Oracle Database 10*g*: Managing Oracle on Linux for DBAs

Student Guide

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Preface

Profile

Before You Begin This Course

Before you begin this course, you should have working knowledge with administering an Oracle database.

How This Course Is Organized

Oracle Database 10*g*: Managing Oracle on Linux for DBAs 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

Title	Part Number
Oracle® Database Administrator's Guide 10g Release 2 (10.2)	B14231-02
Oracle® Database Installation Guide 10g Release 2 (10.2) for Linux x86	B15660-02
Oracle® Database Release Notes 10g Release 2 (10.2) for Linux x86	B15659-05

Additional Publications

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

Typographic Conventions

What follows are two lists of typographical conventions that are used specifically within text or within code.

Typographic Conventions Within Text

Convention	Object or Term	Example
Uppercase	Commands, functions, column names, table names, PL/SQL objects, schemas	Use the `SELECT` command to view information stored in the `LAST_NAME` column of the `EMPLOYEES` table.
Lowercase, italic	Filenames, syntax variables, usernames, passwords	**where:** *role* is the name of the role to be created.
Initial cap	Trigger and button names	Assign a When-Validate-Item trigger to the ORD block. Choose Cancel.
Italic	Books, names of courses and manuals, and emphasized words or phrases	For more information on the subject see *Oracle SQL Reference Manual* Do *not* save changes to the database.
Quotation marks	Lesson module titles referenced within a course	This subject is covered in Lesson 3, "Working with Objects."

Typographic Conventions (continued)

Typographic Conventions Within Code

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	`./runInstaller`

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Introduction

Objectives

After completing this lesson, you should be able to:

- **Interpret Linux kernel version information**
- **Identify a tainted kernel**
- **Use common Linux commands**
- **Write a simple bash shell script**

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Suggested Course Schedule

1: Introduction
2: Preparing Linux for Oracle
3: Installing Oracle on Linux
4: Managing Storage
5: Automatic Storage Management
6: Creating the Database

7: Customizing Oracle on Linux
8: Managing Memory
9: Using Linux Measurement Tools
10: Tuning Performance
11: Debugging Oracle on Linux

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Supported Linux Distributions

	x86	x86-64	Itanium
EL 4	✓	✓	
RHEL AS/ES 3	✓	✓	✓
RHEL AS/ES 4	✓	✓	✓
SuSE SLES-9	✓	✓	✓
SuSE SLES-10		✓	
Asianux 2.0		✓	

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Supported Linux Distributions

This chart shows the supported Linux distributions for Oracle Database 10*g*R2.

Enterprise Linux is available on x86 and x86-64 platforms.

The Red Hat versions are:

- Advanced Server 3 and 4 (RHEL/AS)
- Edge Server 3 and 4 (RHEL/ES)

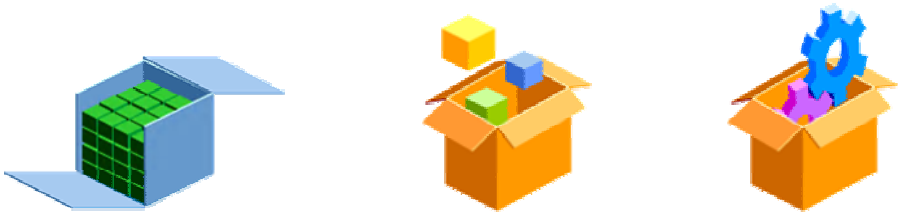
The supported SuSE Linux version is SuSE Linux Enterprise Server 9.

The supported Asianux-based distributions are:

- Red Flag DC Server 5.0 and later
- Miracle Linux 4.0 and later

Linux Distribution: Overview

- The core parts of the Linux system are the following:
  - Packages
  - The kernel
- Certified distributions are made up of packages that contain programs.



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Linux Distribution: Overview

The Linux software distribution consists of a software set that is provided by a vendor, usually in the form of packages. Various packages are installed based on the responses in the dialog that occurs during installation. Packages can provide the kernel, kernel patches, modules, applications, and file systems.

Linux Packages

The Linux system is made up of software that is delivered as packages:

- **Packages deliver:**
  - **Applications**
  - **The kernel**
  - **Configurations**
- **Packages are built from:**
  - **Sources**
  - **Patches**

Enterprise Linux uses the Red Hat Package Manager (RPM) package format.

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Linux Packages

Modules

The modules in a Linux distribution can be either kernel based or loadable. Kernel-based modules have to be compiled in, whereas loadable modules can be added without recompiling. All the stock kernels include support for loadable modules.

Packages

The Linux software for most of the supported distributions is assembled into packages. These are precompiled binaries that can be installed on and removed from your system with a package manager. With packages, you can update the kernel, patch, and add functionality. Some third-party vendors distribute binary modules that are loaded into the kernel. These modules may be proprietary modules where the source code is not available for Linux developers to investigate. If there are such modules loaded, then Oracle will support that OS fully, except in the event that the problem is caused by a proprietary module. In this case, support will be deferred to the supplier of that module.

Note: Package management is covered in detail in the lesson titled “Preparing Linux for Oracle.”

Linux Kernel

The Linux kernel is the core of the operating system. It is:

- **Configurable**
- **Supportable**
  - **Supplied kernel**
  - **Patched by vendor**
  - **A certified, unmodified distribution**

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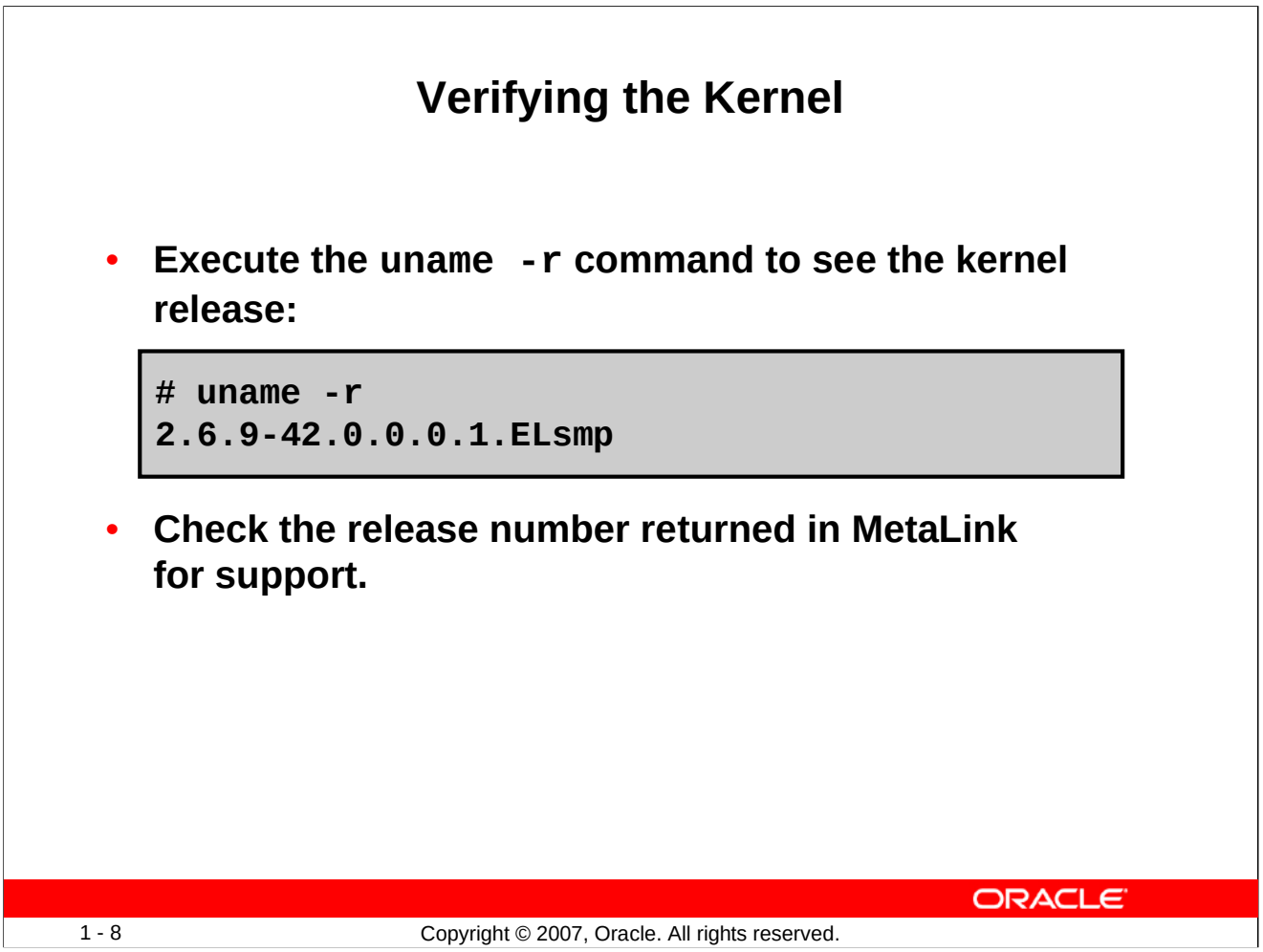
Linux Kernel

Linux, like most modern operating systems, has a kernel that is loaded at boot time and stays in the memory. The kernel in Linux, unlike in many other operating systems, can be customized infinitely. You can include or exclude modules that make up the kernel, by using the kernel configuration file.

If the kernel still does not behave to your satisfaction, source code is available for you to change it to your specification. This can lead to a support problem. If you are running a kernel that is different than the one that was tested by the vendor, then Oracle Support Services (OSS) cannot identify where the problem is, in your database or the OS.

Oracle Corporation supports only stock kernels. That means only kernels supplied by the certified distributions are supported. Kernels that are patched by packages by the kernel vendor are also supported. For more information about kernel support, see note 228374.1, *Linux Operating System Support*, on MetaLink.

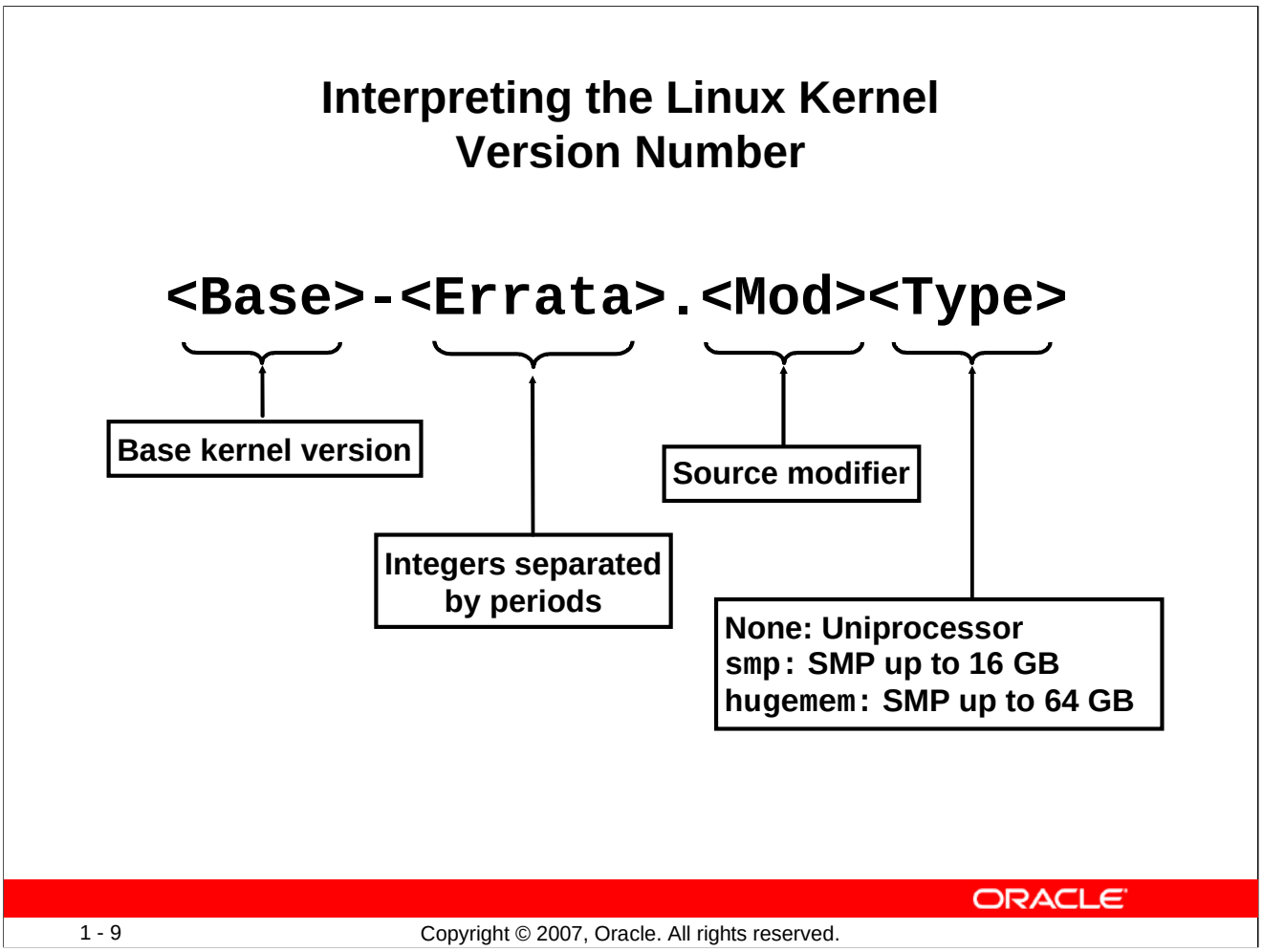


Verifying the Kernel

View the kernel release using the `uname` command, as shown.

You can see the *name* of the release on EL by viewing the `/etc/enterprise-release` file. For example:

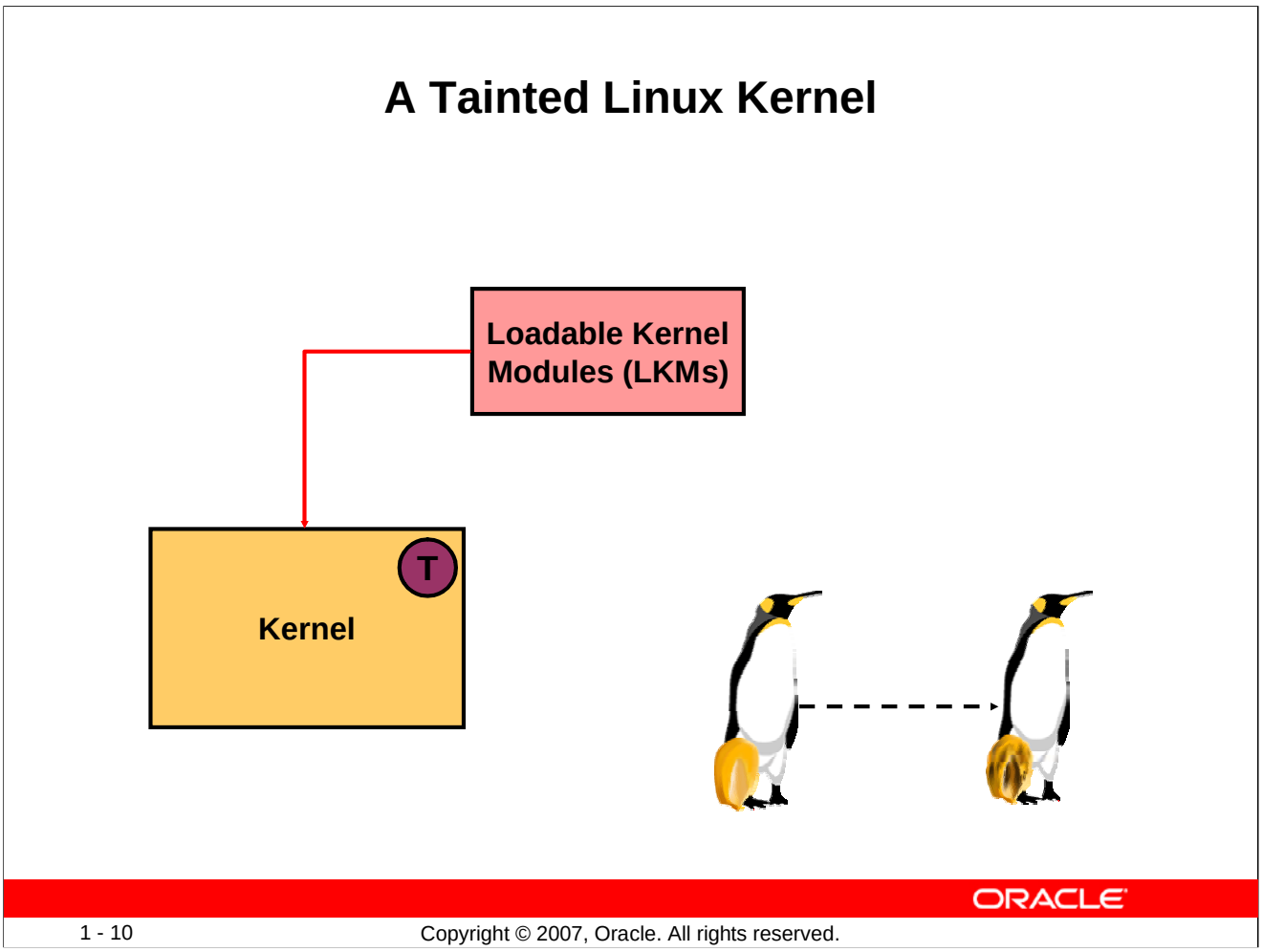
```
# cat enterprise-release
Enterprise Linux Enterprise Linux AS release 4 (October Update 4)
```



Interpreting the Linux Kernel Version Number

The Linux kernel version numbers reflect information about the kernel. More than just what revision of the source code was used to compile it, it shows what machine models it runs on, and also the source from where the kernel originated. The fields of the version number are as follows:

- **Base:** The base kernel version. This is typically three or four integers separated by periods. This number can be traced back to a year when that kernel version was first made available. The first two integers do not change very often. For example, the current version, referred to as "the two six kernel" for 2.6, was originally available in 2003, and is still, as of 2006, the base version number. This course is based on the 2.6.9 kernel.
- **Errata:** An extra version number to reflect fixes after the base version was released. This typically reflects errors that were fixed, or minor enhancements to the kernel.
- **Mod:** The source modifier for the kernel. This indicates where the kernel originated from. The values of this field can vary greatly. For example, it could be a developer's initials, or an organization's initials. The kernel being used in this course has EL as a source modifier, which stands for Enterprise Linux.
- **Type:** The type of architecture the kernel is targeted for. This can be `hugemem`, `smp`, or `blank`. The meanings of `hugemem` and `smp` are covered in the lesson titled "Managing Memory."



A Tainted Linux Kernel

A General Public License (GPL) is a software license that provides for basically free use of software under certain conditions. It is commonly used in the open source community.

A kernel that is delivered with a GPL distribution is considered untainted. There are two actions that cause a kernel to become tainted:

- A non-GPL module is loaded into the kernel.
- A module is force-loaded into the kernel. Consider that a given module is compiled for use with a specific version of a kernel. If that module is introduced to a kernel with a different version number, then an error is returned, and the module is not loaded into the kernel. The sysadmin (SA) may choose to force the module to load anyway. Force loading causes the kernel to be marked as tainted.

If a kernel is tainted, Oracle may or may not support it, depending on the source of the tainting. Here are two cases where a tainted kernel is supported:

- OCFS: See MetaLink note 276450.1.
- EMC Powerpath driver: See MetaLink note 284823.1.

Checking for a Tainted Kernel

Determine whether a kernel is tainted by:

- **Viewing the contents of `/proc/sys/kernel/tainted`:**

```
# cat /proc/sys/kernel/tainted
0
```

`0` = not tainted
`1` = tainted

- **Running `lsmod` to list the status of modules:**

```
# lsmod
Module                  Size  Used by    Not tainted
oracleasm              48020  1
loop                   15817  4
```

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Checking for a Tainted Kernel

A tainted kernel is one that has had modifications done to it that are not normally supported.

The `/proc/sys/kernel/tainted` file indicates whether the kernel is tainted or not. Zero means it is not tainted, and one means it is tainted.

You can also run the `lsmod` command, and look for the tainted string in the header. This may also be blank, indicating it is not tainted.

Supported Hardware

- **Oracle Corporation does not certify hardware; only OS platforms.**
- **Customers must check with the OS vendors for supported hardware.**

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Supported Hardware

Oracle Corporation supports a given Linux distribution on any platform or drivers that the vendor supports. For details about hardware configurations that are certified with Enterprise Linux, see http://linux.oracle.com/hardware.html.

Common Linux Commands and Programs

- `ls`: List files
- `cp`: Copy files
- `mv`: Move and rename files
- `mkdir`: Make a directory
- `alias`: Define command macros
- `rm`: Remove files and directories
- `more`: Page through output
- `head`: Show beginning of file contents
- `tail`: Show end of file contents
- `df`: Display filesystem space usage
- `du`: Display directory disk space usage

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Common Linux Commands and Programs

- `cat`: Show and concatenate files
- `grep`: Search for patterns in files
- `chmod`: Change permissions of files
- `chown`: Change owner of files
- `zip`: Compress and package files together
- `gedit`: A WYSIWYG text editor
- `export`: Make environment settings global
- `ps`: List running processes
- `touch`: Change file time stamps
- `id`: Show information about the current user
- `sudo`: Execute commands as another user

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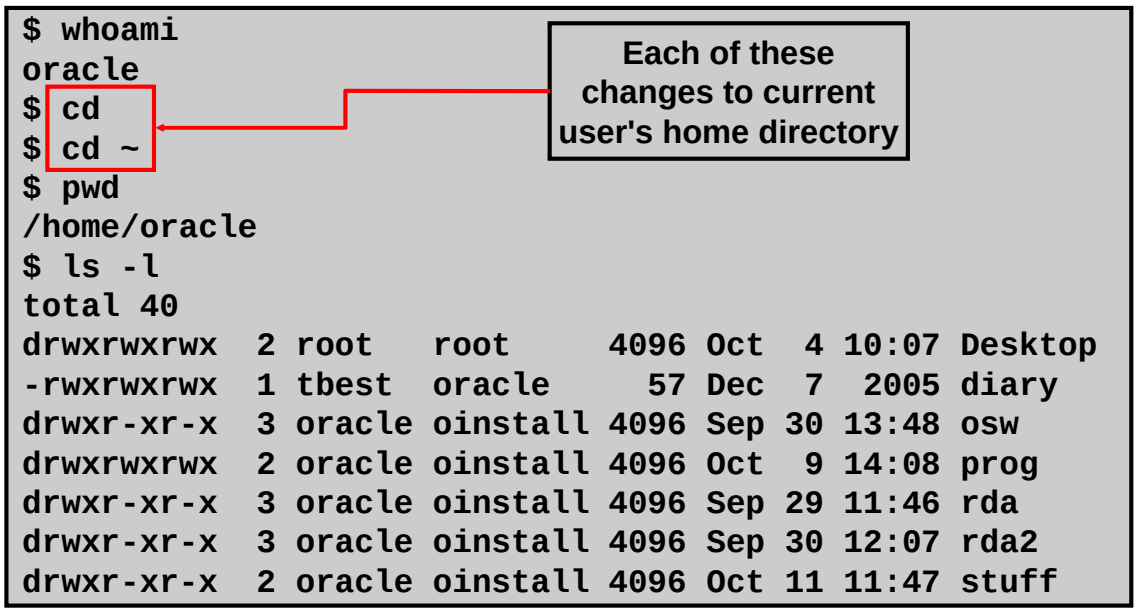
Note

Use the `man` command to see the manual pages for any command. For example, the following displays the manual pages for the `touch` command:

```
$ man touch
```

Navigating the File System



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Navigating the File System

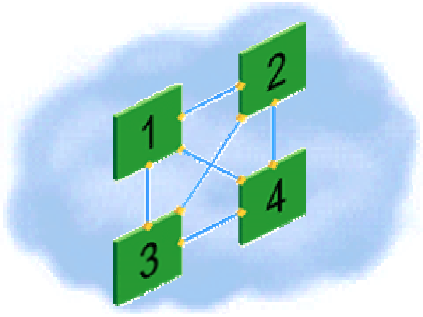
Use the following conventions when navigating the file system:

- Use a slash to separate directory names.
- Use a period to indicate the current directory.
- Each user has a home directory, which can be referred to using the tilde character.
- Mostly use `cd`, `pwd`, and `ls` to navigate and explore the file system from the command line.
- Permissions are noted in the form of a user and group associated with the entry, and a set of permission bits. File system security and permission bits are covered in detail in the lesson titled “Installing Oracle on Linux.”

The Virtual File System

The virtual file system on Linux is referenced as the `/proc` directory, and:

- **Does not exist on any permanent media**
- **Is a representation of what is in kernel memory**
- **Can be compared to the v$ views in an Oracle database instance, except that they can be modified**



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The Virtual File System

The contents of the `/proc` file system represent the current state of the operating system kernel. This information is stored in memory, actually in the kernel. The `/proc` file system is a means for allowing a system administrator to access it easily, because a file system is a ubiquitous information structure.

Some of the information is simply represented as files under the `/proc` directory, such as:

- **`meminfo:`** Memory segment sizes and statistics
- **`uptime:`** Number of seconds since the system was rebooted, followed by the number of seconds the system has been idle
- **`partitions:`** Names and sizes of disk partitions

But there are also virtual files stored under subdirectories, such as:

- **`net:`** Network-related information
- **`sys:`** Low-level operating system settings, including kernel parameters

Using the Virtual File System

You use the virtual file system to:

- **View the current state of the kernel**
- **Change kernel parameters**

```
# cd /proc/sys/kernel
# ls -l threads-max
-rw-r--r--  1 root root 0 Dec 28 18:12 threads-max
# echo 16375 >/proc/sys/kernel/threads-max
```

```
# cd /proc/sys/kernel
# ls -l tainted
-r--r--r--  1 root root 0 Dec 28 18:14 tainted
# echo 0 >tainted
-bash: tainted: Operation not permitted
```

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Using the Virtual File System

You can consider the virtual file system as a set of files. The can be viewed simply by using commands such as `cat` or `more`. You can also change the values of some kernel parameters by writing values into the appropriate file. You can tell if the file can be changed by looking at its write permissions. If it has the write bit on, then you can edit it. If it does not, then you are not able to update it; it is intended to be read-only.

The first example in the slide modifies the maximum number of threads on the system. Note that the file listing shows up as writable.

In the second example, an attempt is made to change the tainted flag, using the virtual file system. Because it is not a writable file, the change fails.

Bash Shell Scripting

Basic attributes of bash shell scripting are:

- **Environment variables**

```
$ SOMEVAR=thisvalue
$ echo $SOMEVAR
thisvalue
```

- **Input and output redirecting**
  - **Write output to file:**

```
$ ls -l >/tmp/filelist
```

  - **Append output to file:**

```
$ date >>/tmp/filelist
```

  - **Pipe output to another command:**

```
$ ls -l | more
```

- **Flow control**
  - **`if`: Test a condition and branch based on the result**
  - **`case`: Actions to take based on a list of conditions**
  - **`while`: Loop while a condition exists**
  - **`for`: Loop while a condition or list exists**

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Bash Shell Scripting

The following are the major scripting features provided by the bash shell:

- **Environment variables:** You can set and interrogate environment variables. You must not put any spaces on either side of the equal sign; an error results if you do so.
- **Input and Output redirection:** You can direct output from one program to be the input of another program. You can also direct input to come from a file, and output to go into a file. Use the greater than sign (“>”) in front of the file name to direct output to the file, creating it if it does not exist, or replacing any existing contents if it does exist. Use two greater than signs (">>") to append the output to an existing file.
- **Flow control:** You have the ability to control the flow of the script using conditional logic. The following are the most common control constructs:
  - **`if`:** Test a condition and branch based on the result
  - **`case`:** Specify actions to take based on a list of conditions
  - **`while`:** Loop while a condition exists
  - **`for`:** Loop while a condition exists or until a list is exhausted

Bash Shell Scripting: Environment Variables

The following are some of the variables that are available:

- **Built-in shell variables:**
  - **PWD: The current working directory**
  - **$#: Number of command shell variables**
  - **$?: Exit value of last command**
  - **$*n*: Positional command-line arguments**
  - **$*: All command-line arguments**
- **Other variables:**
  - **HOME: The current user's home directory**
  - **PATH: List of directories to search for programs**
  - **PS1: Primary prompt string**

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Bash Shell Scripting: Environment Variables

The following variables are available in the bash shell:

- **PWD:** The current working directory
  ```
  $ echo $PWD
  /home/oracle
  ```
- **$#:** The number of command shell variables. This allows you to know how many command-like values were provided so that they can be processed, for example, by a loop.
- **$?:** The exit status value of the last command. This is useful for taking action based on the success or failure of previous commands or other called shell scripts.
- **$*n*:** Any of the command-line parameters, according to their position (for example, `$1`, `$2`, and so on). `$0` is the command or script name as it was invoked on the command line.
  - For this example script called `showparams.sh`:
    ```
    echo $0
    echo $2
    ```
  - This is the output, based on this invocation:
    ```
    $ ./showparms.sh abc xyz
    ./showparms.sh
    xyz
    ```
- **$*:** All command-line parameters passed in to the shell script

Bash Shell Scripting: Environment Variables (continued)

The following variables are also available in the bash shell:

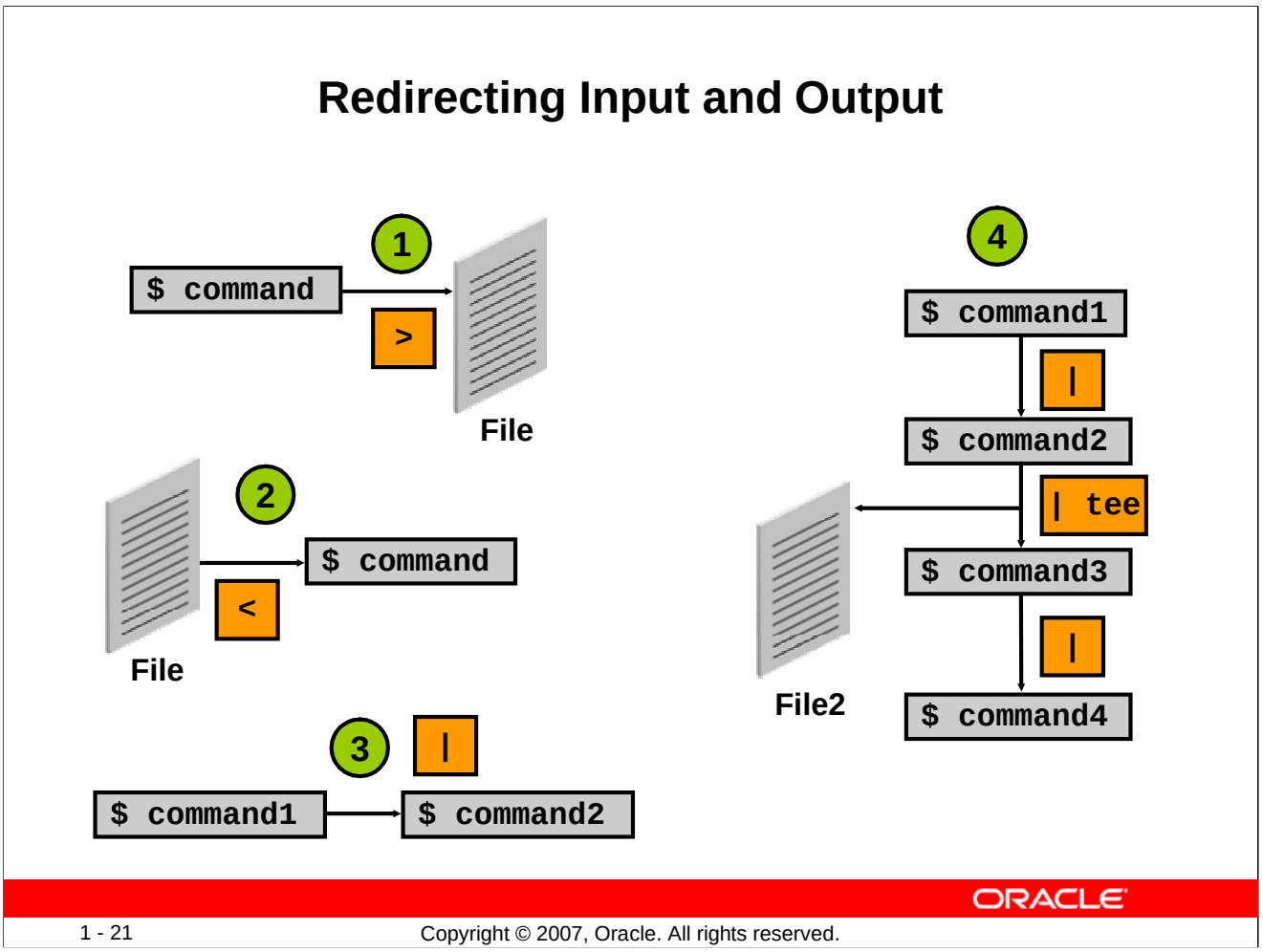
- **HOME:** The current user's home directory. A shortcut for this is the tilde character ("~"). For example:

```
$ echo $HOME
/home/oracle
$ cd ~
$ pwd
/home/oracle
```

- **PATH:** The list of directories to be searched when looking for a command or executable file that is being invoked. Each directory is separated by a colon (":") .
  - An example of a PATH setting is:
    `/usr/local/bin:/bin:/usr/bin:/home/vncuser/bin`
  - Which means that any unqualified command or script names entered on the command line will be located by searching these directories, in the order specified. An unqualified script is one that has no directory specification in front of it.
- **PS1:** Primary prompt string. This defines what is displayed at the command-line prompt. This can contain literal strings, but special characters may be included to display dynamic values based on your environment. These are some of the most often used characters:
  - **\h:** The host name, up to the first period
  - **\u:** The current user's name
  - **\w:** The current directory, shown fully
  - **\W:** The same as \w, except that it shows only the last subdirectory name, not the full directory name

  In the following example, the username, machine name, and current directory are included in the prompt:

```
[vncuser@EDRSR9P1 ~]$ echo $PS1
[\u@\h \W]\$
[vncuser@EDRSR9P1 ~]$ cd /tmp/files
[vncuser@EDRSR9P1 files]$
```



Redirecting Input and Output

You can redirect from where input for a command program comes, and also to where the output goes. This enables you to string together many commands and files in a single OS command line submittal.

When redirecting input and output from and to a file, respectively, you use the I/O redirection syntax, which is made up of the following characters:

- **>:** The greater than sign, which means direct the output to the specified file
- **<:** The less than sign, which means read the input from the specified file
- **>>:** Two greater than signs, which means append the output to the specified file that may already exist

If you want to direct input and output from or to another command, respectively, then use the pipe character, which is **|**(the vertical bar).

You can also direct output to a file and to the terminal at the same time. This is a way to see the output on the terminal and also have it written to a file. Use the `tee` keyword to do this.

Redirecting Input and Output (continued)

In the slide, the following scenarios are illustrated:

1. A command is run, and its output is written to a file. The following example writes the directory listing out to the `out.txt` file:

```
ls –a >out.txt
```

2. A command is run, and its input is taken from a file. In the example, the `factor` command is used, which calculates and displays the prime factors of the provided number, which come from the standard input stream. You can indicate that `factor` should read a list of numbers from a file by redirecting input from a file that contains those numbers:

```
$ factor <numbers.dat
23: 23
55: 5 11
103: 103
86: 2 43
256: 2 2 2 2 2 2 2 2
```

   This presumes the `numbers.dat` file has the following contents:

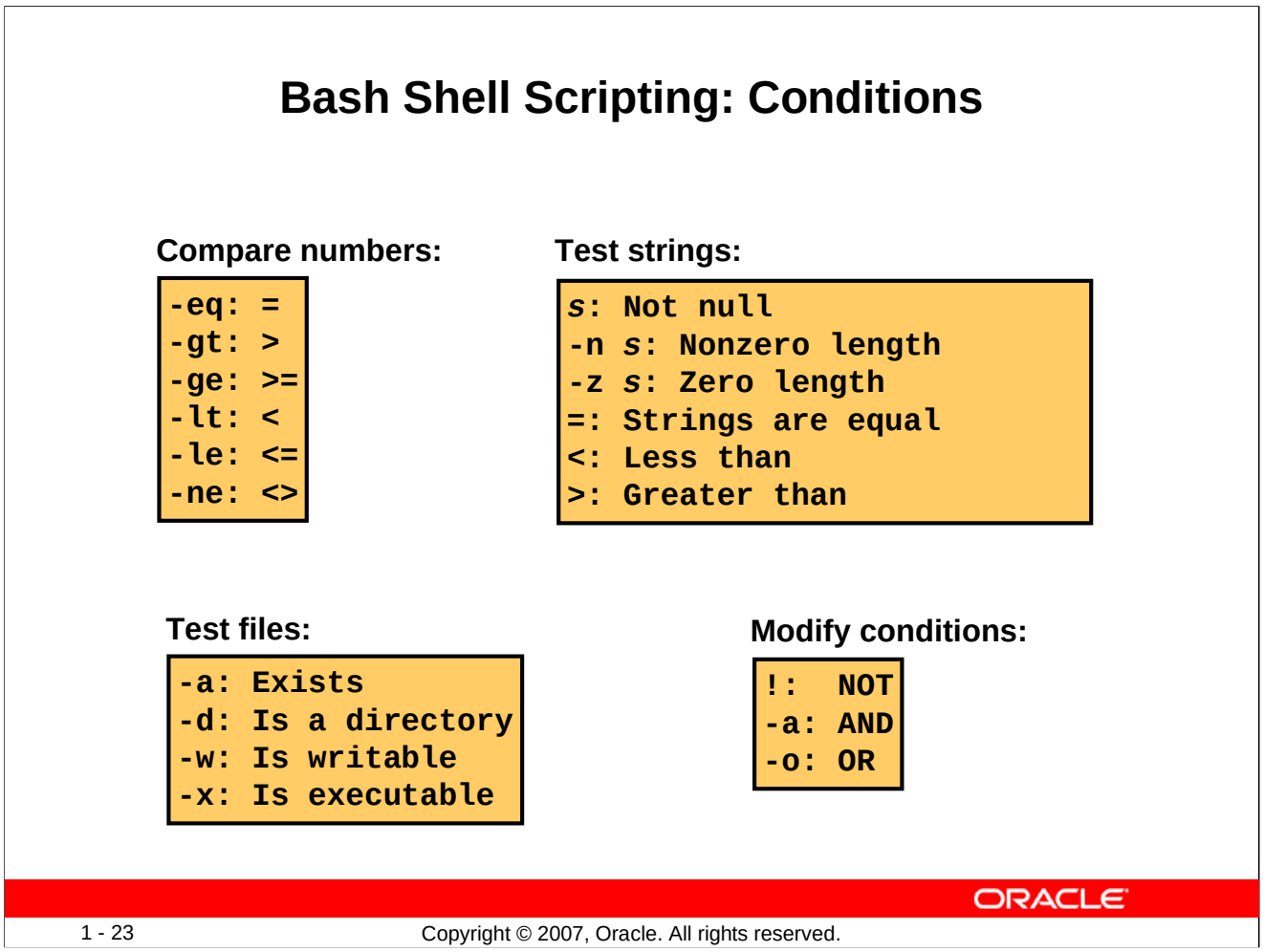
```
23
55
103
86
256
```

3. A command is run, and its output is provided as input to a second command. In the following example, the process listing is searched for incidents of the string `_pmon_`, which is the Oracle Database process monitor. There are three occurrences: one for each database instance running, and one for the `grep` command itself because it is also a running process at the time.

```
$ ps -ef | grep _pmon_
oracle 6985     1  0 Sep27 ?     00:01:29 asm_pmon_+ASM
oracle 6886     1  0 Oct15 ?     00:00:22 ora_pmon_orcl
oracle 3571 21645  0 12:34 pts/3 00:00:00 grep _pmon_
```

4. A series of four commands are run, each accepting as input the output of the previous command. Also, the output of the second command is written to a file. This example parses out the process listing down to displaying only the names of the two database instances that are currently running a `pmon` process. Note that `grep –v` searches for those lines in the input that do *not* have the given string. That serves to eliminate the process that is the `grep` command itself, which was shown in example (3). The `cut` command is used here to extract only characters 58 through 61 inclusive.

```
$ ps -ef | grep _pmon_ | tee all_pmon.txt | grep -v grep | cut -
c58-61
+ASM
orcl
```



Bash Shell Scripting: Conditions

In the slide are some common syntaxes for testing conditions in the bash shell. Put the condition expression inside brackets:

```
[ cond ]
```

It is required that you put a space on each side of the condition to separate it from the brackets. You can use the test syntax instead of the brackets, but there are some syntax variations for some constructs. For details, see the manual pages for `bash` and `test`.

Some examples of condition-testing syntax are listed below:

- Test if the first command-line argument is a number greater than 5:

```
[ $1 > 5 ]
```

- Test if the file `somefile.dat` exists in the current directory:

```
[ -a somefile.dat ]
```

Bash Shell Scripting: case

Syntax:

```
case value in
  pattern1) commands1;;
  pattern2) commands2;;
esac
```

Example:

```
case $1 in
  up) sqlplus / as sysdba <<-END1
    startup;
    END1
    ;;
  down) sqlplus / as sysdba <<-END2
    shutdown immediate;
    END2
    ;;
  *) echo Unknown;;
esac
```

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Bash Shell Scripting: case

The `case` statement provides a way for you to define criteria, and then execute certain commands based upon that criteria. It is much like a series of `if-then-else` statements. The *value* is evaluated, and based upon its match to the patterns listed, the corresponding commands are executed. Only the commands associated with the first pattern matched are executed.

The example in the slide either starts up or shuts down the database, based on the input parameter, which can either be `up` or `down`. If it is neither of these, then the string `Unknown` is output.

Not unique to the `case` statement are the labels that delimit the input to the sqlplus invocation. When sqlplus is called, all the data appearing until the label name, END1 or END2, is encountered are sent to the sqlplus program as input.

Bash Shell Scripting: `while`

Syntax:

```
while condition
do
  commands
done
```

Example:

```
ps -ef | grep -i oracle |\
awk '{print $2}' |\
while read PID
do
  kill -9 ${PID}
done
```

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Bash Shell Scripting: `while`

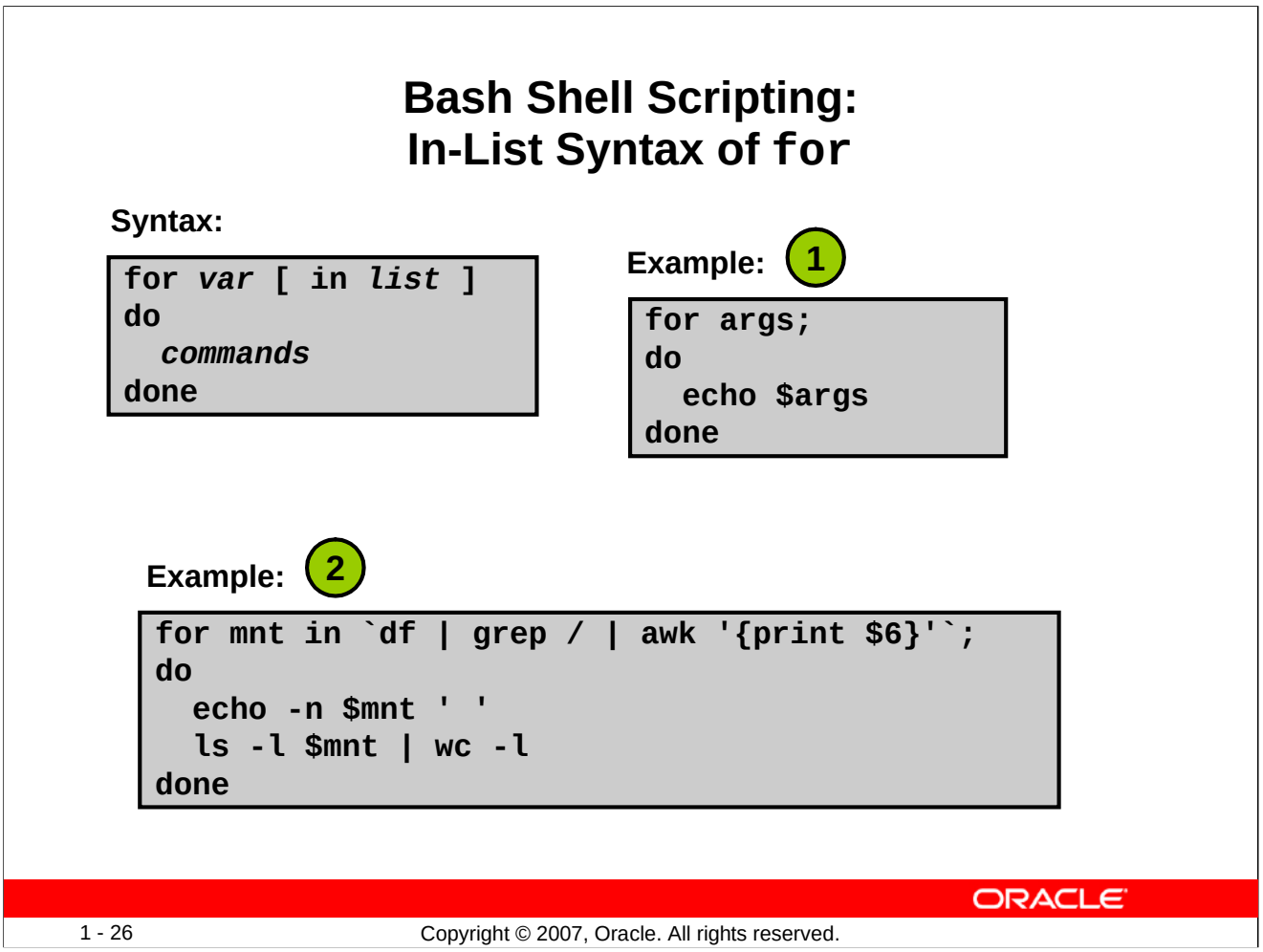
The `while` statement specifies a loop to execute as long as a certain condition remains true. In the example in the slide, a series of commands are run to filter down to the list of process IDs that have anything to do with oracle. Each of those process IDs is read by the `while` loop and fed to a `kill` command. This, in effect, kills all of these processes.

The commands, which pipe their output to one another, work together to filter out the process IDs thus:

1. The `ps` command lists every process on the system, in full format. This causes the user name and program name to be included in the listing.
2. The `grep` command searches for and outputs only those lines that contain the string `oracle`, regardless of case.
3. The `awk` command, which is actually a programming language in itself, outputs only the second field of the listing. The first field is the username, and the second field is the process ID.

So, only the process ID is piped into the `while` loop, which reads one at the top of each iteration, until they are exhausted. The kill statement refers to the variable that appeared in the `read` statement in the `while` condition. There is nothing special about the variable name. Here, it is `PID`, but it could be anything.

Note: For more information about `awk`, see the `man` pages.

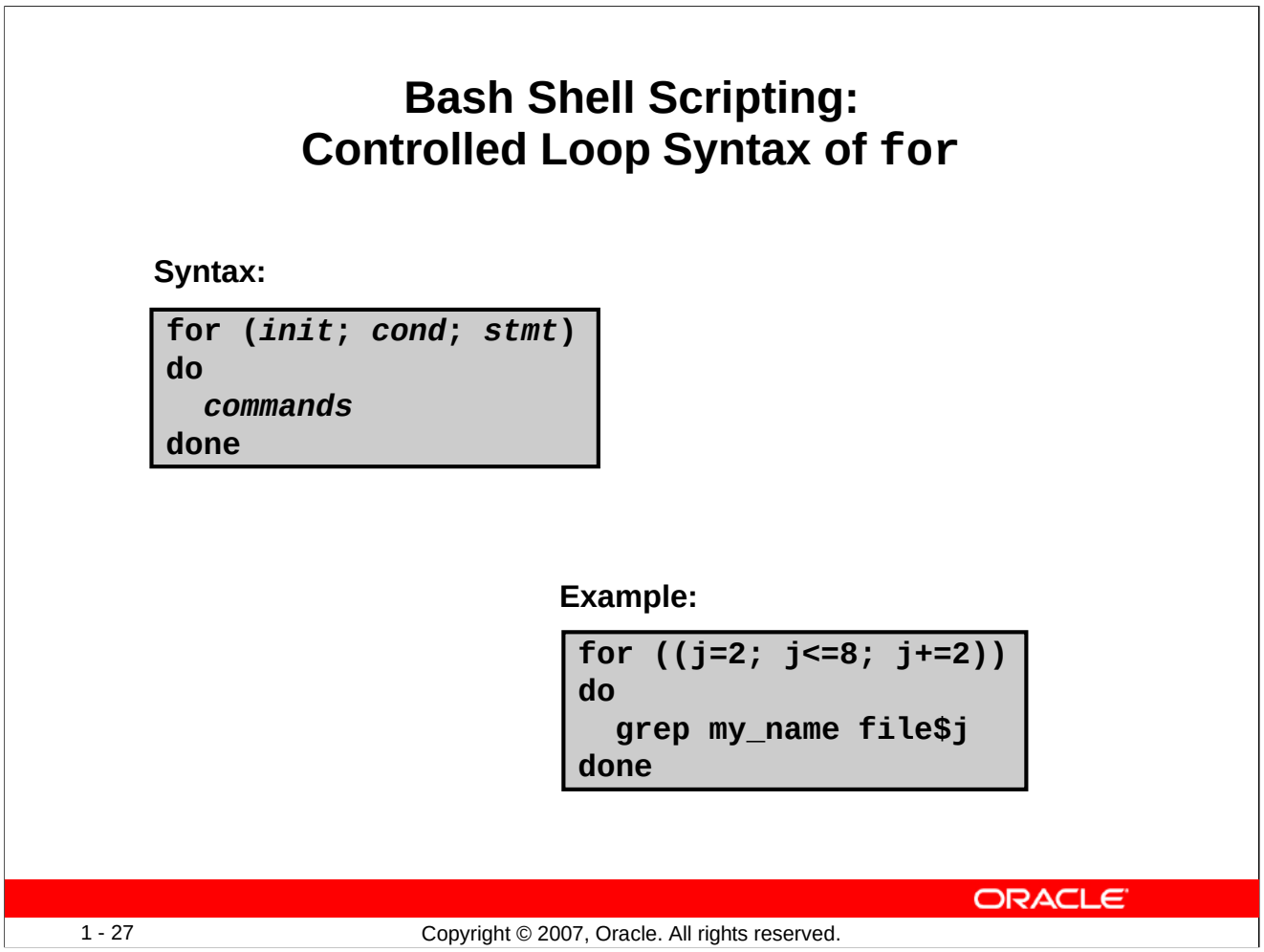


Bash Shell Scripting: In-List Syntax of `for`

There are two types of syntax for the `for` statement. The in-list syntax takes a list of items as input for processing in the loop. If no list is specified, the list of arguments supplied on the command line is processed. If a list is specified, that list is processed. The list can be the output of a command.

In the first example in the slide, because it is simply a variable name in the in-list, the values are taken from the command line provided as the shell was invoked. So, this would in effect display the white-space delimited arguments, each on a line by itself.

In example number two, the in-list is a command. The command generates a set of values, and each of those values is passed through the for loop separately. In this case, the `df` command generates a list of mount points, which are filtered down to only the mount points by searching for a slash. That is needed to remove the headings from the `df` output. Then the `awk` statement prints the mount point itself, such as `/dev/shm`. So, just the mount point is passed into the `for` loop. In the loop, the mount point is printed without a carriage return. That is done with the `–n` parameter of the `echo` command. A space is also printed, just for visual separation. Then, the number of entries in the mount point is printed using the `ls` command, and the entries are counted using the `wc` command. This does a word count, but the `–l` parameter causes it to count the lines instead.



