Oracle Tablespaces, etc.: Managing the Disk Resource

CS634
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These slides are not based on “Database Management Systems” 3rd ed, Ramakrishnan and Gehrke

Look at disks we have to work with on dbs2

```
dbs2(24)% df –lk (local filesystems, subset)
Filesystem           kbytes    used   avail capacity  Mounted on
/dev/dsk/c1t0d0s3    8263373 5166817 3013923    64%    /disk/sd0d
/dev/dsk/c1t1d0s3    8263373 8180740       0   100%    /disk/sd1d
/dev/dsk/c1t0d0s4    8263373       9 8180731     1%    /disk/sd0e
/dev/dsk/c1t0d0s5    8263373       9 8180731     1%    /disk/sd0f
/dev/dsk/c1t1d0s4    8263373 1049116 7131624    13%    /disk/sd1e
/dev/dsk/c1t0d0s7    18415754      9 18231588    1%    /disk/sd0h
/dev/dsk/c1t0d0s6    16526762      9 16361486    1%    /disk/sd0g
/dev/dsk/c1t1d0s5    8263373 7343660  837080    90%    /disk/sd1f
/dev/dsk/c1t1d0s6    16526762      9 16361486    1%    /disk/sd1g
/dev/dsk/c1t1d0s7    18415754 2181679 16049918  12%    /disk/sd1h
```

- This shows two disks, /dev/dsk/clt0d0 (aka sd0) and /dev/dsk/clt1d0 (sd1), with 5 partitions each with fs's, of size 8GB, 8GB, 8GB, 16GB, and 18GB (total 50GB).
- Old disks, now would see bigger disks, but these are sufficient for our use.

Partitions of a Disk (or RAID)

- A disk can be split up into partitions, commonly only 2 or 3, but 5 each on dbs2's disks.
- A partition is a consecutive sequence of cylinders of the disk.
  - Thus it limits seek time for files within it.
- Partitions are created before file systems. Each partition may have its own filesystem.
- Under UNIX/Linux (including MacOS), file systems can be pasted together by "mounting" one filesystem on a directory of another already in use.
  - The first filesystem to be put in use has the root directory of the final filesystem.
  - You can tell what partition your current directory is part of by using the "df ." command.
- This describes local disks and partitions. It is also possible to mount a remote filesystem via NFS (network file system).
  - However, for database use, we want local disk.

Oracle Data Files: *.dbf

Disk sd0 has Oracle binaries and disk sd1 has Oracle data files, on 3 partitions:

```
dbs2(36)% sudo ls -l /disk/*/data/ora*/*
/disk/sd1d/data/oracle-10.1/dbs2:
-rw-r-----   1 oracle   104865792 Feb 23 12:06 caspar.dbf
… smaller files deleted from list…
-rw-rw----   1 oracle   1090527232 Feb 23 13:42 sysaux01.dbf
-rw-rw----   1 oracle   524296192 Feb 23 13:40 system01.dbf
-rw-rw----   1 oracle   1574969344 Feb 22 09:01 temp01.dbf
-rw-rw----   1 oracle   2123374592 Feb 23 13:42 undotbs01.dbf
-rw-rw----   1 oracle   2915049472 Feb 23 12:06 users01.dbf
/disk/sd1e/data/oracle-10.1/dbs2:
-rw-r-----   1 oracle   1073750016 Feb 23 13:40 system02.dbf
/disk/sd1f/data/oracle-10.1/dbs2:
-rw-r-----   1 oracle   3221233664 Feb 23 13:36 undotbs02.dbf
-rw-r-----   1 oracle   4294975488 Feb 23 12:06 users02.dbf
```

Tablespaces are created from OS files

- Oracle, simple case:
- CREATE TABLESPACE tblspname
- DATAFILE 'filename1' SIZE 300G, 'filename2' SIZE 300G, …; -- other files
- Don't need SIZE if file already exists
- These files need to be as contiguous on disk as possible for best performance
- Suggest reinitializing the filesystem before creating the file.
- Alternatively, use "raw partitions", but not for novices.
- Remember a hardware RAID

Tablespaces in other products

- Create tablespace command exists in mysql 5.7, but not our v 5.6.
- For mysql v 5.1-5.6, can only set up the one and only all-inclusive system tablespace at initialization. You can add a file to it later under some conditions.
- DB2 has tablespaces much like Oracle.
- MS Sql Server has "file groups"

