Oracle Solaris 11 Advanced System Administration

Student Guide - Volume I

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Preface

Profile

Before You Begin This Course

Before you begin this course, you should be able to perform basic Oracle Solaris 11 system administration tasks.

How This Course Is Organized

Oracle Solaris 11 Advanced System Administration is an instructor-led course featuring lectures and hands-on exercises. Online demonstrations and written practice sessions reinforce the concepts and skills that are introduced.

Related Publications

Oracle Publications

Additional Publications

- System release bulletins
- Installation and user's guides
- *read.me* files
- International Oracle User's Group (IOUG) articles
- *Oracle Magazine*

Typographic Conventions

The following two lists explain Oracle University typographical conventions for words that appear within regular text or within code samples.

1. Typographic Conventions for Words Within Regular Text

Convention	Object or Term	Example
Courier New	User input; commands; column, table, and schema names; functions; PL/SQL objects; paths	Use the `SELECT` command to view information stored in the `LAST_NAME` column of the `EMPLOYEES` table. Enter `300`. Log in as `scott`
Initial cap	Triggers; user interface object names, such as button names	Assign a When-Validate-Item trigger to the ORD block. Click the Cancel button.
Italic	Titles of courses and manuals; emphasized words or phrases; placeholders or variables	For more information on the subject see *Oracle SQL Reference Manual* Do *not* save changes to the database. Enter *`hostname`*, where *`hostname`* is the host on which the password is to be changed.
Quotation marks	Lesson or module titles referenced within a course	This subject is covered in Lesson 3, “Working with Objects.”

2. Typographic Conventions for Words Within Code Samples

Convention	Object or Term	Example
Uppercase	Commands, functions	`SELECT employee_id` `FROM  employees;`
Lowercase, italic	Syntax variables	`CREATE ROLE` *`role`*`;`

Initial cap	Forms triggers	`Form module: ORD`
		`Trigger level: S_ITEM.QUANTITY item`
		`Trigger name: When-Validate-Item`
		`. . .`

Lowercase	Column names, table names, filenames, PL/SQL objects	`. . .`
		`OG_ACTIVATE_LAYER`
		`(OG_GET_LAYER ('prod_pie_layer'))`
		`. . .`
		
		`SELECT last_name`
		`FROM   employees;`

Bold	Text that must be entered by a user	`CREATE USER` **`scott`** `IDENTIFIED BY` **`tiger`**`;`

1

Introduction

Overview

- Course goals
- Course agenda
- Introductions
- Your learning center
- Your lab environment

Welcome to the *Oracle Solaris 11 Advanced System Administration* course. This course is designed to teach more advanced skills to system administrators who are able to perform basic Oracle Solaris 11 system administration tasks.

Course Goals

The goals of this course are to:

- Enable you to perform advanced Oracle Solaris 11 system administration tasks successfully and efficiently
- Present tasks that cover a variety of advanced system administration responsibilities:
  - OS installation by using AI
  - IPS and package management
  - Network, zones, and RBAC configuration
  - Business applications, services, and process management
  - System evaluation, monitoring, and troubleshooting
- Provide numerous and meaningful practice opportunities

Course Agenda: Day 1

- Lesson 1: Introduction
- Lesson 2: Managing the Image Packaging System (IPS) and Packages
  - Configuring a Local IPS Package Repository
  - Managing Packages and Package Publishers
- Lesson 3: Installing Oracle Solaris 11 on Multiple Hosts
  - Planning for an Oracle Solaris 11 OS Installation by Using the Automated Installer

Oracle Solaris 11 Advanced System Administration consists of five days of lecture and practices.

On the first day, in addition to the Course Introduction, you cover Lesson 2. You learn how to configure a local IPS repository, as well as how to perform advanced package management and how to manage package publishers.

You also start Lesson 3, in which you learn how to plan for an Oracle Solaris 11 installation by using the Automated Installer (AI).

Note: Each lesson begins with a discussion of how to plan for a specific task.

Course Agenda: Day 2

- Lesson 3: Installing Oracle Solaris 11 on Multiple Hosts (continued)
  - Installing Oracle Solaris 11 by Using the Automated Installer
  - Configuring Oracle Solaris Images
- Lesson 4: Managing Business Application Data
  - Planning for Data Storage Configuration and Backup
  - Managing Data Redundancy with Mirrored Storage Pools
  - Backing Up and Recovering Data with ZFS Snapshots
  - Managing Data Storage Space with ZFS File System Properties

On the second day, you conclude Lesson 3 by looking at how to perform the automated installation. You also learn how to configure Oracle Solaris images. As part of Lesson 3, you perform an automated installation.

Lesson 4 is about managing business application data. You begin this lesson with a discussion of how to plan for data storage configuration and backup, and then look at how to manage data redundancy with mirrored ZFS storage pools. You then learn how to perform more advanced ZFS tasks, such as backing up and recovering data with ZFS snapshots and managing data storage space with ZFS file system properties.

Course Agenda: Day 3

- Lesson 4: Managing Business Application Data (continued)
  - Troubleshooting ZFS Failures
- Lesson 5: Configuring Network and Traffic Failover
  - Configuring Systems on a Local Network
  - Configuring a reactive network, NFS, and Link Aggregation
  - Using IPMP
- Lesson 6: Configuring Zones and the Virtual Network
  - Configuring Virtual Network Components
  - Configuring Zones with VNICs
  - Allocating System Resources to Zones

On the third day, you conclude Lesson 4 by learning about how to troubleshoot ZFS failures. You then cover two more lessons.

In Lesson 5, you configure network and traffic failover. You learn how to configure systems on a local network and how to configure a reactive network, Network File System (NFS), and link aggregation. You also focus on how to use IP multi-pathing (IPMP).

As part of each lesson, you apply what you have learned in a series of hands-on practices.

Lesson 6 is about configuring zones and the virtual network. You are introduced to the components of a virtual network and you learn how to configure those components. You also learn how to configure zones with virtual network interfaces (VNICs) and how to allocate system resources to zones.

Course Agenda: Day 4

- Lesson 7: Managing Services and Service Properties
  - Configuring SMF Services
  - Troubleshooting SMF Services
- Lesson 8: Configuring Privileges and Role-Based Access Control
  - Configuring and Managing Privileges
  - Configuring and Using RBAC
- Lesson 9: Securing System Resources by Using Oracle Solaris Auditing
  - Configuring Oracle Solaris Auditing
  - Administering Oracle Solaris Auditing

On the fourth day, you cover Lessons 7, 8, and 9.

Lesson 7 focuses on the Service Management Facility (SMF) services, where you learn how to configure and troubleshoot SMF services.

Lesson 8 is about setting up and maintaining privileges and role-based access control (RBAC). You learn how to configure and manage privileges, as well as how to configure and use RBAC.

Lesson 9 is about securing system resources by using Oracle Solaris Auditing. You learn how to configure the audit services and audit logs, as well as how to administer the audit services and how to manage audit records.

As with the previous lessons, you practice each of the tasks presented in these two lessons.

Course Agenda: Day 5

- Lesson 10: Managing Processes and Priorities
  - Managing System Processes
  - Managing Process Scheduling Priority
  - Managing the Scheduling Class of a Zone
  - Monitoring and Configuring the FSS
- Lesson 11: Evaluating System Resources
  - Configuring System Resources
  - Monitoring System Performance
- Lesson 12: Monitoring and Troubleshooting Software Failures
  - Configuring System Messaging
  - Configuring System Crash and Core Dump Facilities

On the fifth and final day, you cover the last three lessons.

In Lesson 10, you learn how to manage processes and priorities. You learn how to manage system processes, process scheduling priority, and the scheduling class of a zone. You also look at how to monitor and configure the Fair Share Scheduler (FSS).

In Lesson 11, you learn how to configure system resources and monitor system performance.

In Lesson 12, you learn how to configure system messaging and configure system crash and core dump facilities.

Note: The class starts at 9 AM and ends at 5 PM each day. There are several short breaks throughout the day, with an hour for lunch.

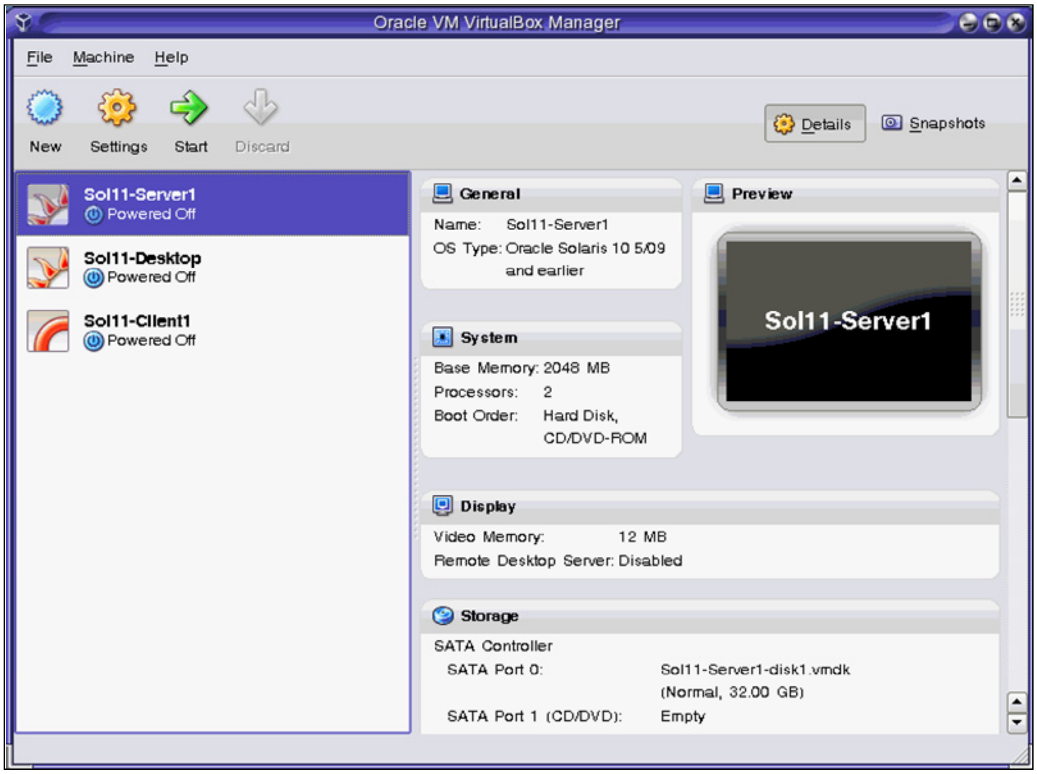
Introductions

- Name
- Company affiliation
- Title, function, and job responsibility
- Experience related to the topics presented in this course
- Reasons for enrolling in this course
- Expectations for this course

Your Learning Center

- Logistics
  - Restrooms
  - Break rooms and designated smoking areas
- Cafeterias and restaurants in the area
- Emergency evacuation procedures
- Instructor contact information
- Cell phone usage
- Online course attendance confirmation form

Your Lab Environment



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As part of each lesson, you practice, in a lab environment, what you learned during the lecture. The lab environment that you use in this course is based on the Oracle VM VirtualBox virtualization software (an example of which is shown in the slide). VirtualBox is a cross-platform virtualization application. It extends the capabilities of your existing computer so that it can run multiple operating systems (inside multiple virtual machines) simultaneously.

Open your Activity Guide to “Practices for Lesson 1: Introduction.” Your instructor will walk you through the material, and you will have a chance to familiarize yourself with the lab environment configuration and setup.

2

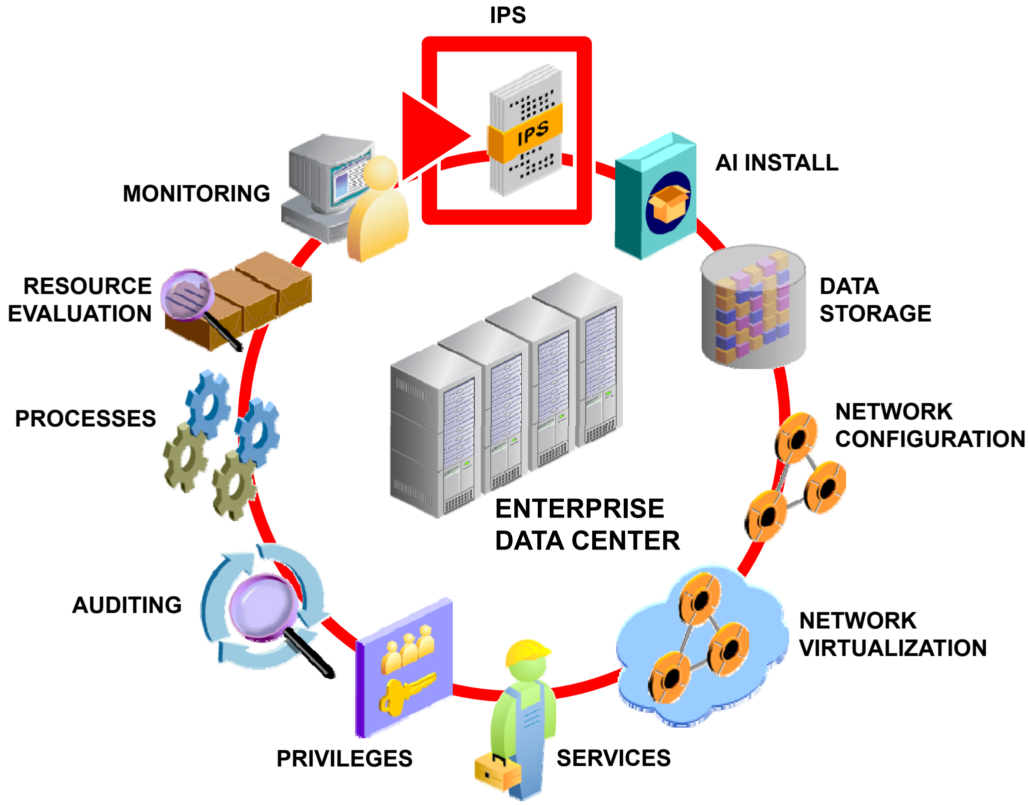
Managing the Image Packaging System (IPS) and Packages

Objectives

After completing this lesson, you should be able to:

- Implement a plan for the Image Packaging System (IPS) and package management
- Configure a local IPS package repository
- Configure network client access to a local IPS server
- Manage signed packages and package properties
- Manage package publishers
- Manage multiple boot environments

Workflow Orientation



This course presents each of the primary system administration tasks in the context of a workflow. Use the graphic shown in the slide at the beginning of each lesson to orient yourself in the workflow environment. You look at why certain tasks precede or follow other tasks and the importance of each task as it pertains to the system administrator's job.

As indicated in the graphic, you start with how to manage the Image Packaging System (IPS) to facilitate software package installation and updates, as well as how to manage business application data in a data storage environment, followed by installation. You then continue with network and zones configuration, followed by how to configure and manage services and privileges. After that, you look at how to use Oracle Solaris auditing, manage processes and priorities, and evaluate system resources. Your final tasks are monitoring and troubleshooting system failures.

The IPS provides you with a comprehensive delivery framework that spans the complete software life cycle, addressing software installation, updates, system upgrades, and the removal of software packages. From the perspective of keeping system software up to date, the IPS framework greatly simplifies software maintenance, application service availability, and data center security.

In this lesson, you learn how to set up a local IPS repository and manage it.

Lesson Agenda

- **Planning for IPS and Package Management**
- Configuring a Local IPS Package Repository
- Configuring Network Client Access to the Local IPS Server
- Managing Signed Packages and Package Properties
- Managing Package Publishers
- Managing Multiple Boot Environments

Importance of Working with a Plan

Implementing tasks in accordance with a plan ensures that the tasks are:

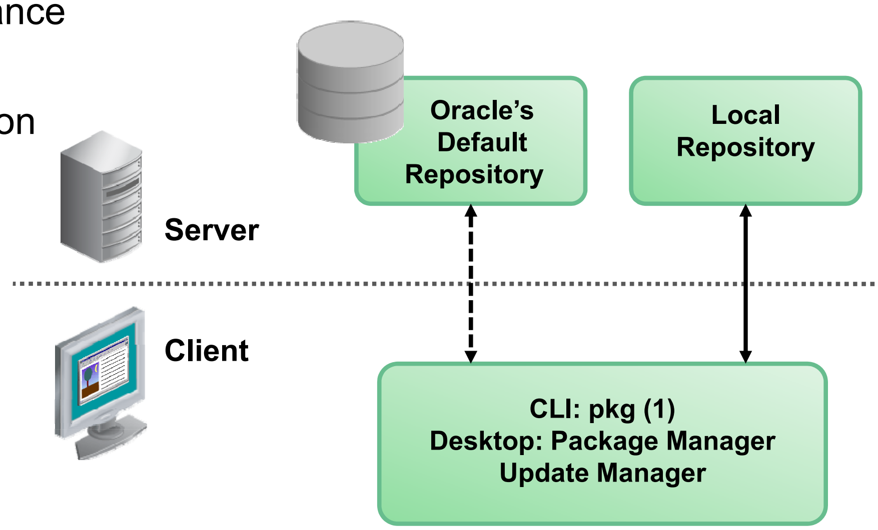
- Assigned to the appropriate personnel
- Completed as required
- Completed on schedule

Regardless of the type of task you are performing, you should execute the task based on a plan, especially for key tasks such as installation. In a large data center environment where system administration responsibilities are distributed among multiple administrators, it is even more important that you understand what your responsibilities are, and why and when you perform them. Often, you will be given directions or a plan by a senior member and asked to execute that plan. In some data centers, the plan is referred to as a "run book."

In this course, you are given a plan at the start of each major task, and then you are asked to implement the task as outlined in the plan.

Planning for IPS and Package Management

- As part of the Oracle Solaris 11 implementation plan, your company wants to set up a local IPS repository.
- A local IPS repository provides the following benefits:
  - Performance
  - Security
  - Replication



As with many companies, your company is concerned about performance and security. In preparation for the Oracle Solaris 11 implementation, the Server Implementation team has been asked to set up a local IPS repository as part of the operating system test environment.

A local IPS repository provides the following benefits to the company:

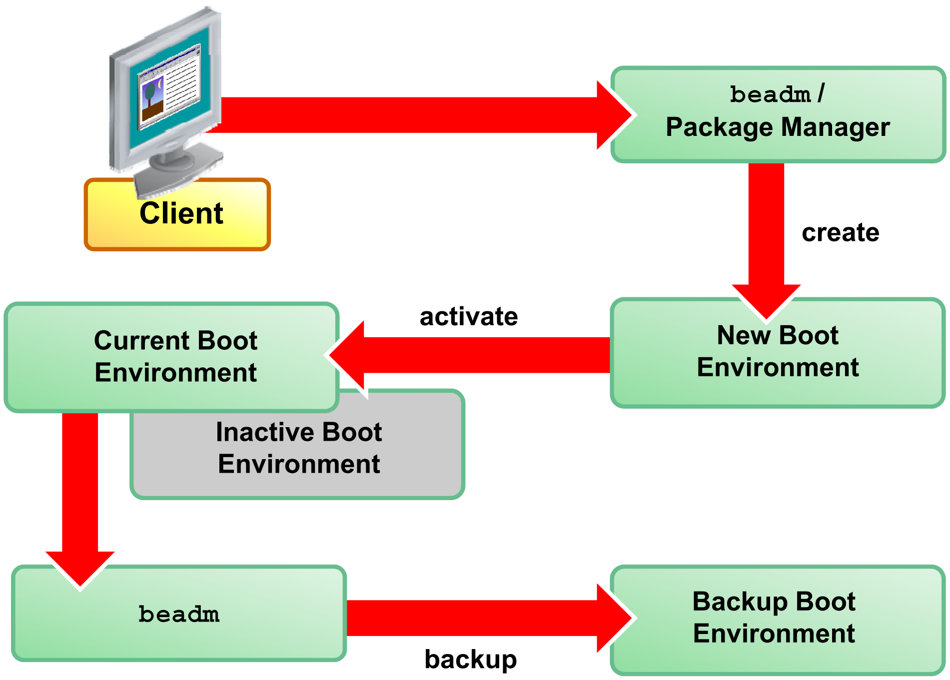
- **Performance:** Having a local package repository provides client access to packages at local network speeds.
- **Security:** You might not want your client systems to have access to the Internet.
- **Replication:** You want to make sure that an installation that you perform next year is exactly the same as the installation you perform today.

Identifying IPS Server System Requirements

Hardware/Software	Requirement
System	x86 or SPARC
Operating system	Oracle Solaris 11
Disk space	13 GB of free space

The other members of your team have selected the system to host the local IPS repository based on the system requirements shown in the slide. They have also selected the client systems that will be networked to the local IPS server to verify that the IPS is functioning correctly.

Planning for Boot Environment Management



In addition to setting up a local IPS repository, your company wants you to test the Oracle Solaris 11 boot environment (BE) technology. Given your company's service-level agreements, having multiple BEs to manage and maintain operating system images will be a critical part of the system administrator's day-to-day tasks in the new Oracle Solaris 11 environment. The BEs play an important role in the company's data backup strategy.

The part of the plan that you will help to implement requires testing of the BE creation and backup functionality by using the `beadm` command, Package Manager, and the ZFS snapshot functionality.

Note: From having taken the *Oracle Solaris 11 System Administration* course (or from your own on-the-job experience), you should be familiar with basic BE administration and with both the `beadm` command and the Package Management GUI. In this course, you build on these basic skills by learning how to manually create a new and complete BE based on the current BE, as well as how to create a snapshot of the BE that will be used as a backup.

Implementing the IPS and Package Management Plan

Your assignment is to:

- Configure a local IPS package repository
- Configure network client access to the local IPS server
- Test the BE creation and backup functionality

As a member of the Server Implementation team, you have the task of configuring the local IPS repository on an x86 system. After configuring the repository, your next task is to configure network client access to the IPS server for the client systems in the test environment. Finally, you ensure that the repository server is functioning as it should by running a series of package-management commands from one of the client systems.

After you verify that the local IPS repository is functioning correctly, you test the Oracle Solaris 11 BE technology by creating both new and backup BEs.

You learn how to configure the local IPS repository in the next few slides.

Quiz

What benefits does a local IPS repository provide?

a. Greater capacity for more packages in the repository
b. Automatically created backup BEs
c. Increased performance for package retrieval

Answer: c

Quiz

Which utility is used to manage BEs in Oracle Solaris 11?

a. `luupgrade`

b. `beadm`

c. BE Manager

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Answer: b

Lesson Agenda

- Planning for IPS and Package Management
- **Configuring a Local IPS Package Repository**
- Configuring Network Client Access to the Local IPS Server
- Managing Signed Packages and Package Properties
- Managing Package Publishers
- Managing Multiple Boot Environments

You know that the company's plan is to manage the IPS by using a local IPS repository. So you should now look at what you need to do to configure a local IPS package repository on one of your local systems.

Configuring a Local IPS Package Repository

Required tasks:

1. Creating a ZFS file system to hold the repository
2. Obtaining software packages from the Oracle Solaris download site
3. Making the contents of the repository available
4. Configuring the repository server service
5. Starting the repository service
6. Setting the local IPS publisher
7. Testing IPS on the local server

To configure a local IPS package repository, you must complete the tasks shown in the slide, which are covered in this section.

Creating a ZFS File System to Hold the Repository

Create a ZFS file system for the local package repository in the root pool.

```
# zfs create rpool/export/IPS

# zfs list
NAME                          USED  AVAIL  REFER  MOUNTPOINT
rpool                        9.94G  21.3G    39K  /rpool
rpool/ROOT                   2.13G  21.3G    31K  legacy
rpool/ROOT/solaris           2.13G  21.3G  1.58G  /
rpool/ROOT/solaris/var        507M  21.3G   505M  /var
rpool/dump                   1.03G  21.3G  1.00G  -
rpool/export                 5.74G  21.3G    33K  /export
rpool/export/IPS             5.74G  21.3G  5.74G  /export/IPS
rpool/export/home             212K  21.3G    37K  /export/home
rpool/export/home/oracle       34K  21.3G    34K
/export/home/oracle
rpool/swap                   1.03G  21.3G  1.00G  -
```


Your first task is to create a ZFS file system for your local package repository. Using a separate ZFS file system for your repository enables you to:

- Achieve better performance
- Set separate file system characteristics
- Recover specified file systems

A recommended practice is to create the new ZFS file system within `rpool`. You can then run the `zfs list` command to verify that the file system is created, as shown in the example in the slide.

Obtaining Software Packages from the Oracle Solaris Download Site

1. Go to the Oracle Solaris download site:
   http://www.oracle.com/technetwork/server-storage/solaris11/downloads/index.html
2. Download the Oracle Solaris 11 Repository Image:
   - Download Part A SPARC, x86 (3.3 GB)
   - Download Part B SPARC, x86 (3.1 GB)
3. Copy the files to the ZFS repository file system.
4. Uncompress the files.
5. Concatenate the files.

```
# unzip sol-11_1-repo-full.iso-a.zip
# unzip sol-11_1-repo-full.iso-b.zip
# cat sol-11_1-repo-full.iso-a sol-11-1-repo-full.iso-b > sol-
11_1-repo-full.iso
# ls /export/IPS
sol-11_1-repo-full.iso
```


After you have created the ZFS file system to hold your local package repository, you are ready to download the Oracle Solaris 11 Repository Image from the Oracle Solaris download site: http://www.oracle.com/technetwork/server-storage/solaris11/downloads/index.html.

The repository image provides you with a complete archive of software packages to allow you to set up a local network IPS repository that client systems can connect to.

The repository image is divided into two files:

- Download Part A SPARC, x86 (3.3 GB)
- Download Part B SPARC, x86 (3.1 GB)

Copy both files to the ZFS repository file system, uncompress them, and concatenate them, as shown in the example in the slide. You can then run the `ls` command for the ZFS file system to see the concatenated ISO file.

Making the Repository File Contents Available

Make the contents of the repository `.iso` file available to the depot server.

```
# lofiadm -a sol-11_1-repo-full.iso
# mount -F hsfs /dev/lofi/1 /mnt
# rsync -aP /mnt/repo /export/IPS
```


After the concatenated repository ISO image is in the ZFS repository file system, you need to make the contents of the file system available to the depot server (`pkg.depotd`), as shown in the example in the slide.

Note: A depot server is a collection of one or more package repositories. The depot server is typically run as a service on the system by `pkg.depotd(1m)`. The `pkg.depotd` service is managed by the service management facility, `smf(5)`, under the service identifier: `svc:/application/pkg/server`.

To perform this task, you use the `lofiadm -a` command, which enables you to associate a file with a block device (in this example, the block device is `/dev/lofi/1`). The file can then be accessed through the block device. This is useful when the file contains an image of a file system (for example, the repository ISO image), because you can then use the block device with normal system utilities for mounting, checking, or repairing the file system.

Note: A block device is a storage device that supports the reading and writing of data in fixed-sized blocks.

Next you mount the device by using the `mount -F hsfs` command. The `-F` option specifies the file system type on which to operate. In this example, the file system type is specified as an ISO 9660 file system (hsfs). The High Sierra file system, hsfs, is a draft predecessor to ISO 9660, so the name reflects the file system's history.

Finally, run the `rsync` program. This program enables you to transfer only the differences between the two sets of files across local disks, directories, or network connection very quickly.

Note: Be sure to specify `/mnt/repo` and not `/mnt/repo/` if you want to copy the `repo` directory and not just the files and subdirectories in the `repo` directory. For more information about the `rsync` command, see the `rsync(1)` man page.

The package repository is very large (approximately 6 GB). Depending on the speed of your host machine, the `rsync` program will take about two to three hours to complete.

Configuring the Repository Server Service

Use the SMF `svccfg` command to configure the repository server service.

```
# svccfg -s application/pkg/server setprop pkg/inst_root=/export/IPS/repo
# svccfg -s application/pkg/server setprop pkg/readonly=true
# svcprop -p pkg/inst_root application/pkg/server
/export/IPS/repo
```

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You now configure the repository server service by using the SMF `svccfg -s` command, as shown in the example in the slide.

In the first command, the `-s` option specifies the start method for the service and associates the local repository file system as the application package server. The `setprop` subcommand sets the name property of the `pkg` property to the ZFS file system where the repository files reside.

The second `svccfg -s` command specifies that the read-only property should be set to `true`.

You can verify that the local repository file system is now specified as the package server by using the `svcprop -p` command, as shown in the example. The `svcprop` utility with the `-p` option prints values of properties in the service configuration repository.

Note: As an alternative, you can also use an NFS share for your IPS repository, as the following example commands show:

```
# zfs set share.nfs=on /export/IPS name=repoSolaris11,path/export/IPS,prot=nfs
# dfshares s11-ss
RESOURCE             SERVER   ACCESS  TRANSPORT
solaris:/export/IPS  solaris  -       -
```

Starting the Repository Service

Use the SMF `svcadm` command to start the repository service.

```
# svcadm refresh application/pkg/server
# svcadm enable application/pkg/server
# svcs application/pkg/server
STATE   STIME          FMRI
online  17:00:56       svc:/application/pkg/server:default
```

Use the `pkgrepo refresh` command to refresh the package repository.

```
# pkgrepo refresh -s /export/IPS/repo
```


After you have the repository server service configured, you can start it by using the SMF `svcadm` command. You first refresh the service and then enable it, as shown in the example in the slide. You can verify that the service is enabled by running the `svcs application/pkg/server` command.

Also keep in mind that when you create a new package repository, you must refresh the repository catalog by using the `pkgrepo refresh` command so that the package search operations work correctly.

Setting the Local IPS Publisher

Use the `pkg set-publisher` command to set the publisher to the local IPS repository.

```
# pkg publisher
PUBLISHER             TYPE   STATUS URI
solaris               origin online http://pkg.oracle.com/solaris/release

# pkg set-publisher -G '*' -g http://server.mydomain.com/ solaris

# pkg publisher
PUBLISHER             TYPE    STATUS URI
solaris               origin  online http://server.mydomain.com/
```


The default publisher for Oracle Solaris 11 systems is `solaris`, and the default origin for that publisher is http://pkg.oracle.com/solaris/release. The publisher's origin is identified by its universal resource identifier (URI). This is the location of a machine or resource on the Internet.

To enable your clients to retrieve packages from your local repository, you need to reset the origin for the `solaris` publisher (as shown in this example) for each client.

The uppercase `-G` option with the `pkg set-publisher` command specifies the origin of the publisher to be removed. The `-g` option specifies the origin of the publisher to be added. In the example, you are removing the origin for the `solaris` publisher and adding the origin for a `solaris` publisher that is on the local IPS server (http://server.mydomain.com/).

Testing IPS on the Local Server

You can test that your IPS server is set up correctly by searching for a package.

```
# pkg search entire
INDEX         ACTION    VALUE              PACKAGE
pkg.fmri     set        solaris/entire    pkg:/entire@0.5.11-0.175.1.0.0.24.2
```


Your final IPS server configuration task is to test that the server is set up correctly. You can do this by searching for a package. In this example, you are looking for the `entire` package. If the search returns the package information, your local IPS server has been configured correctly.

Practice 2-1 Overview: Configuring a Local IPS Package Repository

This practice covers the following topics:

- Verifying that the `/export/IPS` file system has been configured on the system
- Determining whether the IPS service is available
- Setting up the `application/pkg/server` service
- Refreshing the package repository
- Adding a new publisher
- Testing IPS on the local server

The practices for this lesson are designed to reinforce the concepts that have been presented in the lecture portion. These practices cover the following tasks:

- **Practice 2-1:** Configuring a local IPS package repository
- **Practice 2-2:** Configuring network client access to the local IPS server
- **Practice 2-3:** Managing multiple boot environments

You will find Practice 2-1 in your Activity Guide. This practice should take about 45 minutes to complete.

Lesson Agenda

- Planning for IPS and Package Management
- Configuring a Local IPS Package Repository
- **Configuring Network Client Access to the Local IPS Server**
- Managing Signed Packages and Package Properties
- Managing Package Publishers
- Managing Multiple Boot Environments

Configuring Network Client Access to the Local IPS Server

This section covers the following topics:

- Determining the client host and domain names
- Checking network connectivity
- Setting the local IPS publisher
- Testing client access to the local IPS server

Determining the Client Host and Domain Names

Use `hostname` and `domainname` to identify the client machine.

```
# hostname
client1

# domainname
mydomain.com
```


Your first task is to identify the client machine's host and domain names. To do this, run the `hostname` and `domainname` commands, as shown in the slide.

Checking Network Connectivity

Verify DNS service access and connectivity with the local IPS server.

```
# nslookup server
Server:         192.168.0.100
Address:        192.168.0.100#53

Name:           server.mydomain.com
Address:        192.168.0.100

# ping server
server is alive
```


Next, you want to verify that the client machine can access DNS services and that it can connect to the local IPS server.

First, run the `nslookup` command with the name of the local IPS server. In the example in the slide, the local IPS server host name is `server`.

Then verify that the client can talk with the local IPS server by running the `ping` command, as shown in the example.

Setting the Local IPS Publisher

Use the `pkg set-publisher` command to set the publisher to the local IPS repository.

```
# pkg publisher
PUBLISHER     TYPE         STATUS URI
solaris       origin       online http://pkg.oracle.com/solaris/release

# pkg set-publisher -G '*' -g http://server.mydomain.com/ solaris

# pkg publisher
PUBLISHER     TYPE         STATUS URI
solaris       origin       online http://server.mydomain.com/
```

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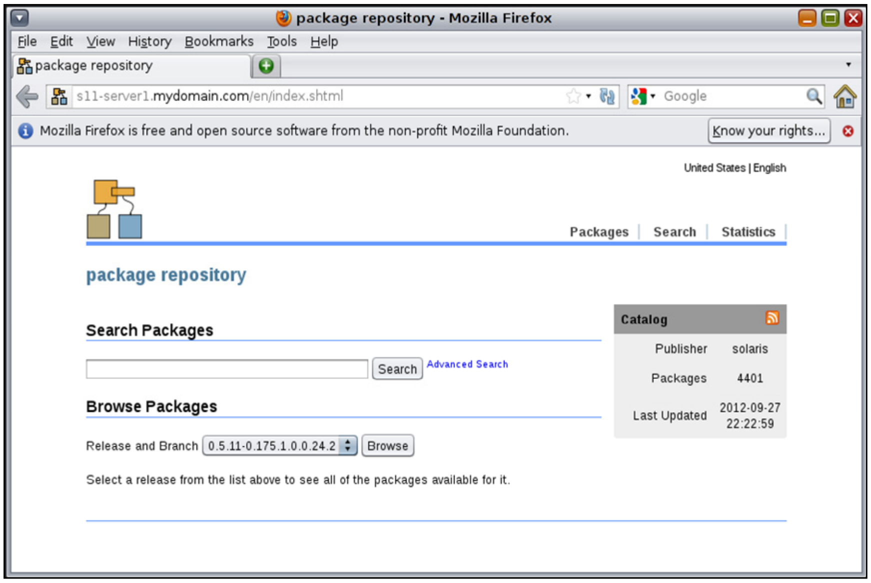
After you have verified network connectivity between the client and the local IPS server, you need to set the publisher to the local IPS publisher, just as you did when you configured the local IPS server.

First, check the current publisher. Next, set the publisher to the local IPS repository, and then verify that the publisher is now the local IPS publisher.

Make a note of the local publisher's URI; you will need it to complete the next task.

Testing Client Access to the Local IPS Server

To test client access to the IPS server, open the local publisher URI in a browser.



The final task is to test the client machine's access to the local IPS server. To do this, open the local publisher's URI in a browser. If a page is returned that reads "package repository," you have successfully configured the client's access to the IPS server. You can now use your local IPS repository to manage your company's software package needs.

Note: In this example, the URI would be http://s11-server1.mydomain.com.

Practice 2-2 Overview: Configuring Network Client Access to the Local IPS Server

This practice covers the following topics:

- Verifying connectivity between the client and the IPS server
- Removing and adding publishers
- Testing client access to the IPS server
- Searching for packages by using the package repository browser

This practice should take about 15 minutes to complete.

Lesson Agenda

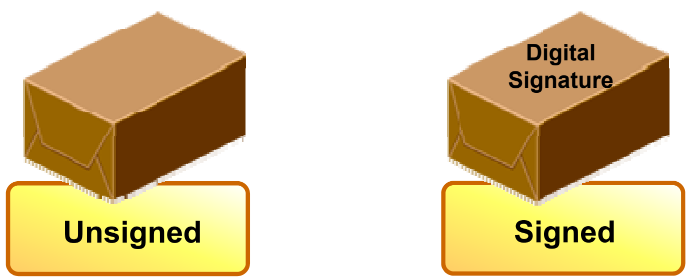
- Planning for IPS and Package Management
- Configuring a Local IPS Package Repository
- Configuring Network Client Access to the Local IPS Server
- **Managing Signed Packages and Package Properties**
- Managing Package Publishers
- Managing Multiple Boot Environments

You have set up your local package repository and verified that the client systems can access it. You are now ready to manage the packages that you get from the repository. Because you already know how to perform basic package management tasks (such as installing, updating, and displaying package information), this topic focuses on how to manage signed packages and package properties. You are introduced to variants and facets, and you learn how to view and purge operation history.

Introducing Signed Packages

Signed packages contain digital signatures that verify that:

- The package came from the entity who signed it
- The entity signed the package
- The package has not been modified
- The entity is trusted



Software packages can be signed or unsigned. A signed package is identical to an unsigned package, except that it has a digital signature that verifies the following:

- The package came from the entity who signed it.
- The entity indeed signed it.
- The package has not been modified since the entity signed it.
- The entity who signed it is a trusted entity.

In other words, a signed package provides the reassurance that the package is secure and, therefore, safe to download and install on your system.

Installing Signed Packages

- Configuring image properties for signed packages
- Configuring publisher properties for signed packages

Before you can install signed packages on your system, you must set specific properties on both the image and the publisher.

Identifying Image Properties for Signed Packages

- `signature-policy`: Determines what checks will be performed on manifests when you install a package into the operating system image
  - `ignore`
  - `verify`
  - `require-signatures`
  - `require-names`
- `signature-required-names`: Defines names that must be seen as common names of certificates while validating the signatures of a package
- `trust-anchor-directory`: Identifies the path name of the directory that contains the trust anchors for the image

You can set three image properties for signed packages. These are `signature-policy`, `signature-required-names`, and `trust-anchor-directory`.

The `signature-policy` property, along with one of its values, determines the checks that are performed on manifests when installing a package into the operating system image. You can use the following values with this property:

- `ignore`: Directs the image to ignore signatures for all manifests
- `verify`: Directs the image to verify that all manifests with signatures are validly signed, but does not require all installed packages to be signed
- `require-signatures`: Directs the image to require that all newly installed packages have at least one valid signature

  Note: The `pkg fix` and `pkg verify` commands also present a warning if an installed package does not have a valid signature.
- `require-names`: Directs the image not only to require that all newly installed packages have at least one valid signature (as with the `require-signatures` property) but also to require that the strings listed in the `signature-required-names` image property appear as common names of the certificates used to verify the chains of trust of the signatures

The next property, `signature-required-names`, defines a list of names that must be seen as common names of certificates while validating the signatures of a package. It is used only when the signature policy is `require-names`.

The last property, `trust-anchor-directory`, identifies the path name of the directory that contains the trust anchors for the image. This path is relative to the operating system image.

The final policy that is applied to a package depends on the combination of image policy and publisher policy. The combination will be at least as strict as the stricter of the two policies taken individually.

Configuring Image Properties for Signed Packages

Use `pkg` with the following subcommands to configure package signature properties for an image:

- `set-property`
- `add-property-value`
- `remove-property-value`
- `unset-property`

Examples:

```
# pkg set-property signature-policy verify
# pkg add-property-value signature-require-names trustedname
# pkg remove-property-value signature-require-names trustedname
# pkg unset-property signature-policy
```


To configure the image properties for signed packages, you use the `pkg` command with the list of subcommands presented in the slide. As you can see from the list of subcommands, you can set, add, remove, and unset properties.

Under "Examples" in the slide, the first command shows how to configure an image to verify all signed packages by setting the `verify` value for the `signature-policy` property.

The second command is an example of how to add the string `trustedname` to the image's list of common names that must be seen in a signature's chain of trust for it to be considered valid.

The third command is an example of how to remove the string `trustedname` from the image's list of common names.

The fourth command shows how to restore the `signature-policy` property to its default value.

Identifying Publisher Properties for Signed Packages

- `signature-policy`: Determines the checks that will be performed on manifests when installing a package into the image from a specified publisher
- `signature-required-names`: Defines names that must be seen as common names of certificates while validating the signatures of a package from a specified publisher

There are two publisher properties that you can set to use signed packages from a specific publisher: `signature-policy` and `signature-required-names`.

The `signature-policy` property is identical to the function of the `signature-policy` image property, except that this property applies only to packages from a specified publisher.

The `signature-required-names` property is identical to the function of the `signature-required-names` image property, except that this property applies only to packages from a specified publisher.

Configuring Publisher Properties for Signed Packages

Use `pkg set-publisher` with the following subcommands to configure package signature properties for a publisher:

- `--set-property`
- `--add-property-value`
- `--remove-property-value`
- `--unset-property`

Examples:

```
# pkg set-publisher --set-property signature-policy=require-
signatures whoisit.com
# pkg set-publisher --add-property-value signature-require-
names=trustedname whoisit.com
# pkg set-publisher --remove-property-value signature-require-
names=trustedname whoisit.com
# pkg set-publisher --unset-property signature-policy
whoisit.com
```


To configure publisher properties for signed packages, you use the `pkg set publisher` command with the list of subcommands presented in the slide. As with image properties, you can set, add, remove, and unset properties. Note that the subcommands are the same as those used for configuring image properties, with one exception: each subcommand is preceded by a double dash (`--`).

Under "Examples" in the slide, the first command shows how to configure an operating system image to require that all packages installed from the publisher `whoisit.com` must be signed.

The second command is an example of how to add the string `trustedname` to the `whoisit.com` publisher's list of common names that must be seen in a signature's chain of trust for it to be considered valid.

The third command is an example of how to remove the string `trustedname` from the `whoisit.com` publisher's list of common names.

The fourth command shows how to unset the `signature-policy` property that requires that all packages installed from the publisher `whoisit.com` must be signed.

Quiz

Which command enables you to configure your current image to ensure that all manifests with signatures are validly signed?

a. `# pkg set-property signature-policy verify`

b. `# pkg set-property signature-policy require-names`

c. `# pkg set-property signature-policy require-signature`

Answer: a

Quiz

What `pkg` subcommand or option of the `set-publisher` subcommand is used to configure publisher properties for signed packages?

a. `set-property`

b. `set-publisher`

c. `set-publisher property`

d. `--set-publisher`

Answer: b

Introducing Variants and Facets

- **Variant:** Mutually exclusive component of a package
  - Appears as a tag on IPS actions
  - Affects whether an IPS action is installable
- **Facet:** Optional component of a package
  - Appears as a tag on IPS actions
  - Affects whether an IPS action is installable

Another way that the IPS allows you to manage your packages, regardless of whether they are signed or unsigned, is through the use of variants and facets. A variant is a mutually exclusive component of a package, such as architecture. Variants appear as tags on IPS actions and affect whether that action is installable. If an action has any variant tags, all variant tags must match the selection criteria to install the action.

Note: An action is defined in the IPS as an installable object, such as a file, directory, link, or dependency. Actions are described in the manifest of a package. Every action consists primarily of its name and a key attribute. Together, these refer to a unique object as it follows a version history.

A facet is an optional component of a package, such as a locale. Facets appear as tags on IPS actions and affect whether that action is installable. If an action has any facet tags, at least one facet tag must match the selection criteria to install the action.

Displaying and Changing Variants and Facets

Variants

- To display the values of all variants, use `pkg variant`.
- To display specific variants, use `pkg variant` *`variant_spec`*.
- To change a variant, use `pkg change-variant --accept` *`variant_spec=instance`*.

Facets

- To display the current values of all facets defined in the current image, use `pkg facet`.
- To display specific facets, use `pkg facet` *`facet_spec`*.
- To change the current value of a facet, use *`pkg change-facet`* `--accept` *`facet_spec`*`=True|False|None`.

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You can display and change the current values for both variants and facets. To display the values of all the variants of an image, you can use the `pkg variant` command. To display specific variants, use the `pkg variant` command with a variant specification (`variant_spec`). You can specify multiple variant specifications.

To change a specific variant, use the `pkg change-variant` command, followed by `--accept` and the variant specification (`variant_spec=instance`). If you want to see what will change without actually implementing the change, you can use the `-n` option as in this example: `# pkg change-variant -n --accept variant.debug=false`.

To display all the facets in the current image, use `pkg facet`. To display specific facets, use the `pkg facet` command with a facet specification (`facet_spec`). You can specify multiple facet specifications. To change a specific facet, use the `pkg change-facet` command, followed by `--accept` (to automatically accept all package licenses without interruption to the update process) and the facet specification (`facet_spec=True|False|None`). Again, you can use the `-n` option to see what changes will occur without actually making the change.

Managing Package History

- To view package history, run `pkg history`.
- To view more verbose package history information, run `pkg history -l`.
- To specify the number of the most recent package history operations to display, use the `-n` option.
- To display log records for a comma-separated list of timestamps, use the `–t` option.
- To purge package history, run `pkg purge-history`.

```
$ pkg history
START                OPERATION             CLIENT              OUTCOME
2012-09-19T20:12:54  update-publisher      transfer module     Succeeded
2012-09-19T20:12:54  refresh-publishers    transfer module     Succeeded
2012-09-19T19:47:54  install               transfer module     Succeeded

# pkg purge-history
```


IPS has a `pkg history` command that enables you to see all the package operations that have been performed on an image, as shown in the example in the slide.

Use the `-l` option if you want to display more information, including the outcome of the command, the time the command completed, the version and name of the client used, the name of the user who performed the operation, and any errors encountered while executing the command.

If you want to display only the most recent operations, use the `-n` option to specify the number of operations that you want to view by.

To display log records for a comma-separated list of time stamps, use the `-t` option and a hyphen (`-`) between a start and finish time stamp. The keyword `now` can be used as an alias for the current time.

