HostListSummaryQuickStats), virtual machines (VirtualMachineQuickStats), and resource pools (ResourcePoolQuickStats). For more information about these objects, see the *vSphere API Reference*.

Performance Counter Metadata

Performance counters are organized by groups of system resources. Examples of performance counter groups are memory, CPU, and disk. The counter groups and specific counters used on any vSphere server depend on the server configuration. The *vSphere API Reference* contains a table for each counter group. The table includes the counter name, type of statistics being collected, unit of measurement, level, and so on. The *vSphere API Reference* page for the PerformanceManager managed object contains links to the tables.

PerfCounterInfo

The PerformanceManager.perfCounter property is an array of PerfCounterInfo data objects. Each object provides metadata for the collected data. A PerfCounterInfo object has a unique key, the counter ID. The actual performance data collected at runtime are identified by this counter ID. The following table lists the PerfCounterInfo properties.

Property	Description
`groupInfo`	Name of the resource group to which this counter belongs, such as disk, cpu, or memory.
`key`	Unique integer that identifies the counter. Also called the counter ID. The value is unique and it is not static—it might, for example, change between system reboots. The counter key on an ESXi system might not be the same as the counter key for the same counter on the vCenter Server system managing the ESXi system. However, the system maps the keys from ESXi to vCenter Server systems automatically.
`level`	Number from 1 to 4 that identifies the level at which data values for this counter are aggregated.
`nameInfo`	Descriptive name for the counter. The name component of a fully qualified counter name, for example `"granted"` is the `nameInfo` property for the `mem.granted.AVERAGE` counter.
`rollupType`	Indicates how multiple samples of a counter are transformed into a single statistical value. Examples of rollup types are average, summation, and minimum. No conversion of values occurs for counters that specify absolute values, such as the total number of seconds that the system has been running continuously since startup. The `PerfSummaryType` is an enumeration containing valid constants for this property.
`statsType`	Type of statistical data that the value represents over the course of the interval, such as an average, a rate, the minimum value, and so on. The `PerfStatsType` is an enumeration containing valid constants for this property.
`unitInfo`	Unit of measure, such as megahertz, kilobytes, kilobytes per second, and so on. The `ElementDescription`’s `key` property is populated using one of the constants available in the `PerformanceManagerUnit` enumeration.

Performance Intervals

The `PerformanceManager` defines performance intervals which specify the period of time between collection events, how much data will be collected, and how long the collected data will be saved.

- An ESXi server has a built-in performance interval that produces discrete data values from counter instances sampled every 20 seconds. The server will maintain this instance data for one hour.
- Additional data collection is specified by historical performance intervals which produce data aggregated from counter instances according to the individual intervals.

The `PerformanceManager.historicalInterval` property is an array of `PerfInterval` objects. The following table lists the `PerfInterval` properties.

Property	Description
samplingPeriod	Number of seconds for the interval. You can modify this property on a vCenter Server only.
length	Period of time for which the server will save the data that it collects. You can modify this property on a vCenter Server only.
level	Level at which the Server collects data. The interval level corresponds to the performance counter level (`PerfCounterInfo.level`). The Server will collect data for all counters with levels that match `PerfInterval.level`, and for all counters with levels lower than `PerfInterval.level`. You can modify this property on a vCenter Server only.
enable	Enable/disable performance data collection. You can modify this property on a vCenter Server only.

Property	Description
key	Unique identifier for the interval. You cannot modify this property.
name	Label for the historical interval; one of the following strings: ■ `"Past Day"` ■ `"Past Week"` ■ `"Past Month"` ■ `"Past Year"` The `PerformanceManager` uses the `samplingPeriod`, `level`, and `length` properties to determine its collection behavior. It does not interpret the name string. You cannot modify this property.

ESXi Server Performance Intervals

An ESXi server collects performance data for each performance counter every 20 seconds. The `PerformanceManager.historicalInterval` array for an ESXi Server contains a single, readonly `PerfInterval` object that specifies rollup data collection every 5 minutes. You cannot retrieve 5-minute rollup data from an ESXi Server directly. You can use a vCenter Server connection to obtain 5-minute rollup data for an ESXi Server. The following table shows the historical interval property values on an ESXi server. You cannot modify this performance interval.

Property	Value	Description
`key`	`1`	Numeric identifier for the `PerfInterval`.
`name`	`PastDay`	Name of the `PerfInterval`.
`samplingPeriod`	`300`	Time interval between data sampling events.
`length`	`129600`	Number of seconds that statistics associated with the interval are kept by the vCenter Server.
`enabled`	`true`	This `PerfInterval` is enabled on the system.
`level`	`null`	Statistics collection level. For an ESXi system, this property is `null`. The `PerfInterval` object on an ESXi system defines the baseline interval.

vCenter Server Performance Intervals

A vCenter Server system aggregates performance data from all ESXi systems that it manages. The amount of data aggregated depends on the level setting configured for the vCenter Server. The level settings are reflected in the `PerformanceManager.historicalInterval` property for the vCenter Server system. `historicalInterval` is an array of `PerfInterval` data objects that define four different level settings, 1 through 4.

The following table lists the default values for the performance intervals on a vCenter Server system.

Key	Name	Sampling Period	Length	Enabled	Level
1	Past Day	300	86400	TRUE	1
2	Past Week	1800	604800	TRUE	1

Key	Name	Sampling Period	Length	Enabled	Level
3	Past Month	7200	2592000	TRUE	1
4	Past Year	86400	31536000	TRUE	1

By default, the collection level is set to 1 for each of the four intervals. Using the default level, a vCenter Server will collect data for all performance counters that specify collection level 1. Using the default length value, a vCenter Server will save collection data for the following time periods:

- 5-minute samples for the past day
- 30-minute samples for the past week
- 2-hour samples for the past month
- 1-day samples for the past year

Data older than a year is purged from the vCenter Server database.

vSphere Performance and Data Storage

The following sections provide information about modifying the operation of the PerformanceManager and vSphere Server performance data collection and storage.

- Modifying Historical Intervals
- Modifying Performance Counter Collection Levels

Modifying Historical Intervals

Changes to a vCenter performance interval are global and apply to all entities in the system. VMware recommends that you do not modify the historical intervals. The PerfInterval data objects in the PerformanceManager.historicalInterval array are related. Modifications to a performance interval affects the entire system and may cause problems.

If you must modify a performance interval, use the PerformanceManager.UpdatePerfInterval method and follow these guidelines.

- Performance data retention time (PerfInterval.length) must be a multiple of the collection interval (PerfInterval.samplingPeriod).
- Performance data retention length must increase in each interval compared to its predecessor. The PerfInterval.length value for each successive performance interval must be greater than the length property for the previous interval in the historical interval array.
- You cannot modify the value of the PerfInterval.samplingPeriod property on ESXi systems.

Modifying Performance Counter Collection Levels

The `PerformanceManager` provides the `UpdateCounterLevelMapping` method to change the collection level for individual performance counters (`PerfCounterInfo.level`). Consider carefully the performance and storage consequences of using the `UpdateCounterLevelMapping` method. If you use this method, you may cause a significant increase in data collection and storage, along with a corresponding decrease in performance. vCenter Server performance and database storage requirements depend on the collection levels defined for the performance intervals (`PerformanceManager.historicalInterval`) and the collection levels specified for individual performance counters (`PerfCounterInfo.level`).

Performance Counter Data Collection

vSphere defines four levels of data collection for performance counters. Each performance counter specifies a level for collection. The historical performance intervals (`PerformanceManger.historicalInterval`) define the sampling period and length for a particular collection level.

The amount of data collected for a performance counter depends on the performance interval and on the type of entity for which the counter is defined. For example, a datastore counter such as `datastoreIops` (the aggregate number of IO operations on the datastore) will generate a data set that corresponds to the number of datastores on a host. If a vCenter Server manages a large number of hosts with a large number of datastores, the Server will collect a large amount of data.

There are other counters for which the vCenter Server collects a relatively smaller amount of data. For example, memory counters are collected as a single counter per virtual machine and a single counter per host.

Performance Counter Data Storage

The performance interval collection level (`PerfInterval.level`) defines the set of counters for which the vCenter Server stores performance data. The Server will store data for counters at the specified level and for counters at all lower levels.

By default, all the performance intervals specify collection level one. Using these defaults, the vCenter Server stores performance counter data in the vCenter database for all counters that specify collection level one. It does not store data for counters that specify collection levels two through four.

Performance Manager Method Interaction

You can use the `UpdateCounterLevelMapping` method to change the collection level for individual counters. You can also use the `UpdatePerfLevel` method to change the collection level for the system-defined performance intervals. These methods can cause a significant increase in the amount of data collected and stored in the vCenter database.

- By default the system-defined performance intervals use collection level one, storing data for all counters that specify collection level one. If you use the `UpdateCounterLevelMapping` method to change the collection level of performance counters to level one, you will increase the amount of stored performance data.