Files to Tablespaces on dbs2

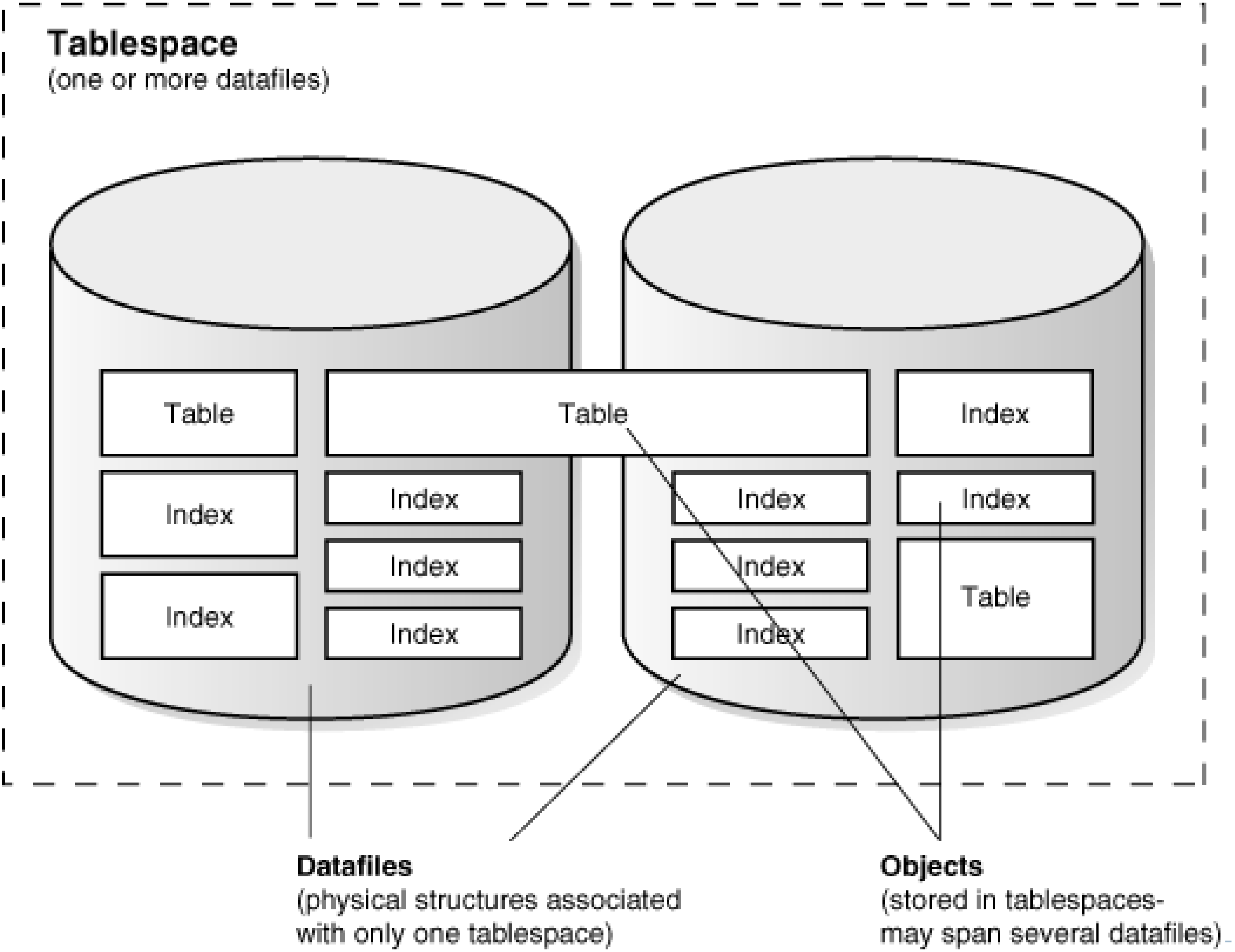
```
SQL> select file_name, tablespace_name, blocks from dba_data_files
FILE_NAME                                         TABLESPACE_NAME      BLOCKS
------------------------------------------------  ---------------      ----------
/disk/sd1d/data/oracle-10.1/dbs2/users01.dbf      USERS                355840
/disk/sd1d/data/oracle-10.1/dbs2/sysaux01.dbf     SYSAUX               133120
/disk/sd1d/data/oracle-10.1/dbs2/undotbs01.dbf    UNDOTBS1             259200
/disk/sd1d/data/oracle-10.1/dbs2/system01.dbf     SYSTEM               64000
/disk/sd1d/data/oracle-10.1/dbs2/caspar.dbf       CASPAR               12800
/disk/sd1e/data/oracle-10.1/dbs2/system02.dbf     S YSTEM              131072
/disk/sd1f/data/oracle-10.1/dbs2/users02.dbf      USERS                524288
/disk/sd1f/data/oracle-10.1/dbs2/undotbs02.dbf    UNDOTBS1             93216
```