Bash Shell Scripting: Controlled Loop Syntax of `for`

The controlled loop syntax is made up of three specifications that control the loop duration. The *`init`* expression is evaluated once, at the top of the first iteration of the loop. At the top of each loop iteration (including the first), *`cond`* (which is the condition for which to remain in the loop) is evaluated. If it is true, execution continues with the *`commands`* in the loop body. If it is false, then the loop is immediately exited, and execution continues after the `done` statement. At the bottom of each loop iteration, *`stmt`* is executed. This is usually a statement that increments or decrements a counter variable, upon which *`cond`* depends.

The example in the slide looks for the string "`my_name`" in the following files: `file2`, `file4`, `file6`, `file8`.

Summary

In this lesson, you should have learned how to:

- **Interpret Linux kernel version information**
- **Identify a tainted kernel**
- **Use common Linux commands**
- **Write a simple bash shell script**

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Practice 1 Overview: Working with Linux

This practice covers the following topics:

- **Identifying the kernel type**
- **Using Linux commands**
- **Writing a simple shell script**

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2

Preparing Linux for Oracle

Objectives

After completing this lesson, you should be able to:

- **Use the package manager to determine and update package support**
- **Set up the operating system environment for Oracle Database**
- **Create the necessary groups and users for Oracle Database**

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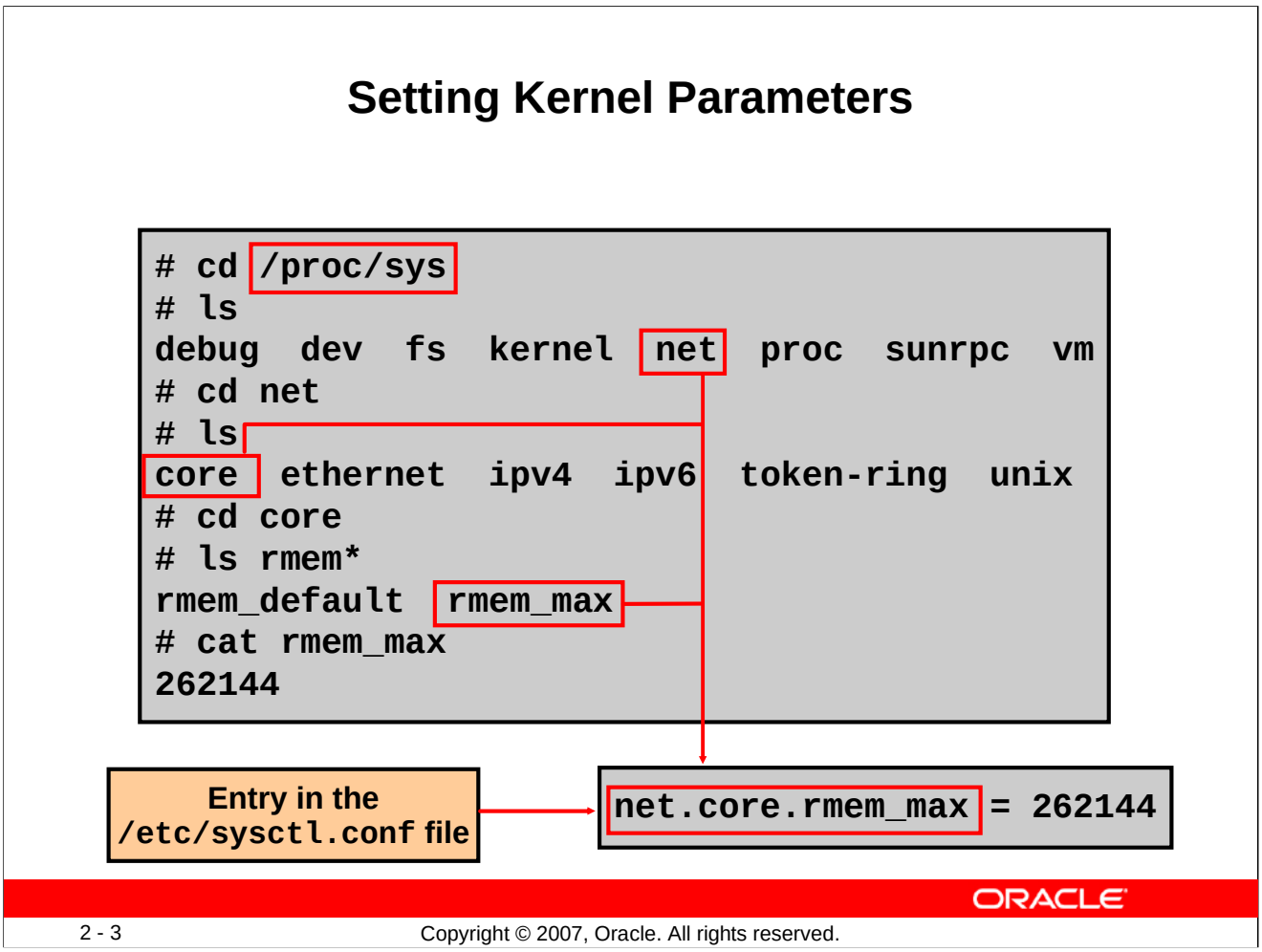
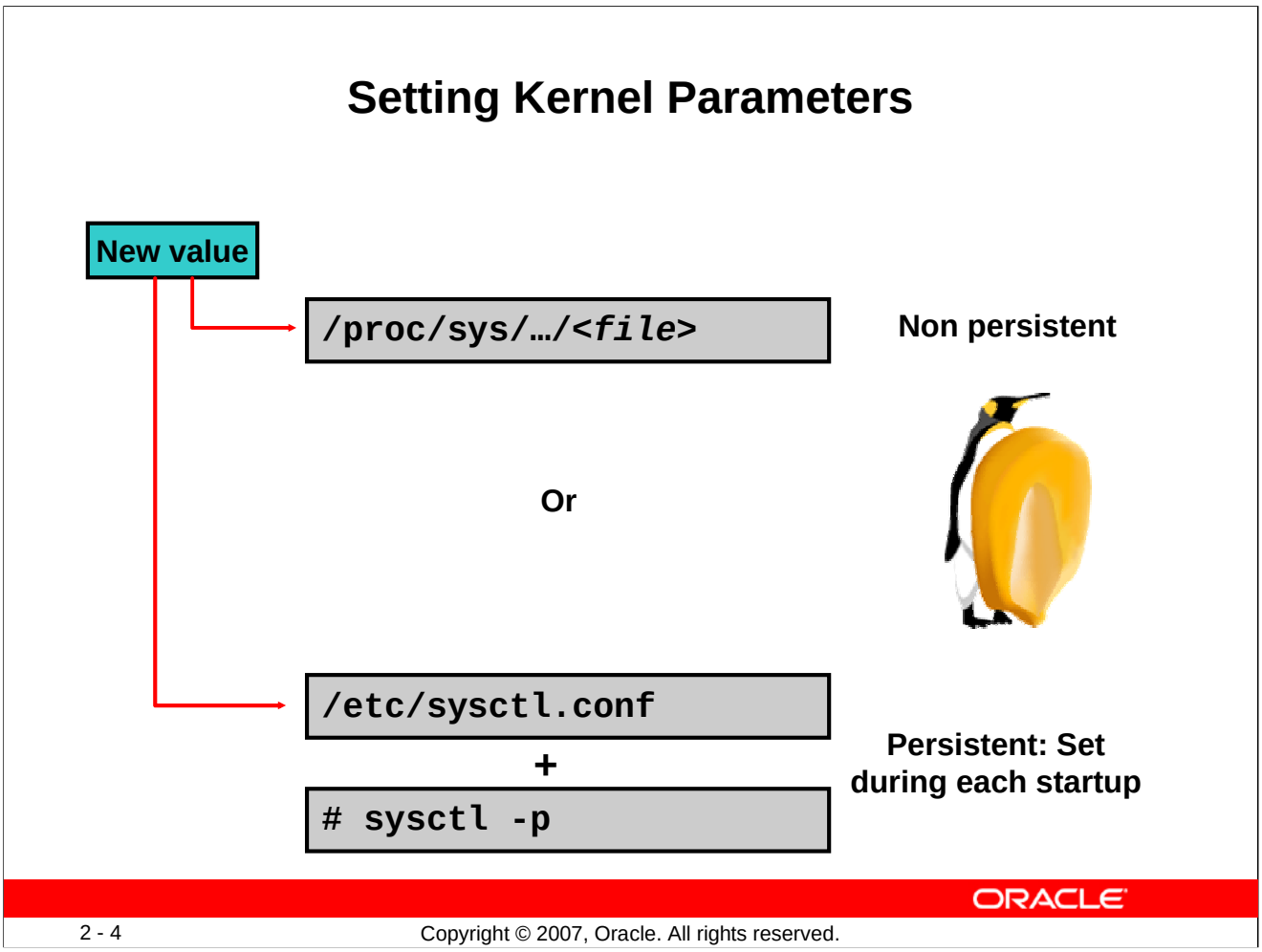


Setting Kernel Parameters

The kernel parameters can be set in either the `/proc/sys` file system or the `/etc/sysctl.conf` file. In the `/etc/sysctl.conf` file, each entry corresponds hierarchically to one of the files in the `/proc/sys` directory. The subdirectory names and the file name combine to define the parameter entry as it appears in the `/etc/sysctl.conf` file.

In the example in the slide, the current value of the `rmem_max` parameter can be viewed by looking at the `/proc/sys/net/core/rmem_max` file. Also, the corresponding `/etc/sysctl.conf` entry is shown as `net.core.rmem_max`.

The difference between these two methods of changing kernel parameters is explained in the following slides.



Setting Kernel Parameters (continued)

To view the current values of kernel parameters, use the `sysctl` utility:

```
# sysctl –a
```

To change a kernel parameter that will be effective only until the next reboot, write the new value into the appropriate file in the `/proc/sys` file system. For example, to change the SHMMAX parameter for this boot session only, use:

```
echo 2147483648 >/proc/sys/kernel/shmmax
```

After that, if the system is rebooted, this change is gone.

Further, you can make the parameter change such that it is reapplied each time the system is rebooted. This effectively makes the change persistent because it is reapplied during each boot sequence. To do this, edit the appropriate line in the `/etc/sysctl.conf` file, and then issue the `sysctl –p` command. The following is an example of an edited line in the `sysctl.conf` file:

```
kernel.shmmax = 2147483648
```

Alternatively, you can issue the following command, and the same persistent setting will be done:

```
sysctl -w kernel.shmmax = 2147483648
```

Setting Kernel Parameters (continued)

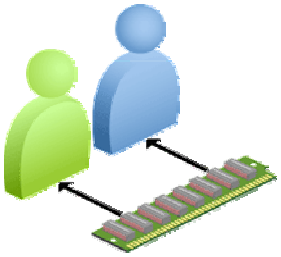
You must have root privileges to perform these operations.

Note: If you make a mistake with a parameter setting and your system does not start, then you must start Linux in the single-user runlevel (runlevel 1). At this runlevel, the `/etc/sysctl.conf` file is not run. The different runlevels will be discussed in detail in the lesson titled “Customizing Oracle on Linux.”

Linux Shared Memory: Overview

Shared memory can be accessed by multiple processes, and thus is used for the System Global Area (SGA). It has the following characteristics:

- **Shared memory is allocated in segments.**
- **Segments have a maximum size.**
- **A limited number of segments can be allocated.**



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Linux Shared Memory: Overview

The shared memory system on Linux works much like the shared memory on other UNIX platforms. Shared memory is allocated in segments. The maximum number of systemwide shared memory segments is set by the `SHMMNI` kernel parameter. The maximum size of each segment is determined by `SHMMAX`. A segment is not necessarily as large as the maximum size; it is only as big as is allocated. If a process needs a larger shared memory area than can be allocated in one segment, then it may allocate multiple segments.

Database instances often allocate multiple segments to accommodate a large SGA. The maximum number of segments to which one process may attach is set by `SHMSEG`.

For details about setting shared memory parameters for your Oracle database, refer to the MetaLink note 153961.1, *Semaphores and Shared Memory – An Overview*. For more information, refer to the MetaLink note 15566.1, *TECH: Unix Semaphores and Shared Memory Explained*.

Shared Memory Parameters for 32-Bit Linux

	Definition	Default	Oracle Minimum Requirement	Oracle Recommendation
shmall	Max number of shared memory pages	2097152 (0x200000)	2097152 (0x200000)	2097152 (0x200000)
shmmax	Max shared segment size in bytes	33554432 (0x2000000)	Half the size of physical memory	2147483648 (0x80000000)
shmmni	Max number of shared segments	4096	4096	4096

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Shared Memory Parameters for 32-Bit Linux

There are three memory-related kernel parameters. For Oracle Database, the `shmmax` parameter is the only one that needs to be modified from its default value. This parameter limits the size of each of the shared memory segments on the system. It should be equal to or larger than the largest SGA on the system; otherwise, the SGA is made up of multiple memory segments. The recommended number shown in the slide is 2 GB. This has been shown to be the setting that provides the greatest efficiency in Oracle's shared memory management. Too small a setting would result in a high number of segments, requiring more work in managing them. Too large a setting could result in failed attempts to allocate the memory segments. In that case, Oracle is forced to attempt other mechanisms that allocate separate shared memory segments. While they are separate, they are returned to the requesting database instance as a single segment. Oracle will attempt to allocate contiguous segments first. If that is not possible, it will allocate non-contiguous segments. The maximum value of this parameter is 4 GB.

The `shmall` parameter defines the maximum amount of shared memory that may be in use at any time on the system. If this is too small, you see out-of-memory errors because the needed memory is not allowed to be allocated. The default allows for over two million pages, which is sufficient for a 4 GB RAM system. This value should always be at least 90% of the physical RAM, divided by the page size. For example, if you have 16 GB of RAM, and a 4 KB page size, then this parameter should be set to:

```
(17179869184 * .9 ) / 4096 = 3774873 KB
```

Shared Memory Parameters for 32-Bit Linux (continued)

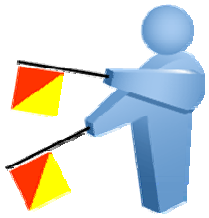
The `shmmni` parameter defines the maximum number of shared memory segments across the system. The default 4096 value is sufficient for any size SGA. This is because any larger SGA would instead require an increase in the size of each shared memory segment.

Note: For details about these kernel parameters, refer to the *Oracle Database Installation Guide 10g Release 2 (10.2) for Linux x86*.

Semaphores

Semaphores control access to critical resources, code, and shared memory:

- **semmsl: Maximum number of semaphores per set**
- **semmns: Total number of semaphores in the system**
- **semopm: Maximum number of operations per semop call**
- **semmni: Maximum number of semaphore sets**



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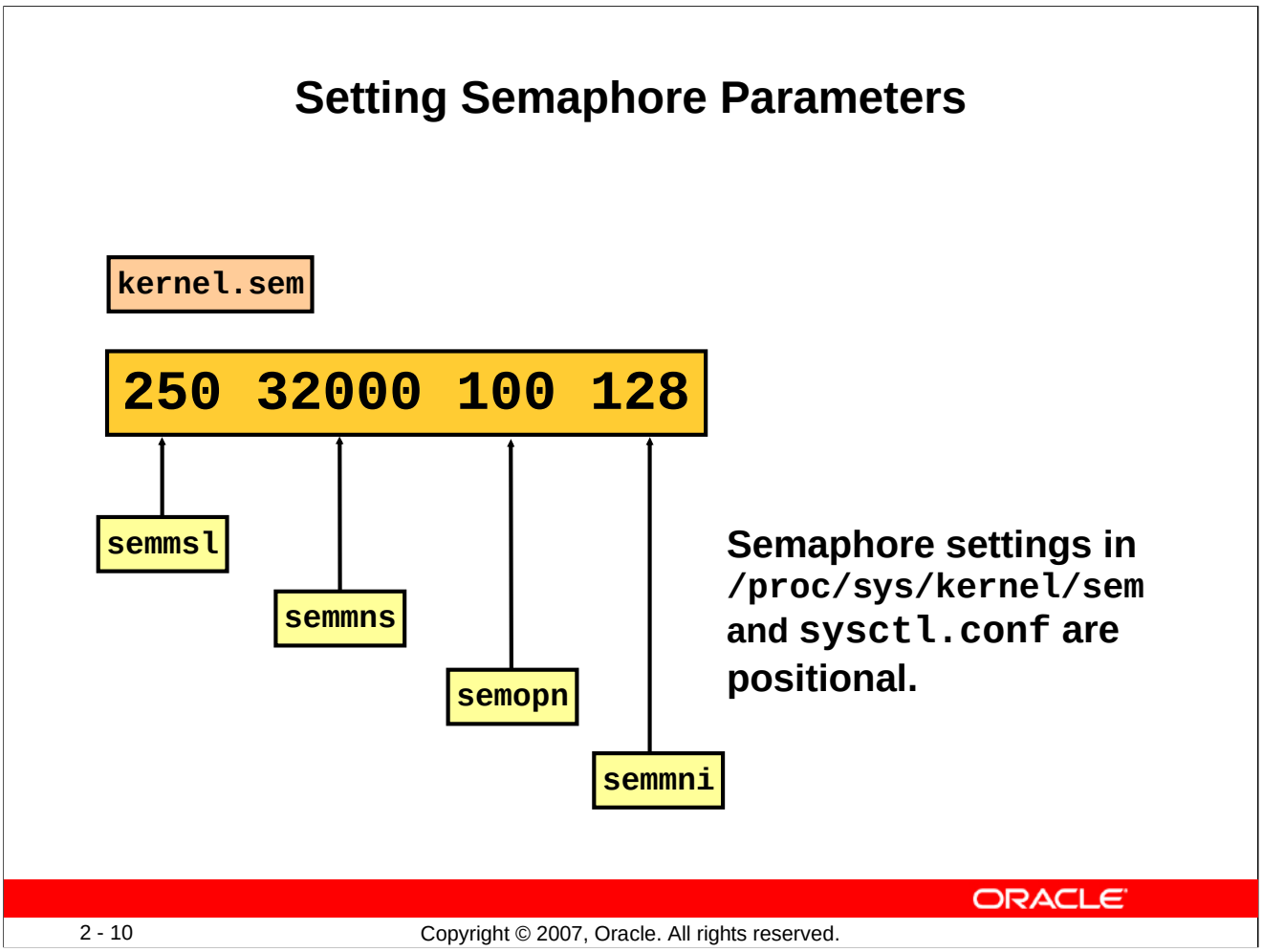
Semaphores

Semaphores are a robust method of controlling access to critical resources. The Oracle instance uses semaphores primarily to control access to shared memory. Semaphores are allocated based on the PROCESSES initialization parameter.

Each Oracle instance tries to allocate one semaphore set at startup. This set must allocate at least as many semaphores as the value of PROCESSES. If it does not, the Oracle instance gets more sets to satisfy the number of semaphores that it needs. If the instance cannot allocate enough semaphores (either in one set or in multiple sets), then the instance does not start.

A semop call is a call to a function that actually uses the semaphores (for example, testing, setting, and clearing).

Note: For details about setting semaphore parameters for your Oracle instance, refer to the Oracle Database installation guide for your particular platform.



Setting Semaphore Parameters

Changing the kernel parameters for semaphores works the same way as the shared memory parameters.

All four of the semaphore parameters are set in a single file, that is, the `sem` file in the `/proc/sys/kernel` directory.

Here are some general recommendations for the settings of the semaphore parameters on Enterprise Linux. You must test and adjust these depending on your system:

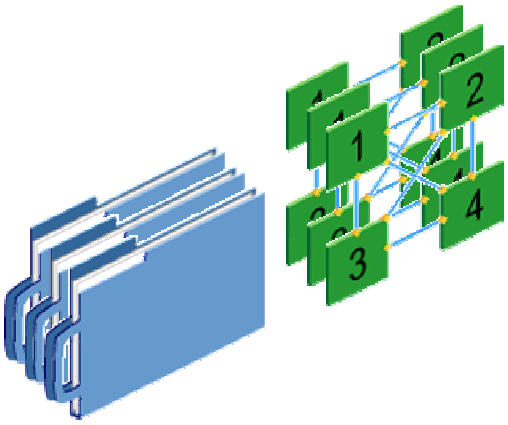
For `semmsl` – 250 or the largest PROCESSES parameter of an Oracle database plus 10

For `semmns` – 32000 or sum of the PROCESSES parameters for each Oracle database, adding the largest one twice, and adding an additional 10 for each database

For `semopm` – 100

For `semmni` – 128

Setting the File Handles Parameter



fs.file-max	65536

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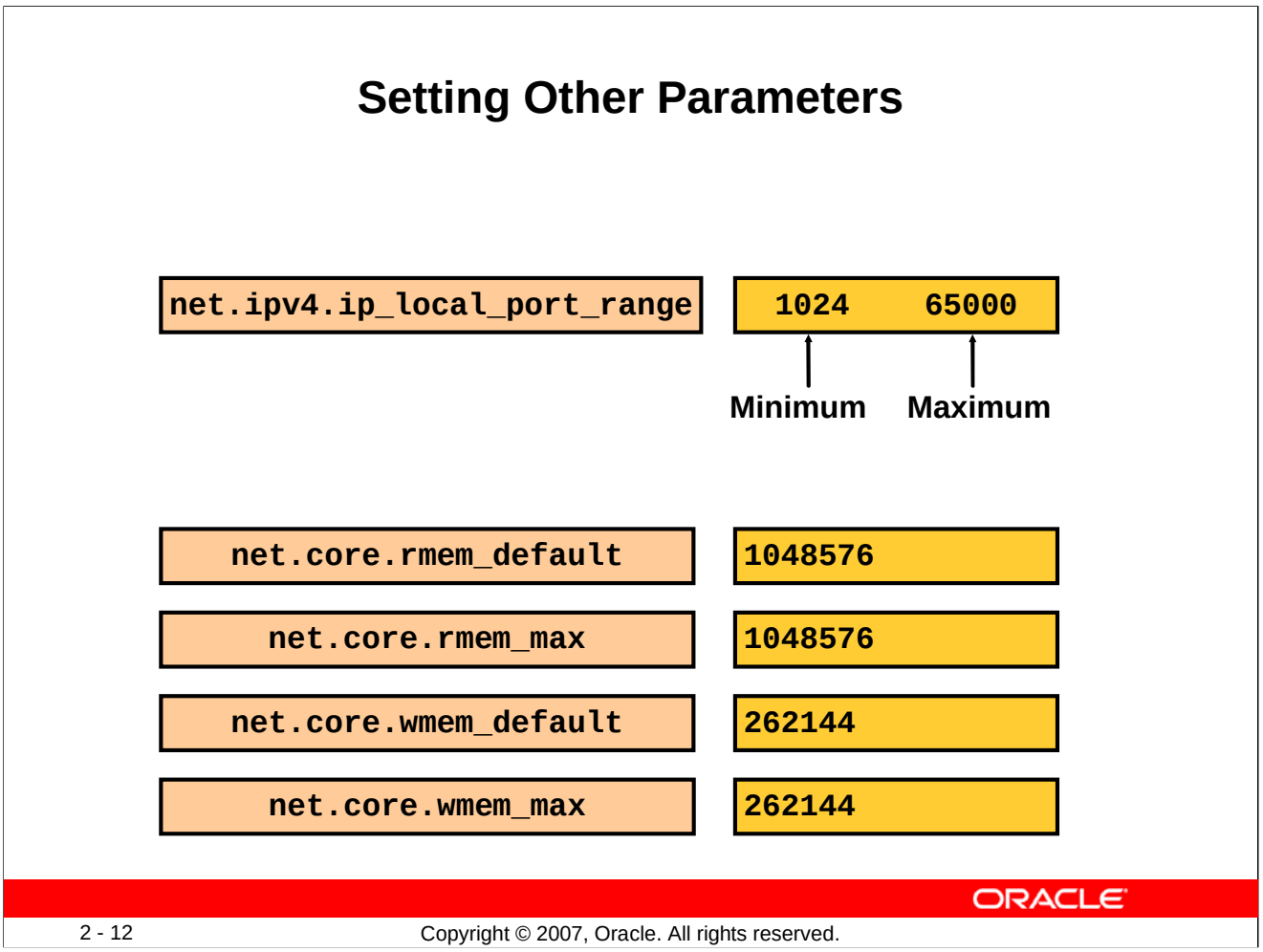
Setting the File Handles Parameter

File Handles is the parameter that determines the maximum number of file handles that the Linux kernel will allocate. The Oracle database background processes open all the data files in addition to redo logs, the alert log, and other supporting files. So, `fs.file-max` needs to be high enough to include all the data files within your database, and all supporting files. The Oracle10*g* Release 2 database can have up to 65,533 data files.

This value is set in `/proc/sys/fs/file-max`. The default value is `65536`, so you can leave that as it is.



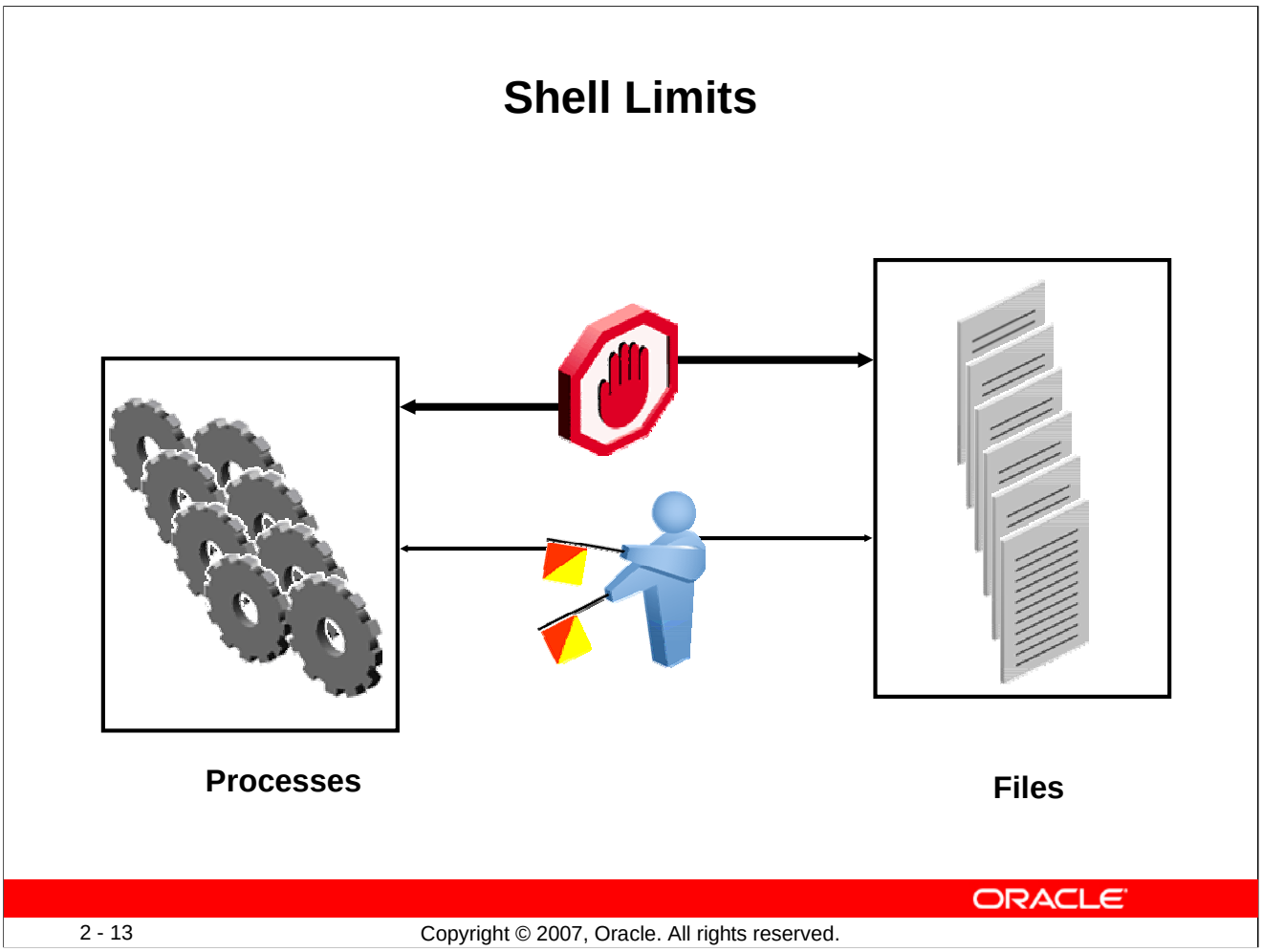
Setting Other Parameters

Setting Socket Parameters

An IP port is assigned to a database-dedicated server process when it starts. The IP port is used to communicate with the user process. By default, the range available is 32768 through 61000. In some databases with a very large number of users, the default range of ports that are available to non-`root` processes may not be adequate. In the example in the slide, the IP port range is set to be from port 1024 through 65000. These ports may be used for Oracle Net connections. Ports below 1024 are reserved for processes running with root privileges.

Setting TCP/IP Window Size Parameters

Set the four TCP/IP window sizing–related parameters to values greater than or equal to the values shown in the slide. These define the read (`rmem`) and write (`wmem`) window sizes for a TCP/IP packet. Defaults are defined, and because TCP/IP communications occur with other machines, the sizes are allowed to adjust upward to attain compatibility. They are not adjusted beyond the specified maximum value.



Shell Limits

Oracle-Related Limits

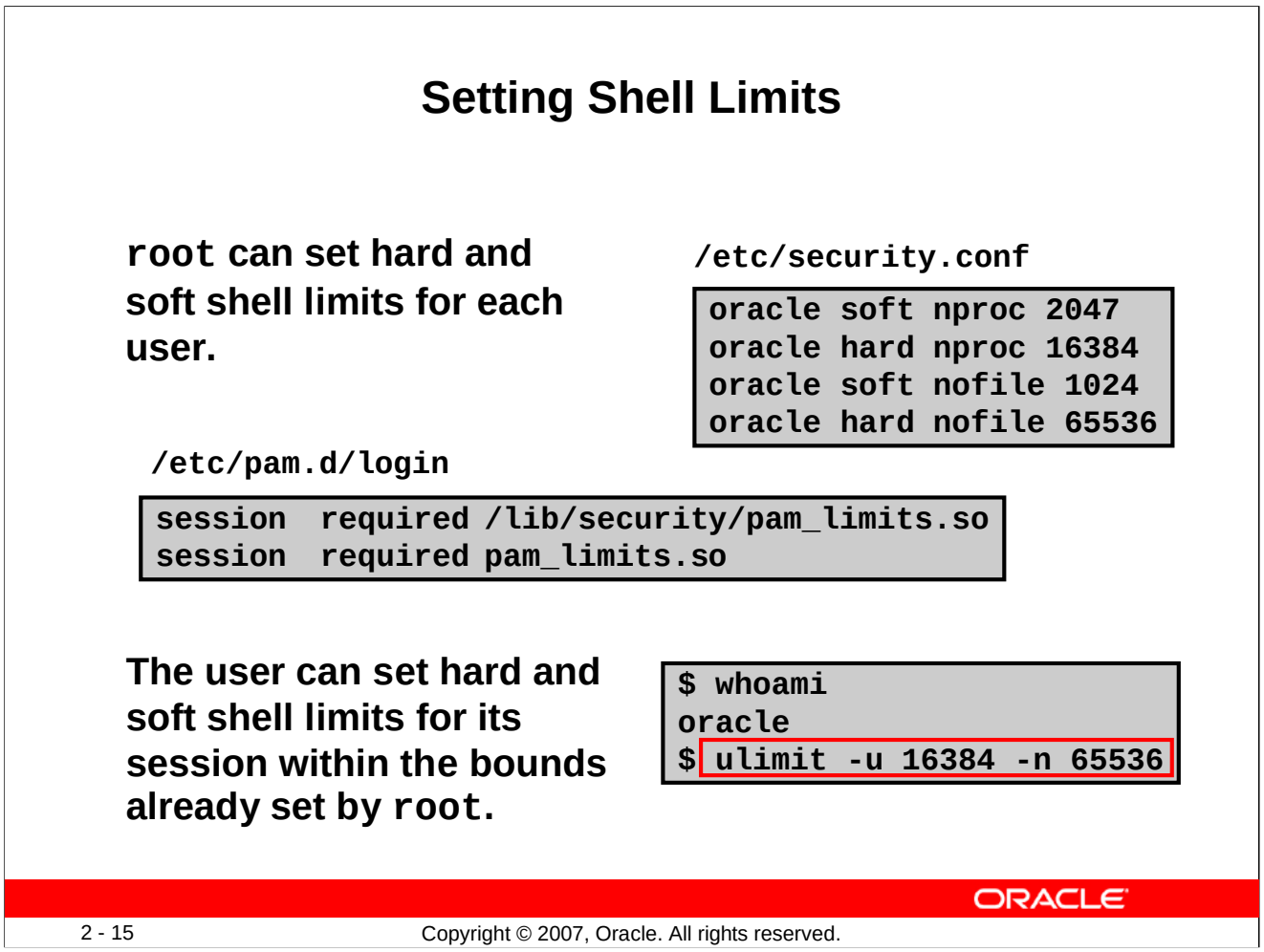
Two limits must be set in order for an Oracle database to function properly. These apply to the `oracle` Linux user. There is little to be gained by not setting each of these to a conservatively high value.

- **`nofile`:** The maximum number of files the user can have open at one time. The `oracle` user opens initialization files, data files, redo log files, and so on, so this should be set high enough to have those files open simultaneously. This is set very close to the maximum number of database files in a single database.
- **`nproc`:** The maximum number of processes a given user can run at once. The `oracle` Linux user owns and starts all the background processes, server processes, and possibly the parallel query and dispatcher processes. This number must be set high enough to accommodate that. The typical increase in process count comes from the number of sessions in the database. So you just need to set this parameter high enough to manage the highest number of sessions, plus some for other processes.

Shell Limits (continued)

Soft Limit Versus Hard Limit

For each of these settings, there is a soft limit and a hard limit. The hard limit can be changed only by the `root` user. The soft limit serves as the limit for the resource at any given time; the user may not exceed that. But the soft limit can be changed by the user, up to the value of the hard limit. The purpose of a limit is to prevent runaway situations, where resources are being used up beyond what was intended by the processes running in the user space. So allowing the soft limit to be adjusted by the user, but never exceeding the `root`-defined hard limit, provides flexibility along with control.



Setting Shell Limits

The `root` user can define the hard and soft limits for each user in a configuration file. The hard limits can be changed only by `root`; the user cannot set either the hard limit or the soft limit above the hard limit. To make these changes, perform the following steps:

1. Add the following to the `/etc/security/limits.conf` file:

```
oraclesoft  nproc      2047
oraclehard  nproc      16384
oraclesoft  nofile     1024
oraclehard  nofile     65536
```

2. Add or edit the following lines in the `/etc/pam.d/login` file:

```
session     required   /lib/security/pam_limits.so
session     required   pam_limits.so
```

`pam_limits.so` is a Pluggable Authentication Module (PAM). It is used to set system resource limits. For more information, see the `man` pages for `pam`.

After an OS user has started a shell, the user can use the `ulimit` command to set the hard limit and soft limit for this specific shell. The hard limit cannot be increased after it is set, and the soft limit cannot be increased above the hard limit. For the example shown in the slide, the `ulimit` command has no effect; it is setting the hard limit and soft limit to the same value they have already been set to.

Setting Shell Limits (continued)

If it were to issue the `ulimit –Sn 50` command (which sets the soft limit for number of open files to 50), then any attempt to open more than that would result in an error. The user could still set it higher (for example, `ulimit –Sn 100`), which would result only in errors when the number of open file requests exceeds 100. However, this cannot be set higher than the hard limit.

Note: A process inherits these settings from the shell from which it is started at the time it is started, so if you change the settings, any processes would have to be restarted for them to take effect. So, for example, the Oracle database would have to be shut down and restarted.

Managing Packages

Patches for Enterprise Linux are managed with the Red Hat Package Manager (`rpm`) utility. This utility is used to install, upgrade, remove, and query packages.

- **To determine whether or not a package is installed:**

```
# rpm -q <package name>
```

- **To install a package:**

```
# rpm -ivh <package name>
```

- **To remove a package:**

```
# rpm -e <package name>
```

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Managing Packages

The recommended method for installing operating system patches and additional functionality is to apply packages from the distribution vendor. Apply packages with `rpm`, a command-line utility with several options for querying, verifying, installing, upgrading, and removing packages.

Managing Packages (continued)

The `rpm` utility accepts several command-line arguments including:

- **`-q`:** Queries the system for a package. A special argument, `-qa`, lists all installed packages. This list can then be filtered by piping to a `grep` command. For example:

```
#rpm -qa |grep gcc
gcc-2.96-108.1
```

- **`-i`:** Installs the named package. The optional `–h` argument shows hash marks on the screen to indicate progress. The optional `–v` argument generates verbose output. For example:

```
#rpm -ivh my_new_package-1.0-14.i386.rpm
Preparing...            ########################################### [100%]
1:my_new_package         ########################################### [100%]
```

- **`-e`:** Erases/removes the selected package. Optional arguments `–h` and `–v` can also be used. For example:

```
# rpm -ev IBMJava2-JRE
```

- **`-U`:** Upgrades the current package. It removes the current package and replaces it with a different version.
  Note: The replacement happens *without* removing any existing configuration files. This is used when upgrading kernel packages because you cannot remove the existing kernel before installing a new one.

```
rpm -Uh kernel-2.4.9-e.27.i686.rpm
Preparing...            ########################################### [100%]
1:kernel-2.4.9-e27       ########################################### [100%]
```

Required Software

Check that the required packages are installed:


```
# rpm -q binutils
binutils-2.15.92.0.2-15
```

You may have to query all of the packages and `grep` for part of the name if you are unsure of the exact name:

```
# rpm -q compat-libstdc++
package compat-libstdc++ is not installed
# rpm -qa | grep  compat-libstdc++
compat-libstdc++-296-2.96-132.7.2
compat-libstdc++-33-3.2.3-47.3
# rpm -q compat-libstdc++-296
compat-libstdc++-296-2.96-132.7.2
```

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Required Software

The *Oracle Database Installation Guide* lists the required packages and version numbers for your Linux distribution. You can determine whether your Linux installation meets those package requirements by using the `rpm` command. The `–q` option queries the repository of installed packages looking for the exact package name you supply. You must supply the package name exactly as it appears in the repository; if it is wrong, it is reported as not installed.

The first example in the slide shows a query of the `binutils` package. The result shows that it is indeed installed, and the version number is `2.15.92.0.2-15`.

The second example shows a query for the `compat-libstdc++` package. Initially, you see that it is not installed. Then, when you query all packages, and then `grep` for the package name or portion thereof, you can see that there must be more to the package name than `compat-libstdc++`. If you query for `compat-libstdc++-296`, you see that it is installed as that package name.

Required Software (continued)

The following are the required packages and versions for Oracle Database 10*g*R2 on Enterprise Linux:

```
binutils-2.15.92.0.2-13.EL4
compat-db-4.1.25-9
compat-libstdc++-296-2.96-132.7.2
control-center-2.8.0-12
gcc-3.4.3-22.1.EL4
gcc-c++-3.4.3-22.1.EL44
glibc-2.3.4-2.9
glibc-common-2.3.4-2.9
gnome-libs-1.4.1.2.90-44.1
libstdc++-3.4.3-22.1
libstdc++-devel-3.4.3-22.1
make-3.80-5
pdksh-5.2.14-30
sysstat-5.0.5-1
setarch-1.6-1
```

Note: This list shows the required RPMs at the time of printing. To ensure that this has not changed, refer to the *Oracle Database Installation Guide* for your Linux distribution.

Linux Patches

Apply the patches recommended by the distribution vendor:

- **Unbreakable Linux Network (ULN) supplies patches automatically.**
- **Other distribution vendors have patch channels.**

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Linux Patches

Linux distribution vendors do not supply megapatches like other UNIX vendors, but supply patches for components. The latest version of all the patches are tested to work together. Each distribution vendor has a subscription service and a method for distributing patches. Enterprise Linux is supported by Unbreakable Linux Network. The latest patches should be applied; especially the kernel patches and the security patches.

Note: Oracle Enterprise Manager Database Control and Grid Control provide an interface for finding and applying patches for the OS and for the database. For details, see *Oracle Database 2 Day DBA 10g Release 2*.

Configuring the X Window System

Install and configure the X Window System with the distribution installation. Before the installation:

- **Determine the monitor model number**
- **Determine the graphics card model number or chipset**

Configuring the X Window System

Oracle Universal Installer (OUI) is a Java-based product, and Java calls the X Window System on UNIX and Linux operating systems. So the X Window System must be enabled. This is usually accomplished during the installation of the Linux distribution.

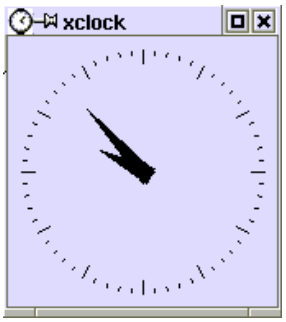
If the X Window System configuration needs to be changed after the installation, there are several files, such as `/etc/X11/XF86Config`, where the X Window System configuration information is kept.

You must know the monitor model number, the graphics card model, the video memory size, and the chipset before configuring these items. With this information, you are able to configure your system correctly.

Testing the X Window System

Test the X Window System with an X client:

- **Set the `DISPLAY` variable:**
  - **Get the host name of the X server.**
  - **Set and export:**
    - **`DISPLAY=`*`hostname`*`:0.0`**
    - **`Export DISPLAY`**
- **Check `xhosts`:**
    - **`xhost +hostname`**
- **Run `xclock`:**
    - **`xclock`**



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Testing the X Window System

The X server is the machine where you are viewing the screen. The X client is a process (running somewhere) that sends the display to where you will be viewing it. In the case of the OUI, X server is the machine in which you view the output, and X client is the machine where the installer runs the database server. To make sure that the installer runs in this configuration, first verify that the X server has connectivity to the database server, and use `telnet` to make a connection. If `telnet` does not work, check the hardware, the wiring, and the host resolution. The host names are translated into IP addresses by either a domain name server (DNS) or through the `/etc/hosts` file. The `ping`, `host`, and `dig` utilities can provide good diagnostic information for solving connection problems.

After a `telnet` connection is established to the database server where the Oracle software will be installed, you must set and export the `DISPLAY` variable. This variable directs the Oracle Installer where to display the install screens. The `DISPLAY` variable contains the host name or IP address and the display number.

For the X server to accept the display from another machine, `xhost` must be executed on the machine where the display is viewed. As the owner of the display (the logged-in user), execute `xhost +<hostname>` where `hostname` is the name or IP address of the database server where the installer is running.

Testing the X Window System (continued)

On the X server, issue a `hostname` command to find the name of the X server. In the following example, the machine `jspiller-us` is the X server where the installer will display the output. Check which hosts are allowed to connect to the X server machine with `xhosts`. With `xhost +<hostname>`, add the name of the database server to the X access control list. In this example, the machine `delphi` is the database server where the installer will be running:

```
$ hostname
jspiller-us
$ xhost
Access control enabled, only authorized clients can connect
$ xhost +delphi
Delphi being added to access control list.
```

Connect to the database server, with `telnet`, set the `DISPLAY` variable and start an X client.

```
$ telnet delphi
$ DISPLAY=jspiller-us:0.0
$ export DISPLAY
$ xclock
```

The `xclock` client should appear on the X server screen or an error message will appear in the `telnet` session.

The `DISPLAY` variable may also be set by using the IP address instead of the name as:

```
$ DISPLAY=192.168.1.2:0.0
```

This method is sometimes helpful when the host name resolution must be bypassed.

For further information about the commands used in this lesson, refer to Appendix C, or the `man` and `info` pages on your Linux system.

Creating Groups

Group	Description	Common Name
Oracle Inventory	Identifies the owner of the Oracle software	`oinstall`
OSDBA	Identifies OS accounts that have database administration privileges (SYSDBA)	`dba`
OSOPER	Identifies OS accounts that have limited database administration privileges (SYSOPER)	`oper`

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Creating Groups

The Oracle Database installation guide names three group identifiers: the Oracle Inventory group, OSDBA, and OSOPER. The members of the OSDBA group own the database files and have the privilege to connect to the database without a password, using AS SYSDBA through OS authentication. The OSOPER group uses the same mechanism to connect with AS SYSOPER with a restricted set of privileges. Each database may have its own OSDBA and OSOPER groups. The Oracle Inventory group has privileges on the software. A DBA that is a member of both OSDBA and the Oracle Inventory group has privileges in specific database instances and the ability to access and upgrade the software through the Oracle Inventory group.

An OSDBA group must be created to manage the database files. By default this group is dba, but this name is arbitrary. If only one group of DBAs administers the databases on this server, then this group may be the same as the Oracle Inventory group for all the databases on this server.

Creating Groups (continued)

When there are multiple groups of DBAs, each administering different databases on the same server, you should create a separate Oracle Inventory group to own the Oracle software. This group is commonly called `oinstall`. For each set of databases that will have a common set of DBAs, create an additional `OSDBA` group. This allows each DBA to have privileges in the database of responsibility but not in other databases.

Creating and Viewing a Group

To create and view the necessary groups:

```
# groupadd –g 503 oinstall
# groupadd dba
# groupadd oper
```

```
[root@edrsr9p1 local]# cat /etc/group
root:x:0:root,vncuser
bin:x:1:root,bin,daemon
.
.
.
oinstall:x:503:
dba:x:504:oracle
oper:x:505:oracle
```

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Creating and Viewing a Group

The `root` user can execute the `groupadd` command to create a group. The group ID or `gid` must be unique. IDs below 500 are typically reserved for system accounts. `-g` is optional; if the group ID is not specified, then the first available group ID above 499 will be assigned. This command places an entry in the `/etc/group` file.

To verify whether the group was created, view the `/etc/group` file.

In the X Window System environment, there are multiple tools available to manage users and groups. Enterprise Linux provides the `system-config-users` GUI tool.

Creating the Oracle Software Owner

The user that owns the Oracle software:

- **Must be created**
- **Has the Oracle Inventory group as its primary group**
- **Must be a member of an OSDBA group**
- **Is commonly named `oracle`**

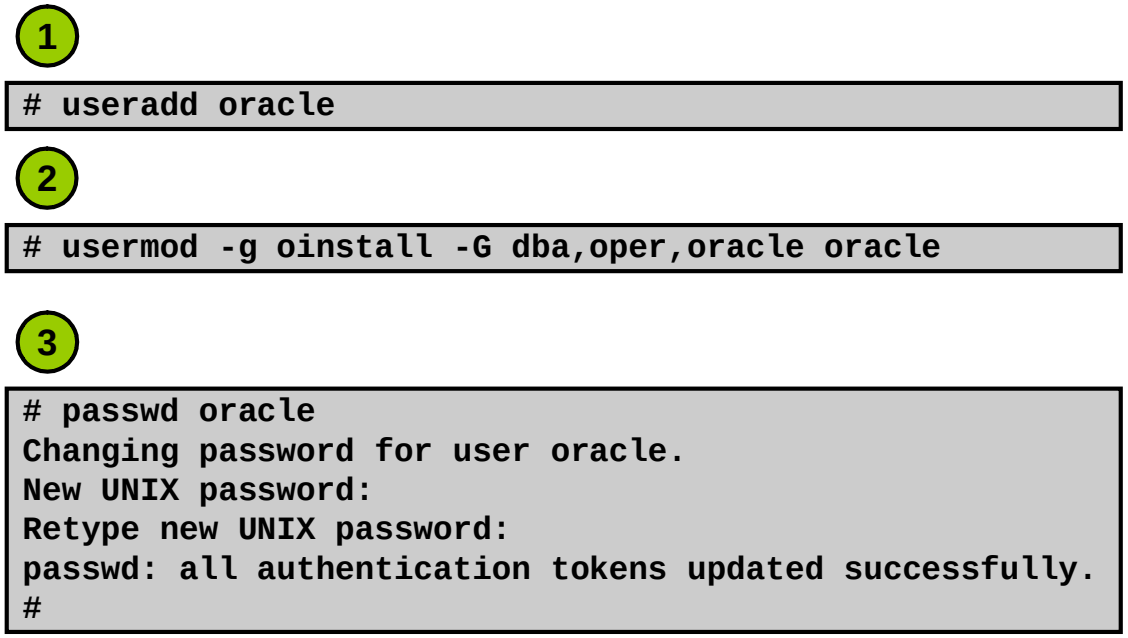
Creating the Oracle Software Owner

The user that runs the Oracle Universal Installer to install Oracle Database is the Oracle software owner. The ownership of the installed files is set based on that user.

Do not run the installer as `root`; that would require root access every time Oracle software maintenance has to be done. The name of this user is commonly `oracle`, but this name is arbitrary. In the following examples, this user is named `oracle`. When this user is created, the primary group can be set. The primary group is set to the Oracle Inventory group. If the `OSDBA` group is different, then the Oracle user must also be a member of that group. The primary group is the one listed in the `/etc/passwd` file. Membership in other groups is set in the `/etc/groups` file.

```
$ id
uid=501(oracle) gid=503(oinstall)
groups=502(oracle),503(oinstall),504(dba),505(oper)
```

Creating the Oracle Software Owner



Creating the Oracle Software Owner (continued)

The `root` user can execute the `useradd` command to create a user. In this example, a user named `oracle` is created with a primary group of `oinstall`. The user ID must be unique. If the user ID is not specified, then the user gets the first available ID above 99, because IDs below 99 are typically reserved for system accounts. If the `-D` option is used with no other options, then `useradd` will show the system defaults. These defaults may be overridden in the command line, completely specified or changed with `-D` followed by the new default. On Enterprise Linux, the default home directory is `/home/<username>`, which is acceptable. You do not need to override it with the `-D` option.

The `useradd` command places an entry in `/etc/passwd` and `/etc/shadow` if shadow passwords are being used. The `–m` option creates the user's home directory and copies a skeleton set of login profiles from `/etc/skel` to the home directory. The `-g` option sets the primary group. If the group is not specified, then a group with the same name as the user is created and set as the primary group. The `-s` option sets the user login shell. In this example, the `-s` option is not required because for Enterprise Linux the bash shell is the default shell. For more information, refer to the `man` pages for `useradd`.

Most Linux distributions are shipped with a graphical user management tool. For Enterprise Linux, use `system-config-users`.

The nobody User

The nobody user:

- **Is an unprivileged user**
- **Is used for executing external jobs**
  - **The `oracle` user would be too powerful.**
- **Should be allowed to have only minimal privileges**

```
# id nobody
uid=99(nobody) gid=99(nobody) groups=99(nobody)
```

ORACLE

The nobody User

The `nobody` user exists to satisfy the need for a minimally privileged OS user. There are times when the database requests that jobs run at the OS level, and this is the user under which the job runs. Oracle Scheduler is one feature that can initiate external jobs. Any programs that are invoked this way are owned by, and run under the permissions granted to, the `nobody` user. So this user starts out with no privileges. The system administrator, as `root`, can add any necessary groups to this user as needed, based on the tasks those external programs must perform.

Simply allowing these programs to run as the `oracle` user would be too liberal a policy, because the `oracle` user is able to shut down the database, and perform many other privileged tasks.

If the `nobody` user does not exist, create it. It is common to use `99` as the user ID and group ID.

