

10

Managing Database Storage Structures

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Objectives

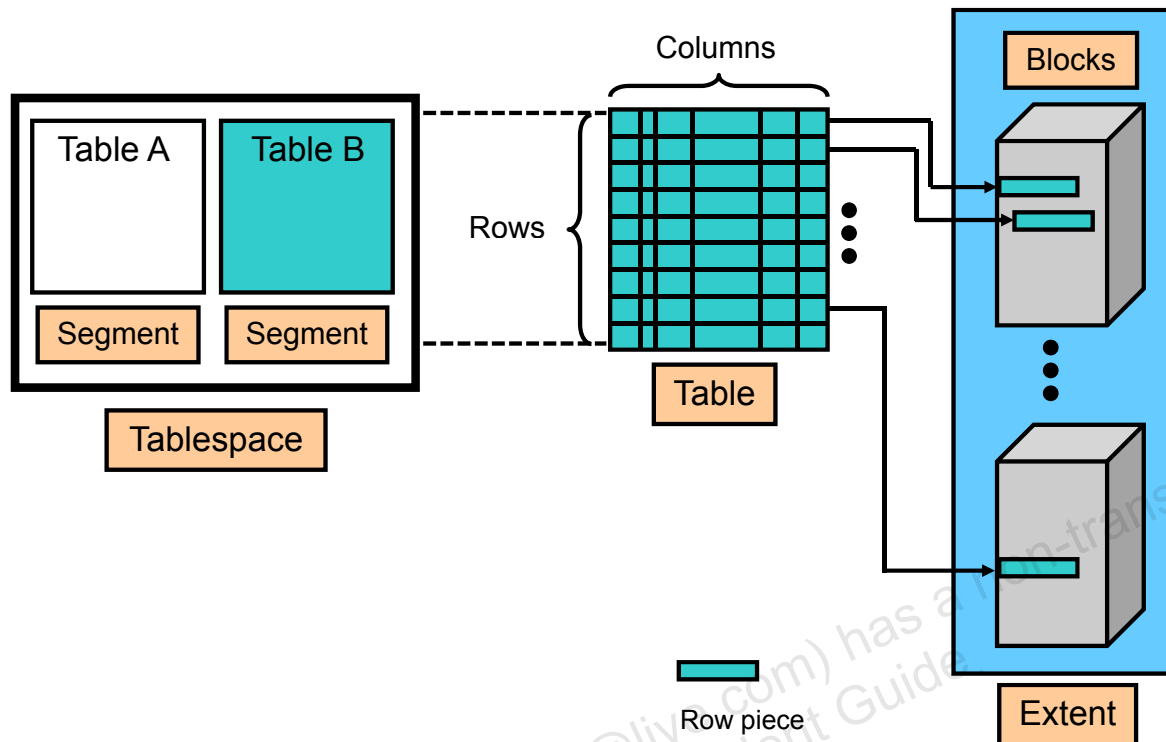
After completing this lesson, you should be able to:

- Describe the storage of table row data in blocks
- Create and manage tablespaces
- Obtain tablespace information

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How Table Data Is Stored



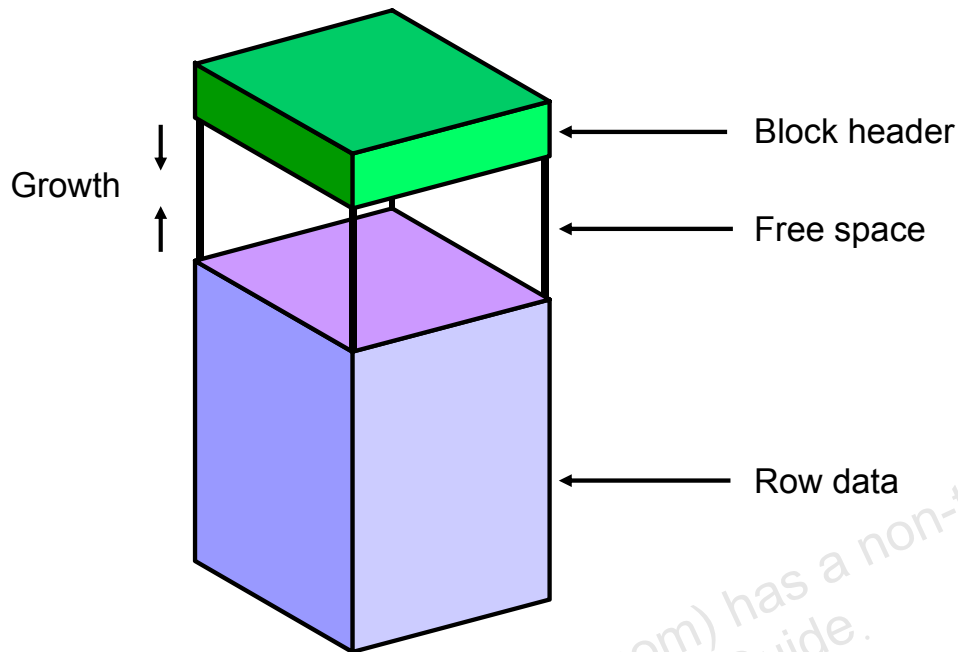
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When a table is created, a segment is created to hold its data. A tablespace contains a collection of segments.

Logically, a table contains rows of column values. A row is ultimately stored in a database block in the form of a row piece. It is called a row piece because, under some circumstances, the entire row may not be stored in one place. This happens when an inserted row is too large to fit into a single block (chained row) or when an update causes an existing row to outgrow the available free space of the current block (migrated row). Row pieces are also used when a table has more than 255 columns. In this case the pieces may be in the same block (intra-block chaining) or across multiple blocks.