- Shows tablespaces SYSTEM (2 files), USERS (2 files), UNDOTBS1 (2 files), SYSAUX (1 file), CASPAR (1 file)

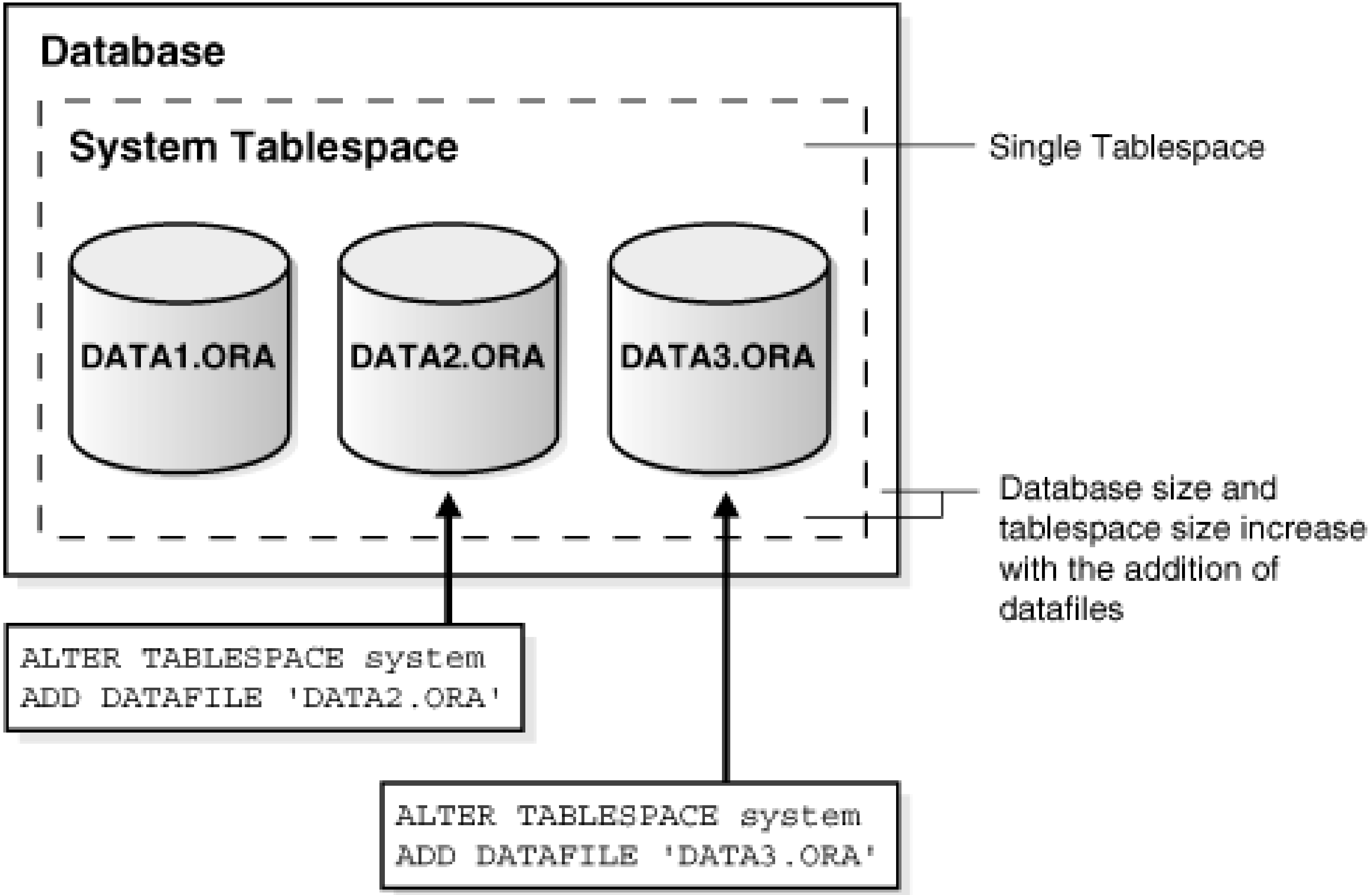
The SYSTEM tablespace

- Every Oracle database contains a tablespace named SYSTEM, which Oracle creates automatically when the database is created.
- The SYSTEM tablespace is always online when the database is open.