Summary

In this lesson, you should have learned how to:

- **Use the package manager to determine and update package support**
- **Set up the operating system environment for Oracle Database**
- **Create the necessary groups and users for Oracle Database**

ORACLE

Practice 2 Overview: Preparing Linux for Oracle

This practice covers the following topics:

- **Using the package manager to determine and update package support**
- **Creating groups and users in preparation for an Oracle database installation**
- **Setting up the operating system environment for Oracle Database 10*g*R2**

ORACLE

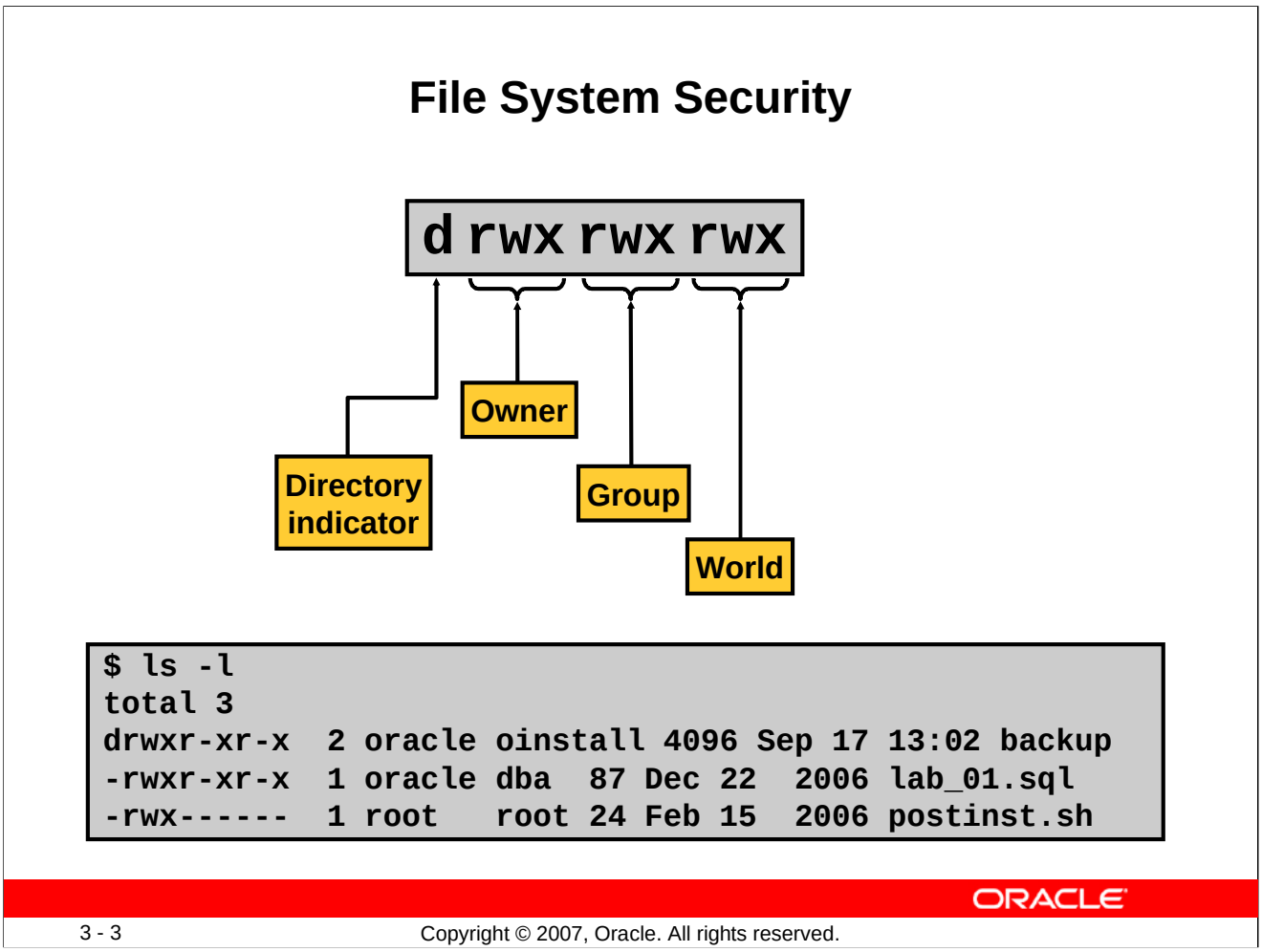
3

Installing Oracle on Linux

Objectives

After completing this lesson, you should be able to:

- **Describe the Linux file system security**
- **Install multiple versions of the Oracle Database software on the same server**
- **Accommodate multiple Oracle homes on one database server**

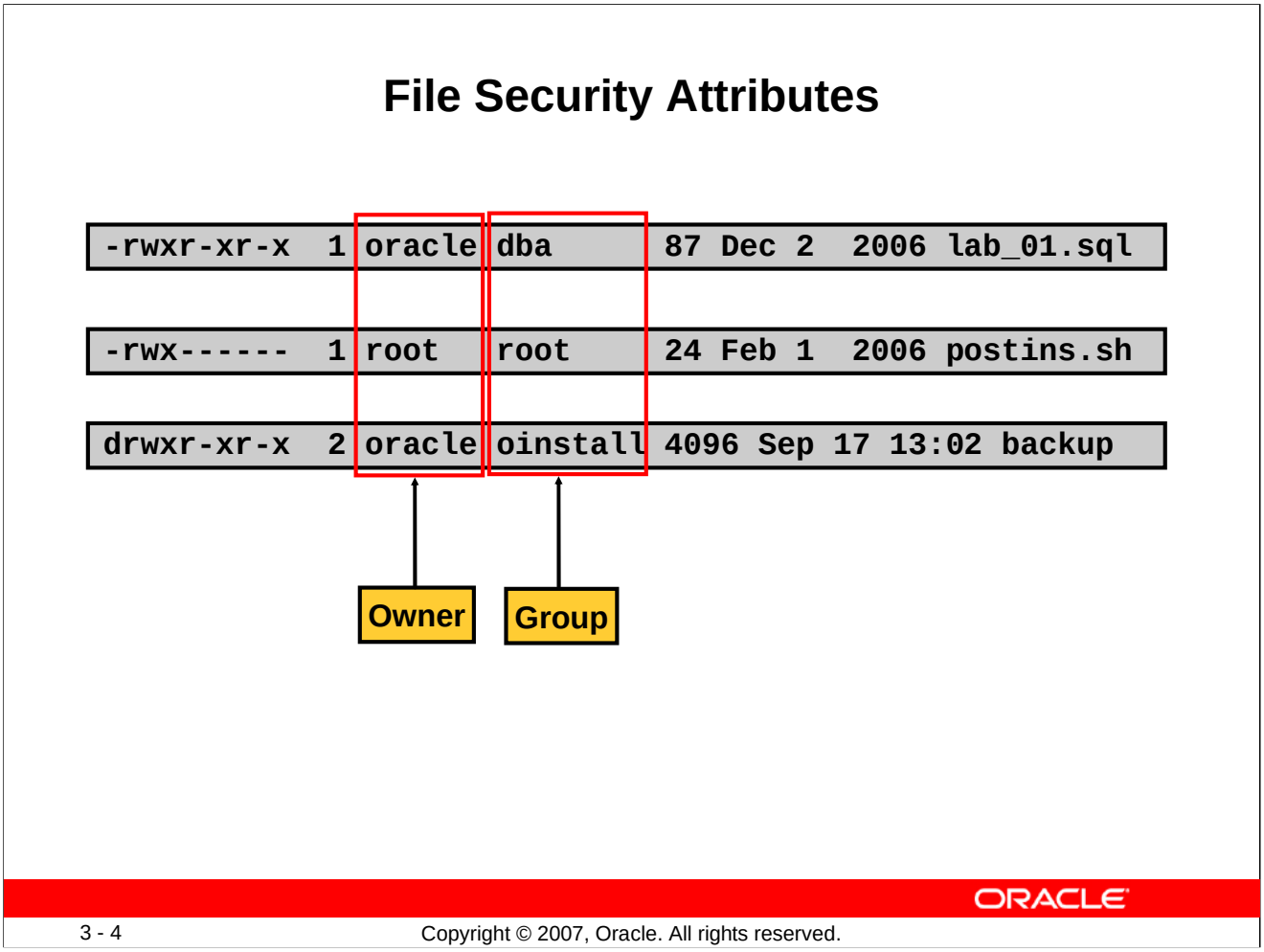


File System Security

Linux file system security is based on permissions attached to each file and directory. There is a set of ten indicators that specify this permission information. Their meanings, from left to right, as they appear in a listing produced by the `ls -l` command, are shown below. If the positional attribute does not apply to the entry, then that permission or attribute is false, or denied.

1. **Directory indicator:** If this is a "d," it indicates that the entry is a directory.
2. **Owner permissions:** This indicates whether the owner of the file is able to read it, write to it, or execute it, respectively, from left to right.
3. **Group permissions:** This indicates whether members of the group that owns the file are able to read it, write to it, or execute it, respectively, from left to right.
4. **World permissions:** This indicates whether all other users (besides the owner and the file's group members) are able to read it, write to it, or execute it, respectively, from left to right.

Note: Execute permission applies to binary programs, shell script files, and directories. It has no meaning for other file types. In the case of a directory, if a user has the execute privilege on a directory, that means they can `cd` to it, list the contents of it, and search it.



File Security Attributes

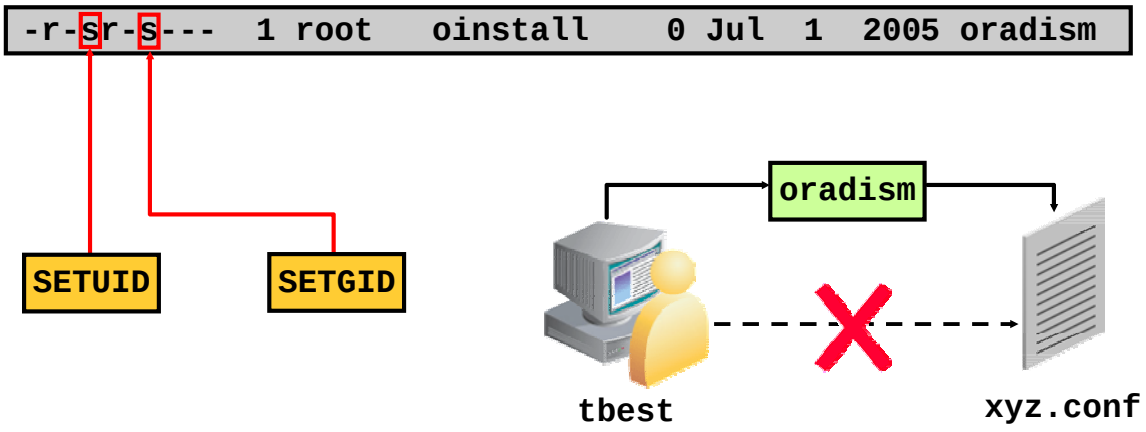
Each file or directory entry has an owner and a group assigned to it, shown in that order as displayed by the `ls -l` command. This information, combined with the permissions indicators on the previous slide, determines who is allowed to do what with each given file or directory.

Regarding the items listed in the slide:

- The first belongs to the `oracle` user, and its group is `dba`. That, combined with the permissions indicators means that the `oracle` user has read, write, and execute permissions on this file. Also, any user in the `dba` group can execute or read this file, but cannot write to it, which is also the case for all other users, based on the last three indicators.
- The second belongs to `root`, and the group is also `root`. Based on the permissions indicators, only root can read, write, or execute this file. Even if there are other users in the root group, they cannot do anything with this file because the group permission indicators are all dashes, which means that those accesses are denied.
- The third entry is a directory.

SETUID and SETGID Bits

The SETUID and SETGID bits indicate that others are allowed to execute a program as though they were the owning user or group.



SUID Bits

When the letter "s" appears in place of the "x" or dash in the permissions bit string, it has a special meaning. It indicates that as this program is invoked, it will be run using the permissions of the user or group that owns it. Regarding the example of the `oradism` executable file shown in the slide, `oinstall` is the group and `root` is the owner. An "s" appears in the executable bit position, for the user and the group. That is, anyone can execute `oradism`, and when they do, every action the `oradism` program attempts will be evaluated, permissions-wise, based on the fact that the requesting user is `root` and the requesting group is `oinstall`.

For example, suppose that the `tbest` user is in the `tbest` and `users` groups only. There is a `/etc/xyz.conf` file which is owned by `root`, and its group is `root`. The `tbest` user cannot access that file at all. But if the `oradism` program accesses that file, anyone who invokes that program will succeed in accessing that file. This is because the decision to allow access to the `/etc/xyz.conf` file is made based on the fact that the requestor is the `root` user.

Choosing a Shell

There are many shells available for Linux:

- **Oracle shell scripts are Bourne shell scripts.**
- **bash is the Bourne-again shell:**
  - **It is Bourne shell compatible.**
  - **It is POSIX compliant.**
- **Korn is a superset of Bourne:**
  - **The Korn shell is required for certain actions.**
- **The C shell is preferred by many.**
- **The working-level shell is a matter of preference.**
- **Most shell scripts specify the shell that is required.**

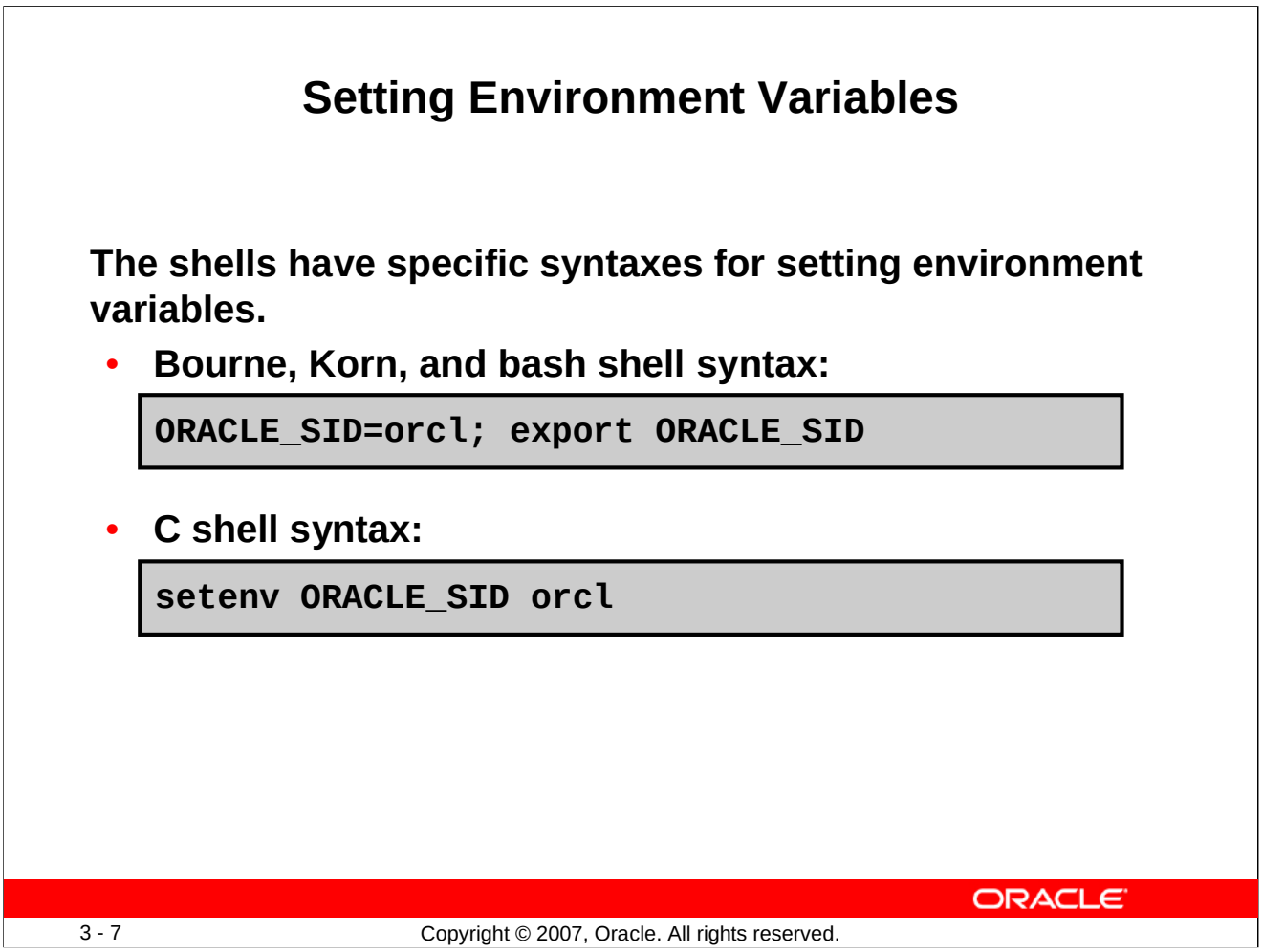
ORACLE

Choosing a Shell

Linux has many popular features. One of the most popular features is that the user interface can be easily customized. There are at least four different shells in the default EL installation. The Bourne shell, one of the first shells that was available on AT&T UNIX, is the standard shell that the Oracle database uses for scripting. The C shell was the BSD UNIX shell. The C shell has many user-friendly features, such as command history, that are not available in the Bourne shell. But the C shell was interpreted, and not compiled like the Bourne shell, and is consequently slower. The Korn shell is a superset of the Bourne shell with command history, and is compiled. The Bourne-again shell, `bash`, was written to be Bourne shell compatible, with features of both the Korn and C shells. It is intended to be POSIX compliant. Some Oracle installation actions require a Korn shell such as the Oracle Internet Directory configuration script, `oidca`.

Most Oracle shell scripts specify the shell that is required in the first line of the script. A first line of `#!/bin/sh` indicates that the script uses the Bourne shell. On Linux, `/bin/sh` is usually a link to the Bourne-again shell (`bash`).

To view the shell that you are currently in, use the `echo $0` command.



Setting Environment Variables

Each shell has a specific syntax for setting an environment variable. The most common syntax for each shell and an example for the `ORACLE_SID` variable are shown. The environment variables are session specific and, therefore, must be set at each login. In each shell, there are specific login scripts that are executed.

- The Bourne shell runs `.profile`.
- The Korn shell runs `.profile` and `.kshrc`.
- The bash shell runs `.bash_profile`, `.profile`, and `.bashrc`.
- The C shell runs `.login` and `.cshrc`.

The Oracle environment variables must be set in the last script to run in each case.

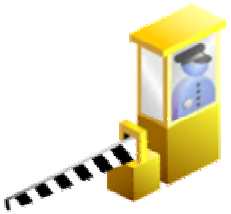
Example: For the bash shell, set `ORACLE_SID` in the `.bashrc` script.

Oracle Support recommends that you create a shell script in the same format as `.bashrc` and source it in the shell that will be running the installer. This has the advantage that after installation the `.bashrc` or `.login` script does not need to be edited for ordinary use with the `oraenv` script. For example, create a file `instenv` with the environment variables, do a `chmod 755` so that it can be executed, and then execute `'. ./instenv'` to run the script without forking a new shell.

User File Creation Mask

Every file that a user creates has a set of permissions controlled by a mask.

- **View the mask with `umask -S`.**
- **Set the mask with `umask -S u=rwx,g=rx,o=rx`.**



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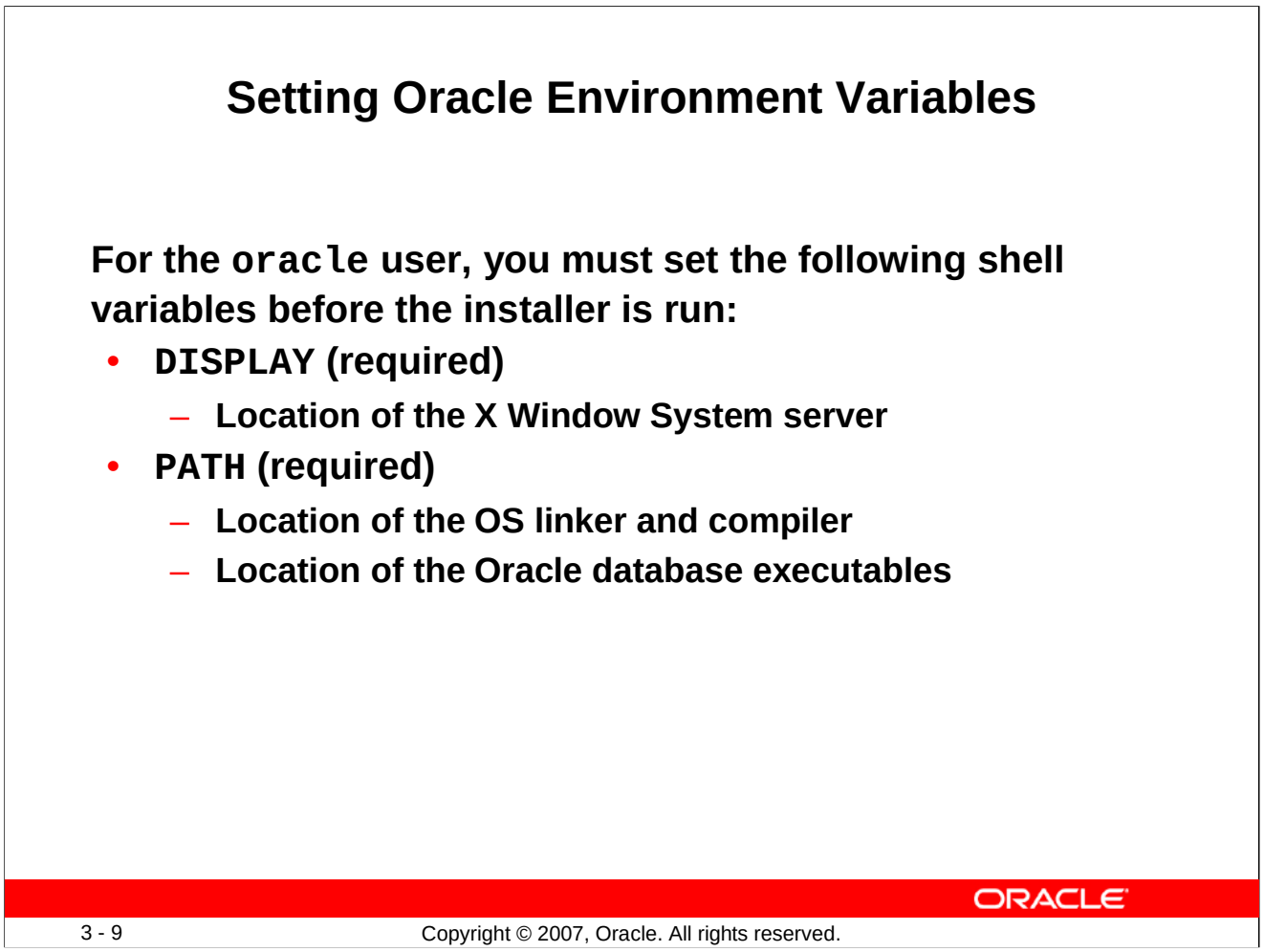
User File Creation Mask

Every file that is created by a user receives a default set of permissions. The permissions determine who can read, write, and execute a file. The example above indicates that the files that are created have permissions set as follows: read, write, execute for the owner (u); read and execute permissions for the group (g); and read and execute permissions for the other (o). For EL, by default, `umask` is set to `u=rwx,g=rx,o=rx`. But if it is not set to this value, it can be changed. In the `.bashrc` script for the `oracle` user, place a line as shown below:

```
umask -S u=rwx,g=rx,o=rx
```

The `umask` can optionally be specified as an octal value, which specifies which permission bits should be off. For example, `022` is the equivalent of the above example. The two bits that are on in the octal value represent the only two permissions that are not allowed: write for group and write for other.

The `umask` must be verified before running the Oracle Universal Installer (OUI) and set for the `oracle` user in the `.bashrc` file.



Setting Oracle Environment Variables

Only two shell variables need to be initialized before the installer is run: the `DISPLAY` variable and the `PATH` variable. Other variables can be initialized to facilitate the installation. The `DISPLAY` variable must be set to the location of the X Window System server. If X-based terminal windows are being used, then the `DISPLAY` is usually set properly in login scripts. Before installation, set the `PATH` variable manually or with a script in the shell where the Oracle Installer is invoked to include the `$ORACLE_HOME/bin` directory. If the `'$ORACLE_HOME'` string is used instead of a full path to set the `PATH` variable, then the `ORACLE_HOME` variable must be set before its use. Usually, base `PATH` is set to `/usr/bin:/bin:/usr/bin/X11R6:/usr/local/bin` by default. If it is not, then set it in the `.bashrc` file.

After the installation, the `PATH` variable for any database user on Linux can be set by using the supplied `oraenv` script. It adds `$ORACLE_HOME/bin` to the end of the existing `PATH` variable.

Optimal Flexible Architecture

Optimal Flexible Architecture (OFA) was introduced to optimize the relationship between the database files and the host operating system. You can use OFA to:

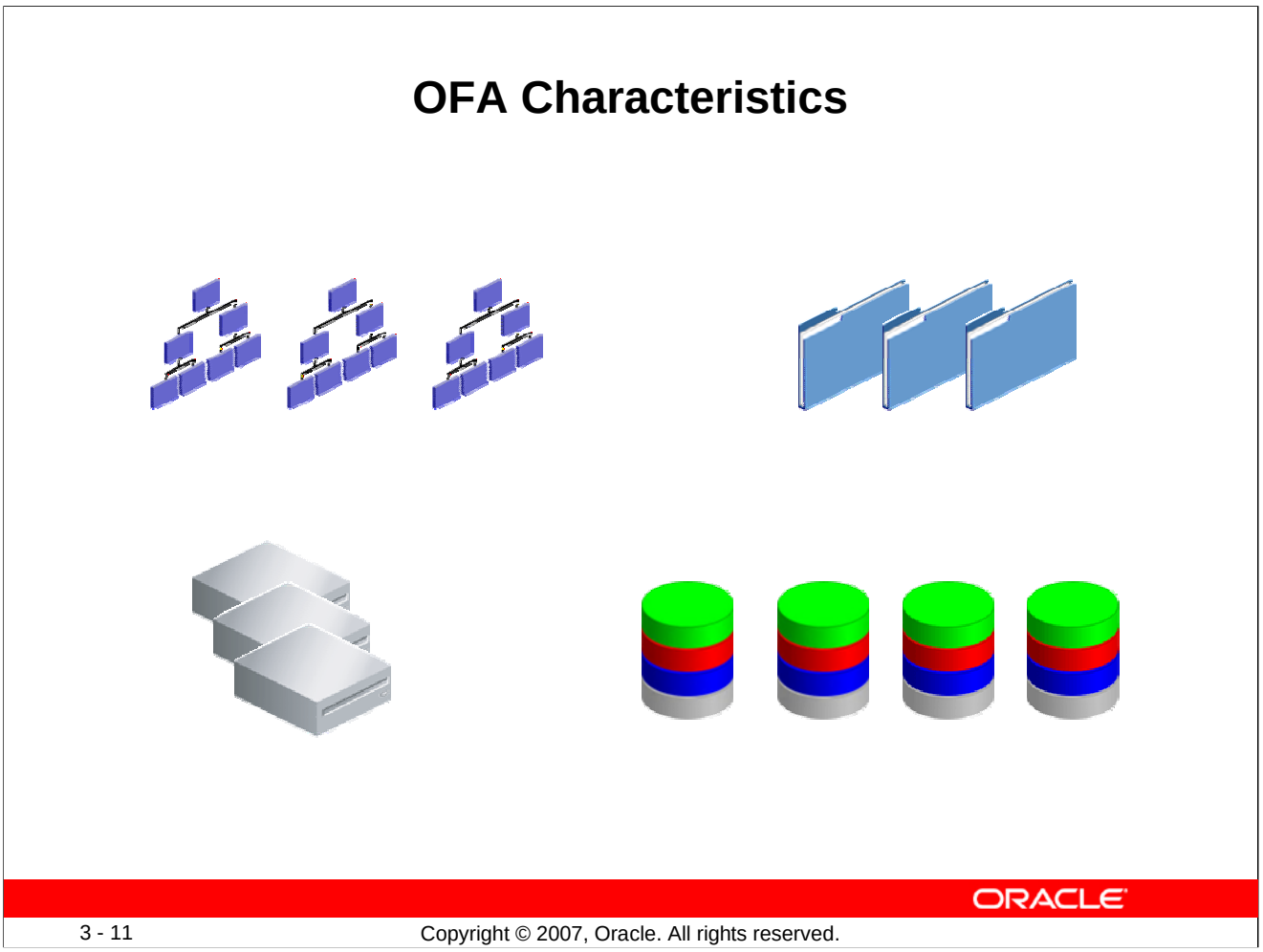
- **Distribute files across multiple mount points:**
  - **Balance I/O for performance**
  - **Increase reliability**
- **Handle large and growing directories**
- **Administer multiple releases**

ORACLE

Optimal Flexible Architecture

Optimal Flexible Architecture (OFA) is a method for configuring the Oracle database and other databases. OFA makes use of the operating system (OS) and disk subsystems capabilities to create an easy-to-administer configuration that allows maximum flexibility for growing and high performance databases. The methods described here are the basics of OFA.

For details about the goals and implementation of OFA, refer to the *Oracle Database Administrator's Guide 10g Release 2* and the *Oracle Database Installation Guide 10g Release 2 (10.2) for Linux x86-64*.



OFA Characteristics

The OFA characteristics translate into specific recommendations for the management of database files, and the structure of the host file systems and directory structure. They are listed here:

- File system organization: The file system is organized to enable easy administration and to facilitate adding data into existing databases, adding users, creating databases, and adding hardware.
- Distributed I/O loads: I/O loads are distributed across enough disk drives to prevent performance bottlenecks.
- Hardware support: In most cases, you do not require new hardware to implement the Optimal Flexible Architecture standard.
- Safeguards Against Drive Failures: By distributing applications across more than one drive, drive failures affect as few applications as possible.
- Distribution of Oracle home directories: The collection of home directories, and further, the contents of each individual home directory can be distributed across disk drives.
- Integrity of login home directories: You can add, move, or delete login home directories without having to revise programs that refer to them.

OFA Characteristics (continued)

- Independence of UNIX directory subtrees: Categories of files are separated into independent UNIX directory subtrees so that files in one category are minimally affected by operations on files in other categories.
- Supports concurrent execution of application software: You can run multiple versions of Oracle software simultaneously, enabling you to test and use a new release before retiring the previous release. Transferring to a new release after an upgrade is simple for the administrator and transparent for the user.
- Separate administrative information for each database: The ability to separate administrative information for each database ensures a reasonable structure for the organization and storage of administrative data.
- Consistent database file naming: Database files are named so that:
  - Database files are easy to distinguish from other files
  - Files belonging to one database are easy to distinguish from files that belong to another database
  - Control files, redo log files, and data files can be identified as such
  - The association of data file to tablespace is clearly indicated
- Separation of tablespace contents: Tablespace contents are separated to minimize tablespace free space fragmentation, minimize I/O request contention, and maximize administrative flexibility.
- I/O loads tuned across all drives: I/O loads are tuned across all drives, including drives storing Oracle data in either Automatic Storage Management disk groups or in raw devices.

Mount Points

To be OFA compliant, the database requires two mount points:

- **Mount points are listed in `/etc/fstab`.**
- **Name mount point `/pm or /pm/q/db`.**
  - **`p` is a string.**
  - **`m` is a unique identifier (2 to 4 digit number).**
  - **`q` indicates Oracle database files (default `oradata`).**
  - **`db` is the database name.**
- **Examples:**
  - **`/u01`**
  - **`/u02/oradata/orcl`**
  - **`/sales01`**

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Mount Points

A database that is fully OFA compliant has at least two mount points: one for the software and at least one for database files. The Oracle Installer requests two directories. The installer does not know if you are supplying mount points or directories. The naming of the database software directory was performed when you created the `ORACLE_HOME` environment variable.

Although there are many correct names that you can use, it is usually a good idea to avoid names that map to hardware. For example, if you choose a name that corresponds to a particular disk controller, then a later upgrade may result in a name that is deceptive. It is much easier to separately track hardware to logical name mappings.

You should not use names that suggest that a mount point is devoted to one application's data unless it is true. For example, you do not want to neglect your Oracle database files just because they were stored under a mount point called `/backup01`.

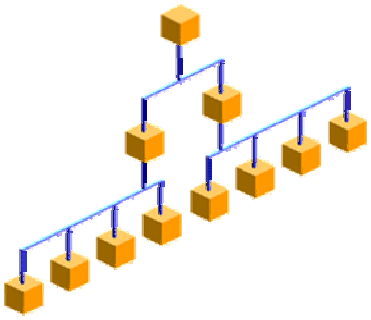
In the original OFA, the concept of a mount point almost always referred to a single physical disk, that is, each disk had one mount point. In today's environment, disks can be very large, and they are partitioned to useful sizes. Each partition requires a mount point.

Note: The usage of Automatic Storage Management (ASM) eliminates many of the concerns about mount points. ASM is covered in detail in the lesson titled "Automatic Storage Management and Automatic Storage Management Library Driver."

ORACLE_HOME and ORACLE_BASE

These are directories to implement an OFA-compliant installation.

```
ORACLE_BASE=/u01/app/oracle
ORACLE_HOME=$ORACLE_BASE/product/10.2.0/db_1
```



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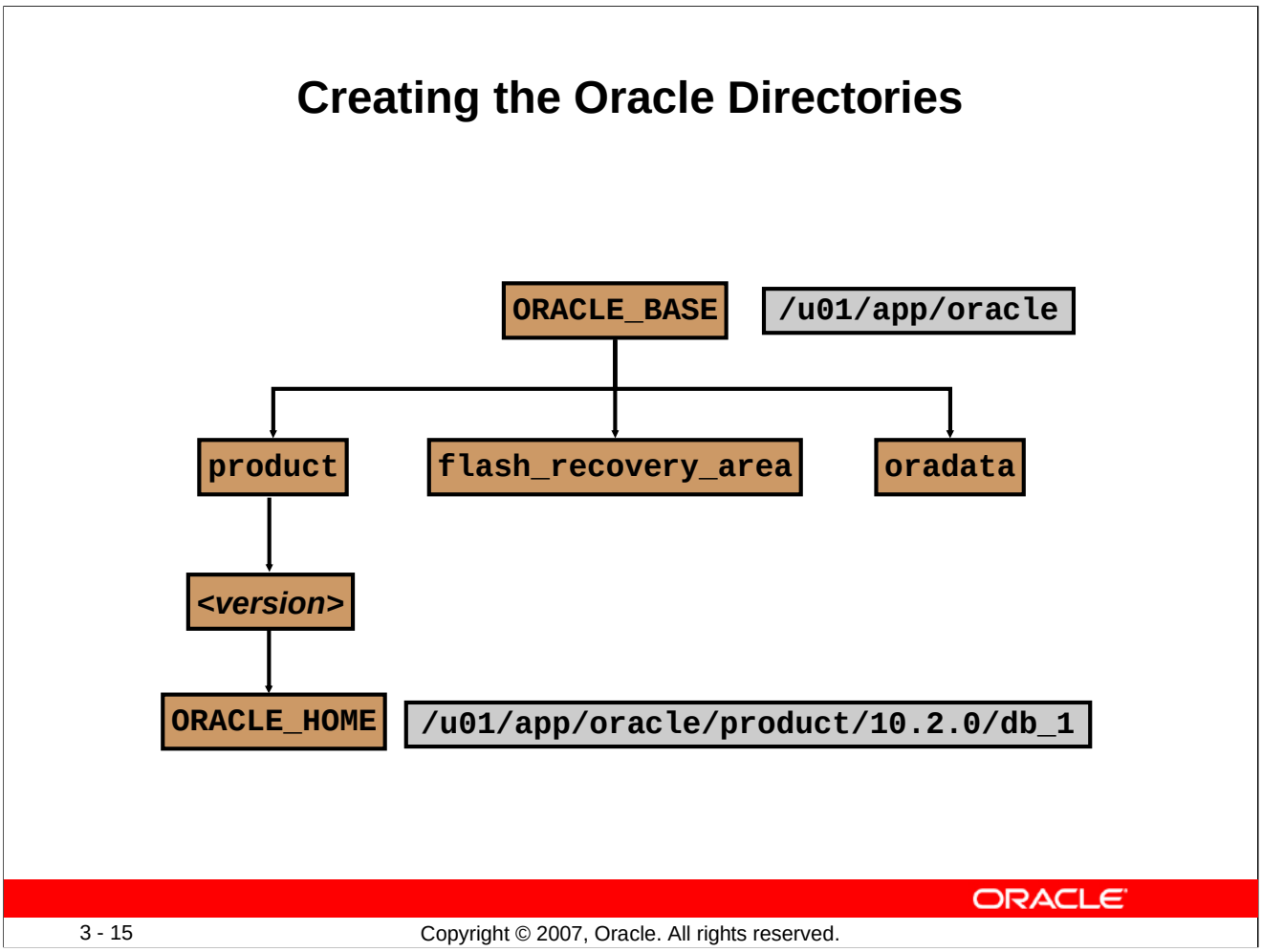
ORACLE_HOME and ORACLE_BASE

What Is ORACLE_HOME Used For?

The ORACLE_HOME directory is used by any user who wants to use the particular database. It identifies the directory that has the proper release distribution and binaries for the database. It also identifies the default location of the parameter file that launches the database. The ORACLE_HOME variable does not have to be preset as an environment variable, it can be set during the installation process. The directory does not have to exist but the directory structure above it must exist and be owned by the user named `oracle`. The ORACLE_HOME variable is typically in the following ORACLE_BASE directory: `ORACLE_HOME=$ORACLE_BASE/product/10.2.0`.

What Is ORACLE_BASE Used For?

The ORACLE_BASE directory is typically a higher-level directory than ORACLE_HOME. It can be used by shell scripts that you create. Typically, your data files and administration files are located below this point. This allows shell scripts to be created that are not dependent on the particular tree structure, and those scripts continue to work on other machines or reconfigured machines and possibly on other releases of the database.



Creating the Oracle Directories

The ORACLE_BASE directory must be created by `root`. The ownership of the directory must be assigned to the `oracle` user and the o`install` group. Following the examples in previous slides, use the command `chown oracle:oinstall /u01/app/oracle`. Repeat this procedure for the directories that are designated to hold database files. The ORACLE_HOME directory is successfully created by the OUI as long as the permissions on the ORACLE_BASE directory are correct.

Installing New Releases

- **Provide a separate tree for each release. This tree is deleted after an upgrade (when it is no longer in use).**
- **Place releases in a directory named h/product/v, where:**
  - **h is the ORACLE_BASE directory**
  - **v is the version identifier or release number**

  Example:
  - **/u05/app/oracle/product/10.2.0**
  - **/u02/app/oracle/product/9.2.0**
- **Maintain the /etc/oratab file, which lists the existing ORACLE_HOME directories.**

Installing New Releases

Each new release gets its own directory. As new releases are added, the old release directories can be removed. Therefore, the release directory should contain only files that are specific to that release. You must store only the files that are installed by the OUI in the ORACLE_HOME directory.

Installing a new release often results in multiple databases running under different releases. Each instance on a machine specifies the release that it uses in the /etc/oratab file. For example:

```
prod:/u02/app/oracle/product/9.2.0:Y
dev:/u05/app/oracle/product/10.2.0:N
```

When a database is upgraded to use a different release, change the oratab file so that users find the proper ORACLE_HOME directory. For example, to move prod to 10.2.0:

```
prod:/u05/app/oracle/product/10.2.0:Y
```

When the 9.2.0 database is removed, the directory is no longer needed and can be removed.

Managing Multiple Versions

Set the user environment when several versions of the database software exist on the same machine.

- **Use generic login scripts.**
- **Use Oracle-supplied scripts to set the environment.**

```
PATH=/usr/bin:/bin:/usr/bin/X11/:/usr/local/bin
ORACLE_SID=orcl

ORAENV_ASK=NO
. oraenv
ORAENV_ASK=
```

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Managing Multiple Versions

You may want to update from your installed version of the Oracle Database to the current release. This requires that you can run multiple releases simultaneously. Often, a small group of users or developers use the new release initially. Later, remaining users switch to using the new release after your applications have been determined to be stable there. You should have a plan to allow easy configuration for multiple database users. Simply installing to `ORACLE_HOME` is not sufficient.

An upgrade from one version of the Oracle Database to another can be very difficult if not planned properly. This is especially true during the period when multiple versions of the database software are on the system, and possibly several databases on the same machine are running from different `ORACLE_HOME` directories. One common problem involves setting the user environment to access a particular database. Another problem has to do with providing proper support libraries for executables. For example, you can execute a program such as SQL*Plus from a different directory, but without the proper version of supporting software libraries defined in `ORACLE_HOME`, the program will usually fail. These problems and the solution on the following page apply only to users that have OS logins on the database server machine.

Managing Multiple Versions (continued)

The solution is to embed a call in each user's login script to a separate file that determines the environment for the user's preferred database. This makes the switching over of all users to a different ORACLE_HOME much simpler. The login script that is used depends on the user login shell. For the bash shell, the login script would be .bashrc. In the slide, setting ORACLE_SID and ORAENV_ASK=NO in .bashrc sets a default environment for this user, without requiring user interaction. Other variations can be set to suit your environment.

Generic Login Script

Each user should have a login script that includes only the environment variables that are specific to that user, such as the instance SID that the user accesses. A call to the Oracle-supplied oraenv script from the login script finds and sets the proper ORACLE_HOME and other site-specific, required environment variables.

oraenv

The oraenv script is provided with the database software and is relocated by the root.sh script at installation. The default location is /usr/local/bin. If the ORAENV_ASK variable is not set, then the oraenv script prompts the user for ORACLE_SID that the user wants to set, and presents a default of ORACLE_SID in the user's environment. This is a convenient way for users to change their environments or access multiple databases. If ORAENV_ASK is set to NO, then oraenv does not prompt the user, but sets ORACLE_HOME and other variables unless ORACLE_SID is set to a value not specified in the /etc/oratab file. In that case, the user is asked to provide ORACLE_HOME for the SID. If ORAENV_ASK is set to anything other than NO (including a blank), then the user will be prompted. Korn, Bourne, and bash shell users can use the oraenv script; coraenv is provided for C shell users. The oraenv script should be customized for each site. If the site requirements change, the DBA can modify oraenv and alter all the users' environments without changing every login script. The oraenv script calls another script, dbhome, which looks up the ORACLE_HOME associated with the ORACLE_SID in the /etc/oratab file. An example of calling oraenv from a login script is:

```
PATH=/usr/local/bin:/$PATH
ORACLE_SID=orcl
export PATH ORACLE_SID
ORAENV_ASK=NO
. oraenv
ORAENV_ASK=
```

Note: The '.' command sources the oraenv script, causing it to run in the current shell. This allows the oraenv script to set environment variables in *this* shell. Without the source command, the parent forks a new shell, the script executes and exits, returning to the calling shell.

Setting Oracle Environment Variables

Additional optional environment variables:

- **ORACLE_BASE: The root of the Oracle software directory structure**
- **ORACLE_SID: The initial instance name**
- **ORA_NLS10: The location of the character set files**
- **TMPDIR and TMP: An optional location for temporary space if required**
- **ORACLE_HOSTNAME: The name of the host on which to install the software; used for servers with multiple network cards**
- **ORACLE_DOC: The location of Oracle documentation**
- **LANG: System language**

ORACLE

Setting Oracle Environment Variables

In an OFA-compliant installation, there will be a root directory for all the Oracle software and database files. This often has the form of `/<mount_point>/app/oracle` and is `$ORACLE_BASE`. The `ORACLE_BASE` variable is set to reduce typing errors during the installation. This directory must exist and be owned by `oracle` with group `dba` before the installer is started. You can set the `ORACLE_SID` in the Database Creation Wizard.

`ORA_NLS10` is required to be set only if the `.nlb` message files and character set files are placed in a directory other than the default directory. The default directory is `$ORACLE_HOME/ocommon/nls/admin/data`.

The OUI can use up to 400 MB of space in the `/tmp` directory, and the OS commands that are run by the installer can use an additional 100 MB of space. If there is not enough space in `/tmp`, then use the `TMPDIR` variable to direct the OS commands to use an alternative directory, and the `TMP` variable to redirect the commands that would normally use the `/tmp` directory.

`ORACLE_DOC` is an optional environment variable that is used to specify the installation location of the Oracle online documentation.

Setting Oracle Environment Variables (continued)

LANG is a mandatory system environment variable that may optionally be changed for the Oracle user. Normally, the LANG variable will be set to something like en_US.utf8 when you install your operating system. For the oracle user, the character set (utf8) should be omitted so that the environment variable is just en_US. Failure to set this variable for the oracle user will limit Oracle Enterprise Manager functionality, including the abilities to:

- Store preferred credentials
- Run jobs
- Access reports

LD_LIBRARY_PATH specifies the path to C libraries. For the oracle user, that path normally includes the system default (/usr/lib and /usr/X11R6/lib), as well as the following:

- $ORACLE_HOME/jdk/jre/lib/i386
- $ORACLE_HOME/jdk/jre/lib/i386/lib
- $ORACLE_HOME/rdbms/lib
- $ORACLE_HOME/lib

Mounting the CD-ROM

To mount the CD-ROM with the Oracle software, perform the following steps:

1. **Insert CD into the CD drive on the server.**
2. **Click the CD-ROM icon or start the User Mount tool.**

Do not make your working directory the CD mount point.

ORACLE

Mounting the CD-ROM

Log in as the Oracle software owner. Insert the CD-ROM marked Disk 1. Start the User Mount tool or click the CD-ROM icon. If a file navigator is displayed, close the navigator. During the installation, the second and third CD-ROMs will have to be mounted. The current CD-ROM cannot be unmounted or ejected if any process, including the navigator, is accessing it. Depending on your access privileges, another terminal session logged in as root may be needed to mount and unmount the CD-ROM. The commands to mount and unmount a CD-ROM are:

```
# mount -t iso9660 /dev/cdrom /media/cdrom
# umount /media/cdrom
```

If `/etc/fstab` has the default settings for mounting `/dev/cdrom`, then the `mount` command can be simplified to the following:

```
# mount /media/cdrom
```

Staging the CDs

On machines that have sufficient disk space, the CD-ROMs can be copied to disk. This allows faster installations and network installations.

Starting the Installer

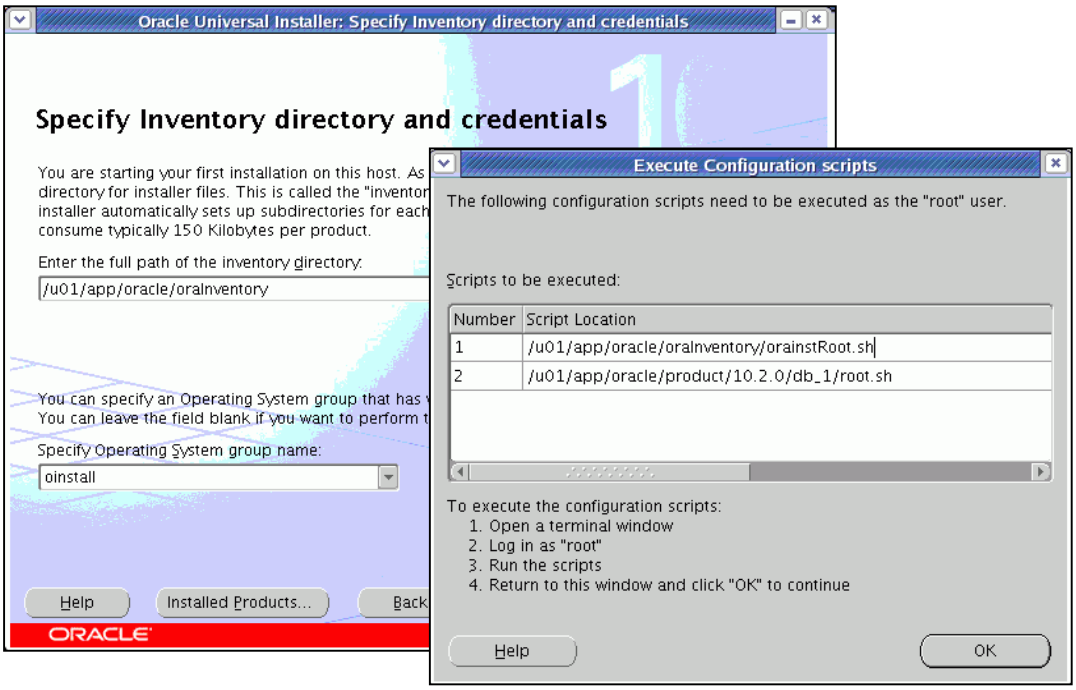
- **Start the OUI from the user's home directory.**
- **At the prompt, issue the `runInstaller` command.**

```
$ cd
$ pwd
/home/oracle
$ /media/cdrom/database/runInstaller
```


Starting the Installer

The `cd` command with no arguments changes your working directory to your `$HOME` directory. Using the `oracle` user created previously, this would be `/home/oracle`. Do not run the `runInstaller` command from the CD-ROM mount point. If you do, you will not be able to eject and insert the CDs when requested by the Oracle Universal Installer (OUI).

Oracle Universal Installer



Oracle Universal Installer

The Oracle Universal Installer is Java based, so it is the same across all platforms that Oracle supports.

After the Welcome screen and before the File Location screen, you are prompted to do the following:

1. Provide the Inventory Location. This defaults to `$ORACLE_BASE/oraInventory`.
2. Provide the Linux Group for the Oracle Inventory user.
3. Run the two specified scripts. You must go to a separate window as `root` and run this script. Follow the instructions in the pop-up window. If the installation fails after this script is run, then the `/etc/oraInst.loc` file must be removed for successful reinstallation. If there are prior Oracle installations on this server, do not remove the `oraInst.loc` file; contact Oracle Support. The `oraInst.loc` file contains a pointer to the location of the inventory and the `ORAINVENTORY` group name. You require this file for removal or upgrading.

Installation Log Files

The log files for the Oracle Universal Installer are in this directory: `$ORACLE_BASE/oraInventory/logs`

```
$ cd $ORACLE_BASE/oraInventory/logs
$ ls *.log
installActions2005-07-07_01-42-01AM.log
```

```
INFO: Configuration assistant "Oracle Database
   Configuration Assistant" succeeded
INFO: Command =
   /u01/app/oracle/product/10.2.0/db_1/bin/isqlplusctl
   start

iSQL*Plus 10.2.0.1.0
Copyright (c) 2003, 2005, Oracle.  All rights reserved.

Starting iSQL*Plus ...
```

ORACLE

Prerequisite Check Results

The results of the installation prerequite checks are in this file: `/u01/app/oracle/oraInventory/logs/results/db`

```
.
.
.
Checking for binutils-2.14;
   found binutils-2.14.90.0.4-35.      Passed
Checking for gcc-3.2;
   found gcc-3.2.3-42.       Passed
Checking for libaio-0.3.96;
   found libaio-0.3.96-3.      Passed
Check complete.
   The overall result of this check is: Passed
```

ORACLE

Oracle Patch Utility

Use OPatch to:

- **Apply other temporary patches**
- **Roll back temporary patches**
- **List installed Oracle components and temporary patches**
- **Attach an installed `ORACLE_HOME` to a central inventory**

```
$ opatch apply
...
OPatch succeeded.
```

ORACLE

Oracle Patch Utility

The Perl-based OPatch allows the application and rolling back of temporary patches. OPatch is installed as part of the Oracle 10*g* Database installation; it can be found under the `$ORACLE_HOME/OPatch` directory.