- If you use the UpdatePerfLevel method to increase the collection level for the system-defined performance intervals, you will increase the amount of stored performance data.

To restore counter levels to default settings use the ResetCounterLevelMapping method.

vSphere Client Management of Performance Statistics

The vSphere Client displays the Performance Manager historical interval collection levels in the vCenter management statistics display. The vSphere Client also displays an estimate of the amount of storage that is required for data collection at the displayed levels. If individual counter levels are modified through the vSphere API (the UpdateCounterLevelMapping method), the vSphere Client will show a modified estimate. However, the vSphere Client cannot detect that the method has been called and it cannot display the current levels for individual counters. If you see a significantly increased estimate for storage, be aware that someone may have used the vSphere API to modify data collection.

Sample Code Reference

The following table lists the sample applications included with the vSphere Web Services SDK that demonstrate some of the topics discussed in this chapter.

Java **(SDK\vsphere-ws\java\JAX-WS\samples\com\vmware\performance)**	**C#** **(SDK\vsphere-ws\dotnet\cs\samples\)**
Basics.java	Basics\Basics.cs
	Basics\Basics.csproj
	Basics\Basics2008.csproj
	Basics\Basics2010.csproj
History.java	History\History.cs
	History\History.csproj
	History\History2008.csproj
	History\History2010.csproj
PrintCounters.java	PrintCounters\PrintCounters.cs
	PrintCounters\PrintCounters.csproj
	PrintCounters\PrintCounters2008.csproj
	PrintCounters\PrintCounters2010.csproj
	QueryMemoryOverhead\QueryMemoryOverhead.cs
	QueryMemoryOverhead\QueryMemoryOverhead.csproj
	QueryMemoryOverhead\QueryMemoryOverhead2008.csproj
	QueryMemoryOverhead\QueryMemoryOverhead2010.csproj
RealTime.java	RealTime\RealTime.cs

Java (SDK\vsphere-ws\java\JAX-WS\samples\com\vmware\performance)	C# (SDK\vsphere-ws\dotnet\cs\samples\)
	`RealTime\RealTime.csproj`
	`RealTime\RealTime2008.csproj`
	`RealTime\RealTime2010.csproj`
`VITop.java`	
`VIUsage.java`	

Diagnostics and Troubleshooting 18

vSphere includes several logs, which you can access and customize. You can also use the `DiagnosticManager` service interface for troubleshooting.

This chapter includes the following topics:

Troubleshooting Best Practices

Approach troubleshooting and problem-solving systematically, and take notes so you can trace your steps. Follow these guidelines to resolve issues with your client application.

- Do not change more than one thing at a time, and document each change and its result. Try to isolate the problem: Does it seem to be local, to the client? An error message generated from the server? A network problem between client and server?
- Use the logging facilities for your programming language to capture runtime information for the client application. See the `Log.cs` sample application as an example.
  - C# client logging example: `\SDK\vsphere-ws\dotnet\cs\samples\AppUtil\Log.cs`
- Use the following VMware tools for analysis and to facilitate debugging.
  - vSphere Web Services API. The `DiagnosticManager` service interface allows you to obtain information from the server log files, and to create a diagnostic bundle that contains all system log files and all server configuration information. The vSphere Client and the MOB provide graphical and Web based access to the `DiagnosticManager`. `PerformanceManager` supports exploration of bottlenecks. See #unique_430.
  - Managed Object Browser (MOB). The MOB provides direct access to live runtime server-side objects. You can use the MOB to explore the object hierarchy, obtain property values, and invoke methods. See #unique_431.

- VMware vSphere Client GUI. The vSphere Client allows you to examine log files for ESXi, vCenter Server, and virtual machines, and to change log level settings. Use vSphere Client menu commands to create reports that summarize configuration information, performance, and other details, and to export diagnostic bundles. The vSphere Client maintains its own local log files.

Overview of Configuration Files and Log Files

ESXi and vCenter Server configuration files control the behavior of the system. Most configuration file settings are set during installation, but can be modified after installation. Log files capture messages generated by the kernel and different subsystems and services. ESXi and vCenter Server services maintain separate log files. The following table lists log files or reports, their locations and associated configuration files.

Description	Log Location	Filename or Names	Configuration File
ESXi service log	/var/log/vmware/	hostd.log [hostd-0.log, ...hostd-9.log]	config.xml
vCenter Server agent log	/var/log/vmware/vpx/	vpxa.log	
Virtual machine kernel core file	/root/	vmkernel-core.<date> vmkernel-log.<date>	syslog.conf, logrotate.conf, various other
syslogd log	/var/log/	messages [messages.1,... messages.4]	syslog.conf, logrotate.conf
Service console availability report	/var/log/	vmkernel [vmkernel.1, ... vmkernel.8]	syslog.conf, logrotate.conf
VMkernel messages, alerts, and availability reports	/var/log/vmkernel		syslog.conf, logrotate.conf
VMkernel warning	/var/log/	vmkwarning [vmkwarning. 1 ... 4 for history]	syslog.conf, logrotate.conf
Virtual machine log file	vmfs/volume/<vm_name>	vmware.log	<vm_name>/<vm_name>.vmx

For developers, the following files are most relevant:

- hostd.log – Host daemon log, see ESXi Log File. Can be used as a SOAP monitor when set to trivia log level as in Generating Logs.
- vpxa.log – Agent log file found on each managed ESXi system.
- vmware.log – Virtual machine log. See Virtual Machine Log Files.

In addition to viewing log files in real time you can also generate reports and complete diagnostic bundles. See Generating Diagnostic Bundles.

ESXi Log File

The ESXi log (`hostd.log`) captures information of varying specificity and detail, depending on the log level. Each request to the server is logged.

You can view the file using the vSphere Client. The raw text form of an ESXi (`hostd`) log file is shown in Example: Sample ESXi Log (hostd.log) Data.

Example: Sample ESXi Log (`hostd.log`) Data

```
...
[2008-05-07 09:50:04.857 'SOAP' 2260 trivia] Received soap response from [TCP:myservername.vmware.com:
443]: GetInterfaceVersion
[2008-05-07 09:50:04.857 'ClientConnection' 2260 info] UFAD interface version is vmware-converter-4.0.0
[2008-05-07 09:50:04.857 'SOAP' 2260 trivia] Sending soap request to [TCP:myservername.eng.vmware.com:
443]: logout
[2008-05-07 09:50:04.857 'ProxySvc Req00588' 3136 trivia] Client HTTP stream read error
[2008-05-07 09:50:04.872 'ProxySvc Req00612' 3136 trivia] Request header:
POST /vmc/sdk HTTP/1.1
User-Agent: VMware-client
Content-Length: 435
Content-Type: text/xml; charset=utf-8
Cookie: vmware_soap_session="F127B435-56C7-4580-BAC4-3034DA1E67B6"; $Path=/
Host: myservername.vmware.com


[2008-05-07 09:50:04.872 'ProxySvc Req00588' 3816 trivia] Closed
[2008-05-07 09:50:08.450 'App' 3560 verbose] [VpxdHeartbeat] Invalid heartbeat from 10.17.218.46
[2008-05-07 09:50:10.013 'App' 3560 verbose] [VpxdHeartbeat] Queuing 10.17.218.45:829 (host-55)
[2008-05-07 09:50:10.013 'App' 1928 verbose] [HeartbeatHandler] 50208862-2752-d94c-2a73-fa2ec9e38ecc:
829 (host-55)
```

Virtual Machine Log Files

Each running virtual machine has its own log file, `vmware.log`, stored on the VMFS volume. By default, the log file is rotated whenever the virtual machine is powered on, but file rotation is configurable.

- ESXi maintains six log files that rotate at each power-cycle (the default) or at a configured file size.
- ESXi can be configured to maintain a specific number of log files. When the limit is reached, the oldest file is deleted.
- VMware recommends a log file size of 500 KB.
- Messages that are generated by VMware Tools are logged separately.

Example: VMkernel Availability Report

```
Availability Report for <servername>
Feb 27, 2008 - May  7, 2008

Availability: 99.949%
```

```
     Total time: 69 days, 15 hours
     Uptime: 69 days, 14 hours
     Downtime: 51 minutes

Note: Downtime is any time the system isn't capable of running
Virtual Machines.  This includes reboots, crashes, configuration and running linux

Downtime Analysis:
     0.1% (51 minutes) downtime caused by:
     13.1% (6 minutes) scheduled downtime
     86.9% (44 minutes) unscheduled downtime

Reasons for scheduled downtime:
     84.9% server rebooting (1 instance)
     9.4% VMkernel unloaded (1 instance)
     5.7% server booting (3 instances)

Reasons for unscheduled downtime:
100.0% unknown (powerfail / reset?) (1 instance)

Stats:
     Current uptime: 8 days, 11 hours
     Longest uptime: 61 days, 2 hours
     Shortest uptime: 38 minutes
     Average uptime: 23 days, 4 hours
     Longest downtime: 44 minutes
     Shortest downtime: 7 seconds
     Average downtime: 8 minutes
     Maximum VMs Sampled:  1
     Average VMs Sampled: 0.94

Server Information:   Number of CPUs:  4 logical 4 cores
      2 packages,  Intel(R) Xeon(R) CPU            5150  @ 2.66GHz
        Installed Memory:     2096416 kB
        Current Build:  78591
Report generated Wed May  7 04:02:04 PDT 2008
```

vCenter Server Log Files

vCenter Server log files are located by default in the Documents and Settings subdirectory of the Windows account used to install the software. For example:

`C:\Documents and Settings\Administrator\Local Settings\Application Data\VMware\`

Important VMware recommends creating a user account especially for vCenter Server installation.