- The SYSTEM tablespace always contains the data dictionary tables for the entire database.

From Oracle Docs



Enlarging a Database by Adding a Datafile to a Tablespace



Single Tablespace

Database size and tablespace size increase with the addition of datafiles

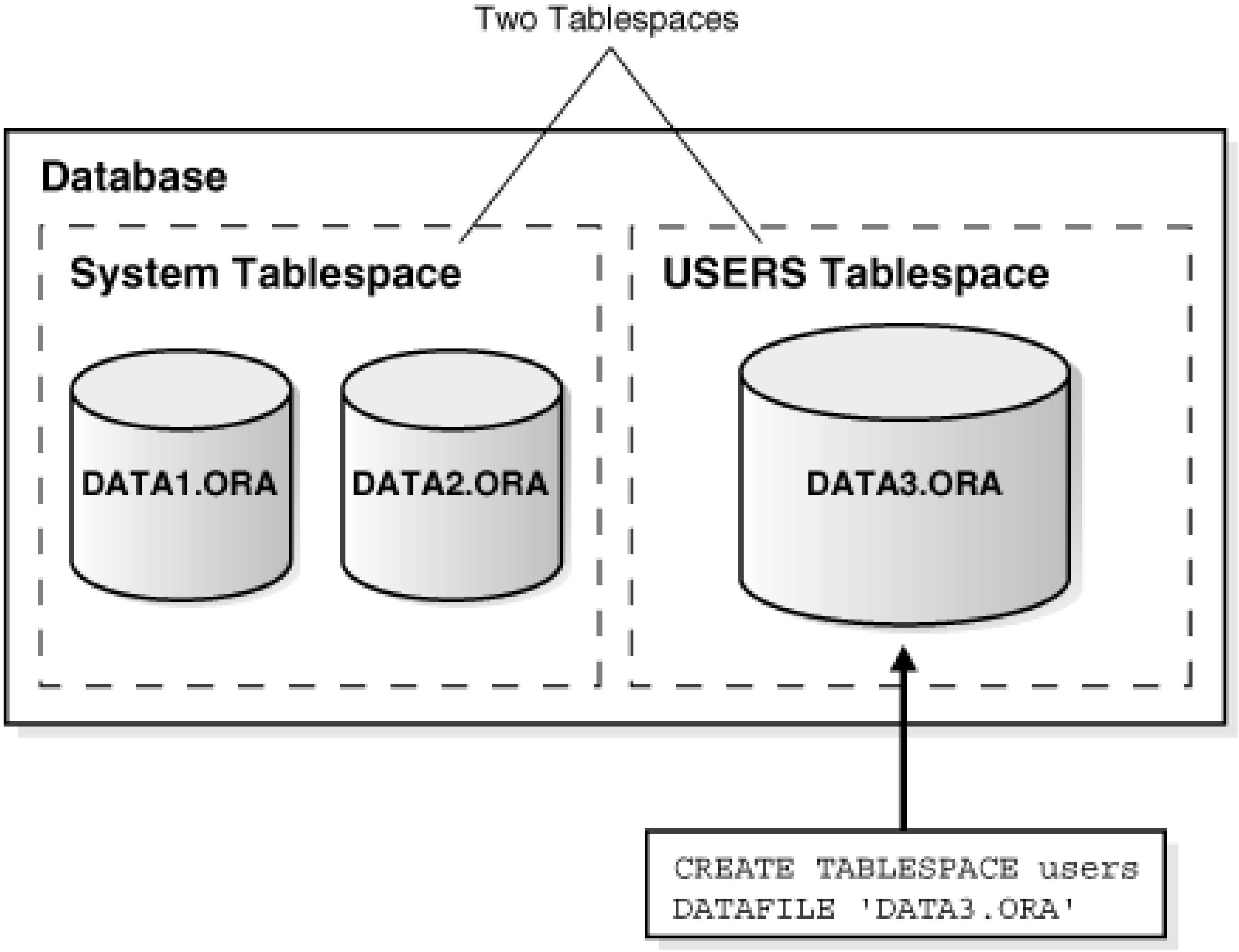
```
ALTER TABLESPACE system
ADD DATAFILE 'DATA2.ORA'
```

```
ALTER TABLESPACE system
ADD DATAFILE 'DATA3.ORA'
```