Use the `pkg purge-history` command to purge the history. However, you need root privileges to perform this action.

For more information, see man `pkg(1)`.

Lesson Agenda

- Planning for IPS and Package Management
- Configuring a Local IPS Package Repository
- Configuring Network Client Access to the Local IPS Server
- Managing Signed Packages and Package Properties
- **Managing Package Publishers**
- Managing Multiple Boot Environments

You will recall having set the publisher when you configured both the local IPS server and the client machines, and when you configured the publisher properties for signed packages. In this topic, you take a brief look at the other management tasks that you can perform on package publishers.

Managing Package Publishers

This section covers the following topics:

- Displaying publisher information
- Specifying publisher stickiness
- Setting the publisher search order
- Disabling or enabling a publisher
- Changing a publisher origin URI

You already know how to perform several of the package publisher management tasks. You know how to display the current publisher (`pkg publisher`), add a publisher (`pkg set-publisher -g`), and remove a publisher (`pkg set-publisher -G`).

The additional tasks listed in the slide are covered in this section.

Displaying Publisher Information

- To display only the highest-ranked publisher in the search order, run `pkg publisher -P`.

```
$ pkg publisher -P
PUBLISHER                   TYPE     STATUS    URI
solaris                     origin   online    http://pkg.oracle.com/solaris/release
```

- To display information about a specific publisher, run `pkg publisher` *`publisher_name`*.

```
$ pkg publisher solaris
       Publisher: solaris
           Alias:
      Origin URI: http://pkg.oracle.com/solaris/release
         SSL Key: None
        SSL Cert: None
     Client UUID: ddee2130-0292-11e2-b9e5-80144f013e20
 Catalog Updated: September 27, 2012 10:22:59 PM
         Enabled: Yes
```


If you are interested in seeing information only about the highest-ranked publisher in the search order, you can run the `pkg publisher` command with the uppercase `-P` option, as shown in the first example in the slide. You can see the publisher name, type, status, and URI.

If you have multiple publishers and you want to see information about a particular publisher, you can use the `pkg publisher` command with the publisher name. As shown in the second example, this command displays the publisher's name, an alias if one has been assigned, the origin URI, the publisher's SSL keys and certificates information if there are any, the client's universally unique identifier (UUID), the date the publisher's catalog was last updated, and whether the publisher is enabled.

Note: For information about specifying SSL keys and certificates for a publisher, see the Image Packaging System man pages.

Specifying Publisher Rankings

To set a publisher to be the highest-ranked publisher in the search order, run `pkg set-publisher -P` *`publisher_name`* or the `--search-first` option.

```
# pkg publisher
PUBLISHER                 TYPE    STATUS   URI
solaris                   origin  online   http://server.mydomain.com
whoisit.com (non-sticky)  origin  online   http://pkg.example.com/release

# pkg set-publisher -P whoisit.com

# pkg publisher
PUBLISHER                 TYPE    STATUS   URI
whoisit.com               origin  online   http://pkg.example.com/release
solaris     (non-sticky)  origin  online   http://server.mydomain.com
```


As you may recall, when you first looked at the publisher information while configuring the local IPS server, the publisher was the default `solaris` publisher from Oracle. You then removed the default publisher origin for the `solaris` publisher and added a new origin to it. The `solaris` publisher then became the highest-ranked publisher in the search order (primarily because it was the only publisher at that point).

Assume that you have since added several publishers to your local IPS server and you want to specify a different publisher as the highest-ranked publisher. To make this change, you use the `-P` option with the `pkg set-publisher` command, followed by the publisher's name, as shown in the example, where you make the `whoisit.com` publisher the highest-ranked publisher. Note how the specified publisher moves to the top of the search order when you run the `pkg publisher` command again. (The "non-sticky" specification is discussed on the next page.)

Note: You can specify the `-P` option when you add a publisher or when you modify an existing publisher. Also, you can choose to use the `--search-first` option to search the higher-ranked publisher.

Specifying Publisher Stickiness

To make a publisher sticky, run `pkg set-publisher --sticky` *`publisher_name`*.

```
# pkg set-publisher --sticky example.com
```

To make a publisher non-sticky, run `pkg set-publisher --non-sticky` *`publisher_name`*.

```
# pkg set-publisher --non-sticky example.com
```


To make sure that a package that was installed from one publisher cannot be updated by another publisher, you can make the publisher "sticky." To do this, you use the `pkg set-publisher --sticky` command, followed by the publisher's name (as shown in the first example in the slide). A newly added publisher is sticky by default.

Conversely, if you want to allow a package that was installed from one publisher to be updated by another publisher (that is, so that publishers that are ranked higher than the specified publisher can provide updates to packages originally installed from the specified publisher), you can use the `pkg set-publisher` command with the `--non-sticky` option (as shown in the second example).

Setting the Publisher Search Order

To move a publisher higher in the search order, run `pkg set-publisher --search-before` *`publisher_name publisher_name`*.

```
# pkg set-publisher --search-before example1.com example2.com
```

To move a publisher lower in the search order, run `pkg set-publisher --search-after` *`publisher_name publisher_name`*.

```
# pkg set-publisher --search-after example1.com example2.com
```


The publisher search order is used to find packages to install. The publisher search order is also used to find packages to update if the publisher that the package was originally installed from is non-sticky.

The high ranked publisher is first in the search order. A newly added publisher is last in the search order by default.

To move a publisher higher in the search order, use the `pkg set-publisher --search-before` command, followed by the name of the publisher that you want to be demoted in the search order, and then the name of the publisher that you want to be promoted in the search order (as shown in the first example in the slide).

To move a publisher lower in the search order, use the `pkg set-publisher --search-after` command, followed by the name of the publisher that you want to be searched first, and then the name of the publisher that you want to be searched thereafter (as shown in the second example).

Disabling and Enabling a Publisher

To disable a publisher, run `pkg set-publisher -d` *`publisher_name`*.

```
# pkg set-publisher -d solaris.com
```

To enable a publisher, run `pkg set-publisher -e` *`publisher_name`*.

```
# pkg set-publisher -e solaris.com
```


There may be times when you need to disable a publisher temporarily. Suppose you have a planned server or network outage. To minimize client down time to other publishers, you decide to temporarily disable your publisher. After the planned down-time window is past, you can enable the publisher again.

To disable a publisher, use the `pkg set-publisher` command with the `-d` option, followed by the publisher's name, as shown in the first example in the slide. A disabled publisher is not used in package operations, such as `list` and `install`. However, you can still modify the properties of a disabled publisher.

Note: The highest-ranked publisher cannot be disabled.

Use the `-e` option with the `pkg set-publisher` command to enable a publisher, as shown in the second example.

Note: To see the disabled or enabled status of a publisher, you can run the `pkg publisher` command with the publisher's name.

Changing a Publisher Origin URI

To change a publisher origin URI, run `pkg set-publisher -g` *`newpublisher_URI`* `-G` *`oldpublisher_URI newpublisher`*.

```
# pkg set-publisher -g http://pkg.example.com/support \
-G http://pkg.example.com/release solaris
```


There may be times when you want or need to change a publisher's origin URI. For example, you want to switch `pkg.example.com/release` to `pkg.example.com/support`. The command to change a publisher's origin URI is very similar to the command that you used to add a new publisher to the local IPS server and remove the default `solaris` publisher. To change the origin URI for a publisher, you add the new URI by using the `-g` option and remove the old URI by using the `-G` option, as shown in the example in the slide.

Quiz

You want to set `mypublisher.com` as the highest-ranked publisher for your local IPS repository. Which command would you use to execute this task?

a. `pkg publisher -P mypublisher.com`

b. `pkg publisher -n mypublisher.com`

c. `pkg set-publisher -P mypublisher.com`

d. `pkg set-publisher -e mypublisher.com`

Answer: c

Quiz

You have three publishers listed in the following order: `mypublisher.com` (the highest-ranked publisher), `solaris`, and `whoisit`. For search-order purposes, you want to move the `whoisit` publisher before the `solaris` publisher. Which command would you use to execute this task?

a. `pkg set-publisher --search-before solaris whoisit`

b. `pkg set-publisher --search-after solaris whoisit`

c. `pkg set-publisher --search-before whoisit solaris`

Answer: a

Lesson Agenda

- Planning for IPS and Package Management
- Configuring a Local IPS Package Repository
- Configuring Network Client Access to the Local IPS Server
- Managing Signed Packages and Package Properties
- Managing Package Publishers
- **Managing Multiple Boot Environments**

As a system administrator, an important part of your job is to manage multiple boot environments (BEs), which includes making a backup of the BEs. You learn how to do this in the next few slides.

Managing Multiple Boot Environments

This section covers the following topics:

- Mounting an inactive boot environment
- Installing a package on an inactive, mounted boot environment
- Uninstalling a package on an inactive, mounted boot environment
- Unmounting an inactive boot environment
- Creating a snapshot of a boot environment
- Creating a boot environment from an existing snapshot

Managing multiple boot environments is part of a system administrator's responsibility. Being able to create multiple BEs not only provides you with a full backup of your operating system image but also gives you the flexibility to create other BEs in which to install and test new packages with your current applications before introducing them into the production environment.

Listing the Boot Environments on the System

To list the boot environments on a system, run `beadm list`.

```
# beadm list
BE         Active  Mountpoint Space   Policy  Created
--         ------  ---------- -----   ------  -------
solaris    NR      /           2.38G  static  2012-11-08 03:50
solaris-1  -       -          169.0K  static  2012-12-10 22:14
```


As you know, before you make any changes to the boot environments on your system, the first thing that you should do is to determine the boot environments that exist on the system by running the `beadm list` command, as shown in the example in the slide.

The environment presented here has two BEs, with the active or current BE being the `solaris` BE.

Mounting an Inactive Boot Environment

To mount an inactive boot environment, run `beadm mount` *`beName mountpoint`*.

```
# beadm mount solaris-1 /solaris-1
# beadm list
BE         Active  Mountpoint Space   Policy  Created
--         ------  ---------- -----   ------  -------
solaris    NR      /            2.38G   static 2012-11-08 03:50
solaris-1  -      /solaris-1 169.01M   static 2012-12-10 22:14
```

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Suppose that you have been asked to install and test several new packages on the operating system. You do not want to impact the production environment, so you decide to mount an existing inactive BE that is a copy of the existing active BE and use that for testing. To do this, you must first mount the inactive BE.

To mount an existing inactive BE, you must run the `beadm mount` command followed by the name of the inactive BE and the location of the mount point, as shown in the example in the slide, where you are mounting the `solaris-1` inactive BE to `/solaris-1`.

Note: If the directory for the mount point does not exist, the `beadm` utility creates the directory and then mounts the boot environment on that directory. If the boot environment is already mounted, the `beadm mount` command fails and does not remount the boot environment at the newly specified location.

To verify that the inactive BE is mounted, run the `beadm list` command again, as shown in the example. As you can see, the boot environment is mounted but remains inactive.

Installing a Package on an Inactive, Mounted Boot Environment

To install a package on an inactive boot environment, run `pkg -R` *`mountpoint`* `install` *`packagename`*.

```
# pkg -R /solaris-1 install newpkg
Creating plan...
               Packages to install:     1
           Create boot environment:    No
    Create backup boot environment:    No

DOWNLOAD                            PKGS    FILES    XFER(MB)   SPEED
Completed                           1/1       3/3    0.1/0.1    43.8k/s

PHASE                                        ITEMS
Installing new actions                       19/19
Updating package state database               Done
Updating image state                          Done
Creating fast lookup database                 Done
```


After verifying that the inactive BE is mounted, you can install one or more packages by using the `pkg install` command with the uppercase `-R` option, the mount point location, and the package name, as shown in the example in the slide.

Note: The uppercase `-R` option specifies an alternate root to be used to identify the specific packages to be installed or updated.

Uninstalling a Package on an Inactive, Mounted Boot Environment

To uninstall a package on an inactive boot environment, run `pkg -R` *`mountpoint`* `uninstall` *`packagename`*.

```
# pkg -R /solaris-1 uninstall newpkg
```


If you want to uninstall a package from an inactive mounted boot environment, the command is basically the same as that for the installation. But instead of using `pkg install`, you use `pkg uninstall` with the uppercase `-R` option, the mount point location, and the package name, as shown in the example in the slide.

Unmounting an Inactive Boot Environment

To unmount an inactive boot environment, run `beadm unmount` *`beName`*.

```
# beadm unmount solaris-1
# beadm list
BE         Active  Mountpoint Space   Policy  Created
--         ------  ---------- -----   ------  -------
solaris    NR      /            2.38G   static 2012-11-08 03:50
solaris-1  -       -          170.01M   static 2012-12-10 22:14
```


Before you reboot the BE, you must unmount it. To unmount an inactive BE, run the `beadm unmount` command, followed by the name of the inactive BE, as shown in the example in the slide.

Note: You cannot unmount the BE that is currently booted.

To verify that the inactive BE is unmounted, run the `beadm list` command again, as shown in the example. As you can see, the boot environment is now unmounted.

From this point, you can activate the inactive boot environment by using the `beadm activate` command, and then reboot the system.

Creating a Backup of a Boot Environment

To create a backup of the boot environment, run `beadm create` *`BEname@snapshotdescription`*.

```
# beadm create solaris@backup
# beadm list -a solaris
BE/Dataset/Snapshot                          Active Mountpoint Space   Policy Created
-------------------                          ------ ---------- -----   ------ -------
solaris
   rpool/ROOT/solaris                        NR     /          2.27G   static 2012-10-29 11:32
   rpool/ROOT/solaris/var                    -      /var       112.37M static 2012-10-29 11:32
   rpool/ROOT/solaris/var@2012-10-29-12:17:23 -     -          760.5K  static 2012-10-29 17:47
   rpool/ROOT/solaris/var@backup             -      -          24.0K   static 2012-10-29 18:06
   rpool/ROOT/solaris/var@install            -      -          18.86M  static 2012-10-29 11:37
   rpool/ROOT/solaris@2012-10-29-12:17:23    -      -          50.27M  static 2012-10-29 17:47
   rpool/ROOT/solaris@backup                 -      -          0       static 2012-10-29 18:06
   rpool/ROOT/solaris@install                -      -          53.28M  static 2012-10-29 11:37
```


To create a backup of the boot environment, use the `beadm create` command followed by the BE name and a backup description. In the example in the slide, you are creating a backup of the `solaris` BE.

To verify that the backup was created, you can run `beadm list -a` followed by the BE name, as shown in the example.

Creating a Boot Environment from an Existing Backup

To create a boot environment from an existing backup, run `beadm create -e` *`BEname@snapshotdescription beName`*.

```
# beadm create -e solaris@backup solaris-2
# beadm list
BE         Active Mountpoint Space   Policy Created
--         ------ ---------- -----   ------ -------
solaris    NR     /           2.38G  static 2012-11-08 03:50
solaris-1  -      -         170.01M  static 2012-12-10 22:14
solaris-2  -      -          28.0K   static 2012-12-10 22:59
# beadm activate solaris-2
# beadm list
BE         Active Mountpoint Space   Policy Created
--         ------ ---------- -----   ------ -------
solaris    N     /            2.38G  static 2012-11-08 03:50
solaris-1  -      -         170.01M  static 2012-12-10 22:14
solaris-2  R      -          28.0K   static 2012-12-10 22:59
# init 6
```


A backup of a boot environment is not bootable. However, you can create a new boot environment from an existing backup, and then activate and boot the new boot environment.

To create a boot environment from a backup, use the `beadm create -e` command followed by the backup description and a new BE name. In the example in the slide, you are creating a new BE called `solaris-2` from the backup `solaris@backup`.

To verify that the backup was created, run `beadm list` (as shown in the example). You can see that `solaris-2` is created.

To make the new BE the current boot environment, you must activate it and then reboot the system, as shown in the example. Note that if you run the `beadm list` command again, you can see that `solaris-2` is now the BE that is active on reboot as designated by the `R` in the `Active` column.

Practice 2-3 Overview: Managing Multiple Boot Environments

This practice covers the following topics:

- Creating a new full BE based on the current BE
- Mounting and updating an inactive BE
- Creating a snapshot of a BE
- Deleting a BE
- Renaming a BE

This practice should take about 30 minutes to complete.

Summary

In this lesson, you should have learned how to:

- Implement a plan for the Image Packaging System (IPS) and package management
- Configure a local IPS package repository
- Configure network client access to a local IPS server
- Manage signed packages and package properties
- Manage package publishers
- Manage multiple boot environments

3

Installing Oracle Solaris 11 on Multiple Hosts

Objectives

After completing this lesson, you should be able to:

- Implement a plan for an Oracle Solaris 11 operating system installation
- Install the Oracle Solaris 11 operating system by using the Automated Installer
- Verify an Oracle Solaris 11 operating system installation
- Build an Oracle Solaris image by using the distribution constructor

ORACLE

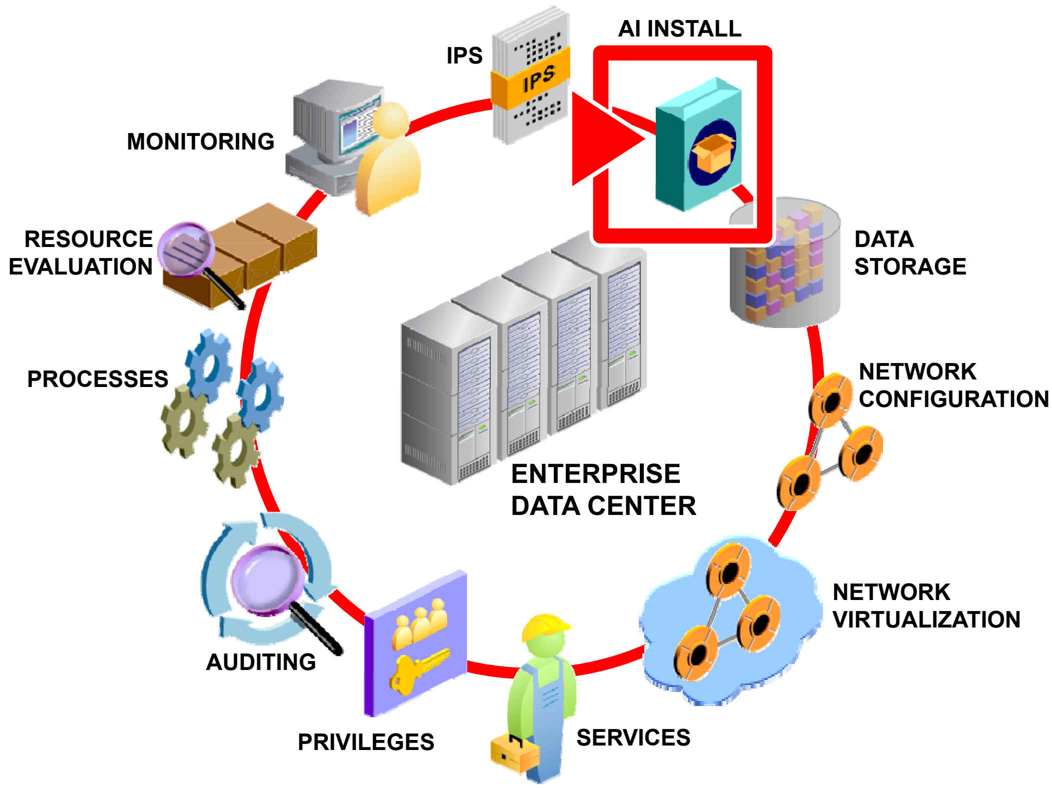
This lesson explains how to perform an installation of the Oracle Solaris 11 operating system on multiple hosts by using the Automated Installer (AI).

It begins by discussing the importance of planning for the OS installation, including an introduction to the automated installation method.

Next, you focus on how to install Oracle Solaris 11 by using the automated installation method, and then how to verify the installation.

The lesson concludes by discussing how to build an Oracle Solaris image for distribution by using a technology called the “distribution constructor.”

Workflow Orientation



Before you begin the lesson, take a moment to orient yourself in the job workflow. So far, you have successfully set up a local IPS repository. The Automated Installer (AI) requires client access to this IPS software package repository to install the OS on multiple client systems in a network. The AI enables you to perform a hands-free installation of both SPARC and x86 systems.

Lesson Agenda

- **Planning for Oracle Solaris 11 Operating System Installations by Using the Automated Installer**
- Installing Oracle Solaris 11 by Using the Automated Installer
- Building an Oracle Solaris Image

Reviewing Your Company's Plan for an Oracle Solaris 11 Implementation

Implementation plan review:

- Update all Solaris x86/64 machines to Oracle Solaris 11.
- Use the Automated Installer (AI) to install the operating system.
  - Allows flexible configuration for disk layout, users, provisioning of zones, and software selection
  - Supports unattended installation on multiple machines
  - Saves significant installation time
- Evaluate by using distribution constructor for future Solaris image deployments.

ORACLE

You may recall from the introductory practice orientation that your company is planning to upgrade all its Solaris x86/64 machines to Oracle Solaris 11. As part of that planning effort, the company tests Oracle Solaris 11 functionality. After reviewing the installation method options for Oracle Solaris 11 (LiveCD, text installer, and Automated Installer), the planning committee decides that, because of the number of machines that your company needs to upgrade, the Automated Installer (AI) will be used to perform the installation.

The benefit of using the AI is that you can install and configure the operating system ISO on one server (either x86 or SPARC) and do not have to replicate the same installation effort on other hosts. The AI provides you with flexible configuration for disk layout, users, provisioning of zones, and software selection. Using AI, the operating system can be installed on client hosts unattended and without any manual intervention. This method saves significant installation time and, therefore, is used widely in the industry.

In addition, the team also wants to evaluate using the distribution constructor for deploying Solaris images.

Planning for an Oracle Solaris 11 AI Installation

The AI installation testing activities include:

- Identifying AI requirements
- Configuring the AI installation server
- Configuring the client system
- Implementing the configuration
- Verifying the installation

As part of the Server Implementation team, you are responsible for completing many of the AI installation testing activities, including those listed in the slide.

Note: Another team has been assigned the responsibility of evaluating the use of the distribution constructor. However, you will be given an overview later in this lesson of how Solaris images are built by using the distribution constructor.

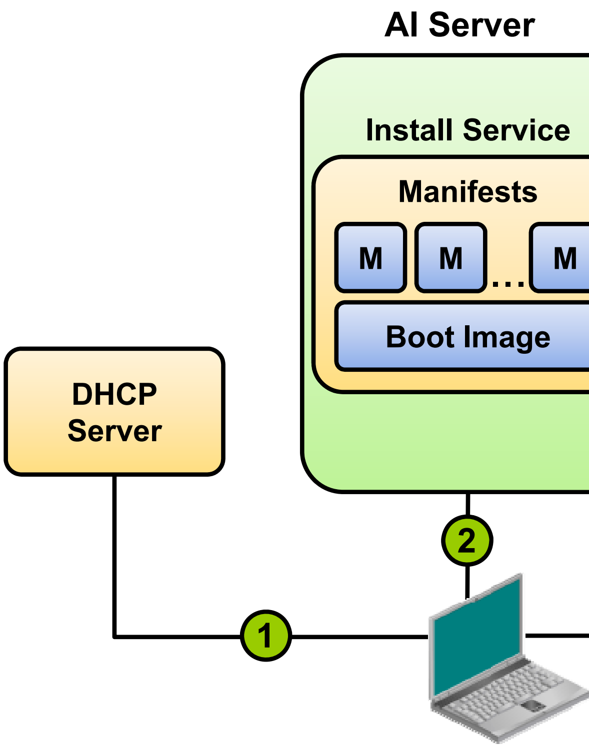
Automated Installation: Overview

- The AI automates the installation of the OS on one or more SPARC and x86 systems over a network.
- The installations differ in architecture, software packages, disk capacity, network configuration, and other parameters.
- Automated installation requires the following components:
  - **AI server:** Provides the install service that contains the installation instructions for the client system
  - **Client system to be installed:** Accesses the IP address information from the DHCP server
  - **DHCP server:** Provides the initial IP addresses and boot information
  - **IPS repository:** Provides the software packages that are identified in the AI manifest file to the client system

The Automated Installer is used to automate the installation of the Oracle Solaris 11 OS on one or more SPARC and x86 systems over a network. The installations can differ in architecture, software packages installed, disk capacity, network configuration, and other parameters.

For an automated installation to run, the components presented in the slide are required.

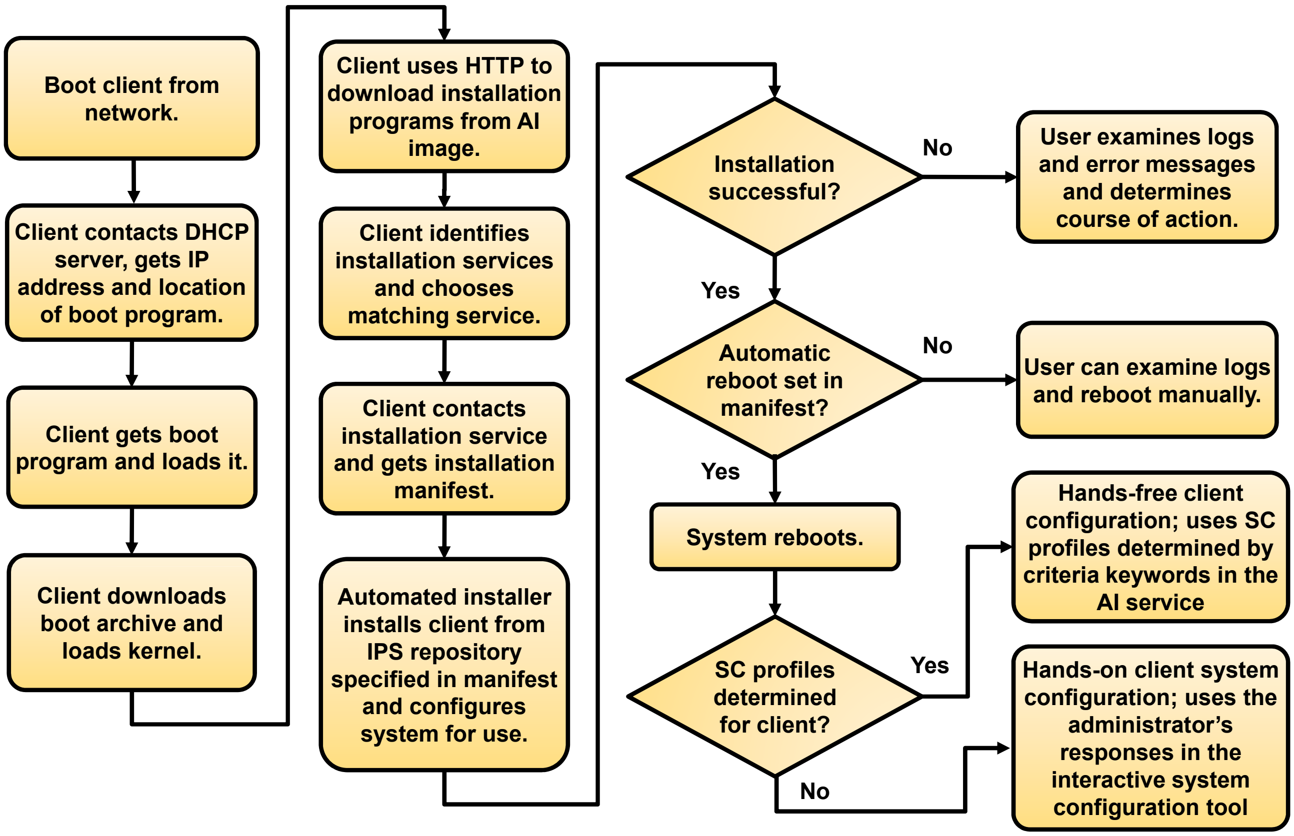
Automated Installation Process



The graphic in the slide illustrates the automated installation process:

1. A client system boots and gets IP and boot information from the DHCP server.
2. The client contacts an install service on the AI server and accesses the boot image and the AI manifest that contains the installation instructions.
3. The client is installed with the operating system, pulling packages from the IPS repository that is specified in the installation instructions.

How the AI Works



Suppose that you have set up an installation server with one or more installation services. You have customized the installation specifications for the installation services to suit your needs. Now you are ready to install the Oracle Solaris 11 OS on the client systems on the network. You need only to boot the client; the process runs to completion without further input from you.

The flowchart in the slide illustrates how a client system is installed. The client browses for available installation services, seeking a service where the installation criteria in the service's manifest file matches the characteristics of the client system. When a match is found, the installation is performed on the client system by using a boot image, and the manifest and SC profile specifications provided by the install service.

Quiz

Which AI component provides installation instructions to the client system?

a. AI server
b. DHCP server
c. IPS repository

Answer: a

Lesson Agenda

- Planning for Oracle Solaris 11 Operating System Installations by Using the Automated Installer
- **Installing Oracle Solaris 11 by Using the Automated Installer**
- Building a Solaris Image

Installing Oracle Solaris 11 by Using the AI

This section covers the following topics:

- Reviewing AI installation server requirements
- Configuring an AI installation server
- Configuring the client system
- Implementing the configuration
- Verifying the installation

Reviewing AI Installation Server Requirements

Hardware	Requirement
Disk space	Approximately 0.75 GB additional disk space for each AI installation service after Oracle Solaris 11 OS has been installed
Memory	Recommended minimum: 1 GB

Software	Requirement
Operating system	Oracle Solaris 11 must be installed.
IP address	A static IP address must be used.
Router	The default route must be set.
DHCP	DHCP must be set up.
IPS repository	The repository must be set up locally.

Before you start to configure a server as your AI installation server, you must check whether the server meets the minimum hardware and software requirements to be an AI server.

Starting with the hardware requirements, you must allow additional disk space for each AI installation service that you need. The disk space requirement presented in the slide is in addition to the disk space that you need for the Oracle Solaris 11 operating system. The minimum requirement to operate an AI installation server is 1 GB of memory.

To meet the AI installation server software requirements, you must have the Oracle Solaris 11 release installed. You also need to configure the AI server to use a static IP address. If the reactive network configurations are currently being used, it can be configured for static IP addressing. AI clients rely on DHCP to obtain their initial IP addresses and boot files. You can configure the AI server to be the DHCP server by using the `installadm` command, or you can use a DHCP server that is already set up in this network.

A local IPS repository needs to be properly configured on your AI server to install the Oracle Solaris 11 OS on multiple network clients.

Verifying AI Install Server Software Requirements

Check the following to verify that the server is ready to be configured as an AI server:

- Static IP address configuration
- Operational DNS
- IPS configured and available from the AI server
- Enabled DHCP server

Assume now that you have selected the server that you want to use as your AI server and that it meets the AI installation server disk space and memory hardware requirements.

You have installed the Oracle Solaris 11 operating system and are now ready to verify that the server meets the remaining software requirements. You do this by performing a series of checks. You ensure that the system has been configured with a static IP address and that the DNS is operational. You also ensure that an IPS repository and an IPS service are properly configured and available locally from this AI server. Finally, you ensure that DHCP server is enabled.

Verifying the Static IP Address

To verify that the operating system is configured with a static IP address, run `svcs network/physical`, followed by `ipadm show-addr`.

```
# svcs network/physical:default
STATE          STIME    FMRI
online         15:02:57 svc:/network/physical:default

# ipadm show-addr
ADDROBJ            TYPE     STATE        ADDR
…
net0/v4            static   ok           192.168.0.112/24
…
#
```


To verify that the operating system is configured with a static IP address (that is, an IP address that has been created manually and not dynamically through the reactive network configuration or DHCP, for example), you first run the `svcs network/physical:default` command to verify that the physical network connection has been manually configured. In the example, you can see that the network that has been set up manually is online.

Next, you run the `ipadm show-addr` command to see the IP address information. In the example, you can see that you have a static network connection for IP address 192.168.0.112/24, and that the state of the connection is `ok`.

Verifying That DNS Is Operational

To verify that the DNS is operational, run `nslookup` *`server domain name`*.

```
# nslookup server1.mydomain.com
Server:         192.168.0.100
Address:        192.168.0.100#53

Name:   server1.mydomain.com
Address: 192.168.0.100
```


Next, you want to check that the DNS is operational. To verify this, run the `nslookup` command followed by the server's domain name. In the example, you can tell from the output that the DNS is operational on this server.

Verifying That IPS Is Available Locally

To verify that the correct local IPS repository is available to your server, run `pkg publisher`.

```
# pkg publisher
PUBLISHER    TYPE      STATUS   URI
solaris      origin    online    http://server1.mydomain.com
```

To test IPS on the local server by searching for the entire package, run `pkg search entire`.

```
# pkg search entire
INDEX       ACTION    VALUE            PACKAGE
pkg.fmri    set       solaris/entire   pkg:/entire@0.5.11-0.175.1.0.0.24.2
```


For AI to work properly, it needs the Image Packaging System (IPS) to be configured correctly and to be available from the AI server. To verify that a local IPS repository is available to the AI server, run the `pkg publisher` command and verify its URI.

To test that the IPS service is available, search for a given package by using the `pkg search` command. Searching for a package is a quick way of determining whether the IPS service is available. Refer to the lesson titled “Managing the Image Packaging System (IPS) and Packages,” which covers IPS-related tasks in greater detail.

Verifying That the DHCP Server Is Enabled

To verify that the DCHP server is enabled, run `svcs -a | grep dhcp`.

```
# svcs -a | grep dhcp
disabled        0:37:40   svc:/network/dhcp/relay:ipv6
disabled        0:37:40   svc:/network/dhcp/server:ipv6
disabled        0:37:40   svc:/network/dhcp/relay:ipv4
online          1:05:06   svc:/network/dhcp/server:ipv4
```


The final check that you must make to verify that the server is ready to be configured as an AI server is to make sure that the DHCP server is up and running. To do this, you run the `svcs -a | grep dhcp` command, as shown in the example. The DHCP server should be in the enabled state.

Practice 3-1 Overview: Verifying System AI Requirements (Optional)

This practice takes you through the steps for checking the existing version of Oracle Solaris 11 to verify the system requirements for the AI installation.

Note: This practice is optional and needs to be completed *only* if you have not completed the Practice 2 tasks.

The practices for this lesson are designed to reinforce the concepts that have been presented in the lecture portion. These practices cover the following tasks:

- **Practice 3-1:** Verifying AI system requirements (optional)
- **Practice 3-2:** Configuring the AI server
- **Practice 3-3:** Deploying the OS on the network client

Practice 3-1 should take you about 15 minutes to complete.

Configuring the AI Install Server

1. Enable the DNS multicast service.
2. Create a directory for the AI service.
3. Verify the `netmasks` file configuration.
4. Create an AI installation service:
   - With a DHCP setup
   - Without a DHCP setup
5. Review the default installation instructions.
6. Add installation criteria to an AI service.

After verifying that the server meets the AI software requirements, you are ready to configure the AI install server. As discussed in the topic on planning for the installation, the AI server is used to store an AI install image and contains the AI service. The AI service specifies the installation instructions for installing the Oracle Solaris 11 OS on a client. To set up the AI install server, you must complete the steps listed in the slide.

Enabling the DNS Multicast Service

To enable the DNS multicast service, run `svcadm enable svc:/network/dns/multicast`.

```
# svcadm enable svc:/network/dns/multicast

# svcs network/dns/multicast
STATE          STIME    FMRI
online          1:32:27 svc:/network/dns/multicast:default
```


As part of configuring the AI install server, you want to ensure that the DNS multicast service is enabled. To enable the DNS multicast service (`svc:/network/dns/multicast`) on the AI server, run the following command:

```
# svcadm enable svc:/network/dns/multicast:default
```

You can then verify that the service is enabled by running the `svcs network/dns/multicast` command as shown in the code example. As you can see in the output, the DNS multicast service is now online.

Installing the AI Installation Tools

To install the AI installation tools, run `pkg install install/installadm`.

```
# pkg install install/installadm
```


After enabling the DNS multicast service, your next task is to download the AI installation tools package.

Note: In this course, you do not perform this step in the practice; it is already done for you.

This package (the `install/installadm` package) contains the `installadm` utility that enables you to perform the following:

- Create and enable install services.
- Set up and update a DHCP server.
- Add custom client installation and configuration instructions.
- Set criteria for clients to use custom installation and configuration instructions.

To install the AI installation tools, run the following command:

```
# pkg install install/installadm
```

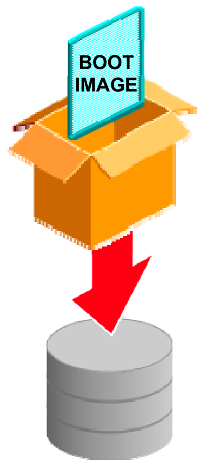
In this example, by default, the `install/installadm` package is being downloaded from the preferred publisher, which, on this system (as you might recall), is the `solaris` publisher.

Note: In the Oracle Solaris 11.1 release, `installadm` supports three new options to improve flexibility for administrators who maintain a set of installation services: `update-service`, `update-profile`, and `set-service`. For information, refer to the `installadm` (1M) man page.

Setting Up the AI Boot Image

Download the AI boot image from:

http://www.oracle.com/technetwork/server-storage/solaris11/downloads/index.html



Note: The AI ISO image must be the same version as the Oracle Solaris OS that you plan to install on the client.

Next, you set up the AI boot image. AI uses this boot image to boot the client.

Note: In this course, you do not perform this step in the practice; it is already done for you.

To download the AI boot image, go to the following site:

http://www.oracle.com/technetwork/server-storage/solaris11/downloads/index.html

Be sure to download the Automated Install image and not the LiveCD image or the text install image to the ZFS root pool file system that you created earlier.

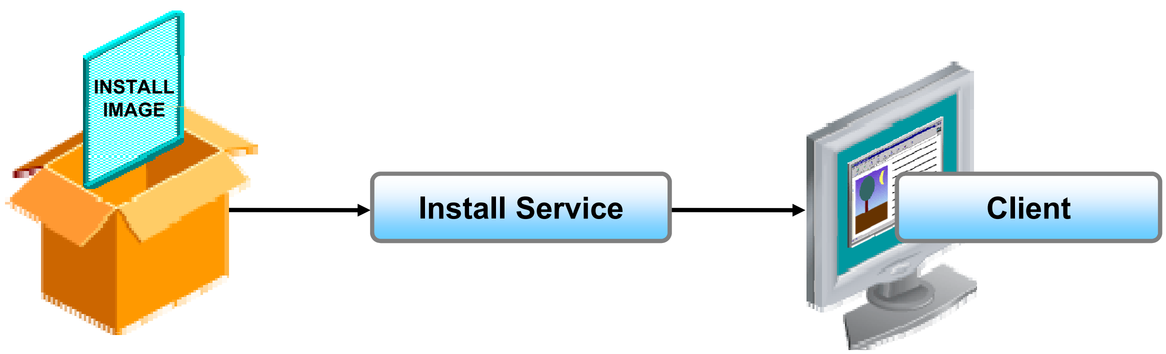
The AI ISO image must be the same version as the Oracle Solaris OS that you plan to install on the client.

Conversely, download the Oracle Solaris 11 SPARC Automated Install image for SPARC clients or the Oracle Solaris 11 x86 Automated Install image for x86 clients. For x86, be sure to download the `.iso` file and not the `.usb` file. The `.usb` file is not suitable for creating an install service.

Configuring an AI Install Service

The AI install service:

- Associates an install image with a named install service
- Enables client systems to use the install service name to find the correct install image
- Is associated with only one boot image
- Can be created with or without a DHCP setup



You are now ready to configure the AI install service.

The AI install service associates an install image with a named install service. Client systems use the install service name to find the correct install image.

An AI install server can have multiple install services. Each install service is associated with only one boot image. To install both SPARC and x86 clients, for example, you need one install service with a SPARC boot image and a second install service with an x86 boot image.

You can create an AI install service with or without a DHCP setup. The process is the same for both x86 and SPARC clients.

Note: Oracle Solaris 11.1 has added support for a new set of role-based authentication control (RBAC) profiles and authorizations for managing the Automated Install service, including the profile Install Service Management. If you have the Install Service Management rights profile, you can use the `pfexec` command to create install services and add system configuration profiles to an install service.

Verifying the `netmasks` File Configuration

To verify the `netmasks` file configuration, run `getent netmasks` *`IP_Address`*.

```
# getent netmasks 192.168.0.0
```

If a network mask entry for the local subnet does not exist in `/etc/netmasks`, update the file.

```
# vi /etc/netmasks
…
192.168.0.0 255.255.255.0
```


Before you create the AI service, you first need to verify that the `netmasks` file configuration for the DHCP service has been configured correctly. To do this, use the `getent netmasks` command followed by the IP address, as shown in the first example in the slide.

DHCP requires that the network mask for the local subnet should be configured in the `/etc/netmasks` file. If an entry does not exist, you must update the `netmasks` file now, as shown in the second example.

Creating an AI Install Service with an ISC DHCP Server Setup

To create an AI install service with ISC DHCP server setup, run `installadm create-service`, followed by the service name, the path to the ISO image, the IP address range, and the path to where the ISO image should be unpacked.

```
# installadm create-service -n basic_ai \
-s /opt/ora/course_files/sol-11_1-ai-x86.iso \
-i 192.168.0.130 -c 5 -d /export/ai/basic_ai
Creating service from: /opt/ora/course_files/sol-11_1-ai-x86.iso
Setting up the image ...

Creating service: basic_ai

Image path: /export/ai/basic_ai
<output omitted>
# installadm list
Service Name Alias Of    Status  Arch   Image Path
------------ --------    ------  ----   ----------
basic_ai       -         on      x86    /export/ai/basic_ai
default-i386 basic_ai    on      x86    /export/ai/basic_ai
```


To create the AI install service with an ISC DHCP server setup, use the `installadm create-service` command as shown in the example.

Note: In this example, the DHCP service is already set up on the server and you are only updating the DHCP with the new IP addresses for the named AI service.

As part of the `installadm create-service` command, you want to:

- Use the `-n` option to specify the service name (as shown in the code example)
- Use the `-s` option to specify the path to the AI ISO image file that is to be used to create the service (as shown in the example)
- Update the ISC DHCP server with the new IP addresses for the named AI service. In this example, the install service serves five IP addresses (`-c`), starting from 192.168.0.130 (`-i`).
- Specify the path where you want the AI ISO image unpacked. The path where the ISO image is unpacked is also called the *target* or *net image*. In this example, you unpack the AI ISO image in `/export/ai/basic_ai`.

Note: When you create the AI install service, its directory is automatically created for you.

During the service creation process, the system displays a number of messages that verify the creation of the target image, the DHCP server setup, the creation of the network table, and the copy of the boot file. An example of the output is provided here:

```
Creating service: basic_ai
Setting up the target image at /export/ai/basic_ai ...
Refreshing install services
Creating default-i386 alias.
Setting the default PXE bootfile in the local DHCP configuration to
   'default-i386/boot/grub/pxegrub'
Refreshing install services
```

You can verify your AI install service creation by using the `installadm list` command as shown in the second example.

To remove an AI install service, use `installadm delete-service` *`svcname`*.

Note: You can also create the x86 AI install service from the net IPS package `pkg:/install-image/solaris-auto-install` instead of an ISO. The following command illustrates doing so without any options specified:

```
# installadm create-service -n basic_ai -y
Creating service from: pkg:/install-image/solaris-auto-install
Download: install-image/solaris-auto-install ... Done
Install Phase ... Done
Package State Update Phase ... Done
Image State Update Phase ... Done
Reading Existing Index ... Done
Indexing Packages ... Done
Creating service: default_ai
Image path: /export/auto_install/default_ai
<output omitted>
```

Creating an AI Install Service Without a DHCP Setup

To create an AI install service without a DHCP setup, run `installadm create-service`, followed by the service name, the path to the ISO image, and the path to where the ISO image should be unpacked.

```
# installadm create-service -n s11-sparc \
-s /var/tmp/images/sparc/sol-11_1-ai-sparc.iso -d /install/images/s11-sparc

Creating service: s11-sparc

Setting up the target image at /install/images/s11-sparc ...
Service discovery fallback mechanism set up
Creating SPARC configuration file
Refreshing install services

Creating default-sparc alias.

No local DHCP configuration found. This service is the default alias
for all SPARC clients. If not already in place, the following should be added to the DHCP
configuration:
            Boot file : http://10.80.238.5:5555/cgi-bin/wanboot-cgi

Service discovery fallback mechanism set up
Creating SPARC configuration file
Refreshing install services
```


Now, you look at how to create an AI install service without a DHCP setup. In this example, an AI install service is being set up for a SPARC client. DHCP is already set up on a different server or will be set up later.

Again, you use the `installadm create-service` command, followed by the service name, the path to the ISO image, and the path to where the ISO image should be unpacked.

If the `create-service` command does not detect DHCP on the AI install server, the command output displays instructions for adding the boot file information to the DHCP configuration table, `dhcptab(4)`. For more information about how to create the DHCP macro, see *Installing Oracle Solaris 11 Systems*.

Note About the AI SMF Service

- Represents the overall state of the AI server application and all the install services
- Is enabled when `installadm create-service` is run

To enable the AI SMF service manually:

```
# svcadm enable svc:/system/install/server:default
```

To disable the AI SMF service manually:

```
# svcadm disable svc:/system/install/server:default
```

ORACLE

On the AI server, the SMF service `svc:/system/install/server:default` represents the overall state of the AI server application and all the install services.

The AI SMF service is enabled when you run the `installadm create-service` command. The AI SMF service is also enabled when you run any other `installadm` command that affects the existing install services.

You can manually enable and disable the AI SMF service by running the commands shown in the examples in the slide. However, you should not disable the AI SMF service if any AI install service is still enabled.

Adding a Client to the AI Install Service

To add a client to the AI install service, run `installadm create-client -c`, followed by the client MAC address and the AI install service name.

```
# installadm create-client -e 08:00:27:85:C7:D6 -n basic_ai

# installadm list -c
Service Name   Client Address      Arch   Image Path
------------   --------------      ----   ----------
basic_ai       08:00:27:85:C7:D6   i386   /export/ai/default_ai
```


After creating the AI install service and setting up DHCP, you are ready to add the client to the AI install service. To do this, use the `installadm create-client` command, followed by the client MAC address (specified by the `-e` option) and the AI install service name (specified by the `-n` option), as shown in the example. This command tells a client exactly which install service to use.