By default, the log files are hidden files. See the procedure for your Windows operating system to make the files visible.

Modifying the Log Level to Obtain Detailed Information

The amount of information captured in the log files varies, depending on the level setting.

Log Level Setting	Description
None	Disables logging.
Error	Logging limited to error messages.
Warning	Error messages plus warning messages are logged.
Info	Default setting on ESXi and vCenter Server systems. Errors, warnings, plus informational messages about normal operations are logged. Acceptable for production environments.
Verbose	Can facilitate troubleshooting and debugging. Not recommended for production environments.
Trivia	Extended verbose logging. Provides complete detail, including content of all SOAP messages between client and server. Use for debugging and to facilitate client application development only. Not recommended for production environments.

For example, the `hostd` service running on ESXi systems has a default log level setting of `info`. The vCenter Server logs are controlled by settings through the vSphere Client.

Setting the Log Level on ESXi Systems

The default log level setting for the ESXi Host Agent is `info`. If you run into issues during development, you can set the log level to `verbose`, or to `trivia` to obtain SOAP message content to use in debugging.

To change the log level for hostd on an ESXi system, use the following steps.

Procedure

1. Connect to the ESXi system using the vSphere Client.
2. On the **Host > Manage** screen, select the **System** tab.
3. On the **System** tab screen, select **Advanced Settings**.
4. Scroll to find the `Config.HostAgent.log.level` setting.

   By default this setting is `info`.
5. Select the `Config.HostAgent.log.level` setting and click **Edit option**.

   A dialog box opens, where you can enter a new setting.
6. Use the drop-down menu to select a new setting, such as **Verbose**, and click **Save**.

   The **Recent Tasks** pane updates to confirm that the change completed.

After the service restarts, the new log level is in effect.

Generating Logs

If you are connected to ESXi by SSH, you can use the `tail` command to explicitly create a log file that captures detail about actions that follow. For example, you can use the vSphere Client to create a new virtual machine and then use the content from the log as a model for how to create your own code.

To start the logging process and capture content to a file, use the following steps.

Procedure

1. Navigate to the location of the `hostd.log` file:

   ```
   cd /var/log/vmware
   ```

2. Run the `tail` command, passing a filename in which to capture output:

   ```
   tail -f hostd.log > yourfilenamehere
   ```

3. Use the vSphere Client to perform whatever action you are having difficulty modeling in your own code. For example, create a new virtual machine and stop the `tail` process with Ctrl-C when the operation completes.

The file contains the SOAP message content and other log messages sent and received by `hostd` during the execution.

Setting the Log Level on vCenter Server Systems

To change log-level settings on vCenter Server, you must use the vSphere Client.

To set logging level for vCenter Server using the VMware vSphere Client, use the following steps.

Procedure

1. Log in to the vSphere Client and connect to the vCenter Server instance.
2. Choose **Administration** and click **Server Settings > Logging Options**.
3. Choose **Trivia** from the pop-up menu and click **OK**.

Using DiagnosticManager

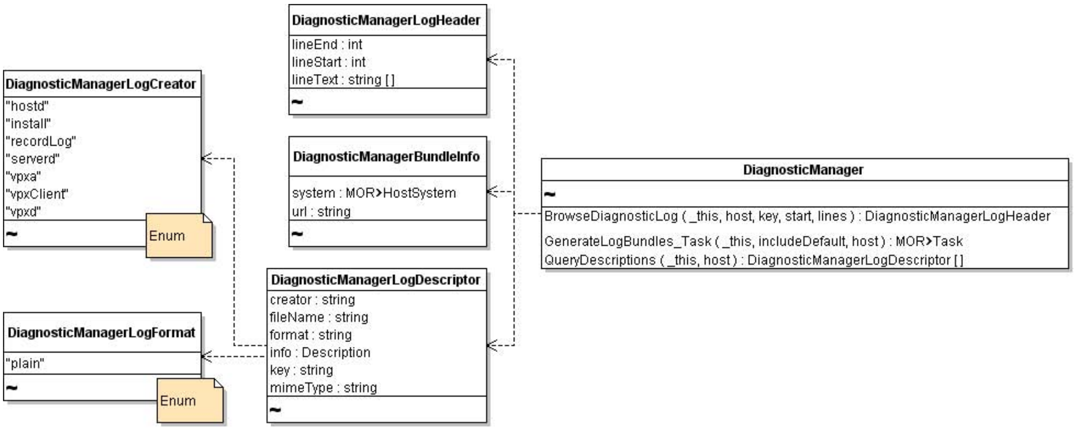
The vSphere API provides access to the `DiagnosticManager`, the service interface for obtaining information from the log files and for generating diagnostic bundles. The logs are populated based on configuration settings, such as `info`, `trivia`, and so on.

The `DiagnosticManager` is a managed object that works service-wide, rather than on a per-session basis. The `DiagnosticManager` has no properties, but provides operations for these tasks:

- Obtaining information about the logs and how they have been defined.
- Generating a diagnostic bundle that can be sent to VMware support for analysis.

Figure 18-1 shows a UML class diagram for `DiagnosticManager`, which is available on ESXi and vCenter Server systems.

Figure 18-1. DiagnosticManager Managed Object and Associated Data Objects


DiagnosticManagerLogHeader
lineEnd : int
lineStart : int
lineText : string [ ]
~
DiagnosticManagerLogCreator
"hostd"
"install"
"recordLog"
"serverd"
"vpxa"
"vpxClient"
"vpxd"
~
Enum
DiagnosticManagerBundleInfo
system : MOR>HostSystem
url : string
~
DiagnosticManager
~
BrowseDiagnosticLog (_this, host, key, start, lines) : DiagnosticManagerLogHeader
GenerateLogBundles_Task (_this, includeDefault, host) : MOR>Task
QueryDescriptions (_this, host) : DiagnosticManagerLogDescriptor [ ]
DiagnosticManagerLogFormat
"plain"
~
Enum
DiagnosticManagerLogDescriptor
creator : string
fileName : string
format : string
info : Description
key : string
mimeType : string
~

As shown in Figure 18-1, `DiagnosticManager` supports these methods:

- `BrowseDiagnosticLog`
- `GenerateLogBundleTask`
- `QueryDescriptions`

The `DiagnosticManagerLogDescriptor.creator` property contains the creator of the log, which is the system or subsystem that controls a specific log.

The `creator` value is populated from the `DiagnosticManagerLogCreator` enumeration. The following table lists all string values currently available from the `DiagnosticManagerLogCreator` enumeration that can populate the `creator` property of the `DiagnosticManagerLogDescriptor` data object.

Name	Description
`hostd`	Host daemon
`install`	Installation
`recordLog`	System record log
`serverd`	Host server agent
`vpxa`	vCenter agent
`vpxClient`	vSphere Client
`vpxd`	vCenter service

Creator	File Name	Format	Info.label	Info.summary	Key	Mime Type
`hostd`	`/var/log/vmware/hostd.log`	plain	ESX Log	ESX log in plain format	`hostd`	text/plain
`hostd`	`/var/log/messages`	plain	ESX Log	ESX log in plain format	`messages`	text/plain
`hostd`	`/var/log/vmkernel`	plain	ESX Log	ESX log in plain format	`vmkernel`	text/plain
`hostd`	`/var/log/vmksummary.txt`	plain	ESX Log	ESX log in plain format	`vmksummary`	text/plain

Creator	File Name	Format	Info.label	Info.summary	Key	Mime Type
hostd	/var/log/vmkwarning	plain	ESX Log	ESX log in plain format	vmkwarning	text/plain
vpxa	/var/log/vmware/vpx/vpxa.log	plain	VirtualCenter Agent Log	VirtualCenter agent log in plain format	vpxa	text/plain

Using the MOB to Explore the DiagnosticManager

The Managed Object Browser (MOB) is a graphical interface that allows you to navigate the objects on a server and to invoke methods. You can access the DiagnosticManager using the MOB.

The following steps show how to explore DiagnosticManager.

Procedure

1 Start the mob by typing the MOB URL (https://hostname.yourcompany.com/mob) into a Web browser.

2 In the ServiceContent data object, click the link (ha-diagnosticmanager or DiagMgr) in the Value column for the diagnosticManager property, to navigate to the DiagnosticManager for the system.

   - For ESXi, ha-diagnosticsmanager is the managed object ID.
   - For vCenter Server, DiagMgr is typically the managed object ID.