Example of use of Alter Tablespace

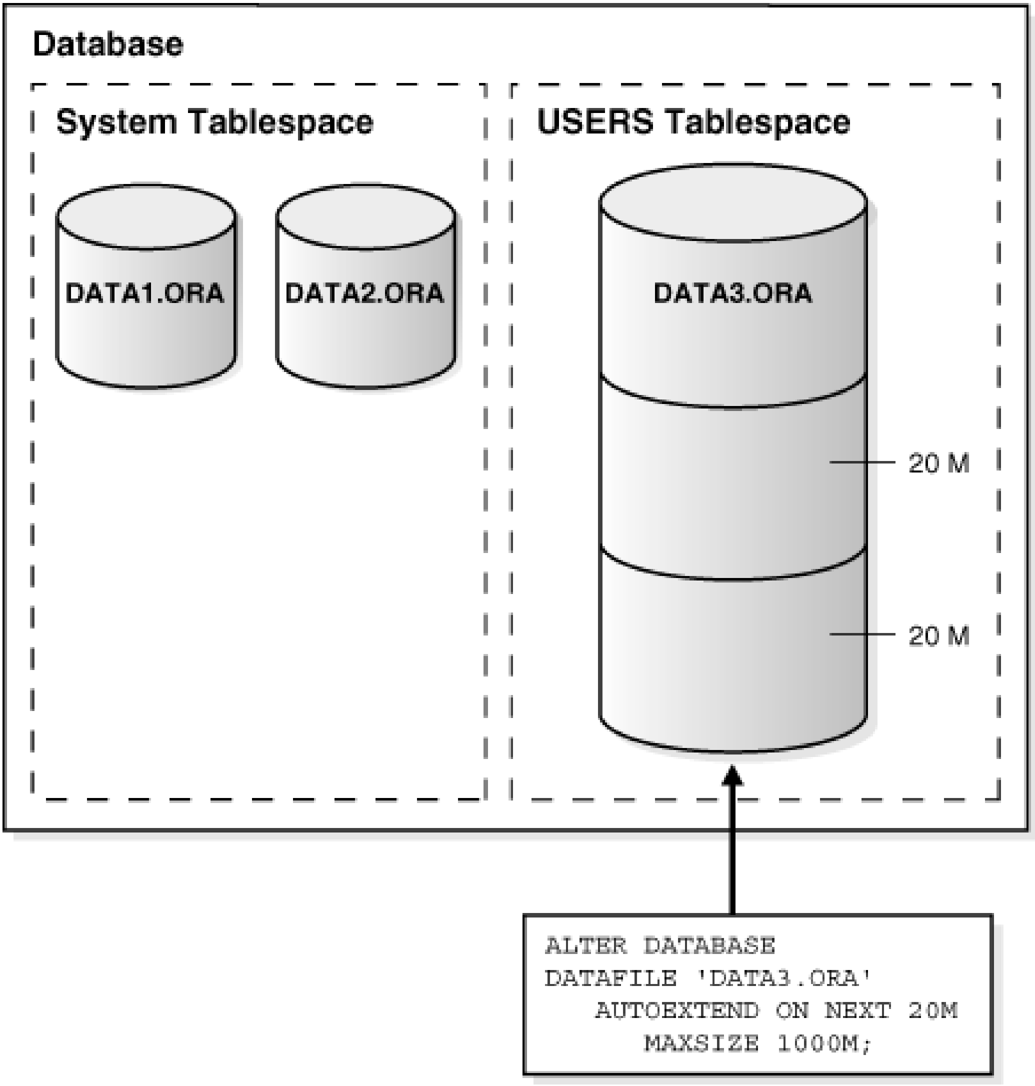
- Command used to expand our USERS tablespace:
- alter tablespace users
-    add datafile '/disk/sd1f/data/oracle-10.1/dbs2/users02.dbf'
-    size 4G;