To install a patch with OPatch, you must have:

- Perl interpreter version 5.005_03 or later installed. Version 5.6 is preferred.
- A Java Runtime Environment (JRE). It is automatically installed with Oracle Database 10*g* Release 2.
- Execute privileges on the `fuser` utility. OPatch uses `fuser` to check that no Oracle database processes are running before it applies a patch. `fuser` is usually located in `/sbin` for Linux distributions and must be copied to the OPatch directory with operating system permissions changed so the Oracle user can execute it.
- Exclusive control of the Oracle Inventory directory. OPatch updates the inventory to reflect interim patches. There can be no other instance of OPatch or OUI running in order for OPatch to succeed.

Oracle Patch Utility (continued)

You can use OPatch to:

List currently installed components: Use the `lsinventory` command to list all installed components for your current ORACLE_HOME including any temporary patches already applied via OPatch.

```
$ opatch lsinventory –oh <ORACLE_HOME> -all
```

The `-oh` <*ORACLE_HOME*> argument can be omitted if you want to display the inventory for the ORACLE_HOME defined by $ORACLE_HOME.

The optional `-all` argument may be used in place of the `-oh` argument to display the contents of ALL ORACLE_HOMEs registered with the inventory.

Apply temporary patches: Use the `apply` command to apply a temporary patch.

```
$ opatch apply <patch directory> <ORACLE_HOME>
```

If the <*patch directory*> argument is not supplied, then OPatch looks for the patch in the current directory. If the <*ORACLE_HOME*> argument is not supplied, then OPatch applies the patch to ORACLE_HOME defined by $ORACLE_HOME.

Remove temporary patches: Use the `rollback` command to remove a temporary patch that has been applied by OPatch.

```
$ opatch rollback –id <patch id> -ph <patch directory>
```

By default, OPatch removes the patch from ORACLE_HOME specified by the $ORACLE_HOME environment variable. You can add the optional flag `–oh <ORACLE_HOME>` if you want to remove the patch from a different ORACLE_HOME. The patch ID and patch directory arguments are mandatory to remove a patch.

Attach an installed ORACLE_HOME to a central inventory: Use the `attach` command to add an ORACLE_HOME to an existing inventory. This may be necessary if the Oracle Database software was transferred from one system to another without the inventory, which is a nonstandard, unsupported installation method.

```
$ opatch attach –name <OH name> -oh <ORACLE_HOME>
```

If ORACLE_HOME is not specified, then OPatch uses ORACLE_HOME defined by $ORACLE_HOME.

For help on any of the OPatch commands, use the `–help` argument:

```
$ opatch –help
$ opatch attach –help
```

Oracle Relink Utilitity

To relink Oracle executables, perform the following steps:

1. **Verify whether `ORACLE_HOME` is correctly set.**
2. **Set `LD_LIBRARY_PATH` to include `$ORACLE_HOME/lib`.**
3. **Execute the appropriate `relink` command to relink the appropriate binaries:**
   - **`relink all`: All Oracle executables**
   - **`relink oracle` Database executables**
   - **`relink network`: Listener, cman, names**
   - **`relink oemagent`: Intelligent Agent**
   - **`relink utilities`: SQL*Loader, `tkprof`, `rman`, `impdp`, `expdp`, `imp`, `exp`**
   - **`relink ctx`: Oracle Text**

ORACLE

Oracle Relink Utility

The Oracle Database 10*g* software is not distributed as a group of complete executables. Instead, Oracle distributes individual object files, library archives of object files, and some source files which then get "linked" at the operating system level during installation to create usable executables. This guarantees a reliable integration with functions provided by the OS system libraries.

If the operating system or Oracle object files change, then Oracle executables should be relinked to create updated executables properly integrated with the operating system.

Relinking occurs automatically when a patch set is installed, but must be performed manually when:

- An OS upgrade has occurred
- A change has been made to the OS system libraries. This can occur during the application of an OS patch.
- A new installation failed during the relinking phase.
- An individual Oracle patch has been applied. Explicit relink instructions are usually either included in README or integrated into the patch install script.

Oracle Relink Utility (continued)

To relink, you can use the relink utility as shown in the preceding slide, or manually relink with the `make` command. Unlike OPatch, the `relink` utility does not return positive feedback. Unless you receive an error message, relink succeeded.

Troubleshooting

If you have problems during the installation:

- **Check the kernel parameter settings**
- **Check the environment variables**
- **Check directory permissions**
- **Verify that the required packages are installed**

ORACLE

Troubleshooting

There are some common problems with the installation. Many are the result of missing a step in the preinstallation setup.

Kernel parameters errors, often the result of typographic errors, can cause `ORA-3113 End of File on communication channel`, or an OS error indicating that there is not enough shared memory or semaphores. These usually show up when the Database Creation Assistant tries to start an instance.

Environment variables can lead to a variety of errors again due to incorrect typing. The directory to be used as the `ORACLE_BASE` must exist and be owned by the user that is running the installer. The C compiler and supporting utilities must be installed and the directory must be included in the `PATH` environment variable.

The OUI is very convenient to use. The error pop-up windows normally allow you to go to another window, fix the problem, and click Retry. The only errors that cannot be fixed in this manner are the environment variables. If you discover that the problem is with environment variables, then you must exit the OUI, change the variable, and restart the installer. The installer inherits the environment when it starts, and the installer environment cannot be changed while the installer is running.

Summary

In this lesson, you should have learned how to:

- **Describe the Linux file system security**
- **Install Multiple versions of Oracle Database software on the same server**
- **Accommodate multiple Oracle homes on one database server**

Practice 3 Overview: Installing Oracle on Linux

This practice covers the following topics:

- **Working with Linux users and groups**
- **Installing Oracle on Linux**

4

Managing Storage

Objectives

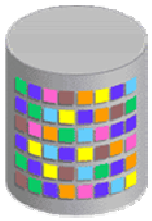
After completing this lesson, you should be able to:

- **Distinguish the differences between certified and supported file systems**
- **Select a file system**

ORACLE

Certified and Supported File Systems

- Linux supports multiple file systems.
- Oracle supports some of the file systems.
- Oracle certifies three file systems:
  - ext3
  - Automatic Storage Management
  - Oracle Cluster File System/Oracle Cluster File System 2
- Criteria for choosing a particular file system are:
  - Reliability
  - Performance
  - Security



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Certified and Supported File Systems

One of the most interesting features of the Linux OS is its support for multiple file systems.

File systems can be defined and built on a partition basis; `ext3`, `XFS`, and `ReiserFS` file systems can coexist on the same Linux system, along with several other file systems and raw partitions. Your choice of which one to use should be based on supportability, reliability, security, and performance.

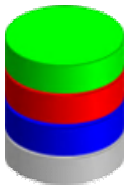
To be acceptable for database use, the file system must perform certain minimum functions such as write acknowledge, write-thru cache, and file permissions. Examples of file systems that are not normally acceptable for database use are `XFS`, and Virtual File Allocation Table (VFAT), which lack file permissions.

There is an important distinction between supported and certified file systems. Oracle only certifies `ext3`, Oracle Automatic Storage Management (ASM), and Oracle Cluster File System/Oracle Cluster File System 2 (OCFS/OCFS2). If it is determined that an issue is caused by the file system and the file system is certified, then Oracle Support will work on the issue. If you choose to run on other file systems, such as `ReiserFS`, and have a file system issue, you will be supported, but it will be the OS vendor providing the file system support.

Disk Partitioning

Linux uses disk partitions effectively to segregate directories and ease recovery:

- `/boot`
- `/`
- `/var/log`
- `/tmp`
- `/home`
- `/<mount_point>/oracle`



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Disk Partitioning

Disk partitioning is not required by Linux or by Oracle software. However, disk partitioning can reduce the time consumed in operations such as planning for recovery, upgrades, and backups.

The larger the partition the longer a file system check (`fsck`) operation takes on bootup. Much of this time can be avoided by using a journaled file system, such as `ext3`. Having a small `/boot` partition that holds only the current kernels separates the tasks of booting the machine and recovering a partition. A typical size of this partition is from 10 MB to 100 MB. For Enterprise Linux, it is recommended that you have approximately 100 MB for the boot partition.

The `/` partition should hold only a few directories that are created with the distribution installation. These directories are overwritten with a new installation or upgrade. (Keep track of any customized configuration files that you place under this partition, because they will also be overwritten during a new installation or upgrade.)

The `/var/log` and `/tmp` should be separate partitions to isolate the effects of runaway processes. The `/tmp` partition should be at least 400 MB.

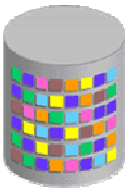
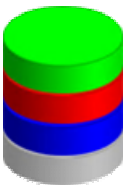
Disk Partitioning (continued)

If these separate partitions become full, the process dies or stops logging. If these directories become full when they are on the / partition, the system can crash. If /home is a separate partition, it can be backed up and restored separately. An OS upgrade need not touch this partition.

Comparing File Systems

Linux supports multiple file systems:

- **Operating system (OS) is file system independent.**
- **Multiple file systems can be on the same server.**
  - **Cross-platform compatibility**
  - **Performance**
  - **Special requirements: Oracle Cluster File System (OCFS)**

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Comparing File Systems

The Linux kernel is file system independent. It has a file system API. If the file system uses the API, it can be supported. A variety of file systems are available with the standard distribution. Some are just for compatibility with other systems, such as `FAT32` for MS Windows compatibility. Others are included for historical reasons, such as `minix` which was the first file system supported by Linux. The most popular file systems are `ext3` and `ReiserFS`. There are other file systems available from various sources. Most of these should be considered experimental. Oracle provides Automatic Storage Management (ASM) and Oracle Cluster File System/Oracle Cluster File System 2 (OCFS/OCFS2). The OCFS is designed for use with Linux clusters running the Real Application Clusters (RAC) database. This file system overcomes the limitations of raw devices on Linux.

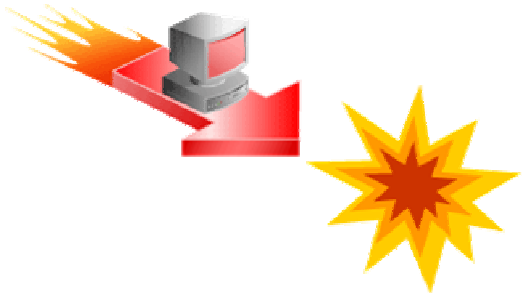
OCFS2 has been designed to be a general purpose cluster file system. With it, you can store not only database-related files on a shared disk, but also store Oracle binaries and configuration files (shared Oracle home) making management of RAC even easier. OCFS2 began shipping as part of the Linux kernel in version 2.6.16.

Oracle recommends using ASM for database files.

File System Characteristics

Certain characteristics are better for database use:

- **Write-thru-cache ability**
- **Write acknowledgement**
- **Security**
- **Journaling**
- **High Performance**



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File System Characteristics

In choosing a file system, performance is important, but not the primary consideration. It does not matter how fast the file system is if the data is corrupted, lost, or compromised. To achieve this end, the Oracle database does not support database files on file systems that do not have a write-thru-cache capability. Supported file systems must acknowledge writes. There are security requirements as well. Oracle server and the database files require special file permissions that are not available on certain file systems. When these file permissions are not set correctly, the Oracle server does not function properly. Data files should be accessible only to the database owner, and all other access should be controlled by the database itself.

Journaling is a popular characteristic. The major benefit is that the changes to the file system are recorded in a journal file similar to database redo logs. If the server crashes or shuts down without synchronizing the disks, then the journal file can be applied to the file system, thus restoring the file system integrity very quickly. This effect can be seen on bootup. The `fsck` command checks journaled file systems more quickly than nonjournaled file systems.

Oracle Database must be able to verify that writes to a disk are completed successfully. Standard NFS, including file systems on NAS devices, may not be able to guarantee that writes to a disk are completed successfully, and this may lead to possible data file corruption.

File System Characteristics (continued)

Oracle recommends that you do not store files on standard NFS. If you use NFS, it is recommended you use a storage vendor and storage device listed in the Oracle Storage Compatibility Program list. This list is available from the following Web site:

http://www.oracle.com/technology/deploy/availability/htdocs/oscp.html

If a storage device is supported, then you can use it to store Oracle software files, Oracle database files, or both.

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Automatic Storage Management

- **Provides a vertical integration of the file system and volume manager for Oracle database files**
- **Spreads database files across available storage for optimal performance and resource utilization**
- **Enables simple and nonintrusive resource allocation**
- **Provides automatic rebalancing**
- **Works in single instance and Real Application Cluster (RAC) databases**

ORACLE

Automatic Storage Management

Automatic Storage Management (ASM) provides an integrated file system and volume manager specifically for Oracle database files.

ASM spreads database files evenly across available disks. ASM enables you to nonintrusively add or remove storage. Disk space can be added or removed while the database is online.

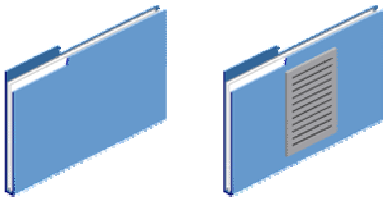
Automatic Storage Management can be used with single instance or RAC.

Managing multiple file systems and hundreds or thousands of files for a large database can be very cumbersome. With ASM, you assign large pools of disks in disk groups to ASM, then allow ASM to manage the files stored on those disks. You need to manage only the disks, not the files.

ext2 and ext3

The ext2 and ext3 file systems are closely related:

- **ext2 can be converted to ext3.**
- **ext3 can be mounted as an ext2 file system.**
- **ext3 is a journaled file system.**
- **ext3 has several performance enhancements.**



ext2 and ext3

The differences between the ext2 and ext3 file systems are important. ext2 has, in computer terms, a long history of improvements and reliability. ext3 starts with the same base and adds journaling and speed. In general, journaling is slower than nonjournaled file systems, but ext3 optimizes the disk head movement to give excellent performance. In several tests that compared ext2, ext3, ReiserFS, and raw, ext3 was the fastest.

ext3 has three journaling levels that may be set with the -o option in the mount command or in the options section of /etc/fstab. The highest level—the one that does the most journaling is data=journal—writes the journal entries for all the data and metadata changes. The lowest level, which does the least journaling, is data=writeback with only metadata being written. The default is data=ordered, where metadata with increased integrity is written.

Comparing ext3 at different journaling levels has not been as thoroughly documented, but preliminary results indicate that setting data=journal is the fastest and most reliable. The other levels of journaling, data=writeback (the lowest) and data=ordered (the default), would be expected to yield performance benefits at the expense of reliability, but do not seem to be faster.

Oracle Clustered File System 2

Oracle Corporation makes OCFS2 available under the General Public License (GPL) for use with Linux.

- **OCFS2 is a general purpose cluster file system that shares between files nodes of a cluster:**
- **OCFS2 can be downloaded from:**
  - **`http://oss.oracle.com`**
- **More information about OCFS2 and other products from Oracle's Linux Projects Development group can be found at Oracle's home for Open Source projects, `http://oss.oracle.com`, and the Oracle Technology Network `http://otn.oracle.com`.**

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Oracle Clustered File System 2

Oracle Clustered File System 2 (OCFS2) is designed to be a general-purpose cluster file system. It can store data files, as well as binaries and configuration files.

Network File System

- **Oracle Compatible Network Attached File Servers**
  - **http://www.oracle.com/technology/deploy/availability/htdocs/vendors_nfs.html**
- **Oracle Storage Compatibility Program (OSCP)**
  - **http://www.oracle.com/technology/deploy/availability/htdocs/oscp.html**

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Network File System

Oracle supports only NFS protocol with network file servers. Oracle does not support CIFS protocol because CIFS protocol cannot guarantee certain write block size and data commitment to disk or cache.

Oracle does not recommend using an NFS device unless the NFS vendor is a member of the Oracle Storage Compatibility Program (OSCP). Members in OSCP test and verify their products compatibility with the Oracle product.

Summary

In this lesson, you should have learned how to:

- **Distinguish between certified and supported file systems**
- **Choose a file system**

ORACLE

5

Automatic Storage Management and Automatic Storage Management Library Driver

Objectives

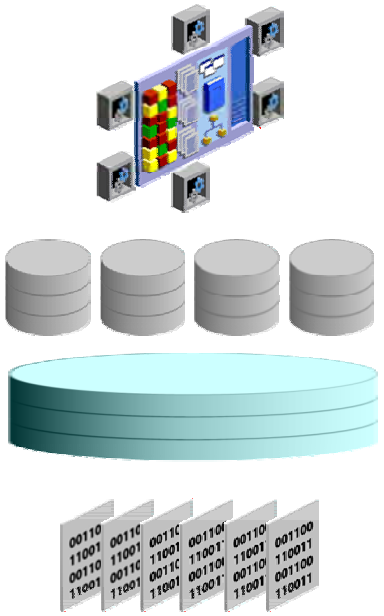
After completing this lesson, you should be able to:

- **Install and initialize Automatic Storage Management Library Driver (ASMLib)**
- **Mark disks for ASMLib**
- **Create an Automatic Storage Management instance**

ORACLE

Automatic Storage Management

- Instance
- Disks
- Disk groups
- Files



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Automatic Storage Management

Instance

The Automatic Storage Management (ASM) instance is a special Oracle instance that manages disks in disk groups. An ASM instance must be configured and running before a database instance can access Automatic Storage Management files. This configuration is performed automatically if the Database Configuration Assistant is used for database creation.

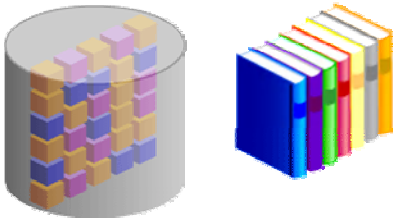
Disk Group

A disk group is a set of disk devices that ASM manages as a single unit. Each disk device can be an individual physical disk, a multiple disk device such as a redundant array of inexpensive disks (RAID) storage array or logical volume, or even a partition on a physical disk. However, in most cases, disk groups consist of one or more individual physical disks. To enable ASM to balance I/O and storage efficiently within the disk group, you must ensure that all devices in the disk group have similar, if not identical, storage capacity and performance.

ASM spreads data evenly across all the devices in the disk group to optimize performance and utilization. You can add or remove disk devices from a disk group without shutting down the database. When you add or remove disks, ASM rebalances the files across the disk group. You can create multiple disk groups to handle specific tasks, such as backup and recovery operations, in addition to regular file storage activities.

Automatic Storage Management Library Driver (ASMLib)

- **Simplifies configuration and management of disks**
- **Eliminates the need for binding raw devices**
- **Download RPMs from http://www.oracle.com**



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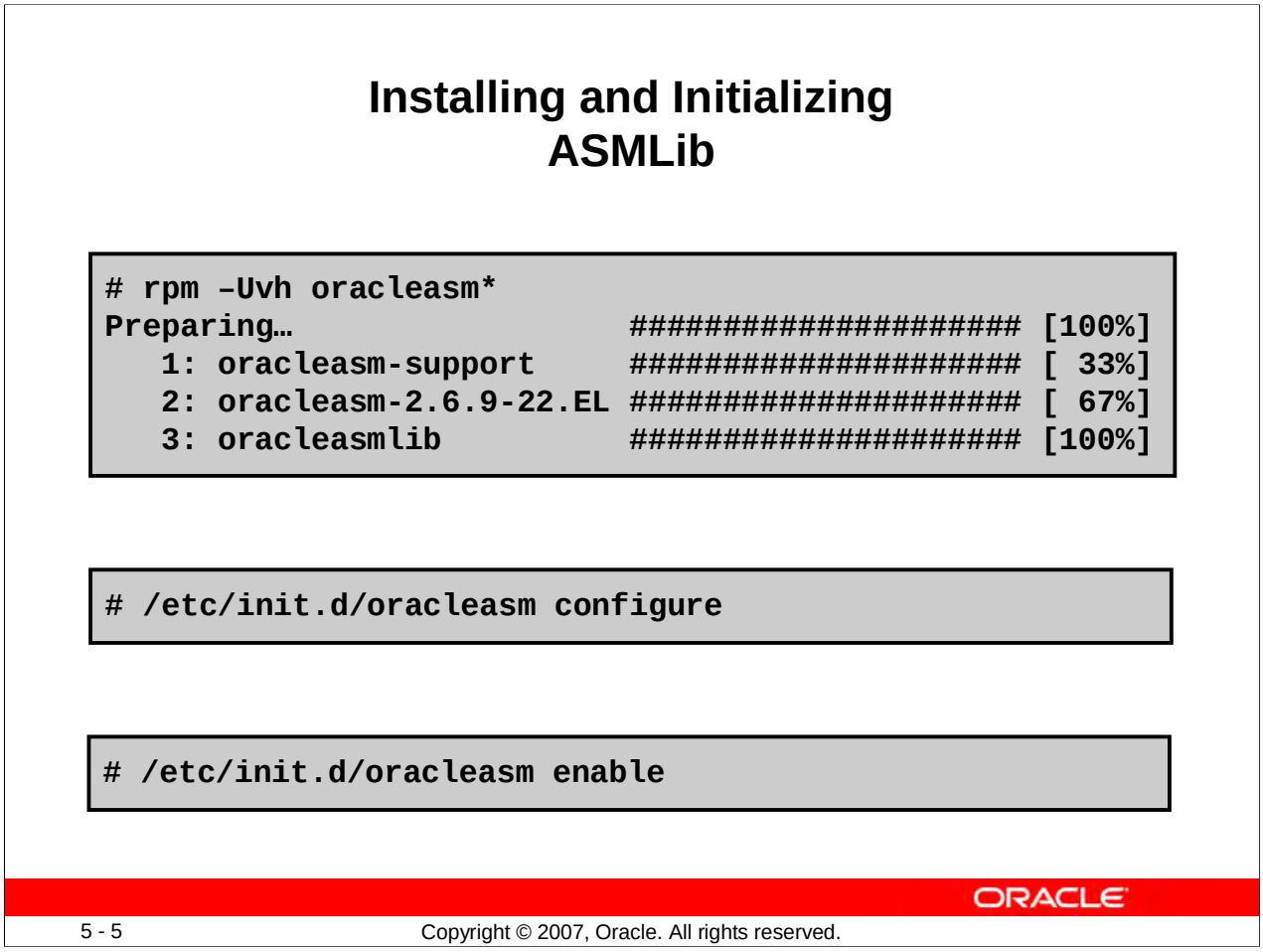
5 - 4

Automatic Storage Management Library Driver (ASMLib)

The Automatic Storage Management library driver (ASMLib) simplifies the configuration and management of the disk devices by eliminating the need to rebind raw devices used with ASM each time the system is restarted.

If you intend to use Automatic Storage Management for database storage for Linux, then Oracle recommends that you install the ASMLib driver and associated utilities, and use them to configure candidate disks. A disk that is configured for use with Automatic Storage Management is known as a candidate disk.

If you do not use the Automatic Storage Management library driver, then each disk device that you want to use must be bound to a raw device.



Installing and Configuring ASMLib

To install ASMLib, you need to download three RPMs from http://www.oracle.com, which are specific to your kernel.

After downloading, install the RPMs with the `Uvh` option.

```
rpm –Uvh oracleasm*
```

After the RPMs are installed, execute `/etc/init.d/oracleasm` with the `configure` option.

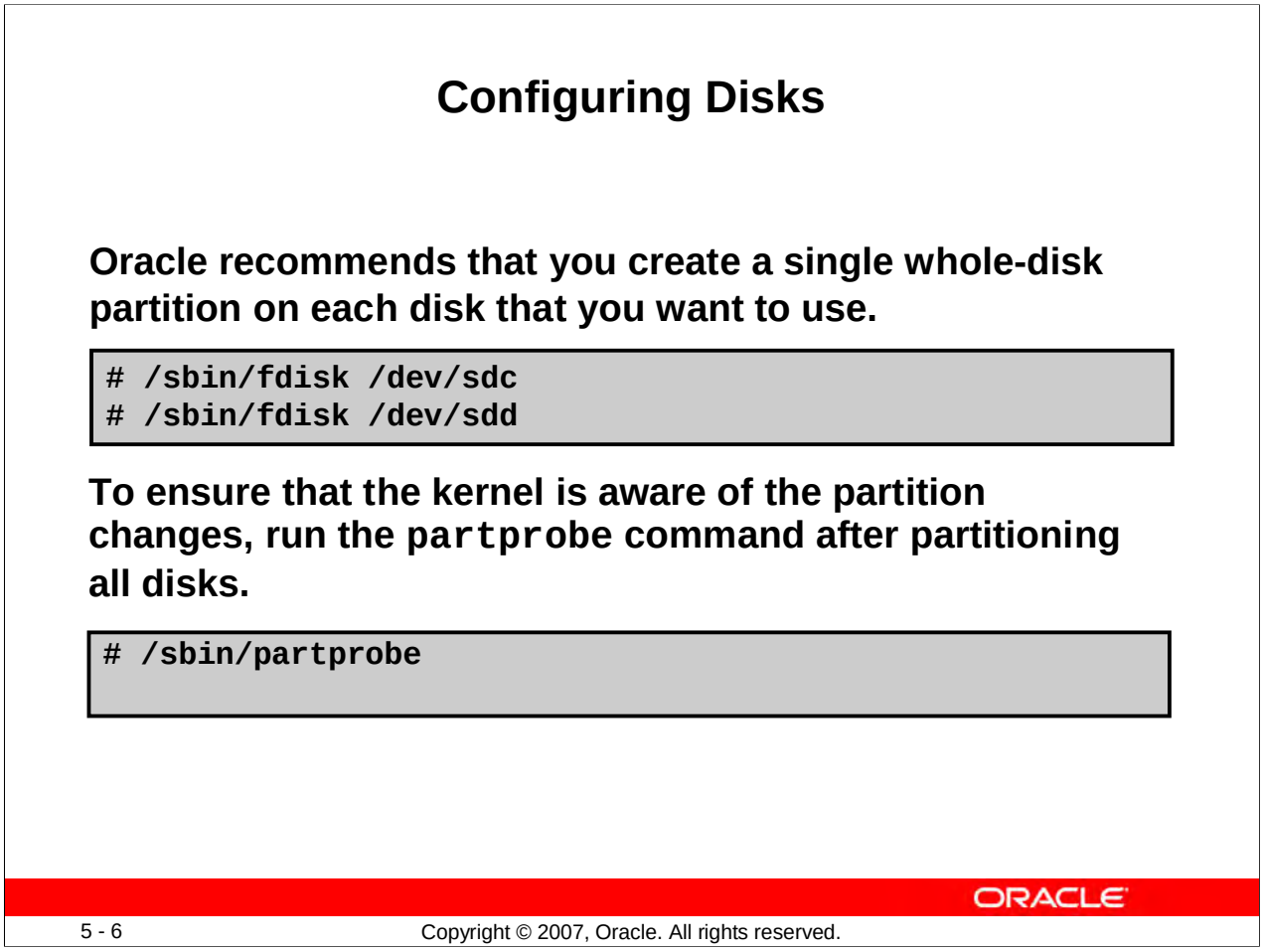
```
/etc/init.d/oracleasm configure
```

You will be prompted four times.

- Default user to own the driver interface
- Default group to own the driver interface
- Start Oracle ASM library driver on boot
- Fix permissions of Oracle ASM disks on boot

The user who owns the driver interface should be the same user who owns the software installation, typically `oracle`. The group to own the driver interface should be the group used for DBAs, typically `dba`. You will want ASMLib to start when the system boots and to fix permissions of ASM disks.

After it is configured, to enable ASM, run the `oracleasm` utility with the `enable` option.



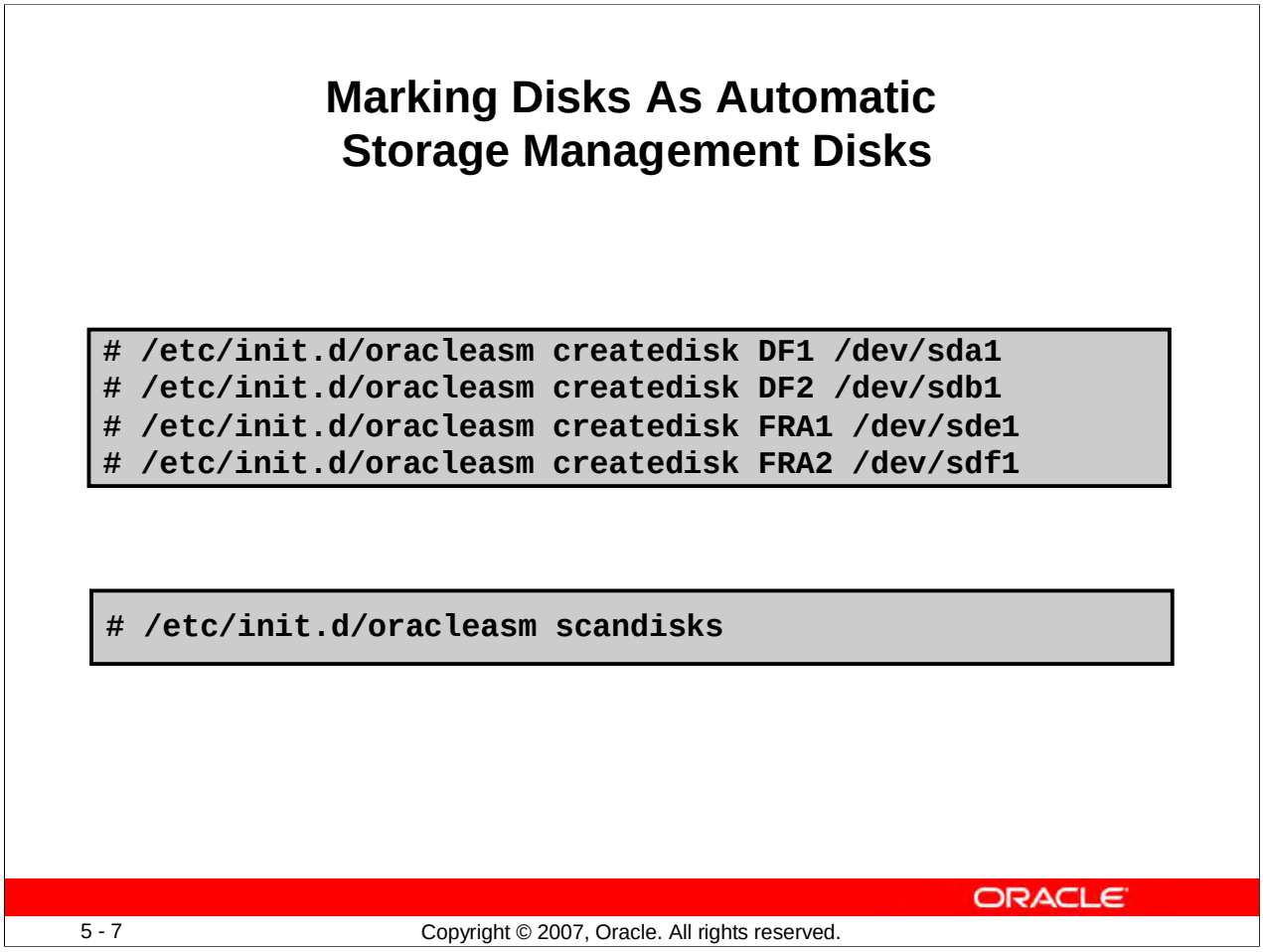
Configuring Disks

Oracle recommends that you create a single whole-disk partition on each disk that you want to use. Use either `fdisk` or `parted` to create a single whole-disk partition on the disk devices that you want to use.

```
/sbin/fdisk /dev/sdc
```

The kernel may be unaware of the partition changes after partitioning the disks. The `partprobe` command searches for partitions information and informs the kernel of partition table changes.

```
/sbin/partprobe
```



Marking Disks As Automatic Storage Management Disks

When using ASMLib, disks must be marked for ASM usage. In the process of marking a disk, you must assign a name to the disk. Meaningful names can be assigned for each disk.

You may create multiple disk groups.

By providing descriptive names to each disk, you will have an easier time assigning disks to disk groups when creating the ASM instance. When choosing names for drives, consider using the physical location of the drive in the name.

Disks are marked by using the `createdisk` option with `/etc/init.d/oracleasm`:

```
/etc/init.d/oracleasm createdisk DF1 /dev/sda1
```

To make the disks available, use the `scandisks` option:

```
/etc/init.d/oracleasm scandisks
```

Creating an ASM Instance

- Use DBCA to create the ASM instance.
- Select Configure Automatic Storage Management.
- Run the `$ORACLE_HOME/bin/localconfig add` command when prompted:

```
$ su –
# /u01/app/oracle/product/10.2.0/db_1/bin/localconfig add
```

- Default parameters for the initialization parameter file are sufficient for a single instance database.
- Create two disk groups:
  - Database
  - Flash recovery area

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Creating an ASM Instance

An ASM instance manages ASM disk groups. Before starting or creating a database instance, which uses ASM to manage its disks, the ASM instance must be running.

When you choose Automatic Storage Management as a database storage mechanism in the Database Configuration Assistant (DBCA), an ASM instance is created and started. You then assign disks to disk groups within DBCA.

If you create multiple single-instance databases on a node, a single ASM instance can handle all the disk groups for the databases on the node.

Note: Screenshots for using DBCA to create an ASM instance can be found in the lab solutions for this lesson in Appendix B.

Oracle recommends that you use ASM for database files and the flash recovery area. Separate disk groups may be created for each.

ASM and ASMLib Installation and Configuration Summary

- Download and install the ASMLib RPMs.
- Run `oracleasm configure`.
- Run `oracleasm enable`.
- Create a single whole-disk partition on each disk.
- Run `partprobe` to ensure that the kernel is aware of the new partitions.
- Mark disks as Automatic Storage Management disks.
- Run `oracleasm scandisks` to make the disks available.
- Create the ASM instance using the Database Configuration Assistant.

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ASM Installation: Best Practices

- **Install ASM in a separate `ORACLE_HOME` from the `ORACLE_HOME` database:**
  - **This provides higher availability and manageability.**
  - **It allows independent upgrades of the database and ASM.**
  - **Deinstallation of the database software can be performed without impacting the ASM instance**
- **Create one ASM instance per node.**

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ASM Installation: Best Practices

Install Automatic Storage Management in a separate `ORACLE_HOME` from the `ORACLE_HOME`(s) database. Creating the ASM Instance from the same `ORACLE_HOME` as the databases creates a single point of failure. A separate `ORACLE_HOME` allows independent upgrades of the ASM and the database. The database or ASM can be upgraded without upgrading the other. The `ORACLE_HOME`s database can be deinstalled without affecting the ASM instance.
Create only one ASM instance per node. The ASM instance will manage storage for all databases on the node.

Disk Group: Best Practices

- **Create two disk groups:**
  - **Database area**
  - **Flash recovery area**
- **Create disk groups using large numbers of similar type disks:**
  - **Same size characteristics**
  - **Same performance characteristics**

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Disk Group: Best Practices

Create two disk groups: one for the database area and the other for the flash recovery area. However, more disk groups can be created; using two will be easier to manage.

Automatic Storage Management performs load balancing. Using disks with the same size and performance characteristics will assist ASM to properly balance the files across the disks.

Summary

In this lesson, you should have learned how to:

- **Install and initialize ASMLib**
- **Mark disks for ASMLib**
- **Create an ASM instance**

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Practice 5 Overview: Installing and Configuring ASMLib and ASM

This practice covers the following topics:

- **Installing Oracle ASMLib RPMs**
- **Configuring ASMLib**
- **Configuring disks**
- **Marking disks for ASM**
- **Creating an ASM instance**

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6

Creating the Database

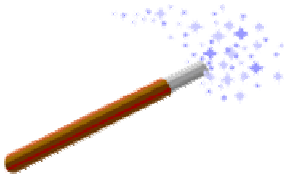
Objectives

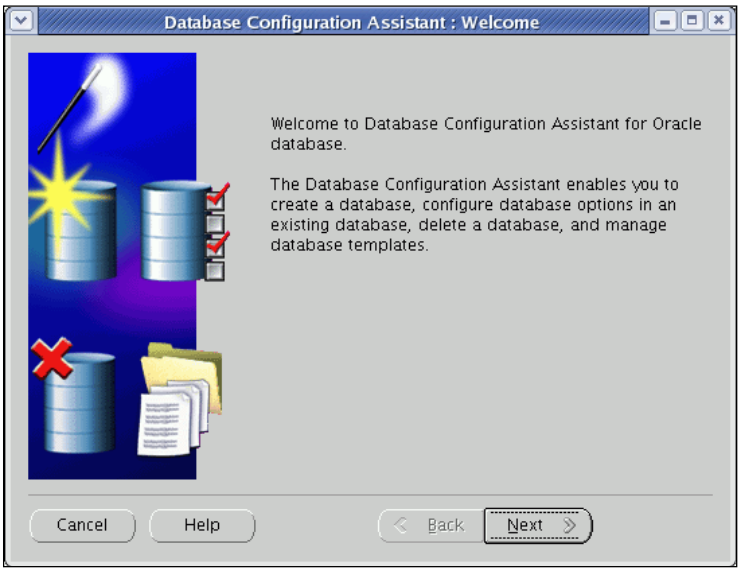
After completing this lesson, you should be able to:

- **Create an Oracle database that uses ASM**
- **Identify the location of various Oracle files**
- **Implement OS authentication**

Creating a Database

```
$ dbca
```





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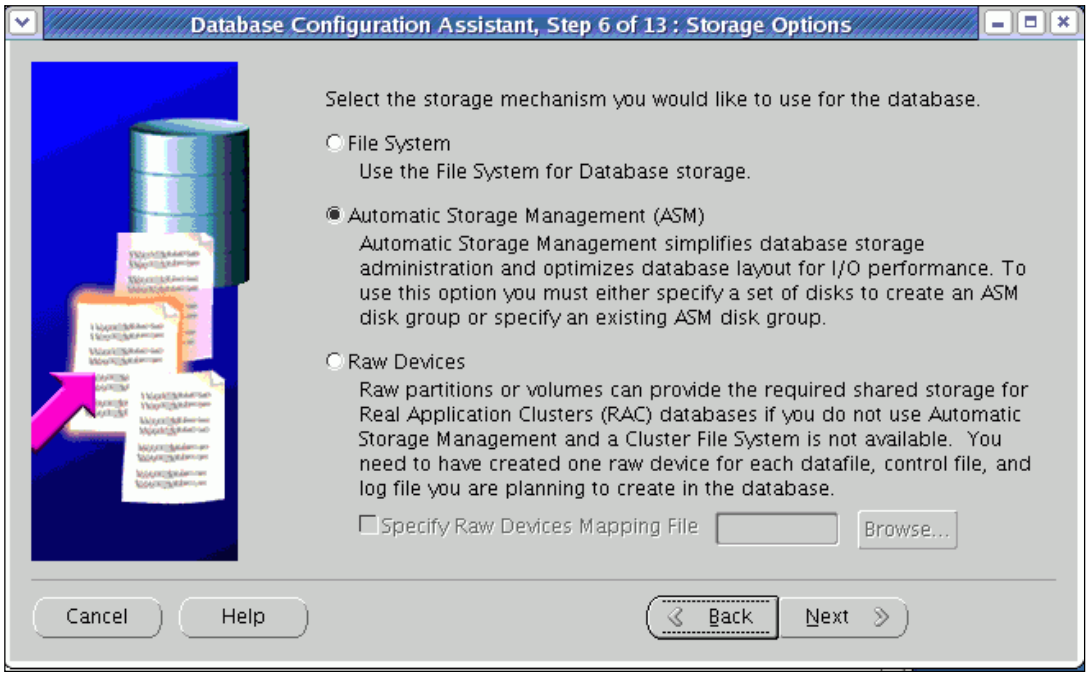
Creating a Database

You can use DBCA to create a database, either in silent mode or via a graphical interface. Using the graphical interface, you answer about 12 questions, and then the creation process starts. Some of the questions are regarding the name of the database, passwords for users, and the storage mechanism to use.

Choosing the Storage Mechanism



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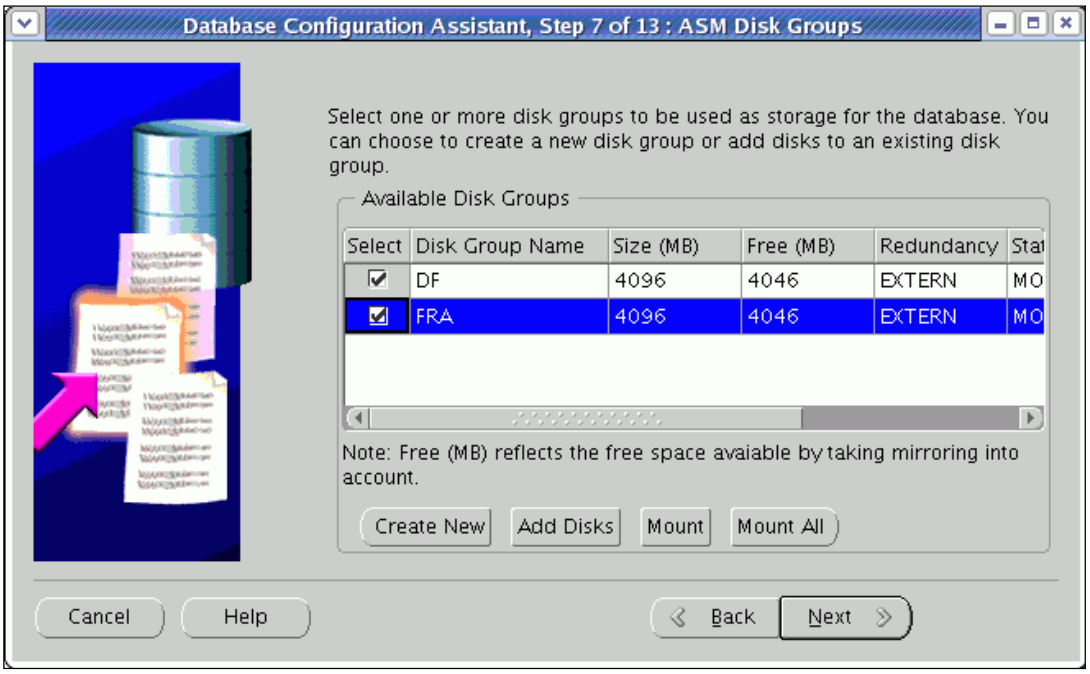
Choosing the Storage Mechanism

You have three options for your database's storage: File System, Automatic Storage Management (ASM), and Raw Devices. These options are explained in detail in the lesson titled "Managing Storage." If you choose Automatic Storage Management, then there must be an ASM instance running at the time.

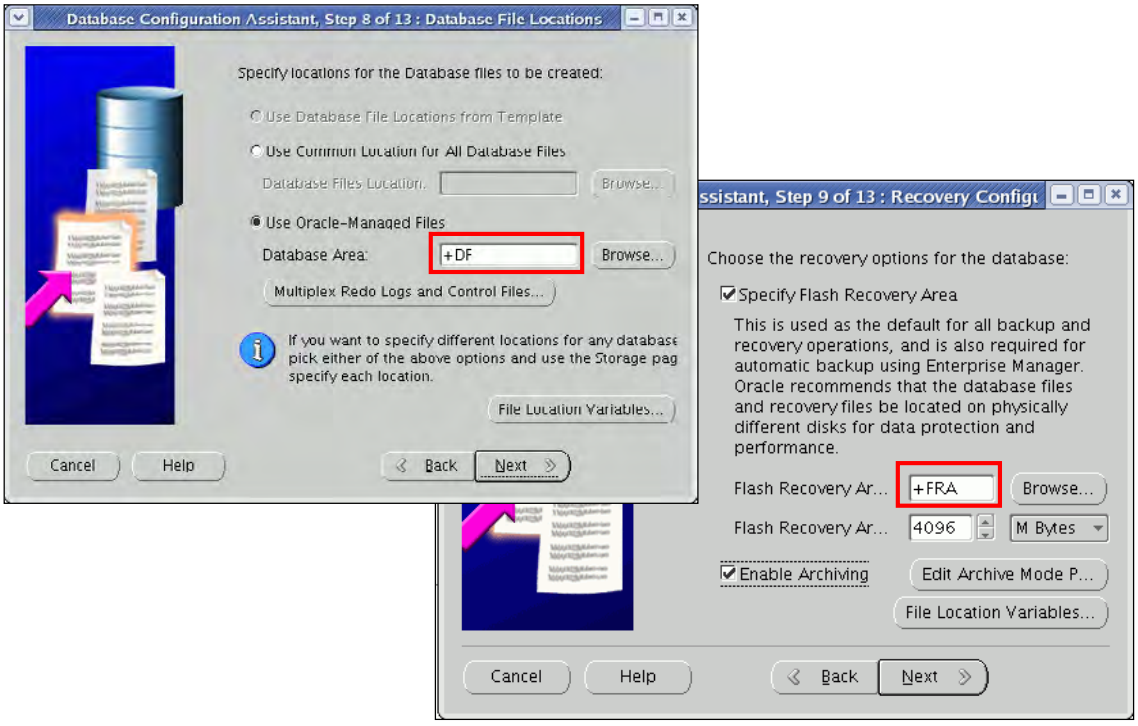
Specifying the ASM Disk Groups



Specifying the ASM Disk Groups

If you choose ASM for the storage mechanism, then you are presented with a list of existing ASM disk groups. Select the disk groups that you plan to use for this database. In the example in the slide, there are two disk groups displayed: DF and FRA. In this case, for example, you may intend to use DF for the data files and FRA for the flash recovery area for this database, so both are selected.

Assigning ASM Disk Groups



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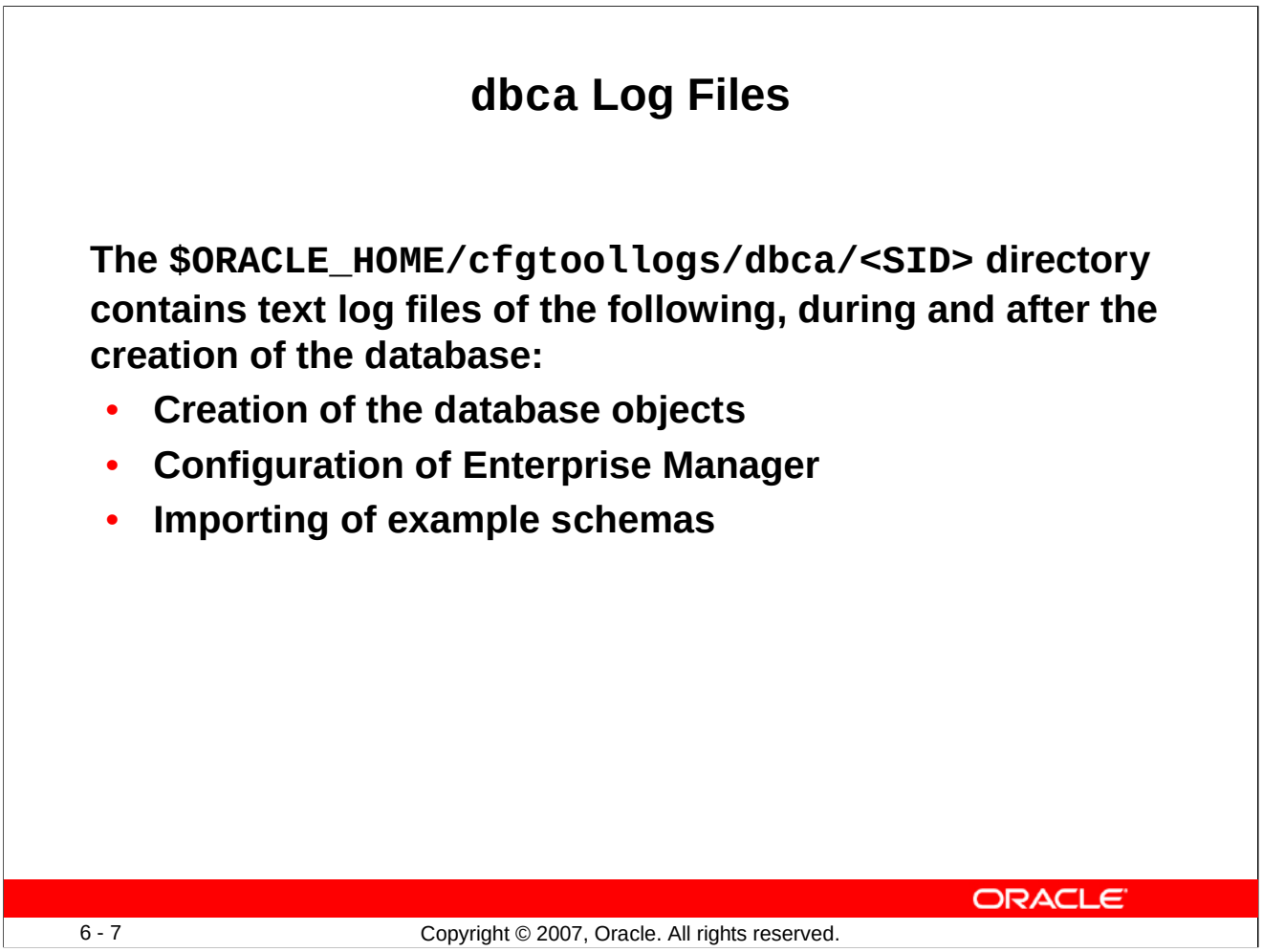
Assigning ASM Disk Groups

Now that dbca is aware of the ASM disk groups that are to be used for this database, you can assign them to be used for database file locations and the flash recovery area. In this example, Oracle-Managed Files is being used, and the +DF disk group is to contain those files. After specifying that, you can specify if there is a flash recovery area, and where it is to be stored. This example is following the Oracle-recommended practice of having a separate disk group for the flash recovery area.



dbca Log Files

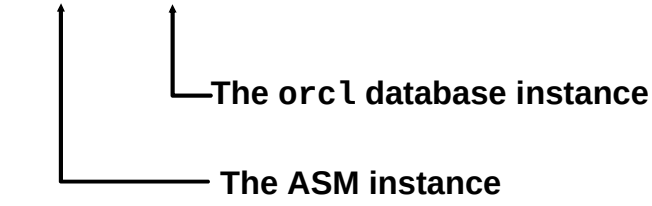
To see the details of the `dbca` execution, you can navigate to the `$ORACLE_HOME/cfgtoollogs/dbca/<SID>` directory and view the log files there, using a text editor. Here are some sample contents of the `tts_example_imp.log` file, which shows the log of the import of the `EXAMPLE` tablespace:

```
$ head tts_example_imp.log

Connected to: Oracle Database 10g Enterprise Edition Release
10.2.0.1.0 - Production
With the Partitioning, OLAP and Data Mining options

Export file created by EXPORT:V10.02.01 via conventional path
About to import transportable tablespace(s) metadata...
import done in US7ASCII character set and AL16UTF16 NCHAR
character set
. importing SYS's objects into SYS
. importing SYS's objects into SYS
. importing HR's objects into HR
```

The Instance admin Directory

The files that serve as diagnostics are located in `$ORACLE_BASE/admin`:

```
$ cd $ORACLE_BASE/admin
$ ls
+ASM  orcl
```



There is a subdirectory for each instance.

The Instance admin Directory

In the `$ORACLE_BASE/admin` directory, there is a subdirectory for each instance. The slide shows there are two instances in this case, the ASM instance, called `+ASM`, and the conventional database instance, `orcl`.