Note: A client can be associated with only one install service.

You can use the `installadm list` command with the `-c` option to verify that the client was added to the AI install service, as shown in the code example.

To delete a client from an install service, use `installadm delete-client`, followed by the client MAC address.

AI Manifest

- Part of the AI install service
- XML file that contains installation and configuration instructions for one or more clients
- Default manifest included in each boot image
- Unpacked along with other files in the image

As was discussed in the topic on planning for the installation, the AI install service provides installation and configuration instructions that can be used for one or more clients. These instructions are contained in an XML file called an AI manifest.

Each boot image includes a default AI manifest that can be used for clients of any install service that is created by using this boot image.

The manifest is unpacked along with the other files in the image.

Identifying the Types of AI Manifests

- **Default AI manifest:** Is an installation manifest that has no criteria associated with it
- **Custom AI manifest:** Provides installation criteria for a specific client
- **Criteria file:** Allows client-specific installation instructions to be associated with AI services

AI has three types of manifests:

- **Default AI manifest:** A default AI manifest is an installation manifest that has no criteria associated with it. The default AI manifest is used by clients when no other installation manifest's criteria match the client.
- **Custom AI manifest:** To perform different installations on different clients by using the same install image, you provide customized AI manifests for that install service. Clients that do not match the criteria specified to use any custom manifest are installed by using the instructions in the default manifest.
- **Criteria file:** The criteria file allows you to associate client-specific installation instructions with AI services. When the client matches the criteria that are specified for a criteria file, the client uses the associated manifest.

You now take a closer look at each manifest type, beginning with the default AI manifest.

Reviewing the Default AI Manifest (`default.xml`)

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- Copyright (c) 2008, 2012, Oracle and/or its affiliates. All rights reserved. -->
<!DOCTYPE auto_install SYSTEM "file:///usr/share/install/ai.dtd.1">
<auto_install>
  <ai_instance name="default">
    <target>
      <logical>
        <zpool name="rpool" is_root="true">
          <filesystem name="export" mountpoint="/export"/>
          <filesystem name="export/home"/>
          <be name="solaris"/>
        </zpool>
      </logical>
    </target>
    <software type="IPS">
      <destination> <!—Specify locales to install-->
      </destination>
      <source>
        <publisher name="solaris">
          <origin name="http://pkg.oracle.com/solaris/release"/>
        </publisher>
      </source>
(XML comments omitted)
      <software_data action="install">
        <name>pkg:/entire@0.5.11-0.175.1</name>
        <name>pkg:/group/system/solaris-large-server</name>
      </software_data>
    </software>
  </ai_instance>
</auto_install>
```


The `default.xml` file of the default AI manifest provides a generic configuration that is applicable to most clients. You want to review this default manifest to determine whether it meets the needs of all the clients that use an install service based on this image.

This slide shows the `default.xml` file. The `<software>` block defines the location of the IPS origin as well as the software packages to install and uninstall. The `entire` package is required so that the system is updated coherently when it is patched or upgraded in the future; it should not be removed during or after system installation. The `solaris-large-server` package is a group package of tools and device drivers that you might want in most environments that you install. This package installs many network and storage drivers, Python libraries, Perl, and much more.

System Configuration Profiles (SC Profiles)

```
<?xml version='1.0'?>
<!--
Copyright (c) 2011, Oracle and/or its affiliates. All rights reserved.
-->
(comments omitted)
<!DOCTYPE service_bundle SYSTEM "/usr/share/lib/xml/dtd/service_bundle.dtd.1">
<service_bundle type="profile" name="sysconfig">
    <service version="1" type="service" name="system/config-user">
      <instance enabled="true"name="default">
        <property_group name="root_account">
          <propval type="astring" name="password" value="encrypted_password"/>
          <propval type="astring" name="type" value="role"/>
        </property_group>
        <property_group type="application" name="user_account">
          <propval type="astring" name="login" value="jack"/>
          <propval type="astring" name="password" value="9Nd/cwBcNWFZg"/>
          <propval type="count" name="gid" value='10'/>
          <propval type="astring" name="description" value="default_user"/>
          <propval type="astring" name="type" value="normal"/>
          <propval type="astring" name="shell" value="/usr/bin/bash"/>
          <propval type="astring" name="roles" value="root"/>
          <propval type="astring" name="profiles" value="System Administrator"/>
        </property_group>
       </instance>
      </service>
```


This slide shows the beginning of a sample SC profile. Here you see the setup for the initial user (default is `Jack`) and the `root` role setup. A simple method for setting passwords is to copy the passwords from the `/etc/shadow` file of the user records and add that information into the password values in the profile.

Note: The system configuration profile (SC profile) specifies client system configuration as a set of configuration parameters in the form of an SMF profile. The SC profile sets SMF properties for appropriate SMF (Service Management Facility) services.

An SMF profile that contains the system configuration is applied during the first boot of the system after installation. The SMF services that are responsible for particular configuration areas process the SMF properties and configure the system accordingly.

You can specify configuration of anything that is configurable via `smf(5)` properties. For example, the SC profile can configure a root account, an initial user, keyboard layout, terminal type, an IPv4 network interface (static or DHCP) and default route, an IPv6 network interface (static or addrconf) and default route, and DNS (nameserver list, search list, and domain).

You can specify multiple sets of system configuration instructions (SC profiles) for each install service. Multiple SC profiles can be associated with each client.

System Configuration Profiles (SC Profiles)

```
<service version="1" type="service" name="system/identity">
     <instance enabled="true" name="node">
       <property_group type="application" name="config">
          <propval type="astring" name="nodename" value="solaris"/>
       </property_group>
     </instance>
   </service>

   <service version="1" type="service" name="system/console-login">
     <instance enabled="true" name="default">
       <property_group type="application" name="ttymon">
         <propval type="astring" name="terminal_type" value="sun"/>
       </property_group>
     </instance>
   </service>

   <service version="1" type=service" name="system/keymap" version="1">
     <instance enabled="true" name="default">
       <property_group type="system" name="keymap">
         <propval type="astring" name="layout" value="US-English"/>
       </property_group>
     </instance>
   </service>
```


In the example shown in the slide, you can see the type tags for the nodename, console terminal type, and keyboard.

System Configuration Profiles (SC Profiles)

```
<service version="1" type="service" name="system/timezone">
    <instance enabled="true" name="default">
      <property_group type="application" name="timezone">
        <propval type="astring" name="localtime" value="UTC"/>
      </property_group>
    </instance>
  </service>

  <service version="1" type="service" name="system/environment">
    <instance enabled="true" name="default">
      <property_group type="application" name="environment">
        <propval type="astring" name="LANG" value="en_US.UTF-8"/>
      </property_group>
    </instance>
  </service>
```


In this section, you see the time zone and the locale type tags.

System Configuration Profiles (SC Profiles)

```
    <service version="1" type="service" name="network/physical" >
      <instance enabled="true" name="default">
          <property_group type="application" name="netcfg">
              <propval type="astring" name="active_ncp" value="Automatic"/>
          </property_group>
      </instance>
    </service>
</service_bundle>
```


The final portion of the file sets up key mapping and network configuration, which are invoked by network configuration profiles (NCPs). NCPs can be set to Active or DefaultFixed, respectively, depending on whether the network configuration should be automatic or manual. Another option is being able to configure so that an interactive system configuration tool is launched during the first reboot of an installed system. Note that, in this example, the active NCP is set to "Automatic."

Now that you are more familiar with the contents of the `default.xml` file and SC profiles, you will look at what you must do to use this file and create a custom AI manifest to perform different installations on different clients by using the same install image.

Adding an SC Profile to an Install Service

Use the `installadm create-profile` command to add the *profile_filename* SC profile to the *svcname* install service.

```
# installadm create-profile -n svcname -f profile_filename
```

Use the `installadm validate` command to validate SC profiles for syntactic correctness.

```
# installadm validate -n svcname -p profile_name
```


Multiple SC profiles can be specified in one `create-profile` command because a single client can use multiple SC profiles. The same client selection criteria, or overlapping criteria, or no criteria can be specified for multiple profiles. When no criteria are specified, the profile is used by all clients that use this install service.

You can use the `installadm create-profile` command to add the *profile_filename* SC profile to the *svcname* install service.

Note: By adding the `-c` option followed by a criteria range to the `create-profile` command, you can specify client selection criteria on the command line.

To validate that an SC profile is syntactically correct, you can use the `install validate -n` *`svcname`* command, as shown in the second example in the slide. The `-p` option is used to validate profiles that have already been added to the *svcname* install service by using the `create-profile` subcommand.

Note: You can use the `-P` option followed by *profile_name* to validate profiles that have not been added to the install service. *profile_filename* is a full path name to the file.

Creating a Custom AI Manifest

To create and apply a custom AI manifest, perform the following steps:

1. Create a directory to store your manifest files.
2. Copy the `default.xml` file to the `basic_ai.xml` file.
3. Modify the `basic_ai.xml` file.
4. Add the new custom AI manifest to the appropriate AI install service.
5. Add the criteria file to associate the client host.

To create and apply a custom AI manifest, you first create a directory to store your manifest files: `/var/tmp/manifests`.

Then you copy the default AI manifest to the `/var/tmp/manifests/basic_ai.xml` file. A copy of the `default.xml` file is located at `/export/ai/basic_ai/auto_install/manifest/default.xml` or in the AI install image at `<AI Image Dir>/auto_install/default.xml`, where `<AI Image Dir>` is the directory reported in the `installadm list` output.

Next you modify the `basic_ai.xml` file. Be sure to reference the Oracle Solaris 11 AI documentation for how to add tags and values to the new manifest file.

Note: There are tag requirements for every AI manifest, with options to add more tags. For example, every manifest must have the following:

- Unique manifest name
- At least one IPS package repository specified
- The `entire` package installed

For more information about the optional tags, such as the `<target>` and `<add drivers>` tags, and examples on how to use them, see the Oracle Solaris AI documentation.

When you finish your modifications, you can add the new custom AI manifest to the appropriate install service. You need to specify the criteria that define the clients that should use these installation instructions.

Selecting the AI Manifest

- The criteria file associates installation instructions with the client.
- The AI manifest selection algorithm is as follows:
  – The client does not match the criteria for any manifest: The client uses the default manifest.
  – The client matches the criteria for a single manifest: The client uses that manifest.
  – The client matches the criteria for multiple manifests: The criteria are evaluated based on ordering.
- The criteria file uses multiple non-overlapping criteria.

Suppose that you have created an AI manifest. You can now create specific installation instructions by client type by using a criteria file. The criteria file allows you to associate client-specific installation instructions with AI services. When the client matches the criteria that are specified for a criteria file, the client uses that manifest.

An AI manifest is selected for a client according to the following algorithm:

- If custom manifests are defined for this install service but the client does not match the criteria for any manifest, the client uses the default manifest.
- If the client matches the criteria that are specified for a single manifest, the client uses that manifest.

- If client characteristics match multiple manifests, the client characteristics are evaluated in the following order:
  - `mac`
  - `ipv4`
  - `platform`
  - `arch`
  - `cpu`
  - `network`
  - `mem`
  - `zonename`
  - `hostname`

  For example, if one criteria specification matches the client's MAC address and another criteria specification matches the same client's IP address, the manifest associated with the MAC address criteria specification is used, because `mac` is higher priority for selection than `ipv4`.

For more information about selection criteria, see the section titled "Selection Criteria" in *Installing Oracle Solaris 11 Systems*.

Criteria File: Examples

- `arch` criteria manifest file:

```
<ai_criteria_manifest>
 <ai_criteria name="arch">
   <value>i86pc</value>
 </ai_criteria>
</ai_criteria_manifest>
```

- `mac` criteria manifest file:

```
<ai_criteria_manifest>
  <ai_criteria name="mac">
      <value>0:14:4F:20:53:94</value>
  </ai_criteria>
</ai_criteria_manifest>
```

- `ipv4` criteria manifest file:

```
<ai_criteria_manifest>
  <ai_criteria name="ipv4">
         <value>192.168.0.114</value>
  </ai_criteria>
</ai_criteria_manifest>
```


The slide shows examples of the `arch`, `mac`, and `ipv4` criteria files.

Adding Installation Criteria to an AI Manifest

To create a manifest for a service and associate it with installation criteria, run `installadm create-manifest`, followed by the service name, the manifest's file path name, and the criteria file's path name.

```
# installadm create-manifest -n basic_ai \
-f /var/tmp/manifests/basic_ai.xml \
-C /var/tmp/manifests/criteria_ai.xml

# installadm list -m
Service Name      Manifest          Status
------------      --------          ------
basic_ai           basic_ai
                   orig_default     Default
default-i386       orig_default     Default

# installadm list -m -n basic_ai
Manifest          Status   Criteria
--------          ------   --------
basic_ai                   mac = 08:00:27:85:C7:D6
orig_default      Default  None
```


Suppose that you have created both a new custom AI manifest and a criteria file that specifies the MAC installation criteria. To add the installation criteria to the AI manifest, use the `installadm create-manifest` command, followed by the AI service name using the `-n` option, the `-f` option and the path name of the custom AI manifest file, and the `-C` option and the path name of the criteria file.

In this example, when a client meets the criteria identified in the `criteria_ai.xml` criteria file, `basic_ai.xml` is applied to that client.

To verify that the manifests have been added to the AI service, use the `installadm list -m` command, as shown in the example in the slide. First, you run the command to list the service name and the name of the custom manifest, and then you run the command again with the service name to see the installation criteria associated with that manifest.

Note: You can also specify the criteria on the command line, as in the following example:

```
# installadm create-manifest -n basic_ai \
 -f /var/tmp/manifests/basic_ai.xml \
 -c mac=08:00:27:85:C7:D6-08:00:27:85:C7:D7
```

You can also use `set-criteria` to modify the criteria after the manifest has been created.

Practice 3-2 Overview: Configuring the AI Server

This practice covers the following topics:

- Enabling the DNS multicast service
- Verifying the `netmasks` file configuration
- Creating an AI install service with a DHCP setup
- Adding installation criteria to an AI service
- Creating a directory to store the AI manifest files
- Modifying the AI manifest files

This practice should take about 1.5 hours to complete.

Configuring the Client System

This section covers the following topics:

- Identifying the client system requirements
- Using Secure Shell to remotely monitor an installation

After completing the install server configuration management tasks, you are ready to configure the client system. First, you must identify the client system requirements. After identifying the requirements, you create a customer system configuration (SC) profile. You use Secure Shell to monitor the installation remotely, and then you review the client installation messages to verify that the installation went smoothly.

Identifying Client System Requirements

Client System	Requirement
Disk space	Recommended minimum: 13 GB
Memory	Recommended minimum: 1 GB
Architectures	• X86: 64-bit only • SPARC: Oracle Solaris M-series and T-series systems only
Network access	• DHCP server that provides network configuration information • AI install server • IPS repository that contains the packages to be installed on the client system

Additional SPARC client system requirements:

- WAN boot support
- Firmware that includes the current version of the OBP that contains the latest WAN boot support

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For automated installation over the network, SPARC and x86 client systems must meet the requirements listed in the table in the slide. Any system that meets these requirements can be used as an AI install client, including laptops, desktops, virtual machines, and enterprise servers.

There are two additional SPARC client system requirements: WAN boot support and firmware that has been updated to include the current version of the Open Boot PROM (OBP) that contains the latest WAN boot support.

Note: The recommended minimums are subject to change with the final release of the software. See the release notes for final disk space and memory recommendations.

Using Secure Shell to Remotely Monitor an Installation

- For x86 client installations, the `menu.lst` file is located in:
  - `/etc/netboot/menu.lst.01MAC_address` if `installadm create-client` was used
  - `/etc/netboot/<service_name>/menu.lst` if `installadm create-client` was not used
- For SPARC client installations, `system.conf` and `wanboot.conf` are in:
  - `/etc/netboot/<service_name>`

  For the `default-sparc` service, symlinks to these files are in `/etc/netboot`.

You can remotely monitor an installation in progress by using Secure Shell. You can do this by setting the `livessh` option to `enable` in the installation configuration file. After enabling access, you can log in to the AI client by using `jack` for both the username and password.

For x86 client systems, the `menu.lst` configuration file is created in the `/etc/netboot/` directory with one of the following file name formats:

- If you used the `installadm create-client` command, the file name is `/etc/netboot/menu.lst.01MAC_address`, where `MAC_address` is the MAC address that was specified in the `installadm create-client` command.
- If you did not use the `installadm create-client` command, the file name is `/etc/netboot/<`*`service_name`*`>menu.lst`, where *`service_name`* is the install service name that was specified in the `installadm create-service` command.

For SPARC client systems, the `system.conf` and `wanboot.conf` files are located in `/etc/netboot/<service_name>` if you have created an install service by using the `installadm create-service` command. For the `default-sparc` service, symlinks to these files are in `/etc/netboot`.

Implementing the Configuration

- To boot a SPARC client and start an installation, use the following command from the OBP prompt:
  `OK boot net:dhcp - install`
- To boot an x86 client from the network, from the GNU GRUB menu, select the `Oracle Solaris 11 11/11 Text Installer and command line` boot option.

When you set up your install server, you created at least one install service for each client architecture and each version of the Oracle Solaris OS that you plan to install. When you created each install service, you created customized installation instructions and post-installation configuration instructions for different clients as needed. You are now ready to implement the configuration. To start the automated installation, you only need to boot the client.

The boot instructions for the SPARC and x86 clients are presented in the slide. Provide the configuration information when prompted.

Note: If you select the second install option shown in the GRUB menu, the AI installation starts automatically.

Reviewing Client Installation Messages

If the client install is successful, you see the following:

- Automated Installation started message

```
Automated Installation started
   The progress of the Automated Installation will be output to
the console
   Detailed logging is in the logfile at
/system/volatile/install_log
   Press RETURN to get a login prompt at any time.
```

- Automated Installation succeeded message

```
Automated Installation finished successfully
The system can be rebooted now
Please refer to the /system/volatile/install_log file for
details
After reboot it will be located at
/var/sadm/system/logs/install_log
```


If the client is able to successfully boot and download the install files, you see the "`Automated Installation started`" message. You can log in as the `root` user with the password `solaris` to monitor the progress of the installation via the installation log, by using `tail -f /system/volatile/install_log`.

Note: To stop the `tail –f` command, press Ctrl + C.

After the installation has completed successfully, you see the "`Automated Installation finished successfully`" message. You have the option of rebooting at this time. The client does not automatically reboot after a successful installation. You do, however, have the option of setting up an automatic reboot in the AI manifest. To enable the automatic reboot, you set the `auto_reboot` attribute of the <ai_instance> tag to `true`. To reboot manually, run the `init 6` command.

If a client installation fails, there are several actions that you can take based on the kind of errors you see:

- Check the installation logs located at `/system/volatile/install_log`.
- Check the connection to the IPS repository. If a client cannot resolve the name of the IPS repository during installation, an error is generated. For this type of error, see if the client can ping the repository. If you get no response, you may have a connectivity problem. If the ping comes back as not having recognized the host, you may have a DNS problem.

- Check whether DNS is configured on your client. You can do this by verifying that a non-empty `/etc/resolv.conf` file exists. If this file does not exist or is empty, check that your DHCP server is providing the DNS server information to the client by running `/sbin/dhcpinfo DNSserv`. If this command returns nothing, the DHCP server is not set up properly. You need to contact your DHCP administrator to correct the problem.
- Check client boot errors. There are a number of possible causes for networking boot errors to occur on both SPARC and x86 systems, such as timing out issues or boot load failures. For more information about the types of errors that may occur and the possible causes of these errors, as well as suggested solutions, see *Installing Oracle Solaris 11 Systems*.

Practice 3-3: Deploying the OS on the Network Client

This practice covers deploying the Oracle Solaris 11 operating system on a network client.

This practice should take about 45 minutes to complete.

Lesson Agenda

- Planning for Oracle Solaris 11 Operating System Installations by Using the Automated Installer
- Installing Oracle Solaris 11 by Using the Automated Installer
- **Building an Oracle Solaris Image**

This topic briefly covers how to build an Oracle Solaris image by using a technology called the "distribution constructor."

Introducing the Distribution Constructor

- Is a command-line tool that is used to build:
  - Preconfigured custom Oracle Solaris images
  - An ISO image based on the XML manifest file
- Allows creation of the following Oracle Solaris image types:
  - x86 or SPARC Oracle Solaris text installer image
  - Oracle Solaris x86 live CD image
  - x86 or SPARC ISO Image for Automated Installations
  - x86 Oracle Solaris Virtual Machine
- Is distributed in the distribution-constructor package, which contains:
  - The `distro_const` command-line utility and its files
  - Sample manifest files

The distribution constructor is a command-line tool for building preconfigured Oracle Solaris images. These images can be used to install the Oracle Solaris software on individual systems and multiple systems that run the Oracle Solaris 11 operating system.

The distribution constructor takes an XML manifest file as input and builds an ISO image that is based on the parameters specified in the manifest file.

Using the distribution constructor, you can create the following types of Oracle Solaris images:

- x86 or SPARC Oracle Solaris text installer image
- Oracle Solaris x86 live CD image
- x86 or SPARC ISO Image for Automated Installations

The distribution constructor is distributed in the distribution-constructor package. The distribution-constructor package contains the `distro_const` command-line utility for building custom Oracle Solaris images. It also contains sample manifest files that are used to build the various image types.

Identifying System Requirements for Using the Distribution Constructor

Requirement	Description
Disk space	Recommended minimum: 8 GB
Oracle Solaris release	• SPARC or x86 Oracle Solaris 11 operating system (OS) must be installed. • Network access to the IPS repositories specified in the manifest file is required. • SPARC images can be created only on a SPARC system. • X86 images can be created only on an x86 system. • The Oracle Solaris release version must match the release version of the image to be built with the distribution constructor.
Required packages	The `distribution-constructor` package must be installed.

This slide shows the system requirements to use the distribution constructor. The recommended minimum disk space for the distribution constructor workspace is 8 GB.

You must have the SPARC or x86 Oracle Solaris 11 operating system (OS) installed on your system. Your installed Oracle Solaris system must have network access. Because the distribution constructor accesses the Image Packaging System (IPS) repositories that are available on the network to retrieve packages for the ISO image, you must have network access to the repositories that you specify in the manifest file. When using the distribution constructor, you can create SPARC images only on a SPARC system. And you can create x86 images only on an x86 system. In addition, the Oracle Solaris release version on your system must be the same as the release version of the image that you use with the distribution constructor.

Note: To run the distribution constructor on your system, you must assume the `root` role by executing the `su -` command.

You must have the `distribution-constructor` package installed on your system.

Note: You can use the Package Manager tool to install the required package, or you can use IPS commands to install this package:

```
# pkg install distribution-constructor
```

Using Distribution Constructor Manifest Files

Manifest File	Manifest Type	Description
`dc_text_x86.xml`	x86 text installer ISO image	Used to create an ISO image that you can boot to initiate a text installation of the Oracle Solaris OS on x86 machines
`dc_text_sparc.xml`	SPARC text installer ISO image	Used to create an ISO image that you can boot to initiate a text installation of the Oracle Solaris OS on SPARC machines
`dc_livecd.xml`	x86 live CD ISO image	Used to create an ISO image that is comparable to the Oracle Solaris live CD
`dc_ai_sparc.xml`	SPARC AI ISO image	Used to create a SPARC AI ISO image for automated installations of the Oracle Solaris OS to SPARC clients
`dc_ai_x86.xml`	x86 AI ISO image	Used to create an x86 AI ISO image for automated installations of the Oracle Solaris OS to x86 clients

This slide lists the default manifest files that are shipped with the distribution-constructor package. After you install the distribution-constructor package, you can locate these manifest files in the `/usr/share/distro_const` directory.

You can create your own custom scripts. If you do create new scripts, you must edit the manifest files to point to these new scripts. See *Creating a Custom Oracle Solaris 11 Installation Image* for more information about creating custom scripts.

Note: To see the list of checkpoints, you can run:

```
# distro_const build -l manifest
```

Building an Image

- The build can be performed in one step:
  - `distro_const build manifest`
- Checkpointing is enabled by default.
- The build can be stopped and resumed at a specific checkpoint (step):
  - `distro_const build -p step manifest`
  - `distro_const build -r step manifest`

You can build an OS in one step or in stages. To build an image in one step, use the `distro_const build` *`manifest`* command without any options. *`manifest`* is the name of the manifest file that you want to use as the blueprint for your image.

To build an image in stages, use the options provided in the `distro_const` command to stop and restart the build process at various steps in the image generation process. This approach enables you to check and debug your selection of files, packages, and scripts for the image that is being built. This process of stopping and restarting during the build process is called *checkpointing*, and it is enabled by default in the manifest file.

To stop and resume at a specific checkpoint, use the following commands:

- `distro_const build -p` *`step manifest`*
- `distro_const build -r` *`step manifest`*

Quiz

The distribution constructor is used to create only Oracle Solaris SPARC text installer images.

a. True

b. False

Answer: b

Quiz

Which command enables you to build an OS image in one step?

a. `distro_const`

b. `distro_const build`

c. `distro_const build` *`manifest`*

Answer: c

Quiz

The process of stopping and restarting during the image build process is called ________.

a. checking
b. checkpointing
c. spotcheck

Answer: b

Summary

In this lesson, you should have learned how to:

- Implement a plan for an Oracle Solaris 11 operating system installation
- Install the Oracle Solaris 11 operating system by using the Automated Installer
- Verify an Oracle Solaris 11 operating system installation
- Build an Oracle Solaris image by using the distribution constructor

In this lesson, you learned how to set up an AI server and use the Automated Installer to install the Oracle Solaris 11 OS on multiple hosts in accordance with an operating system installation plan.

You then learned how to build a Solaris image by using the distribution constructor.

4

Managing Business Application Data

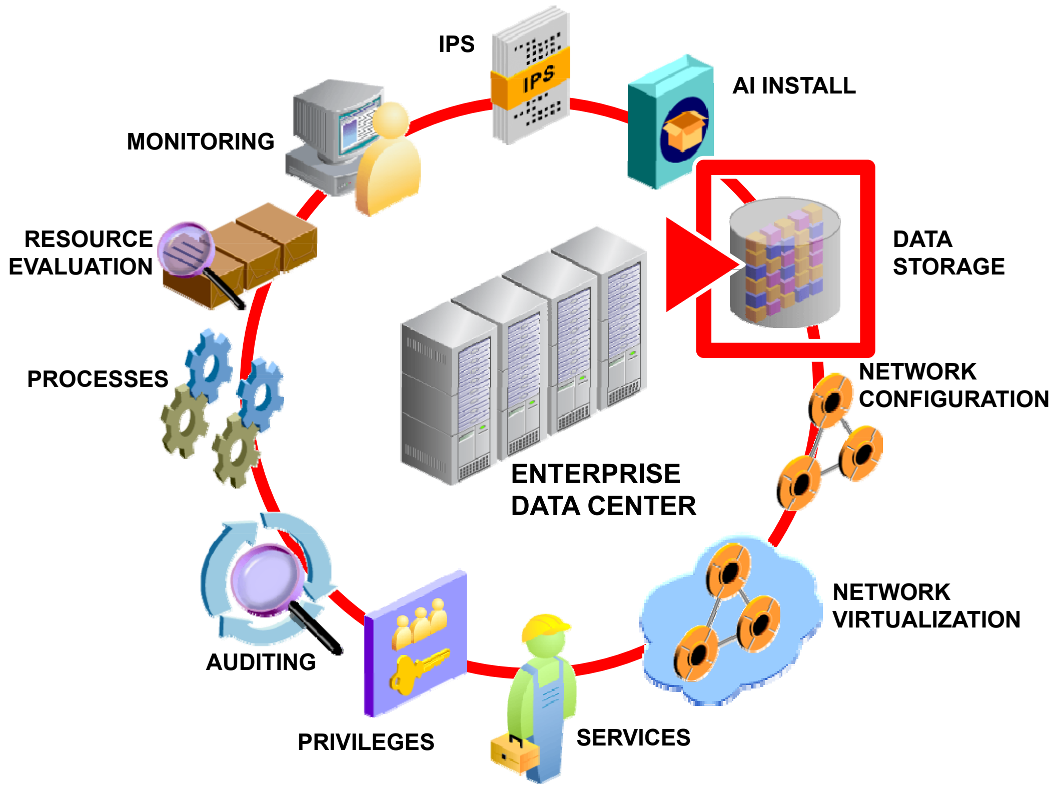
Objectives

After completing this lesson, you should be able to:

- Implement a plan for data storage configuration and backup
- Manage data redundancy with a mirrored storage pool
- Configure data backup and restore by using ZFS snapshots
- Manage data storage space by using ZFS file system properties
- Troubleshoot ZFS issues

This lesson discusses how to use the many powerful features of ZFS to manage your business application data.

Workflow Orientation



Before you begin the lesson, take a moment to orient yourself in the job workflow. You have successfully installed the operating system by using AI and you have created a local IPS repository. Your next task is to set up and manage storage for your company's business application data, such as customer and product information. Providing an environment in which data is readily accessible while at the same time secure is an important aspect of a system administrator's day-to-day responsibilities.

Lesson Agenda

- **Planning for Data Storage Configuration and Backup**
- Managing Data Redundancy with Mirrored Storage Pools
- Backing Up and Recovering Data with ZFS Snapshots
- Managing Data Storage Space with ZFS File System Properties
- Troubleshooting ZFS Failures

Planning for Data Storage Configuration and Backup

- Ensure that critical business application data is protected, backed up, recoverable, and accessible.
- The decision has been made to support the business applications by:
  - Providing data redundancy by using mirrored storage pools
  - Setting up file systems to store the data
  - Backing up the file systems by using snapshots
  - Minimizing storage space by using the ZFS file system `compression` property

As part of the Oracle Solaris 11 implementation plan, your company wants to ensure that its critical application data is protected, backed up regularly, and easily recoverable. At the same time, your company wants to ensure that the data remains highly accessible to its users. And, where possible, it wants to minimize data storage space requirements. The implementation planning committee has decided to use the power and flexibility of ZFS to meet these objectives by:

- Providing data redundancy by using mirrored storage pools
- Setting up file systems to store the data
- Backing up the file systems that store the data by using the ZFS snapshot technology
- Minimizing the amount of file system space that is needed to store the data by using the ZFS `compression` property

Determining Storage Pool Requirements

As part of planning, the following storage pool requirements should be identified:

- Devices
  - Disks that are at least 128 MB in size
  - Not in use by other parts of the operating system
  - Individual slices on a preformatted disk or entire disks formatted as a single, large slice
  - Use of log and cache devices for improved performance
- Level of data redundancy option
  - Non-redundant (striped) configurations
  - Mirrored
  - RAID-Z

Before setting up the data storage environment, the ZFS storage pool requirements need to be identified. First, the devices that will be used to store the company's data need to be identified. The devices that are selected must meet the following criteria:

- They must be disks that are at least 128 MB in size.
- They must not be in use by other parts of the operating system.
- The devices can be individual slices on a preformatted disk, or they can be entire disks that ZFS formats as a single, large slice.
- You also want to decide whether to include cache and log devices in the storage pool or not. Because ZFS processes synchronous transactions by allocating space from the main storage pool, having a separate device for the intent log on a Solid State Drive (SSD) or a dedicated disk may improve performance for some workloads. Cache devices provide an additional layer of caching between the main memory and disk. Using cache devices provides the greatest performance improvement for random read-workloads of mostly static content.

The level of redundancy is another storage requirement that should be addressed during planning. The level of redundancy determines the types of hardware failures the pool can withstand. ZFS supports non-redundant (striped) configurations, as well as mirroring and RAID-Z (a variation on RAID-5 and RAID-6). As you know, your company has decided to use mirrored storage pools.

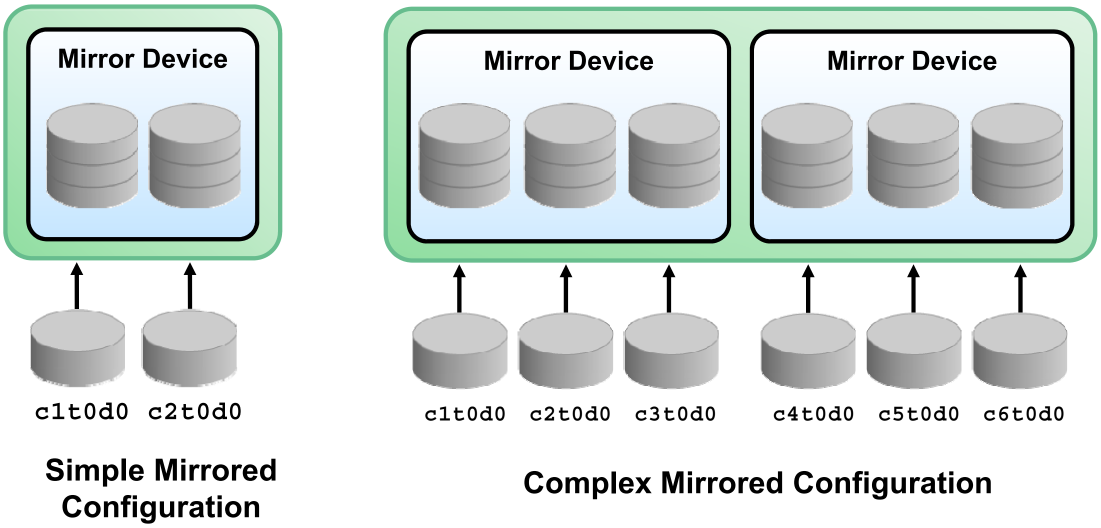
Mirrored Storage Pool Data Redundancy Features

- Data redundancy features
  – Mirrored storage pool configuration options
  – Self-healing data
- Dynamic striping

In ZFS, a mirrored storage pool provides data redundancy through its configuration options and self-healing data features. ZFS also supports dynamic striping in a mirrored storage pool.

Mirrored Storage Pool Configuration

- At least two disks are required.
- Many disks can be used.
- Multiple mirrors can be created in each pool.



A mirrored storage pool configuration requires at least two disks, preferably on separate controllers. Many disks can be used in a mirrored configuration. In addition, you can create multiple mirrors in each pool.

The graphic on the left shows an example of a simple mirrored configuration. The storage pool contains one mirror with two disks. In this example, you can lose only one disk before you start losing data.

An example of a more complex mirrored configuration is shown in the graphic on the right. Here the storage pool contains two mirrors with three disks each.

With the more complex mirrored configuration example, you can lose up to two disks in each mirror and not lose any data.

Self-Healing Data

- This is supported in a mirrored or RAID-Z configuration.
- When a bad data block is detected:
  – Correct data is fetched from another replicated copy
  – Bad data is repaired by replacement with the good copy

ZFS provides for self-healing data in a mirrored or RAID-Z configuration. When a bad data block is detected, not only does ZFS fetch the correct data from another replicated copy, but it also repairs the bad data by replacing it with the good copy.

Dynamic Striping

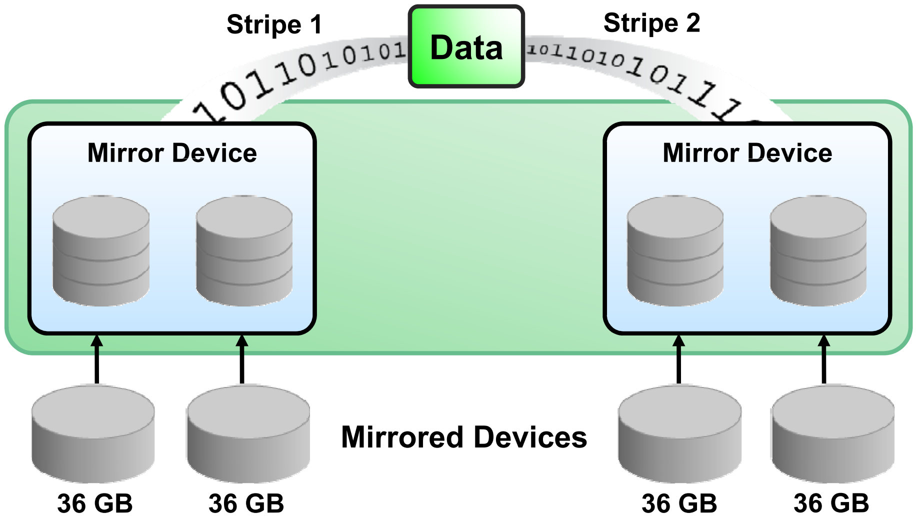
- Data is dynamically striped across all top-level virtual devices.
- Data placement is done at write time.
- When a new virtual device is added, data is gradually allocated to the new device.

Note: Although ZFS supports combining different types of virtual devices within the same pool, the recommended practice is to use top-level virtual devices of the same type with the same redundancy level in each virtual device.

ZFS dynamically stripes data across all top-level virtual devices. The decision about where to place data is done at write time, so no fixed-width stripes are created at allocation time. When new virtual devices are added to a pool, ZFS gradually allocates data to the new device to maintain performance and space allocation policies.

Note: Although ZFS supports combining different types of virtual devices within the same pool, this practice is not recommended. This is because your fault tolerance is only as good as your worst virtual device. The recommended practice is to use top-level virtual devices of the same type with the same redundancy level in each virtual device.

Dynamic Striping in a Mirrored Pool



The graphic in the slide shows how data is striped across mirrored top-level virtual devices. In this configuration, you have two top-level mirrored virtual devices, each containing two disks of 36 GB. This configuration provides data redundancy. You can lose a disk in either mirrored set and still not suffer any loss of data.

Note: A virtual device is a logical device in a pool that can be disks, disk slices, or files. A pool can have any number of virtual devices at the top of the configuration, known as top-level virtual devices or top-level vdevs. You can configure these virtual devices to stand alone within a pool (referred to as an *unreplicated* or *non-redundant* configuration) or combine them into a mirror or RAID-Z virtual device to provide data redundancy. Disks, disk slices, or files that are used in pools outside of mirrors and RAID-Z virtual devices function as top-level virtual devices themselves.

Determining File System Requirements

- Determine how to set up your file systems to:
  - Store business application data efficiently
  - Facilitate data backup and restore operations
- One recommended approach is to:
  - Create one file system for the main application
  - Create sub–file systems for each of the sub-applications
- This approach ensures the ease of:
  - Backing up the entire file system
  - Backing up the data on each of the sub–file systems
  - Restoring the entire file system
  - Setting file system properties at the highest level and having sub–file systems inherit the property values

After the storage pool requirements have been identified, the next thing that needs to be determined is the file system requirements. Generally, you create a file system for each business application that is running on the system. Within that file system, you create sub–file systems to support each of the main application's sub-applications. For example, suppose that your company uses the Oracle Customer Relationship Management (CRM) application. To support this application, you create a file system in your mirrored storage pool for this application. You then create sub–file systems for each of the Oracle CRM sub-applications, such as Finance, Marketing, and HR.

The benefits of this approach are that because one business application can be stored in one file system, the file system can be backed up easily in one command by creating a ZFS snapshot. In addition, every application can have its data backed up separately. Conversely, when you need to restore the entire file system (that is, the whole application), you can do so easily with one command by using the ZFS rollback snapshot feature.

Other benefits of this approach are that ZFS file system properties can be managed at the highest level and sub–file systems can inherit the property values.

Identifying Your Data Backup and Restore Strategy

As part of planning, you should identify your data backup and restore strategy:

- Use ZFS snapshots to create file system backups.
- Use send and receive commands to save incremental changes between snapshots or for remote replication.

As you just saw, your data backup and restore strategy should be a part of your file system layout requirements discussion. Your strategy should clearly indicate how you intend to back up and restore application data. Having a strategy in place for backing up and restoring critical application data is crucial to the success of any company.

Through its snapshot technology, ZFS provides a fast and easy way to not only back up data but also to recover data. Knowing how snapshots work and how they consume space as they change is important when you formulate your backup and restore strategy. Your strategy should also include naming conventions for snapshots, how often snapshots are taken, and how they are maintained. You will be able to create initial backups of your file systems by using snapshots. For backing up data, you use the ZFS send/receive functionality that allows you to save incremental changes between snapshots or to replicate a ZFS file system in a remote location. You can copy the file system from one system to another system. You learn how to use the send/receive functionality later in this lesson.

Determining Ways to Save Data Storage Space

As part of planning, you should determine ways to save data storage space.

ZFS offers a file system `compression` property that:

- Is used to enable or disable compression for a file system
- Compresses only new data on an existing file system if it is enabled after file system creation

Many companies are concerned about having enough space to store their data. Finding ways to minimize the amount of data storage space used in the data storage environment is always a challenge. Fortunately, ZFS offers a file system `compression` property that you can use to enable or disable compression for a file system. Enabling compression on a file system with existing data compresses only new data. Existing data remains uncompressed.

You learn how to use this property later in this lesson.

Implementing the Data Storage Configuration and Backup Plan

Your assignment is to:

- Configure and test the functionality of a mirrored storage pool
- Create snapshots of the file systems within the mirrored storage pool to use as backups
- Set and test the ZFS `compression` property on the file systems
- Troubleshoot ZFS device and data issues

Now that you have a better understanding of what is involved in planning for data storage configuration and backup, you are ready to receive your assignment. Your assignment consists of three tasks. The first task is to configure a mirrored storage pool. You then create snapshots of the file systems within the pool to use as backups. You also set the ZFS `compression` property on the file systems to test how to best minimize the amount of data storage space that your business application data is using. Finally, you troubleshoot several ZFS failures related to device and data issues.

In the next section, you learn how to accomplish the first task, which is to configure a mirrored storage pool.

Quiz

ZFS supports data redundancy in a mirrored storage pool configuration, but it does not support dynamic striping in a mirrored storage pool configuration.

a. True

b. False

Answer: b

Quiz

ZFS enables you to minimize the amount of data storage space used within a storage pool by using a file system property called _______________.

a. `minimize`
b. `restrictsize`
c. `compressratio`
d. `compression`

Answer: d

Lesson Agenda

- Planning for Data Storage Configuration and Backup
- **Managing Data Redundancy with Mirrored Storage Pools**
- Backing Up and Recovering Data with ZFS Snapshots
- Managing Data Storage Space with ZFS File System Properties

You know how the company wants to store its data assets. Now you learn how to configure the data storage environment to ensure data redundancy.

Managing Data Redundancy with Mirrored Storage Pools

This section covers the following topics:

- Creating a mirrored storage pool
- Adding log and cache devices to a storage pool
- Managing devices in a ZFS storage pool

Creating a Mirrored Storage Pool

To create a new ZFS mirrored storage pool, use `zpool create` followed by the pool name, the `mirror` keyword, and the storage devices that will compose the mirror.

```
# zpool create hrpool mirror c1t0d0 c2t0d0 mirror c3t0d0 c4t0d0
```

Data is:

- Dynamically striped across both mirrors
- Redundant between each disk within a mirror

To create a mirrored storage pool, you use the `zpool create` command followed by the pool name, the `mirror` keyword, and the storage devices that will compose the mirror. Multiple mirrors can be specified by repeating the `mirror` keyword on the command line.

The command shown in the example creates a pool called `hrpool` with two 2-way mirrors. The first mirror contains the devices `c1t0d0` and `c2t0d0`, and the second mirror contains the devices `c3t0d0` and `c4t0d0`.

Data is dynamically striped across both mirrors, with data being redundant between each disk within a mirror.

Adding Log Devices to a Storage Pool

A log device:

- Can be added as part of, or after, pool creation
- Can be removed
- Is designated by the keyword `log`

```
# zpool create datapool mirror c1t1d0 c1t2d0 log mirror
c1t5d0 c1t8d0
```


You can specify a separate log device when a pool is created or add it after the pool is created. You can also remove a log device from a pool. The keyword `log` is used to designate a device as the log device.

In the code example in the slide, a mirrored storage pool called `datapool` is created that consists of two virtual devices. The first virtual device contains the disks `c1t1d0` and `c1t2d0`. The second virtual device, which is the log device, contains the disks `c1t5d0` and `c1t8d0`.

Adding Cache Devices to a Storage Pool

- Can be added as part of, or after, pool creation
- Can be removed
- Cannot be mirrored or be a part of a RAID-Z configuration
- Are designated with the keyword `cache`

```
# zpool create appool mirror c0t2d0 c0t4d0 cache c0t0d0
```

Note: You can monitor cache statistics with `zpool iostat`.

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You can create a storage pool with one or more cache devices to cache storage pool data. You can remove cache devices from the pool after the pool is created. However, cache devices cannot be mirrored or be part of a RAID-Z configuration. The keyword `cache` is used to designate a cache device.

In the code example in the slide, a mirrored pool called `appool` is created that consists of two disks: `c0t2d0` and `c0t4d0`. By using the keyword `cache`, you have designated the device `c0t0d0` in the pool for the cache.

Note: Cache statistics can be monitored by using the `zpool iostat` command.

Managing Devices in ZFS Storage Pools

The tasks that you can perform with the devices in a pool include:

- Adding top-level virtual devices
- Attaching and detaching devices
- Taking a device offline
- Bringing a device online
- Designating hot spares

After you have created a pool, there are several tasks that you can perform to manage the physical devices within the pool, such as adding top-level virtual devices, attaching and detaching devices, taking a device offline, bringing a device online, and designating hot spares.

You now take a closer look at each of these tasks, beginning with how to add a device to a storage pool.

Adding Devices to a Storage Pool

To add a new virtual device to a pool, use the `zpool add` command.

```
# zpool add appool mirror c2t1d0 c2t2d0
```

By adding a new top-level virtual device, space is:

- Dynamically added to the pool
- Immediately available to all the data sets within the pool

Note: A data set is a generic name for the following ZFS entities: file systems, snapshots, or volumes.

ORACLE

To add a new virtual device to a pool, use the `zpool add` command. By adding a new top-level virtual device, space is dynamically added to the pool. This space is immediately available to all the data sets within the pool.

Note: A data set is a generic name for the following ZFS entities: file systems, snapshots, or volumes.

In the code example in the slide, you are adding a mirrored device to an existing pool called `appool`. The mirror consists of two disks: `c2t1d0` and `c2t2d0`.

Note: Use `zpool status` to determine the disks that are currently configured for a storage pool. Then, before adding a device to the pool, you must execute the `format` command to identify any additional disks configured in the system.

Attaching Devices to a Storage Pool

To attach a new device to an existing mirrored or non-mirrored pool, use the `zpool attach` command.