Enlarging a Database by Adding a New Tablespace



```
CREATE TABLESPACE users
DATAFILE 'DATA3.ORA'
```

Enlarging a Database by Dynamically Sizing Datafiles



```
ALTER DATABASE
DATAFILE 'DATA3.ORA'
   AUTOEXTEND ON NEXT 20M
      MAXSIZE 1000M;
```

Tables and indexes are in a particular tablespace

```
SQL> select table_name, tablespace_name from user_tables;
TABLE_NAME                     TABLESPACE_NAME
------------------------------ ------------------------------
ACCOUNT                        USERS
AGENTS                         USERS
APERF_RESULT                   USERS
…
SQL> select index_name, tablespace_name from user_indexes;
INDEX_NAME                     TABLESPACE_NAME
------------------------------ ------------------------------
BITS1                          USERS
BITS2                          USERS
K100X                          USERS
```

- …   not an accident: account eoneil has default tablespace USERS

Create table can specify tablespace

- CREATE TABLE [schema.]tablename
- (coldef | table_constraint}
- {, coldef | table_constraint, . . .}
- [TABLESPACE tblspname]
- [STORAGE…] ← will cover later today
- [PCTFREE n] [PCTUSED n] ← for pages of table
- [other clauses] ←partitioning support is in here
- [AS subquery]
- This tablespace will override the default for the user
- Create index is similar

PCTFREE and PCTUSED for table

- PCTFREE n, n goes from 0 to 99, default 10.
- PCTUSED n, n goes from 1 to 99, default 40.
- The PCTUSED n clause specifies a condition where if page gets empty enough, inserts will start again!
- Require PCTFREE + PCTUSED < 100, or invalid.
- Example, if PCTFREE 10 PCTUSED 80, then stop inserts when >90% full, start again when <80% full.

Uses of tablespaces: control over disk resources

- In a two-disk system, can use one disk for table, other for index to speed up range searches
- Put table in tablespace USERS, composed of files on one disk, create tablespace USERIND for indexes, composed of file(s) on other disk.
- In a shared system, put one project on high-end disks made into one tablespace using RAID, another project on cheap disks made into another tablespace, also using RAID.
- With RAID, can mix tables and indexes pretty freely.

Block Size (i.e., page size)

- “Oracle recommends smaller Oracle Database block sizes (2 KB or 4 KB) for online transaction processing (OLTP) or mixed workload environments and larger block sizes (8 KB, 16 KB, or 32 KB) for decision support system (DSS) workload environments” from Burleson
- How is this block size specified by the DBA?
- You might expect it to be specified by the tablespace, but it’s more central than that:
- The block size determines the page buffer size in the all-important database page buffer
- So most Oracle installations have a single page size

Multiple page sizes?

- From same page as previous quote
- **WARNING**: *Using multiple blocksizes effectively requires expert-level Oracle skills and an intimate knowledge of your I/O landscape. While deploying multiple blocksizes can greatly reduce I/O and improve response time, it can also wreak havoc in the hands of inexperienced DBA's. Using non-standard blocksizes is not recommended for beginners*
- So we'll assume a single block size
- What is it for dbs2's site?
- It is fixed for each tablespace, so we can find out from dba_tablespaces:

Finding the block size of an Oracle DB

```
SQL> select tablespace_name, block_size from
dba_tablespaces;

TABLESPACE_NAME                BLOCK_SIZE
------------------------------ ----------
SYSTEM                               8192
UNDOTBS1                             8192
SYSAUX                               8192
TEMP                                 8192
USERS                                8192
CASPAR                               8192
```

- So we see it’s 8KB, larger than recommended for OLTP,
- But small for DSS, i.e., a compromise.

Extents of disk in Oracle

An extent is a (hopefully contiguous) part of a file, composed of a whole number of blocks/pages.