3 Click the link to the reference to display the managed object reference to the DiagnosticManager in the MOB.

   DiagnosticManager provides three operations that allow you to obtain information about the descriptions currently available in the log file and log file content.

   Because DiagnosticManager can track multiple ESXi systems, you can use the QueryDescriptions operation to return the names of keys used for all hosts. From this array, select the key for the host from which you want to obtain the log file.

4 On QueryDescriptions, click the **Invoke Method** link.

   The vCenter Server system returns the contents of the log file for the selected host as a string array for the lineText property of DiagnosticManagerLogHeader.

The string array returned through the MOB in this way is the content of the log file. The content contained in the log file is the same content that is available through the following other mechanisms:

- Displayed in the vSphere Client
- Included in a diagnostic bundle created through the DiagnosticManager.GenerateLogBundles_Task method.
- Available in the hostd.log file
- Returned to a client application that you write

What to do next

For more information about using the DiagnosticManager, see Chapter 19 Managed Object Browser.

Generating Diagnostic Bundles

Typically, customers create diagnostic bundles at the request of VMware technical support. Diagnostic bundles also allow developers to quickly obtain all configuration files and log files in a complete package.

The generated compressed files are packaged in a file having the following pattern:

```
<fqdn-hostname>-esxsupport-yyyy-mm-dd@hh-mm-ss.tgz
```

Export Diagnostic Data By Using the vSphere Client

You can use the vSphere Client interface to generate diagnostic bundles.

Procedure

1 Connect to the ESXi system using the vSphere Client.

2 On the **Host > Monitor** screen, select the **Logs** tab.

The **Recent Tasks** pane updates to indicate that the system is generating a diagnostic bundle.

When the task completes, the vSphere Client opens a dialog box that allows you to download the bundle.

Managed Object Browser 19

The Managed Object Browser (MOB) is a graphical interface that allows you to navigate the objects on a server and to invoke methods. Any changes you make through the MOB take effect on the server.

This appendix explains how to use the MOB. The examples invoke `PerformanceManager` query methods to demonstrate how to pass primitive data types, arrays, and complex data types (data objects, including managed object references) using the MOB.

This chapter includes the following topics:

- Using the MOB to Explore the Object Model
- Using the MOB to Invoke Methods

Using the MOB to Explore the Object Model

The Managed Object Browser, or MOB, is a Web-based server application available for all ESXi and vCenter Server systems. The MOB lets you examine the objects that exist on the server and navigate through the hierarchy of live objects by clicking on links. The MOB populates the browser with actual runtime information, for example, the names of properties.

Caution Despite the word "browser" in its name, the MOB is not a read-only mechanism. The MOB allows you to make changes on the server by clicking the **InvokeMethod** link associated with methods.

Accessing the MOB

The MOB runs in a web browser and is accessed by using the fully-qualified domain name or IP address for the ESXi or vCenter Server system.

To access the MOB, use the following steps.

Procedure

1 Start a Web browser.

2 Enter the fully-qualified domain name (or the IP address) for the ESXi or vCenter Server system:

```
https://hostname.yourcompany.com/mob
```

3 Enter the user account and password for the system.

If warning messages regarding the SSL certificate appear, you can disregard them and continue to log in to the MOB, if VMware is the certificate authority and you are not in a production environment.

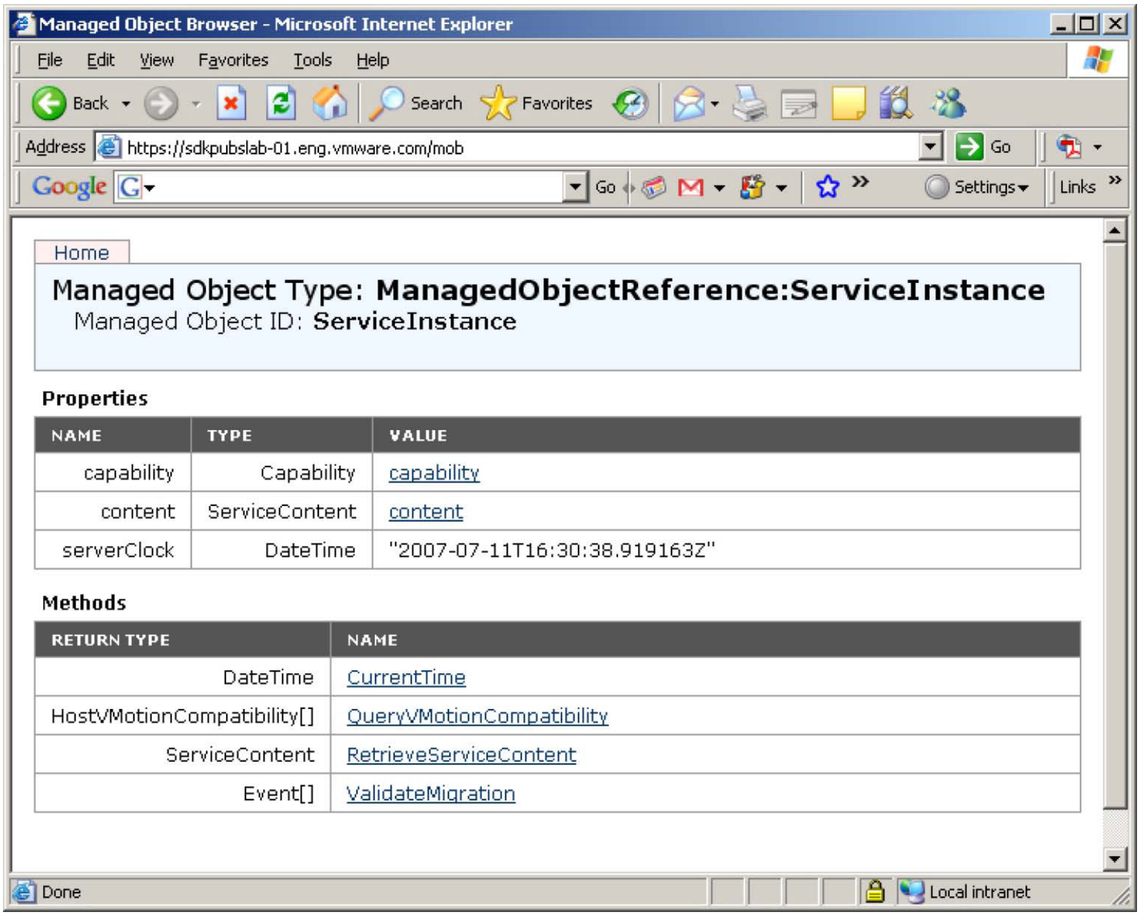
The MOB reveals the underlying structures of the object model. Seeing the structure in conjunction with the *API Reference Guide*, can help with understanding the model.

Using the MOB to Navigate the VMware Infrastructure Object Model

Upon successful connection to the MOB, the browser displays the managed object reference for `ServiceInstance`. Client applications do not use managed objects directly, but interact with server-side managed objects by reference, using instances of the `ManagedObjectReference` data created for this purpose.

The page lists the properties and methods available through a `ServiceInstance` object. The `ServiceInstance` methods and properties provide access to the entire set of services and inventory objects available on the server. See #unique_444.

Figure 19-1. Managed Object Browser Connected to a VirtualCenter Server System



Managed Object Browser - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address
https://sdkpubslab-01.eng.vmware.com/mob
Go
Google
Go
Settings
Links
Done
Local intranet

Home

Managed Object Type: **ManagedObjectReference:ServiceInstance**

Managed Object ID: **ServiceInstance**

Properties

NAME	TYPE	VALUE
capability	Capability	capability
content	ServiceContent	content
serverClock	DateTime	"2007-07-11T16:30:38.919163Z"

Methods

RETURN TYPE	NAME
DateTime	CurrentTime
HostVMotionCompatibility[]	QueryVMotionCompatibility
ServiceContent	RetrieveServiceContent
Event[]	ValidateMigration

The MOB lets you examine the relationships among objects by looking at the properties and their values, and then drilling down into the objects. To explore the objects on the server, click the links in the **Value** column to navigate to the page that displays the object.

For example, to find out more about `ServiceContent`, click the **content** link to display the `ServiceContent` data object instance.

Using the MOB to Invoke Methods

You can use the MOB to invoke methods as follows:

Procedure

1. In the display of the object in which the method lives, click the name of the method.

   A browser window displays information about the parameter name and type and allows you to specify parameter values.

2. Specify parameter values, using the method appropriate for the type, and click **Invoke Method**.

   The rest of this section discusses how to pass different types of parameters to the MOB.

Passing Primitive Datatypes to Method

vSphere Web Services SDK data types are defined in the WSDL using XML Schema markup. The primitive data types are specified using the `xsd` namespace. For example, a string value for a property is defined as data type `xsd:string`. Enter a primitive value in the MOB as plain text, without quotation marks or other markup. For example, to enter an integer value of 10, type `10` in the field.