Database Block: Contents



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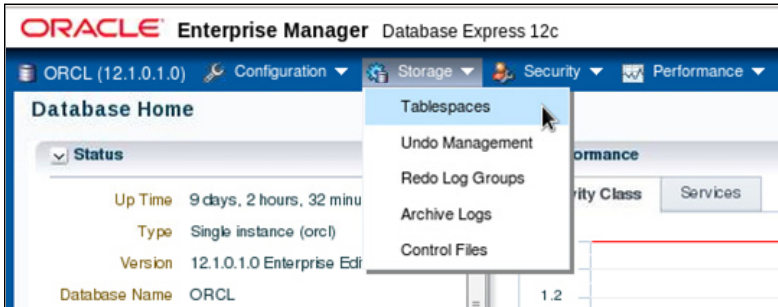
- **Block header:** The block header contains the segment type (such as table or index), data block address, table directory, row directory, and transaction slots of approximately 23 bytes each, which are used when modifications are made to rows in the block. The block header grows downward from the top.
- **Row data:** This is the actual data for the rows in the block. Row data space grows upward from the bottom.
- **Free space:** Free space is in the middle of the block, enabling the header and the row data space to grow when necessary. Row data takes up free space as new rows are inserted or as columns of existing rows are updated with larger values.

Examples of events that cause header growth:

- Row directories that need more row entries
- More transaction slots required than initially configured

Initially, the free space in a block is contiguous. However, deletions and updates may fragment the free space in the block. The free space in the block is coalesced by the Oracle server when necessary.

Exploring the Storage Structure



The screenshot shows the 'Tablespaces' page in Oracle Enterprise Manager Database Express 12c. The page displays a table of database tablespaces with columns for Name, Size, Free Space, Used (%), Auto..., Max..., Status, Type, Group..., Auto..., and Directory. The table lists several tablespaces: EXAMPLE, SYSAUX, SYSTEM, TEMP, UNDOTBS1, and USERS.

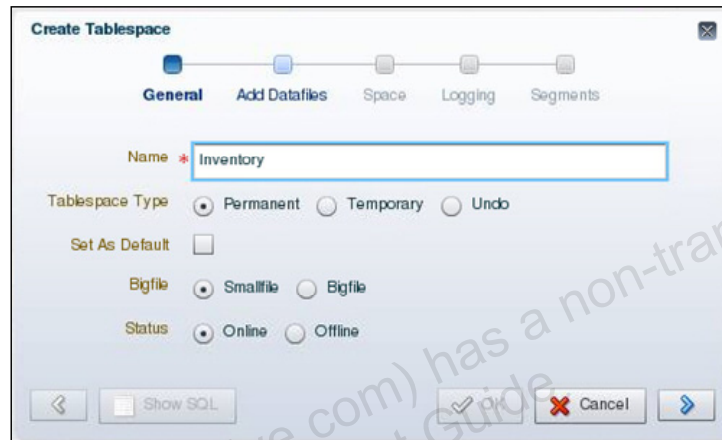
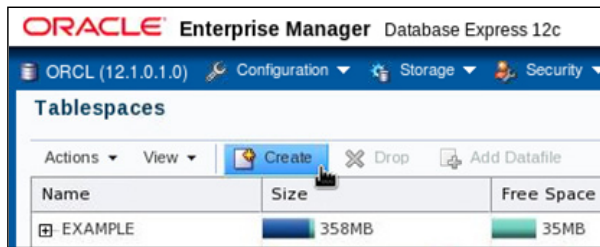
Name	Size	Free Space	Used (%)	Auto...	Max...	Status	Type	Group ...	Auto...	Directory
EXAMPLE	358MB	35MB	90.2	✓	Unlimit	●	FILE		✓	/u01/app/oracle/oradata/...
SYSAUX	1GB	55MB	95	✓	Unlimit	●	FILE		✓	/u01/app/oracle/oradata/...
SYSTEM	800MB	6MB	99.3	✓	Unlimit	●	FILE		✓	/u01/app/oracle/oradata/...
TEMP	103MB	102MB	1	✓	Unlimit	●	FILE		✓	/u01/app/oracle/oradata/...
UNDOTBS1	150MB	137MB	8.9	✓	Unlimit	●	FILE		✓	/u01/app/oracle/oradata/...
USERS	5MB	3MB	33.8	✓	Unlimit	●	FILE		✓	/u01/app/oracle/oradata/...

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You can easily view the storage structures of your database through Enterprise Manager Database Express. Detailed information about each structure can be obtained by selecting the structure in the Storage menu.

Creating a New Tablespace



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1. Expand the Storage menu and then select Tablespaces.
2. Click Create.
3. Enter a name for the tablespace.
4. In the Tablespace Type field, select Permanent.
Permanent tablespaces store permanent database objects that are created by the system or users.
5. In the Bigfile field, select Smallfile. Bigfile tablespaces are used with extremely large databases, in which ASM or other logical volume managers support the striping or redundant array of independent disks (RAID) and dynamically extensible logical volumes.
6. In the Status field, select Online.
Online means that users can read and write to the tablespace after it is created. This is the default.
7. Click the blue arrow to add data files to the tablespace.