One tablespace made of two files:

```
   File1                              File2
|-------------------------------|  |--------------------------|
  |----|        |--|                 |-----|                |---|
  extents for one table
```

Note extents can be of different sizes—by default they get bigger and bigger as the table grows.

Goal: less seeking because lots of related data is close by on disk

STORAGE clause of Create Table

[STORAGE ([INITIAL n [K|M|G]] [NEXT n [K|M|G]] [MINEXTENTS n] [PCTINCREASE n])]

INITIAL n: size in bytes of initial extent (default 5 pages)

NEXT n: size in bytes of next extent (default 5 pages)

PCTINCREASE n: increase from one extent to next, starting from third one. (default 50%)

- MINEXTENTS n: start at creation with this number of extents; used when know initial use will be very large

DEFAULT STORAGE clause of Create Tablespace

[DEFAULT STORAGE ([INITIAL n [K|M|G]] [NEXT n [K|M|G]] [MINEXTENTS n] [PCTINCREASE n])]

- Sets defaults for create table and create index in that tablespace
- Example: tablespace for warehouse tables should have larger extents by default
- DEFAULT STORAGE (INITIAL 10M NEXT 10M)
- Downside: a little side table takes 10M
- But 10M in a warehouse is trivial.

Other Database Files

- So far, considered the files holding pages of data for tables and indexes
- Other important files: saw redo*.dbf, undotbs01.dbf
- Redo log files: information that allows for crash recovery
  - The current such file is appended to constantly as the DB is changed, read only in crash recovery
  - The system cuts over to another of these files periodically
  - For a serious database, should be mirrored, since otherwise is a single point of failure
- Undo tablespace: information that allows for rollbacks and also snapshots for efficient reads
  - This data is written and read, more like the DB data, so held in a tablespace, unlike the redo log

RAID and Oracle, from Burleson

- RAID 5: slow for updates, but in wide use for safety
- Mirroring/shadowing: Great for redo log file

RAID	**Type of Raid**	**Control File**	**Database File**	**Redo Log File**	**Archive Log File**
0	Striping	Avoid	OK	Avoid	Avoid
1	Shadowing	Best	OK	Best	Best
1+0	Striping and Shadowing	OK	Best	Avoid	Avoid
3	Striping with static parity	OK	OK	Avoid	Avoid
5	Striping with rotating parity	OK	Best if RAID0-1 not available	Avoid	Avoid

Example:1TB Database with 2000 ops/s

- Burleson says: ***Size first for IO capacity, then for volume.***
- 2000 ops/sec means 20 7200 rpm disks or 10 15Krpm disks, roughly, not counting parity disks or mirrors or spares
- So say 12 15Krpm disks in a RAID1+0, plus 12 mirrors for data
- 2 disks for mirrored log, RAID 1, plus 5 spares.
  - Smart RAID controller with memory cache best here
- 1TB/12 = 83 GB, so 143GB disks are fine for data.

1TB example

- Build RAID for data
  - End up with new empty filesystem /disk/raida
- Build RAID for redo log
  - End up with new empty filesystem /disk/raidb
- Create tablespace DBDATA and let Oracle create one huge file /disk/raida/dbdata.dbf
- Change database to use redo logs on /disk/raidb:
  - alter database add logfile group 5 (‘/disk/raid/redo05a.log',
  - ‘/disk/raid/redo05b.log') size 500m;
- Create tables and indexes in tablespace DBDATA

Oracle Project Account

- Create an Oracle account for the project, and make its default tablespace be DBDATA

```
create user myproject identified by pw default tablespace dbdata
    temporary tablespace temp;
```

- This simplifies the createdb.sql, etc.
- Makes it less likely that someone accidentally makes a table in tablespace USERS for the project, off on wrong disks.
- Make a project rule that DBA actions are done as this user
- If user already exists:

```
alter user myproject default tablespace dbdata;
```

Summary

- Hierarchy of data containers:
- Files containing blocks/pages 8KB each on dbs2
- Tablespace: some number of files ganged together
- Extent: some number of blocks in a certain file and thus in a certain tablespace, by default, bigger and bigger as a table grows
- Table or Index: some number of extents all in the same tablespace
- Separately: redo log file, no page structure, just append records describing DB changes.