To obtain information about the available performance counters at level 4 on the server, enter a `4` in the `level` field of the `PerformanceManager.QueryPerfCounterByLevel` method. (This method is available only on the vCenter Server `PerformanceManager` API, not from an ESXi system.)

In response to the query, the array of `PerfCounterInfo` data objects and nested objects, with populated values from the server, displays in the Web browser.

Passing Arrays of Primitives to Methods

For an array, use the name of the parameter as the name of the property. For example, the `PerformanceManager.QueryPerfCounter` method requires an array of integers for the `counterId` parameter, as follows:

```
<counterId>58</counterId><counterId>65603</counterId><counterId>65604</counterId>
```

Even if you want to submit a single value for a single array element, you must wrap the parameter name around the value in this way.

Passing Complex Structures to Methods

For complex datatypes, enter the value as defined by the XML Schema in the WSDL. You can obtain the WSDL definition from the *vSphere API Reference* using the **Show WSDL type definition** links. Each data object type has an associated link.

Simple Content

The data object type ManagedObjectReference is one of the most commonly required parameters to be passed to the server. For example, the MOB for the PerformanceManager.QueryPerfProviderSummary method shows that the method requires a single parameter, the managed object reference (an instance of ManagedObjectReference) of the entity for which you want to obtain the PerfProviderSummary object.

Using the *vSphere API Reference* for ManagedObjectReference type, you can obtain the schema information from the **Show WSDL type definition** link at the bottom of the documentation page for ManagedObjectReference.

Example: XML Schema Definition of ManagedObjectReference Data Object

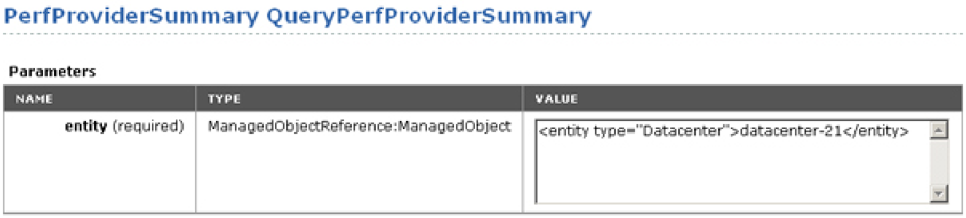
```
<complexType xmlns="http://www.w3.org/2001/XMLSchema" xmlns:vim25="urn:vim25"
name="ManagedObjectReference">
     <simpleContent>
          <extension base="xsd:string">
              <attribute name="type" type="xsd:string"/>
          </extension>
     </simpleContent>
</complexType>
```

Example: XML Schema Definition of ManagedObjectReference Data Object shows that a managed object reference is defined as a <SimpleContent> element that consists of a string that specifies the attribute type with its associated value, also as string. Use this information to construct the appropriate structure by replacing type with the parameter name from the MOB, setting the value as needed, and submitting in the entry field of the MOB. (The value for the Datacenter is displayed in the MOB.)

```
<entity type=”Datacenter”>datacenter-21</entity>
```

Figure 19-2 shows the result of using the definition listed in Example: XML Schema Definition of ManagedObjectReference Data Object to specify the managed object reference for a target datacenter to the PerformanceManager.QueryPerfProviderSummary method.

Figure 19-2. Using the MOB to Pass Complex Types to a Method



PerfProviderSummary QueryPerfProviderSummary

Parameters

NAME	TYPE	VALUE
entity (required)	ManagedObjectReference:ManagedObject	<entity type="Datacenter">datacenter-21</entity>

As another example, one of the parameters required by the VirtualMachine.CloneVM_Task method is a folder. In this case, the parameter is defined as a managed object reference to a specific Folder object. Using the same definition shown in Example: XML Schema Definition of ManagedObjectReference Data Object, the result is as follows:

```
<folder type="Folder">folder-87</folder>
```

Although both examples submit a ManagedObjectReference to the MOB, each is specific to the parameter name required by the method (entity type for PerformanceManager.QueryPerfProviderSummary method, folder type for the VirtualMachine.CloneVM_Task method).

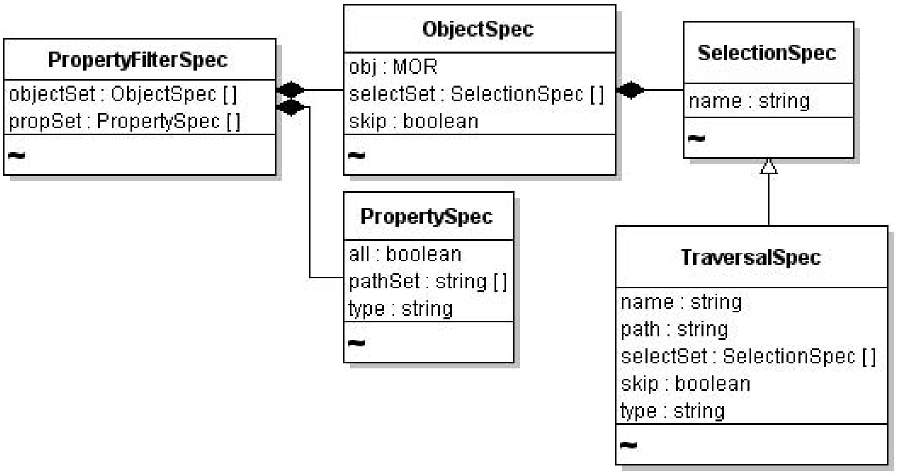
Complex Content

Many of the data objects required for method invocation consist of XML Schema elements defined as <complexContent> that can encompass many other elements.

For example, the PropertyCollector.CreateFilter method has a spec parameter that must be defined before method invocation. The spec parameter is defined as an instance of a PropertyFilterSpec.

Figure 19-3 shows the relationships among several data objects that PropertyFilterSpec consists of.

Figure 19-3. PropertyFilterSpec and Associated Data Objects



To submit complex data structures such as this to the MOB, start by navigating the *vSphere API Reference*. Find the PropertyFilterSpec data object. Find the **Show WSDL type definition** link, and click it to display the XML Schema definition (see Example: XML Schema Definition of PropertyFilterSpec Data Object Type).

Example: XML Schema Definition of PropertyFilterSpec Data Object Type shows that the PropertyFilterSpec data object is a <complexContent> element that extends the DynamicData class with a sequence of two additional properties propSet (of type PropertySpec) and objectSet (of type ObjectSpec).

Example: XML Schema Definition of PropertyFilterSpec Data Object Type

```
<complexType xmlns="http://www.w3.org/2001/XMLSchema" xmlns:vim25="urn:vim25"
name="PropertyFilterSpec">
     <complexContent>
          <extension base="vim25:DynamicData">
              <sequence>
                  <element name="propSet" type="vim25:PropertySpec" maxOccurs="unbounded"/>
                  <element name="objectSet" type="vim25:ObjectSpec" maxOccurs="unbounded"/>
              </sequence>
          </extension>
     </complexContent>
</complexType>
```

Because both elements are defined as a sequence, they must exist in the order listed. To obtain the definitions of `propSet` and `objectSet`, you must navigate further into the *vSphere API Reference*. Example: XML Schema Extract for PropertySpec shows only the relevant parts of the XML Schema definition for `PropertySpec`. The `minOccurs=”0”` attribute means that the element does not have to exist. The `maxOccurs=”unbounded”` attribute means that the element can be populated as an array of any size. (When `minOccurs` is not set, but `maxOccurs` is set, the default for `minOccurs` defaults to 1, meaning one instance is required.)

Example: XML Schema Extract for PropertySpec

```
<sequence>
     <element name="type" type="xsd:string"/>
     <element name="all" type="xsd:boolean" minOccurs="0"/>
     <element name="pathSet" type="xsd:string" minOccurs="0" maxOccurs="unbounded"/>
</sequence>
```

Navigate through the *vSphere API Reference* to the `ObjectSpec` definition. Example: ObjectSpec Definition as XML Schema shows the excerpt.