Creating a New Tablespace

Create Tablespace

General Add Datafiles Space Logging Segments

Using Oracle-Managed Files ☒ ⓘ

Datafiles * /u01/app/oracle/oradata/orcl/inventory01.dbf + X

File Name
/u01/app/oracle/oradata/orcl/inventory01.d

File Size * 100M ⓘ

Reuse Existing File ☐

Auto Extend ☒ ⓘ

Increment 100M

Maximum File Size Unlimited

⏪ Show SQL OK Cancel ⏩

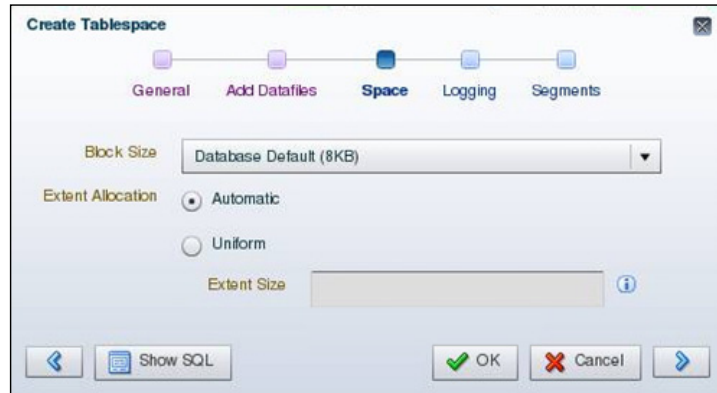
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A tablespace must have at least one file.

8. On the Add Datafiles page, enter a file directory and file name for the data file.
9. Enter the desired file size.
10. Select “Auto Extend” to automatically extend the data file when it is full and specify an increment amount in the Increment field. This causes the data file to extend automatically each time it runs out of space. It is limited, of course, by the physical media on which it resides. Leave Maximum File Size as Unlimited or enter a maximum size.
11. Click the blue arrow to continue.

Creating a New Tablespace



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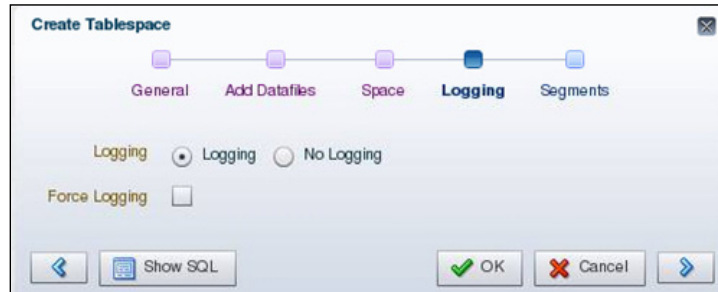
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Block Size: This field shows the block size that is used for the tablespace being created.

Extent Allocation: The extents can be allocated in one of the following two ways:

- **Automatic:** Also called autoallocate, it specifies that the sizes of the extents in the tablespace are system managed. You cannot specify Automatic for a temporary tablespace.
- **Uniform:** It specifies that the tablespace is managed with uniform extents of a size that you specify. The default size is 1 MB. All extents of temporary tablespaces are uniform. You cannot specify Uniform for an undo tablespace.

Creating a New Tablespace



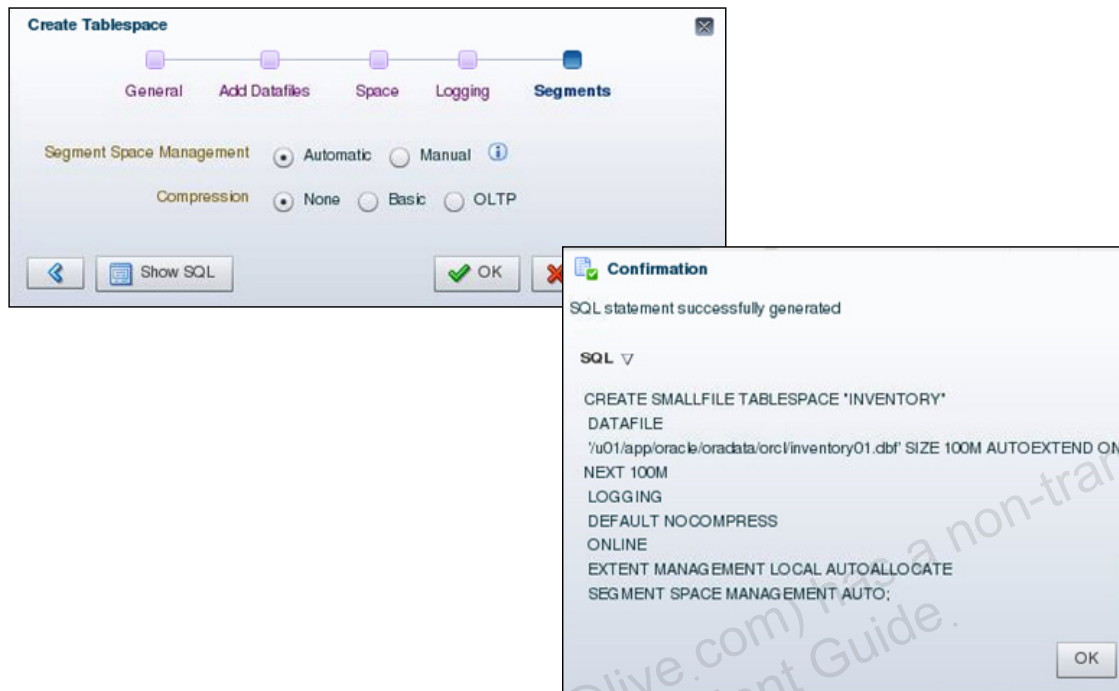
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Logging: The `LOGGING` clause sets the default logging value for any segment created in the tablespace. Changes made to objects in the tablespace are written to the redo log. If logging is not enabled, any direct loads using `SQL*Loader` and direct load `INSERT` operations are not written to the redo log, and the objects are thus unrecoverable in the event of data loss. When an object is created without logging enabled, you must back up those objects if you want them to be recoverable. Choosing not to enable logging can have a significant impact on the ability to recover objects in the future. Use with caution. For more details about the logging clause, see the *Oracle Database SQL Reference*.