Parameter and Dump Files

The following subdirectories are in the `$ORACLE_BASE/admin/$ORACLE_SID` directory:

- **`adump`: Audit files**
- **`bdump`: Background process trace files**
- **`cdump`: Core dump files**
- **`udump`: User process trace files**
- **`dpdump`: Default Data Pump output directory**
- **`pfile`: Oracle database initialization parameter files**

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Parameter and Dump Files

There is a set of diagnostic directories under each of these instance subdirectories. These can be referred to when looking for information such as trace files and core dumps, among other things. Here is an example of the contents of two of the subdirectories:

```
$ ls -l *
+ASM:
total 16
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:38 bdump
drwxr-x---  2 oracle oinstall 4096 Sep 25 08:16 cdump
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:13 pfile
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:38 udump

orcl:
total 24
drwxr-x---  2 oracle oinstall 4096 Sep 26 06:05 adump
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:39 bdump
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:16 cdump
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:16 dpdump
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:26 pfile
drwxr-x---  2 oracle oinstall 4096 Sep 26 05:39 udump
```

The `portlist.ini` File

The `portlist.ini` file contains all of the port number information for Oracle-related applications, including:

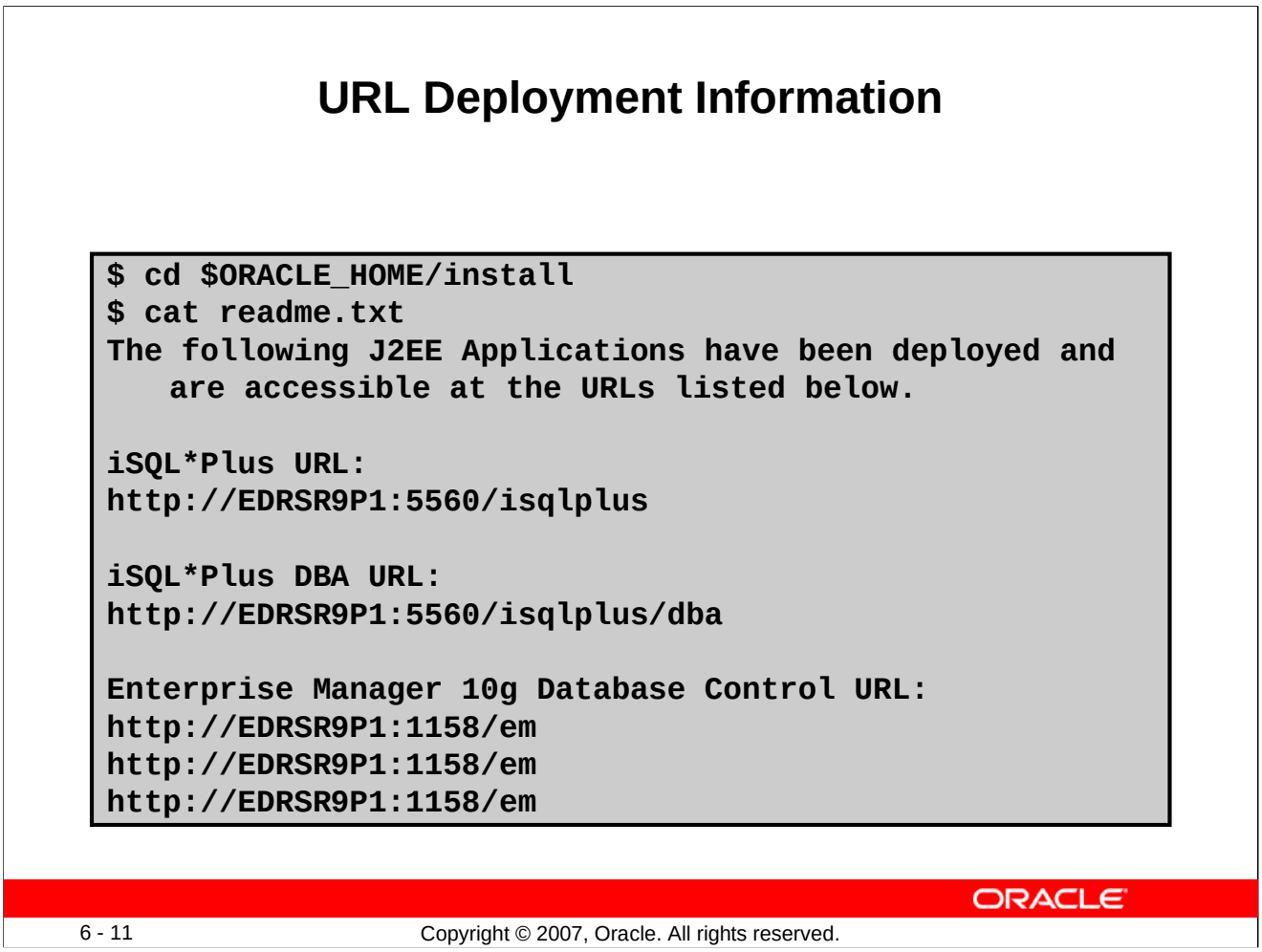
- ***i*SQL*Plus**
- **Enterprise Manager Console**

```
$ cd $ORACLE_HOME/install
$ cat portlist.ini
iSQL*Plus HTTP port number =5560
Enterprise Manager Console HTTP Port (orcl) = 1158
Enterprise Manager Agent Port (orcl) = 3938
```

ORACLE

The `portlist.ini` File

The `portlist.ini` file is in the `$ORACLE_HOME/install` directory and contains the record of port numbers that are used for browser-based applications. For example, this `portlist.ini` file indicates that 1158 is the port number for Enterprise Manager Console for the `orcl` instance.

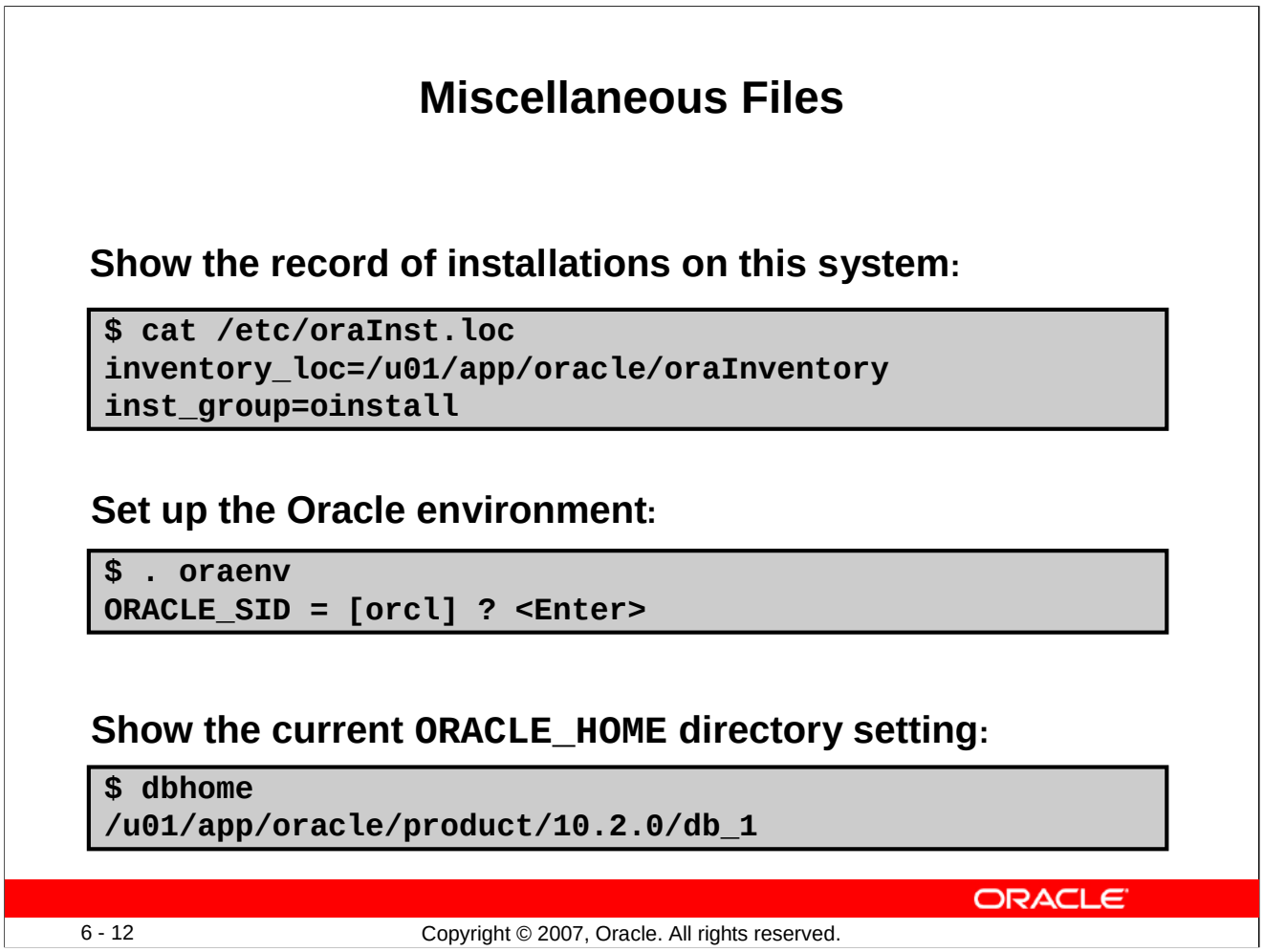


URL Deployment Information

The `readme.txt` file in the `$ORACLE_HOME/install` directory lists the URLs for any J2EE applications that have been deployed.

To start the Enterprise Manager Database Control application, enter the following command as the owner of the Oracle software installation (for example, `oracle`):

```
$ emctl start dbconsole
```

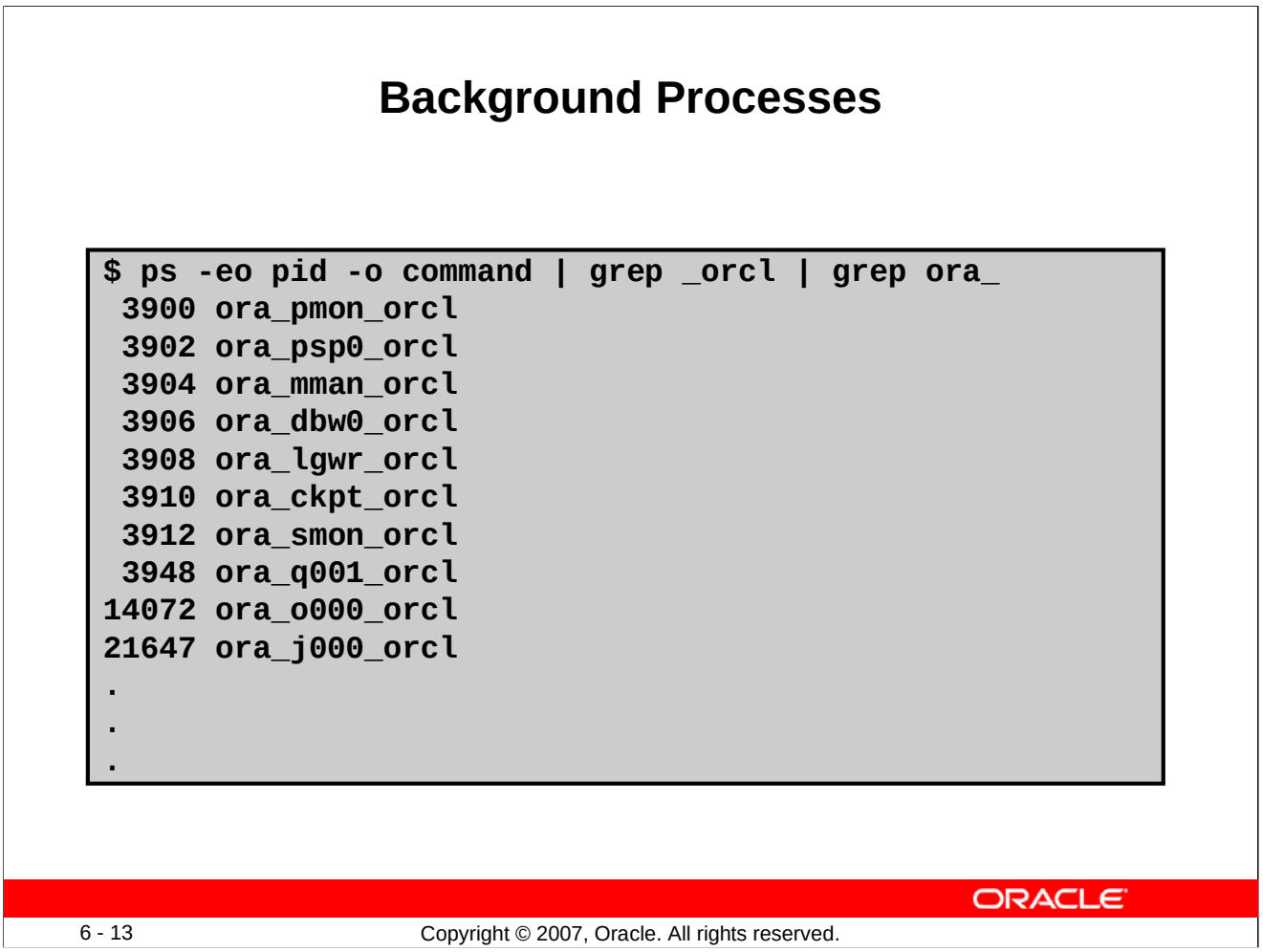


Miscellaneous Files

The `/etc/oraInst.loc` file contains a pointer to the Oracle software inventory directory. It also specifies the Linux group name that owns the Oracle software. This directory gets created automatically when using the Oracle Universal Installer (OUI), but it must be created and populated manually if you are performing a silent installation, and it does not already exist. If Oracle products have already been installed on the system, then it exists already.

The `oraenv` script, located in the `$ORACLE_HOME/bin` directory, sets up your Oracle environment for you based on the value of `ORACLE_SID`. This is useful to run if you need to switch from one database to another on the same system.

The `dbhome` script reports the current Oracle home directory.



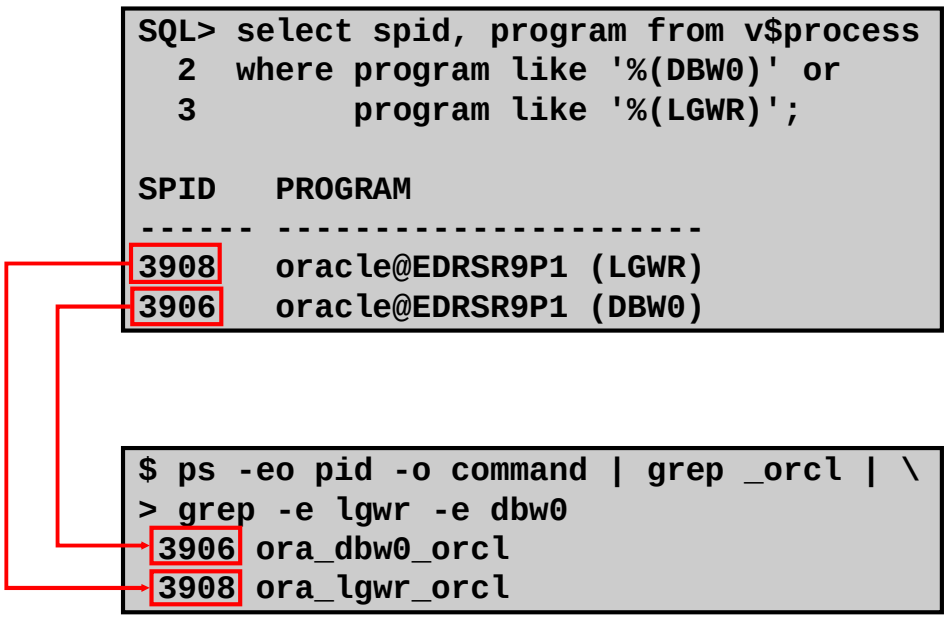
Background Processes

There are several processes that make up the executable part of an Oracle instance. You can list these in Linux by issuing the `ps` command. Just listing all processes will be too much information, if you want to see only the processes that belong to a single instance. So, you can use `grep` to filter the information out. All the database instance process names start with the string `ora_` and end with the string `_<SID>`. So, if you are interested in the `orcl` instances processed, grepping as shown in the slide shows you that.

The ASM instance process names all start with `_asm` and end with the string `_<SID>`. So, the following command shows you the processes for the `+ASM` instance:

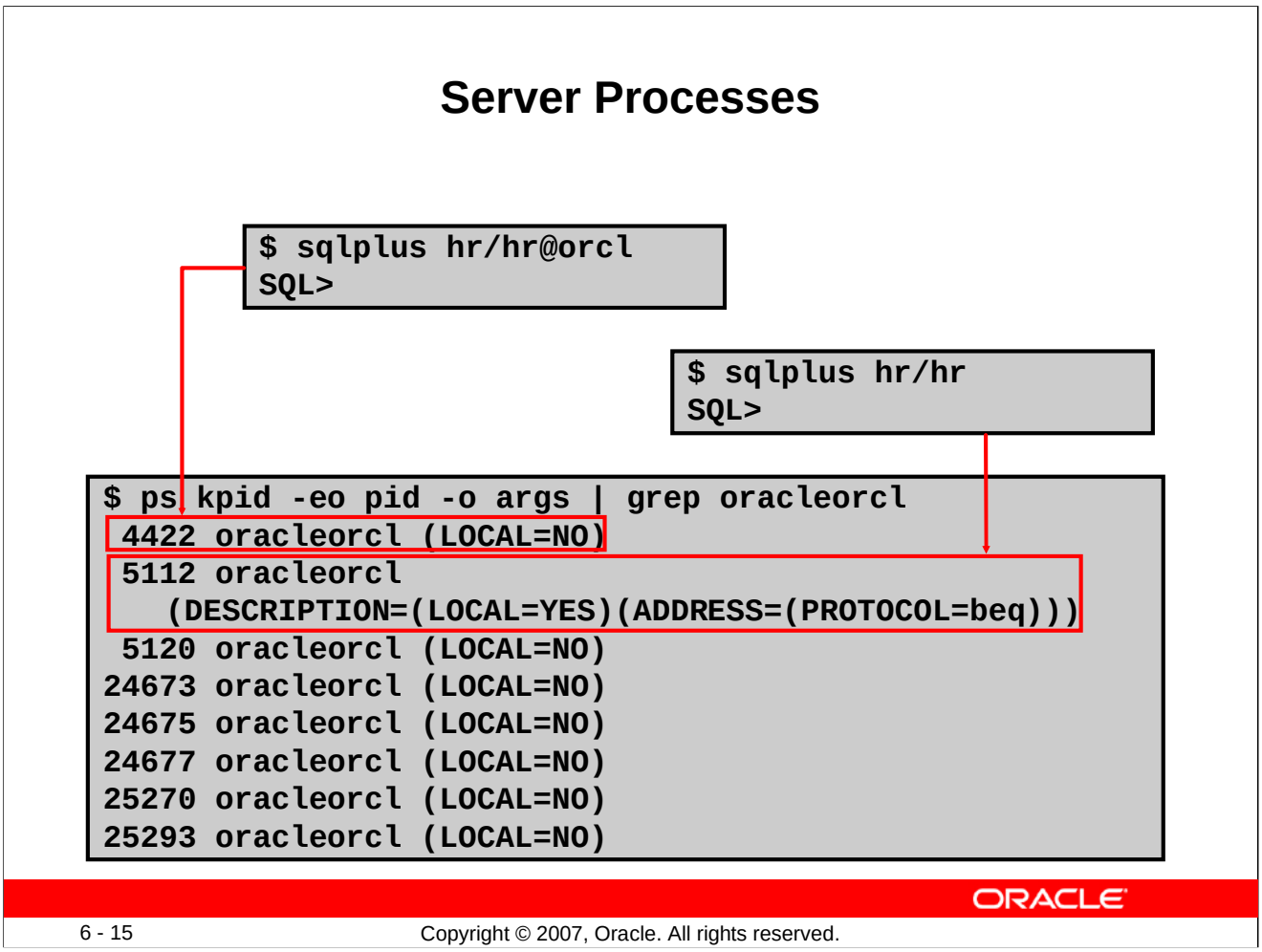
```
$ ps -eo pid -o command | grep _+ASM | grep asm_
 6985 asm_pmon_+ASM
 6987 asm_psp0_+ASM
 6989 asm_mman_+ASM
 6991 asm_dbw0_+ASM
 6993 asm_lgwr_+ASM
   .
   .
   .
```

Background Processes



Background Processes (continued)

After the instance is run, you can map the process IDs from the `v$process` view to the process IDs listed by OS commands. The `SPID` column of the `v$process` view contains the OS process ID, or in Linux, this is referred to as the PID.



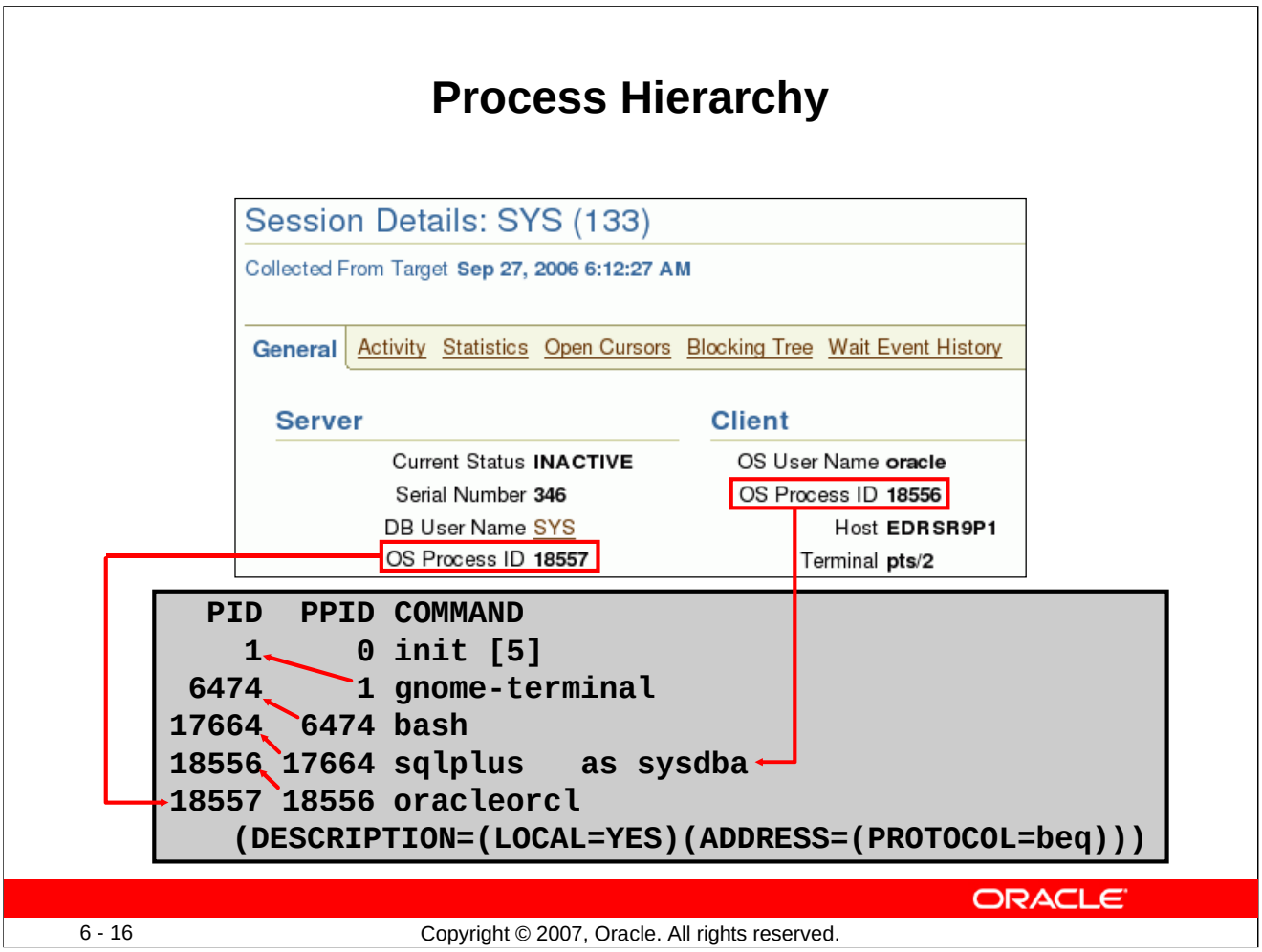
Server Processes

In an instance that is running in dedicated server mode, there is a one-to-one correspondence of session to server process. A server process is the process that gets started that is dedicated to accessing the data files on behalf of a database session, with the purpose of executing commands and returning results.

On Linux, all the server processes are named with this pattern: "`oracle<SID>`". So, in this case, where the instance name is `orcl`, all the server process names are `oracleorcl`. You can see server processes appear and disappear from the Linux process list, as sessions are created and disconnected.

In the example in the slide, there are two sessions. One was started with a service name specifier, which resulted in process 4422 being spawned. Note that the argument says `LOCAL=NO`. That is because it came through the listener. Then another SQL*Plus session was established, this time without using a service name. The server process for that session is 5112, and the argument indicates that `LOCAL=YES`.

Note: For shared server mode, there are other processes involved, called dispatchers, and there is no longer a one-to-one correspondence of session to server process. For more information about shared server mode, refer to the *Oracle Database Administrator's Guide*.



Process Hierarchy

When one process starts another process, the first process is referred to as the parent, and the spawned process is referred to as the child process. This can be observed in Oracle Database processes if you list the parent process IDs in Linux.

The example in the slide shows the session details for a particular session that was created using SQL*Plus. So, the database records the client process ID as 18556, which is the SQL*Plus process. This process started the dedicated server process, identified by a process ID of 18557. So, in the `ps` listing, the SQL*Plus process is the parent of the server process. You can continue to follow the process hierarchy until you get to the init process. The SQL*Plus program was invoked from inside the bash shell (running in the Gnome windowing system), which was invoked by the init process, which started the operating system at boot time.

Implementing OS Authentication for DBAs

OS authentication is the provisioning of access to the database based on the OS username rather than a database username, and is implemented by doing the following:

1. **Create the needed OS accounts for users.**
2. **Define the `OSDBA` and `OSOPER` operating system groups.**
3. **Assign those groups to the users you want authenticated.**
4. **Set `REMOTE_LOGIN_PASSWORDFILE` parameter to `NONE`.**

Now, as one of those users, you can log in, including `AS SYSDBA` or `AS SYSOPER` in the connect string.

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Implementing OS Authentication for DBAs

Provisioning of access is the process of authenticating a user to the database, that is, allowing access to it. Operating system authentication is a type of access provisioning that imposes the operating system credentials onto the database, allowing the database to discern access based on that, rather than the database requiring username and password information. By default, the database is configured to allow certain users to connect without a password. The database considers the OS to be trusted to provide the authentication service. The configuration shown is for privileged users and is configured by default when using the Oracle Universal Installer. A privileged user is granted the `SYSDBA` or `SYSOPER` privilege.

Any OS user that is a member of the `OSDBA` group, named `dba` by default, can connect to the database with "`/ as SYSDBA`" included in the connect string.

Summary

In this lesson, you should have learned how to:

- **Create an Oracle database that uses ASM**
- **Identify the location of various Oracle files**
- **Implement OS authentication**

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Practice 6 Overview: Creating a Database

This practice covers the following topics:

- **Creating a database that uses ASM storage**
- **Interrogating the installation**

7

Customizing Oracle on Linux

Objectives

After completing this lesson, you should be able to:

- **Create automated startup/shutdown scripts**
- **Automate tasks using scheduling tools**
- **Configure Linux startup and shutdown sequence**

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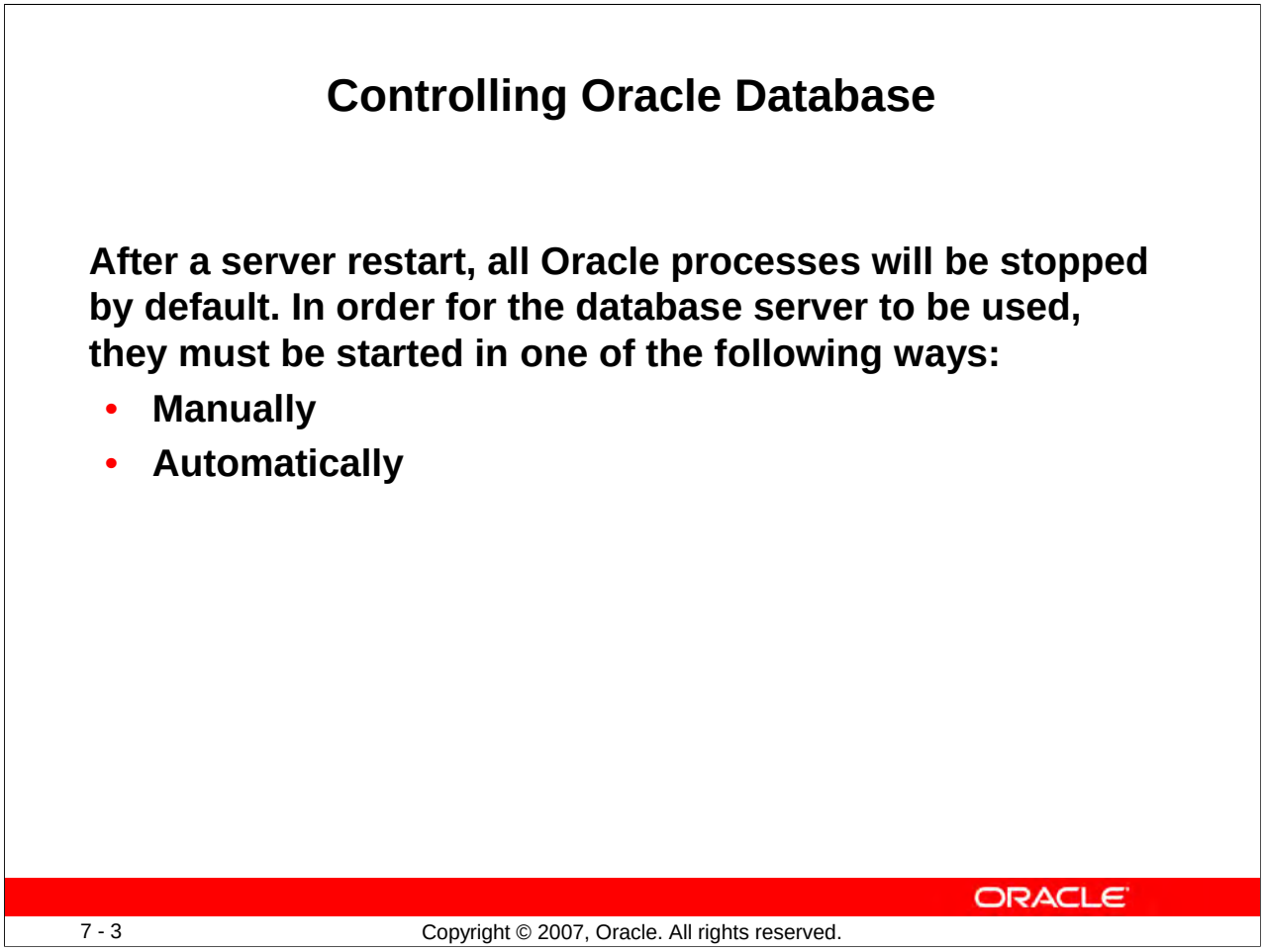


Controlling Oracle Database

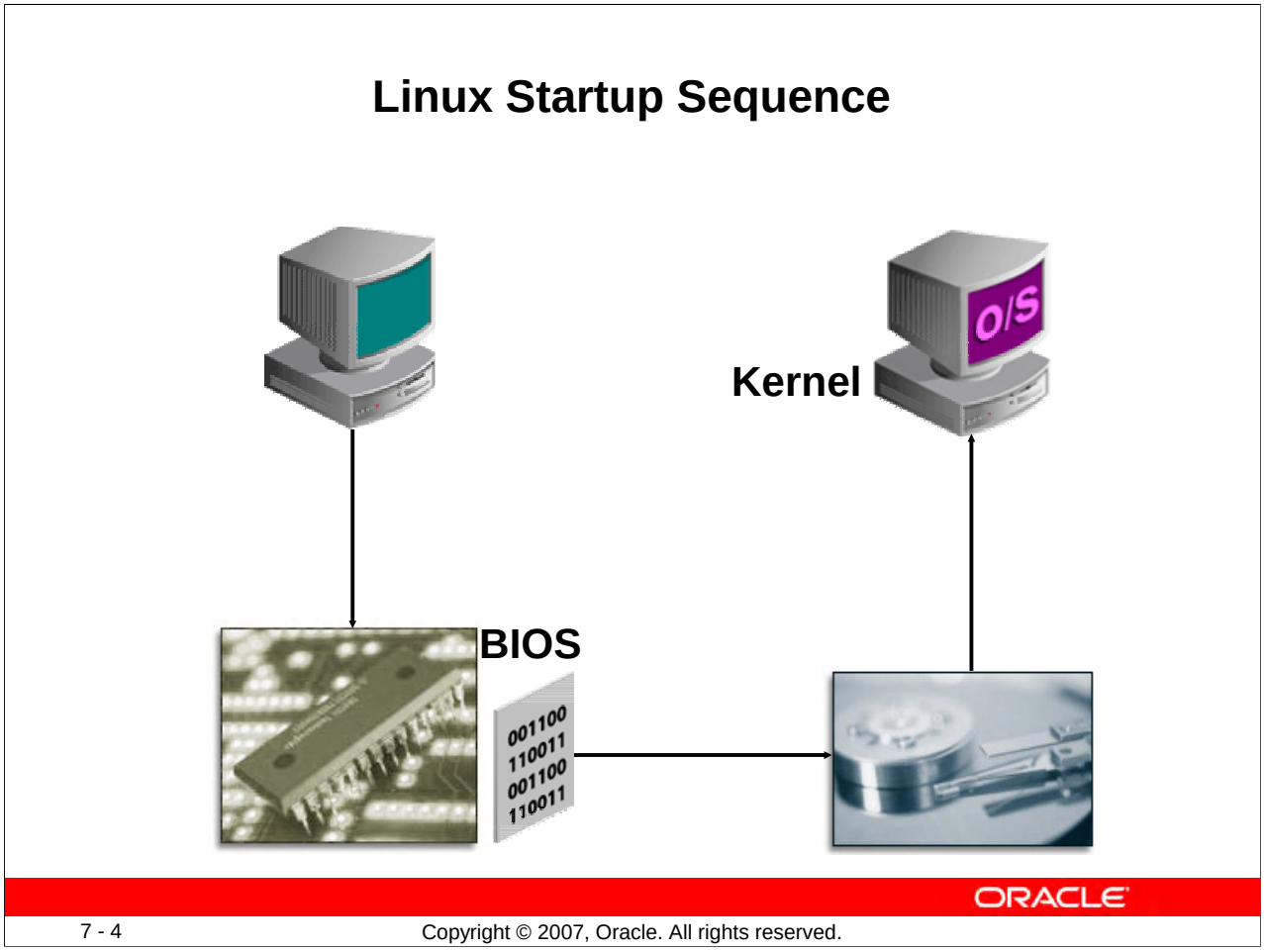
By default, the database instance and its related services do not start when the Linux server is started. Depending on your needs you will want to start all or some of the following services:

- Database Listener
- ASM Instance
- Database Instance
- DB Console
- iSQL*Plus

These can be started manually through standard commands:

- `lsnrctl start`
- `sqlplus "/ as sysdba"` and then execute the `startup` command
- `emctl start dbconsole`
- `isqlplusctl start`

Or, they can be started automatically. The next few pages discuss how to start the Oracle database and related services automatically.



Linux Startup Sequence

Although there are distribution-specific differences, most servers running Linux will start up basically in the same way.

The first step is to initialize the Built-In Operations System (BIOS). BIOS resides in a ROM chip, usually on the system motherboard. BIOS initializes the hardware on the motherboard and much of the hardware that is attached to the motherboard in preparation for loading the actual operating system. BIOS will also look for a bootable device, searching in the order defined within the BIOS program. When it finds a bootable device, it checks the Master Boot Record (MBR) of that disk for a boot loader. As soon as the boot loader is found, BIOS loads the code into memory and passes control of the system over to the boot loader. Enterprise Linux uses the GRand Unified Bootloader (GRUB).

There are other boot loaders available such as the Linux Loader (LILO), but none as flexible as GRUB, which can load Linux, Windows, and more. The boot loader displays a menu of boot options from the MBR. (In a dual boot system, this is where you are offered the chance to select which operating system [OS] will be used.) It then uses the settings found in the MBR to load the selected operating system kernel.

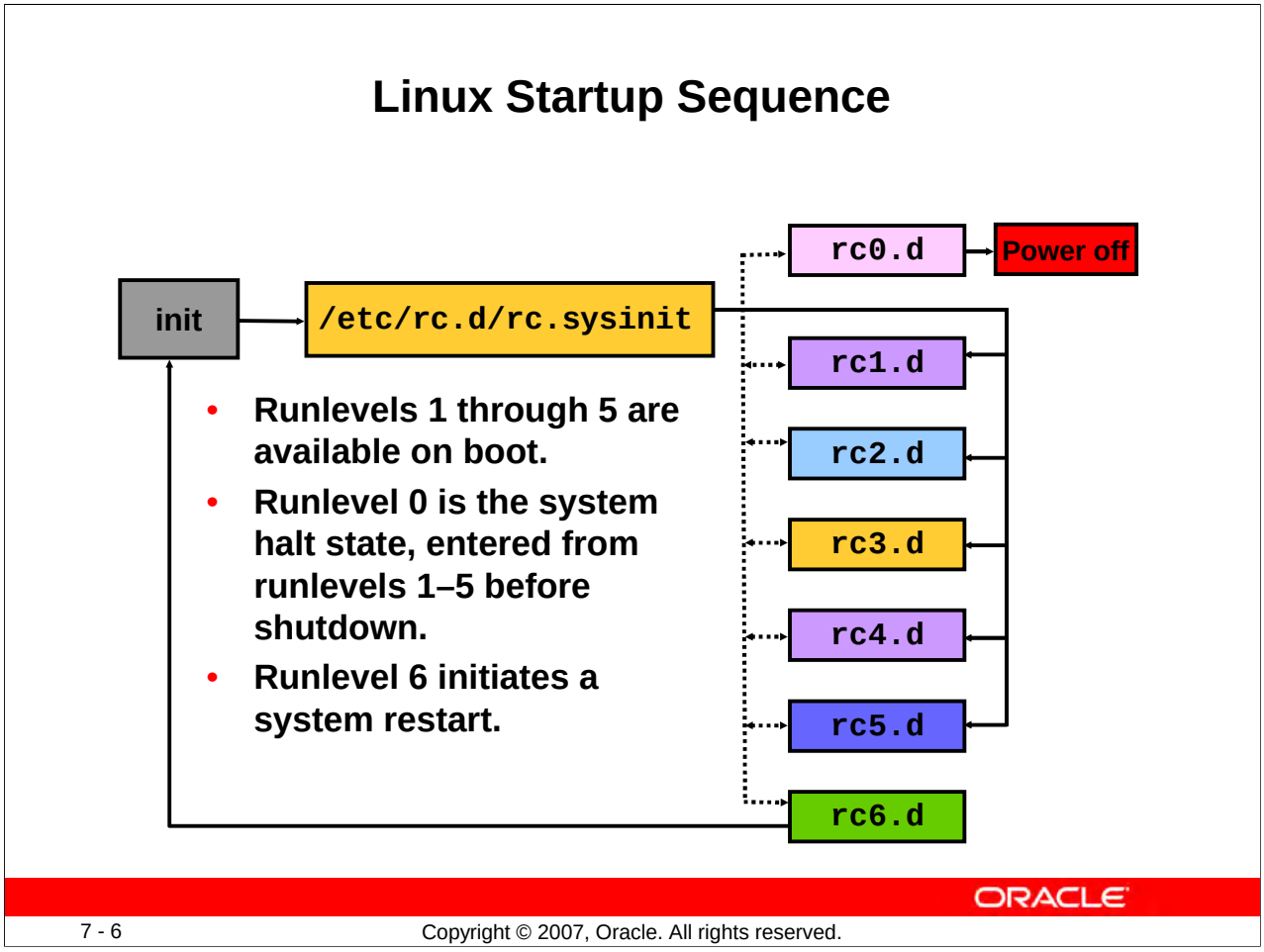
Linux Startup Sequence (continued)

After the kernel is loaded, it checks `/sbin` and starts the `init` process. This is process number one. The `init` process reads `/etc/inittab`, which contains instructions telling the kernel to run a basic setup script that describes actions such as how to set the system clock, where the swap file is located, and what the global environment variables are.

In Enterprise Linux, that basic setup script is `/etc/rc.d/rc.sysinit`.

Here is where you become concerned as the administrator. After the basic setup script is run, the `init` process continues reading `/etc/inittab` and makes its decisions on what to do next based on which of the seven *runlevels* you have booted to. The runlevel you select will determine who can log on, how many users can be logged on, and what services are available. The runlevels are described in detail later in the lesson.

In Enterprise Linux, there are a series of directories under `/etc/rc.d` with names such as `rc0.d`, `rc1.d`…`rc6.d`. For example, if you were to boot to runlevel 5 (the default), then the `init` process would run scripts located in `rc5.d`. On most systems, you will find that the scripts are not actually in these directories, rather there are links to the scripts.



Linux Startup Sequence

Each runlevel is associated with its own subdirectory. Within any given level's subdirectory, you will see scripts with names like these. These files are from `rc5.d`:

```
K02NetworkManager K74nscd          S10network     S56rawdevices
K05saslauthd      K74ntpd          S12syslog      S56xinetd
K10dc_server      K87auditd        S13irqbalance  S80sendmail
K10psacct         K89netplugd      S13portmap     S85gpm
K12dc_client      K90bluetooth     S14nfslock     S90canna
K12FreeWnn        K94diskdump      S15mdmonitor   S90crond
K20nfs            S01sysstat       S25netfs       S95anacron
K24irda           S05kudzu         S26apmd        S95atd
K35smb            S08arptables_jf  S28autofs      S97messagebus
K35vncserver      S08iptables      S55sshd        S99local
```

The scripts are executed in alphabetical sequence as the runlevel is entered. In this case, as runlevel 5 is entered, the script `S01sysstat` is executed, then `S05kudzu`, and so on until all scripts have completed. Scripts beginning with a "K" (for "kill") are intended to stop services, scripts beginning with an "S" (for "start") are intended to start services.

Linux allows movement between runlevels through the `init` command. From runlevels 1–5, you can move to any other runlevel, including the two special runlevels 0 and 6. Runlevel 6 initiates a system reset. Runlevel 0 enters the system halt state (all services stopped) and is used to properly shut the system down before the power is turned off.

Linux Runlevels

Runlevels determine which services are available.

- **Linux runlevels:**
  - **0 = halt**
  - **1 = single user**
  - **3 = multiuser, network**
  - **5 = multiuser, X**
- **The default runlevel is usually 5 but can be changed.**
- **Servers usually use runlevel 3.**
- **Runlevels can also be changed with the `init` command.**

```
# init 3
```

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Linux Runlevels

Linux uses runlevels to determine which services to start or stop. For example, at certain runlevels the graphic user interface might not be started. The meaning and services started at the different runlevels is distribution dependent, but for Enterprise Linux it is as follows:

- Runlevel 0: Halt. It is used to shut down the system.
- Runlevel 1: Single-user (maintenance) mode. Only `root` may log in.
- Runlevel 2: Multiuser mode, text-based console only
- Runlevel 3: Multiuser mode with networking
- Runlevel 4: For custom use
- Runlevel 5: The default mode; multiuser with networking and active X session
- Runlevel 6: Reboot. This shuts everything down and then starts it back.

Booting to a Nondefault Runlevel

The GRand Unified Bootloader (GRUB) provides a way to specify the runlevel on startup from the OS selection menu. For Enterprise Linux, you press [E] then scroll down to select the kernel, press [E] again, press the spacebar, enter the runlevel you want to boot to, then press [B].

Your current and previous runlevel can be found with the `runlevel` command.

Database Startup and Shutdown

Create a `dbora` service script to automate startup and shutdown.

- **Create a script named `dbora`.**
- **Place it in the `/etc/rc.d/init.d` directory.**
- **Use `chkconfig` to set the runlevels.**

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Database Startup and Shutdown

Most servers are not shut down often, and the system administrator may not be familiar with the commands for doing a proper shutdown of the database. Because of this, it is a good idea to provide a script to shut down the database in each of the runlevel directories. This ensures that the database does a proper shutdown without DBA involvement. If a server crashes, you want the database to be open as soon as possible after the machine is started. By placing startup scripts in each of the proper runlevel directories, the database and related services can be started automatically.

Create a Script Named `dbora`

The name of this script is arbitrary. Naming it `dbora` can be convenient because the name of the script is echoed to the console during the boot process. This script can start all the database-related processes as is shown in the example, or the script may be broken into multiple scripts that start and stop the processes separately. In this example, the order in which the processes are started is important. Start the listener first, next the ASM instance, then the database, and finally DB Console (because it connects to a repository in the database on startup).

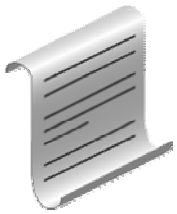
Database Startup and Shutdown (continued)

The stop commands are in sequence and the database is stopped in the end. Any process that is not stopped here is stopped by the `killall` command later during the shutdown process. Enterprise Linux uses a subsystem lock file at `/var/lock/subsys/<service_name>`. The stop script runs only if the lock file exists.

Administrative Scripts

Oracle provides a set of administrative scripts.

- **Start up and shut down databases by using:**
  - **`dbstart`**
  - **`dbshut`**



Administrative Scripts

Oracle provides the `dbstart` and `dbshut` scripts that must be modified for your site. These scripts read the `oratab` file, determine which databases participate in automated startup or shutdown, and start up or shut down these databases.

The `oratab` file is created by `root.sh` and updated by the Database Configuration Assistant (DBCA) when creating a database.

A colon, ":", is used as the field terminator. A new line terminates the entry. Lines beginning with a pound sign, "#", are comments.

Entries are of the form:

```
$ORACLE_SID:$ORACLE_HOME:<N|Y>
```

The first and second fields are the system identifier and home directory of the database, respectively. The third field indicates to the `dbstart` utility whether the database should be brought up at system boot time, indicated by `Y` or `N`, meaning yes or no, respectively.

Example of the entries in `/etc/oratab` :

```
+ASM:/u01/app/oracle/product/10.2.0/db_1:Y
orcl:/u01/app/oracle/product/10.2.0/db_1:Y
```

ASM and database instances created without using DBCA will not appear in the `oratab` file. Entries will need to be made manually in the file for those instances.

Administrative Scripts (continued)

dbstart

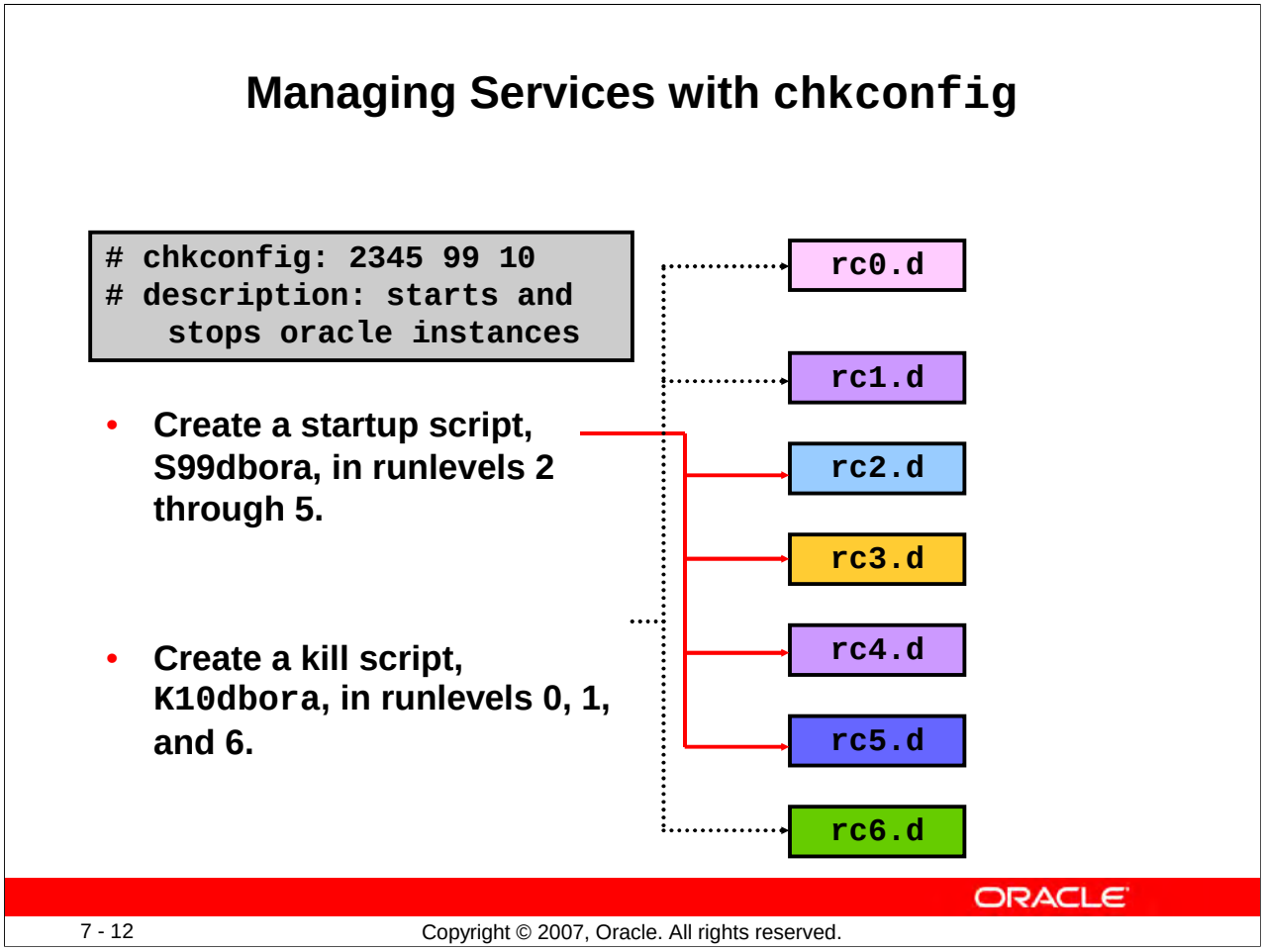
`dbstart` first starts the listener, then scans `oratab` twice. Databases that use ASM for managing storage require the ASM instance to be started before the database instance. On the first scan, `dbstart` looks for ASM instances with a "Y" in the third field. Values of `$ORACLE_SID` which start with a "+" denote an ASM instance. When found the instances are started. On the second scan, the script looks for database instances with a "Y" in the third field. The `dbstart` script that is provided with 10.2.0.1.0 contains an error. The Metalink note 336299.1 documents this issue. To solve this problem, perform the following steps:

1. Edit `$ORACLE_HOME/bin/dbstart`
2. Go to line 78.
3. Replace the line with:
   ```
   ORACLE_HOME_LISTNER=$ORACLE_HOME
   ```
4. Save the file and exit the editor.
5. Execute `dbstart`.

The script can be customized to start other utilities, such as DB Control.

dbshut

The `dbshut` performs `shutdown immediate`. This mode terminates all connections and then shuts down the database. The `dbshut` script can be modified to shut down DB Console before shutting down the database. This would allow for a faster shutdown of the database.



Managing Services with chkconfig

System administrators must create a link in each runlevel directory for each service that should be available at that runlevel. A manual creation of these links is time consuming and prone to errors. A tool called `chkconfig` is provided in Linux distributions modeled after a tool on `IRIX`, which provides a simple way to add and delete services to runlevels. You can also use the graphical tool `system-config-services` to manage services.