Example: ObjectSpec Definition as XML Schema

```
...
<sequence>
     <element name="obj" type="vim25:ManagedObjectReference"/>
     <element name="skip" type="xsd:boolean" minOccurs="0"/>
     <element name="selectSet" type="vim25:SelectionSpec" minOccurs="0" maxOccurs="unbounded"/>
</sequence>
...
```

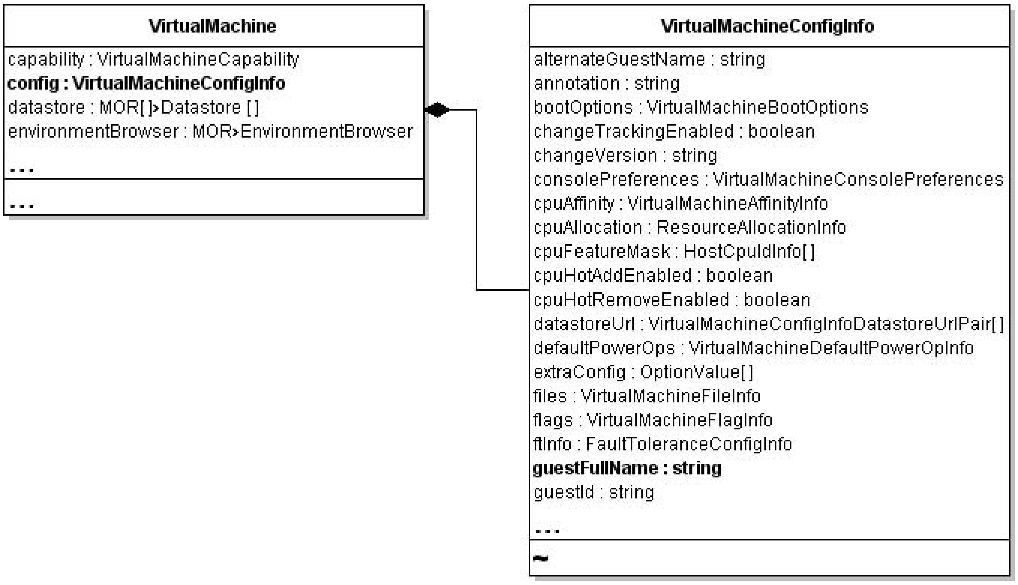
Extrapolating from the WSDL definitions shown in Example: XML Schema Definition of PropertyFilterSpec Data Object Type, Example: XML Schema Extract for PropertySpec, and Example: ObjectSpec Definition as XML Schema might produce results similar to those shown in Example: CreateFilter Spec Property Entry.

Example: CreateFilter Spec Property Entry

```
<spec>
     <propSet>
          <type>VirtualMachine</type>
          <all>false</all>
          <pathSet>config.guestFullName</pathSet>
     </propSet>
     <objectSet>
          <obj type="Folder">group-v4</obj>
          <skip>true</skip>
     </objectSet>
</spec>
```

In this example, the `<spec>` element identifies the `spec` parameter of the `CreateFilter` method. The order of the element tags is as defined in the XML Schema for the property (Example: XML Schema Definition of PropertyFilterSpec Data Object Type). The `pathSet` property defines the full path to the nested data object of interest. In Example: CreateFilter Spec Property Entry, the `pathSet` property defines the path to the `guestFullName` property of the target virtual machine. Example: ObjectSpec Definition as XML Schema shows the UML of these nested data objects.

Figure 19-4. Nested Data Objects


VirtualMachine
capability : VirtualMachineCapability
config : VirtualMachineConfigInfo
datastore : MOR[ ]>Datastore [ ]
environmentBrowser : MOR>EnvironmentBrowser
...
...
VirtualMachineConfigInfo
alternateGuestName : string
annotation : string
bootOptions : VirtualMachineBootOptions
changeTrackingEnabled : boolean
changeVersion : string
consolePreferences : VirtualMachineConsolePreferences
cpuAffinity : VirtualMachineAffinityInfo
cpuAllocation : ResourceAllocationInfo
cpuFeatureMask : HostCpuIdInfo[ ]
cpuHotAddEnabled : boolean
cpuHotRemoveEnabled : boolean
datastoreUrl : VirtualMachineConfigInfoDatastoreUrlPair[ ]
defaultPowerOps : VirtualMachineDefaultPowerOpInfo
extraConfig : OptionValue[ ]
files : VirtualMachineFileInfo
flags : VirtualMachineFlagInfo
ftInfo : FaultToleranceConfigInfo
guestFullName : string
guestId : string
...
~

All of these details are available in the *vSphere API Reference*. By examining the WSDL definition, you can construct the strings needed to submit parameters through the MOB.

Using the MOB Along With the API Reference

The following table provides a brief summary of the steps involved when you use the MOB and the *vSphere API Reference* together.

Datatype	How to Input Values for Methods
Primitive	Enter the value as plain text regardless of its data type (`int`, `string`, `boolean`). Do not use quotes or other markup.
Array	Use the name of the parameter as the name of the element, wrap the values in a series of opening and closing tags for each array element.
Complex	Obtain XML Schema format information from the *vSphere API Reference* for the type (from the **Show WSDL type definition** link). Use the schema definition to construct the sequence of tags around the value (or values) you want to pass to the MOB.

HTTP Access to vSphere Server Files 20

In most cases, client applications interact with vSphere servers by using the vSphere Web Services SDK. In some cases, direct access to configuration files, log files, and other data on an ESXi or vCenter Server systems is more efficient.

This chapter includes the following topics:

Introduction to HTTP Access

ESXi and vCenter Server systems support file access using HTTP and secure HTTP. You can use HTTP/HTTPS for the following kinds of access.

- Datastore access on ESXi and vCenter Server systems.
- ESXi configuration and log file access on ESXi systems.
- Update bundle access on ESXi systems.

You can use the HTTP methods `GET`, `HEAD`, `PUT`, and `DELETE` to access files. The URL of the HTTP/HTTPS request must contain an embedded keyword that specifies the type of access. The following table shows the server access types with the corresponding URL keyword and HTTP methods.

Server Access	URL Keyword	HTTP Method or Methods
Datastore	folder	`GET`, `HEAD`, `PUT`, `DELETE`
ESXi configuration file	host	`GET`, `HEAD`, `PUT` (See Host File Access (/host) for the specific methods supported for each file type.)
Update bundle	tmp	`PUT`

Use the `PUT` method to create new files or overwrite existing files. You can create a subdirectory by using a URL that is consistent with the supported top-level directories. You cannot create datastores or datacenters because the URL must refer to a valid datacenter or datastore.

You can use a Web browser to browse and download files. You cannot use a Web browser to post or delete files.

URL Syntax for HTTP Access

The URL specification in an HTTP request to a vSphere server includes one of the following keywords, which determines the type of access.

- Datastore Access (/folder)
- Host File Access (/host)
- Update Package Access (/tmp)

Datastore Access (/folder)

An HTTP request for datastore access uses the following syntax:

```
http-method http[s]://server/folder[[/path]?dcPath=path[&dsName=name]]
```

http-method	One of the methods `GET`, `HEAD`, `PUT`, or `DELETE`.
http:// or https://	Access protocol (standard access or secure access).
`server`	ESXi or vCenter Server target system. The server value can be an IP address or a DNS name.
`/folder`	Specifies datastore access on an ESXi or vCenter Server system. The datastore URL can include the following optional elements: ■ *path* – Path to a file or directory in the datastore, relative to the root of the datastore. ■ `dcPath` – Inventory path to a datacenter. Specify the datacenter path as a name-value pair in the request. For a datacenter named `Datacenter` located in the root folder, the `dcPath` value is `MyDatacenter`. For a datacenter named `YourDatacenter` located in the folder `NorthAmerica` which is located in the root folder, the `cdPath` value is `NorthAmerica/YourDatacenter`. ■ `dsName` – Datastore associated with the datacenter. Specify the datastore name as a name-value pair in the request.

The following examples illustrate the syntax. If the target server is an ESXi system, `dcPath=DCPATH&` is optional and defaults to `dcPath=ha-datacenter`.

Example	Description
`/folder`	Directory listing of known datacenters on this server.
`/folder?dcPath=path`	Directory listing of all datastores available at the specified datacenter.
`/folder?dcPath=path&dsName=name`	Top-level directory listing of the datastore.
`/folder/path?dcPath=path&dsName=name`	Directory listing of all files in a datastore directory.

`/folder/path/disk-flat.vmdk?`
`dcPath=`*`path`*`&dsName=name`
	Access individual files.

Host File Access (/host)

An HTTP request for access to ESXi configuration files uses the following syntax:

```
GET http[s]://my_system/host
http-method http[s]://my_system/host/file
```

Syntax Element	Description
http-method	One of GET, HEAD, or PUT, depending on the type of configuration file (see the following table).
http:// or https://	Access protocol (standard access or secure access).
esx-server	IP address or a DNS name.
/host	List of configuration files that you can access. (Use /host to retrieve the list.)
/host/file	A specific ESXi configuration file.

The following table shows ESXi host configuration files and the corresponding HTTP/HTTPS methods for access. The set of files might change from version to version.