Note: If `FORCE LOGGING` mode is in effect for the database, it takes precedence over the tablespace logging setting. The database can be put into `FORCE LOGGING` mode at the time of database creation or after database creation using the `ALTER DATABASE FORCE LOGGING` command.

Creating a New Tablespace



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Segment Space Management: Segment space management can be specified as:

- **Automatic:** The Oracle Database server uses bitmaps to manage the free space in segments. The bitmap describes the status of each data block in a segment with respect to the amount of space in the block that is available for inserting rows. As more or less space becomes available in a data block, the new state is reflected in the bitmap. With bitmaps, the Oracle database manages free space more automatically. As a result, this form of space management is called Automatic Segment Space Management (ASSM).
- **Manual:** This specifies that you want to use free lists for managing free space in segments. Free lists are lists of data blocks that have space available for inserting rows. This form of managing space in segments is called manual segment space management because of the need to specify and tune the `PCTUSED`, `FREELISTS`, and `FREELIST GROUPS` storage parameters for schema objects created in the tablespace. This is supported for backward compatibility; it is recommended that you use ASSM.

Compression Options: Data segment compression is disabled by default. Enabling data segment compression can save disk space usage, reduce memory use in the buffer cache, and speed up query execution during reads. There is, however, a cost in CPU overhead for data loading and DML. It is especially useful in online analytical processing (OLAP) systems, where there are lengthy read-only operations, but can also be used in online transaction processing (OLTP) systems.

For more details about when to use the compression clause, see the *Oracle Database Administrator's Guide*.

Overview of Tablespaces Created by Default

- EXAMPLE (optional)
- SYSAUX
- SYSTEM
- TEMP
- UNDOTBS1
- USERS

Name	Size	Free Space	Used (%)	Auto...	Max...	Status	Type	Group ...	Auto...	Directory
EXAMPLE	358MB	35MB	90.2	✓	Unlimit	●	Permanent		✓	/u01/app/oracle/oradata/...
SYSAUX	1GB	55MB	95	✓	Unlimit	●	Permanent		✓	/u01/app/oracle/oradata/...
SYSTEM	800MB	6MB	99.3	✓	Unlimit	●	Permanent		✓	/u01/app/oracle/oradata/...
TEMP	103MB	102MB	1	✓	Unlimit	●	Temporary		✓	/u01/app/oracle/oradata/...
UNDOTBS1	150MB	137MB	8.9	✓	Unlimit	●	Permanent		✓	/u01/app/oracle/oradata/...
USERS	5MB	3MB	33.8	✓	Unlimit	●	Permanent		✓	/u01/app/oracle/oradata/...

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The following tablespaces are created by default when you create an Oracle database:

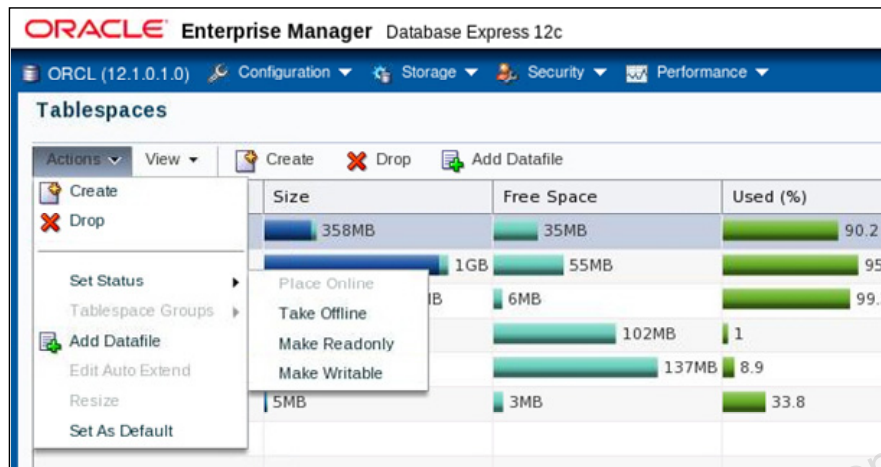
- **SYSAUX:** This is an auxiliary tablespace to the **SYSTEM** tablespace. Some components and products that used the **SYSTEM** tablespace or their own tablespaces in earlier releases of Oracle Database now use the **SYSAUX** tablespace.
- **SYSTEM:** The **SYSTEM** tablespace is used by the Oracle server to manage the database. It contains the data dictionary and tables that contain administrative information about the database. These are all contained in the **SYS** schema and can be accessed only by the **SYS** user or other administrative users with the required privilege.
- **TEMP:** Your temporary tablespace is used when you execute a SQL statement that requires the creation of temporary segments (such as a large sort or the creation of an index). Just as each user is assigned a default tablespace for storing created data objects, each user is assigned a temporary tablespace. The best practice is to define a default temporary tablespace for the database, which is assigned to all newly created users unless otherwise specified. In the preconfigured database, the **TEMP** tablespace is specified as the default temporary tablespace. This means that if no temporary tablespace is specified when the user account is created, Oracle Database assigns this tablespace to the user.

- **UNDOTBS1:** This is the undo tablespace used by the database server to store undo information. If a database uses Automatic Undo Management, then it can only use a single undo tablespace at any given time. This tablespace is created at database creation time.
- **USERS:** This tablespace is used to store user objects and data. If no default tablespace is specified when a user is created, then the **USERS** tablespace is the default tablespace for all objects created by that user. For the **SYS** and **SYSTEM** users, the default permanent tablespace is **SYSTEM**.