A service script named `dbora` can have the following comment lines. These comment lines specify the runlevels and the order numbers for the start and kill.

```
# chkconfig: 2345 99 10
# description: starts and stops oracle instances
```

This says that the links to this script should be named `S99dbora` and `K10dbora`. The start scripts will be present at the runlevels 2, 3, 4, and 5. The kill scripts will be present at the runlevels 0, 1, and 6.

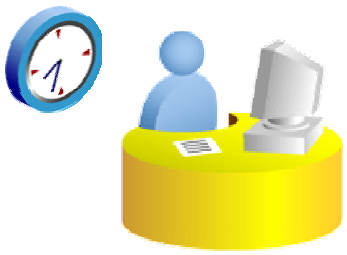
With these comment lines in place, the `chkconfig --add dbora` command

adds the links to the script into the appropriate directories. `chkconfig --del dbora` removes the links and `chkconfig --list dbora` shows the runlevels and the state of the `dbora` service at each runlevel.

Automating Jobs

Automate the following jobs to leverage your time:

- **Backups**
- **Database startup and shutdown**
- **Gathering database statistics**
- **Monitoring database health**
- **Monitoring processes: listener, agent, HTTP server**



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Automating Jobs

Much of your work as a DBA must be done outside normal working hours, or at least during off-peak hours. In many companies, you are asked to support more databases and more hours of the day or night. Automating routine jobs is a way of reducing the work load. These routine jobs include:

- Doing backups and maintaining backup scripts
- Starting up and shutting down the database
- Gathering statistics on the database and OS
- Monitoring the health of the database and related processes

Ensure that the database starts up when the machine boots, and more importantly make sure that the database does a proper shutdown before the machine is shut down. Monitor the database and related processes so that you are aware of a problem before the users start contacting you.

OS Scheduling Tools

Linux offers the standard UNIX tools for scheduling:

- **`cron` and `anacron`**
- **`at` and `batch`**
- **Task Scheduler**

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OS Scheduling Tools

Linux offers several scheduling tools that usually are a variation of the standard `cron` and `at` tools, or a GUI for one of these tools. Task Scheduler is one of these user interfaces that makes `cron` and `at` easier to use.

`cron`

The system `cron` daemon is started as part of the boot process. Security for `cron` is handled by the system administrator by using the `/etc/cron.allow` and `/etc/cron.deny` files. Only users listed in the `/etc/cron.allow` file are allowed to use `cron`, users listed in the `/etc/cron.deny` file cannot use `cron`. If neither of these files exist, only the superuser is allowed to use `cron`. The `cron` daemon checks the system-level schedule in the `/etc/crontab` file and user-level schedules in the `/var/spool/cron` directory. In Enterprise Linux, there is also a set of directories `/etc/cron.hourly`, `/etc/cron.daily`, `/etc/cron.weekly`, and `/etc/cron.monthly` that hold executable scripts. If the system administrator puts an executable script into one of these directories, then `cron` runs the script at the appropriate interval.

OS Scheduling Tools (continued)

`cron` (continued)

The format of an entry in the `crontab` file is <*`minute`*> <*`hour`*> <*`day`*> <*`month`*> <*`weekday`*> <*`cmd`*>. If any of these fields has a "*", then the meaning is "every." A `crontab` entry to run a backup script might look like the following:

```
14 22 * * 1-5 su - oracle -c /usr/local/bin/backup.cmd >/dev/null 2>&1
```

This command runs 14 minutes after 10 p.m. every weekday of every month, Monday through Friday. The command says, log in as the `oracle` owner and execute `backup.cmd`, sending the standard out to `/dev/null`, the bit bucket, and standard error to the same place.

`anacron`

It is an interesting variation of `cron` that does not require the system to be running continuously. The `anacron` daemon periodically checks the `/etc/anacrontab` file, and verifies whether the task has been executed within the time specified in the Period field of the configuration file. If not, `anacron` executes the command specified after waiting for the number of minutes specified in the Delay field.

`at` and `batch`

The `at` command executes a command once at a specified time, as opposed to `cron` that executes recurring commands. The `atd` daemon runs the `at` commands and the `batch` commands. The `batch` commands wait until the system load average drops below 0.8, and then executes the given commands.

Task Scheduler

There are GUI task schedulers available that are front ends for `cron` in both the Gnome and the K(ommon) Desktop Environment (KDE).

Job Capabilities of DB Console

DB Console provides a way to schedule jobs against the database or node. You can schedule:

- **SQL scripts**
- **PL/SQL blocks**
- **Stored procedures**
- **RMAN scripts**
- **PERL scripts**
- **OS commands**

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Job Capabilities of DB Console

Using DB Console, you can schedule a job to run at a particular time or interval. Each job can be run against the database instance or the node. A job can be SQL scripts, OS commands, RMAN scripts, PERL scripts, a PL/SQL block, or a stored procedure. DB Console uses `dbms_scheduler` from the database providing a convenient way to centralize your recurring jobs. You can use the Job Wizard to create, register, execute, and save jobs.

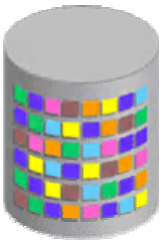
Using Oracle Enterprise Manager Grid Control to manage your node and database provides even greater flexibility in the types of jobs that can be created.

Database Backups

Database backups are essential. The options for backing up your database are:

- **User-managed backup with OS tools**
- **User-managed backup with third-party tools**
- **Server-managed backup with RMAN**

Database



Backup

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Database Backups

Backups are required by most businesses. The method and the frequency are often dictated by business requirements. The method should be chosen based on availability requirements, convenience, performance, and mean time to recover (MTTR).

User-Managed Backups with OS Tools

Backups can be created by using standard OS tools, such as `tar`, `cpio`, and `cp`. It is the user's responsibility to understand the limitations of these tools.

User-Managed Backups with Third-Party Tools

There are several third-party backup solutions. The most important consideration is whether the tool you choose coordinates with the Oracle database. The database must be shut down, or the tablespaces put into backup mode before the back up takes place. Many vendors provide an Oracle database agent module to provide this functionality.

Server-Managed Backups with RMAN

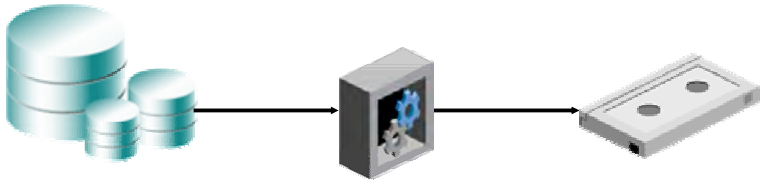
Oracle Corporation provides an integrated tool called Recovery Manager (RMAN) to perform backups or use the DB Console interface to RMAN. This tool works with the database instance to make reliable backups.

Note: Use the full pathname to invoke RMAN: `$ORACLE_HOME/bin/rman`. By doing this, you avoid any path problems. There is a different Linux utility named `rman`.

Backing Up with RMAN

Recovery Manager is the recommended solution, because it:

- **Provides tight integration with the Oracle database**
- **Understands raw partitions**
- **Can be scripted and scheduled**
- **Allows finer-grained recovery options**
- **Is required to back up an ASM-based database**



```
RMAN> BACKUP DATABASE;
```

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Backing Up with RMAN

The Recovery Manager tool is bundled with every installation of the Oracle database. It uses the instance to facilitate the backup. RMAN handles raw partitions in the same manner that the database instance does. RMAN can be scripted and scheduled from OS schedulers or as an Enterprise Manager Job. A full database backup can be simple (such as the command shown in the slide) or complex, depending on your requirement. Recovery Manager has a full range of commands that allow detailed control of the backup.

You should use the available tools to make the backups self-scripting so that the backup scripts have zero maintenance.

Automatic Storage Management requires RMAN for taking backups.

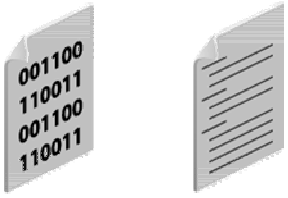
RMAN backups are covered in the *Oracle Database 10g: Administration Workshop II* and the *Oracle Database 10g: Backup and Recovery* course and in the *Backup and Recovery Basics* and *Backup and Recovery Advanced User's Guide*.

Oracle Secure Backup is also available for backups. Oracle Secure Backup delivers tape data protection for the Oracle database and file systems in distributed Linux and Network Attached Storage (NAS) environments. Safeguarding data and access to the backup domain, Oracle Secure Backup leverages the proven security technologies of secure sockets layer (SSL) and encryption.

Server Parameter File

With an Oracle 10*g* database, you can use a server parameter file SPFILE or the initialization parameter file PFILE:

- **An SPFILE is recommended.**
- **SPFILE is maintained by the server.**
- **The STARTUP command always uses the same SPFILE.**
- **The default location for the SPFILE with ASM is <diskgroup>/<sid>/.**



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Initialization Parameter Files

When you start the instance, an initialization parameter file is read. There are two types of parameter files:

- **Server parameter file:** This is the preferred type of initialization parameter file. It is a binary file that can be written to and read by the database server and *must not be edited manually*. It resides in the server that the Oracle database is executing on, and is persistent across shutdown and startup. This is often referred to as an SPFILE. The default name of this file, which is automatically sought at startup, is `spfile<SID>.ora` located in `$ORACLE_HOME/dbs`. For a database using ASM, the default name of the SPFILE is `spfile<sid>.ora` with the file located in `<diskgroup>/<sid>/` (for example, `+DF/orcl/spfileorcl.ora`)
- **Text initialization parameter file:** This type of initialization parameter file can be read by the database server, but it is not written to by the server. The initialization parameter settings must be set and changed manually by using a text editor so that they are persistent across shutdown and startup. The default name of this file, which is automatically sought at startup if an SPFILE is not found, is `init<SID>.ora`.

It is recommended that you create a server parameter file (SPFILE) as a dynamic means of maintaining initialization parameters. By using a server parameter file, you can store and manage your initialization parameters persistently in a server-side disk file.

Summary

In this lesson, you should have learned how to:

- **Create automated startup/shutdown scripts**
- **Automate tasks using scheduling tools**
- **Configure Linux startup and shutdown sequence**

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Practice 7 Overview: Automating Tasks

This practice covers the following topics:

- **Automating the startup and shutdown of the database**
- **Adding starting and stopping DB Control to dbstart and dbshut**

Practice 7 Overview: Automating Tasks

For detailed instructions on performing this practice, see Practice 7 in Appendix A.

8

Managing Memory

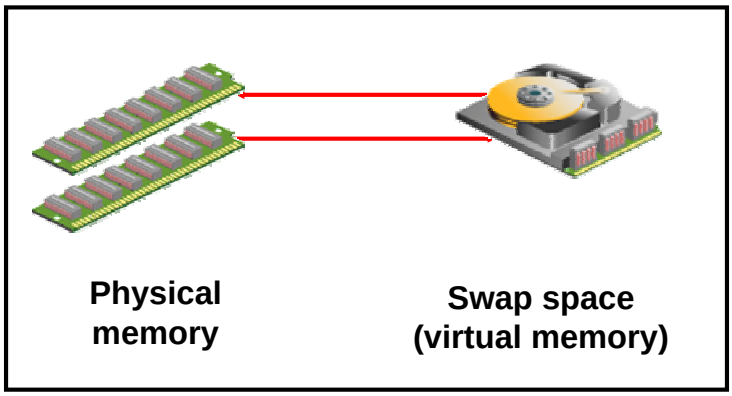
Objectives

After completing this lesson, you should be able to:

- List the memory models available in Linux kernels
- Implement hugepages
- Describe `/proc/meminfo` contents
- List the implications of Linux memory configuration on Oracle Database
- Identify the issues regarding 32-bit OS versus 64-bit OS

Swap Space

The swap space makes more memory available to the system even when physical memory is limited.



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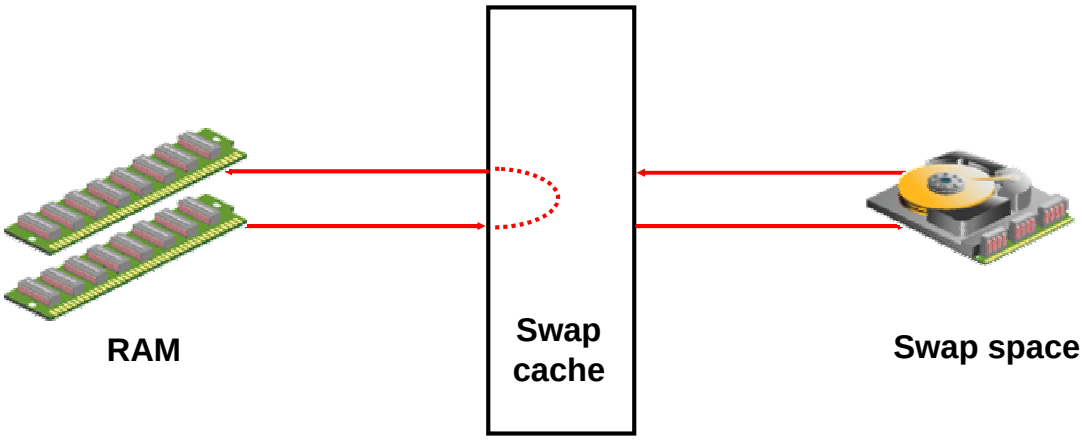
Swap Space

Often there are demands for more memory than what is actually installed on the machine. To mitigate the effects of this limitation, swap space is set up. Swap space is an area of disk that is set aside to hold some of the contents of physical memory, or RAM, at certain times. As Linux switches from running one process to another, it may need to allocate some memory in RAM to support the new process. If there is not enough RAM available, instead of failing the process, Linux copies the contents of some of the RAM to the swap space. This process of copying memory contents from RAM to disk and back again is why this disk area is referred to as swap space; Linux continually swaps the contents of physical RAM and disk, as needed. The result is that there is effectively more memory available for processes to use.

Swap Cache

The swap cache tracks the state of swapped pages and reduces the swap I/O activity.



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Swap Cache

A closer look at the RAM/swap space interaction reveals the swap cache mechanism. The swap cache is an area of RAM that is set aside to track the pages that are swapped out to disk, and, whether they have been written to since that time. The purpose of this is to short-circuit any unnecessary I/O. Consider the page out operation, where a page is swapped out to disk, and then later, is needed back in memory. If, while it was swapped out onto disk, the in-memory page was not reused for anything else, then there is no need to read the page back in from disk; it is already in memory. Likewise, if a page is swapped in, and then swapped out, the swap out operation may not require that the page be written to disk again. If the page had not been modified at all while it was swapped in, then its contents still match what is already stored on disk, and thus, there is no need to write it to disk again. The details of the processes that write a page out and read a page in follow.

Page Out Operation

If a page residing in memory is not used, it ages. The older a page, the more likely it is to be overwritten. The `swap` looks for the oldest pages in each process every few seconds. If there is a demand for free pages, `swap` overwrites the old pages. These pages are moved to the `swap` cache in memory if they are dirty, or discarded if they are not dirty. If a page is needed again before being moved from the cache to disk, then it is reloaded from the cache. Otherwise, it gets flushed from the cache to the disk after a period of time.

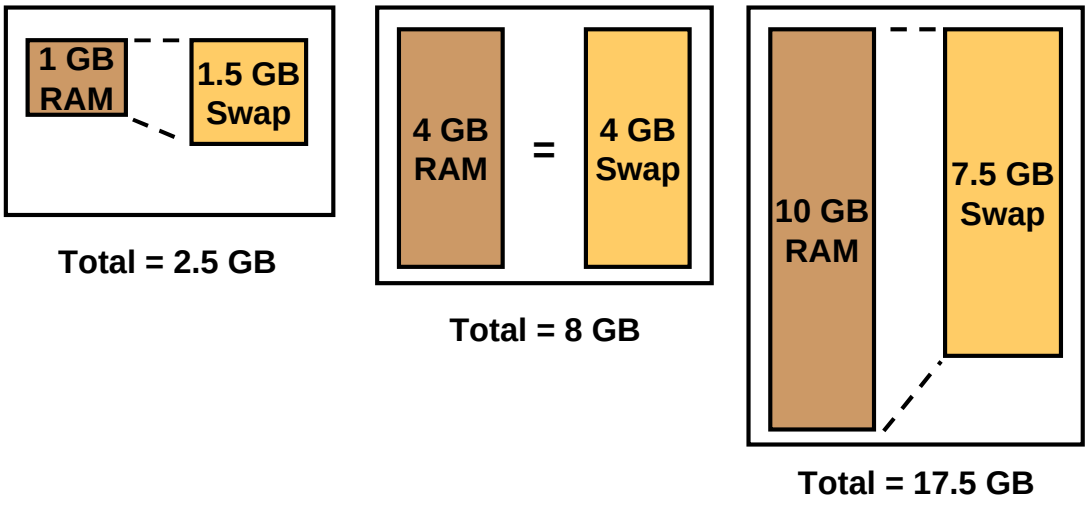
Swap Cache (continued)

Page In Operation

If the process tries to access a page that is not mapped into physical memory, a page fault occurs. A page fault causes the process to suspend. The page is read from a disk or a swap cache. The page is loaded into a free page of memory. This page is mapped to the Translation Lookaside Buffer (TLB). Then the process is placed on the run queue. To bring a page into memory, a free page must exist. The `swap` process works to keep a pool of free pages available for these *page in* operations.

Sizing Swap Space

Swap space should be sized based on the amount of RAM installed.



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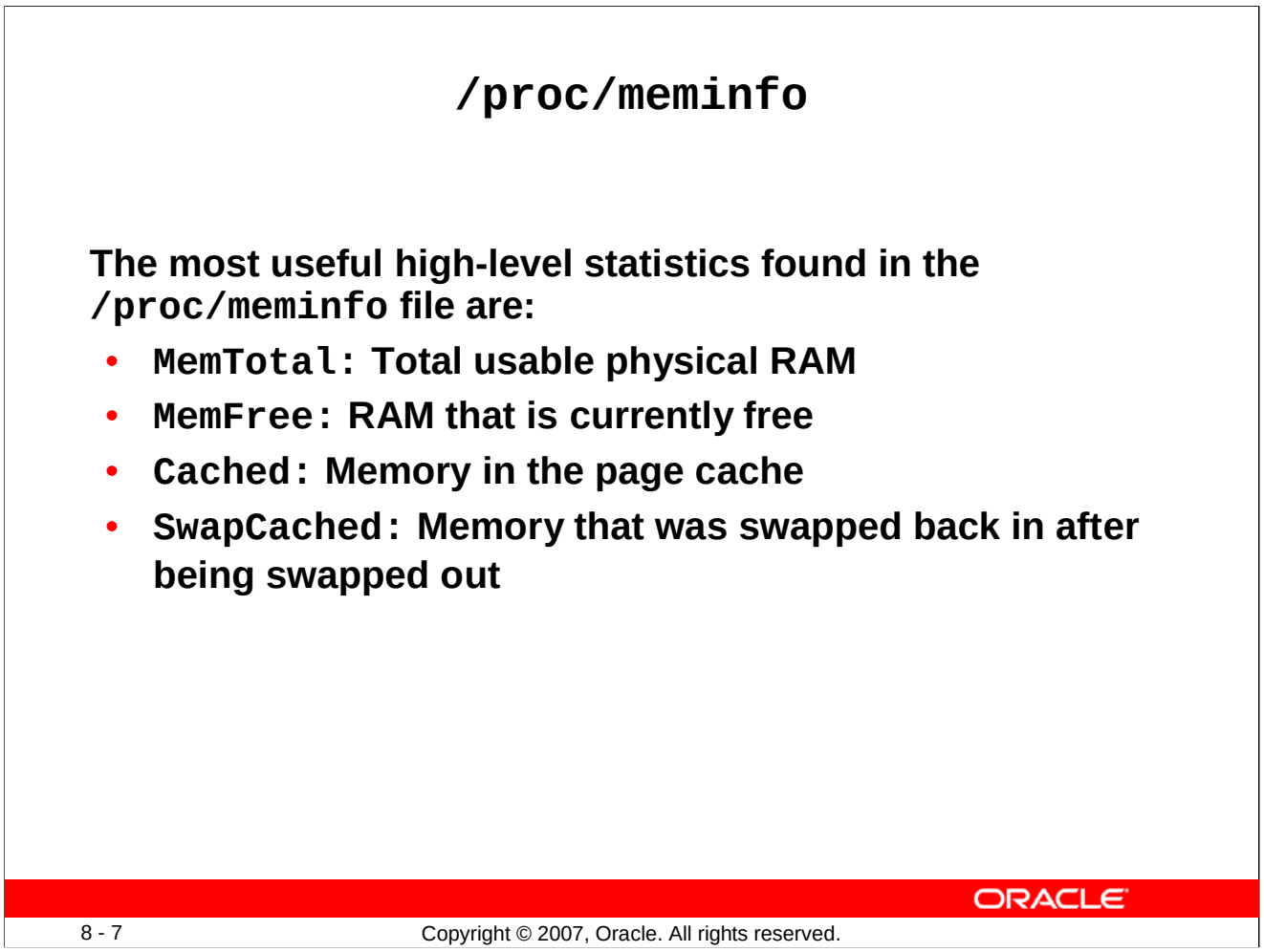
Sizing Swap Space

The amount of swap space to allocate depends on the amount of RAM installed on the machine. The following conditions show the RAM size followed by the reasonable swap space size, respectively:

- **<= 2 GB:** 150% of the RAM size
- **Between 2 GB and 8 GB:** Equal to the RAM size
- **> 8 GB:** 75% of the RAM size

Some examples are shown in the slide. You can use the `free` command to see the size of the swap space, and also to see how much of it is being used. You can also view the contents of `/proc/swaps`.

Note: Diagram sizes are not to scale.



/proc/meminfo

The /proc/meminfo virtual file shows the current state of memory for the Linux kernel. The following information can be found there:

- **MemTotal:** The total physical memory in the system. All of your server's physical memory should be reported here at all times.
- **MemFree:** Total amount of memory that is currently free
- **Cached:** Memory in the pagecache (diskcache) minus SwapCached. This does not include SwapCache.
- **SwapCached:** Memory that once was swapped out and has been swapped back in, but is still in the swap file. This is a performance feature because if memory is needed it does not need to be swapped out again; it is already in the swap file. This saves I/O.

Evaluating Free Memory

As reported by `top`, the situation seems dire because it appears that almost all memory is being used:

```
Mem: 16124948K used, 42724K free
```

But the `free` command shows that 13 GB of this memory is cache, which is available to processes as needed:

```
 shared     buffers      cached
1710184      351312    13330324
```

•••

•••

```
   total        used        free
16167672    16129820       37852
```

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`top` and `free`

Some of the used memory that the `top` command reports is actually being used for cache. That means that it is available to be reassigned if another process requires it. The slide illustrates how the `top` command memory information can be misleading. It appears that only 42 MB of memory is free. But the `free` command reports that 13 GB is currently being used for cache. By the nature of caching, that memory buffer is useful, but not all of it is always necessary. If another process starts up, or an existing one requests more memory than is reported in the free category of the `top` command, then some of this cache memory can be allocated to those memory requests, and that will be reflected in a higher `used` value, and a lower `cached` value. So, there is more memory available for use by processes than appears as reported by the `top` command.

Memory Terminology

Some terminology:

- **Page table: A data structure that maps virtual addresses to physical addresses**
- **Translation Lookaside Buffer (TLB): Cache in the CPU that contains part of the page table, for performance**
- **Hugetlb: An entry in the TLB that point to a hugepage**
- **Hugetlbfs: An in-memory file system introduced in the 2.6 Linux kernel**
- **Page Address Extentions (PAE): A technique for adding 4 bits onto the memory address value, allowing a 32-bit machine to address 64 GB instead of 4 GB**

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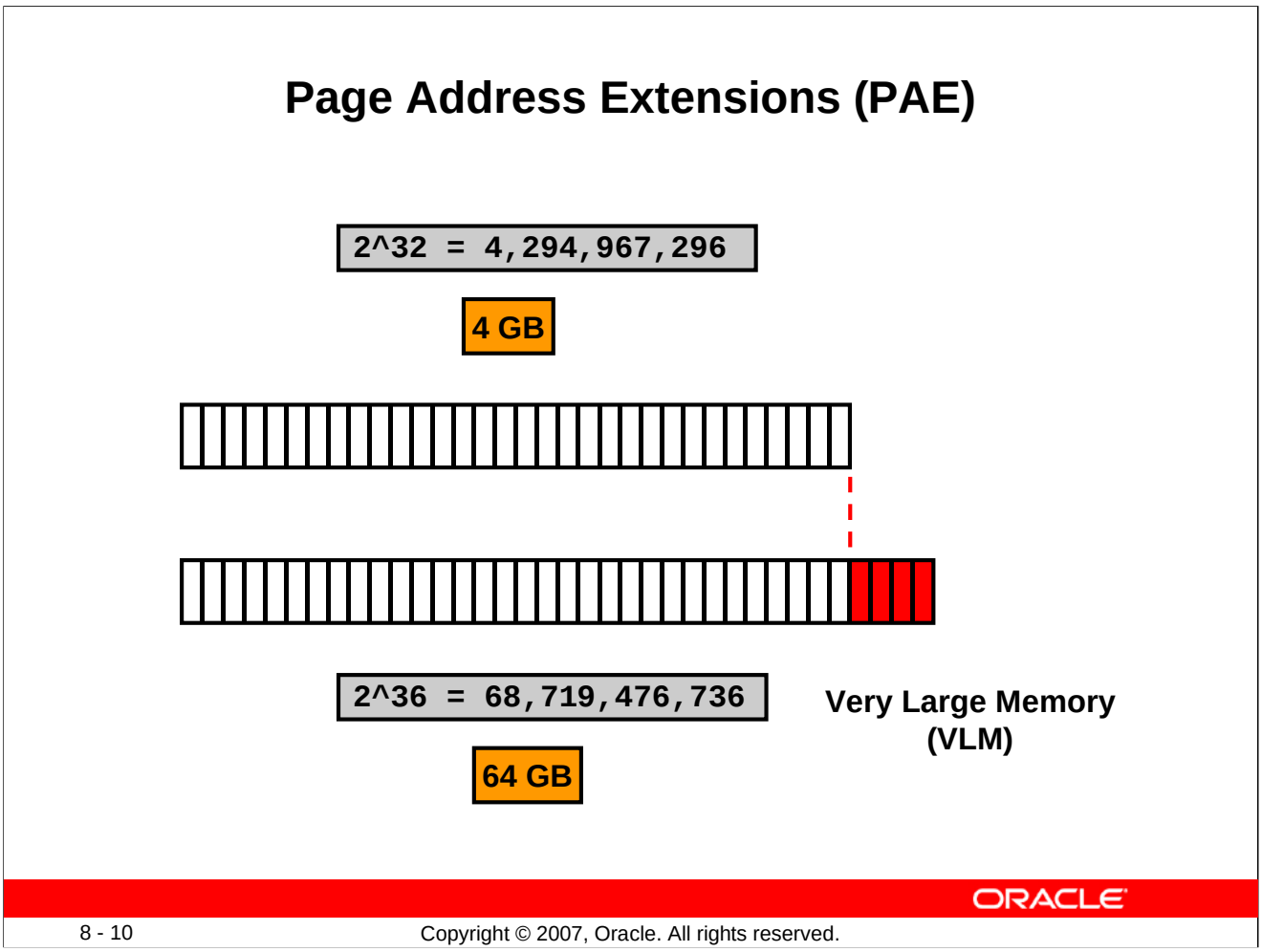
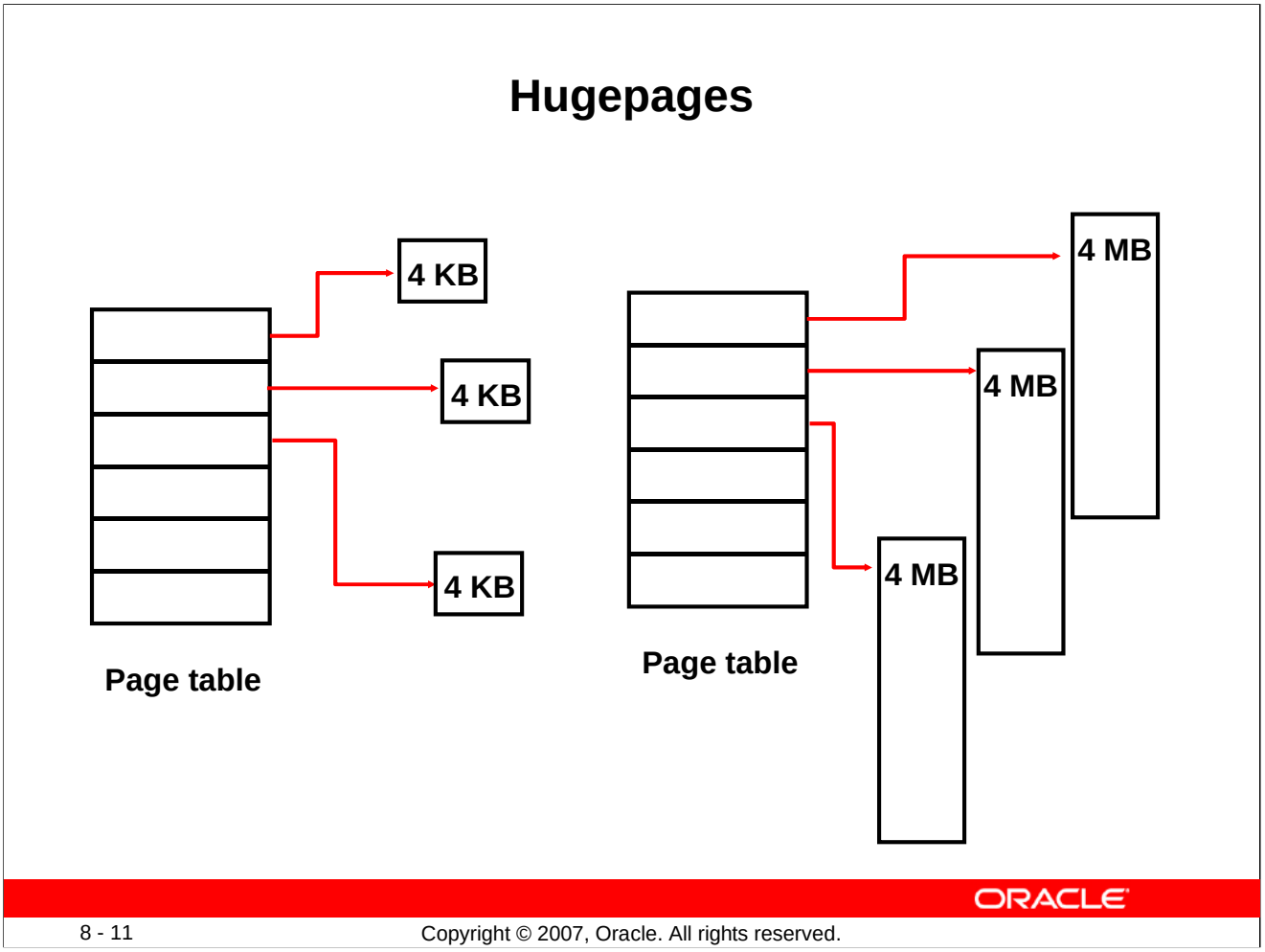


Page Address Extensions (PAE)

A 64-bit Linux system can address 16 exabytes; an extension of the addressing system is not necessary. But a 32-bit system can address only 4 GB of memory, because 2 raised to the thirty-second power is roughly 4 billion.

In order to get above 4 GB virtual memory on IA-32 architecture, a technique known as Page Address Extensions (PAE) is used. It is a method that translates 32-bit (2**32 = 4 GB) linear addresses to 36-bit (2**36 = 64 GB) physical addresses. In the Linux kernel, the support is provided through a compile time option that produces two separate kernels: the SMP kernel which supports only up to 4 GB VM and the enterprise kernel that can go up to 64 GB VM (also called Very Large Memory [VLM]). The enterprise kernel is able to use up to 64 GB pagecache without any modifications. This means applications such as Oracle can make use of the large memory and scale up to a large number of users without loss of performance or reliability.



Hugepages

The regular page size in Linux is 4 KB. That means each entry in the page table can point to a 4 KB size page. A smaller page size like this not only limits the amount of memory that can be addressed, but it also causes more overhead in the management of the page table entries because there are more entries required.

If you increase the page size to 4 MB, this provides for a lot more addressable memory, without the extra overhead, because the number of page table entries can remain the same. This is referred to as hugepages. Also, hugepages are not swapped out, and thus provide for better performance because they remain in physical memory.

Implementing Hugepages on 32-Bit Linux

To implement the hughpages feature:

- **Configure Linux to mount `ramfs` at boot time**
- **Increase locked memory limit**
- **Configure instance parameters for VLM**
- **Set the hugepages kernel parameter**

Note: Using this feature removes the ability to configure automatic shared memory management. You must configure `DB_CACHE_SIZE` instead.

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Implementing Hugepages on 32-Bit Linux

To configure hugepages, perform the following steps:

1. Log on as `root`.
2. Configure Linux to mount `ramfs` over `/dev/shm` at every boot. Edit `/etc/rc.local` and add the following:
   ```
   umount /dev/shm
   mount -t ramfs ramfs /dev/shm
   chown oracle:oinstall /dev/shm
   ```
   where `oracle` is the Oracle owner and `oinstall` is the group for Oracle owner account.
3. Reboot the server.
4. Log on as `root`.
5. Check whether `/dev/shm` is mounted with the type `ramfs`:
   ```
   # mount | grep shm
   ```
6. Check the permissions of `/dev/shm`:
   ```
   # ls -ld /dev/shm
   ```
7. Increase max locked memory limit. Edit `/etc/security/limits.conf` and add:
   ```
   *          soft    memlock        3145728
   *          hard    memlock        3145728
   ```

Implementing Hugepages on 32-Bit Linux (continued)

8. Log in as the `oracle` Linux user.
9. Check max locked memory limit:
```
$ ulimit –l
3145728
```
10. Configure instance parameters for VLM:
    a. Convert the `DB_CACHE_SIZE`, `DB_xK_CACHE_SIZE` parameters to `DB_BLOCK_BUFFERS`.
    b. Add the `USE_INDIRECT_DATA_BUFFERS=TRUE` parameter.
    c. Configure SGA size according to needs.
    d. Remove `SGA_TARGET` if set.
11. Start up the instance.
12. Examine the memory allocation:
```
$ ls -l /dev/shm
$ ipcs -m
```
13. Configure hugepages.
    a. Get Hugepagesize from:
```
$ grep Hugepagesize /proc/meminfo
```
    b. Compute `nr_hugepages = max(ipcs -m) / (Hugepagesize * 1024) + 1`.
    c. Set kernel parameter:
```
# sysctl -w vm.nr_hugepages=<value from above>
```
    d. Set parameter for every boot. Edit `/etc/sysctl.conf` for `vm.nr_hugepages=<value from above>`
14. Check the available hugepages:
```
$ grep Huge /proc/meminfo
```
15. Restart the instance.
16. Check available hugepages (1 or 2 pages free)
```
$ grep Huge /proc/meminfo
```

Note: If the setting of `nr_hugepages` is not effective, you may need to reboot the server.

Implementing a Large SGA

There are two methods to implement a large SGA under Linux:

- **Alter the Linux memory map so the SGA can use more than 1.7 GB (up to about 2.7 GB).**
- **Relocate the Database Buffer Cache so it uses a memory-based file system (up to 60 GB).**

These methods can be combined, enabling very large SGAs. The theoretical limit for a Linux SGA is 62 GB; practical limitations are closer to 20 GB.

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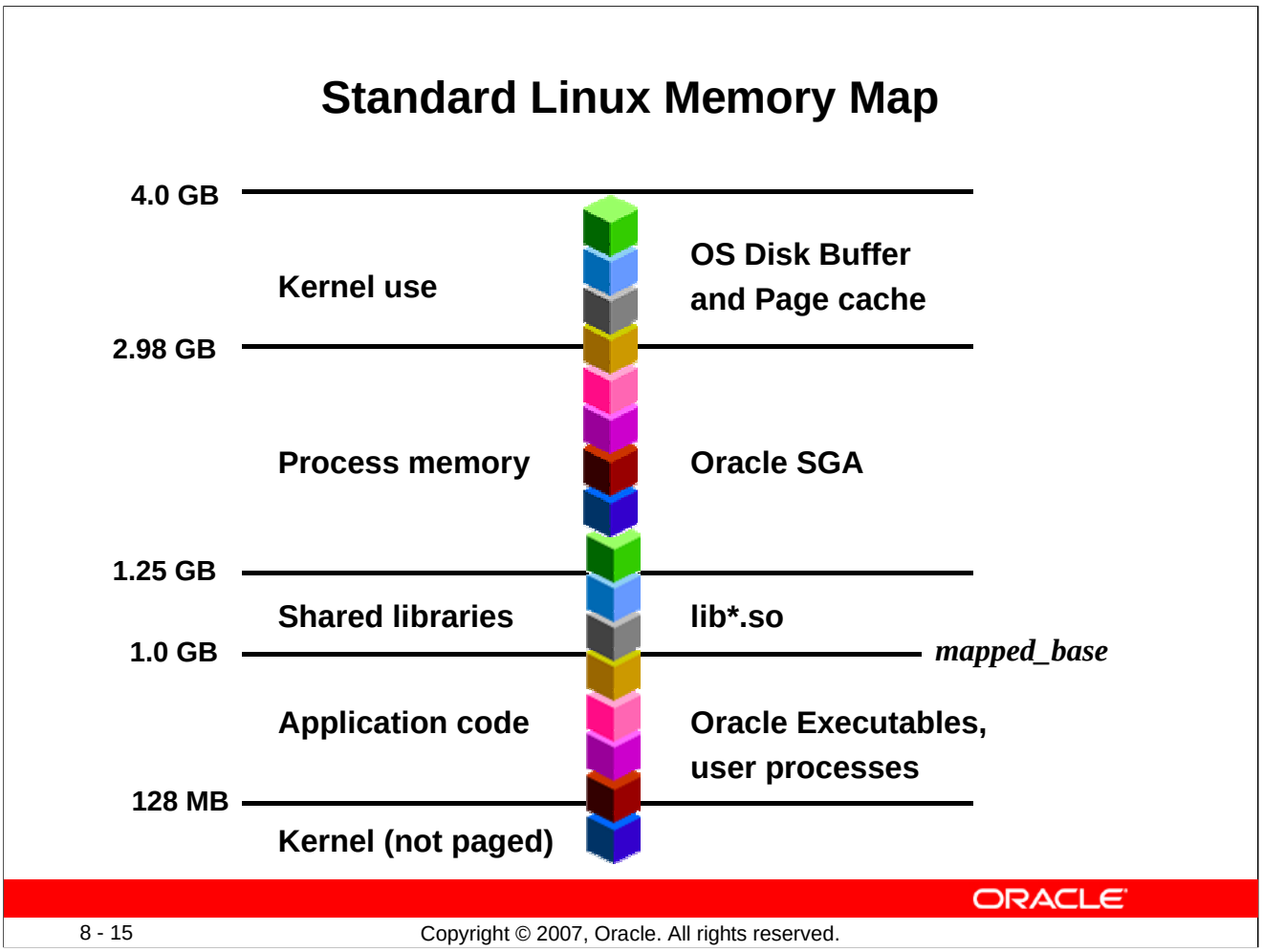
Implementing a Large SGA

There are two Linux memory limitations that affect the maximum size of the SGA. One of those is a *process* limitation and the other is a *kernel* limitation.

Kernel Limitations

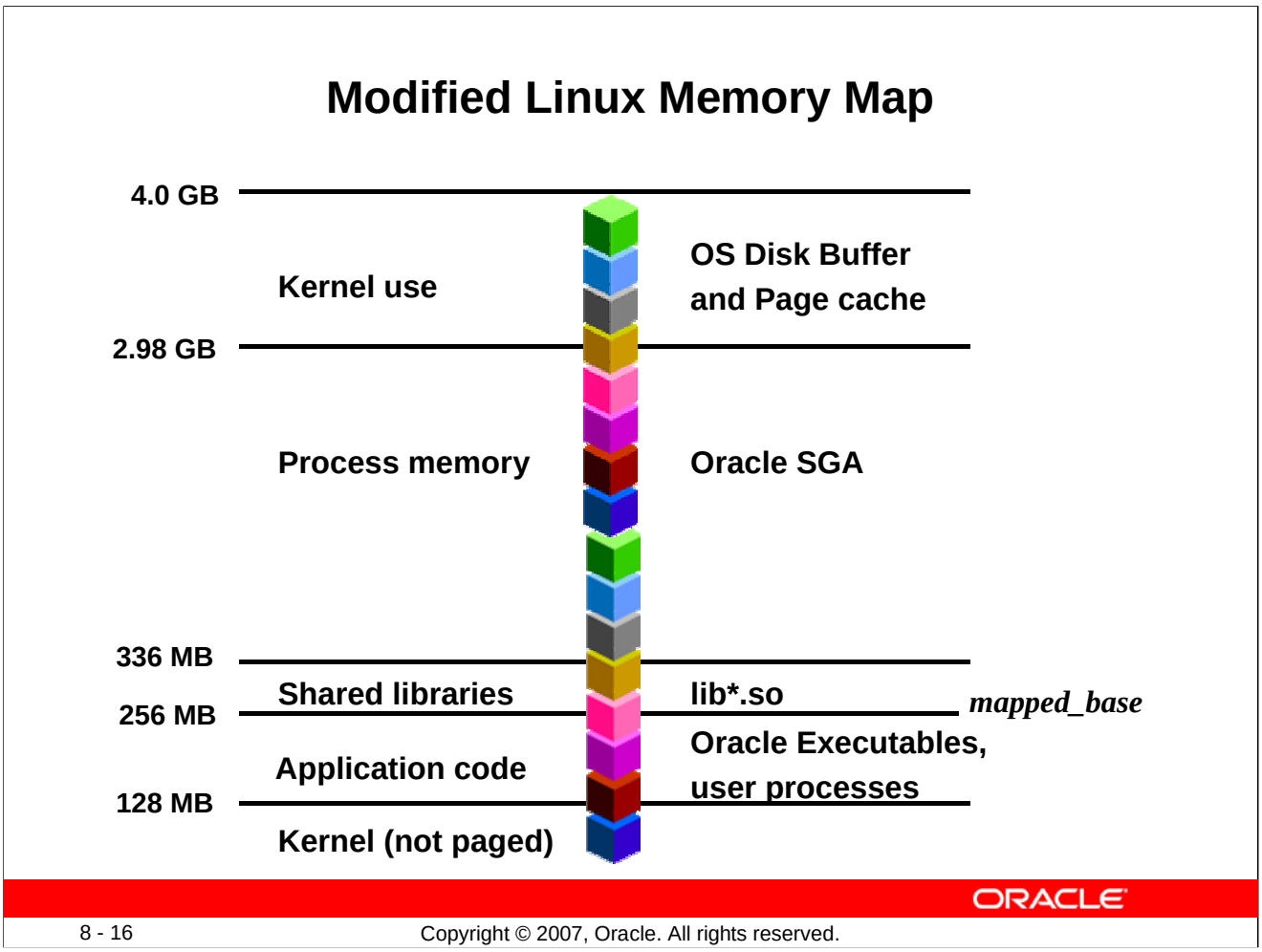
A 32-bit processor cannot access more than 2^{32} bytes (4 GB) of RAM without assistance. That assistance comes in the form of PAE that breaks up the memory into chunks that can be handled by the 32-bit processor. Those chunks are accessed through an extra layer of memory address translation.



Standard Linux Memory Map

With 4 GB of RAM, the Linux kernel will normally divide it up as shown in the slide. The kernel takes up a fairly small amount of RAM at the base of the memory map (the diagram in the slide is not to scale). The kernel will also reserve the top portion of the memory map for disk buffer caching and memory page table maintenance. The area in between is left for applications, such as Oracle Database.

The application area is divided into three sections: a section for application code, a section for application memory, and a section for shared libraries. With Oracle, user processes and background processes, such as PMON, SMON, and DBW*n*, reside in the application code area, whereas the SGA resides in the application memory area. The starting point in the memory map for shared libraries and process memory is controlled by `mapped_base`. As you can see, process memory can occupy the section from about 1.25 GB to 2.98 GB, giving the SGA a maximum size of around 1.7 GB. The only way to accommodate the SGA is to take away space from other application area sections.



Modified Linux Memory Map

It is possible to modify the Linux memory map and allocate more memory to the SGA. The kernel will still take up about 128 MB at the base of the map as well as the upper 1 GB, but the three application areas can be redistributed by changing the `mapped_base`.

As you can see in the slide, lowering `mapped_base` expands the area available to the SGA at the expense of room for shared libraries and application code. The theoretical limit for the SGA using this method is approximately 2.7 GB.

From a practical standpoint, you have to worry about shrinking the space for application code too much because it does little good to have a large SGA if your users cannot create sessions to access it. Ensure that you leave enough room below `mapped_base` for your applications to run.

You can check the memory mappings by looking at a `/proc/<pid>/maps` file for any process ID. The lowest address for the `ld*.so` shared library files is where shared libraries are mapped.

Altering the Linux Memory Map

To alter the Linux Memory Map and implement an SGA between 1.7 GB and 2.7 GB, perform the following steps:

1. **Modify `shmmax`.**
2. **Modify a shell for starting the database instance by lowering `mapped_base`.**
3. **Relocate the SGA:**
   a. **Modify `ksms.s`.**
   b. **Relink the database executables.**

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Altering the Linux Memory Map to Accommodate a Larger SGA

This procedure is used for setting an SGA larger than 1.7 GB and smaller than 2.7 GB on a machine with 4 GB or less of real memory. Remember that you need to leave room for application code, so even as this example maximizes the SGA in real life, you would probably set the `mapped_base` higher. This is not especially difficult, but you have to be careful. If you perform these steps incorrectly, you will receive unexpected error messages (`ORA-3113`, attach errors, or server processes just dying, and so on).

Lowering `mapped_base` and Relocating the SGA Method

Advantages:

- You can increase the SGA from the default of 1.7 GB up to 2.7 GB.
- It works with any 8.1.7, 9.0.1 or 9.2.x, and 10.1 and 10.2 database.
- The entire SGA (shared pool, buffer cache, and so on) can be increased in size.

Disadvantages:

- Local startup/shutdown of the database is allowed only from a modified Linux shell.
- It requires a thorough understanding to be implemented correctly.
- Less virtual memory remains available for the PGA, so activities such as sorting need to be tuned differently.

Altering the Linux Memory Map to Accommodate a Larger SGA (continued)

Modifying shmmax

The shmmax parameter can be changed dynamically, but unless you want to repeat the change every time you reboot the server, you should enter the change in the /etc/sysctl.conf file. The previous rule of thumb of limiting shmmax to half of real memory does not apply here. It is assumed that the amount of SGA needed has already been determined. The amount of process memory needed is also known. The sum of the SGA, the process memory, and the kernel and OS caches must be sized to be allocated without excessive paging.

Lowering mapped_base

The mapped_base is an address in virtual memory where the mmap starts looking for a chunk of memory to allocate to the shared memory. The larger memory addresses are considered lower in memory. By starting the search at a lower address, a larger shared memory allocation up to 2.7 GB is possible. The mapped_base parameter is set on a per process basis, so it cannot be set during boot up, or for the entire system.

Lowering the mapped base is a requirement for *every* shell that spawns an Oracle server process on the server. This includes any shell that is used to connect locally to the database and the shell used to start the listener. (This way, listener-spawned processes inherit a lowered mapped_base.) This step will have to be performed *every time* you start the instance. This means you will not be able to start the instance using Oracle Enterprise Manager or other tools. The mapped_base parameter is inherited by any process spawned by a shell that has mapped_base lowered.

Start a shell as the oracle user. In the shell, find the process ID by using ps or echo $$.

Start another shell as the root user and lower the mapped_base with the following command:

```
# echo 268435456 > /proc/<your process ID>/mapped_base
```

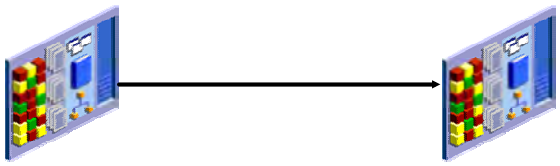
where 268435456 is decimal for 0 x 10000000.

Relocating the SGA

Execute the following commands as the Oracle software owner:

```
$ cd $ORACLE_HOME/rdbms/lib
$ cp ksms.s ksms.s_orig   /* if ksms.s exists,
back it up first.*/
$ genksms -s 0x15000000 > ksms.s

$ make -f ins_rdbms.mk ksms.o
$ make -f ins_rdbms.mk ioracle
```



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Relocating the SGA

In this procedure, the `ksms.s` library is modified, and the database executable is relinked to use a lowered address for the SGA. The address of 0X15000000 is safe, and lower addresses may be usable down to about 0x12000000, but these lower addresses must be thoroughly tested. Other Oracle-supplied executables may use addresses below 0X15000000 and can be incompatible with these changes.

After these changes have been made, an SGA of approximately 2.7 GB can be allocated.

Reversing the Change

If things go wrong and you want to return to your original values, then you can do one of the following:

- If `ksms.s` existed before you began this process:
  `$ cp ksms.s_orig ksms.s`
- If `ksms.s` did not exist, use the following command to return to the default installed value:
  `$ genksms > ksms.s`
  After you restore or regenerate `ksms.s`:
  ```
  $ make -f ins_rdbms.mk ksms.o
  $ make -f ins_rdbms.mk ioracle
  ```

Relocating the Database Buffer Cache

These steps relocate the database buffer cache so that instead of occupying a portion of the application area within memory, it resides in a virtual file system. To do this, perform the following steps:

1. **Set shmmax to hold the entire SGA.**
2. **Enable hugepages for performance boost.**
3. **Enable shared memory file system.**
4. **Set the initialization parameters and restart the**
5. **instance. (Dynamic SGA parameters are not available.)**

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Relocating the Database Buffer Cache

It is possible to relocate the position of the database buffer cache so that it does not occupy space with the rest of the SGA in the application area of the memory map. This not only allows for much larger database buffer caches, but also frees up memory within the 2.7 GB limit for other areas of the SGA such as the shared or Java pools.

Setting shmmax to Hold the Entire SGA

From any root Linux shell, set the `shmmax` kernel parameter to half the size of physical RAM available on your system. The value for `shmmax` cannot exceed 4294967295, or 4 GB:

```
# echo 4000000000 > /proc/sys/kernel/shmmax
```

Again, set it at boot up by setting `kernel.shmmax` in `/etc/sysctl.conf`.

Relocating the Database Buffer Cache (continued)

Ensuring that hugepages Are Enabled

Ensure that hugepages are enabled, as described earlier in this lesson.

Implementing a Large SGA

Mounting a Shared Memory File System (SHMFS)

As root, mount a shared memory file system and mount it at every boot up by changing the /etc/fstab file:

```
# mount -t shm shmfs -o size=8g /dev/shm
```

Add the following line to the /etc/fstab file:

```
none    /dev/shm        tmpfs   size=8g         0 0
```

This creates an shmfs file system on /dev/shm of 8 GB size. The size parameter accepts the "k"and "m" multipliers as well. When the database instance is started with the extended buffer cache feature enabled, a file is created in /dev/shm that corresponds to the SGA database buffer cache.

Configure the Instance to Use the Shared Memory File System

Set the following initialization parameters, assuming an 8 KB block size and 3.8 GB cache:

```
USE_INDIRECT_BUFFERS = TRUE
DB_BLOCK_BUFFERS = 475000
```

Note: Multiple database buffer cache block sizes and the dynamic SGA buffer cache parameters cannot be used with INDIRECT_BUFFERS. The database buffer cache size must be set with DB_BLOCK_BUFFERS.