Configuration File	HTTP Access Method(s)	Configuration File	HTTP Access Method(s)
hostAgentConfig.xml	GET, HEAD, PUT	ipmi0_sel.raw	GET, HEAD
sfcb.cfg	GET, HEAD, PUT	ipmi0_sel	GET, HEAD
openwsman.conf	GET, HEAD, PUT	ipmi0_sdr_content.raw	GET, HEAD
license.cfg	GET, HEAD, PUT	ipmi0_sdr_header.raw	GET, HEAD
vmware.lic	GET, HEAD, PUT	ipmi0_sensor_readings.raw	GET, HEAD
vmware_config	GET, HEAD, PUT	ipmi1_sel.raw	GET, HEAD
vmware_configrules	GET, HEAD, PUT	ipmi1_sel	GET, HEAD
proxy.xml	GET, HEAD, PUT	ipmi1_sdr_content.raw	GET, HEAD
snmp.xml	GET, HEAD, PUT	ipmi1_sdr_header.raw	GET, HEAD
syslog.conf	GET, HEAD, PUT	ipmi1_sensor_readings.raw	GET, HEAD
ssl_cert	GET, HEAD, PUT	ipmi2_sel.raw	GET, HEAD
ssl_key	PUT	ipmi2_sel	GET, HEAD
hosts	GET, HEAD, PUT	ipmi2_sdr_content.raw	GET, HEAD
motd	GET, HEAD, PUT	ipmi2_sdr_header.raw	GET, HEAD
vpxa.cfg	GET, HEAD, PUT	ipmi2_sensor_readings.raw	GET, HEAD
esx.conf	GET, HEAD, PUT	ipmi3_sel.raw	GET, HEAD
config.log	GET, HEAD	ipmi3_sel	GET, HEAD
messages	GET, HEAD	ipmi3_sdr_content.raw	GET, HEAD
hostd.log	GET, HEAD	ipmi3_sdr_header.raw	GET, HEAD
vpxa.log	GET, HEAD	ipmi3_sensor_readings.raw	GET, HEAD

Update Package Access (/tmp)

An HTTP request for update package access uses the following syntax:

```
PUT http[s]://esx–server/tmp/file–path
```

http:// or https://	Access protocol.
`esx–server`	IP address or a DNS name.
`/tmp/file–path`	Target file on an ESX/ESXi system.

Privilege Requirements for HTTP Access

HTTP access to a vSphere file is access to a datastore object that is associated with the folder structure in the vSphere inventory. HTTP access requires the same privileges needed to obtain these files using any other mechanism, such as the vSphere Client.

The following table shows the required privileges.

Object Associated with File	Portion of URL	Required Privileges
Root folder	`/folder`	`System.View`
Datacenter	`?dcPath`	`Datastore.Browse`
		`Datastore.FileManagement`
Datastore	`&dsName`	`Datastore.Browse`
		`Datastore.FileManagement`
Host	`/host`	`Host.Config.AdvancedConfig`
	`/tmp/`	`Host.Config.SystemManagement`

Sample Program Overview 21

The VMware vSphere Web Services SDK includes samples for both the Java and C# platforms. This chapter lists the available sample programs and provides some information about each program. Both the Java and C# samples have been re-compiled with JAX-WS bindings for this release, and they use JAX-WS credential store classes that allow you to ignore certificates when you connect to a server with the samples.

This chapter includes the following topics:

- Java Sample Programs (JAXWS Bindings)
- C# Sample Programs

Java Sample Programs (JAXWS Bindings)

When you download the SDK, you can find the Java sample programs and related files in the following directories.

- `SDK\vsphere-ws\java\JAXWS\samples\com\vmware` – Top-level directory for Java samples. Details listed in the following table.
- `SDK\vsphere-ws\java\JAXWS\samples\com\vmware\security` – Credential store utilities
- `SDK\vsphere-ws\java\JAXWS\samples\com\vmware\vim25` – Stub directories. The `vim25` directory contains stubs for VirtualCenter 2.5 and later, including vSphere 4.0 and later.
- `SDK\vsphere-ws\java\JAXWS\samples\com\vmware\vm` – samples written for a single VM

Directory	Example	Description
`alarm`	`VMPowerStateAlarm`	Creates an alarm to monitor a virtual machine's power state.
`events`	`EventFormat`	Retrieves and formats the last event from the host daemon or `vpxd`. Includes a function that formats the event message.
	`EventHistoryCollectorMonitor`	Demonstrates how to create and monitor an `EventHistoryCollector`. Uses the `latestPage` property of `EventHistoryCollector` to filter the events.

Directory	Example	Description
	VMEventHistoryCollectorMonitor	Standalone client that demonstrates how to perform the following tasks: Logging into the web service. Creating EventHistoryCollector filtered for a single virtual machine. Monitoring events using the latestPage property of the EventHistoryCollector.
general	Browser	Prints all managed entities and for each entity its type, reference value, property name, property value, inner object type, inner reference value and inner property value.
	Connect	Connects to an ESXi system or a vCenter Server system.
	Create	Creates a managed entity such as a folder, datacenter, or cluster.
	Delete	Deletes a managed entity from the inventory tree. The managed entity can be a virtual machine, a ClusterComputeResource, or a folder.
	GetCurrentTime	Retrieves the current time from the vSphere Server.
	GetHostName	Retrieves the hostname of the ESXi Server.
	GetUpdates	Demonstrates how to use the PropertyCollector to monitor one or more properties of one or more managed objects. In particular this sample monitors one or all virtual machines and all hosts or one host for changes to some basic properties.
	LicenseManager	Demonstrates uses of the licensing API using License managed object reference.
	Move	Moves a managed entity from its current location in the inventory to a new location in a specified folder
	PropertyCollector	Illustrates the use of the PropertyCollector API.
	RemoveManagedObject	Destroys or unregisters a managed inventory object like a Host, VirtualMachine, or Folder.
	Rename	Renames a managed entity object.
	SearchIndex	Illustrates the use of the SearchIndex API.
	SimpleClient	Connects to the server, logs in, lists the inventory contents (managed entities) at the console, and logs out.
	TaskList	Displays a list of tasks performed on a specified managed object.
guest	CreateTemporaryFile	Creates a temporary file inside a virtual machine.
	DownloadGuestFile	Downloads a file from the guest to a specified path on the host where the client is running.
	RunProgram	Runs a specified program inside a virtual machine. RunProgram re-directs output to a temporary file inside the guest and downloads the output file.

Directory	Example	Description
	UploadGuestFile	Uploads a file from the client machine to a specified location inside the guest operating system.
host	AcquireSessionInfo	Acquires a session with a vCenter Server or ESXi host and prints a cim service ticket and related session information to a file.
	AddVirtualNic RemoveVirtualNic	Adds a virtual NIC to a port group on a virtual switch. Removes a virtual NIC from a port group.
	AddVirtualSwitch RemoveVirtualSwitch	Adds a virtual switch to a host. Removes a virtual switch from the host.
	AddVirtualSwitchPortGroup RemoveVirtualSwitchPortGroup	Adds a port group to a virtual switch. Removes a port group from a virtual switch.
	DVSCreate	Creates a distributed virtual switch.
	HostProfileManager	Demonstrates the use of HostProfileManager and ProfileComplainceManager.
	NIOCForDVS	Adds a network resource pool to a distributed virtual switch.
httpfileaccess	GetVMFiles	Retrieves configuration files, snapshots files, log files, and virtual disk files of a virtual machine and places them on the system on which the program is run.
	ColdMigration	Puts virtual machine files into a specified datacenter and datastore and registers and reconfigures the corresponding virtual machine.
performance	Basics	Displays available performance counters or other metadata for an ESXi host.
	History	Reads performance measurements from the current time, or from a specified start time, for a specified duration.
	PrintCounters	Writes the available counters of a managed entity into the specified file at the specified location. The managed entity can be a host system, a virtual machine, or a resource pool.
	Realtime	Displays performance measurements from the current time at the console.
	VItop	An ESXtop-like sample application that lets administrators specify the CPU and memory counters by name to obtain metrics for a specified host.
	VIUsage	Creates a GUI for graphical representation of the counters.
scheduling	DeleteOneTimeScheduledTask	Demonstrates deleting a ScheduledTask.
	OneTimeScheduledTask	Demonstrates creating a ScheduledTask using the ScheduledTaskManager.
	WeeklyRecurrenceScheduledTaks	Demonstrates creating a weekly recurrent scheduled task.

Directory	Example		Description
`scsilun`	`SCSILunName`		Displays the `CanonicalName`,`Vendor`, `Model`, `Data`, `Namespace` and `NamespaceId` of the host's SCSI LUN.
security	credstore	Base64	A fast, memory efficient class that encodes and decodes to and from BASE64 in full accordance with RFC 2045.
		CredentialStore	Creates an example credential store.
		CredentialStoreAdmin	A command-line tool that provides complete access to the credential store backing file on the local machine.
		CredentialStoreFactory	Factory class providing instances of a credential store.
		CredentialStoreImpl	Implementation class for `CredentialStoreAdmin`.
		CredentialStoreObfuscate	Converts the hostname string to lowercase, so that a uniform representation of the hostname is used to obfuscate and de-obfuscate the password.
		CredentialStoreStorage	This class provides the same functionality as `FileInputStream`, except that the close() method is overridden so that `FileInputStream` class' close() method does not get called.
`simpleagent`	`SimpleAgent`		Accesses the local credential store to obtain a single user account to log in to the specified server.
	`CreateUsers`		Creates a user account and password and stores them in the local credential store.
storage	CreateStorageDRS		Creates storage DRS.
	SDRSRecommendation		Runs storage DRS on an SDRS cluster to obtain SDRS recommendations.
	SDRSRules		Configures rules for an SDRS cluster.
vApp	OVFManagerExportVAPP		Demonstrates the `OvfManager` by exporting VMDKs and OVF Descriptors of all VMs in the vApps.
	OVFManagerExportVMDK		Demonstrates how the `OvfManager` exports VMDKs from a VM to the localSystem.
	OVFManagerImportLocal		Use this class to import or deploy an OVF Appliance from a local drive.
	OVFManagerImportVAppFromUrl		Use this class to import or deploy an OVF Appliance from a specified URL.
vim25	This directory contains the Java classes that define the JAXWS bindings to the vSphere API.		
`vm`	`VMClone`		Locates an existing virtual machine on the vCenter Server system, makes a template from this virtual machine, and deploys instances of the template onto a datacenter.
	`VMCreate`		Creates a virtual machine. Different command-line input creates the virtual machine in different ways.
	`VMDeltaDisk`		Creates a delta disk on top of an existing virtual disk in a virtual machine, and simultaneously removes the original disk using the reconfigure API. Use delta disks in conjunction with linked virtual machines.