The **EXAMPLE** tablespace contains the sample schemas that can be installed when you create the database. The sample schemas provide a common platform for examples. Oracle documentation and courseware contain examples based on the sample schemas.

Note: To simplify administration, it is common to have a tablespace for indexes alone.

Altering a Tablespace



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After you create a tablespace, you can alter it in several ways as the needs of your system change.

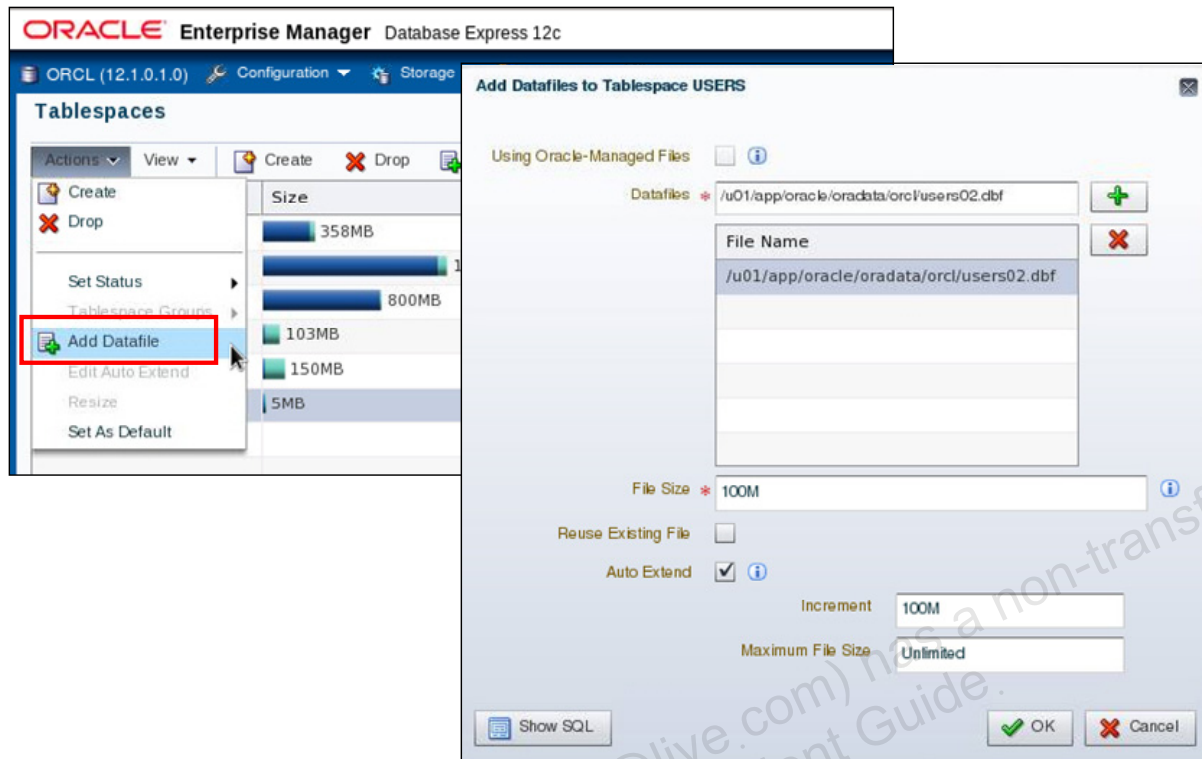
Changing the status: A tablespace can be in one of three different statuses or states. Any of the following three states may not be available because their availability depends on the type of tablespace.

- **Read Write:** The tablespace is online and can be read from and written to.
- **Read Only:** Specify read-only to place the tablespace in transition read-only mode. In this state, existing transactions can be completed (committed or rolled back), but no further data manipulation language (DML) operations are allowed on objects in the tablespace. The tablespace is online while in the read-only state. You cannot make the SYSTEM or SYSAUX tablespaces read-only.
Note: The undo and temporary tablespaces cannot be made read-only.
- **Offline:** You can take an online tablespace offline so that this portion of the database is temporarily unavailable for general use. The rest of the database is open and available for users to access data. When you take it offline, you can use the following options:
 - **Normal:** A tablespace can be taken offline normally if no error conditions exist for any of the data files of the tablespace. Oracle Database ensures that all data is written to disk by taking a checkpoint for all data files of the tablespace as it takes them offline.

- **Temporary:** A tablespace can be taken offline temporarily even if there are error conditions for one or more files of the tablespace. Oracle Database takes the data files (which are not already offline) offline, performing checkpointing on them as it does so. If no files are offline, but you use the Temporary clause, media recovery is not required to bring the tablespace back online. However, if one or more files of the tablespace are offline because of write errors, and you take the tablespace offline temporarily, the tablespace requires recovery before you can bring it back online.
- **Immediate:** A tablespace can be taken offline immediately without Oracle Database taking a checkpoint on any of the data files. When you specify Immediate, media recovery for the tablespace is required before the tablespace can be brought online. You cannot take a tablespace offline immediately if the database is running in NOARCHIVELOG mode.

Note: System tablespaces may not be taken offline.