```
# zpool attach appool c1t1d0 c2t1d0
```


You can use the `zpool attach` command to attach a new device to an existing mirrored or non-mirrored virtual device (vdev). With this command, you can transform a two-way mirrored configuration into a three-way mirrored configuration, for example, or convert a non-redundant storage pool into a redundant storage pool.

In the example in the slide, a new device, `c2t1d0`, is being attached to an existing device, `c1t1d0`, to create either a mirrored pool or a three-way mirror in an already mirrored pool.

Attaching Devices to a Storage Pool

```
# zpool attach appool c1t1d0 c2t1d0
# zpool status
  pool: appool
 state: ONLINE
 scrub: resilver completed after 0h0m with 0 errors on Tue Dec
13 14:11:33 2011
config:
    NAME          STATE     READ  WRITE  CKSUM
    appool        ONLINE       0      0      0
      mirror-0    ONLINE       0      0      0
        c0t1d0    ONLINE       0      0      0
        c1t1d0    ONLINE       0      0      0
        c2t1d0    ONLINE       0      0      0 73.5K resilvered
```

Resilvering: The process of transferring data from one device to another device

You can run the `zpool status` command to verify that the device is attached successfully. In the example in the slide, you can see that the `c2t1d0` device has been attached to the mirrored pool named `appool`. You can also see that the new device has already been resilvered. In ZFS, the new device begins to resilver immediately.

Note: *Resilvering* is the process of transferring data from one device to another device.

Taking Devices Offline in a Storage Pool

To take a device offline, use `zpool offline` followed by the pool name and the device name.

```
# zpool offline hrpool c1t0d0
bringing device c1t0d0 offline
```

When a device is offline:

- ZFS does not send it any requests
- It remains offline after a system reboot

  Note: Use `zpool offline -t` to take a device offline temporarily.
- It is not detached from the storage pool

When hardware is unreliable or not functioning properly, ZFS continues to read or write data to the device, assuming that the condition is only temporary. If the condition is not temporary, you can instruct ZFS to ignore the device by taking it offline. You can take a device offline by using the `zpool offline` command followed by the pool name and the device name. In the code example in the slide, the `c1t0d0` device is taken offline. This device is located in the pool named `hrpool`.

When a device is taken offline, ZFS does not send any requests to that device.

By default, the offline state is persistent; consequently, the device remains offline even after the system is rebooted. If you want to take a device offline temporarily and have it automatically returned to the `ONLINE` state after the system is rebooted, use the `zpool offline -t` command instead.

When a device is taken offline, it is not detached from the storage pool. This means that you cannot use the device in another pool.

Detaching Devices from a Storage Pool

To detach a device from a mirrored storage pool, use the `zpool detach` command.

```
# zpool detach appool c2t1d0
```

Note: This operation is refused if there are no other valid replicas of the data.

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To detach a device from a mirrored storage pool, you can use the `zpool detach` command.

Note: The device should already be offline.

For example, if you want to detach the `c2t1d0` device that you just attached to the mirrored pool `appool`, you can do so by entering the command `zpool detach appool c2t1d0` as shown in the code example. You can verify that the device has been detached by running the `zpool status` command again.

Note: This operation is refused if there are no other valid replicas of the data.

Bringing Devices Online in a Storage Pool

To bring a device online, use `zpool online` followed by the pool name and the device name.

```
# zpool online hrpool c1t0d0
bringing device c1t0d0 online
```

When a device is brought back online, data that was added to the storage pool while the device was offline resilvers to the device.

Note: You cannot use `zpool online` to replace a disk.

To bring back a device online, use the `zpool online` command followed by the pool name and the device name.

Data that was added to a storage pool when a device was offline resilvers to the device after it is brought back online.

Note: You cannot use device onlining to replace a disk. If you take a device offline, replace the drive, and try to bring it online, it remains in the faulted state.

Replacing Devices in a Storage Pool

To replace a failed device with another device in the same location, use `zpool replace` followed by the pool name and the device name.

```
# zpool replace hrpool c1t1d0
```

If the device is in a different location, specify both devices.

```
# zpool replace hrpool c1t1d0 c1t2d0
```

Note: The replacement device must be greater than or equal to the minimum size of all the devices in the configuration.

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There are two reasons why you may want or need to replace a device. You may want to replace a device with a larger device, or you may need to replace a failing or failed device.

To replace a device, use the `zpool replace` command followed by the pool name and the device name.

If you are physically replacing a device with another device in the same location in a redundant pool, you need to identify only the replaced device. ZFS recognizes that it is a different disk in the same location. In the first example in the slide, you are replacing disk `c1t1d0` in the pool named `hrpool`.

If you are replacing a device in a storage pool with a disk in a different location, you must specify both devices. This is shown in the second example, where you are replacing disk `c1t1d0` in the pool named `hrpool` with disk `c1t2d0`.

Note: For the replacement operation to be successful, the replacement device must be greater than or equal to the minimum size of all the devices in a mirror or RAID-Z configuration.

Designating Hot Spares in a Storage Pool

With the ZFS hot spares feature, you can:

- Identify disks to replace a failed or faulted device in one or more storage pools
- Designate these devices as hot spares:
  - When you create the pool (`zpool create`)
  - After you have created a pool (`zpool add`)

  Note: The designated device must be equal to or larger than the size of the largest disk in the pool.

After a failed device has been replaced and resilvered, the spare is automatically detached and made available.

An in-progress spare replacement can be canceled.

If the faulted device is detached, the spare assumes its place and is removed from the spare's list of all active pools.

The ZFS hot spares feature enables you to identify disks that can be used to replace a failed or faulted device in one or more storage pools. Designating a device as a hot spare means that the device is not an active device in a pool, but if an active device in the pool fails, the hot spare automatically replaces the failed device.

You can designate devices as hot spares with the `zpool create` command when you are creating a pool or with the `zpool add` command if the pool has already been created.

Note: The device or devices that you designate as a spares must be equal to or larger than the size of the largest disk in the pool.

After a failed device has been replaced and resilvered, the spare is automatically detached and made available. An in-progress spare replacement can be canceled by detaching the spare. If the original faulted device is detached, the spare assumes its place in the configuration and is removed from the spare's list of all active pools.

You now look at some examples of how to designate hot spares, beginning with how to designate a hot spare when you are creating a pool.

Designating Hot Spares in a Storage Pool

To designate hot spares to a pool that you are creating, use `zpool create` followed by the pool name, the configuration, the keyword `spare`, and the names of the spares.

```
# zpool create appool mirror c1t1d0 c2t1d0 spare c1t2d0 c2t2d0
# zpool status appool
pool: appool
 state: ONLINE
 scrub: none requested
config:
        NAME         STATE     READ   WRITE  CKSUM
        appool       ONLINE       0       0      0
         mirror-0    ONLINE       0       0      0
           c1t1d0    ONLINE       0       0      0
           c2t1d0    ONLINE       0       0      0
        spares
         c1t2d0      AVAIL
         c2t2d0      AVAIL
```


To designate hot spares to a pool that you are creating, use `zpool create` followed by the pool name, the configuration, the keyword `spare`, and the names of the spares. In the example in the slide, a pool called `appool` is being created. Within this pool is a mirror that contains two disks: `c1t1d0` and `c2t1d0`. Two spares, `c1t2d0` and `c2t2d0`, have been designated.

If you look at the status of `appool`, you can see that the spares are part of the pool and that they have a status of available.

In this scenario, if either or both of the mirrored disks were to fail, ZFS automatically replaces them with one or both of the available spares.

Now you look at how to add spares to an existing pool.

Designating Hot Spares in a Storage Pool

To add hot spares to an existing pool, use `zpool add` followed by the pool name, the keyword `spare`, and the name of the hot spares.

```
# zpool add appool spare c1t3d0 c2t3d0
# zpool status appool
pool: appool
 state: ONLINE
 scrub: none requested
config:
    NAME          STATE     READ  WRITE    CKSUM
    appool        ONLINE       0      0        0
      mirror-0    ONLINE       0      0        0
        c1t1d0    ONLINE       0      0        0
        c2t1d0    ONLINE       0      0        0
    spares
      c1t3d0      AVAIL
      c2t3d0      AVAIL
```


To designate hot spares by adding them to a pool after the pool is created, use the `zpool add` command followed by the pool name, the keyword `spare`, and the name of the disks that you want to designate as hot spares.

In the example in the slide, you have designated disks `c1t3d0` and `c2t3d0` as the spares and are adding them to the pool named `appool`.

Then, you run the `zpool status` command for the pool to verify that the spares have been added successfully and they have. Notice that both spares have a status of available (`AVAIL`).

Again, as you saw in the previous example, if either or both of the mirrored disks were to fail, ZFS automatically replaces them with one or both of the available spares.

Next, you look at an example in which one of the active devices in `appool` has faulted and ZFS has automatically replaced the faulted device with one of the available spares.

Designating Hot Spares in a Storage Pool

Example of a hot spare replacing a faulted device:

```
# zpool status appool
pool: appool
 state: DEGRADED
status: One or more devices could not be opened.  Sufficient replicas
    exist for the pool to continue functioning in a degraded state.
action: Attach the missing device and online it using 'zpool online'.
   see: http://www.sun.com/msg/ZFS-8000-2Q
 scrub: resilvered completed 0h12m with 0 errors on Tue Dec 13 14:16:04
    2011
config:
    NAME           STATE     READ     WRITE   CKSUM
    appool         DEGRADED     0         0       0
      mirror-0     DEGRADED     0         0       0
        c1t1d0     ONLINE       0         0       0
        spare-1    UNAVAIL      0         0       0
          c2t1d0   UNAVAIL      0         0       0 cannot open
          c1t3d0   ONLINE       0         0       0 58.5K resilvered
    spares
      c1t3d0       INUSE      currently in use
      c2t3d0       AVAIL
```

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In this example, disk `c2t1d0` has faulted and is replaced automatically by the hot spare `c1t3d0`, which has been resilvered and now appears as an active device in the mirrored pool. Notice also that the status of the hot spare `c1t3d0` has changed from available (`AVAIL`) to in use (`INUSE`).

Next, you look at how to return a hot spare to the spares set after a failed device is replaced and is back online.

Removing Hot Spares in a Storage Pool

To remove a hot spare, use `zpool remove` followed by the pool name and the name of the hot spare.

```
# zpool remove appool c1t2d0
# zpool status appool
pool: appool
(output omitted)
    spares
      c1t3d0        AVAIL
```

Note: You cannot remove a hot spare if it is currently being used by the storage pool as an active device.

To remove a hot spare from a storage pool, use the `zpool remove` command followed by the pool name and the name of the hot spare. In this example, you are removing the hot spare `c1t2d0` from the pool named `appool`, leaving just one hot spare in the pool: `c1t3d0`.

As you can see in this example, after it is removed, the hot spare no longer appears in the spares set.

Note: You cannot remove a hot spare if it is being used by the storage pool as an active device.

Practice 4-1 Overview:
Managing Data Redundancy with a ZFS Mirrored Pool

This practice covers the following topics:

- Creating ZFS mirrored pools
- Adding disks to a ZFS storage pool
- Adding a cache device to a ZFS storage pool
- Destroying a ZFS storage pool

The practices for this lesson are designed to reinforce the concepts that have been presented in the lecture portion. These practices cover the following tasks:

- **Practice 4-1:** Managing data redundancy with a ZFS mirrored pool
- **Practice 4-2:** Using ZFS snapshots for backup and recovery
- **Practice 4-3:** Using a ZFS clone
- **Practice 4-4:** Configuring ZFS properties
- **Practice 4-5:** Troubleshooting ZFS failures

Practice 4-1 should take about 30 minutes to complete.

Lesson Agenda

- Planning for Data Storage Configuration and Backup
- Managing Data Redundancy with Mirrored Storage Pools
- **Backing Up and Recovering Data with ZFS Snapshots**
- Managing Data Storage Space with ZFS File System Properties
- Troubleshooting ZFS Failures

Backing Up and Recovering Data with ZFS Snapshots

This section covers the following topics:

- Creating and destroying ZFS snapshots
- Holding ZFS snapshots
- Renaming, displaying, and rolling back ZFS snapshots
- Determining ZFS snapshot differences
- Creating and destroying ZFS clones
- Sending and receiving ZFS snapshot data

Creating and Destroying a ZFS Snapshot

To create a snapshot, use `zfs snapshot` followed by the snapshot name.

```
# zfs snapshot hrpool/home/qarpt@friday
```

To destroy a snapshot, use `zfs destroy` followed by the snapshot name.

```
# zfs destroy hrpool/home/qarpt@friday
```

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You can use the `zfs snapshot` command to create a snapshot, which takes as its only argument the name of the snapshot that you want to create.

In the example in the slide, you are creating a snapshot of `hrpool/home/qarpt` that is named `friday`.

Note: To create a recursive snapshot, use `zfs snapshot -r` and the snapshot name (for example, `zfs snapshot -r hrpool/home@now`).

To destroy a ZFS snapshot, use the `zfs destroy` command followed by the snapshot name. In the example in the slide, you are destroying the snapshot named `hrpool/home/qarpt@friday`.

There are several things that you must keep in mind when attempting to destroy a ZFS snapshot.

- A data set cannot be destroyed if snapshots of the data set exist.
- If clones have been created from a snapshot, they must be destroyed before the snapshot can be destroyed.

Now you take a look at how to hold ZFS snapshots.

Holding a ZFS Snapshot

- The snapshot hold feature:
  - Prevents a snapshot from being destroyed by using `zfs destroy`
  - Allows a snapshot with clones to be deleted pending the removal of the last clone by using `zfs destroy -d`
- The snapshot user-reference count:
  - Is initialized to zero
  - Increases by one whenever a hold is put on the snapshot
  - Decreases by one whenever a hold is released
  - Must be at zero before the snapshot can be destroyed

Remote replication of ZFS data sets can result in different automatic snapshot policies on the two sides of a replication pair. For example, the sending side may want to keep five snapshots at one-minute intervals, whereas the receiving side may want to keep 10 snapshots at one-minute intervals. This can result in the older snapshots being destroyed inadvertently by `zfs receive` because they no longer exist on the sending side. The ZFS snapshot hold feature addresses this issue. Holding a snapshot (`zfs hold`) prevents it from being destroyed. If a hold exists on a snapshot, you will not be able to destroy it by using the `zfs destroy` command. You will look at the two options that you have for destroying a held snapshot in the following slides.

In addition, the snapshot hold feature allows a snapshot with clones to be deleted pending the removal of the last clone by using the `zfs destroy -d` command. You take a closer look at how this is done in subsequent slides.

Each snapshot has an associated user-reference count, which is initialized to zero. This count increases by one whenever there is a hold on the snapshot and decreases by one whenever the hold is released. As discussed, a snapshot can be destroyed only if it has no clones. In the Oracle Solaris 11 release, the snapshot must also have a zero `user-reference` count before it can be destroyed.

Holding a ZFS Snapshot

To hold a snapshot or set of snapshots, use `zfs hold keep` followed by the snapshot name.

```
# zfs hold keep hrpool/home/report@snap1
```

To recursively hold the snapshots of all descendant file systems, use `zfs hold` with `-r`, followed by `keep` and the snapshot name.

```
# zfs hold -r keep hrpool/home@now
```

Note: Each snapshot has its own tag namespace, and tags must be unique within that space. `keep` is only a tag.

To hold a snapshot or set of snapshots, use the `zfs hold keep` command followed by the snapshot name. In the first example, a hold tag (`keep`) is being put on `hrpool/home/report@snap1`.

You can use the `-r` option with the `zfs hold` command and the `keep` hold tag to recursively hold the snapshots of all descendant file systems, as shown in the second example. Here, you are holding the snapshots of all the descendant file systems of `hrpool/home@now`.

Note: Each snapshot has its own tag namespace, and tags must be unique within that space. In this example, `keep` is a user-defined tag.

Holding a ZFS Snapshot

To display a list of held snapshots, use `zfs holds` followed by the snapshot name.

```
# zfs holds hrpool/home@now
NAME             TAG   TIMESTAMP
hrpool/home@now  keep  Mon Dec 10 12:40:12 2012
```

To display a recursive list of held snapshots, use `zfs holds` with `–r`, followed by the snapshot name.

```
# zfs holds -r hrpool/home@now
NAME                    TAG   TIMESTAMP
hrpool/home/report@now  keep  Mon Dec 10 12:40:12 2012
hrpool/home/jjones@now  keep  Mon Dec 10 12:40:12 2012
hrpool/home@now         keep  Mon Dec 10 12:40:12 2012
```


You can use the `zfs holds` command followed by the snapshot name to display a list of held snapshots. In the first example, snapshot holds are being displayed for `hrpool/home@now`. Notice that the output returns the name of the snapshot, the tag name (in this case, `keep`), and the time stamp.

You can use the `-r` option with the `zfs holds` command and the snapshot name to get a recursive list, as illustrated in the second example.

Holding a ZFS Snapshot

Two options to destroy a held ZFS snapshot:

1. Use `zfs destroy -d`, followed by the snapshot name, and then release the snapshot hold, which removes the snapshot.
2. Release the held snapshot, and then destroy it by using `zfs destroy`.

To release a held snapshot or set of snapshots, use `zfs release -r` followed by `keep` and the snapshot name.

```
# zfs release -r keep hrpool/home@now
```

Note: `-r` enables a recursive release of the hold.

As mentioned before, if a hold exists on a snapshot, you will not be able to destroy it by using the `zfs destroy` command. To destroy the snapshot, you have two options:

- You can destroy the held snapshot by using the `zfs destroy -d` command followed by the snapshot name, and then release the snapshot hold, which removes the snapshot.
- You can release the snapshot and then destroy it by using the `zfs destroy` command without the `-d` option.

Note: If a held snapshot has associated clones, you must destroy the clones first before you can destroy the held snapshot.

To release a hold on a snapshot or set of snapshots, use the `zfs release` command with the `-r` option, followed by the hold tag `keep` and the snapshot name. `-r` enables a recursive release of the hold and is optional. In the example in the slide, you are releasing the recursive hold on the `hrpool/home@now` snapshot.

This snapshot can be destroyed if all the holds have been released.

Holding a ZFS Snapshot

Snapshot hold properties:

- `defer_destroy`: Set to `on` if the snapshot has been marked for deferred destruction by using the `zfs destroy -d` command.
- `Userrefs`: Set to the number of holds on the snapshot.

The snapshot hold information is identified through two properties:

- The `defer_destroy` property is `on` if the snapshot has been marked for deferred destruction by using the `zfs destroy -d` command. Otherwise, the property is `off`.
- The `userrefs` property is set to the number of holds on this snapshot, which is also referred to as the *user-reference count*.

Holding a ZFS Snapshot

To view the ZFS snapshot hold properties, use `zfs get -r defer_destroy,userrefs` followed by the file system name.

```
# zfs get -r defer_destroy,userrefs hrpool/home
NAME                      PROPERTY       VALUE     SOURCE
hrpool                    defer_destroy  -         -
hrpool                    userrefs       -         -
hrpool/home               defer_destroy  -         -
hrpool/home               userrefs       -         -
hrpool/home/report@now    defer_destroy  off       -
hrpool/home/report@now    userrefs       1         -
hrpool/home/jjones@now    defer_destroy  off       -
hrpool/home/jjones@now    userrefs       1         -
hrpool/home@now           defer_destroy  off       -
hrpool/home@now           userrefs       1         -
```


You can view these properties by using the `zfs get -r` command followed by the comma-separated property name and the file system name.

In the example in the slide, the `defer_destroy` and `userrefs` properties for `hrpool/home` are displayed. As you can see from the output, each of the `@now` snapshots has the `defer_destroy` property set to `off`, which is the default, and a value of `1` for the `userrefs` property, which indicates that each of these snapshots has one hold on it.

Renaming a ZFS Snapshot

To rename a snapshot, use `zfs rename` followed by the snapshot name.

```
# zfs rename hrpool/home/report@121011 hrpool/home/report@today
```

Note: Snapshots must be renamed within the same pool and data set from which they were created.

You can rename a snapshot by using the `zfs rename` command followed by the snapshot name. In the example in the slide, the snapshot `report@121011`that resides in `hrpool/home` is renamed to `report@today`.

Note: Snapshots must be renamed within the same pool and data set from which they were created.

Renaming a ZFS Snapshot

To recursively rename snapshots, use `zfs rename -r` followed by the snapshot name.

```
# zfs list
NAME                          USED    AVAIL  REFER    MOUNTPOINT
users                         270K    16.5G   22K     /users
users/home                    76K     16.5G   22K     /users/home
users/home@yesterday          0       -       22K     -
users/home/jjones             18K     16.5G   18K     /users/home/jjones
users/home/jjones@yesterday   0       -       18K     -
# zfs rename -r users/home@yesterday @2daysago
# zfs list -r users/home
NAME                          USED    AVAIL  REFER    MOUNTPOINT
users/home                    76K     16.5G   22K     /users/home
users/home@2daysago           0       -       22K     -
users/home/jjones             18K     16.5G   18K     /users/home/jjones
users/home/jjones@2daysago    0       -       18K     -
```


You can recursively rename snapshots with the `zfs rename -r` command followed by the snapshot name.

In the example in the slide, only those snapshots that are named `@yesterday` are renamed to `@2daysago`.

You can see a before-and-after picture with the list of file systems before the `zfs rename -r` command is run in the first half of the example, and then the change that has occurred in the second half of the example. In short, any snapshot with the `@yesterday` name was changed to `@2daysago` after the `rename` command was run.

Next, you look at how to display and access ZFS snapshots.

Displaying a ZFS Snapshot

To display only snapshots, use `zfs list -t snapshot`.

```
# zfs list -t snapshot
NAME                          USED  AVAIL  REFER    MOUNTPOINT
hrpool/home/qarpt@tuesday     18K       -    21K    -
hrpool/home/qarpt@wednesday   19K       -   280K    -
hrpool/home/qarpt@thursday     0        -   538K    -
```

The `listsnapshots` pool property is:

- Used to enable or disable the display of snapshots
- Disabled by default
- Enabled by using `zpool set listsnapshot=on` *`<poolname>`*

You can use the `zfs list -t snapshot` command to display snapshots as shown in this example.

You can enable or disable the display of snapshot listings in the `zfs list` output by using the `listsnapshots` pool property. This property is disabled by default.

To enable this property, use `zpool set listsnapshots=on`, followed by the pool name.

Note: If you disable this property, you must use the `zfs list -t snapshot` command to display snapshot information.

Displaying a ZFS Snapshot

To list the snapshots created for a specific file system, enter `zfs list -r -t snapshot` followed by the file system name.

```
# zfs list -r -t snapshot -o name,creation hrpool/home
NAME                           CREATION
hrpool/home/qarpt@tuesday      Tue Dec 11 10:03 2012
hrpool/home/qarpt@wednesday    Wed Dec 12 10:03 2012
hrpool/home/qarpt@thursday     Thu Dec 13 10:03 2012
hrpool/home/bonus@now          Fri Dec 14 11:04 2012
```


You can list the snapshots that were created for a particular file system by using the `zfs list` command with the `-r` and `-t snapshot` options, followed by the file system name.

In the example in the slide, the snapshots created for the file system `hrpool/home` are listed. This information is displayed by using the `name` and `creation` properties.

Displaying a ZFS Snapshot

The snapshots of file systems are accessible in the `.zfs/snapshot` directory within the root of the file system.

```
# ls /home/qarpt/.zfs/snapshot
tuesday wednesday thursday
```


The snapshots of file systems are accessible in the `.zfs/snapshot` directory within the root of the file system. For example, if `hrpool/home/qarpt` is mounted on `/home/qarpt`, the `hrpool/home/qarpt@thursday` snapshot data is accessible in the `/home/qarpt/.zfs/snapshot/thursday` directory, as shown in the example in the slide.

Now you take a quick look at snapshot space accounting.

Snapshot Space Accounting

- When a snapshot is created, its space is:
  - Initially shared between the snapshot and the file system
  - Possibly shared with previous snapshots
- As the file system changes, the previously shared space:
  - Becomes unique to the snapshot
  - Is counted in the snapshot's `used` property
- Deleting snapshots can increase the amount of space that is unique for use by other snapshots.

Note: The value for a snapshot's space `referenced` property is the same as that for the file system when the snapshot was created.

When a snapshot is created, its space is initially shared between the snapshot and the file system, and possibly with previous snapshots.

As the file system changes, space that was previously shared becomes unique to the snapshot, and thus is counted in the snapshot's `used` property.

Additionally, deleting snapshots can increase the amount of space that is unique for use by other snapshots.

Note: The value for a snapshot's space `referenced` property is the same as that for the file system when the snapshot was created.

Snapshot Space Accounting

To display the amount of space consumed by snapshots and descendant file systems, use `zfs list -o space`.

```
$ zfs list -o space -r rpool
NAME                         AVAIL   USED  USEDSNAP  USEDDS  USEDREFRESERV  USEDCHILD
rpool                        59.1G  7.84G       21K    109K              0      7.84G
rpool@snap1                      -    21K         -       -              -          -
rpool/ROOT                   59.1G  4.78G         0     31K              0      4.78G
rpool/ROOT@snap1                 -      0         -       -              -          -
rpool/ROOT/solaris1          59.1G  4.78G     15.6M   4.76G              0          0
rpool/ROOT/solaris1@snap1        -  15.6M         -       -              -          -
rpool/dump                   59.1G  1.00G       16K   1.00G              0          0
rpool/dump@snap1                 -    16K         -       -              -          -
rpool/export                 59.1G    99K       18K     32K              0        49K
rpool/export@snap1               -    18K         -       -              -          -
rpool/export/home            59.1G    49K       18K     31K              0          0
rpool/export/home@snap1          -    18K         -       -              -          -
rpool/swap                   61.2G  2.06G         0     16K          2.06G          0
rpool/swap@snap1                 -      0         -       -              -          -
```


You can display the amount of space that is consumed by snapshots and descendant file systems by using the `zfs list -o space` command (as in the slide example).

From this output, you can see the amount of space that is:

- Available on each file system
- Being used
- Being consumed by snapshots of each data set (`USEDSNAP`)
- Being used by the data set itself (`USEDDS`)
- Being used by a refreservation set on the data set (`USED REFRESERV`)
- Being used by the children of this data set (`USEDCHILD`)

Now you look at how to roll back a ZFS snapshot.

Rolling Back a ZFS Snapshot

To discard all the changes made since a specific snapshot, enter `zfs rollback` followed by the snapshot name.

```
# zfs rollback hrpool/home/qarpt@thursday
```

By default, `zfs rollback` rolls back only to the most recent snapshot.

To destroy more recent snapshots, enter `zfs rollback` with `–r`, followed by the snapshot name.

```
# zfs rollback -r hrpool/home/qarpt@tuesday
```


You can use the `zfs rollback` command followed by the snapshot name to discard all the changes made since a specific snapshot.

The `zfs rollback` command causes the file system to revert to its state at the time the snapshot was taken.

In the example in the slide, the `hrpool/home/qarpt` file system is rolled back to the `thursday` snapshot.

By default, the `zfs rollback` command cannot roll back to a snapshot other than the most recent snapshot.

To roll back to an earlier snapshot, you must destroy all intermediate snapshots. To do this, you must specify the `-r` option with the `zfs rollback` command followed by the snapshot name, as shown in the second example. Here, the `hrpool/home/qarpt` file system is rolled back to the `tuesday` snapshot. For this operation to take place, the `wednesday` and `thursday` snapshots must be destroyed.

Now that you have an idea of how to work with ZFS snapshots, you turn your attention to ZFS clones.

Identifying ZFS Snapshot Differences

To determine ZFS snapshot differences, use `zfs diff` followed by the snapshot names.

```
# zfs snapshot datapool/hrdata@before
# touch /datapool/hrdata/newfile
# zfs snapshot datapool/hrdata@after
# zfs list -r -t snapshot -o name,creation
NAME                              CREATION
datapool/hrdata@before            Thu Dec 13 14:54 2012
datapool/hrdata@after             Thu Dec 13 14:59 2012
rpool/ROOT/solaris@install        Tue Dec 18 22:33 2012
# zfs diff datapool/hrdata@before datapool/hrdata@after
M       /datapool/hrdata/
+       /datapool/hrdata/newfile
#
```


To determine the differences between ZFS snapshots, you can use the `zfs diff` command. The output of this command provides a high-level description of the differences between a snapshot and a descendant data set. The descendant can be either a snapshot of the data set or the current data set. For each file that has undergone a change between the original snapshot and the descendant, the type of change is described along with the name of the file. In the case of a rename, both the old and new names are shown. The type of change follows any time stamp displayed and is described with a single character. The definition of each of these characters is provided in the next slide.

In the example, a `before` snapshot of the `datapool/hrdata` ZFS file system was taken. A new file (`newfile`) was then created in /`datapool/hrdata`. Then another snapshot (`after`) of the same ZFS file system was taken. The `zfs list` command is used to list the snapshots based on name and creation date. The `zfs diff` command is then run to determine the differences between the `before` and `after` snapshots. The `M` in the `zfs diff` command output indicates that the `/datapool/hrdata/` directory has been modified, and the `+` indicates that a file `/datapool/hrdata/newfile` exists in the later snapshot.

Identifying ZFS Snapshot Differences

File or Directory Change	Identifier
File or directory is modified, or file or directory link has changed.	`M`
File or directory is present in the older snapshot but not in the newer snapshot.	`-`
File or directory is present in the newer snapshot but not in the older snapshot.	`+`
File or directory is renamed.	`R`

The table in this slide summarizes the file or directory changes that are identified by the `zfs diff` command. For more information about the `zfs diff` command, see `zfs(1M)`.

Creating and Destroying a ZFS Clone

To create a clone, enter `zfs clone` followed by the snapshot name from which the clone is to be created, and the name of the new file system or volume.

```
# zfs snapshot hrpool/ws/gate@yesterday
# zfs clone hrpool/ws/gate@yesterday hrpool/home/qarpt/summary
```

To destroy a clone, use `zfs destroy` followed by the clone name.

```
# zfs destroy hrpool/home/qarpt/summary
```


Now you switch your focus to ZFS clones, beginning with a brief review of how to create and destroy ZFS clones.

To create a clone, use the `zfs clone` command, specifying the snapshot from which to create the clone and the name of the new file system or volume.

In the example in the slide, a clone named `hrpool/home/qarpt/summary` is created with the same initial contents as the snapshot `hrpool/ws/gate@yesterday`.

The new file system or volume can be located anywhere in the ZFS hierarchy.

The type of the new data set (for example, file system or volume) is the same as the snapshot from which the clone was created.

Note: You cannot create a clone of a file system in a pool that is different from where the original file system snapshot resides.

To destroy a ZFS clone, use the `zfs destroy` command followed by the clone name. In the example in the slide, the clone named `hrpool/home/qarpt/summary` is destroyed.

Remember that clones must be destroyed before the parent snapshot can be destroyed.

Now you look at how to replace a ZFS file system with a ZFS clone.

Replacing a ZFS File System with a ZFS Clone

With the clone replacement process, you can:

- Clone and replace file systems so that the original file system becomes the clone of the newly created file system
- Destroy the file system from which the clone was originally created

Note: Without clone promotion, you cannot destroy the original file system of active clones.

ZFS uses a process called *clone replacement* (or *promotion*), which enables you to replace an active ZFS file system with a clone of that file system. This process facilitates the ability to clone and replace file systems so that the original file system becomes the clone of the newly created file system. In addition, this process makes it possible to destroy the file system from which the clone was originally created.

Note: Without clone promotion, you cannot destroy the original file system of active clones.

This feature is good to have if, for some reason, you absolutely need to modify production data. (Under normal circumstances, you would not use this method. Instead, you would introduce the modifications through databases and other tools.) To accommodate this special situation, create a clone from the file system's snapshot. This clone is nothing but a copy of the production file system; however, it is writeable and editable. So now a programmer (or system administrator) can open it like any other file system, modify the data and, considering it as a newer copy of the file system, overlay the production file system with it. Because you do not want to modify production data directly, being able to use clones is useful.

Replacing a ZFS File System with a ZFS Clone

To replace an active ZFS file system with a clone of that file system, use `zfs promote` followed by the clone name.

```
# zfs snapshot hrpool/reviews/q4@today
# zfs clone hrpool/reviews/q4@today hrpool/reviews/q4sum
# zfs list -r hrpool/reviews
NAME                        USED   AVAIL  REFER  MOUNTPOINT
hrpool/reviews              314K   8.24G  25.5K  /hrpool/reviews
hrpool/reviews/q4            288K  8.24G  288K   /hrpool/reviews/q4
hrpool/reviews/q4@today         0  -      288K   -
hrpool/reviews/q4sum            0  8.24G  288K   /hrpool/reviews/q4sum
```

```
# zfs promote hrpool/reviews/q4sum
# zfs list -r hrpool/reviews
NAME                        USED   AVAIL  REFER  MOUNTPOINT
hrpool/reviews              316K   8.24G  27.5K  /hrpool/reviews
hrpool/reviews/q4               0  8.24G  288K   /hrpool/reviews/q4
hrpool/reviews/q4sum         288K  8.24G  288K   /hrpool/reviews/q4sum
hrpool/reviews/q4@today         0      -  288K   -
```


The clone replacement process is a two-step operation. First, you replace an active ZFS file system by promoting the clone.

In the first example, you can see from the `zfs list` output that the `hrpool/reviews/q4` file system has been cloned by using the `hrpool/review/q4@today` snapshot.

In the second example, the original `hrpool/reviews/q4` file system is replaced with the cloned file system, `hrpool/reviews/q4sum`, by promoting the clone.

In the `zfs list` output, you can see that the storage used by the original `q4` file system has been replaced with the `q4sum` file system.

Replacing a ZFS File System with a ZFS Clone

To rename the promoted file systems to the original name, use `zfs rename` followed by the current file system name and a new file system name.

```
# zfs rename hrpool/reviews/q4 hrpool/review/q4legacy
# zfs rename hrpool/reviews/q4sum hrpool/reviews/q4
# zfs list -r hrpool/reviews
NAME                         USED  AVAIL   REFER    MOUNTPOINT
hrpool/reviews               316K  8.24G   27.5K    /hrpool/reviews
hrpool/reviews/q4            288K  8.24G   288K     /hrpool/reviews/q4
hrpool/reviews/q4@today         0      -   288K     -
hrpool/reviews/q4legacy         0 8.24G    288K     /hrpool/reviews/q4legacy
```


After you have replaced the original ZFS file system with the clone, you will want to complete the second and final step of the process by renaming the file systems.

To do this, use the `zfs rename` command followed by the current file system name and a new file system name.

In the example in the slide, you renamed the original `hrpool/reviews/q4` file system to `hrpool/reviews/q4legacy` and the original clone file system, `hrpool/reviews/q4sum`, to `hrpool/reviews/q4`, which was the name of the original file system.

In the `zfs list` output, you can see that the name changes have taken effect.

The original file system and snapshot can be deleted.

Now you turn your attention to the last topic in this lesson: sending and receiving ZFS data. It begins by discussing how to send ZFS data.

Sending ZFS Snapshot Data

The `zfs send` command:

- Is used to send ZFS snapshot data for backup purposes
- Sends a copy of a snapshot to another pool:
  - On the same system
  - On a different system
- Creates a stream representation of a snapshot that is written to standard output
  - By default, a full stream is generated.
  - The output can be redirected to a file, to a different system, or to a device.

You can send your ZFS snapshot data by using the `zfs send` command. With this command, you can send a copy of a snapshot to another pool on the same system or to a pool on a different system that is used to store backup data.

The `zfs send` command creates a stream representation of a snapshot that is written to standard output. By default, a full stream is generated. You can redirect the output to a file, to a different system, or to a device (for example, a mag tape).

Sending ZFS Snapshot Data

To send a ZFS snapshot, enter `zfs send` followed by the snapshot name and destination.

```
# zfs send hrpool/data@snap1
```

To send incremental ZFS snapshot data, use `zfs send -i`.

```
# zfs send -i hrpool/data@snap1 hrpool/data@snap2
```


To send a ZFS snapshot, use the `zfs send` command followed by the snapshot name and destination, as shown in the first example.

You can also send incremental data by using the `-i` option with the `zfs send` command, as shown in the second example.

Note that the first argument is the earlier snapshot (`snap1`) and the second argument is the later snapshot (`snap2`).

Now you look at how to receive ZFS snapshot data.

Receiving ZFS Snapshot Data

The `zfs receive` command:

- Is used to receive ZFS snapshot data
- Receives the snapshot from:
  - Another pool:
    - On the same system
    - On a different system
  - A file or device
- Creates a snapshot whose contents are specified in the stream that is provided on standard input
- Has an alias, `recv`

Note: If a full stream is received, a new file system is created as well.

You can receive ZFS data by using the `zfs receive` command. This command receives snapshot data from another pool on the same system or from another pool on a different system. It can also receive snapshot data from a file or device.

The `zfs receive` command creates a snapshot whose contents are specified in the stream that is provided on standard input.

Note: If a full stream is received, a new file system is created as well.

Receiving ZFS Snapshot Data

Keep the following key points in mind when you receive a file system snapshot:

- The snapshot and the file system are received.
- The file system and all the descendant file systems are unmounted.
- The file systems are inaccessible while they are being received.
- The original file system to be received must not exist while it is being transferred.
- If a conflicting file system name exists, `zfs rename` can be used to rename the file system.

Receiving ZFS Snapshot Data

To receive a ZFS file system snapshot, use `zfs receive` followed by the snapshot name and the location from which you want to retrieve the file system.

```
# zfs send hrpool/jobdesc@1215 > /bkups/jobdesc.121511
# zfs receive hrpool/jobdesc2@today < /bkups/jobdesc.121511
# zfs rename hrpool/jobdesc hrpool/jobdesc.old
# zfs rename hrpool/jobdesc2 hrpool/jobdesc
```


To receive a ZFS file system snapshot, use the `zfs receive` command followed by the snapshot name and the location from which you want to retrieve the file system.

In the example in the slide, the `hrpool/jobdesc@0930` snapshot of the `hrpool/jobdesc` file system is sent to the destination backup system called `/bkups/jobdesc.093011`.

Next, the `hrpool/jobdesc2@today` snapshot of the `hrpool/jobdesc2` file system is retrieved from the backup system. Then the `hrpool/jobdesc` file system is renamed to `hrpool/jobdesc.old` and the `hrpool/jobdesc2` file system is renamed to `hrpool/jobdesc`.

Remote Replication of ZFS Snapshot Data

To remotely copy snapshot data from one system to another system, use `zfs send` and `zfs receive`.

```
# zfs send hrpool/report@today | ssh newsys zfs recv sandbox/restfs
```


You can use the `zfs send` and `zfs receive` commands to remotely copy (replicate) a snapshot stream representation from one system to another system.

In the example in the slide, the `hrpool/report@today` snapshot data is sent, and it is received in the `sandbox/restfs` file system. This command also creates a `restfs@today` snapshot on the `newsys` system. In this example, the user has been configured to use `ssh` on the remote system.

ZFS also supports sending and receiving complex snapshot streams. For more information about remote replication of ZFS snapshot data and about sending and receiving ZFS data in general, see the appropriate sections of *Oracle Solaris Administration: ZFS File Systems*.

Practices 4-2 and 4-3 Overview: Using ZFS Snapshots for Backup and Recovery and Using a ZFS Clone

These practices cover the following topics:

- Creating and destroying ZFS snapshots
- Rolling back ZFS snapshots
- Restoring ZFS snapshots
- Sending and receiving ZFS snapshot data
- Creating and destroying ZFS clones

These practices should take about one hour to complete.

Lesson Agenda

- Planning for Data Storage Configuration and Backup
- Managing Data Redundancy with Mirrored Storage Pools
- Backing Up and Recovering Data with ZFS Snapshots
- **Managing Data Storage Space with ZFS File System Properties**
- Troubleshooting ZFS Failures

Managing Data Storage Space with ZFS File System Properties

This section covers the following topics:

- Setting ZFS properties
- Inheriting ZFS properties
- Querying ZFS properties
- Mounting and sharing ZFS file systems
- Setting ZFS quotas and reservations

Setting ZFS Properties

To modify any settable data set property, use `zfs set` followed by *`property=value`* and the data set name.

```
# zfs set atime=off hrpool/home
```

Note: Only one property can be set or modified during each `zfs set` invocation.

You can also set a property during the creation of a data set by using `zfs create`.

```
# zfs create -o atime=off hrpool/home
```


To modify any settable data set property, use the `zfs set` command followed by *`property=value`* and a data set name. In the example in the slide, the `atime` property is set to `off` for `hrpool/home`.

Note: Only one property can be set or modified during each `zfs set` invocation.

You can also use the `zfs create` command to set properties when you are creating the file system. In this example, you are setting the `atime` property to `off` as you create the file system `hrpool/home`.

Now you look at how ZFS property inheritance works.

Inheriting ZFS Properties

- All settable properties inherit their values from their parents.
- All inheritable properties have an associated source.

Source Value	Definition
`default`	The property setting was not inherited or set locally.
`local`	The property was explicitly set on the data set by using the `zfs set` command.
`inherited` from *dataset-name*	The property was inherited from the named ancestor.

All settable properties, except for quotas and reservation properties, inherit their values from their parents.

All inheritable properties have an associated source. The source indicates how a property was obtained. The source of a property can have the following values:

- **`default`:** The property setting was not inherited or set locally. This source is a result of no ancestor having the property as source local.
- **`local`:** The property was explicitly set on the data set by using the `zfs set` command
- **`inherited` from *dataset-name*:** The property was inherited from the named ancestor

If no ancestor has an explicit value set for an inherited property, the default value for the property is used.

Inheriting ZFS Properties

```
# zfs list
NAME                            USED  AVAIL  REFER  MOUNTPOINT
datapool                        176K  1.95G    23K  /export/share
datapool/software                65K  1.95G    23K  /export/share/software
datapool/software/solaris        42K  1.95G    21K  /export/share/software/solaris
datapool/software/solaris/ar     21K  1.95G    21K  /export/share/software/solaris/ar
```

```
# zfs get -r compression datapool
NAME                            PROPERTY     VALUE     SOURCE
datapool                        compression  off       default
datapool/software               compression  off       default
datapool/software/solaris       compression  off       default
datapool/software/solaris/ar    compression  off       default
```


You now walk through an example of how ZFS property inheritance works.

First, you run the `zfs list` command to see the file system hierarchy, as shown in the first output in the slide.

Next, you run the `zfs get -r` command for the `compression` property, as shown in the second output. Here you can see that the `compression` property is set to `off`, which is the default, for all the file systems.

Inheriting ZFS Properties

```
# zfs set compression=on datapool/software/solaris
# zfs get -r compression datapool
NAME                          PROPERTY     VALUE   SOURCE
datapool                      compression  off     default
datapool/software             compression  off     default
datapool/software/solaris     compression  on      local
datapool/software/solaris/ar  compression  on      inherited from datapool/software/solaris
```


Next, you set the `compression` property to `on` for the `datapool/software/solaris` file system.

If you run the `zfs get -r compression` command for `datapool`, you can see how the child file system inherits the ZFS property. Note that the compression value for `datapool/software/solaris` is now set to `on` and the `SOURCE` has changed from `default` to `local`.

You can also see how `datapool/software/solaris/ar` has inherited the `compression` property value of `on` from its parent file system.

Inheriting ZFS Properties

To clear a property setting and have the setting inherited from the parent, use `zfs inherit` followed by the property name and the system file name path.

```
# zfs inherit compression datapool/software/solaris
# zfs get -r compression datapool
NAME                            PROPERTY      VALUE     SOURCE
datapool                        compression   off       default
datapool/software               compression   off       default
datapool/software/solaris       compression   off       default
datapool/software/solaris/ar    compression   off       default
```


If you want to return the `datapool/software/solaris` file system's compression value to `off`, you can do so by using the `zfs inherit` command. This command clears a property setting, thereby causing the setting to be inherited from the parent.

In the example in the slide, `zfs inherit` is used to unset the `compression` property, thereby causing the property to inherit the default setting of `off`. Because neither `datapool` nor `datapool/software` has the `compression` property set locally, the default value is used. If both `datapool` and `datapool/software` have `compression` `on`, the value set in the most immediate ancestor is used.

Now you look at how to query ZFS properties.

Querying ZFS Properties

You can query property values with:

- `zfs list`
- `zfs get`
  - Complex queries
  - Scripting
  - Any data set property

The simplest way to query property values is by using the `zfs list` command. However, for complex queries and for scripting, you can use the `zfs get` command to obtain more detailed information in a customized format. The `zfs list` command is covered in detail in the *Oracle Solaris 11 System Administration* course. This course focuses on using the `zfs get` command for querying ZFS properties.

Querying ZFS Properties

To retrieve any data set property, use `zfs get` followed by the property name and the data set name.

```
# zfs get checksum hrpool/ws
NAME                PROPERTY          VALUE          SOURCE
hrpool/ws           checksum          on             default
```


You can use the `zfs get` command to retrieve any data set property, followed by the property name and the data set name. In the example in the slide, the `zfs get` command is used to retrieve the `checksum` property value for `hrpool/ws`. As you can see, the `VALUE` is set to `on` and the `SOURCE` is `default`.

Querying ZFS Properties

The source values in `zfs get` are shown in the following table:

Source Value	Definition
`default`	The property setting was not inherited or set locally.
`local`	The property was explicitly set on the data set by using the `zfs set` command.
`inherited` from *dataset-name*	The property was inherited from the named ancestor.
`temporary`	This property value was set by using the `zfs mount -o` option and is valid only for the lifetime of the mount.
`- (none)`	This property is a read-only property. Its value is generated by ZFS.

In addition to the `default`, `local`, and `inherited` from data set–name source values that you have already seen, you may see two other source values in the `zfs get` output:

- **`temporary`:** Is set by using the `zfs mount -o` option and is valid only for the lifetime of the mount
- **`- (none`:** Is a read-only property with a value that is generated by ZFS

Querying ZFS Properties

To retrieve all properties for the specified data set, use `zfs get all` followed by the data set name.