Verify that the following initialization parameters are *not* set:

```
DB_CACHE_SIZE
DB_2K_CACHE_SIZE
DB_4K_CACHE_SIZE
DB_8K_CACHE_SIZE
DB_16K_CACHE_SIZE
DB_32K_CACHE_SIZE
```

Start up the Oracle database instance. If you are using this method in conjunction with altering the Linux memory map, then do not forget to reset mapped_base before starting the instance. The memory allocated to DB_BLOCK_BUFFERS will now be consumed from the shared file system located at (in this example) /dev/shm leaving up to 2.7 GB for other SGA areas.

Note: It is possible to make your buffer cache too large to the point where it defeats any performance gains. For details, see the *Oracle Database Performance Tuning Guide*.

hugemem Kernel

The hugemem kernel:

- **Can address up to 64 GB of RAM**
- **Is required in order to address more than 16 GB of RAM**
- **Supports multiple processors**
- **Makes use of Physical Address Extension (PAE)**
- **Allows up to 4 GB to be used per process**
- **Provides for a 3.6 GB SGA without implementing VLM**

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hugemem Kernel

The hugemem kernel is provided by the `kernel-hugemem` package. It is a kernel that was developed to take advantage of memory greater than 16 GB. It can even provide some benefit on systems with as little as 6 GB of memory. There is no definite RAM size that defines where the cutoff of benefit is, but if you have processes that can take advantage of up to 4 GB of address space, then this kernel may provide some advantage. That is because the hugemem kernel not only provides for addressing up to 64 GB of memory, but it also provides up to 4 GB of memory per process. So even if you have only 12 GB, but you have a process that requires a large amount of memory for itself, then the hugemen kernel can be beneficial.

Summary

In this lesson, you should have learned how to:

- List the memory models available in Linux kernels
- Implement hugepages
- Describe `/proc/meminfo` contents
- List implications of Linux memory configuration on Oracle Database
- Identify issues regarding 32-bit OS versus 64-bit OS

Practice 8 Overview: Managing Memory

This practice covers the following topics:

- **Understanding the contents of `/proc/meminfo`**
- **Viewing shared memory segment information**

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9

Using Linux Measurement Tools

Objectives

After completing this lesson, you should be able to:

- **Use Linux monitoring tools**
- **Interpret memory measurements**
- **Interpret I/O measurements**

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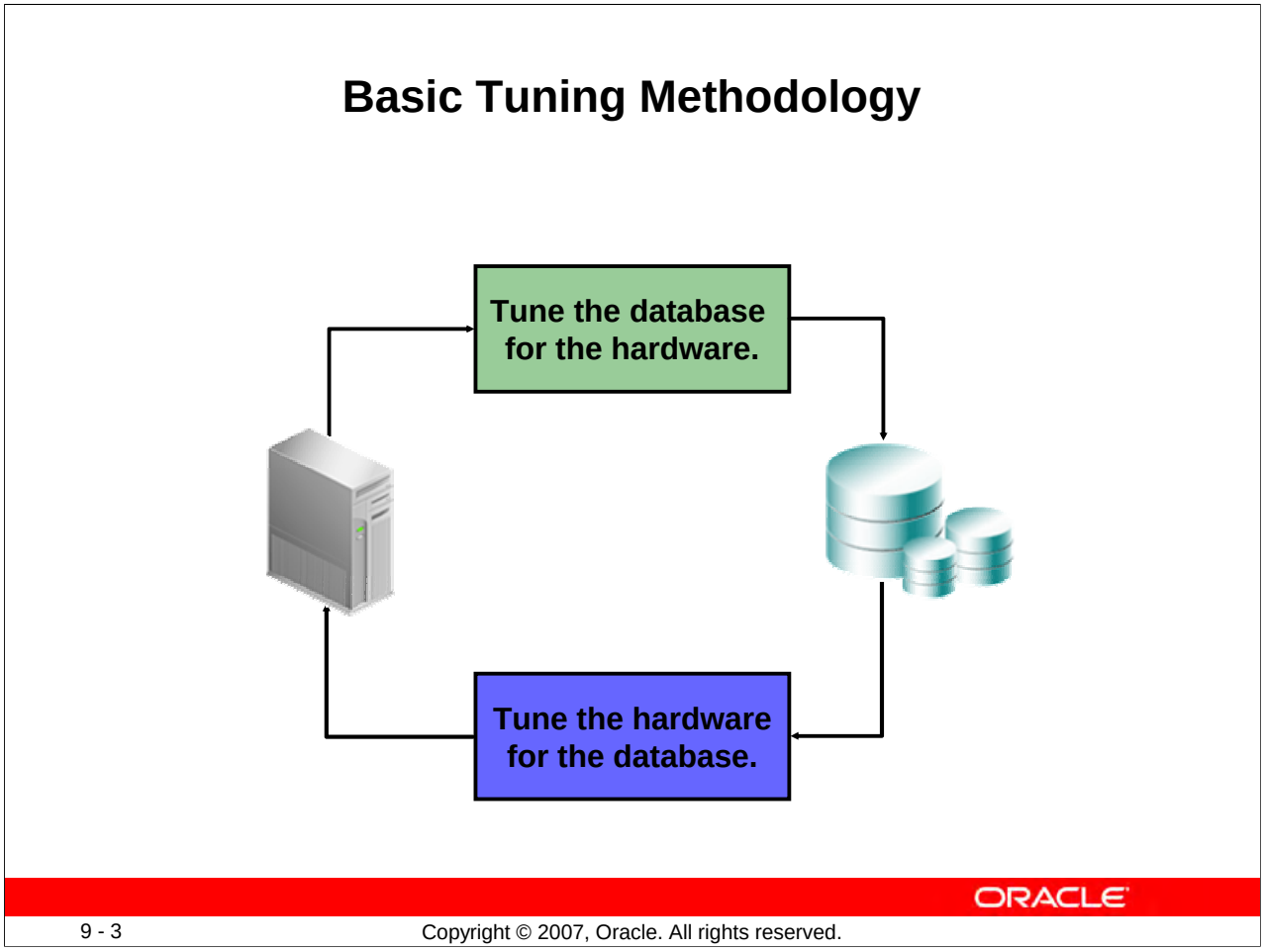


Basic Tuning Methodology

When you tune your system, you have to work in a cycle. In most cases, you start with a given hardware configuration where you deploy your Oracle database. First, you work with this hardware and tune it for best performance.

Be ready to reevaluate your hardware configuration as system requirements change. When evaluating new hardware, your primary considerations should be based on memory, storage I/O capability, and CPU power. For most systems, the requirements should be evaluated in that order.

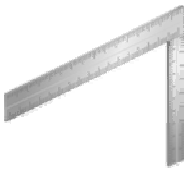
Over time, your system requirements change and you need to modify your hardware. For this, you may need to tune your database. This process continues for the life of your system.

Standard Measurement Tools

Linux has measurement tools that are common to UNIX platforms:

- **Top Resource Consumers: `top`**
- **System Activity Reporter: `sar`**
- **Virtual Memory Statistics: `vmstat`**
- **I/O Statistics: `iostat`**
- **System Log files: `/var/log/messages`**





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Standard Measurement Tools

Linux, like every operating system (OS), has tools available for measuring system performance. The Open Source community has developed a series of tools that measure almost everything that you want to measure. Many of those are traditional tools adopted from the UNIX environment. The tools mentioned here are the ones that are available across most UNIX and Linux environments. However, this is not an all-inclusive list. These tools are either installed by default with your distribution or freely available via the World Wide Web.

Top Resource Consumers: `top`

The real-time monitoring tool `top` is available on almost every flavor of UNIX/Linux. It shows the CPU load averages, memory usage, I/O waits, and a detailed listing of the top processes sorted by some resource, and CPU utilization, by default. Use `top` to *begin* your tuning and then drill down with other tools.

`top` is particularly useful for diagnosing CPU and I/O issues, though not as reliable for Oracle memory issues. Although `top`'s aggregate memory statistics are dependable, individual process memory numbers should not be relied upon. Memory statistics for a process show all allocated memory, including shared memory. Because Oracle processes share the System Global Area (SGA), it shows up multiple times. The same shared memory segment will show up as belonging to PMON, SMON, CKPT, and the other Oracle processes.

Standard Measurement Tools (continued)

System Activity Reporter: `sar`

`sar` provides a variety of ways to look at the system activity including memory, I/O, and CPU usage. In addition to viewing snapshots of system activity, `sar` collects regular samples of statistics to a file that can be queried for particular activity at particular times. If you are already familiar with `sar` from some other UNIX variant, check the `man` pages to verify the options because they are different on Linux. It is usually executed with three arguments:

```
$ sar <options> <interval> <count>
```

The `<options>` flag determines what the output of `sar` will be. The report can include statistics on memory use, I/O, system processes, interrupts, network and so on.

In addition to providing real-time metrics, `sar` samples the `/proc` file system at 10-minute intervals and records the data in `/var/log/sa` as a `sa#` file where # is the day of the month. A full month's worth of statistics are retained so that the administrator can use `sar` to view past statistics as well as current. For example, to view the CPU statistics for the 23rd of the month:

```
sar –u 2 4 –f /var/log/sa/sa23
```

Virtual Memory Statistics: `vmstat`

Probably the best tool for monitoring memory usage, the `vmstat` program reports information about processes, memory, paging, block I/O, traps, and CPU activity. It is usually executed with two arguments:

```
$ vmstat <interval> <count>
```

with `<interval>` being the number of seconds between statistics samplings and `<count>` being the number of samples to take. Unlike `sar`, the `vmstat` report allows very little customization. (You can give a `–n` option before the interval to suppress the report page header.)

I/O Statistics: `iostat`

Disk activity, disk queue lengths, and hot spots are all important pieces of information for tuning the I/O related to the database. The `iostat` program provides these statistics, overlapping and extending the disk statistics available from `sar`.

System Log Files: `/var/log/message ../syslog`

The operating system maintains various log files that can be of use in monitoring and tuning the system.

Linux Tools

Linux also has tools that are specific to this operating system:

- **X-based tools: `xosview`**
- **The `/proc` virtual file system**
- **Free and used memory: `free`**

Linux Tools

Graphical Measurement Tools

For Linux systems running the X Window System (X), there are a variety of graphical tools that can be installed to monitor performance. They have the advantage of being easy to interpret.

X-Operating System View: `xosview`

The `xosview` tool shows CPU, disk, memory, and network activity. SuSE and UnitedLinux install `xosview` by default. The package for `xosview` is distributed with Enterprise Linux, but is not part of the default installation.

Note: Remember that X-based tools tend to influence the output by their own load on the CPU; because of this, they may not be the most accurate measurements of CPU usage.

Virtual Process File System: `/proc`

The `/proc` file system is a virtual file system that provides a look into the background workings of the operating system. You can think of it as the Linux equivalent to Oracle's `v$` views. The `/proc` file system exists in many UNIX variants, whereas its contents are greatly expanded under Linux.

Free Memory: `free`

The `free` command displays the total amount of free and used physical and swap memory in the system, as well as the shared memory and buffers used by the kernel.

Linux Tools (continued)

Process Tree: `pstree`

This tool displays the relationship between processes in a tree structure, with parents to the left and children to the right:

```
$ pstree
 init-+-2*[Xvnc]
      |-apmd
      |-oafd
      |-26*[oracle]
      |-perl-+-emagent---emagent---4*[emagent]
             `-java---java---52*[java]
```

Because the `init` process is system process number 1, it will always appear to the left. In this snippet from the `pstree` output, you can see that there are two `Xvnc` processes running, 26 `Oracle` process running, and that the `perl` process has started two children, each of which has started several other processes.

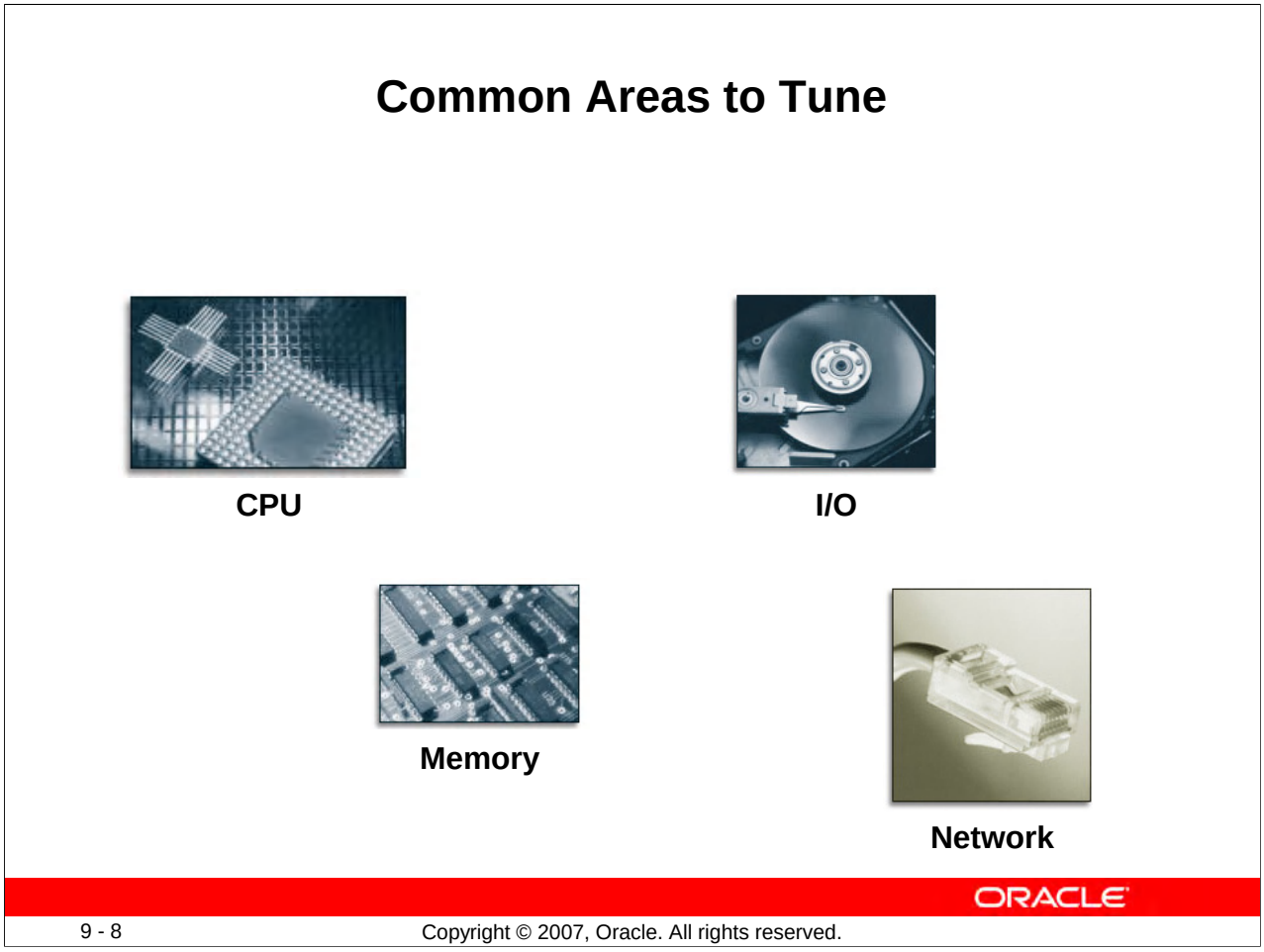
Resource Limits: `ulimit`

This tool shows the resources available to your shell. This tool is shell dependent; with the C shell you would use `limit –h` instead.

```
/> bash
# ulimit –a  (the –a flag shows all current limits)
core file size        (blocks, -c) 0
data seg size         (kbytes, -d) unlimited
file size             (blocks, -f) unlimited
max locked memory     (kbytes, -l) 4
max memory size       (kbytes, -m) unlimited
open files                    (-n) 1024
pipe size          (512 bytes, -p) 8
stack size            (kbytes, -s) 10240
cpu time             (seconds, -t) unlimited
max user processes            (-u) 7168
virtual memory        (kbytes, -v) unlimited
```

And *many* more

If it is measurable, chances are that there is a Linux package already written to measure it. Many more utilities may be available depending on your distribution and which packages you have installed. Consult your distribution-specific documentation for more information. Also, Oracle provides Oracle Enterprise Manager DB Control, which provides a great deal of performance-monitoring information about the systems it is monitoring.



Common Areas to Tune

System performance depends on how efficiently system resources are used. In most systems, the key resources that affect performance are CPU, memory, disk I/O, and network.

Central Processing Unit (CPU)

The CPU is the heart of your system. If CPU performance is poor it does not matter what else you tune, your system will be slower than it could be.

Memory

Memory is a common system bottleneck. It is usually divided into two generic categories: real and virtual (swap). Any running process consumes some memory.

Disk Input/Output (I/O)

Although other device I/O can affect performance, disk I/O is usually the most critical type of I/O. How fast and reliably can you move data to and from a disk? This is often the slowest factor in a system, and can be one of the most difficult to tune.

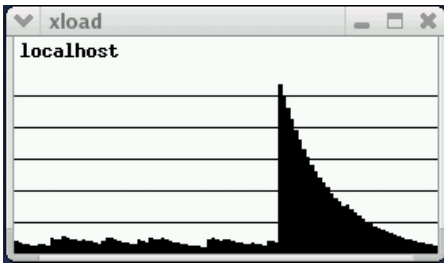
Network

The network is the gateway into your system. Few modern systems are self-contained within a single server. Most depend on external connections either from clients or middle-tier machines.

Monitoring and Tuning CPU

Tools for monitoring and tuning CPU include:

- `top`
- `pstree`
- `vmstat`
- `mpstat –p All`
- `sar -u`
- `xosview`
- `xload`



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Monitoring and Tuning CPU

Before you start tuning the CPU, you must identify if the CPU is a bottleneck for system performance. For this step, you normally use high-level tools such as `top`, `pstree`, or one of the many graphical utilities available for Linux, such as `xosview` and `xload`. If CPU is a problem for your system, then you drill down to find the source of that bottleneck with fine-grained tools such as `sar` or `vmstat`.

`/proc` Virtual File System

All the tools mentioned in the slide use the `/proc` virtual file system as a source of performance information. The raw data contained within `/proc` exposes a wealth of information about CPU resources. Interesting files include:

- `/proc/cpuinfo`
- `/proc/stat`
- `/proc/loadavg`

Is the CPU a Bottleneck?

Is the CPU a bottleneck?

- **How many CPUs does the machine have?**
- **What is the load average?**
- **What is the load factor?**
  - **<1: CPU probably not a bottleneck**
  - **Between 1 and 2: Running at capacity**
  - **>2: CPU may be a bottleneck, investigate**
- **Partial output from `top`:**

```
09:11:01 up 59 min, 12 users, load avg: 4.32, 5.03, 4.72
320 processes: 307 sleeping, 12 running, 1 zombie, 0 stopped
cpu states: 69.8% user 4.6% system 1.5% nice 0.0% iowait 23.9% idle
```

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Is the CPU a Bottleneck?

To answer this, you have to know a few things about your system:

- How many CPUs does your machine have? You can find this by checking `/proc/cpuinfo` or with commands such as `mpstat`.
- What is the average load on your system? There are many ways to find this, but the easiest is to use `top`. The output from `top` shows you the load average for the past 10 minutes with three samples (now, 5 minutes ago, and 10 minutes ago).
  `load average: 4.32, 5.03, 4.72`
- What is the *load factor* for your system? The load average does not mean a lot taken by itself. It gives only the number of processes receiving service from the CPUs at any given time. These numbers would be a matter for concern on a uniprocessor box (or even a two-processor box), but would not be something to worry about on a four or more processor box. Load factor is a more relevant metric. To calculate the load factor, divide the load average by the number of CPUs:

$$\frac{\text{load average}}{\#\text{CPUs}} = \text{load factor}$$

Is CPU a Bottleneck? (continued)

- If your load factor is:
  - <1, you have CPU capacity to spare and it is unlikely that you are CPU bound
  - Between 1 and 2, your system is running at capacity
  - >2, CPU may be a bottleneck in your system, and you should investigate further using other tools such as `sar` or `vmstat`

Full Output from the `top` Command

```
09:11:01  up 59 min, 12 users,  load average: 4.32, 5.03, 4.72
320 processes: 307 sleeping, 12 running, 1 zombie, 0 stopped
CPU states: 69.8% user   4.6% system   1.5% nice   0.0% iowait  23.9% idle
Mem: 385112k av,  378740k used,    6372k free,       0k shrd,   37812k buff
                    287620k actv,       0k in_d,    6384k in_c
Swap: 779144k av,  303648k used,  475496k free                   90592k cached

  PID USER     PRI  NI  SIZE  RSS SHARE STAT %CPU %MEM   TIME CPU COMMAND
 1973 root      25   0 23480 9872   956 R    59.4  2.5   4:28   0 X
 2487 oracle    15   0 29596  24M  1576 S     2.5  6.6   1:41   0 jre
 2816 susan     15   0 21768  19M  1036 S     2.3  5.1   0:15   0 jre
 2126 oracle    16   0  1080 1048   420 S     2.1  0.2   0:56   0 top
 3218 root      16   0  1504 1504   860 R     2.1  0.3   0:02   0 top
 3028 oracle    25  10  2820 2636  2052 R N   1.5  0.6   0:06   0 sproingies
 2061 oracle    15   0  5852 2168  1100 S     0.9  0.5   0:08   0 rhn-applet-gui
 1675 root      15   0  1800  728   540 S     0.7  0.1   0:12   0 snmpd
 2602 oracle    15   0  8284 6452  1552 S     0.7  1.6   0:30   0 dbsnmp
 1426 root      15   0   200  164   116 R     0.5  0.0   0:08   0 syslogd
 2329 root      15   0 25876   9M   824 R     0.5  2.6   6:52   0 X
   15 root      15   0     0    0     0 SW    0.3  0.0   0:09   0 kjournald
 3008 root      15   0 12612  11M  7864 S     0.3  3.0   0:04   0 rhn-applet-gui
 2212 root      15   0 26124  10M   812 R     0.1  2.7   9:01   0 X
 2262 rlowenth  15   0  5836 2144  1084 S     0.1  0.5   0:12   0 rhn-applet-gui.
```

Many people do not realize that `top` is an interactive utility. From within `top`, you can enter "`?`" to see a list of options. One more useful interactive command is "`u`" which allows you to identify a single user for the `top` display output. For example, if you enter "`u`" and then type in "`oracle`" then your list of processes would include only processes started by `oracle`. The `top` displays' default refresh rate is every two seconds, but you can change that interval with the "`s`" command. When `top` is run by `root`, you can kill processes directly from within `top` by using the "`k`" command.

CPU Measurements

Identify the following CPU statistics and interpret them:

- **CPU idle time**
- **CPU time spent executing user code**
- **CPU time spent executing system code**
- **Processes waiting for CPU time (run-queue)**

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CPU Measurements

Although there are dozens of different CPU measurements that you can look at, the ones listed in the slide are the most important. These have the same meaning but slightly different labels depending on the tool that is used to view them.

CPU Idle Time

This indicates the amount of time that CPU is in an idle state. Idle time is labeled `%idle` in `sar`, `id` (under the `CPU` heading) in `vmstat`, and `idle` in `top`. If you are experiencing performance problems, and CPU shows high idle time, then the system is not CPU bound.

CPU Time Spent Executing User and System Codes

These statistics have to be considered together. Together they represent the useful work that is being done by the CPU. User time indicates the time that is spent in executing code in the user space. System time measures the time that is spent in executing system calls. Every application has a characteristic ratio of user to system. With an Oracle database, you should expect a ratio of *approximately* 60% user code to 40% system code. If the user code percent is significantly higher, then there may be inefficiencies in the application code. If the system code percentage is significantly higher, look for system activity, such as high rates of disk I/O or memory swap.

CPU Measurements (continued)

`run-queue size`

The run queue size indicates the number of processes that are ready to run. Processes that are blocked (waiting on I/O or for other reasons) are not counted in the run queue. All the processes in the run queue are waiting for a time slice of the CPU. If the run queue size is more than one, performance could probably be increased by adding additional CPUs.

Obtaining CPU Measurements

There are several ways to obtain the key CPU metrics. Each of these tools gives a slightly different view of the same information about the CPU activity.

```
# vmstat <interval> <count>
# mpstat -P <CPU> <interval> <count>
# sar -u <interval> <count>
# sar -q <interval> <count>
# iostat -c <interval> <count>
```

`vmstat`, `mpstat`, and `iostat` get their information directly from the `/proc` file system.

Measuring CPU Activity with vmstat

```
# vmstat <interval> <count>
```

```
# vmstat 2 5
  procs          system      cpu
 r  b  w …   in     cs   us   sy    id
 0  0  0 …   11     42    3    1    96
 1  0  0 … 106    141    0    1    99
 0  0  0 … 109    134    0    0   100
 1  0  0 … 103    146    7    1    92
 0  0  0 … 107    125    0    0   100
```

Note: Memory and IO statistics removed for readability

Measuring CPU Activity with vmstat

The output of `vmstat` shows the key CPU metrics measured over the specified interval and time period. In the partial listing in the slide:

- `cpu / us` = CPU time spent executing user code
- `cpu / sy` = CPU time spent executing system code
- `cpu / id` = Idle CPU time
- `procs / r` = Processes waiting for CPU (run-queue size)

Other CPU metrics shown are:

- `procs / b` = Processes in uninterruptible sleep
- `procs / w` = Processes swapped out, but runnable
- `system / in` = Interrupts per second
- `system / cs` = Context switches per second

A full example of the vmstat command follows:

```
# vmstat 2 2
  procs                  memory    swap          io     system         cpu
r  b  w   swpd   free   buff  cache  si  so    bi    bo   in    cs  us  sy  id
0  0  0  78748  48720  97540 453688   0   0     4    60   11    42   3   1  96
1  0  0  78748  48716  97540 453688   0   0     0     8  106   141   0   1  99
```

Measuring CPU Activity with `mpstat`

Unlike the `vmstat` command, the `mpstat` command allows you to drill down into CPU statistics by processor. In a multiprocessor system, this can give you a more detailed picture of what your CPUs are doing other than `vmstat`. Unfortunately, `mpstat` will not show you the run-queue size. A full example of the `mpstat` command is as follows:

```
$ mpstat -P ALL 1 1
Linux 2.4.9-e.3enterprise (delphi)      04/01/2003
08:09:21 AM  cpu   %user   %nice %system   %idle    intr/s
08:09:22 AM  all   19.50    0.00   31.50   49.00    111.00
08:09:22 AM    0   27.00    0.00   42.00   31.00    111.00
08:09:22 AM    1   12.00    0.00   21.00   67.00    111.00
```

Measuring CPU Activity with `sar`

You can also use the System Activity Reporter (`sar`) command to retrieve information about CPU performance. Like the `mpstat` command, the `sar` command returns information about the division of work within the system.

```
$ sar -u 2 5
Linux 2.4.9-e.3enterprise (delphi)      04/01/2003

08:12:14 AM       cpu     %user     %nice   %system     %idle
08:12:16 AM       all     30.50      0.00      1.75     67.75
08:12:18 AM       all     39.75      0.00      1.00     59.25
08:12:20 AM       all     36.25      0.00      1.75     62.00
08:12:22 AM       all     23.75      0.00      1.50     74.75
08:12:24 AM       all     33.25      0.00      1.50     65.25
  Average:        all     32.70      0.00      1.50     65.80
```

Measuring CPU Activity with `sar` (continued)

To monitor the processor queue, including the run-queue (displayed with `sar` as `runq-sz`), you can use the `sar –q` command.

```
#sar -q 2 5
Linux 2.4.9-e.3enterprise (delphi)      04/01/2003

08:12:30 AM   runq-sz  plist-sz   ldavg-1   ldavg-5
08:12:32 AM         1        79      1.17      0.98
08:12:34 AM         1        79      1.17      0.98
08:12:36 AM         2        79      1.16      0.98
08:12:38 AM         1        79      1.16      0.98
08:12:40 AM         1        79      1.16      0.98
  Average:          1        79      1.16      0.98
```

Also shown with `sar -q` are:

`plist-sz`: Process list size showing the number of processes running in memory

`ldavg`: The load average for the last minute and the last five minutes

Measuring CPU Activity with `iostat`

Although it is normally used to measure data flow to and from disk devices, `iostat` also produces basic CPU statistics.

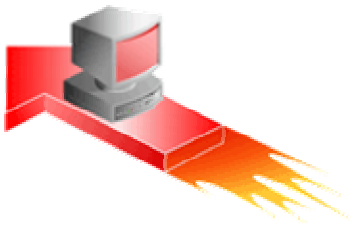
```
$ iostat -c 2 3
Linux 2.4.9-e.3enterprise (delphi)      04/01/2003

avg-cpu: %user   %nice    %sys   %idle
           3.50    0.05    0.83   95.61
```

Interpreting CPU Measurements

When interpreting CPU measurements, observe cases where the system has:

- **High idle time with poor response time**
- **Too much time spent executing user code**
- **Too much time spent executing system code**
- **Run-queue size more than double the number of CPUs**
- **Extremely high context requests per second**



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Interpreting CPU Measurements

The key to understanding the CPU measurements is that CPU is consumed on behalf of the application. Therefore, if an Oracle instance and processes are consuming all the CPU resources, check the database application and tune the SQL. Some key points to consider when interpreting CPU measurements are:

- High idle time with poor response time indicates that the processes are getting blocked. This means I/O, network, and swapping should be checked.
- If the `%user` to `%system` ratio on the Oracle server processes is much greater than the 60:40 ratio expected, then it indicates that the application code must be tuned. If the ratio is much lower, that is, `%system` is larger, then look for I/O or virtual memory problems.
- On a properly sized system, the run-queue size should seldom be more than the number of CPUs. If the run-queue size is greater than two times the number of CPUs available, then check `sar -wW` or `vmstat` for swapping and switching activity. A large run-queue size indicates a CPU bottleneck. This could indicate an undersized system or possibly insufficient memory.

Interpreting CPU Measurements (continued)

- Each process takes virtual memory. When more process memory is required than is available in real memory, paging takes place. As more processes are added, more memory is required, and more CPU overhead is required to process the paging and context switching requests. This can continue until the CPU spends most of its time paging and switching. This situation is called thrashing.

Reducing CPU Bottlenecks

If you determine that CPU is the limiting factor in your system:

- **Increase CPU resources**
- **Decrease CPU demand**
- **Schedule CPU demand more efficiently**

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Reducing CPU Bottlenecks

CPU is usually a finite resource. Sometimes it is *possible* to increase CPU resources (upgrade the processor or add additional processors), but it is usually difficult or expensive unless you are working in a grid system. Therefore, you usually concentrate on either using existing resources more efficiently or offloading unnecessary work to other systems.

Using Your CPU More Efficiently

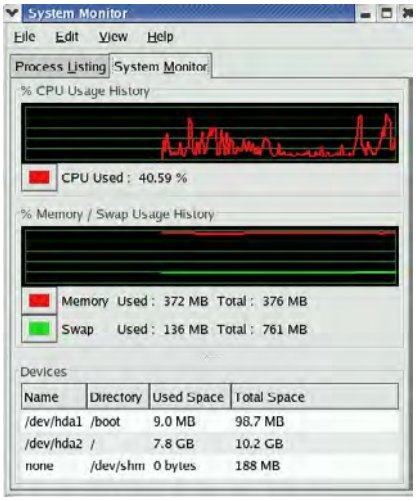
There are some basic things you can do to make your CPU more efficient:

- Schedule non-time-critical jobs to run during times when CPU is less loaded. For example, database backups, index rebuilds, optimizer statistics collection, and batch jobs could run at night rather than during the day.
- Employ a resource management system (such as Oracle Resource Manager) to ensure that your most important jobs are serviced first, and that too many batch jobs cannot be started simultaneously. The use of system process priority manipulation to assign resources to more important processes is not recommended for Oracle processes because Oracle has its own built-in process management system.
- Reduce the demand on your CPU by eliminating unnecessary work or offloading work to a different server.

Monitoring and Tuning Memory

Tools for monitoring and tuning memory include:

- `top`
- `free`
- `vmstat`
- `sar -B`
- `xosview`
- `System Monitor`



Gnome System Monitor

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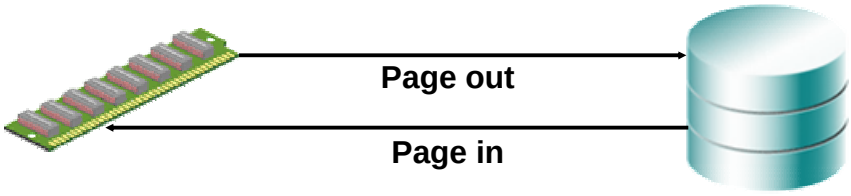
Monitoring and Tuning Memory

In addition to the tools listed in the slide, a great deal of information about system memory use can be obtained from the `/proc` virtual file system.

Measuring Memory Usage

Measure memory utilization and paging. Significant memory statistics include:

- **Total memory**
- **Context switches**
- **Pages in and out**
- **Inactive pages**
- **Demand rate**



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Measuring Memory Usage

The instance uses SGA memory to increase performance. Linux uses the buffer cache and page cache memory to increase performance. A well-tuned memory reduces the I/Os by caching frequently used pages. Poorly tuned or insufficient memory often shows up first as an I/O bottleneck with high activity on the `swap` partition.

Total Memory

Use `free`, `top`, or `cat /proc/meminfo` to find the total memory on your system. Physical memory is labeled `mem` in these tools.

Context Switches

Context switches can be seen in `vmstat` under the `system` group of columns. They are in the column labeled `cs`. A context switch takes place each time the CPU starts working on a different process. In a context switch, the TLB is reloaded for the new process, and other housekeeping details are taken care of.

Measuring Memory Usage (continued)

Pages Out

Pages out and pages in are measured in 1 KB blocks, even though the memory page size is 4 KB. Pages out are seldom zero, and should not be a cause for concern as some “page out” activity is normal. The `swap` process frequently moves a few pages out to swap to be sure that free pages are always available for page in operations. As more pages of real memory are needed, the number of pages moved to swap increases.

Pages In

The number of pages in is a good measure of RAM shortage. A page in operation occurs when a memory page is pulled from virtual memory back to RAM. As processes access pages that are not mapped or have been paged out, a page in is registered. Ideally, the average pages in over time is near zero. This means that all the processes fit in real memory. As more processes start and require memory, the pages in increase. This is a key measurement when adjusting the SGA size for the database. If the pages in increases significantly after an increase in SGA size, it may indicate that the SGA is too large.

Inactive Pages

This is also known as free or freeable memory. Inactive “clean” pages can be immediately replaced by other memory pages. Inactive “dirty” pages are free but must be written to disk before they can be used.

Demand Rate

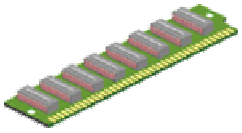
This is also known as “Inactive Page Target.” This is one of the most important memory statistic. It is shown as the `inatarpg` column with `sar -B`. The value shown is the average number of pages per second, within the last minute, the system needed to make “free” to meet memory demands. This value may also be seen as `inact_target` in `/proc/meminfo`. This is the goal the kernel tries to reach to make sure that there are enough inactive pages available.

Measuring Total Memory

```
#top

#free

#cat /proc/meminfo
```



Measuring Total Memory

The `top` command gives an excellent overview of the system activity. In the header portion, the `Mem` line shows total physical memory, memory used, free memory, shared memory, amount of memory in the buffer cache, and amount of memory in the page cache in kilobytes. Remember that individual process memory reported with `top` is meaningless for Oracle processes because shared memory is reported for each process.

```
#top
9:12pm  up 15:44,  4 users,  load average: 1.02, 0.65, 0.33
235 processes: 231 sleeping, 4 running, 0 zombie, 0 stopped
cpu states: 40.2% user, 59.7% system,  0.0% nice,  0.0% idle
Mem: 512284K av,  508348K used,   3936K free,  5200K shrd, 67428K buff
Swap:522072K av,  115088K used, 406984K free              242740K cached

  PID USER     PRI  NI  SIZE  RSS SHARE STAT %CPU %MEM   TIME COMMAND
 1017 root      15   0  5944 5544  4360 S     0.7  1.0   2:10 Xvnc
20866 oracle    15   0 86360  67M 54228 S     0.5 13.4   0:10 java
 1212 root      16   0  1188 1188   832 R     0.3  0.2   0:00 top
    1 root      15   0   508  460   460 S     0.0  0.0   0:04 init
    2 root      15   0     0    0     0 SW    0.0  0.0   0:00 keventd
```

Measuring Total Memory (continued)

The `free` command also shows total memory and swap usage. The `-/+ buffers/cache` line indicates the adjustment to free and used memory by the kernel's disk buffers and page cache (how much a process *could* get if it requested it—the kernel will dump its own page cache and disk buffers to support running processes):

```
#free
             total       used       free     shared    buffers     cached
Mem:      512284     506880       5404       5200      68196     239984
-/+ buffers/cache:   198700     313584
Swap:     522072     114884     407188
```

All the utilities that collect statistics gather information from the `/proc` file system. The virtual `meminfo` "file" gives an instantaneous snapshot of memory usage.

```
# cat /proc/meminfo
      total:     used:      free:    shared:  buffers:   cached:
Mem:  1054806016 1029685248 25120768       0  136949760  617668608
Swap: 534601728  22032384   512569344
MemTotal:      1030084 kB
MemFree:         24532 kB
MemShared:           0 kB
Buffers:        133740 kB
Cached:         585920 kB
SwapCached:      17272 kB
Active:         674312 kB
ActiveAnon:     214892 kB
ActiveCache:    459420 kB
Inact_dirty:         0 kB
Inact_laundry:  159476 kB
Inact_clean:     14016 kB
Inact_target:   169560 kB
HighTotal:      130524 kB
HighFree:         2032 kB
LowTotal:       899560 kB
LowFree:         22500 kB
SwapTotal:      522072 kB
SwapFree:       500556 kB
HugePages_Total:     0
HugePages_Free:      0
Hugepagesize:     4096 kB
```

A few key statistics from the `meminfo` output are:

- **`Mem`:** The current state of physical RAM in the system, including a full breakdown of total, used, free, shared, buffered, and cached memory utilization in bytes
- **`MemFree`:** The amount of physical RAM left unused by the system. It is usually very low.
- **`Active`:** The total amount of buffer or page cache memory that is in active use
- **`Inact_dirty`:** Buffers that might need writing to disk or swap. It should be relatively low.
- **`Inact_target`:** Demand rate. This is the goal the kernel tries to reach to make sure that there are enough inactive pages available.
- **`SwapFree`:** The total amount of swap free. It should not stay below 20% of SwapTotal.

Measuring Memory with sar

```
#sar -B <frequency> <count>

#sar -R <frequency> <count>
```

```
#sar -B 2 3

#sar -R 2 3
```

sar

The System Activity Reporter (`sar`) has many options.

The `-B` option shows pages in and pages out per second (`pgpgin/s`, `pgpgout/s`); the number of active pages (`activepg`); and the inactive dirty, inactive clean, and inactive target pages (`inadtypg`, `inaclnpg`, `inatarpg`). The inactive target is the demand rate.

```
# sar -B 2 3
Linux 2.4.9-e.3 (EDD1R28P1)     02/26/2003

08:19:03 PM  pgpgin/s pgpgout/s  activepg  inadtypg  inaclnpg  inatarpg
08:19:05 PM   1994.00    126.00     85630     18848      4802     32733
08:19:07 PM   2934.00  11680.00     85968     23722      3605     32733
08:19:09 PM    940.00    420.00     88629      4175     20266     32733
Average:      1898.80   5554.40     87859     12015     12492     32733
```

sar (continued)

The -R option shows the number of pages freed per second, the number of additional shared memory pages, buffer pages, and cache pages used, frmpg/s, shmpg/s, bufpg/s, and campg/s. Negative values indicate fewer pages used.

```
# sar -R 2 3
Linux 2.4.9-e.3 (EDD1R28P1)     02/26/2003

08:18:47 PM   frmpg/s   shmpg/s   bufpg/s   campg/s
08:18:49 PM      0.50      0.00      0.00   -109.50
08:18:51 PM      3.50      0.00     -1.50    140.50
08:18:53 PM     -4.00      0.00     -4.00    -93.00
Average:         0.10      0.00     -1.10    -61.30
```

vmstat

The vmstat command has two parameters: frequency and count. Frequency is the number of seconds between samples, and count is the number of samples to take.

In this example, vmstat samples every two seconds for a total of five samples. The first output line of vmstat shows all the activity since the last reboot. The following example shows a loaded system, but with little swapping. Pages in are represented by "si" and pages out are shown with "so."

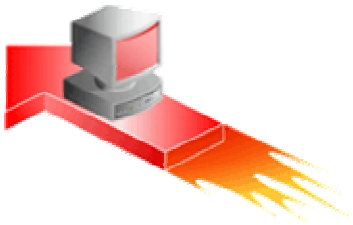
Note: The first line of output includes all activity since the last vmstat report.

```
# vmstat 2 5
   procs                  memory    swap          io     system         cpu
 r  b  w   swpd   free   buff  cache  si  so    bi    bo   in    cs  us  sy  id
 1  0  0 296004   3092  73268  61324   0   3    11    51  135   588  10   4  86
 1  0  0 296004   3076  73268  61324   0   0     0     2  109   372  66  34   0
 1  0  0 296004   3076  73268  61324   0   0     0    32  109   199  59  41   0
 1  0  0 296004   3072  73268  61316   0   0     0    24  110   331  40  60   0
 1  0  0 296004   3076  73268  61300   0   0     2    10  107   373  51  49   0
```

Interpreting Memory Measurements

When interpreting memory measurements, observe cases where the system has:

- **High swap memory usage**
- **Kernel file cache that continue to be allocated despite low system memory**
- **High page ins/page outs**
- **Low inactive pages**



Interpreting Memory Measurements

Remember that a single measurement is meaningless. The key to using memory statistics is measurement over a period of time. You can use the average demand rate (when the system performance is acceptable) as a baseline to compare with when the system performs poorly. This, along with the pages in over the same time periods, may indicate memory problems.

High Swap Memory Usage

Indicates memory demand is too high for the available RAM. If this is consistently high, then consider adding RAM.

Kernel File Cache Continues to Be Allocated Despite Low System Memory

This may be an indication of kernel problems. (Earlier Linux kernels did not release file cache quickly enough.)

Interpreting Memory Measurements (continued)

High Page Ins

This can indicate that the SGA is too large for available memory, or that the SGA needs to be "locked" into RAM. If you are using a supported enterprise distribution, then use the hugepages feature. If using a nonenterprise kernel, then set `lock_sga=true` to lock the SGA into RAM. Note that this requires the `oracle` user to have the `CAP_IPC_LOCK` privilege granted through and advanced permissions management system such as the Linux Intrusion Detection System (LIDS).

Low Inactive Pages

This indicates that you do not have enough memory. The best solution is to increase RAM.

Reducing Memory Bottlenecks

If you determine that memory is the limiting factor in your system, then:

- **Increase memory resources**
- **Decrease memory demand**

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Reducing Memory Bottlenecks

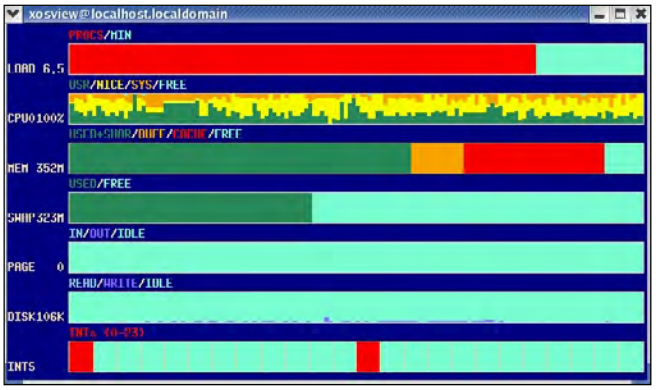
All the solutions are in the form of *Use less memory* or *Get more memory*.

- Identify nonessential memory consumption and eliminate it. Look for running non-Oracle processes and eliminate those you can do without.
- Use Linux hugepages.
- Reducing the SGA is not usually acceptable, but check the installation and configuration. Are you using the Java Virtual Machine (JVM)? If not, reduce `JAVA_POOL_SIZE` to zero. Can your buffer cache be reduced without affecting performance? Although the SGA would not complain about excessive pool sizes (within reason), your server certainly will.
- Reduce the number of user processes. Without restricting the number of users, the number of user processes can be reduced by using shared servers if the workload supports them.
- Reduce the amount of process memory with `PGA_AGGREGATE_TARGET`.
- Add memory to your server.

Monitoring and Tuning I/O

You should monitor the I/O across all devices to balance which device gives the best overall performance. Tools for monitoring I/O include:

- **`/proc` file system**
- **`sar -d`**
- **`iostat –d -p`**
- **`vmstat`**
- **`xosview`**



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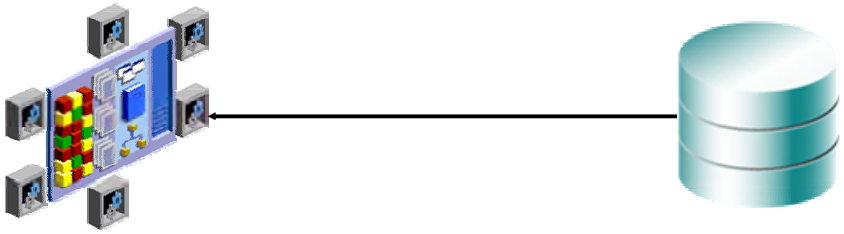
Monitoring and Tuning I/O

Which tools you use to tune disk I/O really depend on your storage system. Tools such as `sar` and `iostat` are common, but tend to show I/O measurements from the operating system's point of view rather than from a hardware standpoint. If your hardware includes large storage arrays from vendors, such as EMC, Network Appliance, HP/Compaq, and Veritas, then you will normally use monitoring tools provided by your vendor. If you are using the Just a Bunch Of Disks (JBOD) technology, then the information provided by operating system tools, such as `sar` and `iostat`, should be sufficient.

Is I/O a Bottleneck?

Is I/O a bottleneck?

- **Take and retain baseline I/O measurements.**
- **Individual measurements (snapshots) are usually of little value. I/O monitoring should be done over time.**
- **I/O issues with the swap partition should be treated as memory problems first.**



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Is I/O a Problem?

With databases, disk I/O is a primary concern. Disk I/O is the single largest performance cost. Most I/O measurements are meaningless without a baseline, so ensure that you capture and retain that. When you notice performance degradation, look for high queue and wait statistics to determine whether I/O is the culprit.

Remember that virtual memory is maintained on disk, and will also show up as I/O. If you spot high I/O statistics on the swap partition, you should troubleshoot it as a memory issue first, then address it as an I/O issue.

I/O Measurements

I/O measurements concentrate on volume and speed:

- **Read I/O operations**
- **Write I/O operations**
- **Request queue size**
- **Transfer rate**
- **Wait time**
- **Service time**

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I/O Measurements

I/O measurements usually concentrate on either the volume of data being handled or the speed with which that data is handled.

Volume

Obviously, the more work that is being done the longer it will take to do that work. When you measure volume, look at read and write volume separately. Also, if your tools allow you to view it, monitor sequential operations as compared with random access. It is usually quicker to write 1 MB of sequential data than to write 20 KB in multiple locations on the disk because of the time required for disk head positioning.

Speed

When monitoring speed, look for transfer rate (bytes per second), wait time (how much time was spent waiting for I/O to respond), and service time (how long does each I/O operation take from start to finish). Of these three, the wait time is the most important from a database performance standpoint.

Measuring I/O with `iostat`

I/O measurements concentrate on volume and speed:

- **Read I/O operations**
- **I/O statistics by device**

```
iostat -d <interval> <count>
```

```
#iostat -d 2 2
Linux 2.6.9-22.EL (HOSTNAME)   10/27/2006
Device:  tps Blk_read/s Blk_wrtn/s Blk_read Blk_wrtn
hda     4.85      49.16      84.01 60104671 102704241
```

- **I/O activity by partition**

```
iostat –d -p <interval> <count>
```

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Measuring I/O with `iostat`

The `iostat` command is used for monitoring system I/O device loading by observing the time the devices are active in relation to their average transfer rates. The first report provides statistics concerning the time since the system was booted. Subsequent reports cover the time since the previous report.

To view I/O statistics by device, use (the `–d` option suppresses CPU statistics):

```
iostat -d <interval> <count>
```

Transfer rate is shown by the `tps`, `Blk_read/s` and `Blk_wrtn/s` columns. Volume measurements for read and write operations can be seen in the `blk_wrtn` and `blk_read` columns.

To see I/O activity by partition, use:

```
iostat –d -p <interval> <count>
```

The `iostat -p` command presents the I/O statistics by partition with the same statistics that can be seen from `V$FILESTAT` on database files.

To display extended statistics by device, use (the `-d –x` option, `-x` and `–p` are mutually exclusive and cannot be used together):

```
iostat –d –x <interval> <count>
```

Measuring I/O with `iostat` (continued)

Speed measurements are shown in three ways: merged requests as `rrqm/s` and `wrqm/s` (how many operations were performed), requests as `r/s` and `w/s` (how many requests were made of the I/O system), and sectors handled per second as `rsec/s` and `wsec/s`.

Volume statistics are shown including average requests size `avgrq-sz.await` gives the average wait time for requests. `avgqu-sz` is a key metric that shows the length of the request queue (this is the I/O equivalent of CPU load). Service time, another key metric, appears as `svctm`. `%util` is the percentage of time the CPU spends handling I/O requests.

The output of the following command has been reformatted to fit the page.

```
# iostat –d -x 2 2
Linux 2.6.9-22.EL (EDRSR24P1)   10/27/2006

Device:    rrqm/s wrqm/s   r/s   w/s  rsec/s  wsec/s    rkB/s    wkB/s
hda          0.26   8.09  2.44  2.39   48.99   83.83    24.50    41.92
<would normally appear on same line as above>
Device:    avgrq-sz avgqu-sz   await  svctm  %util
hda           27.51     0.34   70.08   2.89   1.40

#iostat -d -p 2 2
Linux 2.6.9-22.EL (EDRSR24P1)   10/27/2006

Device:            tps   Blk_read/s   Blk_wrtn/s   Blk_read   Blk_wrtn
hda               4.84        49.08        83.93   59993375  102593945
hda1              0.02         0.01         0.00      15083       5179
hda2              0.00         0.00         0.00       1595         70
hda3              0.59         2.30         2.40    2806293    2932664
hda5             12.60        46.77        81.52   57168926   99656032
```

As you can see in the above example, `hda5` is the only partition that is really affecting system performance.

Measuring I/O with `sar`

`sar –b` shows transfer rate as `tps`. The transfers are broken down into read/write with `rtps/wtps` showing the number of requests per second and `bread/s` and `bwrtn/s` showing the number of data blocks per second.

`sar –d` shows transfer rates and blocks per second per device.

```
# sar -d 2 2
02:57:44 PM       DEV       tps    blks/s
02:57:46 PM    dev3-0      6.50     96.00

02:57:46 PM       DEV       tps    blks/s
02:57:48 PM    dev3-0      1.50    112.00

Average:          DEV       tps    blks/s
Average:       dev3-0      4.00    104.00
```

Remember that `sar` can show history information for up to one month in the past, so this tool allows you to easily compare current rates with historical figures.

Measuring I/O with `vmstat`

`vmstat` provides information on overall I/O throughput.