Adding a Data File to a Tablespace



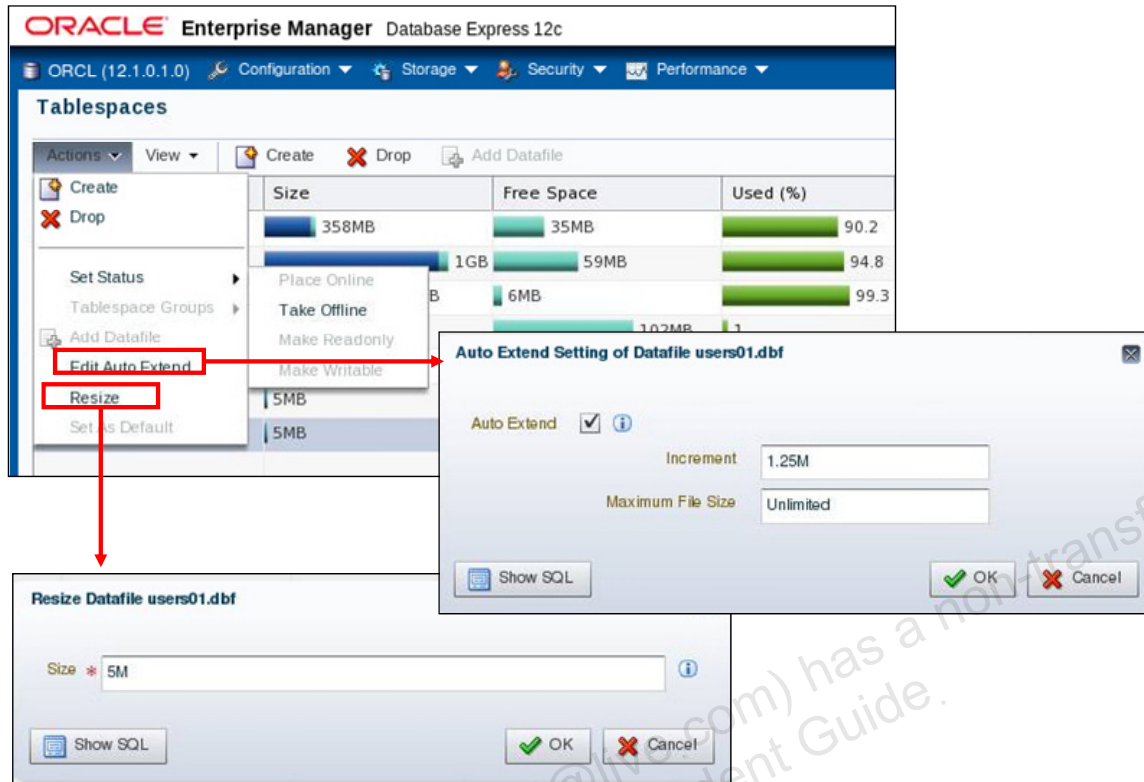
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Changing the size: You can add space to an existing tablespace by either adding data files to the tablespace or changing the size of an existing data file. To add a new data file to the tablespace, click Add. Then enter the information about the data file on the Add Datafile page.

Note: You cannot add additional data files to bigfile tablespaces.

Making Changes to a Data File



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You can change settings of a data file by expanding the tablespace on the Tablespaces page, selecting the data file, and selecting the appropriate task in the Actions menu.

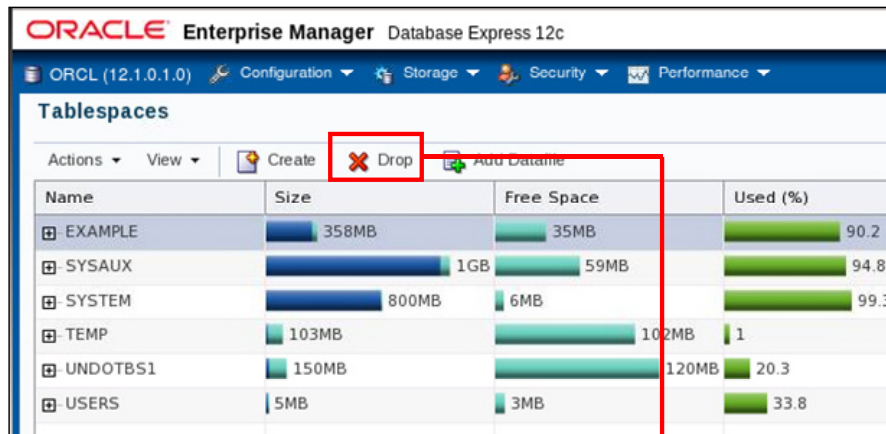
To take a data file offline, select "Take Offline" from the "Set Status" menu.

To change the size of an existing data file:

1. Expand the tablespace on the Tablespaces page and select the data file.
2. Select Resize in the Actions menu.
3. Then, on the Edit Datafile page, you can change the size of the data file. You can make the tablespace either larger or smaller. However, you cannot make a data file smaller than the used space in the file; if you try to do so, you get the following error:

ORA-03297: file contains used data beyond requested RESIZE value

Dropping Tablespaces



ORACLE Enterprise Manager Database Express 12c

ORCL (12.1.0.1.0) Configuration Storage Security Performance

Tablespaces

Actions View Create **Drop** Add Datafile

Name	Size	Free Space	Used (%)
EXAMPLE	358MB	35MB	90.2
SYSAUX	1GB	59MB	94.8
SYSTEM	800MB	6MB	99.3
TEMP	103MB	102MB	1
UNDOTBS1	150MB	120MB	20.3
USERS	5MB	3MB	33.8

Drop Tablespace EXAMPLE

☒ Drop Contents

☒ Drop Datafiles

☒ Drop Constraints

Show SQL

OK Cancel

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You can drop a tablespace and its contents (the segments contained in the tablespace) from the database if the tablespace and its contents are no longer required. You must have the DROP TABLESPACE system privilege to drop a tablespace.