```
# zfs get all hrpool
NAME      PROPERTY        VALUE                  SOURCE
hrpool    type            filesystem             -
hrpool    creation        Tue Dec 18 9:33 2012   -
hrpool    used            72K                    -
hrpool    available       66.9G                  -
<output omitted>
```


You can use the special `all` keyword to retrieve all data set properties. The example in the slide uses the `all` keyword to retrieve all existing data set properties for the `hrpool` file system.

Querying ZFS Properties

To specify the property types to display, use `zfs get -s` followed by the source value and the data set name.

```
# zfs get -s local all hrpool
NAME      PROPERTY       VALUE                    SOURCE
hrpool    compression    on                       local
```

With the `-s` option, you can:

- Specify the desired source types with a comma-separated list
- Use the following source types: `default`, `local`, `inherited`, `temporary`, and `none`

You can use the `-s` option with the `zfs get` command to specify, by source value, the type of properties to display.

This option takes a comma-separated list that indicates the desired source types. Only properties with the specified source type are displayed. The valid source types are `default`, `local`, `inherited`, `temporary`, and `none`.

In the example in the slide, you have specified to show all properties with a `local` source value for the file system `hrpool`. Only the `compression` property met the specified criteria, and has been retrieved.

Querying ZFS Properties

The following `zfs get` options are designed for scripting:

- `-H`
  - Omits header information
  - Presents all white space as tabs
- `-o`
  - Allows customization of output
  - Takes a comma-separated list of literal fields to display, together with a separate list of properties

```
# zfs get -H -o value compression hrpool/home
on
```


The `zfs get` command supports the `-H` and `-o` options, which are designed for scripting.

The `-H` option omits any header information and presents all white spaces as tabs.

You can use the `-o` option to customize the output. This option takes a comma-separated list of literal fields (`name`, `value`, `property`, and `source`) to be output, followed by a space and an argument, which is a comma-separated list of properties.

The example shows how to retrieve a single value by using the `-H` and `-o` options with `zfs get`. In the example, you are retrieving the `hrpool/home compression` property value. The value returned is `on`.

This concludes our discussion of setting, inheriting, and querying ZFS properties. Next, you briefly look at mounting and sharing ZFS file systems.

Mounting and Sharing ZFS File Systems

This section covers the following topics:

- Overriding a default ZFS mount point
- Managing legacy mount points
- Sharing and unsharing ZFS file systems

Note

The basics of mounting and unmounting ZFS file systems are covered in the *Oracle Solaris 11 Fundamentals for System Administrators* course. If you are not familiar with how to perform these tasks, see *Oracle Solaris Administration: ZFS File Systems* for details.

Overriding Default ZFS Mount Points

- By default, all ZFS file systems are mounted:
  - By ZFS at boot by using an SMF service
  - Under `/path`, where *path* is the name of the file system
- The default mount point can be overridden by setting the `mountpoint` property to a specific path by using `zfs set`.
- When a default mount point is overridden, ZFS automatically:
  - Creates the mount point if needed
  - Mounts the file system to the new mount point

Note: There is no need to edit the `/etc/vfstab` file.

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By default, all ZFS file systems are mounted by ZFS at boot by using the Service Management Facility's (SMF) `svc://system/filesystem/local` service. File systems are mounted under `/path`, where *path* is the name of the file system.

You can override the default mount point by setting the `mountpoint` property to a specific path by using the `zfs set` command. ZFS automatically creates this mount point, if needed, and automatically mounts the associated file system. ZFS file systems are automatically mounted at boot time without requiring you to edit the `/etc/vfstab` file.

Introducing the mountpoint Property

The mountpoint property:

- Is inherited
- Can be set to none to prevent the file system from being mounted automatically
- Can be set to legacy to manage through legacy mount interfaces
  - This setting prevents ZFS from automatically mounting and managing the file system.
  - The file system must be managed by using legacy tools (mount, umount) and /etc/vfstab.

Note: To determine whether a file system can be mounted, check the value of the canmount property and the mountpoint property.

The mountpoint property is inherited. For example, if pool/home has mountpoint set to /export/stuff, then pool/home/user inherits /export/stuff/user for its mountpoint property.

You can set the mountpoint property to none to prevent the file system from being mounted automatically.

If you prefer, you can explicitly manage file systems through legacy mount interfaces by setting the mountpoint property to legacy. However, doing so prevents ZFS from automatically mounting and managing this file system. If you decide to take this approach, you must manage the file systems by using legacy tools (including the mount and umount commands) and the /etc/vfstab file.

Note: To determine whether a file system can be mounted, check the value of the canmount property and the mountpoint property.

Automatic Mount Point Behavior

- When changing from a `legacy` or `none` mount point, ZFS automatically mounts the file system.
- If ZFS is managing the file system but is currently unmounted, and the `mountpoint` property is changed, the file system remains unmounted.
- When the `mountpoint` property is changed, ZFS automatically reassigns the mount point.
- Mount point directories are created as needed.
- Any data set whose `mountpoint` property is not legacy is managed by ZFS.

Note: A default mount point can be created by using `zpool create –m`.

The type of mount point (automatic or legacy) determines how the mount point behaves.

For example, automatic mount points exhibit the following behaviors:

- When changing from a `legacy` or `none` mount point, ZFS automatically mounts the file system.
- If ZFS is managing the file system but is currently unmounted and the `mountpoint` property is changed, the file system remains unmounted.
- When the `mountpoint` property is changed, ZFS automatically unmounts the file system from the old mount point and remounts it to the new mount point.
- Mount point directories are created as needed. If ZFS is unable to unmount a file system because it is active, an error is reported and a forced manual unmount is necessary.
- Any data set whose `mountpoint` property is not `legacy` is managed by ZFS.

Note: You can set the default mount point for the root data set at creation time by using the `zpool create -m` option.

Legacy Mount Point Behavior

- Legacy file systems must be managed by using the `mount` and `umount` commands and the `/etc/vfstab` file.
- ZFS does not automatically mount legacy file systems on boot.
- The ZFS `mount` and `unmount` commands do not operate on legacy file systems.
- To automatically mount a legacy file system on boot, you must add an entry to the `/etc/vfstab` file.

Legacy mount points exhibit the behaviors outlined in the slide:

Managing Legacy Mount Points

To manage ZFS file systems with legacy tools, use `zfs set` followed by `mountpoint=legacy` and the file system name.

```
# zfs set mountpoint=legacy hrpool/home/reports
```

To mount the file system, use `mount -F` followed by the file system type, the file system name, and a mount point.

```
# mount -F zfs hrpool/home/reports /mnt
```


As stated previously, you can manage ZFS file systems with legacy tools by setting the `mountpoint` property to `legacy`.

To set up and manage a ZFS file system in legacy mode, use the `zfs set` command followed by the `mountpoint=legacy` property and the file system name, as shown in the first example in the slide.

You can then mount the file system by using the Solaris legacy mount command `mount` with the `-F` option, followed by the file system type, the file system name, and a mount point, as illustrated in the second example.

Now that you know how to manage a legacy mount point in ZFS, you will look at how to share and unshare ZFS file systems.

`share.nfs` Property: Introduction

- ZFS automatically shares file systems by using the `share.nfs` property.
- The `share.nfs` property is a comma-separated list of options to pass to the `share` command.
  - The value `on`:
    - Is an alias for the default share options
    - Provides read/write permissions to anyone
  - The value `off` indicates that the file system is not managed by ZFS.
- All file systems whose `share.nfs` property is not `off` are shared during boot.

In Oracle Solaris 11.1 release, the `share.nfs` property replaces the `sharenfs` property to define and publish an NFS share. Similar to directories, ZFS can automatically share file systems by using the `share.nfs` property. If you use this method, you do not have to modify the `/etc/dfs/dfstab` file when a new file system is added.

The `share.nfs` property is a comma-separated list of options to pass to the `share` command. The value `on` is an alias for the default share options, which provides read/write permissions to anyone. The value `off` indicates that the file system is not managed by ZFS.

All file systems whose `share.nfs` property is not `off` are shared during boot.

Setting the `share.nfs` Property

To share a new file system, use the `zfs set` syntax similar to what is shown in the following example:

```
# zfs set share.nfs=on hrpool/home/reports
```

- The `share.nfs` property is inherited.
- Setting `share.nfs` to `off`:
  - Prevents a file system from automatically being shared
  - Allows the file system to be shared by using legacy methods

By default, all file systems are unshared. To share a new file system, use the `zfs set` syntax (similar to what is shown in the example in the slide). In the example shown, the `share.nfs` property is set to `on` for the `hrpool/home/reports` file system.

The `share.nfs` property is inherited, and file systems that are created or exist below a shared file system are automatically shared.

Setting the `share.nfs` property to `off` prevents a file system from being automatically shared and allows the file system to be shared by using legacy methods.

Unsharing ZFS File Systems

To explicitly unshare a file system, use `zfs unshare` followed by the file system name or mount point.

```
# zfs unshare hrpool/home/reports
```

To unshare all ZFS file systems, use `zfs unshare` with the `-a` option.

```
# zfs unshare -a
```


Although most file systems are automatically shared and unshared during boot, creation, and destruction, file systems sometimes need to be explicitly unshared. To do so, use the `zfs unshare` command followed by the file system name or mount point. In the first example in the slide, the `hrpool/home/reports` file system is being unshared.

To unshare all ZFS file systems on the system, you can use the `-a` option, as shown in the second example.

Note: `zfs unshare` is a temporary unshare. It does not change the `share.nfs` property of the file system (or its children).

Sharing ZFS File Systems

To share a file system, use `zfs share` followed by the file system name.

```
# zfs share hrpool/home/reports
```

To share all ZFS file systems, use `zfs share` with the `-a` option.

```
# zfs share -a
```


Most of the time, the automatic behavior of ZFS—sharing on boot and creation—is sufficient for normal operation. If, for some reason, you unshare a file system, you can share it again by using the `zfs share` command. In the first example in the slide, the `hrpool/home/reports` file system is being shared.

You can also share all ZFS file systems on the system by using the `-a` option, as shown in the second example.

Setting ZFS Quotas and Reservations

This section covers the following topics:

- Setting quotas on ZFS file systems
  - User quotas
  - Group quotas
- Displaying user and group space usage
- Removing user and group quotas
- Setting reservations on ZFS file systems

Introducing the `quota`, `reservation`, `refquota`, and `used` Properties

- Use the `quota` property to set a limit on the pool space used by a file system.
- Use the `reservation` property to guarantee a specified amount of space for a file system from a pool.
- Use the `refquota` property on a data set to limit the amount of disk space that a data set can consume.
- The amount of space used by a file system is reported by the `used` property.

You can use the `quota` property to set a limit on the amount of space that a file system can use. In addition, you can use the `reservation` property to guarantee that some amount of space is available to a file system. Both properties apply to the data set on which they are set and to all descendants of that data set.

For example, if a quota is set on the `hrpool/home` data set, the total amount of space used by `hrpool/home` and all of its descendants cannot exceed the quota. Similarly, if `hrpool/home` is given a reservation, `hrpool/home` and all of its descendants draw from that reservation.

To limit the amount of disk space that a data set can consume, you can use the `refquota` property. Unlike the `quota` and `reservation` properties, this property does not include the disk space that is consumed by descendants.

The amount of space used by a data set and all of its descendants is reported by the `used` property.

Setting Quotas for ZFS File Systems

To set a quota on a file system, use `zfs set` followed by `quota=`, the space amount, and the file system name.

```
# zfs set quota=10g hrpool/home/reports
```

To display the quota setting for a file system, use `zfs get` followed by `quota` and the file system name.

```
# zfs get quota hrpool/home/reports
NAME                    PROPERTY      VALUE     SOURCE
hrpool/home/reports     quota         10.0G     local
```

Note: The quota cannot be less than the current data set usage.

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ZFS quotas can be set and displayed by using the `zfs set` and `zfs get` commands.

In the first example in the slide, you are setting a quota of 10 GB on `hrpool/home/reports`. To do this, you use the `zfs set` command followed by `quota=10g` and the file system name.

In the second example, you are displaying the values of the `quota` property. To do this, you use the `zfs get` command followed by the property name `quota` and the file system name.

Note: You cannot set a quota to an amount that is less than what is currently being used by a data set.

Setting Quotas for ZFS File Systems

To limit the amount of disk space that a data set can consume, use `zfs set` followed by `refquota=`, the space amount, and the data set name.

```
# zfs set refquota=10g hrstaff/tsmith
# zfs list -t all -r hrstaff
NAME                          USED  AVAIL  REFER  MOUNTPOINT
hrstaff                       150M  66.8G    32K  /hrstaff
hrstaff/tsmith                150M  9.85G   150M  /hrstaff/tsmith
hrstaff/tsmith@yesterday         0      -   150M  -
# zfs snapshot hrstaff/tsmith@today
# zfs list -t all -r hrstaff
hrstaff                       150M  66.8G    32K  /hrstaff
hrstaff/tsmith                150M  9.90G   100M  /hrstaff/tsmith
hrstaff/tsmith@yesterday     50.0M      -   150M  -
hrstaff/tsmith@today             0      -   100M  -
```

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You can set a `refquota` on a file system to limit the amount of disk space that a data set can consume. As was mentioned previously, this hard limit does not include the disk space that is consumed by descendants.

In the example, you are setting a `refquota` of 10 GB on `hrstaff/tsmith`. To do this, you use the `zfs set` command followed by `refquota=10g` and the file system name. You then run the `zfs list` command with the `-t` option to see the snapshots associated with the `hrstaff` data set. Then you create a new snapshot of `hrstaff/tsmith` and call it `hrstaff/tsmith@today`. When you run the `zfs list -t` command again, you will see that `tsmith`’s 10 GB quota is not affected by the space that is consumed by the snapshots.

Setting a User Quota on a ZFS File System

To set a user quota on a file system, use `zfs set` followed by `userquota@<name>=`, the space amount, and the file system name.

```
# zfs create finance/tax
# zfs set userquota@rsmart=10g finance/tax
```

To display the user quota setting for a file system, use `zfs get` followed by `userquota@<name>` and the file system name.

```
# zfs get userquota@rsmart finance/tax
NAME                PROPERTY            VALUE      SOURCE
finance/tax         userquota@rsmart    10g        local
```


You can set *user* or *group* quota on the amount of space consumed by the files that are owned by a particular user or group.

You can set a user quota by using the `zfs set userquota` command followed by the username, the amount of space that you want to allocate to the user, and the file system name. In the first example in the slide, you first create the file system `finance/tax`. Then you set the user quota to 10 GB for the username `rsmart`.

To display the current user quota, use the `zfs get` command followed by the `userquota` (`userquota@<name>`) command and the file system name.

Setting a Group Quota on ZFS File System

To set a group quota on a file system, use `zfs set` followed by `groupquota@<name>=`, the space amount, and the file system name.

```
# zfs create finance/ar
# zfs set groupquota@ar=20GB finance/ar
```

To display the group quota setting for a file system, use `zfs get` followed by `groupquota@<group>` and the file system name.

```
# zfs get groupquota@staff finance/ar
NAME                 PROPERTY            VALUE     SOURCE
finance/ar           groupquota@ar       20G       local
```

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To set group quota, use the `zfs set groupquota` command followed by the amount of space that you want to allocate to the group and the file system name. In the first example in the slide, you first create the file system `finance/ar`. Then you set the group quota to 20 GB for the group `ar`.

To display the current group quota, use the `zfs get` command followed by the `groupquota` (`groupquota@<name>`) command and the file system name.

Note: Enforcement of user or group quotas might be delayed, which means that users might exceed their quota before the system notices that they are over quota and refuses additional writes.

Displaying User and Group Space Usage

To display general user space usage, use `zfs userspace` followed by the file system name.

```
# zfs userspace finance/tax
TYPE         NAME      USED      QUOTA
POSIX User   root      227M      none
POSIX User   rsmart    455M      10g
```

To display general group space usage, use `zfs groupspace` followed by the file system name.

```
# zfs groupspace finance/ar
TYPE         NAME      USED      QUOTA
POSIX Group  root      217M      none
POSIX Group  ar        217M      20G
```


You can display general user and group space usage by using the `zfs userspace` and `zfs groupspace` subcommands, respectively, as illustrated in the examples in the slide.

Identifying User and Group Space Usage

To identify individual user space usage, use `zfs userused@<name>` followed by the file system name.

```
# zfs get userused@rsmart finance/tax
NAME                 PROPERTY             VALUE     SOURCE
finance/tax          userused@rsmart      455M      local
```

To identify group space usage, use `zfs groupused@<name>` followed by the file system name.

```
# zfs get groupused@ar finance/ar
NAME                 PROPERTY             VALUE     SOURCE
finance/ar           groupused@ar         217M      local
```


You can identify individual user space usage by using the `zfs get` command followed by `userused@<name>` and the file system name, as shown in the first example in the slide. Here, you want to identify the space used by `rsmart` in the file system `finance/tax`. You can see that 455 MB of space is being used.

Similarly, you can identify group space usage by using the `zfs get` command followed by `groupused@<name>` and the file system name, as shown in the second example. Here, you want to identify the space used by the group `ar` in the `finance/ar` file system. You can see that 217 MB of space is being used.

Note: The user and group quota properties are not displayed by using the `zfs get all` *dataset* command that displays a listing of all file system properties.

Removing User and Group Quotas

To remove a user quota, use `zfs set userquota@<name>=none` followed by the file system name.

```
# zfs set userquota@rsmart=none finance/tax
```

To remove a group quota, use `zfs set groupquota@<name>=none` followed by the file system name.

```
# zfs set groupquota@staff=none finance/ar
```


You can remove a user or group quota by using the `zfs set` command to set the user or group quota property to `none`, as illustrated in the examples in the slide.

Now you look at how to set reservations on ZFS file systems.

Identifying Reservation Restrictions

- A ZFS *reservation* is an allocation of space from the pool that is guaranteed to be available to a data set.
- Space cannot be reserved for a data set if that space is not currently available in the pool.
- The total amount of all outstanding unconsumed reservations cannot exceed the amount of unused space in the pool.
- A data set can use more space than it has reserved if:
  - Unreserved space is available in the pool
  - Its current usage is below its quota
- A data set cannot consume space that is reserved for another data set.

Setting Space Reservation on a Data Set and Snapshot

To set a space reservation on a data set and snapshot, use `zfs set` followed by `reservation`, the space amount, and the file system name.

```
# zfs set reservation=20g finance/ap
# zfs list
NAME            USED      AVAIL     REFER     MOUNTPOINT
finance         20.0G     13.2G     19K       /finance
finance/ap      10g       33.2G     18K       /finance/ap
```


To guarantee space allocation on a data set and snapshot, you can set ZFS reservations by using the `zfs set reservation=` command.

Regular reservations are accounted for in the parent's used space.

In the example in the slide, you are setting the reservation value of the `finance/ap` file system to 20 GB from 10 GB.

Note: A reservation on a file system is shared with its descendants.

If you run the `zfs list` command, you can see that the smaller of the two quotas (10 GB versus 20 GB) that you just set for `finance/ap` is displayed.

Notice also that the increase in reserved space is reflected in the `USED` and `AVAIL` space columns of the parent (`finance`). The amounts have changed from 10 GB to 20 GB in the `USED` column and from 23.2 GB to 13.2 GB in the `AVAIL` column.

Setting Space Reservation on a Data Set

To set a space reservation on a specific data set, use `zfs set` followed by `refreservation=`, the space amount, and the file system name.

```
# zfs set refreservation=10g finance/ap
# zfs list
NAME          USED     AVAIL    REFER    MOUNTPOINT
finance       10.0G    23.2G    19K      /finance
finance/ap    10g      33.2G    18K      /finance/ap
```

- The space consumed by descendants, snapshots, and clones is not included.
- The setting counts against the parent data set's quotas and reservation.

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You can use a reservation property called `refreservation` to set a space reservation on a specific data set that does *not* include the space consumed by descendants, snapshots, and clones.

The `refreservation` value is accounted for in the parent data set's space used, and counts against the parent data set's quotas and reservations.

To set this property, use the `zfs set` command followed by `refreservation=`, the amount of space that you want to allocate, and the file system name. In this example, you are reserving 10 GB of space for the file system `finance/ap`. Notice how this is reflected in the `AVAIL` column.

Displaying Reservation Values

To see the values of both reservations, use `zfs get` followed by `reservation`, `refreservation`, and the file system name.

```
# zfs get reservation,refreservation finance/ap
NAME            PROPERTY          VALUE     SOURCE
finance/ap      reservation       20G       local
finance/ap      refreservation    10g       local
```

Note: If `refreservation` is set, a snapshot is allowed only if enough free pool space exists outside this reservation to accommodate the current number of referenced bytes in the data set.

To see the values of both reservations for the `finance/ap` file system, you can use the `zfs get` command followed by the `reservation` and `refreservation` property names (separated by a comma) and the file system name, as shown in the example in the slide. In the example, both the `reservation` and `refreservation` property values are displayed for the `finance/ap` file system. With this view, you can see that the `reservation` property is set to 20 GB and the `refreservation` property is set to 10 GB.

Note: If `refreservation` is set (as it is in this example), a snapshot is allowed only if enough free pool space exists outside this reservation to accommodate the current number of referenced bytes in the data set.

Now that you have a better understanding of how to set quotas and reservations on ZFS file systems, you can practice what you have learned.

Practice 4-4 Overview: Configuring ZFS Properties

This practice covers the configuration of:

- Quota and reservation properties
- The share property
- ZFS compression

This practice should take about 1.5 hours to complete.

Lesson Agenda

- Planning for Data Storage Configuration and Backup
- Managing Data Redundancy with Mirrored Storage Pools
- Backing Up and Recovering Data with ZFS Snapshots
- Managing Data Storage Space with ZFS File System Properties
- **Troubleshooting ZFS Failures**

You now look at how to troubleshoot several different types of ZFS failures, including ZFS device and data issues.

Troubleshooting ZFS Failures

- Identifying problems in ZFS
- Repairing a damaged ZFS configuration
- Repairing a missing device
- Repairing a damaged device
- Repairing damaged data

In this section, you are shown how to identify and recover from ZFS failure modes. Information about preventing failures is provided as well.

Identifying Problems in ZFS

This section covers the following topics:

- Overview of troubleshooting in ZFS
- The basic recovery process
- Configuring `syslog` for FMD messages
- Determining problems in a ZFS storage pool
- Interpreting `zpool status` output

Troubleshooting in ZFS: Overview

The `zpool status` command is central to ZFS troubleshooting. This command does the following:

- Analyzes various failures in the system
- Identifies the most severe problem
- Presents a suggested action
- Presents a link to a knowledge article for more information
- Presents only a single problem

All ZFS troubleshooting is centered on the `zpool status` command. This command analyzes various failures in the system and identifies the most severe problem, presenting you with a suggested action and a link to a knowledge article for more information. Note that `zpool status` identifies only a single problem with a pool, although multiple problems can exist.

Basic Recovery Process

The basic recovery process is as follows:

1. Identify errors through the Fault Management Daemon (FMD) messages displayed on the system console or in `/var/adm/messages`.
2. Find further repair instructions in `zpool status -x`.
3. Repair the failures:
   – Replace the faulted or missing device and bring it online.
   – Restore the faulted configuration or corrupted data from a backup.
4. Verify the recovery by using `zpool status -x`.
5. Back up the restored configuration, if applicable.

The slide lists the basic steps that you should perform to recover from ZFS problems.

Note: You see and interpret FMD messages during the practice that follows this lecture.

Configuring `syslog` for FMD Messages

1. Create a new file named `/var/adm/messages.fmd` for Fault Management Daemon to log the device-related messages.
2. Back up the current `/etc/syslog.conf` file.
3. Edit the `/etc/syslog.conf` file by entering a new line below the existing line as follows:

```
*.err;kern.debug;daemon.notice;mail.crit   /var/adm/messages
daemon.err                                /var/adm/messages.fmd
```

4. Restart the `syslog` service for the new configuration to take effect by using `svcadm restart system-log`.

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Determining Problems in a ZFS Storage Pool

- Use `zpool status -x` to determine if a known problem exists.
- If no bad pools exist, the "all pools are healthy" status is returned.

```
# zpool status -x
all pools are healthy
```

- Without the `-x` flag, the status of all pools (regardless of health) is displayed.

The easiest way to determine if a known problem exists on a system is to use the `zpool status -x` command. This command displays only pools that exhibit problems.

If no bad pools exist on the system, the command displays a simple "`all pools are healthy`" message, as shown in the example in the slide.

Without the `-x` flag, the command displays the complete status for all pools (or the requested pool, if specified on the command line), even if the pools are otherwise healthy.

You now look at an example of a `zpool status` output.

Interpreting `zpool status` Output

Header section

```
# zpool status hrpool
  pool: hrpool
 state: DEGRADED
status: One or more devices has been taken offline by the
        administrator. Sufficient replicas exist for the pool to
        continue functioning in a degraded state.
action: Online the device using 'zpool online' or replace the
        device with 'zpool replace'.
 scrub: none requested
config:
       NAME              STATE       READ   WRITE   CKSUM
       hrpool            DEGRADED       0       0       0
         mirror-0        DEGRADED       0       0       0
           c1t0d0        ONLINE         0       0       0
           c1t1d0        OFFLINE        0       0       0
errors: No known data errors
```


The header section in the `zpool status` output (as highlighted in the example in the slide) contains the following fields, some of which are displayed only for pools that exhibit problems:

- **`pool`:** Name of the pool
- **`state`:** Current health of the pool
- **`status`:** Description of what is wrong with the pool
- **`action`:** Recommended action for repairing the errors
- **`see`:** Reference to a knowledge article that contains detailed repair information (displayed only when a pool is exhibiting problems; see slide 116 for an example)
- **`scrub`:** Current status of a scrub operation. This information is distinct from whether any errors are detected on the system, although this information can be used to determine the accuracy of the data corruption error reporting. If the last scrub ended recently, it is likely that any known data corruption has been discovered.
- **`errors`:** Known data errors or the absence of known data errors. ZFS maintains a persistent log of all data errors associated with the pool. This log is rotated whenever a complete scrub of the system finishes. Data corruption errors are always fatal.

Interpreting `zpool status` Output

Configuration (`config`) field: first section

```
# zpool status hrpool
  pool: hrpool
 state: DEGRADED
status: One or more devices has been taken offline by the
        administrator. Sufficient replicas exist for the pool to
        continue functioning in a degraded state.
action: Online the device using 'zpool online' or replace the
        device with 'zpool replace'.
 scrub: none requested
config:
       NAME              STATE      READ   WRITE  CKSUM
       hrpool            DEGRADED      0       0      0
         mirror-0        DEGRADED      0       0      0
           c1t0d0        ONLINE        0       0      0
           c1t1d0        OFFLINE       0       0      0

errors: No known data errors
```


The configuration (`config`) field in the `zpool status` output, which is highlighted in the example in the slide, describes the configuration layout of the devices comprising the pool, their state, and any errors generated from the devices.

The state can be one of the following: `ONLINE`, `DEGRADED`, `FAULTED`, `OFFLINE`, `REMOVED`, or `UNAVAIL`.

If the state is anything but `ONLINE`, the fault tolerance of the pool has been compromised.

Interpreting `zpool status` Output

Configuration (`config`) field: second section

```
# zpool status hrpool
  pool: hrpool
 state: DEGRADED
status: One or more devices has been taken offline by the
        administrator. Sufficient replicas exist for the pool to
        continue functioning in a degraded state.
action: Online the device using 'zpool online' or replace the
        device with 'zpool replace'.
 scrub: none requested
config:
       NAME              STATE        READ   WRITE   CKSUM
       hrpool            DEGRADED        0       0       0
         mirror-0        DEGRADED        0       0       0
           c1t0d0        ONLINE          0       0       0
           c1t1d0        OFFLINE         0       0       0

errors: No known data errors
```


The second section of the configuration output, which is highlighted in the example in the slide, displays error statistics (that is, the number of errors). These errors are divided into three categories:

- **`READ`**: The I/O error occurred while issuing a read request.
- **`WRITE`**: The I/O error occurred while issuing a write request.
- **`CKSUM`**: Checksum error. The device returned corrupted data as the result of a read request.

These errors can be used to determine if the damage is permanent.

Determining Problems in a ZFS Storage Pool

ZFS displays `syslog` messages for the following:

- Device state transition
- Data corruption
- Pool failures and device failures

In addition to persistently keeping track of errors within the pool, ZFS also displays `syslog` messages when events of interest occur.

The following scenarios generate events to notify the administrator:

- Device state transition
- Data corruption
- Pool failures and device failures

Repairing a Damaged ZFS Configuration

- ZFS maintains a cache of active pools and their configuration on the root file system in `/etc/zfs/zpool.cache`.
- To recover the configuration, you can:
  - Export the pool (if it is visible at all)
  - Re-import it

ZFS maintains a cache of active pools and their configurations on the root file system in `/etc/zfs/zpool.cache`.

If this file is corrupted or somehow becomes out of sync with what is stored on disk, the pool can no longer be opened.

ZFS tries to avoid this situation, although arbitrary corruption is always possible.

This situation typically results in a pool disappearing from the system when it should otherwise be available. This situation can also occur as a partial configuration that is missing an unknown number of top-level virtual devices.

In either case, you can recover the configuration by exporting the pool (if it is visible at all) and re-importing it.

Repairing a Missing Device

If a device cannot be opened, `UNAVAIL` is displayed in the `zpool status` output.

```
# zpool status hrpool
  pool: hrpool
state: DEGRADED
status: One or more devices could not be opened.  Sufficient replicas exist for
        the pool to continue functioning in a degraded state.
action: Attach the missing device and online it using 'zpool online'.
   see: http://www.sun.com/msg/ZFS-8000-2Q
scrub: none requested
config:

        NAME         STATE     READ WRITE CKSUM
        hrpool         DEGRADED     0     0     0
          mirror-0   DEGRADED     0     0     0
            c1t0d0   ONLINE       0     0     0
            c1t1d0   UNAVAIL      0     0     0  cannot open

errors: No known data errors
```


If a device cannot be opened, it appears as `UNAVAIL` in the `zpool status` output, as highlighted in the example in the slide.

Repairing a Missing Device

- An UNAVAIL status means that:
  - The device could not be opened when the pool was first accessed
  - The device has since become unavailable
- If the device causes a top-level virtual device to be unavailable, nothing in the pool can be accessed.
- To restore normal operation, reattach the device to the system.

An UNAVAIL status means that ZFS was unable to open the device when the pool was first accessed, or that the device has since become unavailable.

If the device causes a top-level virtual device to be unavailable, nothing in the pool can be accessed. This is to avoid the possibility of the fault tolerance of the pool being compromised.

In either case, the device simply needs to be reattached to the system to restore normal operation. You now look at how this can be done.

Reattaching a Device

Device Type	Action
Network-attached drive	Restore connectivity.
USB or other removable media	Reattach to the system.
Local disk	Determine if it is a disk or controller problem.

Exactly how a missing device is reattached depends on the device in question:

- If the device is a network-attached drive, connectivity should be restored.
- If the device is a USB or other removable media, it should be reattached to the system.
- If the device is a local disk, a controller may have failed resulting in the device being no longer visible to the system. In this case, the controller should be replaced, at which point the disks will be available again.

Repairing a Missing Device

- ZFS may not automatically detect device availability if:
  - The pool was degraded
  - The device was replaced while the system was up
- Use `zpool online` to notify ZFS that the device is now available and ready to be reopened.

```
# zpool online hrpool c0t1d0
```


After a device is reattached to the system, ZFS may or may not automatically detect its availability.

If the pool was previously faulted, or the system was rebooted as part of the attach procedure, ZFS automatically rescans all devices when it tries to open the pool.

However, if the pool was degraded and the device was replaced while the system was up, you must notify ZFS that the device is now available and ready to be reopened by using the `zpool online` command, as shown in the example in the slide, where you are bringing device `c0t1d0` back into the pool named `hrpool`.

Repairing a Damaged Device

This section covers the following topics:

- Determining the cause of device failure
- Clearing transient errors
- Replacing a device in a ZFS storage pool
- Viewing resilvering status

Determining the Cause of Device Failure

Possible causes of device failure

- Bit rot
- Misdirected reads or writes
- Administrator error
- Temporary outage
- Bad or flaky hardware
- Offlined device

If you have a device failure, the first thing that you must do is to determine what caused the device to fail. The damage to the device could have been caused by a several possible situations:

- Bit rot
- Misdirected reads or writes
- Administrator error
- Temporary outage
- Bad or flaky hardware
- Offlined device

So how do you determine what caused the damage?

Determining the Cause of Device Failure

Use `zpool status -v` to examine the error counts.

```
# zpool status -v
  pool: hrpool
 state: UNAVAIL
status: One or more devices are faulted in response to IO failures.
action: Make sure the affected devices are connected, then run 'zpool
        clear'.
   see: http://www.sun.com/msg/ZFS-8000-HC
 scrub: scrub completed after 0h0m with 0 errors on Tue Oct  4 13:08:42 2011
config:

        NAME        STATE     READ WRITE CKSUM
        hrpool      UNAVAIL      0     0     0  insufficient replicas
          c1t0d0    ONLINE       0     0     0
          c1t1d0    UNAVAIL      4     1     0  cannot open

errors: Permanent errors have been detected in the following files:

/hrpool/data/aaa
/hrpool/data/bbb
/hrpool/data/ccc
```

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The first step is to examine the error counts in the `zpool status` output by using the `zpool status -v` command, as shown in the example in the slide.

The errors are divided into I/O errors and checksum errors, both of which may indicate the possible failure type.

A typical operation predicts a very small number of errors (just a few over long periods of time).

If you are seeing large numbers of errors, the situation probably indicates impending or complete device failure.

Also take some time to read the knowledge article that is referenced in the `see` section of the `zpool status` output. It contains detailed repair information that you might find useful.

Determining the Cause of Device Failure

Check the system log:

- A large number of SCSI or fibre channel driver messages indicates serious hardware problems.
- If no `syslog` messages are generated, damage is likely to be transient.

The other source of information is the system log. If the log shows a large number of SCSI or fibre channel driver messages, the situation probably indicates serious hardware problems.

If no `syslog` messages are generated, the damage is likely to be transient.

The question to ask is: *Is another error likely to occur on this device?*

If the answer to this question is "No," you can clear the transient errors. You now take a brief look at how to do this.

Clearing Transient Errors

- To clear the error counters for RAID-Z or mirrored devices and to clear any errors associated with the device, use `zpool clear` *`poolname devicename`*.

```
# zpool clear hrpool c1t0d0
```

- To clear all errors associated with the virtual devices in the pool and to clear any data error counts associated with the pool, use `zpool clear` *`poolname`*.

```
# zpool clear hrpool
```

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If the device errors are deemed to be transient (that is, if they are unlikely to affect the future health of the device), the device errors can be safely cleared to indicate that no fatal error occurred.

To clear the error counters for RAID-Z or mirrored devices, use the `zpool clear` command followed by the device name, as shown in the first example in the slide. This syntax clears any errors associated with the device.

To clear all errors associated with the virtual devices in the pool and to clear any data error counts associated with the pool, use the `zpool clear` command followed by the pool name. This is shown in the second example, where the transient errors are being cleared from the `hrpool` pool.

Replacing a Device in a ZFS Storage Pool

- For a device to be replaced, the device must be part of a replicated configuration.
- The disk is part of a replicated configuration; therefore, sufficient replicas from which to retrieve good data must exist.
- A device cannot be safely replaced if:
  - The loss of a device causes the pool to become faulted
  - The device contains too many data errors in an unreplicated configuration

If you determine that the damage to the device is permanent or that permanent damage is likely in the future, you must replace the device. Whether the device can be replaced depends on the configuration. The device must be part of a replicated configuration. The disk is part of a replicated configuration; therefore, sufficient replicas from which to retrieve good data must exist.

If the loss of a device causes the pool to become faulted, or if the device contains too many data errors in an unreplicated configuration, the device cannot safely be replaced.

Replacing a Device in a ZFS Storage Pool

- Use `zpool replace` *`poolname devicename`* to replace a device with a new device in the same location.

```
# zpool replace hrpool c1t0d0
```

- To replace a damaged device with a different device, use `zpool replace` *`poolname devicename devicename`*.

```
# zpool replace hrpool c1t0d0 c2t0d0
```


Use the `zpool replace` command followed by the pool and device names to replace a device with a new device in the same location. This is shown in the first example, where you are replacing the device `c1t0d0` in the pool named `hrpool`.

Or, if the `autoreplace` property is set, you can physically replace the device in the same location.

If you are replacing the damaged device with a different device, use the `zpool replace` command followed by the pool name, the name of the device that you are replacing, and the name of the device that is replacing the damaged device. This is shown in the second example, where you are replacing the damaged device `c1t0d0` in the pool named `hrpool` with the device `c2t0d0`.

Viewing Resilvering Status

Resilvering:

- Is the process of moving data from one device to another
- Is monitored by using `zpool status`
- Resilvers only the minimum amount of necessary data
- Is interruptible and safe

The process of replacing a drive can take an extended period of time, depending on the size of the drive and the amount of data in the pool.

The process of moving data from one device to another is known as *resilvering* and can be monitored by using the `zpool status` command. ZFS resilvers only the minimum amount of necessary data. Resilvering is interruptible and safe.

Scrubbing

- Examines all data to discover silent errors due to hardware faults or disk failure
- Supports automatic repair of any damage discovered during the scrub
- Is monitored by using `zpool status`
- Cannot be run if:
  - Another scrub is already in progress
  - A resilver is in progress
- Is begun by using `zpool scrub` *`pool`*

Scrubbing and resilvering are very similar operations. The difference is that resilvering examines only data that ZFS knows to be out of date (for example, when attaching a new device to a mirror or replacing an existing device), whereas scrubbing examines all data to discover silent errors due to hardware faults or disk failure.

The scrub examines all data in specified pools to verify that it checksums correctly. For replicated (mirror or raidz) devices, ZFS automatically repairs any damage discovered during the scrub. The `zpool status` command reports the progress of the scrub and summarizes the results of the scrub after completion.

Because scrubbing and resilvering are I/O-intensive operations, ZFS allows only one at a time. If a scrub is in progress, a subsequent `zpool scrub` returns an error, with the advice to use `zpool scrub -s` to cancel the current scrub. If a resilver is in progress, ZFS does not allow a scrub to be started until the resilver completes.

To begin the scrub operation, you use `zpool scrub` *`pool`*.

Repairing Damaged Data

This section covers the following topics:

- Data corruption overview
- Identifying the type of data corruption
- Repairing a corrupted file or directory
- Repairing ZFS storage pool–wide damage

Data Corruption: Overview

- Data corruption can occur if:
  - The pool is not replicated
  - Corruption occurred while the pool was degraded
  - An unlikely series of events conspired to corrupt multiple copies of a piece of data
- Two basic types of data can be corrupted:
  - Pool metadata
  - Object data

ZFS uses checksumming, replication, and self-healing data to minimize the chances of data corruption. ZFS verifies data during normal operation, as well as through scrubbing.

Nonetheless, data corruption can occur if the pool is not replicated, if corruption occurred while the pool was degraded, or if an unlikely series of events corrupted multiple copies of a piece of data.

Two basic types of data can be corrupted:

- Pool metadata
- Object data

Identifying the Type of Data Corruption

Use `zpool status -v poolname` to identify the type of data corruption.

Object data corruption example:

```
# zpool status hrpool -v
  pool: hrpool
 state: ONLINE
status: One or more devices has experienced an error resulting in data
        corruption. Applications may be affected.
action: Restore the file in question if possible. Otherwise restore
        the entire pool from backup.
   see: http://www.sun.com/msg/ZFS-8000-8A
<output omitted>
errors: Permanent errors have been detected in the following files:
/hrpool/data/abc
/hrpool/data/def.txt
/hrpool/data/ghi.txt
```


The `zpool status -v` command shows that corruption has occurred; it also shows where the corruption occurred.

The code output in the slide is an example of object data corruption. Notice that the state of the pool called `hrpool` is `ONLINE` but the status reveals that "`One or more devices has experienced an error resulting in data corruption.`" Notice also that the `errors` section lists several files in which errors have been detected.

Identifying the Type of Data Corruption

Pool metadata corruption example:

```
# zpool status -v sales
pool: sales
   id: 1422736890544688191
 state: FAULTED
status: The pool metadata is corrupted.
action: The pool cannot be imported due to damaged devices or data.
   see: http://www.sun.com/msg/ZFS-8000-72
config:
         sales FAULTED corrupted data
         c1t1d0 ONLINE
```


If the data corruption is in pool-wide metadata, the output is slightly different, as shown in this example. Notice that the state of the pool called `sales` is `FAULTED` and the status is "`The pool metadata is corrupted.`"

Repairing a Corrupted File or Directory

- The system may still be able to function.
- Any damage is effectively unrecoverable.
- No good copies of the data exist anywhere on the system.
- If the data is valuable, restore the affected data from backup.
- If the damage is within a file data block, remove the file.

If a file or directory is corrupted, the system may still be able to function, depending on the type of corruption.

Any damage is effectively unrecoverable. No good copies of the data exist anywhere on the system.

If the data is valuable, your only choice is to restore the affected data from backup.

If the damage is within a file data block, the file can safely be removed, thereby clearing the error from the system.

Repairing ZFS Storage Pool–Wide Damage

If you cannot open or import a pool because of damage to the pool metadata, you must perform either of the following:

- Attempt to recover the pool by using `zpool clear -F` *`poolname`* or `zpool import -F` *`poolname`*.
  - An attempt is made to roll back to an operational state.
  - To review a damaged pool and see recommended recovery steps, use `zpool status`.
- Restore the pool and all its data from a backup copy.
  - Save the pool configuration as displayed in `zpool status`.
  - Destroy the pool by using `zpool destroy -f` *`poolname`*.
  - Keep a file of the data set layout and local property settings.
  - Reconstruct the complete pool configuration.
  - Populate the data by using the backup / restore strategy.

If the damage is in pool metadata, and if that damage prevents the pool from being opened or imported, you have two options.

- You can attempt to recover the pool by using the `zpool clear -F` command or the `zpool import -F` command followed by the pool name. These commands attempt to roll back the last few pool transactions to an operational state. You can use the `zpool status` command to review a damaged pool and the recommended recovery steps.
- If the pool cannot be recovered by the pool recovery method, you must restore the pool and all its data from a backup copy. The approach that you use to restore the pool varies widely depending on the pool configuration and backup strategy. First, save the configuration as displayed by the `zpool status` command so that you can re-create it after the pool is destroyed. Then use the `zpool destroy -f` command to destroy the pool. In addition, you should keep a file that describes the layout of the data sets and the various locally set properties in a safe place, because this information becomes inaccessible if the pool is ever rendered inaccessible. With the pool configuration and data set layout, you can reconstruct your complete configuration after destroying the pool. You can then populate the data by using whatever backup or restoration strategy you use.

Practice 4-5 Overview: Troubleshooting ZFS Failures

This practice covers the troubleshooting of:

- ZFS device issues
- ZFS data errors in a mirror pool

This practice should take about 30 minutes to complete.

Summary

In this lesson, you should have learned how to:

- Implement a plan for data storage configuration and backup
- Manage data redundancy with a mirrored storage pool
- Configure data backup and restore by using ZFS snapshots
- Manage data storage space by using ZFS file system properties
- Troubleshoot ZFS issues

In this lesson, you were shown how to implement a plan for data storage configuration and backup. You learned how to provide data redundancy for your company's business application data by configuring a mirrored storage pool. You were also taught how to use snapshots to back up and recover data. You were shown how to manage data storage space by using several ZFS file system properties. Finally, you were shown how to troubleshoot several ZFS issues that have to do with devices and data.

5

Configuring Network and Traffic Failover

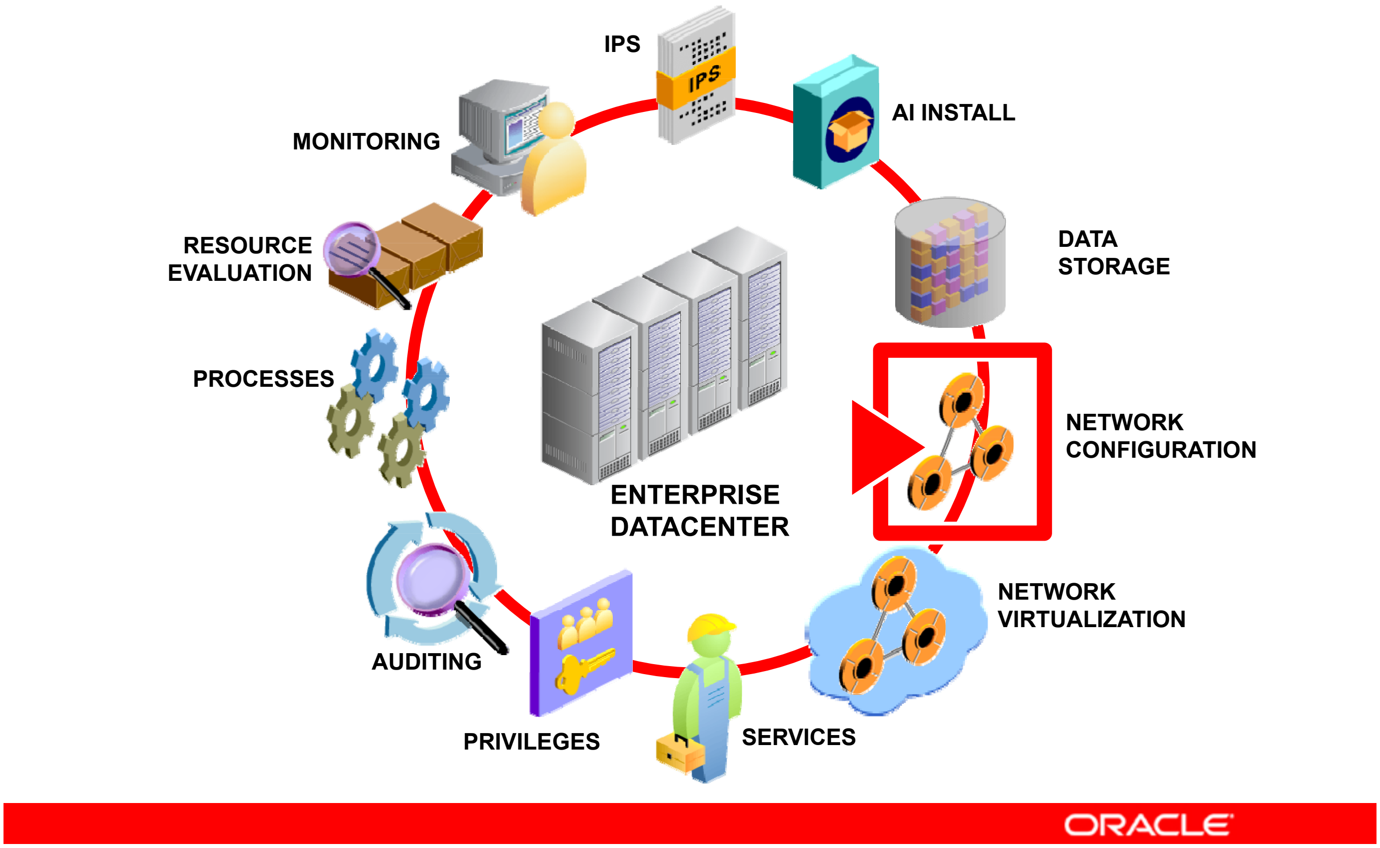
Objectives

After completing this lesson, you should be able to:

- Implement a plan for network and traffic failover configuration
- Configure the following:
  - Systems on a local network
  - A reactive network
  - Network File System
  - Link aggregation
  - An IPMP group
- Implement link failover by using IPMP
- Monitor an IPMP group

In this lesson, you learn how to configure and monitor an IP multipathing (IPMP) group on an existing local network for traffic failover in accordance with a plan. In addition, you are introduced to and shown how to configure a reactive network and Network File System (NFS).

Workflow Orientation



Before you begin the lesson, take just a moment to orient yourself in the job workflow. You have successfully installed the operating system and have updated it. You have configured the data storage environment and are now ready to configure the physical network. In an enterprise environment, as a general practice, the client and server machines are all networked together. The application data is transmitted over the network to the data storage medium, such as databases. The users interact with the database for query and update purposes. If network connectivity is not working optimally, the whole data transmission operation is affected. As a system administrator, it is your responsibility to ensure the network is configured appropriately and is always operational.

Lesson Agenda

- **Planning for Network and Traffic Failover**
- Configuring Systems on a Local Network
- Configuring a Reactive Network
- Configuring Network File System
- Configuring Link Aggregation
- Configuring an IPMP Group
- Implementing Link Failover by Using IPMP
- Monitoring an IPMP Group

Planning for Network and Traffic Failover

Network and traffic failover planning is required to ensure that:

- Network needs of the business and the user community are supported
- Network communications remain uninterrupted
- Network performance is good

Your company wants assurance that the new operating system will support the user community's needs. Given the amount of network traffic your company has on a daily basis, and the number of transactions that occur over the network—both internal and external to the company—the business cannot afford unplanned network down time. As part of your company's predeployment testing plan, your group will be focused on testing network connectivity functionality and performance with the goal of ensuring that when the operating system is deployed, the network configuration supports both uninterrupted network communications and good network performance.

In this topic you are introduced to several key Oracle Solaris 11 network features that will enable you to meet your company's network connectivity requirements.

Configuring a Host For TCP/IP

Network configuration checklist:

- ☑ IP addresses
- ☑ Netmask
- ☑ Domain name
- ☑ Name service
- ☑ Default router

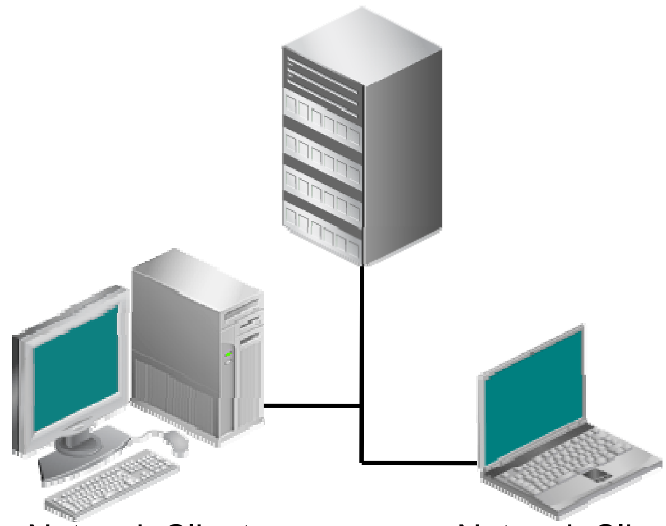
After a network is physically in place, the network configuration process involves configuring the network interfaces and associated IP addresses. Daemons and services that implement the TCP/IP protocol are made available to the system based on this configuration or acquired from the network configuration server, known as *network client mode*.

A typical TCP/IP network configuration requires the following information:

- IP address of each network interface on every system. The address scheme can be IP version 4 (IPv4) or IP version 6 (IPv6) and it may include subnet addressing.
- Netmask in use on each system's network and subnetmask, if applicable
- Name service or directory service that your network uses, such as NIS, LDAP, or DNS
- Domain name for your network, such as oracle.com
- Default router addresses

Configuring Network Services

- RARP/ARP
- TFTP
- NFS
- Name service
  – NIS, LDAP, DNS



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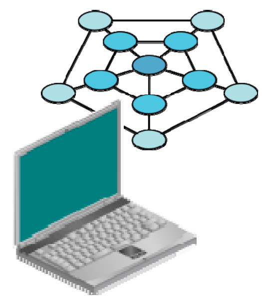
If there is at least one host configured as a network client, then there must be at least one machine, usually configured locally, that supplies the TCP/IP configuration information and other directory services and acts as a server for the clients. The server can be configured with different protocols, such as:

- **Reverse Address Resolution Protocol (RARP):** Maps Ethernet addresses to IPv4 addresses and is the reverse of ARP. Clients obtain their IP addresses by using this service.
- **Trivial File Transfer Protocol (TFTP):** An application that allows for the transfer of files between systems
- **Network File Servers (NFS):** Enables clients to transparently access data from a file server. You will configure an NFS server later in this lesson.
- **Name services:** For example, NIS, LDAP, and DNS

Reactive Network Configuration

Reactive network configuration consists of:

- Network Configuration Profiles (NCPs)
- Location profile
- Network Configuration Units (NCUs)
- External Network Modifiers (ENMs)
- Known WLANs



In Oracle Solaris 11.1, NWAM has been renamed to reactive network configuration. You can manage network configuration automatically using the reactive network configuration feature. Reactive network configuration works according to the default policy rules defined by the system, or you can customize it using Network Configuration Profiles (NCPs). It is dynamic in design, so it can respond to a system's changing configuration. For example, if a laptop is unplugged from an Ethernet cable, reactive network configuration can automatically connect to a wireless network. Therefore, location profiles are another big component of reactive network configuration. They house the systemwide network configuration in both system-defined and user-defined locations.

Network Configuration Units (NCUs) are containers that store all the individual configuration objects that make up an NCP. Each object correlates to an individual link or interface in the system.

External Network Modifiers (ENMs) are profiles to manage external applications, such as a virtual private network (VPN) application.

All the known wireless local area networks (WLANs) to your system are contained in a list that reactive network configuration maintains (and can reference) to help determine the order in which connections to available wireless networks are attempted.

Network File System Servers and Clients

- Server versus client roles
- Advantages of NFS:
  - Accesses the same data
  - Reduces storage costs
  - Provides data consistency and reliability
  - Provides transparency
  - Reduces administration overhead
  - Provides heterogeneous environments
  - Enables automatic file sharing

The terms client and server are used to describe the roles that a computer assumes when sharing file systems over a network. The computers that access the files are called clients and the computers that share their files are called servers. The Network File System (NFS) is a service that provides file sharing. Any computer can access any other computer's file systems as well as its own. A computer can assume the role of a client or server or both at any time. Clients access the files on the server by mounting the shared file system, thereby accessing it directly and transparently, just like any other local mount on their system.

The advantages of NFS are numerous. Because multiple computers can access the same files and the same data, it reduces the storage costs because clients don't need local disk space to have copies of the file. Sharing the files by using NFS is also transparent to the user and provides data consistency and reliability throughout all the applications. This reduces the time that system administrators need to maintain the system. NFS also supports heterogeneous environments, which is pertinent in today's multiplatform world, and with NFS the file sharing can be automatic.

Network Performance Concepts

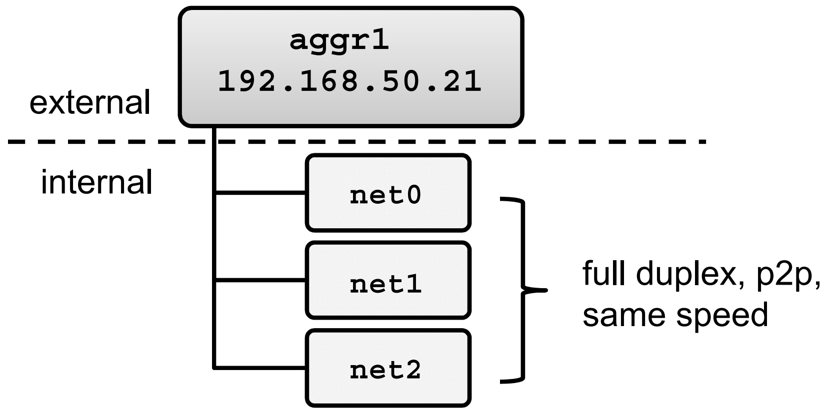
- **Bandwidth:** Bit rate for sending or receiving data over a network
- **Failover:** Ability to substitute a backup component for one that becomes unavailable
- **Load balancing:** Distribution of workload to achieve optimal utilization
- **Resource management:** Setting of bandwidth and resource limits for OS-forced network sharing policies

When planning your network configuration, there are several key performance concepts that you need to take into consideration:

- **Bandwidth:** Increasing bandwidth is a never-ending task for the network administrator and there are many methods to achieve this, some of which are discussed in this lesson.
- **Failover:** When a server, system, or network goes down, the ability to automatically switch over to a redundant or standby service is called an automatic failover. In networking, failover can be achieved with link aggregation. Also, through the Oracle Solaris IPMP functionality, you can combine multiple network connections in parallel to provide failover and increase network throughput.
- **Load balancing:** Another way to maximize throughput and minimize response time may entail load balancing, which simply means to distribute the workload across multiple networking resources, as can be achieved with the integrated load balancer in Oracle Solaris.
- **Resource management:** Using virtual network interface cards (VNICs), users can consolidate server workloads, establish flows, and better enforce resource limits, which means more efficient handling of network traffic and the ability to offer a better QoS without adding overhead.

Link Aggregation

- Provides performance advantages
- Links must be of the same speed, full duplex, and point-to-point.
- Utilizes the `dladm` command



Also called "trunking," link aggregation consists of two or more IP interfaces on a system, which are combined to form a single, logical unit for the purposes of increasing bandwidth or achieving automatic failover, load balancing, and redundancy. Having one IP address for all aggregated interfaces instead of one per interface is also easier to administer in many respects, and is less demanding on the network address pool. For systems that run an application with heavy queries, a link aggregation can be dedicated to that application's traffic for ease of administration. For sites that do not want to expose their internal interfaces for security purposes, link aggregation ensures the interfaces are hidden from external applications. In this example, a link aggregation named `aggr1` has an exposed IP address of 192.168.50.21, but the internal interfaces `net0`, `net1`, and `net2` are not seen externally.

The Link Aggregation Standard states that all links must be full-duplex, point-to-point links that operate at identical speeds.

You can create, modify, and delete link aggregations by using the `dladm` command. You learn how to perform these tasks later in this lesson.

Load Balancing and Aggregation Policies

In policy making, determination of the outgoing link is done by hashing the specific header of each packet:

- **L2 (Networking):** MAC header
- **L3 (Addressing):** IP header
- **L4 (Communication):** TCP/UDP or other ULP header

When planning to use link aggregation, it is best to define a policy for outgoing traffic to establish load balancing. A policy can specify how packets are distributed across the available links. These are the possible layer specifiers for the aggregation policy. The default—as shown in the `dladm` man page—is L4, but any combination of these policies is valid.

Note: ULP stands for Upper Layer Protocol.

Aggregation Modes and Switches

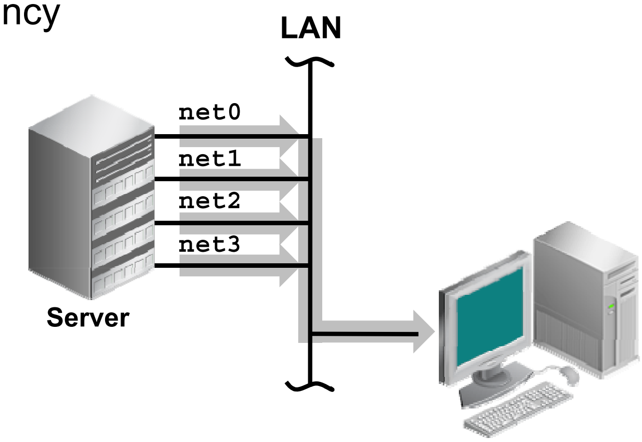
LACP switch modes:

- **Off:** Default mode, no LACPDUs
- **Active:** LACPDUs at specified, regular intervals
- **Passive:** LACPDUs only when received from switch

If the aggregation topology is connected through a switch and supports the link aggregation control protocol (LACP), you can configure LACP for the switch and the aggregation by using one of these modes. The LACP packets are called LACP Data Units or (LACPDUs). If the switch and the aggregation are both configured in passive mode, then they cannot exchange LACPDUs.

IPMP: Introduction

- Performance advantages
  - Fault tolerance
  - Load spreading
  - Increased bandwidth
  - Transparent redundancy
- IPMP groups
  - Active-active
  - Active-standby



Another useful Oracle Solaris feature that provides physical interface failure detection, packet load balancing, and transparent redundancy is IP multipathing (IPMP). IPMP makes it possible to assign an IP address to a group of network interfaces. If the IP is bound to an NIC in an IPMP group and the NIC fails, the group can bind the IP address to another NIC in the group. As a result, a client that uses the IP to contact a service does not experience a loss of service.

This means any port, NIC, cable, or switch failures don't impact any connections because IPMP assigns interfaces to an IP address while continually monitoring the underlying interfaces to ensure a connection is maintained. If IPMP detects that the IP interface being used has failed, it swaps it to a working IP interface. Applications do not need to be aware that they are running on a system managed by IPMP. IPMP can be configured for both IPv4 and IPV6.

The IPMP load-spreading feature increases bandwidth by spreading the outbound load between two or more physical NICs on the same system to the same IPMP group. An IPMP group is represented as an IPMP interface, which is treated like any other interface on the IP layer. These interfaces can belong to an IPMP group in either an active-active or active-standby configuration.

Active-active configuration means all the underlying interfaces are ready and currently available for use by the IPMP group. An active-standby configuration means that at least one interface is in standby mode but can be automatically deployed in the case of a failed interface.

IPMP Components

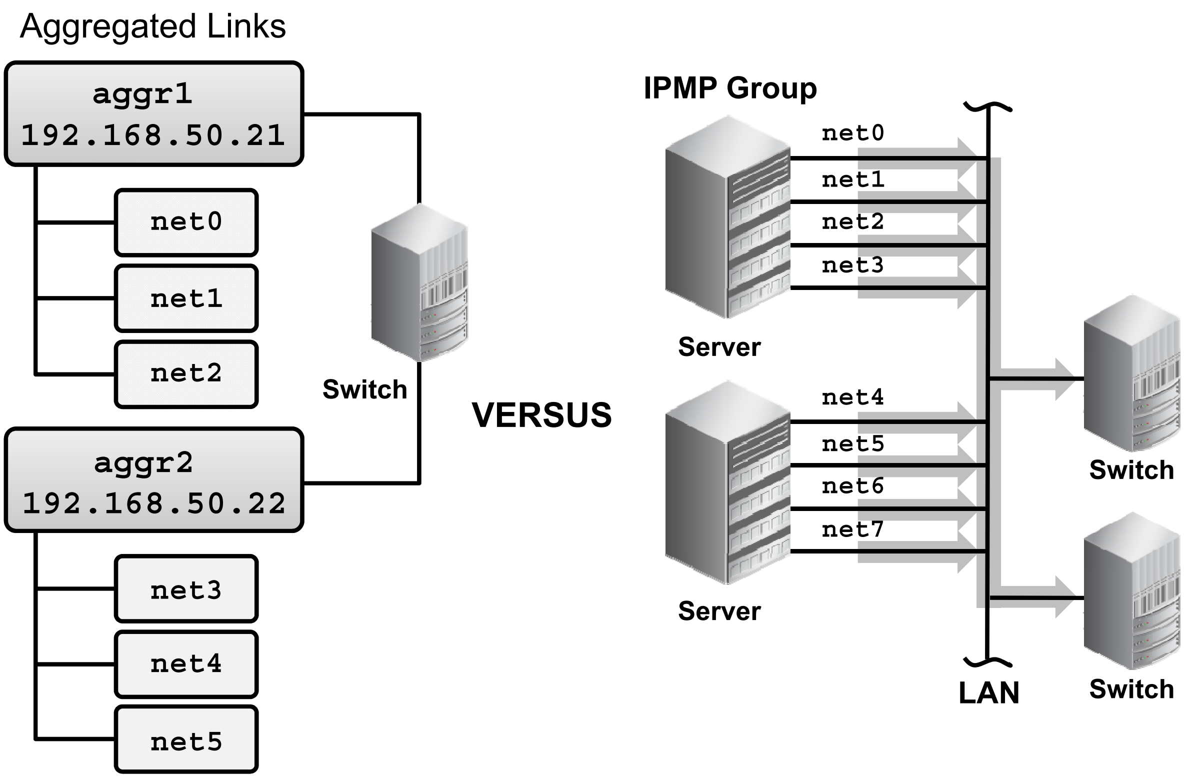
- IPMP daemon: `in.mpathd`
- IPMP service: `svc:/network/ipmp`
- Configuration file: `/etc/default/mpathd`
- IPMP administration command: `ipadm`
- IPMP display information command: `ipmpstat`
- Customized IPMP interface names
- Dynamic Host Control Protocol

IPMP consists of the following components:

- **IPMP daemon (`in.mpathd`):** Detects failure by sending ICMP echo probes through the interface and also monitors the `RUNNING` flag on the interface. If a failure is detected from one of these methods, the daemon chooses the standby IP address or next appropriate IP address and failover occurs.
- **IPMP service (`svc:/network/ipmp`):** Sets IPMP properties, such as enabling or disabling transitive probing
- **Configuration file (`/etc/default/mpathd`):** Is used to specify the daemon's default behavior. This file can be used to set parameters, such as specifying which interfaces to probe for failure and the time duration. This file can also be used to specify what the status of a failed interface should be after it is repaired, or whether to monitor all interfaces, including those not belonging to an IPMP group.
- **IPMP administration command (`ipadm`):** Is used to administer IP interfaces that are part of an IPMP group

- **IPMP display information command (`ipmpstat`):** Provides information about the IPMP configuration, such as the underlying IP group interfaces, the test and data IP addresses in use, the types of failure detection being used, and interfaces that have failed (if applicable)
- **Customized IPMP interface names:** With the ability to customize link names, link configuration is no longer bound to the physical NIC, which means greater flexibility in administering IP interfaces and IPMP itself. For example, if a failover occurs, the new NIC can be given the same name as the failed one, provided they are of the same type. The same configuration files can then be used, thus saving valuable administration time.
- **Dynamic Host Control Protocol:** Used by IPMP to create and assign IP addresses

Comparing Link Aggregation and IPMP



In link aggregations, incoming traffic is spread over the multiple links that comprise the aggregation. Thus, networking performance is enhanced as more NICs are installed to add links to the aggregation. IPMP's traffic uses the IPMP interface's data addresses as they are bound to the available active interfaces. If, for example, all the data traffic is flowing between only two IP addresses but not necessarily over the same connection, then adding more NICs will not improve performance with IPMP because only two IP addresses remain usable.

The two technologies complement each other and can be deployed together to provide the combined benefits of network performance and availability. For example, except where proprietary solutions are provided by certain vendors, link aggregations currently cannot span multiple switches. Thus, a switch becomes a single point of failure for a link aggregation between the switch and a host. If the switch fails, the link aggregation is likewise lost, and network performance declines. IPMP groups do not face this switch limitation. Thus, in the scenario of a LAN using multiple switches, link aggregations that connect to their respective switches can be combined into an IPMP group on the host. With this configuration, both enhanced network performance as well as high availability are obtained. If a switch fails, the data addresses of the link aggregation to that failed switch are redistributed among the remaining link aggregations in the group.

Implementing the Network and Traffic Failover Plan

Your assignment is to:

- Test the reactive network configuration and NFS
- Configure link aggregation
- Configure link failover by using IPMP

Quiz

What is the default policy for link aggregation?

a. L2 (Networking): MAC header
b. L3 (Addressing): IP header
c. L4 (Communication): TCP/UDP or other ULP header

Answer: c

Quiz

IPMP can be configured for both IPv4 and IPv6.

a. True
b. False

Answer: a

Quiz

Which IPMP component is responsible for detecting failures?

a. IPMP daemon
b. IPMP service
c. DHCP

Answer: a

Quiz

Link aggregation and IPMP cannot be deployed together.

a. True

b. False

Answer: b

Lesson Agenda

- Planning for Network and Traffic Failover
- **Configuring Systems on a Local Network**
- Configuring a Reactive Network
- Configuring Network File System
- Configuring Link Aggregation
- Configuring an IPMP Group
- Implementing Link Failover by Using IPMP
- Monitoring an IPMP Group

Configuring Systems on a Local Network

This section covers the following topics:

- Configuring a physical network interface manually
- Deleting a physical network interface manually
- Displaying TCP/IP network information

Configuring a Physical Network Interface Manually

1. Check the current status of the `network/physical:default` service by using `svcs network/physical`. If the service is not up and running, enable it by using `svcadm enable network/physical:default`.
2. Create the network interface by using `ipadm create-ip` *`interface`*.
3. Specify the IP address by using `ipadm create-addr –T static -a` *`addrobj`*.
4. Verify the network interface configuration by using `ipadm show-if`.
5. Verify the IP address information by using `ipadm show-addr`.

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To configure a physical network interface manually (as opposed to having it done automatically for you by the reactive network configuration), you complete the steps listed in the slide.

Notes for step 2: The `ipadm` command is used to configure and manage IP network interfaces, addresses, and TCP/IP protocol properties. The `create-ip` subcommand creates an IP interface that handles both IPv4 and IPv6 packets. The address of the IPv4 interface will be set to `0.0.0.0` and the address of the IPv6 interface will be set to `::`. This subcommand, by default, causes the information to persist, so that on the next reboot this interface will be instantiated.

Notes for step 3: The `create-addr subcommand with the -T static -a` option creates a static IPv4 or IPv6 address on the specified interface. If the interface on which the address is created is not plumbed, this subcommand will implicitly plumb the interface. By default, a configured address will be marked `up`, so that it can be used as a source or destination of or for outbound and inbound packets.

Notes for step 4: The `show-if` subcommand displays network interface configuration information, either for all the network interfaces configured on the system, including the ones that are only in the persistent configuration, or for the specified network interface.

Configuring a Physical Network Interface Manually: Example

```
# svcs network/physical
STATE          STIME    FMRI
online         9:34:40 svc:/network/physical:default
# ipadm create-ip net0
# ipadm create-addr –T static -a 192.168.0.112/24 net0/v4add1
# ipadm show-if
IFNAME     CLASS    STATE    ACTIVE OVER
lo0        loopback ok       yes    --
net0       ip       ok       yes    --
# ipadm show-addr
ADDROBJ            TYPE     STATE        ADDR
lo0/v4             static   ok           127.0.0.1/8
net0/v4add1        static   ok           192.168.0.112/24
lo0/v6             static   ok           ::1/128
```


The example in the slide presents the steps for configuring a physical network interface manually. First, you check if the `network/physical:default` service is online and find that it is. You then create the network interface `net0` and specify the IP address. To verify that your network interface is working, use the `ipadm show-if command`. Here you can see that `net0` is in the `ok` state and active. The final step is to verify the IP address for the new network interface by using the `ipadm show-addr` command.

Deleting a Physical Network Interface Manually

1. Delete the IP address by using `ipadm delete-addr` *`addrobj`*.
2. Delete the network interface by using `ipadm delete-ip` *`interface`*.
3. Verify that the network interface has been deleted by using `ipadm show-if`.
4. Verify that the IP address information has been deleted by using `ipadm show-addr`.

To delete a physical network interface manually, you complete the steps listed in the slide.

Notes for step 1: The `delete-addr subcommand` deletes all the addresses identified for the specified interface. It also removes these addresses from the persistent data store. This means these addresses will not be instantiated on reboot.

If the address object is a DHCP-controlled address, `delete-addr` removes the address from the system without notifying the DHCP server, and records the current lease for later use.

Notes for step 2: The `delete-ip` subcommand deletes the interface from active configuration. All addresses configured on the interface will be torn down. Further, all the persistent information related to the interface will be removed from the persistent data store and, for this reason, the interface is not to be instantiated on reboot. To disable an interface from active configuration (rather than delete the interface), you can use the `disable-if` subcommand.

> **Note:** If you use the `ipadm delete-ip` *`interface`* command first, you do not need to use the `ipadm delete-addr` *`addrobj`* command because the former automatically removes all IP addresses associated with the specified interface.

Deleting a Physical Network Interface Manually: Example

```
# ipadm delete-addr 192.168.0.112/24 net0/v4add1
# ipadm delete-ip net0
# ipadm show-if
IFNAME     CLASS    STATE    ACTIVE OVER
lo0        loopback ok       yes    --
# ipadm show-addr
ADDROBJ            TYPE     STATE        ADDR
lo0/v4             static   ok           127.0.0.1/8
lo0/v6             static   ok           ::1/128
```


The example in the slide presents the steps for deleting a physical network interface manually. In this case, you first delete the IP address associated with the network interface `net0` and then the interface itself. To verify that the network interface has been deleted, use the `ipadm show-if` command. Here, you can see that `net0` is no longer part of the configuration. The final step is to verify that the IP address has been deleted as well, by using the `ipadm show-addr` command.

Displaying TCP/IP Network Information

This section covers the following topics:

- Displaying the status of network interfaces
- Displaying the routing table
- Capturing packets from the network

Displaying the Status of Network Interfaces

To display the status of the network interfaces, use `netstat -i`.

```
# netstat -i
Name Mtu  Net/Dest Address   Ipkts   Ierrs Opkts  Oerrs Collis Queue
lo0  8232 software localhost 1280    0     1280   0     0      0
net0 1500 loopback khan      1628480 0     347070 16    39354  0
```


The main utility for displaying network statistics is `netstat`. The `netstat -i` command shows the state of the interfaces that are used for IP traffic. The output includes names of the physical interfaces, counts for input and output packets (`Ipkts` and `Opkts`) plus additional information, such as counts for input and output errors (`Ierrs` and `Oerrs`) and Collisions (`Collis`). You can study these stats to determine the health of the network.

Displaying the Routing Table

To display known routes, use `netstat -r`.

```
# netstat -r
Routing Table:  IPv4
Destination    Gateway      Flags   Ref   Use    Interface
-----------    --------     -----   ---   ----   ---------
localhost      localhost    UH      0     2817   lo0
earth          pluto        U       2     14293  net0
default        tothestars   UG      0     14142
. . . . .
```


The `netstat -r` command shows the routing tables for either IPv4 or IPv6. In this example, the `UH` flags mean the route is up through a host, as opposed to `UG`, which is through a gateway. The `Ref` column shows the current number of routes that share the same link layer, and the `Use` column indicates the number of packets sent.

Note: If you set the `DEFAULT_IP=VERSION4` in the `/etc/default/inet_type` file, the IPv6 statistics will be omitted from the `netstat` displays.

Capturing Packets from the Network

To capture packets, use `snoop`.

```
# snoop -v
Using device net0 (promiscuous mode)
ETHER:  ----- Ether Header -----


ETHER:  Packet 1 arrived at 13:52:2.50694
ETHER:  Packet size = 106 bytes
ETHER:  Destination = 0:7:e9:24:45:93,
ETHER:  Source      =
0:3:ba:45:a6:d4,

ETHER:  Ethertype = 0800 (IP)
. . . . .
IP:   ----- IP Header -----


IP:   Version = 4
IP:   Header length = 20 bytes
IP:   Type of service = 0x00
IP:         xxx. .... = 0 (precedence)
IP:         ...0 .... = normal delay
IP:         .... 0... = normal throughput
. . . . .
^C
```


The `snoop` command is a useful troubleshooting or informational tool. It captures packets from a datalink or IP interface and displays their content. If a datalink or IP interface is not specified on the command line, then `snoop` will pick a datalink to use based on ones that have been configured for IP traffic. It can display packets in a single-line summary form or in verbose multiline forms. The output mode runs until a Ctrl + C character is entered. The captured packets can also be saved to a file by using `snoop`.

This example shows a truncated output that uses the multiline verbose mode.

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Configuring a Reactive Network

This section covers the following topics:

- Configuring a reactive network profile
- Creating a location profile
- Activating and deactivating profiles
- Querying the profile information
- Removing NCPs
- Working with the reactive network service through SMF
- Modifying the reactive network configuration

Creating a Network Configuration Profile

To create an NCP, use the `netcfg` utility.

```
# netcfg
netcfg> create ncp my_profile
netcfg:ncp:my_profile> create ncu phys net1
Created ncu 'net1'. Walking properties …
activation-mode (manual) [manual|prioritized]> manual
link-mac-addr>
link-autopush>
link-mtu>
netcfg:ncp:my_profile:ncu:net1> list
ncu:net1
        type                        link
        class                       phys
        parent                      "my_profile"
        activation-mode             manual
        enabled                     true
netcfg:ncp:my_profile:ncu:net1> end
Committed changes
netcfg:ncp:my_profile> list
NCUs:
        phys     net1
```


Using the interactive `netcfg` tool, you can create a Network Configuration Profile (NCP) and any Network Configuration Units (NCUs) within it.

Note: You will recall from the first topic that NCUs are containers that store all the individual configuration objects that make up an NCP. Each object correlates to an individual link or interface in the system.

When creating the NCU, the system will interactively walk you through the creation process of setting properties. You can use the defaults by pressing Enter or by entering the desired configuration for each step. In this example, the activation mode is set to `manual` by typing it in when prompted and all the default link properties are selected by pressing Enter. When you are done, you can list the NCU to display the configuration.

Note that after the `end` command commits the changes to the NCU, you can enter another `list` command at the profile level to list all the NCUs contained within the profile.

Creating a Location Profile

Use the `netcfg` utility:

```
# netcfg
netcfg> create loc office
Created loc 'office'.  Walking properties ...
activation-mode (manual) [manual|conditional-any|conditional-all]>
conditional-all
conditions> "system-domain is mydomain.com"
nameservices (dns) [dns|files|nis|ldap]> dns
nameservices-config-file ("/etc/nsswitch.dns")> <return>
dns-nameservice-configsrc (dhcp) [manual|dhcp]> manual
dns-nameservice-domain> "mydomain.com"
dns-nameservice-servers> "192.168.0.100"
dns-nameservice-search> <return>
dns-nameservice-sortlist> <return>
dns-nameservice-options> <return>
nfsv4-domain> <return>
ipfilter-config-file> <return>
ipfilter-v6-config-file> <return>
ipnat-config-file> <return>
ippool-config-file> <return>
ike-config-file> <return>
ipsecpolicy-config-file> <return>
netcfg:loc:office> list
```


You can also create a location profile in interactive mode by using `netcfg`. Much like in the previous slide, the system will walk you through setting the properties of your location profile and then enable you to list them. In this example, a location profile called `office` is created. When entering the `conditional-all` property, the next prompt asks you to state the conditions. In this case, the system domain is set to the domain name. When a name service (such as DNS) is selected, the properties for that name service appear so that you can set them. Again, you can accept the default setting by pressing Enter or by entering the desired setting.

Note: The output continues in the next slide.

Listing a Location Profile

```
netcfg:loc:office> list
loc:office
        activation-mode                   conditional-all
        conditions                        "system-domain is
mydomain.com”
        enabled                           false
        nameservices                      dns
        nameservices-config-file          "/etc/nsswitch.dns”
        dns-nameservice-configsrc         manual
        dns-nameservice-domain            "mydomain.com
        dns-nameservice-servers           "192.168.0.100”
netcfg:loc:office> verify
All properties verified
netcfg:loc:office> commit
Committed changes
netcfg:loc:office> end
netcfg> exit
```


The `list` command (at the location profile level within the `netcfg` command) lists the properties of the `office` location profile that was just created in the previous slide. The `verify` command then verifies all the properties, and the `commit` command commits the changes. The location profile creation process is complete after you exit the command.

Modifying Profiles

```
# netcfg
netcfg> select ncp my_profile
netcfg:ncp:my_profile> select ncu net1
netcfg:ncp:my_profile:ncu:net1>list
ncu:net1
          type                link
          class               phys
          parent              "my_profile"
          activation-mode     manual
          enabled             true
netcfg:ncp:my_profile:ncu:net1>set activation-mode=prioritized
netcfg:ncp:my_profile:ncu:net1>list
ncu:net1
          type                link
          class               phys
          parent              "my_profile"
          activation-mode     prioritized
          enabled             true
```

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To modify a profile, use the `netcfg` utility. First, select the profile and then the NCU. You can then set a different property by using the `set` subcommand and the syntax of *`property=value`*.

In this example, the activation mode is changed from `manual` to `prioritized`. Some properties (such as `type`, `class`, and `enabled`) are read-only and cannot be modified.

Listing Reactive Network Profiles

Use the `netcfg` utility to list all the NCPs and locations:

```
# netcfg list
NCPs:
     Automatic
     my_profile
     start_state
Locations:
     aces
     Automatic
     classroom
     NoNet
     User
```


You can use the `netcfg list` command to list all the current NCPs and location profiles on the system, which includes the system-defined profiles and locations, such as `Automatic`, `NoNet`, and `User`. Any custom NCPs and locations created also appear, such as the `my_profile` profile and `office` location.

Enabling and Disabling Reactive Network Profiles

Use the `netadm` utility to enable and disable an NCP or location profile.

- To enable the newly created profiles:

```
# netadm enable office
Enabling loc ‘office’
# netadm enable my_profile
Enabling ncp ‘my_profile’
```

- To disable the newly created profiles:

```
# netadm disable office
Disabling loc ‘office’
# netadm enable -p ncp Automatic
Enabling ncp ‘Automatic’
```


After the reactive network profiles are created and verified, you can use the `netadm enable` command to enable the profiles. When enabling or disabling profiles, if the profile name is not unique, the profile type (NCU/loc/NCP) must be specified with the `-p` option. To disable a location profile, use the `netadm disable` command. To disable an NCP, enable another one in its place. You cannot disable an NCP with the `netadm disable` command.

Profiles are also automatically enabled according to the policies set, or when an event occurs such as switching from an Ethernet cable to a wireless connection.

Displaying Profile States

To list reactive network profiles and their current states, use the `netadm` utility.

```
# netadm list
TYPE         PROFILE        STATE
ncp          Automatic      disabled
ncp          start_state    online
ncu:phys     net0           online
ncu:ip       net0           online
loc          aces           online
loc          Automatic      offline
loc          NoNet          offline
loc          User           disabled
```


The states reported are `online`, `offline`, `disabled`, `initialized`, or `uninitialized`.

Displaying Profiles and Their Auxiliary States

To list reactive network profiles and their auxiliary states, use `netadm list -x`.

```
# netadm list -x
TYPE       PROFILE      STATE     AUXILIARY STATE
ncp        Automatic    disabled  disabled by administrator
ncp        start_state  online    active
ncu:phys   net0         online    interface/link is up
ncu:ip     net0         online    interface/link is up
loc        aces         online    active
loc        Automatic    offline   conditions for activation are unmet
loc        NoNet        offline   conditions for activation are unmet
loc        User         disabled  disabled by administrator
```

Creating a Backup of a Profile

To create a backup of a reactive network profile, use `netcfg export –f profile`.

```
# netcfg export -f oracle_ncp_backup ncp my_profile
# ls *backup
oracle_ncp_backup
```


To create a backup of a profile, use the `netcfg export -f` command followed by the name of the backup file and the profile. In the example, a backup called `oracle_ncp_backup` is being created for the `my_profile` profile. You can verify that the backup has been created by using the `ls *backup` command. The backup is listed.

Removing Reactive Network Profiles

To remove a profile, use `netcfg destroy`.

```
# netcfg destroy loc office
# netcfg destroy ncp my_profile
```

Practice 5-1 Overview: Managing a Reactive Network

This practice covers the following topics:

- Assessing the current reactive network configuration
- Creating and deploying a reactive network profile

The practices for this lesson are designed to reinforce the concepts that have been presented in the lecture portion. These practices cover the following tasks:

- **Practice 5-1:** Managing reactive network
- **Practice 5-2:** Configuring the Network File System
- **Practice 5-3:** Configuring a link aggregation
- **Practice 5-4:** Configuring IP multipathing

Practice 5-1 should take you about 30 minutes to complete.

Lesson Agenda

- Planning for Network and Traffic Failover
- Configuring Systems on a Local Network
- Configuring a Reactive Network
- **Configuring Network File System**
- Configuring Link Aggregation
- Configuring an IPMP Group
- Implementing Link Failover by Using IPMP
- Monitoring an IPMP Group

Configuring Network File System (NFS)

This section covers the following topics:

- Configuring the NFS server
- Checking the NFS services status
- Configuring the NFS client
- Selecting a different version of NFS on a server
- Enabling the automounter service
- Displaying NFS server and client statistics

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Configuring the NFS Server

1. Create a ZFS file system for the files you want to share.
2. To share the file system:
   a. Set the ZFS `share` property.
   b. Set the ZFS `sharenfs` property to `on`.
3. Use the `share` command to verify what is being shared.

```
# zfs create rpool/export/home/docs
# zfs set share_name=docs,path=/export/home/docs,prot=nfs \
rpool/export/home/docs
name=docs,path=/export/home/docs,prot=nfs
# zfs set sharenfs=on rpool/export/home/docs
# zfs set compression=on rpool/export/home/docs
# share
docs    /export/home/docs  nfs sec=sys,rw
```

ORACLE

You configure the NFS server by creating a file system for the files you want to share and then setting the `sharenefs` property for that file system, as shown in the steps in the slide.

Notes for step 2a: The `share` property shares ZFS file systems that have the `sharenfs` or `sharesmb` property set. Sharing a file system with the NFS or SMB protocol means that the file system data is available over the network. ZFS file systems that have the `sharenfs` or `sharesmb` property set are automatically shared when a system is booted.

Notes for step 2b: The `sharenfs` property controls whether a file system is available over NFS and what options are used. If set to `on`, the `zfs share` command is invoked with no options.

In the example, a ZFS file system called `rpool/export/home/docs` is created. In the next two steps, you share the file system, specifying the NFS protocol (`prot=nfs`). As a best practice, you set the `compression` property to `on`. The final step is to verify that the `/export/home/docs` is being shared—and it is.

Checking the NFS Services Status

To check the status of the NFS services, use `svcs -a | grep nfs`.

```
# svcs -a | grep nfs
disabled          7:01:37 svc:/network/nfs/cbd:default
disabled          7:01:37 svc:/network/nfs/client:default
online           16:30:02 svc:/network/nfs/status:default
online           16:30:05 svc:/network/nfs/mapid:default
online           16:30:07 svc:/network/nfs/rquota:default
online           16:30:08 svc:/network/nfs/nlockmgr:default
online           17:21:32 svc:/network/nfs/server:default
```

Configuring the NFS Client

1. Verify that you can view the shared resource by using `dfshares` *`server`*.
2. Create a directory to use as the mount point.
3. Specify the resource to be mounted by using `mount -F nfs -o ro` *`server`*`:`*`resource`* `/`*`directory`*.
4. Verify that the files within the shared resource can be shared.

```
# dfshares server1
RESOURCE                              SERVER      ACCESS     TRANSPORT
server1:/export/home/docs             server1     -          -
# mkdir /docs
# mount -F nfs -o ro server1:/export/home/docs /docs
# cd /docs
server1:/docs# ls
assetlist
```

ORACLE

You configure the NFS client by ensuring that you can see the shared resource and then specifying the resource to be mounted, as shown in the steps in the slide.

Notes for step 3: To unmount a directory, you use the following command:

```
# unmount /directory
```

In the example, you first verify that you can view the shared resource `/export/home/docs` on `server1`. Next, you create a directory called `/docs` to use at the mount point. You then specify the resource to be mounted in the directory that you just created. The final step is to verify that the file within the shared resource `/export/home/docs` can be shared, and it can.

Selecting a Different Version of NFS on a Server

To select a different version of NFS on a server or client, use the `sharectl` set command.

Example:

To set a server or client to provide only NFS version 3:

```
Server:
# sharectl set -p server_versmax=3 nfs
# sharectl set -p server_versmin=3 nfs

Client:
# sharectl set -p client_versmax=3 nfs
# sharectl set -p client_versmin=3 nfs
```


Although there have been previous versions of the NFS protocol in use, NFS version 4 (NFSv4) has more features than the previous versions and is the most widely used version to date. It is also now the default version in Oracle Solaris. To select different versions of NFS on a server or client, use the `sharectl set` command as shown in this example.

See the documentation for more detailed information about NFS version 2 or 3.

Enabling the Automounter

To enable or disable the automounter service, use the `svcadm` command.

Enable service:
```
# svcadm enable autofs
```

Mount file system:
```
# cd /net/server1/export/share/local
```

Disable service:
```
# svcadm disable autofs
```


In addition to mounting the file systems automatically during boot time or on demand using the command line, you can also mount the file systems with the automounter (`autofs`). The automounter provides advantages over the other two methods; however, in many situations, all three methods are used. The automounter uses the `/net` file system. After the autofs service is enabled, you can change the directory using the `/net` path from the client.

The automounter can be customized using specific SMF properties and by editing the automounter maps.

Displaying NFS Server and Client Statistics

To display statistics about the NFS service on the client or server, use the `nfsstat` command.

```
# nfsstat -c
Client rpc:
Connection oriented:
calls     badcalls  badxids   timeouts newcreds  badverfs    timers
1595799   1511      59        297      0         0           0
cantconn nomem     interrupts
1198     0         7
Connectionless:
calls     badcalls  badxids   timeouts newcreds  badverfs    timers
1595799   1511      59        297      0         0           0
. . . . .
Client nfs:
calls     badcalls  clgets    cltoomany
1640097   3112      1640097   0
. . . . .
Client nfs_acl:
Version 2: (3105 calls)
null      getacl    setacl    getattr   access
0 0%      0 0 %     0 0%      3105 100% 0 0%
```


To display useful information about the Remote Procedure Calls (RPC) and NFS data, use the `nfsstat` command. This example is for the client, using the `-c` option but similar information is displayed when using the `-s` option for the server. The ouptput for the client uses the following stats:

- `calls`: Total number of RPC calls made
- `badcalls`: Total number of calls rejected by the RPC layer
- `badxids`: Number of times a reply from a server was received that didn't correspond to a call
- `timeouts`: Number of times a call timed out while waiting for a reply from the server
- `newcreds`: Number of times authentication information had to be refreshed
- `badverfs`: Number of times the call failed due to a bad verifier in the response
- `timers`: Number of times the calculated time-out value was greater than or equal to the minimum specified timeout value for a call
- `clgets`: Number of times the CLIENT handle was received
- `cltoomany`: Number of times the CLIENT handle cache had no unused entries

Practice 5-2 Overview: Configuring the Network File System

This practice covers the configuration of the following:

- NFS server
- NFS client

This practice should take you about 15 minutes to complete.

Lesson Agenda

- Planning for Network and Traffic Failover
- Configuring Systems on a Local Network
- Configuring a Reactive Network
- Configuring Network File System
- **Configuring Link Aggregation**
- Configuring an IPMP Group
- Implementing Link Failover by Using IPMP
- Monitoring an IPMP Group

Preparing for Link Aggregation

Before configuring the link aggregation:

1. Make sure the links are to specification.
2. Set switch LACP mode.
3. Use the `dladm show-link` command to verify state. You may need to delete the interface first.