Directory	Example	Description
	VMDiskCreate	Creates a virtual disk.
	VMLinkedClone	Creates a linked virtual machine from an existing snapshot.
	VMManageCD	Configures a CDROM for a virtual machine. Also lists information about the CDROMs associated with a virtual machine.
	VMManageFloppy	Configures a floppy drive for a virtual machine. Also lists information about the floppy drives associated with a virtual machine.
	VMotion	Checks whether migration with VMotion is feasible between two hosts. Performs the migration if the hosts are compatible.
	VMpowerOps	Performs power operations on a virtual machine.
	VMPromoteDisks	Consolidates a linked virtual machine by using the VirtualMachine.PromoteDisks method.
	VMReconfig	Reconfigures a virtual machine. Includes reconfiguring the disk size and disk mode.
	VMRelocate	Relocate a linked virtual machine using disk move type.
	VMSnapshot	Performs virtual machine snapshot operations

C# Sample Programs

The C# (.NET) sample programs are located in the SDK\vsphere-ws\dotnet\cs\samples\ directory. Details listed in the following table. Each of the examples listed in the table is actually a directory that contains a .cs file, a .csproj file, a *filename*2008.csproj file, and a *filename*2010.csproj file.

The samples include a GeneratingStubs.txt file and a readme_dotnet.html file at top level.

The readme file explains how to build the examples using Visual Studio 2005 or Visual C# 2005 Express.

Example	Description
AddVirtualNic	Adds a virtual NIC to the ESXi system. First specifies a HostVirtualNicSpec, and then adds the NIC to the host.
AddVirtualSwitch	Adds a virtual switch to the ESXi system.
AddVirtualSwitchPortGroup	Adds a virtual port group to the ESXi system.

Example	Description
`AppUtil`	Contains the following utility applications: ■ `AppUtil` – Utility application that drives the user input mechanism for other samples and includes some other utility functions. ■ `ArgumentHandlingException` – Handles command-line exceptions. Used by `AppUtil`. ■ `CertPolicy` – Handles certification problems by displaying informational messages. ■ `ClientUtil` – Client utilities related to prompting the user and logging. Used by AppUtil. ■ `Log` – Logger to file or console. ■ `OptionSpec` – Option parsing utility. ■ `ServiceUtils`, `ServiceUtilsV25` – Utilities for connecting to the server. ■ `VMUtils` – Utility that sets values for a basic virtual machine. Some of the setup, such as adding a floppy disk drive, might not always be needed.
`Basics`	Uses the `PerformanceManager` for basic monitoring.
`Browser`	Retrieves the contents of the `ServiceInstance` starting at the root folder, and prints a listing of `ManagedEntity` objects. Optionally, obtains properties for a specific type, or by default, for `ManagedEntity` itself.
`CIMInfo`	`CIMInfo` versioning sample that retrieves the details of `CIM_Fan` like `Activecooling`, `Caption`, `CommunicationStatus` and so on.
`ColdMigration`	Migrates a powered off virtual machine from one host to another.
`Connect`	Simple example that logs in and logs out.
`Create`	Creates a `Folder`, `Cluster`, `Datacenter` or standalone host. Prompts the user for the item to create and where to put the item, for example, in a folder.
`CreateUser`	Creates a user. Specifies permissions for the user using the `AuthorizationManager`.
`CredentialStorePSCmdLets`	Multiple commandlets for managing the credential store.
`Delete`	Deletes a managed entity.
`DeleteOneTimeScheduledTask`	Extracts a task from `scheduledTaskManager` and deletes it. This sample is well commented and illustrates using the `PropertyCollector`. You can create the task using the `OneTimeScheduledTask` example.
`DisplayNewProperties`	Retrieves the specified set of properties for the given managed object reference into an array of result objects (returned in the same order as the property list)
`DisplayNewPropertiesHost`	Displays properties of an ESXi host. The properties displayed depend on the version of the host.
`DisplayNewPropertiesVM`	Displays a set of properties for a virtual machine. The properties displayed depend on the version of the software on the host.
`EventFormat`	Retrieves and formats the last event on the ESXi or vCenter Server system. Demonstrates event formatting.
`EventHistoryCollectorMonitor`	Creates an `EventHistoryCollector` and monitors the corresponding events.
`GetUpdates`	Retrieves updates for a virtual machine or an ESXi host.
`GetVirtualDiskFiles`	Retrieves the virtual disk files from a host’s datastores.

Example	Description
`GetVMFiles`	Downloads the files in the virtual machine configuration directory as well as the files in the virtual machine snapshot, suspend, and log directories. Writes progress to the console.
`History`	Displays the performance measurements of a specified counter of a specified ESXi for a specified duration, or 20 minutes (default) at the console.
`HostPowerOps`	Performs reboot, shutdown, or suspend (power off to standby) operations on an ESXi system.
`LicenseManager`	Displays licensing information. The user can specify a license server,
`MobStartPage`	Includes a program, image files, and HTML files for displaying a Managed Object browser.
`Move`	Moves a managed entity from one folder to another.
`OneTimeScheduledTask`	Creates a `ScheduledTask` that powers off a virtual machine and schedules the task using a `OnceTaskScheduler`. You can delete the task using the `DeleteOneTimeScheduledTask` commandlet.
`PrintCounters`	Defines a `printEntityCounters` function that prints counters for a virtual machine, host, or resource pool.
`PropertyCollector`	Illustrates use of the `PropertyCollector`.
`QueryMemoryOverhead`	Illustrates use of the `QueryMemoryOverhead` method. The folder includes two examples, `QueryMemoryOverheadV25` uses the currently valid `QueryMemoryOverheadEx` method, `QueryMemoryOverhead` uses the deprecated `QueryMemoryOverhead` method.
`RealTime`	Displays the current performance measurements of selected CPU counters of any specified virtual machine at the console.
`RecordSession`	Records a session and allows you to retrieve a specified set of properties for a specified managed object reference into an array of result objects.
`RemoveManagedObject`	Removes a host from a cluster or a virtual machine from a host. Handles errors, for example, if the host is not in a cluster, by printing that information to the command line.
`RemoveVirtualNic`	Removes a virtual NIC from the ESXi system.
`RemoveVirtualSwitch`	Removes a virtual switch from the ESXi system.
`RemoveVirtualSwitchPortGroup`	Removes a virtual port group from the ESXi system.
`Rename`	Renames a managed entity.
`SCSILunName`	Prints the virtual machine file system volumes on a specified SCSI LUN.
`SearchIndex`	Illustrates the use of the `SearchIndex` API.
`SimpleClient`	Demonstrates connecting to a service, logging on to service, obtaining service content, and logging out from the service.
`SSPI`	Illustrates how to use an SDK application with Microsoft SSPI.
`SSPICIMClient`	Illustrates how to use an CIM client application with Microsoft SSPI.
`TaskList`	Displays currently running tasks and their state.
`VMClone`	Clones a virtual machine.
`VMCreate`	Creates a virtual machine.

Example	Description
`VMEventHistoryCollectorMonitor`	Returns all events on the latest page on the `EventHistoryCollector`.
`VMotion`	Validates that migration with VMotion is feasible between two hosts, and performs the migration if the hosts are compatible.
`VmPowerOps`	Retrieves a reference to a virtual machine and invokes power operations specified on the command line on that virtual machine.
`VMPowerStateAlarm`	Creates an alarm that monitors virtual machine state and sends email if the virtual machine power is off. Includes error handling, for example, when the command is attempted with an ESXi host as a target.
`VMReconfig`	Reconfigures a virtual machine by changing its memory, cpu, disk, nic, or cd.
`VMSnapshot`	Performs snapshot operations such as create, revert to, remove, remove all, and so on.
`VMware.Security.CredentialStore`	Illustrates use of the VMware credential store.
`WatchVM`	Monitors updates on a virtual machine using the `PropertyCollector`.
`WeeklyRecurrenceScheduledTask`	Creates a task that reboots a virtual machine once a week.