When you drop a tablespace, the file pointers in the control file of the associated database are removed. If you are using Oracle Managed Files (OMF), the underlying operating system files are also removed. Otherwise, without OMF, you can optionally direct the Oracle server to delete the operating system files (data files) that constitute the dropped tablespace. If you do not direct the Oracle server to delete the data files at the same time that it deletes the tablespace, you must later use the appropriate commands of your operating system if you want them to be deleted.

You cannot drop a tablespace that contains active segments. For example, if a table in the tablespace is currently being used, or if the tablespace contains undo data that is needed to roll back uncommitted transactions, you cannot drop the tablespace. It is best to take the tablespace offline before dropping it.

Viewing Tablespace Information

```
SQL> SELECT tablespace_name, status, contents, logging,
2 extent_management, allocation_type,
3 segment_space_management
4 FROM dba_tablespaces;
```

TABLESPACE_NAME	STATUS	CONTENTS	LOGGING	EXTENT_MAN	ALLOCATIO	SEGMENT
SYSTEM	ONLINE	PERMANENT	LOGGING	LOCAL	SYSTEM	MANUAL
SYSAUX	ONLINE	PERMANENT	LOGGING	LOCAL	SYSTEM	AUTO
UNDOTBS1	ONLINE	UNDO	LOGGING	LOCAL	SYSTEM	MANUAL
TEMP	ONLINE	TEMPORARY	NOLOGGING	LOCAL	UNIFORM	MANUAL
USERS	ONLINE	PERMANENT	LOGGING	LOCAL	SYSTEM	AUTO
EXAMPLE	ONLINE	PERMANENT	NOLOGGING	LOCAL	SYSTEM	AUTO

```
SQL> SELECT file_name, file_id, tablespace_name
2 FROM dba_data_files;
```

FILE_NAME	FILE_ID	TABLESPACE_NAME
/u01/app/oracle/oradata/orcl/system01.dbf	1	SYSTEM
/u01/app/oracle/oradata/orcl/sysaux01.dbf	3	SYSAUX
/u01/app/oracle/oradata/orcl/users01.dbf	6	USERS
/u01/app/oracle/oradata/orcl/example01.dbf	2	EXAMPLE
/u01/app/oracle/oradata/orcl/undotbs01.dbf	4	UNDOTBS1



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Tablespace and data file information can also be obtained by querying the following:

- **Tablespace information:**
 - DBA_TABLESPACES
 - V\$TABLESPACE
- **Data file information:**
 - DBA_DATA_FILES
 - V\$DATAFILE
- **Temp file information:**
 - DBA_TEMP_FILES
 - V\$TEMPFILE

Oracle Managed Files (OMF)

Specify file operations in terms of database objects rather than file names.

Parameter	Description
DB_CREATE_FILE_DEST	Defines the location of the default file system directory for data files and temporary files
DB_CREATE_ONLINE_LOG_DEST_n	Defines the location for redo log files and control file creation
DB_RECOVERY_FILE_DEST	Default location for the fast recovery area

Example:

```
SQL> ALTER SYSTEM
      2  SET DB_CREATE_FILE_DEST='/u01/app/oracle/oradata';
SQL> CREATE TABLESPACE tbs_1;
```

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Oracle Managed Files eliminate the need for you to directly manage the operating system files in an Oracle database. You specify operations in terms of database objects rather than file names. The database internally uses standard file system interfaces to create and delete files as needed for the following database structures:

- Tablespaces
- Redo log files
- Control files
- Archived logs
- Block change tracking files
- Flashback logs
- RMAN backups

A database can have a mixture of Oracle-managed and unmanaged files. The file system directory specified by either of these parameters must already exist; the database does not create it. The directory must also have permissions for the database to create the files in it.

The example shows that after DB_CREATE_FILE_DEST is set, the DATAFILE clause can be omitted from a CREATE TABLESPACE statement. The data file is created in the location specified by DB_CREATE_FILE_DEST. When you create a tablespace as shown, default values are assigned to all parameters.

Oracle-managed files have a specific naming format. For example, on Linux- and UNIX-based systems the following format is used:

```
<destination_prefix>/o1_mf_%t_%u_.dbf
```

Do not rename an Oracle-managed file. The database identifies an Oracle-managed file based on its name. If you rename the file, the database is no longer able to recognize it as an Oracle-managed file and will not manage the file accordingly.

The following example sets the default location for data file creations to `/u01/oradata` and then creates a tablespace `tbs_1` with a data file in that location.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata';
```