```
# dladm show-link
LINK            CLASS   MTU     STATE           OVER
net0            phys    1500    unknown         --
net1            phys    1500    unknown         --
net2            phys    1500    unknown         --
```


Before configuring link aggregation, you need to make sure the links to be combined are full-duplex and point-to-point, and that they operate at identical speeds. If using a switch, configure the ports to be used as an aggregation. If the switch supports LACP, configure it for active or passive mode. Use the `dladm show-link` command to display the data links and VLANs on the system and their state. If the link is in use, plumbed, or up, then the link should be deleted first with the `ipadm delete-if` command.

Creating Link Aggregation

The following commands are used to create and display link aggregation:

- `dladm create-aggr`
- `dladm show-aggr`

```
# dladm create-aggr -l net0 -l net1 aggr1
# dladm show-link
LINK       CLASS     MTU  STATE   OVER
net0       phys      1500 up      --
net1       phys      1500 up      --
net2       phys      1500 up      --
net3       phys      1500 up      --
aggr1      aggr      1500 up      --     net0 net1
# dladm show-aggr
LINK    POLICY  ADDRPOLICY      LACPACTIVITY    LACPTIMER      FLAGS
aggr1   L4      auto            off             short          -----
```


To create a link aggregation, you use the `dladm create-aggr` command as seen here. Display the newly created aggregated link by using the `show-link` subcommand or display aggregations separately using the `show-aggr` subcommand. In the example, notice that the policy defaulted to L4 and that the LACP switch mode is in the default `off` setting.

After creating a static address for the new interface `aggr1` and rebooting the system, the aggregated link will be configured.

Modifying Link Aggregation

The following commands are used to modify link aggregation:

- `dladm modify-aggr`
- `dladm add-aggr`
- `dladm remove-aggr`

```
# dladm modify-aggr --policy=L3 aggr1
# dladm add-aggr -l net2 -l netg3 aggr1
# dladm remove-aggr -l net0 aggr1
```


To modify the parameters of the specified link aggregation, use the `dladm modify-aggr` command. For example, if you want a policy for managing data that is based on the addressing (IP, layer 3) instead of the communication protocol (TCP/UDP, layer 4), enter the top command in this example. To add links to the specified aggregation, use the `add-aggr` subcommand or, to remove links, use the `remove-addr` subcommand as seen in the bottom two lines of this example.

Deleting Link Aggregation

The following command is used to delete aggregation:

`dladm delete-aggr`

```
# dladm delete-aggr aggr1
```

Practice 5-3 Overview: Configuring a Link Aggregation

This practice covers the following topics:

- Creating a link aggregation
- Removing a link aggregation

This practice should take you about 15 minutes to complete.

Lesson Agenda

- Planning for Network and Traffic Failover
- Configuring Systems on a Local Network
- Configuring a Reactive Network
- Configuring Network File System
- Configuring Link Aggregation
- **Configuring an IPMP Group**
- Implementing Link Failover by Using IPMP
- Monitoring an IPMP Group

Configuring an IPMP Group

This section covers the following topics:

- Creating an IPMP group
- Adding IP addresses to an IPMP group
- Moving an interface from one IPMP group to another
- Deleting or disabling an IPMP group

Creating an IPMP Group

1. Create IP interfaces for the data links to use in the IPMP group by using the `ipadm create-ip` command.
2. Create the IPMP group by using the `ipadm create-ipmp` command.

```
# ipadm create-ip link0_ipmp0
# ipadm create-ip link1_ipmp0
# ipadm create-ipmp ipmp0
# ipadm add-ipmp -i link0_ipmp0 -i link1_ipmp0 ipmp0
# ipmpstat -g
GROUP     GROUPNAME   STATE   FDT     INTERFACES
ipmp0     ipmp0       ok      --      link1_ipmp0 link0_ipmp0
```

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To create an IPMP group, follow the steps listed in the slide. In this example, create two IP interfaces are being created for the data links `net0` and `net1`.

Note: Before creating IP interfaces for the data links shown in the example, you renamed data links `net0` and `net1` to `link0_ipmp0` and `link1_ipmp0`, respectively, using the `dlamd rename-link` command.

You then create an IPMP group called `ipmp_group0` with the `ipadm create-ipmp` command. Finally, you add the specified network interfaces to the IPMP group that you just created. You run the `ipmpstat -g` command to display the group information.

Adding IP Addresses to an IPMP Group

1. Add addresses to an IPMP group by using the `ipadm create-addr` command.
2. Verify the results with the `ipadm show-addr` command.

```
# ipadm create-addr -T static -a 192.168.0.112/24 ipmp0/v4add1
# ipadm create-addr -T static -a 192.168.0.113/24 ipmp0/v4add2
# ipadm show-addr
ADDROBJ                TYPE        STATE       ADDR
ipmp0/v4add1           static      ok          192.168.0.112/24
ipmp0/v4add2           static      ok          192.168.0.113/24
```


To add static type addresses to the IPMP interfaces, use the `ipadm create-addr` command as seen in this example, and then display the results with the `ipadm show-addr` command.

Moving an Interface from One IPMP Group to Another Group

1. Remove the interface from the IPMP group by using the `ipadm remove-ipmp` command.
2. Add it to another group by using the `ipadm add-ipmp` command.

```
# ipadm remove-ipmp -i link0_ipmp0 ipmp0
# ipadm add-ipmp -i link0_ipmp0 ipmp1
```


To move an interface from one IPMP group to another group, you remove the interface from the first group and add it to another group. The steps for completing this task are presented in the slide.

In this example, the `link0_ipmp0` interface is removed from `ipmp0` with the `ipadm remove-ipmp` command. It is then added to the `ipmp1` group by using the `ipadm add-ipmp` command.

Deleting or Disabling an IPMP Group

To delete an IPMP group, use the `ipadm delete-ip` command.

```
# ipadm delete-ipmp ipmp0
```

To disable an IPMP group, use the `ipadm disable-if` command.

```
# ipadm disable-if -t ipmp0
```


To delete an IPMP group, you use the `ipadm delete-ipmp` command. This means all addresses configured on this interface will be torn down and all the persistent information will be removed. If there are any underlying interfaces, the `-f` option is used to force the deletion. As an alternative, you can also disable the IPMP group from active configuration by using the `disable-if` subcommand.

Note: The `–t` option makes the operation temporary. See man `ipadm(1M)` for more details.

Lesson Agenda

- Planning for Network and Traffic Failover
- Configuring Systems on a Local Network
- Configuring a Reactive Network
- Configuring Network File System
- Configuring Link Aggregation
- Configuring an IPMP Group
- **Implementing Link Failover by Using IPMP**
- Monitoring an IPMP Group

Implementing Link Failover by Using IPMP

This section covers the configuration of:

- An active-active IPMP group
- An active-standby IPMP group

Configuring an Active-Active IPMP Group

1. Create IP interfaces by using `ipadm`.
2. Create an IPMP group and add the interfaces to the group.
3. Create static IP addresses for data access.

```
# dladm rename-link net0 link0_ipmp0
# dladm rename-link net1 link1_ipmp0
# ipadm create-ip link0_ipmp0
# ipadm create-ip link1_ipmp0
# ipadm create-ipmp ipmp0
# ipadm add-ipmp -i link0_ipmp0 -i link1_ipmp0 ipmp0
# ipadm create-addr -T static -a 192.168.0.112/24 ipmp0/v4add1
# ipadm create-addr -T static -a 192.168.0.113/24 ipmp0/v4add2
# ipadm show-addr
ADDROBJ            TYPE     STATE        ADDR
lo0/v4             static   ok           127.0.0.1/8
ipmp0/v4add1       static   ok           192.168.0.112/24
ipmp0/v4add2       static   ok           192.168.0.113/24
lo0/v6             static   ok           ::1/128
link0_ipmp0/_a     static   ok           fe80::a00:27ff:fec0:b88a/10
link1_ipmp0/_a     static   ok           fe80::a00:27ff:fe35:4321/10
```

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IPMP groups are configured as either active-active or active-standby configurations. In an active-active IPMP group configuration, all underlying interfaces are active, which means they are currently available for use by the IPMP group. This is the default setting when adding the interfaces to the IPMP group.

In this example, you first create IP interfaces for the `net0` and `net1` datalinks after renaming these datalinks `link0_ipmp0` and `link1_ipmp0` respectively. Then you create an IPMP group called `ipmp_group0` and the interfaces are added to that group. After you assign static addresses to be used for data access, you display the IPMP group address information by using the `ipadm show-addr` command. All the interfaces are currently available for use. So this is an active-active configuration.

Assigning Test Addresses

To assign test addresses to an IPMP sub-interface, use `ipadm create-addr -T static -a IP_address link/test`.

```
# ipadm create-addr -T static -a 192.168.0.142/24 link0_ipmp0/test
# ipadm create-addr -T static -a 192.168.0.143/24 link1_ipmp0/test
# ipadm show-addr
ADDROBJ            TYPE      STATE         ADDR
lo0/v4             static    ok            127.0.0.1/8
link0_ipmp0/test   static    ok            192.168.0.142/24
link1_ipmp0/test   static    ok            192.168.0.143/24
ipmp0/v4add1       static    ok            192.168.0.112/24
ipmp0/v4add2       static    ok            192.168.0.113/24
lo0/v6             static    ok            ::1/128
link0_ipmp0/_a     static    ok            fe80::a00:27ff:fec0:b88a/10
link1_ipmp0/_a     static    ok            fe80::a00:27ff:fe35:4321/10
```


It is highly recommended that you assign a static IP address to each IPMP subinterface to be used for link testing. This is done using the `ipadm create-add -T static -a` command that was used to assign an IP address to the IPMP group to be used for data access.

In the example, you assign static addresses to `link0_ipmp0` and `link1_ipmp0` to be used for link testing. Next, you display the IPMP group address information by using the `ipadm show-addr` command. Here you can see that the two test addresses are currently available for use.

Configuring an Active-Standby IPMP Group

1. Set at least one interface's property to standby by using the `ipadm set-ifprop` command.
2. Confirm the results.

```
# ipadm show-ifprop -p standby link2_ipmp0
IFNAME       PROPERTY  PROTO PERM  CURRENT   PERSISTENT  DEFAULT POSSIBLE
link2_ipmp0 standby   ip    rw    off       --          off     on,off
# ipadm set-ifprop -p standby=on -m ip link2_ipmp0
# ipadm show-ifprop -p standby link2_ipmp0
IFNAME       PROPERTY  PROTO PERM  CURRENT   PERSISTENT  DEFAULT POSSIBLE
link2_ipmp0 standby   ip    rw    on        on          off     on,off
```


In an active-standby IPMP group configuration, at least one interface is configured to be on standby. The reserve interface is idle but if it supports link-failure notification, then it could become active. The multipathing daemon monitors all the standby interfaces and is aware of their availability. If a link failure occurs, then the reserve interface springs into action and failover occurs. The multipathing daemon also uses probe-based failure detection if a link is configured with a test address. The daemon sends probes to the link to keep constant watch for any failures and the standby interface is automatically deployed as needed.

In this example, the current standby setting is displayed for the `net2` interface, which you have renamed to `link2_ipmp0`. Note that `standby` is currently set to `off`. Then the `standby` property is set by using the `ipadm set-ifprop` command, and the results are displayed.

Lesson Agenda

- Planning for Network and Traffic Failover
- Configuring Systems on a Local Network
- Configuring a Reactive Network
- Configuring Network File System
- Configuring Link Aggregation
- Configuring an IPMP Group
- Implementing Link Failover by Using IPMP
- **Monitoring an IPMP Group**

Monitoring an IPMP Group

This section covers the following topics:

- Displaying IPMP group information
- Obtaining IPMP address information
- Verifying IPMP interface information
- Obtaining probe target information
- Checking probe information

Displaying IPMP Group Information

To display IPMP group information, use `ipmpstat -g`.

```
# ipmpstat -g
GROUP GROUPNAME STATE FDT    INTERFACES
ipmp0 ipmp0     ok    10.00s link1_ipmp0 link0_ipmp0 (link2_ipmp0)
```


As shown in the example, the output from this command displays the IPMP group information, such as group name, state, failed detection time (FDT), and interface names. If probe-based failure detection is disabled, the FDT filed is empty. Note that interface `link2_ipmp0` is in parentheses, indicating that it is in standby mode.

Obtaining IPMP Address Information

To display IPMP address information, use `ipmpstat -an`.

```
# ipmpstat -an
ADDRESS          STATE  GROUP  INBOUND     OUTBOUND
::               down   ipmp0  --          --
192.168.0.113    up     ipmp0  link1_ipmp0 link1_ipmp0 link0_ipmp0
192.168.0.112    up     ipmp0  link0_ipmp0 link1_ipmp0 link0_ipmp0
```


The output for this command displays the address information for the IPMP, the state, the group, and the inbound and outbound links.

Note, in this example, that the inbound traffic is restricted to one interface depending on which IP address is used, and the outbound traffic is spread across both the interfaces.

Verifying IPMP Interface Information

To verify IPMP interface information, use `ipmpstat -i`.

```
# ipmpstat -i
INTERFACE    ACTIVE  GROUP      FLAGS     LINK    PROBE    STATE
link2_ipmp0  yes     ipmp0      -s-----   up      ok       ok
link1_ipmp0  yes     ipmp0      --mbM--   up      ok       ok
link0_ipmp0  no      ipmp0      -------   up      failed   failed
```


The output for this command displays the interface, whether the link is active or not, the IPMP group, flags, the link status, the probe status, and the state of the interface.

In this example, both `link1_ipmp0` and `link2_ipmp0` are active, up, and in the `ipmp0` IPMP group. The third link in the group, `link2_ipmp0`, is active and up, but in standby mode.

The flags in this output are defined as:

- **`i`**: Unusable due to being `INACTIVE`
- **`s`**: Masked `STANDBY`
- **`m`**: Nominated to send/receive IPv4 multicast for its IPMP group
- **`b`**: Nominated to send/receive IPv4 broadcast for its IPMP group
- **`M`**: Nominated to send/receive IPv6 multicast for its IPMP group
- **`d`**: Unusable due to being `down`
- **`h`**: Unusable due to being brought `OFFLINE` by `in.mpathd` (IPMP daemon) because of a duplicate hardware address

Obtaining Probe Target Information

To display information about test address targets, use `ipmpstat -nt`.

```
# ipmpstat -nt
INTERFACE   MODE       TESTADDR            TARGETS
link1_ipmp0 multicast  192.168.0.143       192.168.0.100 192.168.0.111
link0_ipmp0 multicast  192.168.0.142       192.168.0.100 192.168.0.111
```

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The output for this command presents the interface, mode, test address, and targets for each probe, as shown in the example.

The `TARGETS` column shows the host name or IP address of the target to which an ICMP probe is sent in firing order for each interface.

Checking Probe Information

To check probe information, use `ipmpstat -pn`.

```
# ipmpstat -pn
TIME      INTERFACE   PROBE  NETRTT  RTT       RTTAVG    TARGET
0.06s     link2_ipmp0 i163   0.26ms  0.49ms    0.33ms    192.168.0.100
0.90s     link1_ipmp0 i162   0.26ms  0.39ms    0.31ms    192.168.0.100
0.92s     link2_ipmp0 i164   0.19ms  0.36ms    0.34ms    192.168.0.100
0.49s     link0_ipmp0 i161   --      --        --        192.168.0.100
-0.49s    link0_ipmp0 i160   --      --        --        192.168.0.100
2.52s     link2_ipmp0 i165   0.23ms  0.39ms    0.34ms    192.168.0.100
2.74s     link1_ipmp0 i163   0.24ms  0.38ms    0.32ms    192.168.0.100
3.69s     link1_ipmp0 i164   0.25ms  0.45ms    0.34ms    192.168.0.100
2.31s     link0_ipmp0 i162   --      --        --        192.168.0.100
…
…
…
<Ctrl+C>
```


The probe mode displays information about the probes being sent by `in.mpathd`. Unlike the other output modes, this mode runs until you terminate it with Ctrl + C.

The output shows a table of times that includes the following columns:

- **`NETRTT`:** Network round-trip time for the probe
- **`RTT`:** Total round-trip time for the probe. Spikes in the total `RTT` that are not present in the `NETRTT` indicate that the local system is overloaded.
- **`RTTAVG`:** Average round-trip time to `TARGET` over `INTERFACE`. If there is not sufficient data to calculate the average, the field will be empty.

Practice 5-4 Overview: Configuring IPMP

This practice covers the following topics:

- Configuring an active-active IPMP configuration
- Configuring an active-standby IPMP configuration
- Removing the IPMP configuration

This practice should take you about one hour to complete.

Summary

In this lesson, you should have learned how to:

- Implement a plan for network and traffic failover configuration
- Configure the following:
  - Systems on a local network
  - A reactive network
  - Network File System
  - Link aggregation
  - An IPMP group
- Implement link failover by using IPMP
- Monitor an IPMP group

6

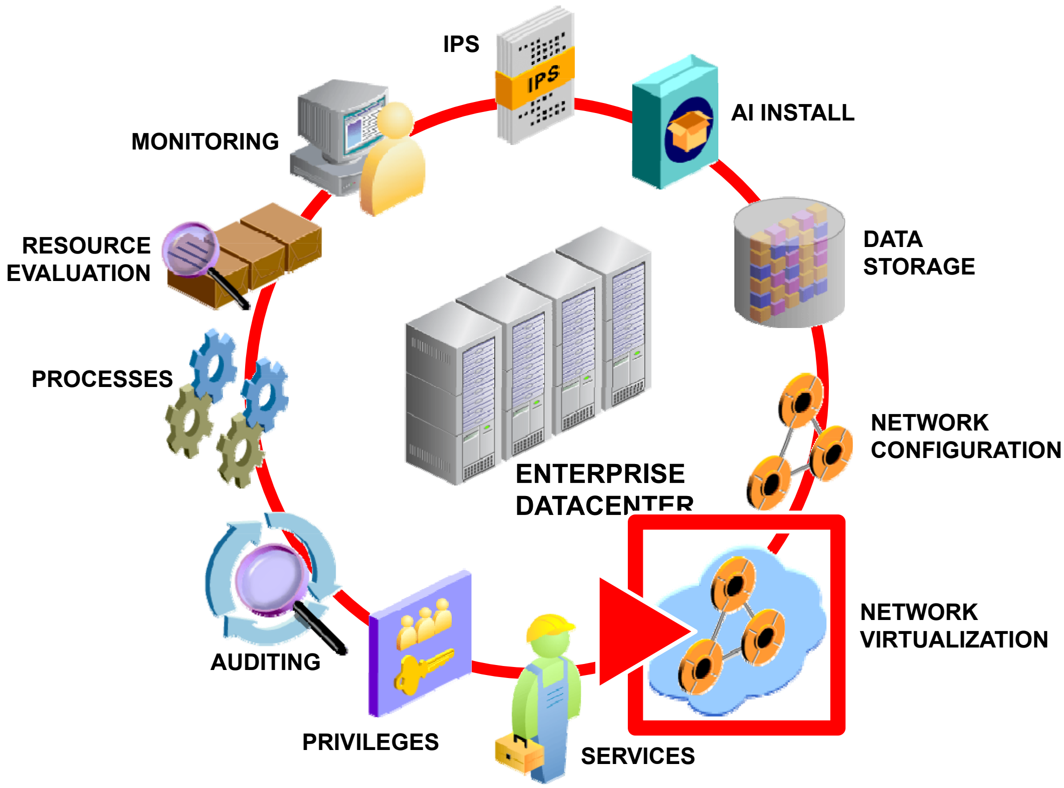
Configuring Zones and the Virtual Network

Objectives

After completing this lesson, you should be able to:

- Implement a plan to configure Oracle Solaris zones with a virtual network
- Create a virtual network
- Configure Oracle Solaris zones to use VNICs
- Allocate resources to an Oracle Solaris zone
- Manage virtual network resources

Workflow Orientation



Before you begin the lesson, orient yourself in the job workflow. You have successfully installed the operating system by using AI, created a local IPS repository, set up the storage environment for your company's business application data, and configured the physical network. Now you are ready to enter the world of virtualization. An increasing number of companies are benefiting from the cost savings that virtualization offers. As a system administrator, you will be expected to know how to support your company's virtualization needs and requirements, including setting up virtual networks and zones.

Lesson Agenda

- **Planning for a Virtual Network and Zones**
- Creating a Virtual Network
- Configuring Zones to Use VNICs
- Allocating and Managing System Resources in a Zone
- Managing Resources on the Virtual Network

Planning for a Virtual Network and Zones

- Identify the virtual network configuration:
  - Virtual switch or etherstub
  - Number of VNICs and name assignments
- Identify the zone configuration:
  - Number of zones
  - Zone configuration details
  - Zone and VNIC assignments
- Identify the requirements for allocating system resources to zones.
- Identify the requirements for managing virtual network resources.

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Your company is exploring ways to improve system and network efficiency and performance. They have heard of the cost-saving benefits of using Oracle Solaris zones to consolidate multiple applications that are running on many systems to a single system, and using the virtual network technology to expand a single system's network interface capacity. Your company now wants to test configuring zones on a virtual network.

The plan for implementing a virtual network includes identifying the virtual network configuration, including whether to create the virtual network with a virtual switch or etherstub, how many virtual network interfaces (VNICs) to create, and what to call each VNIC. The plan also identifies how many zones to configure, how to configure the zones, and what the zone-to-VNIC assignments are.

In addition, your company wants to investigate allocating system resources, such as CPUs and memory, to the zones that use the Oracle Solaris 11 resource control features, specifically resource pools and resource capping. Finally, the plan identifies the requirements for implementing virtual network resource management. As part of the network efficiency and performance initiative, your company wants to be able to control and manage its virtual network resources. They are specifically interested in testing the use of flows. In the following slides, you are introduced to virtual networks and how to configure zones to use a virtual network. You are also introduced to resource pools and capping, and how to manage virtual network resources by using flows.

Network Virtualization and Virtual Networks

- Network virtualization
  - Is the process of combining hardware network resources and software network resources
  - Provides efficient, controlled, and secure sharing of network resources
- Virtual networks
  - External networks: Several local networks administered by software as a single entity
  - Internal networks: One system using virtual machines or zones that are configured over at least one pseudonetwork interface

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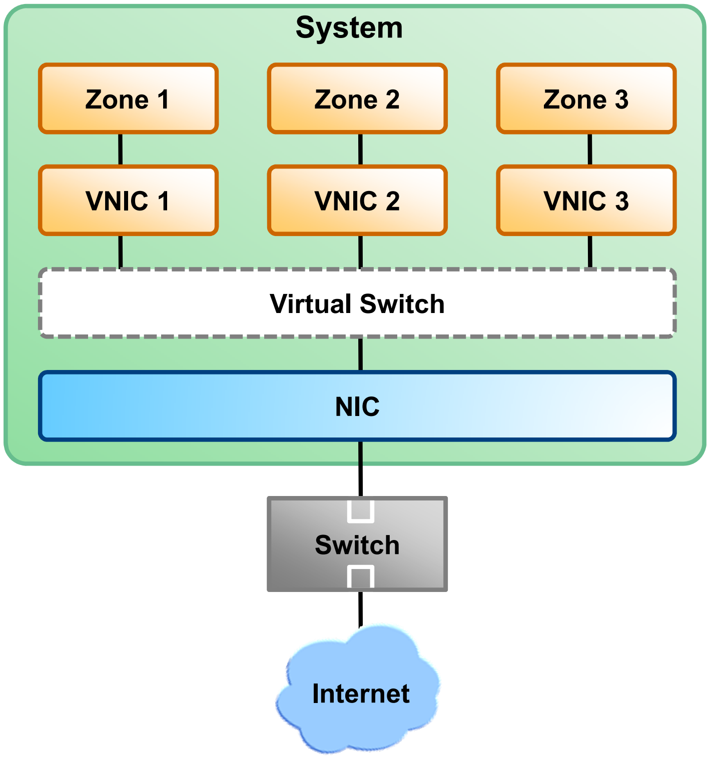
Planning for Oracle Solaris Zones

Network virtualization is the process of combining hardware network resources and software network resources into a single administrative unit. The goal of network virtualization is to provide systems and users with efficient, controlled, and secure sharing of the networking resources.

The end product of network virtualization is the virtual network. Virtual networks are classified into two broad types: external and internal. External virtual networks consist of several local networks that are administered by software as a single entity. The building blocks of classic external virtual networks are switch hardware and VLAN software technology. Examples of external virtual networks include large corporate networks and data centers.

An internal virtual network consists of one system using virtual machines or zones that are configured over at least one pseudonetwork interface. These containers can communicate with each other as though they are on the same local network, thus providing a virtual network on a single host. The building blocks of the virtual network are virtual network interface cards or virtual NICs (VNICs) and virtual switches. Oracle Solaris network virtualization provides the internal virtual network solution, which will be in focus in this course.

Virtual Network Components



An internal virtual network built on Oracle Solaris consists of the following components:

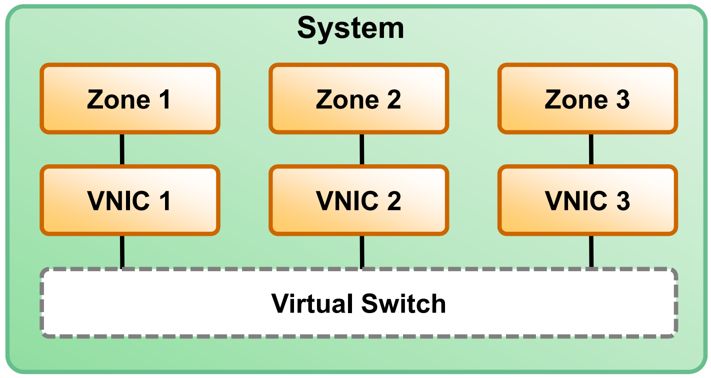
- At least one network interface card (NIC)
- A virtual NIC (VNIC), which is configured on top of the network interface. The VNIC is a virtual network device with the same datalink interface as a physical interface.
- A virtual switch, which is configured at the same time as the first VNIC on the interface. The virtual switch provides the same connectivity between VNICs on a virtual network that switch hardware provides for the systems connected to a switch's ports.
- A container, such as a zone or virtual machine, which is configured on top of the VNIC

The graphic in the slide shows these components and how they fit together on a single system. The single system has one NIC. The NIC is configured with three VNICs. Each VNIC supports a single zone. Therefore, Zone 1, Zone 2, and Zone 3 are configured over VNIC 1, VNIC 2, and VNIC 3, respectively. The three VNICs are virtually connected to one virtual switch. This switch provides the connection between the VNICs and the physical NIC upon which the VNICs are built. The physical interface provides the system with its external network connection.

Alternatively, you can create a virtual network based on the etherstub. Etherstubs are purely software and do not require a network interface as the basis for the virtual network. In this lesson, you learn how to create a virtual network by using an etherstub.

Introducing Zone Configuration by Using VNICs

- Step 1: Create the virtual switch or etherstub.
- Step 2: Create the VNICs.
- Step 3: Configure the zones to use the VNICs.



To configure zones to use a virtual network, the first step is to create your virtual network by creating the virtual switch or etherstub. The second step is to create the VNICs over the switch or etherstub. After you have the VNICs created, the third step is to configure your zones to use the VNICs.

Allocating System Resources to a Zone

To allocate system resources to a zone, perform the following steps:

- Specify a subset of the system's processors that should be dedicated to a zone while it is running.
- Limit the amount of CPU resources that can be consumed by a zone.
- Control the allocation of available CPU resources among zones, based on their importance.
- Limit the amount of physical memory.

After a zone is running, the zone and the applications that are running within it consume a percentage of the system's CPU, physical memory, and process resources. The resource usage by a zone is based on its workload. The workload can increase or decrease based on several factors. By monitoring zone resource usage, a system administrator can determine if a zone is utilizing too much of a system's resources, the type of resource being used, and when the impact to the system is occurring, that is, on a regular basis or on a periodic basis.

As a system administrator, if you know where, when, and why the resource impacts are happening, you can allocate or control the system resources that are being used by doing the following:

- Specify a subset of the system's processors that should be dedicated to a zone while it is running.
- Limit the amount of CPU resources that can be consumed by a zone.
- Control the allocation of available CPU resources among zones, based on their importance.
- Limit the amount of physical memory.

Managing System Resource Allocation to a Zone

System resource allocation to a zone can be controlled by:

- **Resource pools:** Used primarily to manage CPU usage
- **Resource capping:** Used to regulate physical memory consumption
- **Process scheduling:** Used to control the allocation of available CPU resources to processes

There are various ways to manage the allocation of system resources to a zone. For example, you can use resource pools to manage CPU usage, resource capping to regulate physical memory consumption, and process scheduling to control the allocation of available CPU resources to processes.

Note: Process scheduling is controlled by the process scheduler. The scheduler supports the use of scheduling classes, which, in turn, are used to define a scheduling policy that is used to schedule processes with a scheduling class. In the Oracle Solaris operating system, the default TimeSharing scheduler (TS) tries to give every process relatively equal access to the available CPUs. However, you can specify that certain processes should be given more resources than others by using the fair share scheduler (FSS), which controls the allocation of the available CPU resources among workloads, based on their importance. This importance is expressed by the number of shares of CPU resources that you assign to each workload.

This lesson focuses on using resource pools and resource capping to manage zone resource allocation. Process scheduling is presented in detail in the lesson titled “Managing Processes and Priorities.”

As part of planning, the resource allocations for each zone should be identified, along with how the resource allocations will be managed (for example, through resource pools or resource capping). If resource allocations for the zones cannot be determined at the time of planning (primarily because of insufficient zone resource usage statistics), they can be set at a later time.

Now you take a closer look at how you can use resource pools and resource capping to manage your zone's resource allocations.

Resource Pool Allocation

- SMF supports two resource pool services:
  - Default resource pool service `svc:/system/pools:default`
  - Dynamic resource pool service `svc:/system/pools/dynamic:default`
- Resource pool services are disabled by default.
- To allocate a resource pool to a zone, you must:
  - Enable the two resource pool services
  - Create a pool configuration file and save it in the default configuration file `/etc/pooladm.conf`
  - Modify the pool configuration file to specify a subset of the system's processors that should be dedicated to a zone
  - Bind the resource pool to the zone

Resource pools enable you to separate workloads so that workload consumption of certain resources does not overlap. This resource reservation helps to achieve predictable performance on systems with mixed workloads. There are two types of resource pool services in the Oracle Solaris service management facility (SMF) that reside on the system: the default resource pool service (`svc:/system/pools:default`), and the dynamic resource pool service (`svc:/system/pools/dynamic:default`), which is dependent on the default pool service. By default, neither of these services is active.

To allocate a resource pool to a zone, you must first enable these services and create a pool configuration file for the current pool configuration that you save in the default `/etc/pooladm.conf` configuration file. This file, which is in XML format, contains a description of the pools to be created on the system and the elements that can be manipulated: system, pool, pset (processor set) and cpu. This configuration file is referred to as the static configuration file. After you have created and saved the pool configuration file, you can modify it to specify a subset of the system's processors that should be dedicated to a zone while it is running. The static configuration file now matches the current dynamic configuration that represents the way you want the system to be configured with respect to how the resource pool or pools will function. After you have modified the pool configuration file and saved the changes, you must allocate or bind the zone to the resource pool.

How Resource Pools Work

- Oracle Solaris software boots.
- The initialization SMF service checks for the `/etc/pooladm.conf` file.
- If the file exists, `pooladm` makes the configuration the active pools' configuration.
- The system creates the dynamic configuration.
- Resources are allocated and monitored by the pools' resource controller (`poold`).

When the Oracle Solaris software boots, an SMF service checks to see if the `/etc/pooladm.conf` file exists. If this file is found and the pools are enabled, the `pooladm` command is invoked to make this configuration the active pools' configuration. The system creates a dynamic configuration to reflect the organization that is requested in `/etc/pooladm.conf`, and the machine's resources are allocated accordingly.

Note: The `pooladm` command is used to activate and deactivate the resource pools facility.

The pools resource controller, `poold`, is started with the dynamic resource pools facility. This system daemon should always be active when dynamic resource allocation is required. The `poold` resource controller identifies available resources and monitors workloads to determine when system usage objectives are no longer being met. The controller then considers alternative configurations in terms of the objectives, and remedial action is taken. If possible, the resources are reconfigured so that the objectives can be met. If this action is not possible, the daemon logs that the user-specified objectives can no longer be achieved. Following a reconfiguration, the daemon resumes monitoring workload objectives.

Now that you have a better idea of how resource pools are used to control zone resource allocations, you will look at memory resource capping.

Memory Resource Capping

- Resource capping is controlled by the `rcapd` daemon.
- The `rcapd` daemon repeatedly samples the resource utilization of projects that have physical memory caps.
- The sampling interval is specified by the administrator.
- When physical memory utilization thresholds are exceeded, the daemon reduces the resource consumption with memory caps.

If there is a memory resource conflict with the zones on your system, you can control the amount of memory that is allocated to each zone with resource capping. Resource capping is controlled by the `rcapd` daemon. The `rcapd` daemon repeatedly samples the resource utilization of projects in zones that have physical memory caps. The sampling interval that is used by the daemon is specified by the administrator. When the system's physical memory utilization exceeds the threshold for cap enforcement, and when other conditions are met, the daemon takes action to reduce the resource consumption of projects with memory caps to levels at or below the caps.

Note: You can use the `rcapadm` command without arguments to display the current status of the resource capping daemon.

For more information about resource capping and the `rcapd` daemon, see "Administering the Resource Capping Daemon" in the *Oracle Solaris Administration: Oracle Solaris Zones, Oracle Solaris 10 Zones, and Resource Management* guide.

Specifying Resource Capping Within a Zone

- The `capped-memory` resource sets limits for physical, swap, and locked memory.
- At least one limit must be set.
- The `rcapd` daemon and `rcap` service must be up and running.

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To allocate the maximum amount of memory that can be consumed by a specified zone and have it as a persistent cap, you can use the `capped-memory` resource. This resource sets limits for physical, swap, and locked memory. Each limit is optional, but at least one must be set.

Note: You can specify a temporary resource cap for a zone by using the `rcapadm` command; however, this setting lasts only until the next reboot. For example, to set a maximum memory value of 512 MB for the `hrzone` zone, you use the following command:

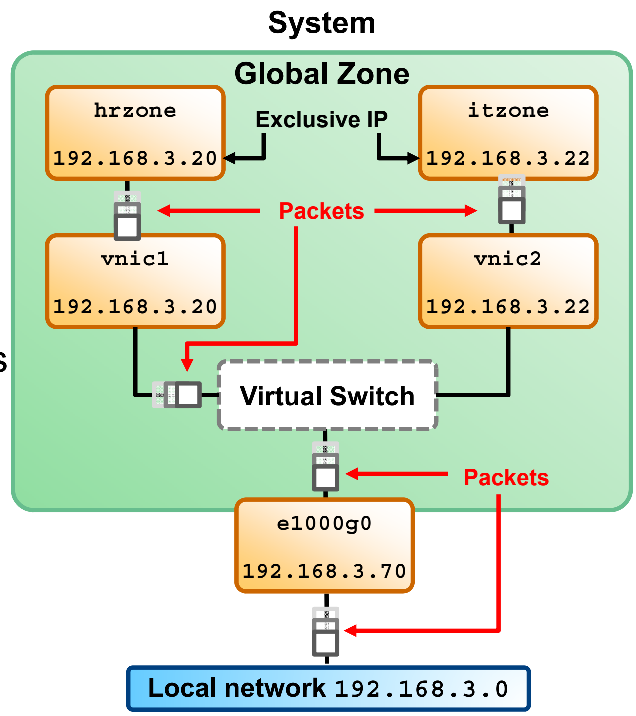
```
# rcapadm -z hrzone -m 512M
```

To use the `capped-memory` resource, the `rcapd` daemon and its associated service (`rcap`) must be up and running. These system facilities provide the capability to use the `capped-memory` option.

In this lesson, you learn how to set a persistent cap for a zone. In the lesson titled “Evaluating System Resources,” you learn how to configure resources at the system level.

Implementing Controls on Network Resources

- Increase the efficiency of virtual networks with resource controls.
- Use resource controls to:
  - Share bandwidth among VNICs
  - Customize link properties
  - Create flows



When a virtual network is configured, a zone sends traffic to an external host in the same fashion as a system without a virtual network. Traffic flows from the zone, through the VNIC to the virtual switch, and then to the physical interface, which sends the data out onto the network.

To increase efficiency on your virtual network, you can implement controls to determine how resources are being used by the networking processes. Resource control is the process of allocating a system’s resources in a controlled fashion. The resource control features of Oracle Solaris enable bandwidth to be shared among the VNICs on a system’s virtual network. Link properties that are specifically related to network resources, such as rings, CPUs, and so on, can be customized to process network packets. In addition, you can also create flows to manage network usage.

Managing Virtual Network Resources by Using Flows

- Flows are created on a per-VNIC basis.
- Flows are used to categorize network packets.
- Flows define and isolate packets with similar characteristics.
- Flows can be assigned specific resources.
- Bandwidth is assigned based on the usage policy for the system.

Resource management for the virtual network involves creating flows on a per-VNIC basis. A flow is a customized way of categorizing network packets to further control how resources are used to process these packets. These flows define and isolate packets with similar characteristics, such as the port number or IP address of the sending host. Packets that share an attribute constitute a flow and are labeled with a specific flow name. Specific resources can then be assigned to the flow. You assign bandwidth based on the usage policy for the system.

Creating Flows and Selecting Flow Properties

- Flows are created according to attributes.
- Attributes are classifications that are used to organize network packets into a flow.
- Flows use properties to control resources:
  - `maxbw`: Maximum amount of a link's bandwidth that packets identified with this flow can use
  - `priority`: Priority given to the packets in a flow:
    - Options: `high`, `medium`, or `low`
    - Default: `medium`

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Creating and Implementing Flows

Flows are created according to the attribute that you determined for each flow. An attribute is a classification that you use to organize network packets into a flow. For example, an IP address or transport protocol, such as TCP, can be used as an attribute. When you create a flow, you identify an attribute as well as a name for the flow.

Flows also have properties that are used to control resources. Currently, there are only two flow properties that can be set:

- **`Maxbw`:** The maximum amount of the link's bandwidth that packets identified with this flow can use. The value you set must be within the allowed range of values for the link's bandwidth.
- **`Priority`:** The priority given to the packets in this flow. The possible values are `high`, `medium`, and `low`; `medium` is the default value.

In the section titled "Allocating and Managing System Resources in a Zone," which will be covered later in this lesson, you learn how to manage virtual network resources by using a flow.

Implementing the Virtual Network and Zones Plan

Your assignment is to:

- Create a virtual network
- Configure zones to use VNICs
- Allocate resources to a zone
- Manage network resources by using flows

Implementing the Data Storage Management Plan

It is now time to test the virtual network functionality in Oracle Solaris 11. Your assignment is to create a virtual network, and then configure zones to use the virtual network interfaces that you have created as part of the virtual network. Next, you allocate resources to a zone by using resource pools. Your last task is to test managing the network resources by using flows.

In the sections that follow, you learn the commands that you need to perform these tasks.

Quiz

A VNIC is a virtual network device with the same datalink interface as a physical interface.

a. True

b. False

Answer: a

Quiz

In which order is a virtual network created?

a. Virtual switch, VNICs, zones
b. Zones, VNICs, virtual switch
c. VNICs, virtual switch, zones

Answer: a

Quiz

Which two properties do flows use to control resources?

a. `speed` and `mtu`

b. `maxbw` and `priority`

c. `flowctrl` and `threshold`

Answer: b

Lesson Agenda

- Planning for a Virtual Network and Zones
- **Creating a Virtual Network**
- Configuring Zones to Use VNICs
- Allocating and Managing System Resources in a Zone
- Managing Resources on the Virtual Network

Creating a Virtual Network

This section covers the following topics:

- Creating a virtual network switch
- Creating the virtual network interfaces
- Displaying the virtual network configuration

Creating a Virtual Network Switch

To create an etherstub, use `dladm create-etherstub` *`etherstub`*.

```
# dladm create-etherstub stub0
```

To verify the creation of the etherstub, use `dladm show link`.

```
# dladm show-link
LINK          CLASS      MTU    STATE    BRIDGE     OVER
net0          phys       1500   up       --         --
net1          phys       1500   unknown  --         --
net2          phys       1500   unknown  --         --
net3          phys       1500   unknown  --         --
stub0         etherstub  9000   unknown  --         --
```


An ethernet stub can be used instead of a physical NIC to create VNICs. VNICs that are created on an etherstub will appear to be connected through a virtual switch, allowing complete virtual networks to be built without physical hardware. The VNICs over an etherstub become independent of the physical NICs in the system. You can use etherstubs to isolate the virtual network from the rest of the virtual networks in the system, as well as the external network to which the system is connected.

You cannot use an etherstub just by itself. Instead, you use VNICs with an etherstub to create the private or isolated virtual networks. You can create as many etherstubs as you require. You can also create as many VNICs over each etherstub as required.

To create an etherstub, use the `dladm create-etherstub` command followed by the etherstub name. In the example, you are creating the etherstub `stub0`.

To confirm the creation of the etherstub, you can use the `dladm show-link` command, as shown in the example in the slide. Here, you can see that `stub0` has been created and that its current state is `unknown`.

Creating the Virtual Network Interfaces

To create a VNIC and attach it to the etherstub, use `dladm create-vnic –l` *`etherstub vnic`*.

```
# dladm create-vnic -l stub0 vnic0
# dladm create-vnic -l stub0 vnic1
# dladm create-vnic -l stub0 vnic2
```


After you have created the etherstub, you can create the VNICs and attach them to the etherstub by using the `dladm create-vnic` command followed by the `-l` option, the etherstub name, and the VNIC name, as shown in the first example in the slide. The `-l` option precedes the link, which can be either a physical link or an etherstub.

Note: `vnic0` is required for the virtual switch. The other VNICs (`vnic1` and `vnic2`) are for use with the zones that will be created.

Displaying the Virtual Network Configuration

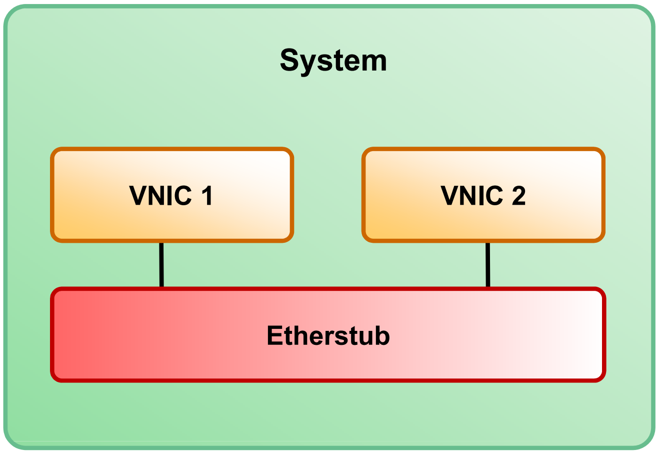
To display the virtual network configuration, use `dladm show-vnic`.

```
# dladm show-vnic
LINK        OVER        SPEED  MACADDRESS         MACADDRTYPE    VID
vnic0       stub0       0      2:8:20:70:d0:f8    random         0
vnic1       stub0       0      2:8:20:80:65:0     random         0
vnic2       stub0       0      2:8:20:1f:c5:bd    random         0
```


To verify that the VNICs are created and to display the virtual network configuration, you can use the `dladm show-vnic` command, as shown in the example in the slide. The `dladm show-vnic` command is used to show the VNIC configuration information for all VNICs, all VNICs on a link, or only a specified *`vnic-link`*. The output for this command displays the name of the link (`LINK`), the name of the physical link over which the VNIC is configured (`OVER`), the maximum speed of the VNIC [in megabits per second (`SPEED`)], the MAC address of the VNIC (`MACADDRESS`), the MAC address type of the VNIC (`MACADDRTYPE`) that can be either a random address assigned to the VNIC (`random`) or a factory MAC address used by the VNIC (`factory`), and the VLAN identifier (VID). The etherstub or virtual switch uses the VLAN identifier to determine the interface to send a data packet to.

In this example, all the VNICs have been configured over etherstub `stub0`. Currently, there is no data passing through the links, so there is no speed being recorded. The MAC addresses are present for each VNIC and they have all been randomly assigned. There is one VLAN and it is identified with VID `0`.

The Virtual Network Configuration So Far



The graphic in the slide illustrates what the virtual network configuration looks like so far. There is the etherstub, and two VNICs connected to the switch.

Now that you have created the network, you are ready to configure your zones on top of this network. You will look at how to do this in the subsequent slides.

Quiz

Which utility is used to create virtual switches and VNICs?

a. `lnkadm`
b. `dladm`
c. `vniccfg`
d. `dlcfg`

Answer: b

Quiz

You have created an etherstub called `stub2`. You now want to create `vnic1` and attach it to `stub2`. Which set of commands do you use to do this?

a. `# dladm create-vnic1`

b. `# dladm create-vnic -l vnic1`

c. `# dladm create-vnic -l stub2 vnic0`

d. `# dladm create-vnic -l stub2 vnic1`

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Answer: c

Practice 6-1 Overview: Creating an Oracle Solaris 11 Virtual Network

This practice covers the following topics:

- Creating a virtual network switch
- Creating the virtual network interfaces
- Displaying the virtual network configuration

The practices for this lesson are designed to reinforce the concepts that have been presented in the lecture portion. These practices cover the following tasks:

- **Practice 6-1:** Creating an Oracle Solaris 11 virtual network
- **Practice 6-2:** Creating two zones by using VNICs
- **Practice 6-3:** Allocating resources to zones
- **Practice 6-4:** Managing the virtual network data flow
- **Practice 6-5:** Removing part of the virtual network

Practice 6-1 should take about 10 minutes to complete.

Lesson Agenda

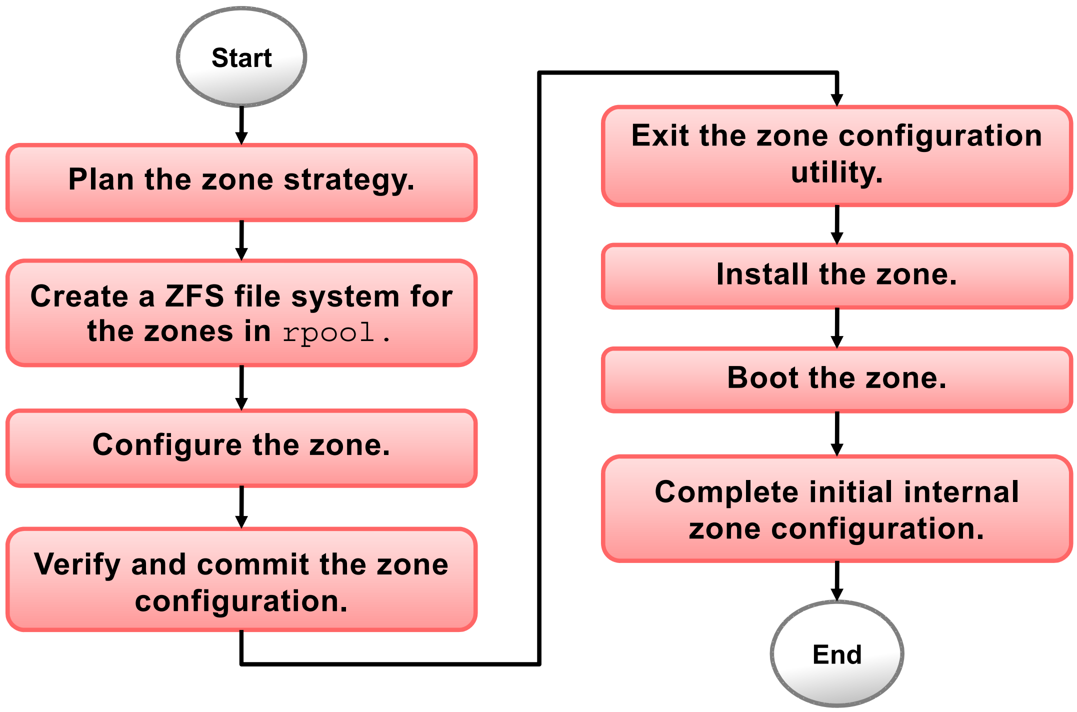
- Planning for a Virtual Network and Zones
- Creating a Virtual Network
- **Configuring Zones to Use VNICs**
- Allocating and Containing System Resources to a Zone
- Managing Resources on the Virtual Network

Configuring Zones to Use VNICs

This section covers the following topics:

- Configuring the zone
- Displaying a zone configuration
- Checking the virtual network configuration for a zone

Zone Configuration Process: Overview



Before configuring a zone or zones to use VNICs, you should know what your company's zone strategy is. That is, how many zones will you create and what type of virtual network setup will you use? You need to create a ZFS file system for the zones in the `root` file system (`rpool`). You then configure the zone or zones. During zone configuration, you identify the VNIC that you want to use for the zone. After completing the configuration, you verify and then commit it. Next, you exit the zone, install it, and boot it. Finally, you return to the zone, log in, and complete the initial internal zone configuration.

Note: To configure additional zones to use other VNICs, you follow the same basic steps.

You now walk through each of these steps, beginning with planning the zone strategy.

Planning the Zone Strategy

- Virtual network configuration: etherstub `stub0` with two VNICs (`vnic1` and `vnic2`)
- Two zones: `hrzone` and `itzone`
- Zone paths: `/zones/hrzone`; `/zones/itzone`
- IP type: exclusive-IP
- VNIC to zone association: `vnic1` for `hrzone`; `vnic2` for `itzone`

Suppose that you have been tasked with creating two zones over a virtual network. Your strategy is to create the virtual network first, which you have already done, and then create the zones. As part of your zones configuration planning, you have identified the following information:

- **Zone names:** The zone name must be unique. You use the names `hrzone` and `itzone` to create your zones.
- **Zone paths:** Each zone requires a path to its root directory that is relative to the global zone's root directory. You are creating a file system called `zones` as part of `rpool`, and then you create two other file systems under zones, one to contain `hrzone` and one to contain `itzone`. The two zone paths should look like this, respectively: `/zones/hrzone` and `/zones/itzone`.
- **IP type:** To use VNICs, a zone must be configured as an exclusive IP zone.
- **Specific VNIC to be associated with the zone:** You use `vnic1` for `hrzone` and `vnic2` for `itzone`.

Now that you know what your zone strategy is, your next step is to create the ZFS file system structure for your zones.

Creating a ZFS File System for Zones in `rpool`

To create a ZFS file system for zones in `rpool`, use `zfs create -o mountpoint=/zones rpool/zones`.