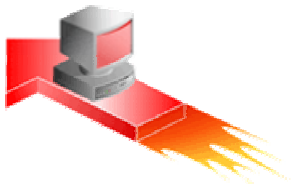
- **bo:** Blocks sent to the storage array (write)
- **bi:** Blocks received from the storage array (read)

```
# vmstat 3 3
  procs                      memory    swap       io     system       cpu
r  b  w   swpd   free   buff  cache  si  so   bi  bo   in   cs  us  sy  id
1  0  0 424800  12540  84636 376516   0   0   10  58    3   31  12   5  24
2  0  0 424800  12536  84636 376516   0   0    0  11  107  451   1   0  99
3  0  0 424800  12536  84636 376516   0   0    0  56  110  451   1   0  99
```

Interpreting I/O Measurements

Look for changes from baseline measurements, especially in queue size or wait times:

- **High volume or queue size across multiple devices**
- **High volume or queue size for one device**
- **High wait times without corresponding high queue sizes**



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Interpreting I/O Measurements

Like memory measurements, the key to using I/O statistics is measurement over a period of time. Take periodic measurements of I/O volume and speed so that when performance degrades, you can identify probable problem devices.

High Request Volume or Queue Size Overall

This indicates that the I/O devices are unable to handle the rate of I/O requests. This means that there are either not enough channels to I/O devices or that existing channels are too slow.

High Request Volume or Queue Size for One Device

It indicates that I/O may not be properly balanced across available devices.

High Wait Times

If wait times are high and queue size is not, verify whether asynchronous I/O is being used if the storage arrays supports it. If not, ensure that I/O slaves are in use. This may also be indicative of hardware problems.

Reducing I/O Bottlenecks

To reduce I/O as a bottleneck:

- **Reduce the volume of I/O through application and memory tuning**
- **Increase I/O throughput by parallelizing I/O**
  - **Multiple disk controllers**
  - **Multiple disks**
  - **Multiple data bus adapters**
- **Select your hardware carefully, and build your storage arrays with performance in mind**
- **Separate redo, data, and index files**

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Reducing I/O Bottlenecks

A good rule of thumb is to tune the application and memory to reduce or eliminate I/O as much as possible. When this is accomplished, balance the remaining I/O across all the available drives and controllers. In general, the more disks and controllers you are working with, the greater your I/O performance can be.

Carefully consider how your storage arrays are built. If you mix drives with different performance characteristics, keep the fastest drives on a different bus than the slowest drives. The controller bus speed is limited to the speed of the slowest device. More data channels means more data bandwidth. Consider adding additional Host Bus Adapters (HBAs).

If you are using Redundant Arrays of Inexpensive Disks (RAID), choose hardware-based RAID over software-managed RAID. Software-managed RAID consumes CPU and memory resources and seldom performs as well as hardware-based RAID. Additionally, RAID 5 generally performs well for read operations, but poorly for write due to the parity calculations required. Try to minimize the number of stripe columns in RAID 5. More columns means more calculations to generate the parity bit.

Remember to place files with different requirements on different disks. For example, your redo log members should be placed on separate disks (away from data and control files) and should be on your *fastest* disks, bus, and controllers.

Summary

In this lesson, you should have learned how to:

- **Use Linux monitoring tools**
- **Interpret memory measurements**
- **Interpret I/O measurements**

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Practice 9 Overview: Using Linux Measurement Tools

This practice covers using:

- **`sar` to measure CPU loads**
- **`vmstat` to measure memory usage**
- **`iostat` to measure disk I/O loads**

Practice 9 Overview: Using Linux Measurement Tools

For detailed instructions on performing this practice, see Practice 9 in Appendix A.

10

Tuning Oracle on Linux

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Objectives

After completing this lesson, you should be able to do the following:

- **Tune supported file systems**
- **Configure initialization parameters**
- **Implement asynchronous input/output (I/O)**
- **Implement advanced memory management techniques**

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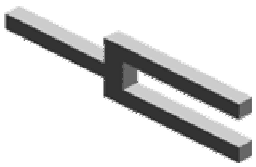
Basic Oracle Database Optimizations

- Use locally managed tablespaces (default).
- Use a larger database buffer cache (within reason).
- Use an appropriately sized database block.
- Use a larger redo log buffer.
- Use multiple database writer processes on Symmetric Multiprocessing (SMP) machines.
- Use Automatic Shared Memory Management.



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Basic Oracle Database Optimizations

Oracle Database has a set of well-known (but often overlooked) features that enhance performance.

Locally Managed Tablespaces

Locally Managed Tablespaces (LMT) are the default in Oracle Database 10*g*. Starting with Oracle9*i* Release 2, even the system tablespace may be locally managed. LMT reduces I/O by managing the extent allocation within a file with a bitmap in that data file instead of updating tables in the data dictionary. This decreases the I/O requirements for the system tablespace. Performance increases of 2% to 15% have been documented using LMT, depending on the application.

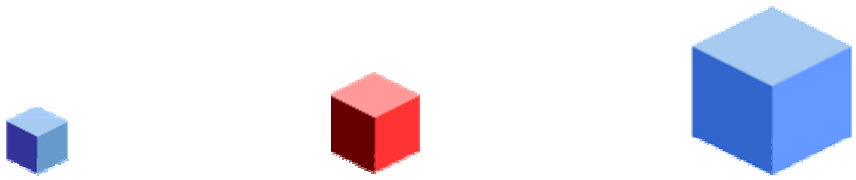
Larger Database Buffer Cache

The database instance caches the most recently used blocks in the database buffer cache. The larger the cache, the more data blocks can be cached. Because a disk access takes much longer than a memory access, each database block that can be cached and reused improves performance. Size the cache according to the `db_cache_advice` feature in Oracle Enterprise Manager. Do not make the cache so large that paging increases or (in extreme cases) it takes longer to search for a block in memory than it would have to just read the block from disk. Performance gains depend on the amount of reuse in the data blocks.

Sizing Database Blocks

The `DB_BLOCK_SIZE` parameter should be set according to the type of application:

- **8 KB block size gives good overall performance.**
- **Smaller blocks give better concurrency with OLTP applications.**
- **Larger blocks reduce the amount of overhead for data warehouse/decision support system (DW/DSS) applications.**



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Sizing Database Blocks

The size of the database block has a large impact on the performance of the application. Tests have shown that the best block size is usually 8 KB. The database block must always be the same size or a multiple of the memory page size. On Linux, the page size is 4 KB but (as discussed in the lesson titled “Linux Measurement Tools”) can be increased to 2 or 4 MB using hugepages.

The database block should also be the same size or a multiple of the file system block size. The block size on the `ext3` file system is 4 KB. Other file systems may use other block sizes.

OLTP Applications

An online transaction processing (OLTP) application is characterized by a large number of concurrent users and relatively small transactions. As the blocks get larger, the probability of two or more users requesting access to the same block simultaneously also increases. This leads to “buffer busy” waits, because only one process can access a block at a time. Smaller blocks reduce the number of rows in the block, which then reduces the likelihood of concurrent access. If your application has these characteristics, then consider setting `DB_BLOCK_SIZE` to 4 KB.

Sizing Database Blocks (continued)

DSS/DW Applications

Data warehouse–type applications are characterized by large data sets and frequent full table scans. Because the data sets are so large that the database buffer cache cannot hold the full set, the set must be read from disk. In this case, use the largest block size available (16 KB on 32-bit Linux). This reduces the percentage of space used by block headers, and increases the number of rows per block, thus reducing the number of I/Os by packing more data into the same number of bytes.

Effect of Block Size on Indexes

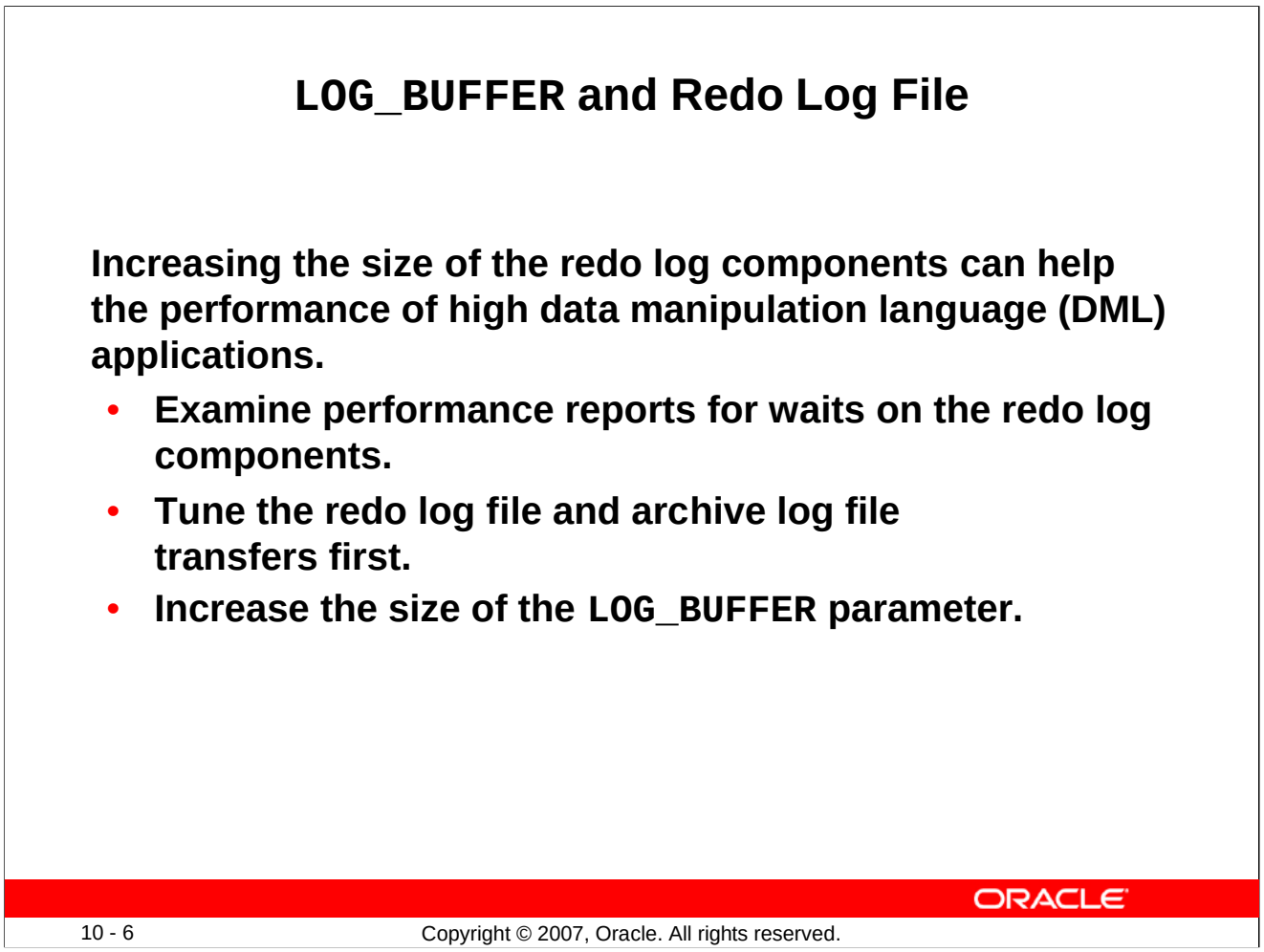
In databases with large tables and small database blocks, consider a very large OLTP application such as credit card processing. The indexes may get quite large. Index lookups are always done serially: first the root block is accessed, and then the first-level branch block is accessed. This process continues to the *n*-1 level branch, finally reaching the leaf block, which is the *n*th level. This lookup may require *n* I/Os for an *n*-level index, if the blocks needed are not already in the cache. Ideally, the index is no more than three levels deep, meaning *n* should be three or less.

In the following example, a 20-level index is chosen to simplify the mathematics. Realistically, an index would seldom get that large.

To illustrate the effect of the block size on an index, assume a 2 KB block size and a 20-level index. If this index were in a database with 4 KB block size, then each leaf would hold at least twice as many index row entries, so that half as many leaf blocks would be used. The first-level branch blocks would hold twice as many leaf pointers, but there would be only half as many leaf blocks, so the number of first-level branch blocks would be reduced to 1/4 of the original index.

Continuing with this exponential reduction in branches would reduce the number of levels to five. The first index required 20 reads for an index lookup, and the rebuilt index requires five reads. This significantly improves the performance of index lookups.

Because of this, you may want to use a larger block size if the application has very large indexes, or consider using partitioned indexes.



LOG_BUFFER and Redo Log File

Every DML statement produces some amount of redo information. This data must be written to the redo log files on commit. The server process does not report `Commit complete` to the user until the redo information has been written to the redo log file. When the current log file is full, a log file switch occurs.

If the `LGWR` process cannot write to the log files fast enough to clear space in the log buffer for other processes that are attempting to execute DML statements, then various wait statistics are incremented. For example, if there is no space in the log buffer at the time an attempt is made to write to it, there will be a `log buffer space` wait event. Increasing the size of the `LOG_BUFFER` can reduce or eliminate these waits. The minimum `LOG_BUFFER` size is 64 KB. An optimal setting for `LOG_BUFFER` varies with application. High-volume DML applications can benefit from a `LOG BUFFER` set to something higher than the default value.

LOG_BUFFER and Redo Log File (continued)

Sizing redo log files is dependent on the speed at which redo is generated. If the switch is delayed for any reason, the processes trying to write into the `LOG_BUFFER` have to wait, and a wait event `log file completion` is recorded. You want to eliminate these waits and at the same time, do not want to size the files so large that they become unmanageable. Redo log files in the range of tens to hundreds of megabytes are considered reasonable. A tentative guideline is to size them such that the log file switch occurs every 20 to 30 minutes. For details, refer to the *Oracle Database 10g: Performance Tuning* course and the *Oracle Database 10g Performance Tuning Guide*.

Advanced Features of Oracle Server

There are a few advanced initialization parameters that affect performance on Linux:

- **DB_WRITER_PROCESSES**
- **DBWR_IO_SLAVES**
- **PRE_PAGE_SGA**

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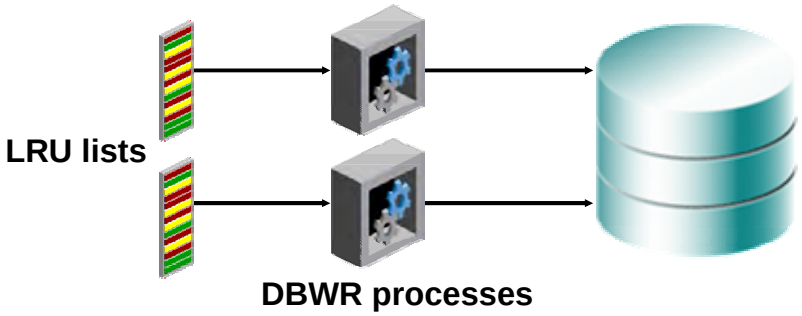
Advanced Features of Oracle Server

The parameters listed here are considered advanced parameters. Very few initialization parameters depend on the OS. The parameters listed in the slide are the ones that are most affected by the OS.

Multiple DBWR Processes

DB_WRITER_PROCESSES:

- **These processes are set to no more than CPU_COUNT, up to 20.**
- **Multiple DBWR processes write from LRU to disk.**
- **These processes can use asynchronous I/O.**
- **These processes are best used in OLTP environments.**



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Multiple DBWR Processes

In high-volume OLTP databases, the standard configuration of the DBWR process may not be able to write changed data blocks back to the disk fast enough to maintain the pool of free buffers for new blocks coming into the database buffer cache. The usual first step is to increase the DB_CACHE_SIZE, but this may not be enough.

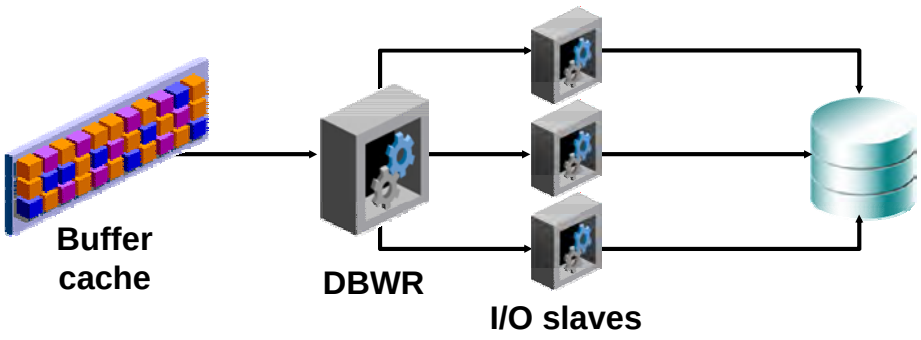
The next step is to increase the number of DB_WRITER_PROCESSES. This starts the specified number of DBWR processes. This can be up to 20 as of Oracle9*i*, Release 2. Each DBWR process handles one or more LRU lists moving dirty buffers to the disk for those lists. If asynchronous I/O is turned on, then all the DBWR processes make use of it.

The default value for DB_WRITER_PROCESSES is (CPU_COUNT+7)/8. For example, with between one and eight CPUs, DB_WRITER_PROCESSES is set to one. If your CPU_COUNT = 20, then DB_WRITER_PROCESSES is set to three. The value of DB_WRITER_PROCESSES must be adjusted incrementally. When increasing the number of DB_WRITER_PROCESSES, consider the number of disk controllers that are available and monitor the disk I/O queues. Too many DB_WRITERS_PROCESSES can cause contention for the controller channel.

DB Writer Slaves

DBWR_IO_SLAVES:

- **Used to simulate asynchronous I/O**
- **One DBWR, multiple writers to disk**



DB Writer Slaves

On systems without asynchronous I/O capability, the database instance provides a way to simulate asynchronous I/O with the DBWR_IO_SLAVES.

Set this parameter to no more than two times the number of disks that the database is spread across. When increasing DBWR_IO_SLAVES, consider the number of disk controllers and monitor the disk I/O queues for contention. Also, when increasing the number of slaves, add only a few at a time, because each of these processes has an overhead cost. If you add too many at once, the overhead of all the processes may outweigh the benefit of the additional processes. Each slave must have a communication area for I/O buffers. This area is taken from the large pool if it is configured, or from the shared pool if the large pool does not exist. Turning on DBWR_IO_SLAVES forces DB_WRITER_PROCESSES to one, and sets the number of slave processes used by the ARCH and LGWR processes to four. Even though I/O slaves are generally used to simulate asynchronous I/O, the slaves use asynchronous I/O if it is turned on.

Note: The use of multiple DBWR processes and I/O slaves are mutually exclusive.

Changing SGA Behavior

- **Normally, unused memory allocated to the System Global Area (SGA) is not mapped to the physical memory until it is used, and infrequently used pages are paged out.**
- **To touch all the SGA at startup, use PRE_PAGE_SGA:**
  - **The SGA is mapped to physical memory.**
  - **The SGA could slow connection processing.**

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Changing SGA Behavior

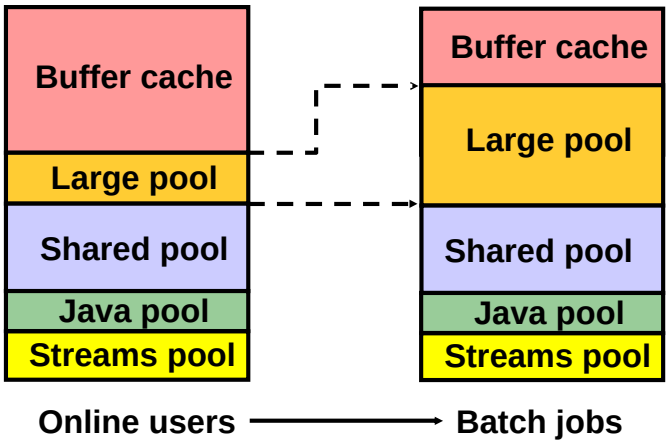
The normal behavior is that shared memory up to SGA_MAX_SIZE is allocated and set up in virtual memory at startup. Unused pages in the SGA are not mapped to physical memory until they are used, and pages in the SGA that are not frequently used may be paged out.

The PRE_PAGE_SGA initialization parameter causes each server process that starts to touch every page of the SGA. This has the advantage of mapping all the SGA pages to physical memory, so that when they are required later, they will be already mapped. The disadvantage is that with large number of pages, each server process that starts touches all the pages, thus increasing the connection time. If some pages are swapped out, those pages have to be swapped in for the touch. This in turn may force other more active pages to swap, further reducing performance. Set PRE_PAGE_SGA = `true` only when there is sufficient real memory to hold the entire SGA.

Automatic Shared Memory Management

- Automatically adapts to workload changes
- Maximizes memory utilization
- Helps eliminate out-of-memory errors

Example:



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Automatic Shared Memory Management

Automatic Shared Memory Management (ASMM) is another key self-management enhancement in the Oracle database. This functionality automates the management of the most important shared memory structures used by an Oracle database instance, and relieves you of having to configure these components manually. Besides making more effective use of available memory and thereby reducing the cost incurred for acquiring additional hardware memory resources, the ASMM feature significantly simplifies Oracle database administration by introducing a more dynamic, flexible, and adaptive memory management scheme.

For example, in a system that runs large online transactional processing (OLTP) jobs during the day (requiring a large buffer cache) and runs parallel batch jobs at night (requiring a large value for the large pool), you would have to simultaneously configure both the buffer cache and the large pool to accommodate your peak requirements.

With ASMM, when the OLTP job runs, the buffer cache grabs most of the memory to allow for good I/O performance. When the data analysis and reporting batch job starts up later, the memory is automatically migrated to the large pool so that it can be used by parallel query operations without producing memory overflow errors.

Basic Linux Optimizations

Basic changes to the Linux default setup can give some performance improvements.

- **Use the latest supported kernel.**
- **Turn off last time-read updates for the database files.**

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Basic Linux Optimizations

Apply the latest supported kernel patches through the `.rpm` files provided by the distribution vendor. This ensures that you are using the most efficient kernel available.

By default, the last time-read attribute (`atime`) is updated every time a file is read. For database files, this is not an important statistic and you can turn it off to reduce the number of I/Os. This parameter can be set for a file with `chattr +A <filename>` or for a directory with `chattr -R +A <directory name>`. To make this change persistent across reboots, change it for a file system by changing the `/etc/fstab` file and adding the `noatime` option to the fourth column.

```
/dev/hdb7      /u3/app/oracle/    ext3    rw,noatime  1 1
```

Choosing a Kernel

Choose the appropriate kernel for best performance:

- **If you have more than 4 GB of physical memory, then use the `enterprise` or `hugemem` kernel.**
- **If you have more than one CPU, then use the `smp` kernel.**
- **Otherwise, use the `uniprocessor` kernel.**

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Choosing a Kernel

The Linux installers tend to make good choices about which kernel to install, and install the kernel that uses your hardware and gives a good performance. If you have to choose which kernel to use, follow these guidelines.

For machines with more than 4 GB of physical memory, an `enterprise` kernel is required. The `enterprise` kernel includes the Physical Address Extensions (PAE) that are required to address more than 4 GB of physical memory. This includes a three-level memory page table, so if you have less than 4 GB of physical RAM, then the three-level page table is an extra overhead that is not required.

For multiprocessor machines, the installer chooses an `smp` kernel. The `smp` kernel has the required extensions to handle scheduling processes on more than one CPU.

The uniprocessor kernel handles up to 4 GB of physical memory on a single processor. An example of the uniprocessor name is 2.4.9-e.3. (Note that there is no special designator.)

An `enterprise` or `smp` kernel may be used on a uniprocessor machine, but has extra overhead associated with the unused features.

Summary

In this lesson, you should have learned how to:

- **Evaluate file systems**
- **Tune supported file systems**
- **Configure initialization parameters**
- **Implement asynchronous input/output (I/O)**
- **Implement advanced memory management techniques**

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Practice 10 Overview: Tuning Performance

This practice covers the following topics:

- **Adjusting the block size of database objects**
- **Identifying poorly performing sessions at the operating system level**

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Dedugging Oracle on Linux

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Objectives

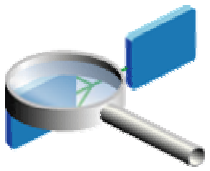
After completing this lesson, you should be able to:

- **Install and configure OS Watcher**
- **Use Oracle Support's Remote Diagnostics Agent**
- **Trace programs and processes with strace**
- **Gather required information for resolving ORA-600 and ORA-7445 errrors**

OS Watcher

OS Watcher (OSW) is a set of scripts that continually run in the background, collecting information about:

- **Processes**
- **I/O**
- **Memory**
- **Network**



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OS Watcher

OS Watcher (OSW) is a collection of shell scripts intended to collect and archive operating system and network metrics to aid support of generic performance issues. OSW operates as a set of background processes on the server and gathers OS data on a regular basis, invoking such utilities as `vmstat`, `netstat` and `iostat`.

Note: For more details, refer to the OS Watcher user's guide in MetaLink note 301137.1. The MetaLink note contains the link for downloading OS Watcher.

Installing OSW

```
$ tar -xf osw.tar
$ cd osw
$ ls -gG
total 56
drwxr-xr-x  11  4096 Sep 30 13:50 archive
-rwxr-xr-x   1  1731 Mar 29  2005 Exampleprivate.net
-rwxr-xr-x   1  4451 Apr  5  2005 OSWatcherFM.sh
-rwxr-xr-x   1 10231 Aug  2  2005 OSWatcher.sh
-rwxr-xr-x   1   334 Mar 28  2005 oswnet.sh
-rwxr-xr-x   1   401 Mar 21  2005 oswsub.sh
-rw-r--r--   1  3029 Mar 22  2005 README
-rwxr-xr-x   1  1101 Mar 18  2005 startOSW.sh
-rwxr-xr-x   1   560 Dec 16  2004 stopOSW.sh
-rwxr-xr-x   1    57 Jun 14  2005 tarupfiles.sh
-rwxr-xr-x   1   409 Mar 18  2005 topaix.sh
```

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Installing OSWatcher

Installation is very simple. Untar the `osw.tar` file, which creates the directory structure under the current directory. The parent directory of all the extracted files is called `osw`. At that point, the software is installed.

Configuring OSW

Configure OSW by changing the command that it runs, which are stored in the `OSWatcher.sh` file:

```
###########################################################
# CONFIGURATION  Determine Host Platform
###########################################################
case $PLATFORM in
  Linux)
    IOSTAT='iostat -x 1 3'
    VMSTAT='vmstat 1 3'
    TOP='eval top -b -n 1 | head -50'
    PSELF='ps -elf'
    MPSTAT='mpstat 1 3'
    MEMINFO='cat /proc/meminfo'
    SLABINFO='cat /proc/slabinfo'
```

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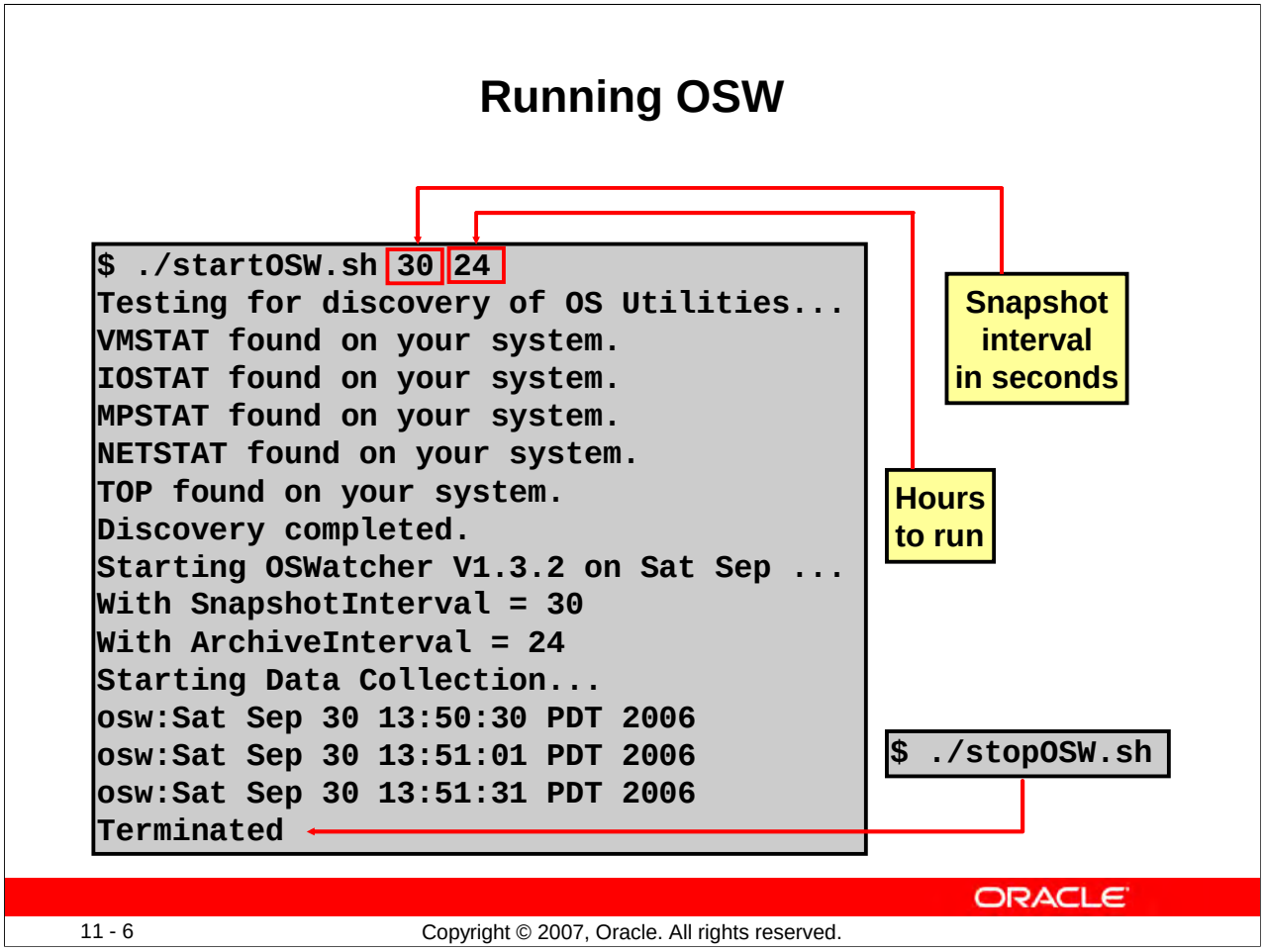
Configuring OSW

OSWatcher can be configured by editing the `CONFIGURATION` section of the `OSWatcher.sh` script. Here, the commands, along with their arguments, are listed. You can edit these here to cause the behavior and output of the commands to change. The default setting for the Linux platform is shown in the slide.

For example, the output from `iostat` with the `-x` option, as shown above, shows the statistics of the hard drive but not the partitions. You could change the `-x` option to `-p /dev/hda` and the output would show the individual partitions.



Running OSW

To run OSW, simply invoke the `startOSW.sh` script:

```
startOSW.sh <snapshot_interval> <hours>
```

where the *snapshot_interval* is the number of seconds there should be between each data sample, and *hours* is the number of hours for which to collect data. Even if the number of hours has not been reached, you can run the `stopOSW.sh` script to stop it at any time.

In the example in the slide, data is being sampled every 30 seconds, and the script will run for 24 hours. But, after three samples have been taken (90 seconds have passed) the `stopOSW.sh` script is run to stop the data collection.

Viewing OSW Output

The archive subdirectory contains the output of an OSW execution, categorized into directories related to each command that runs.

```
$ ls
oswiostat oswmpstat  oswprvtnet oswslabinfo oswvmstat
oswmeminfo oswnetstat oswps oswtop
$ head -4 oswmeminfo/EDRSR9P1_meminfo_09.30.06.1300.dat
zzz ***Sat Sep 30 13:50:31 PDT 2006
MemTotal:      1035320 kB
MemFree:        451920 kB
Buffers:          1020 kB
```

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Viewing OSW Output

The only directory immediately under the `osw` installation directory is called `archive`. That is where all output is stored. In that directory is a subdirectory for each command that is being repeatedly run during the session. The subdirectory names are made up by prepending the string "`osw`" to the command name. They are:

- `oswiostat`
- `oswmeminfo`
- `oswmpstat`
- `oswnetstat`
- `oswprvtnet`
- `oswps`
- `oswslabinfo`
- `oswtop`
- `Oswvmstat`

Under each of those directories are the files that contain the collected data. The names of those files follow this pattern for organizational purposes:

```
<hostname>_<command>_<timestamp>.dat
```

Remote Diagnostics Agent

The Remote Diagnostics Agent (RDA) is a tool you can run on your database server that gathers information relevant to:

- **Performance issues**
- **Installation/configuration issues**
- **ORA-600, ORA-7445, and ORA-3113 errors**
- **Upgrade, migration, and linking issues**



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Remote Diagnostics Agent (RDA)

The Remote Diagnostics Agent is a tool that you can use to gather comprehensive information about your database server, including Linux parameters, database settings, and network information, and so on. This information is compiled into HTML, and so is easily browseable by category.

The output is written in the form of HTML files, which are also collected into a single ZIP file. This makes it easy to send the information to Oracle Support for analysis. It is also a good way for you to see a summary of your entire system.

Note: See MetaLink Note 314422.1 for details on downloading, installing, and running the RDA.

Installing the RDA

```
$ gunzip rda_4.5-060912.tar.gz
$ tar -xf rda_4.5-060912.tar
$ cd rda
$ ls -gG
total 112
-r--r--r--  1  4087 Jul  6 01:58 DISCLAIM.txt
drwxr-xr-x  2  4096 Sep 30 12:07 hcve
drwxr-xr-x  2  4096 Sep 30 12:07 modules
drwxr-xr-x  4  4096 Sep 30 12:07 RDA
-r-xr-xr-x  1  3415 Apr 25 05:50 rda.cmd
-r-xr-xr-x  1 40066 Sep  8 08:03 rda.pl
-r-xr-xr-x  1  3442 Apr 25 05:50 rda.sh
-r--r--r--  1 13103 Aug  4 06:41 README_Unix.txt
-r--r--r--  1 14539 Aug  4 06:41 README_VMS.txt
-r--r--r--  1 13101 Aug  4 06:41 README_Windows.txt
```

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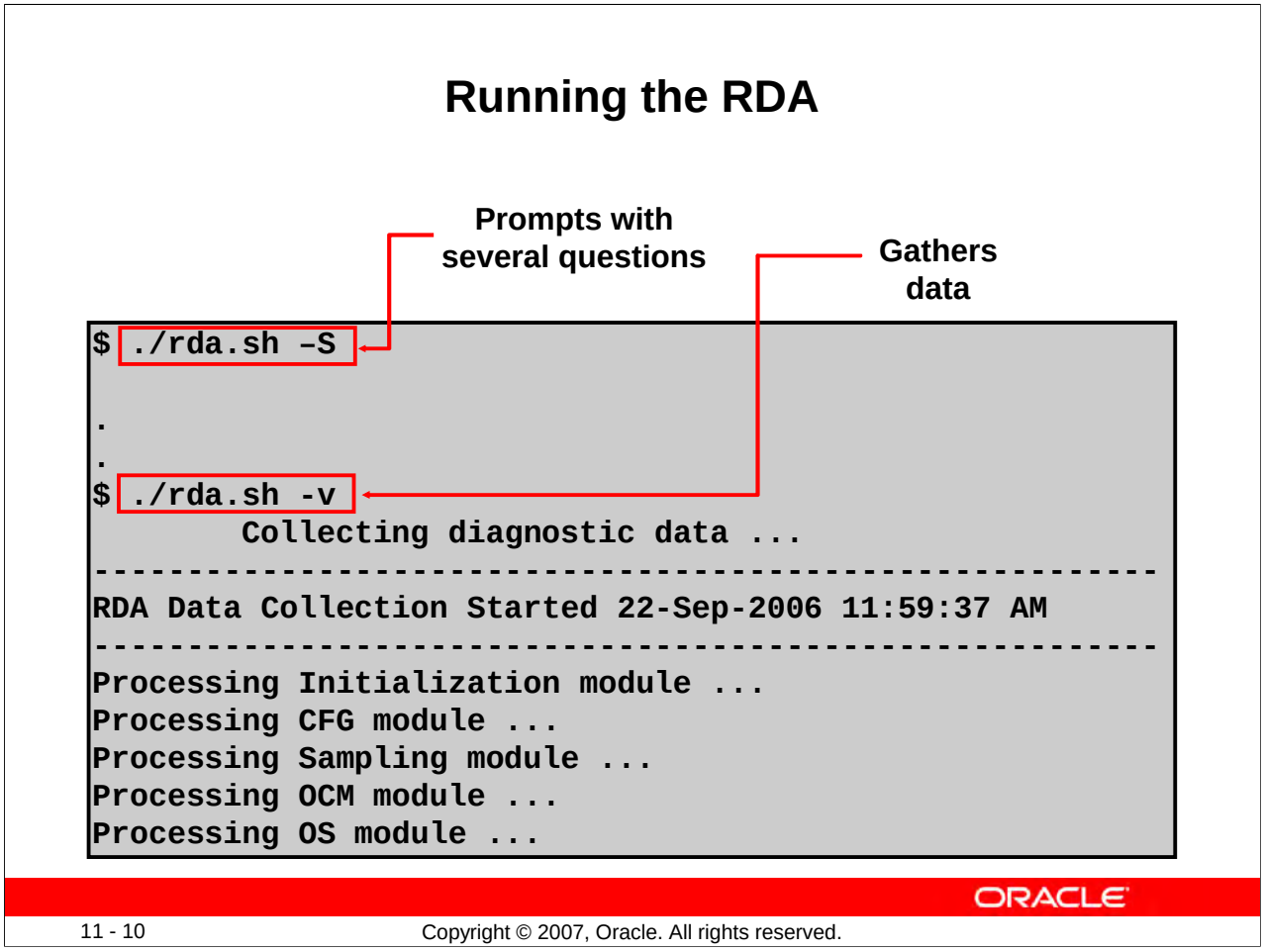
Installing the RDA

Installation is very simple. Extract the `gzip` file using gunzip, and then untar the extracted tar file, which creates the directory structure under the current directory. The parent directory of all the extracted files is called `rda`. At that point, the software is installed; there is no need to run an installation script.



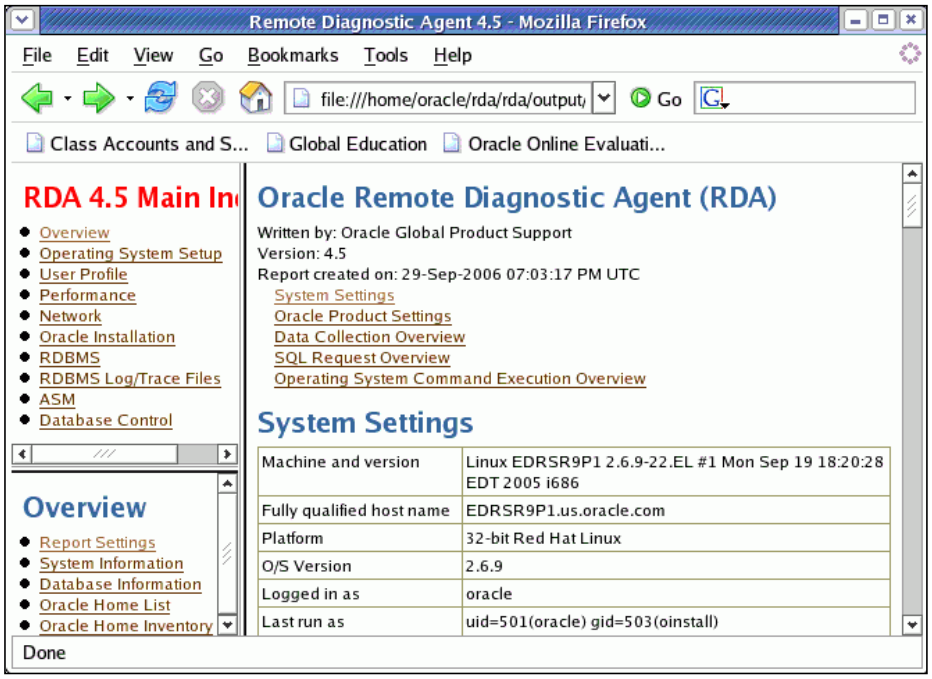
Running the RDA

There are two steps involved in running the RDA:

1. **Setup:** Run the `rda.sh` script with the `-S` parameter to perform the setup. This prompts you for information about your installation including Oracle home directories, ASM instance information, and location of certain files such as the initialization file.
2. **Gather data:** This step actually collects the data about your system. As each area (referred to as `module`) is interrogated, the name is output on the command line.

Note: Root cannot connect to a database as "/ as sysdba." When running `rda.sh` as the root OS user, choose a different schema for connecting to the database.

Viewing the RDA Output



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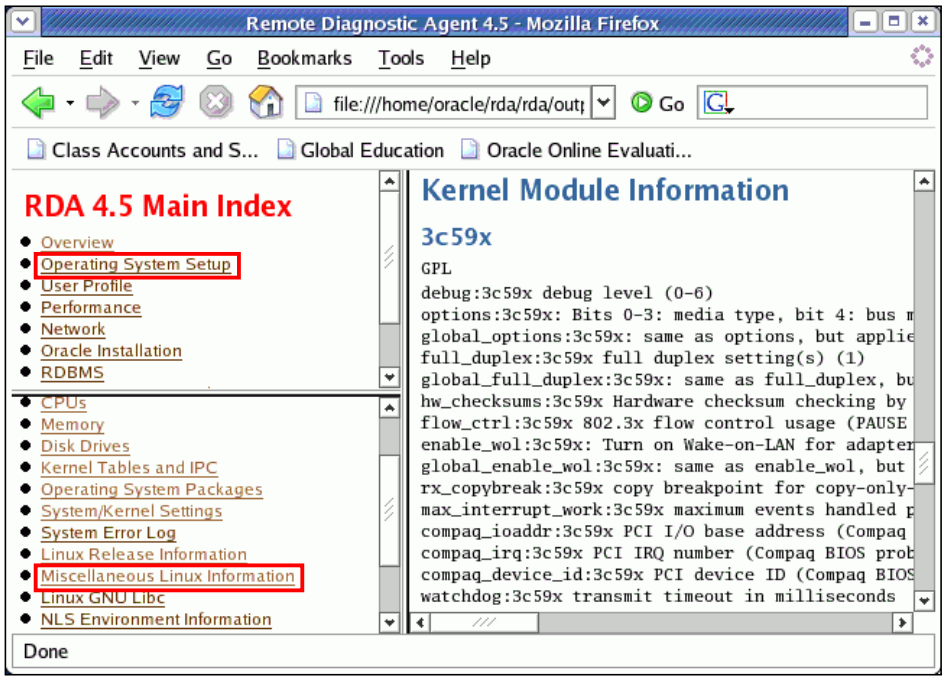
Viewing the RDA Output

Run a browser, and open the file that is referenced at the end of the data collection run. That displays the main page, an example of which is shown in the slide. There are frames to easily navigate to the various categories of information.

Navigating the RDA Output



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Navigating the RDA Output

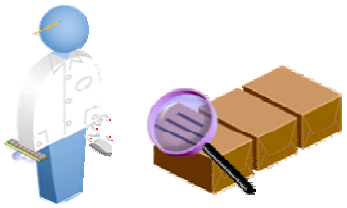
In the example in the slide, you see that you can choose to look at the Operating System Setup, and then choose Miscellaneous Linux Information.

strace

- Diagnostic utility
- Records system calls
- Trace a specified command
- Trace an existing process

```
$ strace –aef –Ttt –o /tmp/date.out date
```

```
$ strace –p 1287 –o /tmp/ora_pmon_orcl.out
```



strace

Strace is a utility that intercepts and records the system calls, which are called by a process, and the signals, which are received by a process. The name of each system call, its arguments and its return value are printed on standard error or to the file specified with the -o option.

strace can trace running background processes or be used when executing a program.

Using a simple shell script, you can see a sample of the output from strace. Script `helloworld.sh` invokes a bash shell, echoes “Hello World!,” and then exits.

`helloworld.sh` shell script:

```
#!/bin/bash
echo “Hello World!”
exit 0
```

The shell script is executed using `strace`:

```
strace –o /tmp/helloworld.out ./helloworld.sh
```

`strace` (continued)

The full output of the trace is 102 lines. The listing below contains the last few lines of the trace.

```
.
.
.
open("./helloworld.sh", O_RDONLY|O_LARGEFILE) = 3
ioctl(3, SNDCTL_TMR_TIMEBASE or TCGETS, 0xbffb28c8) = -1 ENOTTY
(Inappropriate ioctl for device)
_llseek(3, 0, [0], SEEK_CUR)            = 0
read(3, "#!/bin/bash\necho \"Hello World!\"\n"..., 80) = 39
_llseek(3, 0, [0], SEEK_SET)            = 0
getrlimit(RLIMIT_NOFILE, {rlim_cur=64*1024, rlim_max=64*1024}) = 0
dup2(3, 255)                            = 255
close(3)                                = 0
fcntl64(255, F_SETFD, FD_CLOEXEC)       = 0
fcntl64(255, F_GETFL)                   = 0x8000 (flags
O_RDONLY|O_LARGEFILE)
fstat64(255, {st_mode=S_IFREG|0755, st_size=39, ...}) = 0
_llseek(255, 0, [0], SEEK_CUR)          = 0
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
read(255, "#!/bin/bash\necho \"Hello World!\"\n"..., 39) = 39
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
fstat64(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(136, 5), ...}) = 0
mmap2(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0xb7de3000
write(1, "Hello World!\n", 13)          = 13
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
munmap(0xb7de3000, 4096)                = 0
exit_group(0)                           = ?
```

ORA-600 Errors

Alert log entry:

```
Tue Oct  3 05:13:08 2006
Errors in file
   /u01/app/oracle/admin/orcl/udump/orcl_ora_18464.trc:
ORA-00600: internal error code, arguments: [kcfrbd_3],
   [1], [3932239], [1], [62720], [62721], [], []
```

ORA-600

ORA-600 errors are raised from the kernel code of the Oracle Database software when an internal inconsistency is detected or an unexpected condition is met. This situation is not necessarily a bug, it might be caused by problems with the operating system, lack of resources, hardware failures, or other conditions.

With the ORA-600 error comes a list of arguments in square brackets. The first of these arguments tells us from where in the code the error was caught and thus is the key information in identifying the problem. This argument is either a number or a character string. The remaining arguments are used to supply further information such as values of internal variables.

When an ORA-600 error is raised a trace file is generated in either USER_DUMP_DEST or BACKGROUND_DUMP_DEST depending on whether the error was caught in a user or a background process. The error is also written in the alert log with the name of the trace file. The trace file contains vital information about what led to the error condition.

ORA-7445 Errors

Alert log entry:

```
Tue Oct  3 05:26:06 2006
Errors in file
   /u01/app/oracle/admin/orcl/udump/orcl_ora_18732.trc:
ORA-07445: exception encountered: core dump [0046A7A2]
   [SIGSEGV] [unknown code] [0x4A49] [] []
```

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ORA-7445 Error

An ORA-7445 error is raised by an Oracle server process when it has received a fatal signal from the operating system. The error may be raised in either a foreground or background process. The process will normally write an error to the alert log, write a trace file in either `USER_DUMP_DEST` or `BACKGROUND_DUMP_DEST`, and create a core dump in `CORE_DUMP_DEST`.

There are many “illegal” operations the operating system can trap; a common example is a process writing to an invalid memory location. To protect the system, the offending process will be sent a fatal signal. Typically, the signals seen are SIGBUS (signal 10, bus error) and SIGSEGV (signal 11, segmentation violation).

There are other Linux signals and exceptions that may happen; however, those are likely caused by an OS program rather than a problem in the Oracle database.

Examples of other signals are SIGINT, SIGKILL, and SIGSYS.

An ORA-7445 is a generic error, and can occur from anywhere in the Oracle code. The precise location of the error is identified by the trace file it produces.

Resolving ORA-600/ORA-7445 Errors

File a service request with Oracle Support providing:

- **The database alert log located in `BACKGROUND_DUMP_DEST`**
- **The trace file mentioned in the alert log**
- **Recent changes to the system environment**
  - **Hardware modifications**
  - **Operating system upgrades**
  - **Restore of data files**
  - **Power failures**
- **Data generated by RDA**

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Resolving ORA-600/ORA-7445 Errors

Unless you are able to identify the cause and possible fix for an ORA-600 error using the references mentioned below, it should be considered as a potentially serious issue and reported to Oracle Support for identification.

Every ORA-600 and ORA-7445 error generates a trace file. The name and location of the trace file is also written to `alert.log`. To help Oracle Support determine what caused the error, you should open a service request and supply the following information:

- The database alert log located in `BACKGROUND_DUMP_DEST`
- The trace file mentioned in the alert log
- Recent changes to the system environment:
  - Hardware modifications
  - Operating system upgrades
  - Restore of data files
  - Power failures
- Data generated by the Remote Diagnostic Agent

The trace file generated contains a call stack trace. A call stack trace or stack trace is the list of routine calls, with the most recently called routine at the top of the list. The stack trace in the trace file is a small portion of the trace starting with the header “Call Stack Trace.”

Resolving ORA-600/ORA-7445 Errors (continued)

Trace file stack trace:

```
----- Call Stack Trace -----
calling             call entry           argument values in hex
location            type point           (? means dubious value)
------------------- ---- --------------- ----------------------------
ksedst()+27         call ksedst1()       0 ? 1 ?
ksedmp()+557        call ksedst()        0 ? 0 ? 0 ? 0 ? 0 ? 0 ?
ksfdmp()+19         call ksedmp()        3 ? BFFFADD0 ? AC05C15 ?
                                         CBC2A40 ? 3 ? CB740C0 ?
kgerinv()+177       call 00000000        CBC2A40 ? 3 ?
kgesinv()+52        call kgerinv()       CBC2A40 ? B72A0020 ?
                                         C50DAE0 ? 5 ? BFFFAE34 ?
ksesin()+46         call kgesinv()       CBC2A40 ? B72A0020 ?
                                         C50DAE0 ? 5 ? BFFFAE34 ?
                                         C50DAE0 ? 5 ? BFFFAE34 ?
kcfrbd()+444        call ksesin()        C50DAE0 ? 5 ? 0 ? 1 ? 0 ? 0 ?
kco_blkchk()+815    call kcfrbd()        2 ? BFFFAED4 ? 1 ? 3C004F ?
1 ? 0 ?
kcb_blkchk()+247    call kco_blkchk()    291A37A4 ? 24580000 ? 0 ?
                                         2000 ? 0 ?
kcb_apply()+870     call kcb_blkchk()    291A37A4 ? 247EE40C ? 0 ?
ktichg_noundo()+770 call kcb_apply()     BFFFB014 ? BFFFB02C ? 0 ? 1 ?
                                         29166220 ? 0 ? 292C95D0 ? 0 ?
ktbchgro()+351      call ktichg_noundo() 29166220 ? 0 ? 1 ? BFFFB02C ?
BFFFB014 ? 291A37A4 ?
ktsfbfmt()+808      call ktbchgro()      0 ? 1 ? CC0F4A4 ? 291A37A4 ?
```

Copy the call stack trace from the trace file into the service request filed with Oracle Support. Doing so will assist Support in resolving the issue.

Summary

In this lesson, you should have learned how to:

- **Use OS Watcher**
- **Use the Oracle Support's Remote Diagnostics Agent**
- **Trace programs and processes with strace**
- **Gather information for resolving ORA-600 and ORA-7445 errors**

Practice 11 Overview: Debugging Oracle on Linux

This practice covers the following topics:

- **Installing and configuring OS Watcher**
- **Gathering OS and database information using RDA**
- **Tracing programs and processes using strace**
- **Forcing ORA-600 and ORA-7445 errors, and then gathering the needed information for Oracle Support**