```
SQL> CREATE TABLESPACE tbs_1;
```

By default, Oracle-managed data files, including those for the `SYSTEM` and `SYSAUX` tablespaces, are 100 MB and auto-extensible.

Note: By default, ASM uses OMF files, but if you specify an alias name for an ASM data file at tablespace creation time or when adding an ASM data file to an existing tablespace, then that file will not be OMF.

Quiz

A database can have a mixture of Oracle-managed and unmanaged files.

- a. True
- b. False

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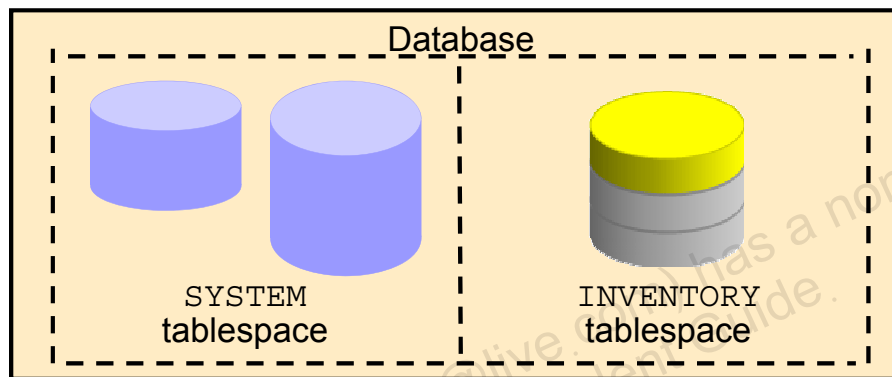
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Answer: a

Enlarging the Database

You can enlarge the database in the following ways:

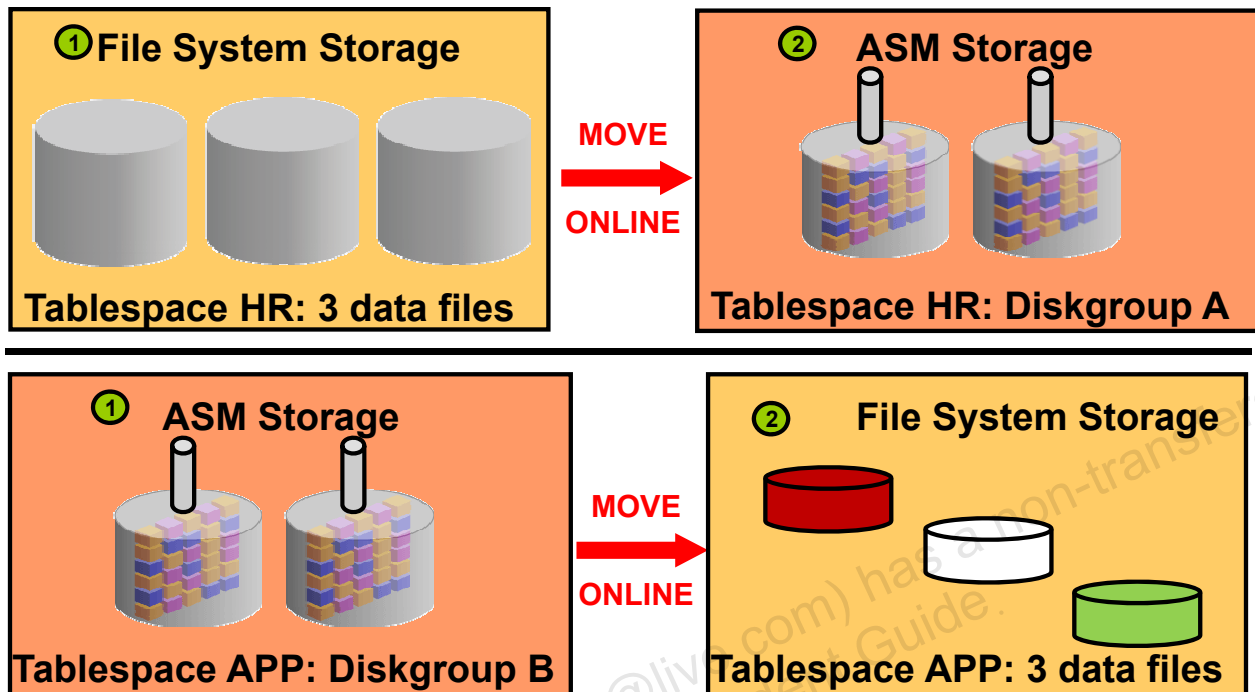
- Create a new tablespace.
- Add a data file to an existing smallfile tablespace.
- Increase the size of a data file.
- Provide for the dynamic growth of a data file.

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These activities can be performed with Enterprise Manager or with SQL statements. The size of the database can be described as the sum of all of its tablespaces.

Moving or Renaming an Online Data File



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You can rename or move an online data file from one kind of storage system to another while the database is opened and accessing the file.

Queries and DML and DDL operations can be performed while the data file is being moved, including the following:

- `SELECT` statements against tables and partitions
- Creation of tables and indexes
- Rebuilding of indexes

Note: If objects are compressed while the data file is moved, the compression remains the same.

Moving or Renaming an Online Data File

- Relocating an online data file:

```
ALTER DATABASE MOVE DATAFILE '/disk1/myexample01.dbf'
TO '/disk2/myexample01.dbf';
```

- Copying a data file from a file system to ASM:

```
ALTER DATABASE MOVE DATAFILE '/disk1/myexample01.dbf'
TO '+DiskGroup2' KEEP;
```

- Renaming an online data file:

```
ALTER DATABASE MOVE DATAFILE '/disk1/myexample1.dbf'
TO '/disk1/myexample01.dbf';
```

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You do not have to shut down the database or take the data file offline while you move a data file to another location, disk, or storage system.

The `TO` clause can be omitted only when an Oracle-managed file is used. In this case, the `DB_CREATE_FILE_DEST` parameter should be set to indicate the new location.

If the `REUSE` option is specified, the existing file is overwritten.

If the `KEEP` clause is specified, the old file will be kept after the move operation. The `KEEP` clause is not allowed if the source file is an Oracle-managed file.

Use the `V$SESSION_LONGOPS` view to display ongoing online move operations. Each ongoing operation has one row. The state transition of a successful online move operation is usually `NORMAL` to `COPYING` to `SUCCESS` and finally to `NORMAL`.

Summary

In this lesson, you should have learned how to:

- Describe the storage of table row data in blocks
- Create and manage tablespaces
- Obtain tablespace information

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Practice 10

- 10-1: Viewing Database Storage Structure Information
- 10-2: Creating a Tablespace

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