```
# zfs create -o mountpoint=/zones rpool/zones
```

To verify that the file system exists and that it has been mounted, use `zfs list rpool/zones`.

```
# zfs list rpool/zones
NAME            USED  AVAIL  REFER  MOUNTPOINT
rpool/zones      31K  22.6G    31K  /zones
```

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The first ZFS file system that you want to create in `rpool` is a file system that will contain all the individual zones' file systems. Typically, this file system is called `zones`. To create this file system, use the `zfs create` command with the `-o` option (to specify the `mountpoint` property), followed by the `mountpoint` property value (`mountpoint=/zones`) and the file system name (`rpool/zones`), as shown in the first example in the slide.

You can then verify that the file system has been created and mounted by using the `zfs list` command followed by the file system name, as shown in the second example.

You will create the zone-specific file system during zone configuration.

Configuring the Zone

To configure a zone, use `zonecfg -z zonename`.

```
# zonecfg -z hrzone
hrzone: No such zone configured
Use 'create' to begin configuring a new zone.
zonecfg:hrzone> create
create: Using system default template 'SYSdefault'
zonecfg:hrzone> set zonepath=/zones/hrzone
zonecfg:hrzone> set autoboot=true
zonecfg:hrzone> add net
zonecfg:hrzone:net> set physical=vnic1
zonecfg:hrzone:net> end
zonecfg:hrzone>
```


The `zonecfg` command is used to create the zone configuration. You must be a superuser or have the appropriate rights profile to configure a zone. To perform the configuration, use the `zonecfg` command with the `-z` option to specify the name of the zone, followed by the zone name, as shown in the example. After you enter the command, and if you are configuring a new zone, you see the following message: "`No such zone configured. Use 'create' to begin configuring a new zone.`"

The next step is to enter `create`. This enables you to create the new zone configuration by setting specific properties, such as the zone path, the IP type, and the network type.

Note: The IP type is set to `exclusive` by default. To set it to `shared`, use the `set ip-type=shared` command.

Then you set the zone path by using the `set zonepath=` command followed by the zone name (for example, `/zones/hrzone`).

Next, you set `autoboot` to `true` by using `set autoboot=true`. This setting indicates that the zone should be booted automatically at system boot. At this point in the configuration, you specify that you want to add a network interface to the zone. To do this, use the `add net` command.

Notice, in the example, that the `zonecfg` prompt for the zone that you are creating has been modified to include "`net`": `zonecfg:hrzone:net`. Here, you can set the network `physical` property to specify the VNIC that you want this zone to use by using `set physical=` followed by the VNIC name (for example, `set physical=vnic1`).

To stop work on the zone's network configuration, enter the `end` command. You have completed the zone configuration.

Verifying, Committing, and Exiting the New Zone Configuration

```
# zonecfg -z hrzone
Use 'create' to begin configuring a new zone.
zonecfg:hrzone> create
zonecfg:hrzone> set zonepath=/zones/hrzone
zonecfg:hrzone> set autoboot=true
zonecfg:hrzone> set ip-type=exclusive
zonecfg:hrzone> add net
zonecfg:hrzone:net> set physical=vnic1
zonecfg:hrzone:net> end
zonecfg:hrzone> verify
zonecfg:hrzone> commit
zonecfg:hrzone> exit
#
```

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After you complete your zone configuration, you need to verify that all the required information is present. You do this by using the `verify` command, as shown in the example in the slide. If all the required information is not present, the system will notify you, in which case you will need to review your configuration to determine what is missing. If no messages are displayed, you can continue to the next step, which is to commit the configuration. The `commit` command takes the configuration from memory and puts it into permanent storage.

After the zone configuration is committed, you can exit the zone configuration session by using the `exit` command.

Note: To configure, verify, commit, and exit `itzone` as per your zone strategy, you repeat the steps that you just covered.

Displaying a Zone Configuration

To display a zone configuration, use `zonecfg -z` *`zonename`* `info`.

```
# zonecfg -z hrzone info
zonename: hrzone
zonepath: /zones/hrzone
brand: solaris
autoboot: true
file-mac-profile:
bootargs:
pool:
limitpriv:
scheduling-class:
ip-type: exclusive
hostid:
fs-allowed:
net:
        address not specified
        allowed-address not specified
        physical: vnic1
        defrouter not specified
<continued on next slide>
```


After you have finished your zone configuration, it is a good practice to review your zone configuration before you install the zone. To display a zone configuration, use the `zonecfg -z` command followed by the zone name and the `info` subcommand, as shown in the slide. Verify that you have set the zone path, IP type, and network interface properties correctly.

Displaying a Zone Configuration

```
<continued from previous slide>
anet:
        linkname: net0
        lower-link: auto
        allowed-address not specified
        configure-allowed-address: true
        defrouter not specified
        allowed-dhcp-cids not specified
        link-protection: mac-nospoof
        mac-address: random
        mac-prefix not specified
        mac-slot not specified
        vlan-id not specified
        priority not specified
        rxrings not specified
        txrings not specified
        mtu not specified
        maxbw not specified
        rxfanout not specified
        vsi-typeid not specified
        vsi-vers not specified
        vsi-mgrid not specified
        etsbw-lcl not specified
        cos not specified
        pkey not specified
        linkmode not specified
```


This slide shows the continuation of the `zonecfg -z hrzone info` command example.

Verifying That a Zone Is in `configured` State

To list all configured and running zones on the system, use `zoneadm list -cv`.

```
# zoneadm list -cv
  ID NAME          STATUS            PATH              BRAND     IP
   0 global        running            /                solaris   shared
   - hrzone        configured         /zones/hrzone    solaris    excl
   - itzone        configured         /zones/itzone    solaris    excl
```


You are now ready to install the zone. But, before you do that, it is a good idea to confirm that the zone is in the `configured` state. You can use the `zoneadm list -cv` command to see all configured and running zones on a system, as shown in the example in the slide. Both the zones that you have created, `hrzone` and `itzone`, have a status of `configured`.

You can now install the configured zones.

Gathering Information for the System Configuration Profile

- Computer Name: `hrzone`
- Wired Ethernet Network Configuration: `Manually`
- IP address of the zone: `192.168.1.100`
- DNS Name service: `Do not configure DNS`
- Alternate Name Service: `None`
- Time Zone, Region, and Location: *Use your local region.*
- Netmask of the IP address: `255.255.255.0`
- Users, username, and password

After you have verified that the zone is in the configured state, you need to create a system configuration profile for the zone, which utilizes the System Configuration Tool (`sysconfig`, for short). The system configuration profile specifies the default locale and time zone, the zone's `root` password, a naming service to use, and other aspects of the application environment, to include (but not limited to) the following:

- The computer name of the zone (for example, `hrzone`)
- IP address of the zone, which is based on the IP address of the zone's VNIC
- Netmask of the IP address

You need to gather this information before creating the system configuration profile. Most of the information is supplied by selecting from a list of choices. Typically, the default options are enough unless your system configuration requires otherwise. After you have supplied the required information for the zone, the zone is restarted.

This slide presents a sample of the type of information that you need to complete the system configuration profile.

Creating the System Configuration Profile

To create the system configuration profile, use `sysconfig create-profile -o pathname`.

```
# sysconfig create-profile -o /opt/ora/data/hrconf.xml

<prompt sequence omitted>

Exiting System Configuration Tool. Log is available at:
/var/tmp/install/sysconfig.log
```


To create a system configuration profile for a zone, use the `sysconfig create-profile -o` command followed by the path name of the location in which you want the profile to reside, as shown in the example in the slide. Using the configuration information that you gathered previously, respond to each of the prompts that are presented. When you have finished, you will be exited from the System Configuration Tool.

Installing the Zone

To install a zone, use `zoneadm -z zonename install -c` *`profile_pathname`*.

```
# zoneadm -z hrzone install -c /opt/ora/data/hrconf.xml

A ZFS file system has been created for this zone.
   Publisher: Using solaris (http://server1.mydomain.com/ ).
       Image: Preparing at /zones/hrzone/root.
Sanity Check: Looking for 'entire' incorporation.
...
        Done: Installation completed in 356.558 seconds.
```


After you have created the system configuration profile, you are ready to install the zone. To install a zone, use the `zoneadm -z` command followed by the zone name, the `install -c` subcommand, and the path name to the system configuration profile, as shown in the example in the slide.

The installation process automatically creates a ZFS file system (data set) for the zone path when the zone is installed. If the file system cannot be created, the zone is not installed. The installation process also verifies the specified publisher and downloads the zone installation packages from IPS. This process normally takes about three to five minutes per zone.

Booting the Zone

To list all running and installed zones on the system, use `zoneadm list -iv`.

```
# zoneadm list -iv
  ID NAME          STATUS            PATH              BRAND     IP
   0 global        running           /                  solaris  shared
   - hrzone        installed         /zones/hrzone      solaris   excl
   - itzone        installed         /zones/itzone      solaris   excl
```

To boot a zone, use `zoneadm -z zonename boot`.

```
# zoneadm -z hrzone boot
# zoneadm -z itzone boot
# zoneadm list -v
  ID NAME          STATUS            PATH              BRAND     IP
   0 global        running           /                  solaris  shared
   1 hrzone        running           /zones/hrzone      solaris   excl
   2 itzone        running           /zones/itzone      solaris   excl
```


The next step is to boot the zone. But, before you do that, it is a good idea to confirm that the zone is in the `installed` state. You can use the `zoneadm list -civ` command to see all the running and installed zones on a system, as shown in the first example in the slide. As you can see, both `hrzone` and `itzone` have a status of `installed`.

You can now boot the installed zones. To boot a zone, use the `zoneadm -z` command followed by the zone name and the `boot` subcommand, as shown in the second example.

To verify that a zone is in `running` state, you can run the `zoneadm list -v` command, as shown in the second part of the second example. Note that the two non-global zones now have assigned IDs.

Checking the Virtual Network Configuration in a Zone

To display the network interface address information for a zone, log in to the zone, and then use `ipadm show-addr`.

```
# zlogin hrzone
[Connected to zone 'hrzone' pts/2]
Oracle Corporation      SunOS 5.11      11.0     November 2011
root@hrzone:~# ipadm show-addr
ADDROBJ            TYPE     STATE        ADDR
lo0/v4             static   ok           127.0.0.1/8
vnic1/v4           static   ok           192.168.1.100/24
lo0/v6             static   ok           ::1/128
vnic1/v6           addrconf ok           fe80::8:20ff:fe43:7986/10
```


Now you learn how to check the virtual network configuration in a zone. First, you need to log in to the zone. Log in to `hrzone`. To do this, use the `zlogin` command again, followed by the zone name, as shown in the example in the slide. After you are logged in, you can use the `ipadm show-addr` command to see the network interface address information for the zone. Here, you can see the IP address assignment of 192.168.1.100 that you made for the `net0` network interface while creating the system configuration profile. You can also see the type and state of the interface.

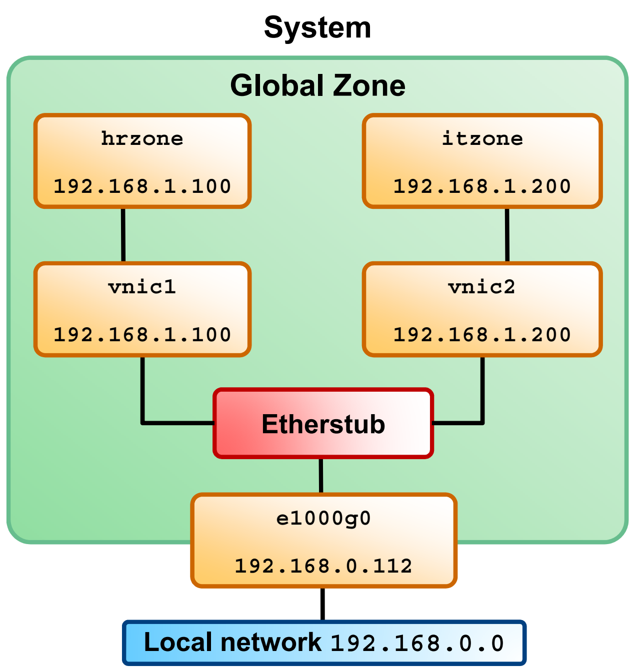
Verifying That a Zone's Virtual Network Interface Connection Is Operational

To verify that a zone's virtual network interface connection is operational, use `ping` and an IP address.

```
root@hrzone:~# ping 192.168.1.200
192.168.1.200 is alive
```


To verify that a zone's virtual network interface connection is operational, ping an IP address from within the zone. In the example, you are pinging the IP address for the second zone that was created, `itzone`. As you can see from the output, the virtual network that connects these two zones is operational.

Virtual Network Configuration



The graphic in the slide illustrates what the final virtual network configuration looks like. You have two zones, `hrzone` and `itzone`, each with a dedicated or exclusive IP address. The `hrzone` zone is using `vnic1` as its network interface, and `itzone` is using `vnic2` as its network interface. The VNICs are using etherstub `stub0`.

Removing the Virtual Network Without Removing the Zones

1. Verify the state of the configured zones.
2. Halt the exclusive IP zones.
3. Verify that the zones have been halted.
4. List the VNICs that were configured for the halted zones.
5. Delete the VNICs.

If you find that you need to use the zones that you have created in a different configuration, or if you need to move the zones to a different zone path or migrate them to another network, you must disable the zone's virtual network while keeping the zones intact.

Note: This procedure assumes that you are running a virtual network that consists of exclusive IP zones.

The steps for removing a virtual network without removing the zones are presented in the slide. You now take a closer look at how to complete each step, beginning with how to verify the state of the configured zones.

Verifying the State of the Configured Zones

To verify the state of the configured zones, use `zoneadm list -cv`.

```
# zoneadm list -cv
  ID NAME             STATUS         PATH              BRAND     IP
   0 global           running        /                 solaris   shared
   - hrzone           running        /zones/hrzone     solaris   excl
   - itzone           running        /zones/itzone     solaris   excl
```


To verify the state of the currently configured zones on the system, use the `zoneadm list` command with the `-cv` option, as shown in the example in the slide. As you can see, `hrzone` and `itzone` are currently running. You can also verify that both zones have exclusive IP addresses.

Halting the Exclusive IP Zones

To halt the exclusive zones, use zoneadm `-z zonename halt`.

```
# zoneadm -z hrzone halt
# zoneadm -z itzone halt
```


After you have verified the status of the zones and that they are exclusive IP zones, you can halt each zone by using the `zoneadm -z` command followed by the zone name and the `halt` subcommand, as shown in the example in the slide. When you halt a zone, you remove the zone's application environment and terminate several system activities.

Note: You can also use the `zoneadm -z` *`zonename`* `shutdown` command to cleanly shut down a zone. Alternatively, for instructions on how to perform the same procedure by using the `zlogin` command, refer to the chapter titled "How to Use `zlogin` to Shut Down a Zone" in the *Oracle Solaris Administration: Oracle Solaris Zones, Oracle Solaris 10 Zones, and Resource Management* guide.

Verifying That the Zones Have Been Halted

To verify the state of the configured zones, use `zoneadm list -iv`.

```
# zoneadm list -iv
  ID NAME             STATUS         PATH             BRAND    IP
   0 global           running        /                solaris  shared
   - hrzone           installed      /zones/hrzone    solaris  excl
   - itzone           installed      /zones/itzone    solaris  excl
```


To verify that the zones have been halted, use the `zoneadm list -iv` command, as shown in the example in the slide. Include the `-i` option to see all the installed zones on the system.

As you can see, `hrzone` and `itzone` have been returned to the `installed` state.

Listing the VNICs That Were Configured for the Halted Zones

To list the VNICs that were configured for the halted zones, use `dladm show-vnic`.

```
# dladm show-vnic
LINK        OVER       SPEED   MACADDRESS          MACADDRTYPE    VID
vnic0       stub0   1000 MBps  2:8:20:70:d0:f8   random         0
vnic1       stub0   1000 MBps  2:8:20:80:65:0    random         0
vnic2       stub0   1000 MBps  2:8:20:1f:c5:bd   random         0
```


The next step is to list the VNICs that were configured for the halted zones. To do this, use the `dladm show-vnic` command, as shown in the example in the slide. You will recall that `vnic0` is for the etherstub; so the two VNICs that you are interested in are `vnic1` and `vnic2`, which correspond to `hrzone` and `itzone`, respectively.

Deleting the VNICs

To delete the VNICs, use `dladm delete-vnic` *`vnicname`*.

```
# dladm delete-vnic vnic0
# dladm delete-vnic vnic1
# dladm delete-vnic vnic2
```


The final step is to delete the VNICs. This is done by using the `dladm delete-vnic` command followed by the VNIC name, as shown in the example in the slide.

Quiz

After you have run the `zonecfg -z` *`zonename`* command, which command would you use to start the configuration of a new zone?

a. `add zone`
b. `begin`
c. `create`
d. `start`

Answer: c

Quiz

To use VNICs, which IP type must a zone be configured as?

a. Shared-IP
b. Exclusive-IP
c. Either shared or exclusive

Answer: b

Quiz

You have created the configuration for a new zone. What is the next step?

a. Boot the new zone.
b. Commit the configuration.
c. Exit the configuration.
d. Verify the configuration.

Answer: d

Practice 6-2: Creating Two Zones by Using VNICs

This practice covers the following topics:

- Configuring two zones by using VNICs
- Displaying the zone configuration, including the interfaces

This practice should take about 45 minutes to complete.

Lesson Agenda

- Planning for a Virtual Network and Zones
- Configuring a Virtual Network
- Configuring Zones to Use VNICs
- **Allocating and Managing System Resources in a Zone**
- Managing Resources on the Virtual Network

Allocating and Managing System Resources in a Zone

This section covers allocating and managing the following:

- CPU resources with resource pools
- Physical memory resources with resource capping

Allocating and Managing CPU Resources with Resource Pools

- Enabling services for resource pools
- Configuring a persistent resource pool
- Binding the zone to a persistent resource pool
- Removing the resource pool configuration

To manage CPU consumption in a zone, you can use a resource pool. To do this, you must first enable pool services, configure the resource pool, and then bind the zone to the pool. When you no longer have the need to manage CPU usage in the zone, you can remove the resource pool. Next, you look at how to perform each of these tasks, beginning with enabling pool services.

For the purposes of training, assume that you have been monitoring the CPU usage of your zones and that `hrzone` is creating a resource conflict. You will create a resource pool that will control the CPU usage of `hrzone`.

Enabling Services for Resource Pools

To activate the resource pool services, run `svcadm enable -r pools/dynamic`.

```
# svcadm enable -r pools/dynamic
```

To verify that the service pools and the `poold` daemon are up, run `svcs *pools*` and `pgrep -lf poold`, respectively.

```
# svcs *pools*
STATE          STIME    FMRI
online         16:08:10 svc:/system/pools:default
online         16:08:11 svc:/system/pools/dynamic:default
# pgrep -lf poold
 2283 /usr/lib/pool/poold
```


You may recall from the first topic, on planning for a virtual network and zones, that resource pool services are not enabled by default. To activate both resource pool services, you can run the `svcadm enable` command with the `-r` option, followed by `pools/dynamic`, as shown in the example in the slide.

To verify that the pool services are online, you can run the `svcs *pools*` command, as shown in the example. You can also verify that the `poold` daemon is running.

Configuring a Persistent Resource Pool

To create the pool configuration file, use `pooladm -s`.

```
# pooladm -s
```

To verify that the file has been created, use `ls -l /etc/pool*`.

```
# ls -l /etc/pool*
-rw-r--r-- 1 root root 1298 Dec 14 16:13 /etc/pooladm.conf
# file /etc/pooladm.conf
/etc/pooladm.conf:      XML document
```


After enabling the resource pool services, you can create the pool configuration file and save it in the default configuration file `/etc/pooladm.conf`. To create the pool configuration file, use the `pooladm` command with the `-s` option, which saves the file.

Note: The `pooladm` command is used to activate and deactivate the resource pools facility.

To verify that the file is created, you can use the `ls -l /etc/pool*` command, as shown in the example in the slide. If you run the `file /etc/pooladm.conf` command, you can see that the file is an XML document.

Note: You examine the contents of the XML document during the practice.

Displaying the Resource Pool Configuration File

To display the resource pool configuration file, use `poolcfg -c info`.

```
# poolcfg -c info
system default
        string  system.comment
        int     system.version 1
        boolean system.bind-default true
        string  system.poold.objectives wt-load

<Complete output presented in the Notes>
```


Before you modify the resource pool configuration, you should familiarize yourself with the contents of the configuration file. To display the file, use the `poolcfg` command with the `-c` option, followed by the `info` subcommand, as shown in the example in the slide.

Note:

- The `poolcfg` utility is used to create and modify the resource pool configuration files.
- Due to space constraints in the slide, the full output for the resource pool configuration is displayed on the next page.

In the output on the next page, notice that the current pool is `pool_default` and that the processor set (pset) is `pset_default`. Below that, you can see that there are two CPUs associated with the default pset. The number of CPUs available to the pset is identified in the pset value `uint pset.size 2`.

Note: A processor set allows the binding of processes to groups of CPUs.

After checking the resource pool configuration and verifying that it is now the default configuration, you can exit the pool by using the `exit` command.

```
system default
        string   system.comment
        int      system.version 1
        boolean  system.bind-default true
        string   system.poold.objectives wt-load

        pool pool_default
                int                 pool.sys_id 0
                boolean             pool.active true
                boolean             pool.default true
                int                 pool.importance 1
                string              pool.comment
                pset                pset_default

        pset pset_default
                int                 pset.sys_id -1
                boolean             pset.default true
                uint                pset.min 1
                uint                pset.max 65536
                string              pset.units population
                uint                pset.load 395
                uint                pset.size 2
                string              pset.comment

                cpu
                        int         cpu.sys_id 1
                        string      cpu.comment
                        string      cpu.status on-line

                cpu
                        int         cpu.sys_id 0
                        string      cpu.comment
                        string      cpu.status on-line
```

Modifying the Resource Pool Configuration File

To create the pset, use `poolcfg -c 'create pset pset_`*`psetname`*` (uint pset.min = x; uint pset.max = x)'`.

```
# poolcfg -c 'create pset pset_1to2 (uint pset.min = 1; uint
pset.max = 2)'
```

To create the pool, use `poolcfg -c 'create pool pool_`*`poolname`*`'`.

```
# poolcfg -c 'create pool pool_hrzone'
```

To associate the pset with the pool, use `poolcfg -c 'associate pool pool_`*`poolname`*` (pset pset_`*`psetname`*`) '`.

```
# poolcfg -c 'associate pool pool_hrzone (pset pset_1to2)'
```


You are now ready to modify the configuration file to control the CPU usage of `hrzone`. To do this, you create a pset, and then you create a pool. You then join or associate the pset with the pool. You now look at each step separately.

Suppose that you have decided to allocate two CPUs to address the workload in `hrzone`. This will enable the kernel to use either one or two CPUs to support `hrzone`'s workload.

To create the pset and define its parameters, use the `poolcfg -c` command followed by `create pset`, the name that you want to give the pset (`pset_`*`psetname`*), and the unassigned integer (`uint`) minimum and maximum values, which are the minimum and maximum numbers of the CPUs that you want allocated to this pset. In the example shown in the slide, you are stating that a minimum of one CPU should be used, with a maximum of two. You have named the pset `pset_1to2`.

Note: The `-c` option is used to specify a command.

To create the pool, use the `poolcfg -c` command again, followed by `create pool` and the name that you want to give the pool (`pool_`*`poolname`*), as shown in the second example. In the example, because you are creating this pool for `hrzone`, you have named the pool `pool_hrzone`.

To associate the pset with the pool, use the `poolcfg -c` command followed by `'associate pool pool_`*`poolname`*` (pset pset_`*`psetname`*`)'`, as shown in the third example.

Note: Psets and pools are created separately to provide flexibility. For example, you could create another pset and associate it with `pool_hrzone` if you wanted to do so.

Displaying and Committing the Modified Resource Pool Configuration File

To display the modified resource pool configuration, use `poolcfg -c info`.

```
# poolcfg -c info
        <Output presented in the Notes>
```

To validate and commit the modified configuration, use `pooladm -n -c`, and then `pooladm -c`.

```
# pooladm -n -c
# pooladm -c
```


To view the modified pool configuration, use the `poolcfg -c` command followed by the `info` subcommand, as shown in the first example in the slide.

Note: Due to space constraints in the slide, the full output for the resource pool configuration is presented on the next page.

In the output on the next page, notice that you now have a pool called `pool_hrzone` and a pset called `pset_1to2` as part of your resource pool configuration.

After viewing the modified pool configuration, you will want to validate and then commit it. To validate the configuration, use the `pooladm` command with the `-n -c` options, as shown in the second example. After the validation is completed, you can commit the configuration by using the `pooladm -c` command. This is your static resource pool configuration file.

```
system default
        string      system.comment
        int         system.version 1
        boolean     system.bind-default true
        string      system.poold.objectives wt-load

        pool pool_default
                int             pool.sys_id 0
                boolean         pool.active true
                boolean         pool.default true
                int             pool.importance 1
                string          pool.comment
                pset            pset_default

        pool pool_hrzone
                boolean         pool.active true
                boolean         pool.default false
                string          pool.scheduler FSS
                int             pool.importance 1
                string          pool.comment
                pset            pset_1to2

        pset pset_default
                int             pset.sys_id -1
                boolean         pset.default true
                uint            pset.min 1
                uint            pset.max 65536
                string          pset.units population
                uint            pset.load 388
                uint            pset.size 2
                string          pset.comment
```

```
    cpu
                    int         cpu.sys_id 1
                    string      cpu.comment
                    string      cpu.status on-line

            cpu
                    int         cpu.sys_id 0
                    string      cpu.comment
                    string      cpu.status on-line

pset pset_1to2
            int             pset.sys_id -2
            boolean         pset.default false
            uint            pset.min 1
            uint            pset.max 2
            string          pset.units population
            uint            pset.load 0
            uint            pset.size 0
            string          pset.comment
```

Displaying the Resource Pool Configuration That Is Currently in Use

To display the resource pool configuration that is currently in use, use `poolcfg -dc info`.

```
# poolcfg -dc info

system default
        string  system.comment
        int     system.version 1
        boolean system.bind-default true
        string  system.poold.objectives wt-load

        pool pool_hrzone
                int     pool.sys_id 1
                boolean pool.active true
                boolean pool.default false
                int     pool.importance 1
                string  pool.comment
                pset    pset_1to2
```


To view the resource pool configuration that the system is currently using (that is, the dynamic pool configuration), use the `poolcfg` command with the `-dc` option, followed by the `info` subcommand, as shown in the example in the slide.

Note: The `-d` option specifies the dynamic pool configuration—that is, the configuration that is operating directly on the kernel state.

As you can see in the example, the pool that you just created, `pool_hrzone`, is the resource pool configuration that is currently in use.

Displaying all Active Resource Pools

To display all the active resource pools on the system, use `poolstat -r all`.

```
# poolstat -r all
 id pool                 type rid rset                  min  max size used load
  1 pool_hrzone          pset   1 pset_1to2               1    2    1 0.00 0.00
  0 pool_default         pset  -1 pset_default            1  66K    1 0.00 0.17
```


If you want to see all the active resource pools on the system, use the `poolstat -r all` command, as shown in the example in the slide.

Note: The `poolstat` utility is used to report statistics on active resource pools.

Here, you can see that there are two active resource pools: the pool that was just created (`pool_hrzone`) and the default pool (`pool_default`).

The output for this command displays the following information:

- Pool ID
- Name of the pool
- Type of resource set. A resource set is a process-bindable resource. Examples of resource sets include processor sets and scheduling classes.
- Resource set ID (`rid`)
- Resource set name (`rset`)
- Minimum resource set size (`min`)
- Maximum resource set size (`max`)

- Current resource set size (`size`)
- Amount of the resource set currently in use (`used`). This measure is calculated as the percentage utilization of the resource set multiplied by its size. If the resource set has been reconfigured during the last sampling interval, this value might be not reported (–).
- Load that is put on the resource set (`load`). For the definition of this property, see `libpool` (3LIB).

Binding the Zone to a Persistent Resource Pool

This section covers the following steps:

1. Listing the current state of the zones
2. Allocating the pool to the zone and confirming the allocation
3. Rebooting the zone to activate the resource pool binding
4. Confirming the availability of the resource pool

Note

In this example, you are binding the zone to a persistent resource pool. Persistent resource pools remain even if the system shuts down and comes back up. You can also configure temporary resource pools. For information about configuring temporary resource pools, see the section titled "Resource Pools" in the *Oracle Solaris Administration: Oracle Solaris Zones, Oracle Solaris 10 Zones, and Resource Management* guide.

Listing the Current State of the Zones

To list the current state of the zones on the system, use `zoneadm list -iv`.

```
# zoneadm list -iv
   ID NAME        STATUS      PATH                  BRAND     IP
   0 global      running     /                     solaris   shared
   1 hrzone      running     /zones/hrzone         solaris   excl
   2 itzone      running     /zones/itzone         solaris   excl
```


Because you want to bind a running zone to the resource pool, you verify that the zone is up and running. To do this, use the `zoneadm list -iv` command, as shown in the example in the slide. As you can see, all zones are up and running.

Allocating the Pool to the Zone and Confirming the Allocation

To allocate the pool to the zone, use `zonecfg -z` followed by the zone name and set `pool=pool_poolname`.

```
# zonecfg -z hrzone set pool=pool_hrzone
```

To confirm that the allocation has been made, use `zonecfg -z zonename info pool`.

```
# zonecfg -z hrzone info | grep pool
pool: pool_hrzone
```


Now that you have verified that the `hrzone` zone is running, you can allocate the pool to that zone. To do this, use the `zonecfg -z` command followed by the zone name and `set pool=pool_`*`poolname`*, as shown in the first example in the slide.

To confirm that the pool allocation has been included in the zone configuration, use the `zonecfg -z` command followed by the zone name, the `info` subcommand, and `| grep pool`, as shown in the second example. In this case, you have confirmation that the resource pool is part of the zone configuration.

Rebooting the Zone to Activate the Resource Pool Binding

To reboot the zone, use `zoneadm -z hrzone shutdown -r`.

```
# zoneadm -z hrzone shutdown -r
```

To verify that the zone is back up and running, use `zoneadm list -iv`.

```
# zoneadm list -iv
  ID NAME        STATUS      PATH                   BRAND     IP
   0 global      running     /                      solaris   shared
   1 hrzone      running     /zones/hrzone          solaris   excl
   2 itzone      running     /zones/itzone          solaris   excl
```


The next step is to reboot the zone to activate the resource pool binding. To do this, use the `zoneadm` command followed by the zone name and the `shutdown` subcommand with the `-r` option, as shown in the first example in the slide.

Note: You can also use `init 6` to reboot.

Next, you want to verify that the zone is back up and running. To do this, run the `zoneadm list -iv` command again, as shown in the second example. As you can see, `hrzone` is back up and running.

Confirming the Availability of the Resource Pool

To confirm the availability of the resource pool, log in by using `zlogin zonename`, and then use `poolcfg -dc info`.

```
# zlogin hrzone
[Connected to zone 'hrzone' pts/2]
Oracle Corporation   SunOS 5.11   11.0   November 2011

# poolcfg -dc info
        <Output presented in the Notes>
# exit
Logout
[Connection to zone 'hrzone' pts/2 closed]
```


Now you want to confirm that the resource pool is available. To do this, you first log in to the zone by using the `zlogin` command followed by the zone name. Then use the `poolcfg` command with the `-dc` options, followed by the `info` subcommand, as shown in the example in the slide.

Note: Due to space constraints in the slide, the full output for the resource pool configuration is presented on the next page.

In the output on the next page, notice that you have a pool called `pool_hrzone` and that its pset is `pset_1to2`. Below that, you can see the details for the pset as well as the two CPUs that you specified.

After you have confirmed the availability of the resource pool and reviewed the resource pool configuration, you can exit the pool by using the `exit` command.

```
system default
    string          system.comment
    int             system.version 1
    boolean         system.bind-default true
    string          system.poold.objectives wt-load

    pool pool_hrzone
         int        pool.sys_id 1
         boolean    pool.active true
         boolean    pool.default false
         int        pool.importance 1
         string     pool.comment
         pset       pset_1to2

    pset pset_1to2
         int        pset.sys_id 1
         boolean    pset.default false
         uint       pset.min 1
         uint       pset.max 2
         string     pset.units population
         uint       pset.load 24
         uint       pset.size 1
         string     pset.comment

         cpu
              int        cpu.sys_id 0
              string     cpu.comment
              string     cpu.status on-line
```

Removing the Resource Pool Configuration

This section covers the following steps:

1. Removing the pool configuration from the zone
2. Rebooting the zone
3. Checking the resource pool configuration for the zone
4. Deleting the resource pool

Removing the Pool Configuration from the Zone

To remove the resource pool configuration from the zone, use `zonecfg -z zonename clear pool`.

```
# zonecfg -z hrzone clear pool
```


To remove the resource pool configuration from the zone, use the `zonecfg -z` command followed by the zone name and the `clear pool` subcommand, as shown in the example in the slide. This action removes the resource pool configuration that you allocated to the zone and replaces it with the default resource pool configuration.

Rebooting the Zone

To reboot the zone, use `zoneadm -z hrzone shutdown -r`.

```
# zoneadm -z hrzone shutdown -r
```

To verify that the zone is back up and running, use `zoneadm list -iv`.

```
# zoneadm list -iv
   ID NAME       STATUS      PATH                  BRAND     IP
    0 global     running     /                     solaris   shared
    1 hrzone     running    /zones/hrzone          solaris   excl
    2 itzone     running     /zones/itzone         solaris   excl
```


The next step is to reboot the zone to activate the change. To do this, use the `zoneadm` command followed by the zone name and the `shutdown` subcommand with the `-r` option, as shown in the first example in the slide.

Next, you want to verify that the zone is back up and running. To do this, run the `zoneadm list -iv` command again, as shown in the second example. As you can see, `hrzone` is back up and running.

Checking the Resource Pool Configuration for the Zone

To check the resource pool configuration for the zone, log in by using `zlogin zonename`, and then use `poolcfg -dc info`.

```
# zlogin hrzone
[Connected to zone 'hrzone' pts/2]
Oracle Corporation   SunOS 5.11   11.0   November 2011

# poolcfg -dc info
        <Output presented in the Notes>
# exit
Logout
[Connection to zone 'hrzone' pts/2 closed]
```


Next, you want to check that the resource pool has been removed. To do this, first log in to the zone by using the `zlogin` command followed by the zone name. Then use the `poolcfg` command with the `-dc` options, followed by the `info` subcommand, as shown in the example in the slide.

Note: Due to space constraints in the slide, the full output for the resource pool configuration is presented on the next page.

In the output on the next page, notice that only the default resource pool configuration is available. The only pool that is available is the `pool_default` pool, and the only pset that is available is `pset_default`. Below the default pset, you can see the two CPUs associated with that pset.

After you have checked the resource pool configuration and verified that it is now the default configuration, you can exit the pool by using the `exit` command.

```
system default
     string            system.comment
     int               system.version 1
     boolean           system.bind-default true
     string            system.poold.objectives wt-load

     pool pool_default
           int         pool.sys_id 0
           boolean     pool.active true
           boolean     pool.default true
           int         pool.importance 1
           string      pool.comment
           pset        pset_default

     pset pset_default
           int         pset.sys_id -1
           boolean     pset.default true
           uint        pset.min 1
           uint        pset.max 65536
           string      pset.units population
           uint        pset.load 268
           uint        pset.size 1
           string      pset.comment

           cpu
                 int         cpu.sys_id 1
                 string      cpu.comment
                 string      cpu.status on-line
```

Deleting the Resource Pool

To delete the resource pool, use `pooladm -x`.

```
# pooladm -x
```


The next step is to delete the resource pool. To do this, use the `pooladm` command with the `-x` option. The `-x` option removes the currently active pool configuration, destroys all defined resources, and returns all formerly partitioned components to their default resources.

Displaying all Active Resource Pools

To display all the active resource pools on the system, use `poolstat -r all`.

```
# poolstat -r all
 id pool                 type rid rset                  min  max size used load
  0 pool_default         pset  -1 pset_default            1  66K    2 0.00 0.73
```


The final step is to verify that the resource pool that you deleted is no longer active on the system. To do this, use the `poolstat -r all` command, as shown in the example in the slide. You can see that there is now only one active resource pool: the default pool (`pool_default`).

Allocating and Managing Physical Memory Resources with Resource Capping

To add a memory cap to a zone, perform the following steps:

1. Configure the zone by using `zonecfg -z zone`.
2. Add the memory cap resource and set each memory cap type as appropriate: physical, swap, and locked.
3. Verify, commit, and exit the zone.

```
# zonecfg -z itzone
zonecfg:itzone> add capped-memory
zonecfg:itone:capped-memory> set physical=50m
zonecfg:itzone:capped-memory> set swap=100m
zonecfg:itzone:capped-memory> set locked=30m
zonecfg:itone:capped-memory> end
zonecfg:itzone> verify
zonecfg:itzone> commit
zonecfg:itzone> exit
```

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As mentioned in the first topic on planning for a virtual network and zones, you have the option of setting memory resource capping in a zone. The steps for adding a memory cap are listed in the slide.

In the example, you are setting the physical, swap, and locked memory resource caps for the zone called `itzone`.

Note: You do not have to set all three limits, but you must set at least one. These settings are persistent.

Practice 6-3 Overview: Allocating Resources to Zones

This practice covers the following topics:

- Enabling services for resource pools
- Configuring a persistent resource pool
- Binding the zone to a persistent resource pool
- Removing the resource pool configuration

This practice should take about 25 minutes to complete.

Lesson Agenda

- Planning for a Virtual Network and Zones
- Configuring a Virtual Network
- Configuring Zones to Use VNICs
- Allocating and Managing System Resources in a Zone
- **Managing Resources on the Virtual Network**

Managing Resources on the Virtual Network

This section covers the following topics:

- Determining the configured VNIC states
- Creating and implementing a flow
- Displaying flow controls
- Setting flow properties
- Displaying flow control properties
- Setting a priority property

Determining the Configured VNIC States

To determine the current state of the VNICs on the system, use `dladm show-link`.

```
# dladm show-link
net1                 phys       1500   unknown   --
net2                 phys       1500   unknown   --
net0                 phys       1500   up        --
net3                 phys       1500   unknown   --
stub0                etherstub  9000   unknown   --
vnic0                vnic       9000   up        stub0
vnic1                vnic       9000   up        stub0
hrzone/vnic1         vnic       9000   up        stub0
vnic2                vnic       9000   up        stub0
itzone/vnic2         vnic       9000   up        stub0
itzone/net0          vnic       1500   up        net0
hrzone/net0          vnic       1500   up        net0
```


Before you create a flow, you want to determine the current state of the VNICs that you want to create the flow for. To do this, use `dladm show-link`, as shown in the example in the slide. As you can see, the VNICs that you created earlier are up.

Creating and Adding a Flow

1. Create a new VNIC by using `dladm create-vnic -l` *`etherstub vnic`*.
2. Select the attribute on which you want to base the flow.
3. Determine how you want to customize the flow's use of the network resources.
4. Add the VNIC as a flow by using `flowadm add-flow -l link -a attribute=value` *`flow`*.

```
# dladm create-vnic -l stub0 vnic3
# flowadm add-flow -l vnic3 -a transport=tcp,local_port=80 http1
# flowadm show-flow
FLOW         LINK           IPADDR       PROTO  LPORT   RPORT  DSFLD
http1        vnic3          --           tcp     80      --     --
```


To create a flow, you first create a new VNIC. You then select the attribute that you want to base the flow on, and then determine how you want to customize the flow's use of resources by selecting the bandwidth and priority settings for the network resource.

Next, you add the VNIC as a flow by using the `flowadm add-flow` command followed by the `-l` option, the link name, the `-a` option that specifies the attribute value, the attribute value, and the flow name.

In this example, you have created a new VNIC, `vnic3`, to add as a flow. The flow is based on the TCP transport protocol, which is the attribute. You have defined the transport as local and assigned it to port `80`. The name of the flow is `http1`.

Displaying Flow Controls

To display the flow controls that are currently configured in the system, use `flowadm show-flow`.

```
# flowadm show-flow
FLOW            LINK      IPADDR         PROTO  LPORT    RPORT    DSFLD
http1           vnic3      --             tcp     --       --       --
```


To display the flow controls that are currently configured in the system, use the `flowadm show-flow` command, as shown in the example in the slide. As you can see, there is only one flow that is currently configured in the system, and that is the flow that you just created.

Setting Flow Properties

To set a flow property, use `flowadm set-flowprop -p property=value` *`flow`*.

```
# flowadm set-flowprop -p maxbw=100M http1
```


To set a flow property, use the `flowadm set-flowprop` command followed by the `-p` option to specify the properties that you want to use to control the resources, property values, and flow name.

In the example in the slide, the maximum bandwidth is set to 100 MB per second.

Note: The value that you set for the bandwidth must be within the allowed range of values for the link's bandwidth. To display the possible range of values for a link's bandwidth, check the `POSSIBLE` field in the output that is generated by the following command: `dladm show-linkprop -p maxbw` *`link`*.

Displaying Flow Control Properties

To display a flow's control properties, use `flowadm show-flowprop flow`.

```
# flowadm show-flowprop http1
FLOW          PROPERTY          VALUE        DEFAULT        POSSIBLE
http1         maxbw             100          --             --
```


If you want to see the control properties that a flow has, you can do so by using the `flowadm show-flowprop` command, as shown in the example in the slide.

Setting a Priority Property

To set a link property, use `dladm set-linkprop -p property=high` *`vnic`*.

```
# dladm set-linkprop -p priority=high vnic1
```

To view the priority property for a link, use `dladm show-linkproperty -p priority` *`vnic`*.

```
# dladm set-linkprop -p priority=high vnic1
# dladm show-linkprop -p priority vnic1
LINK     PROPERTY        PERM VALUE      DEFAULT        POSSIBLE
vnic1    priority        rw   high       high           low,medium,high
```


After you set the flow properties, you can also set a priority property on the link. To do so, use the `dladm set-linkprop` command followed by the `-p` option to specify the priority value, the priority value itself, and the name of the VNIC, as shown in the first example in the slide. The possible priority values are low, medium, and high. In this example, the link priority for `vnic1` is set to high.

To view the priority property for a link, you can use the `dladm show-linkprop` command followed by the `-p` priority subcommand and the name of the VNIC, as shown in the second example.

Practices 6-4 and 6-5 Overview: Managing the Virtual Network Data Flow and Removing Part of the Virtual Network

These practices cover the following topics:

- Managing resources on the virtual network by using data flows
- Dismantling the virtual network and zones

Each practice should take about 10 minutes to complete.

Summary

In this lesson, you should have learned how to:

- Implement a plan to configure Oracle Solaris zones with a virtual network
- Create a virtual network
- Configure Oracle Solaris zones to use VNICs
- Allocate resources to an Oracle Solaris zone
- Manage virtual network resources