INFS602 Physical Database Design

Database Storage Structures

Learning Outcomes

- Database Architecture
- Role of the Database Administrator
- General Performance Issues
- Examine Oracle's Storage Structures

Physical Design Activities

- Designing data structures to improve performance
- Defining recovery policies
- Designing and implementing Concurrency Control policies
- Tuning applications (SQL statement tuning)
- Enroling users & granting them necessary privileges

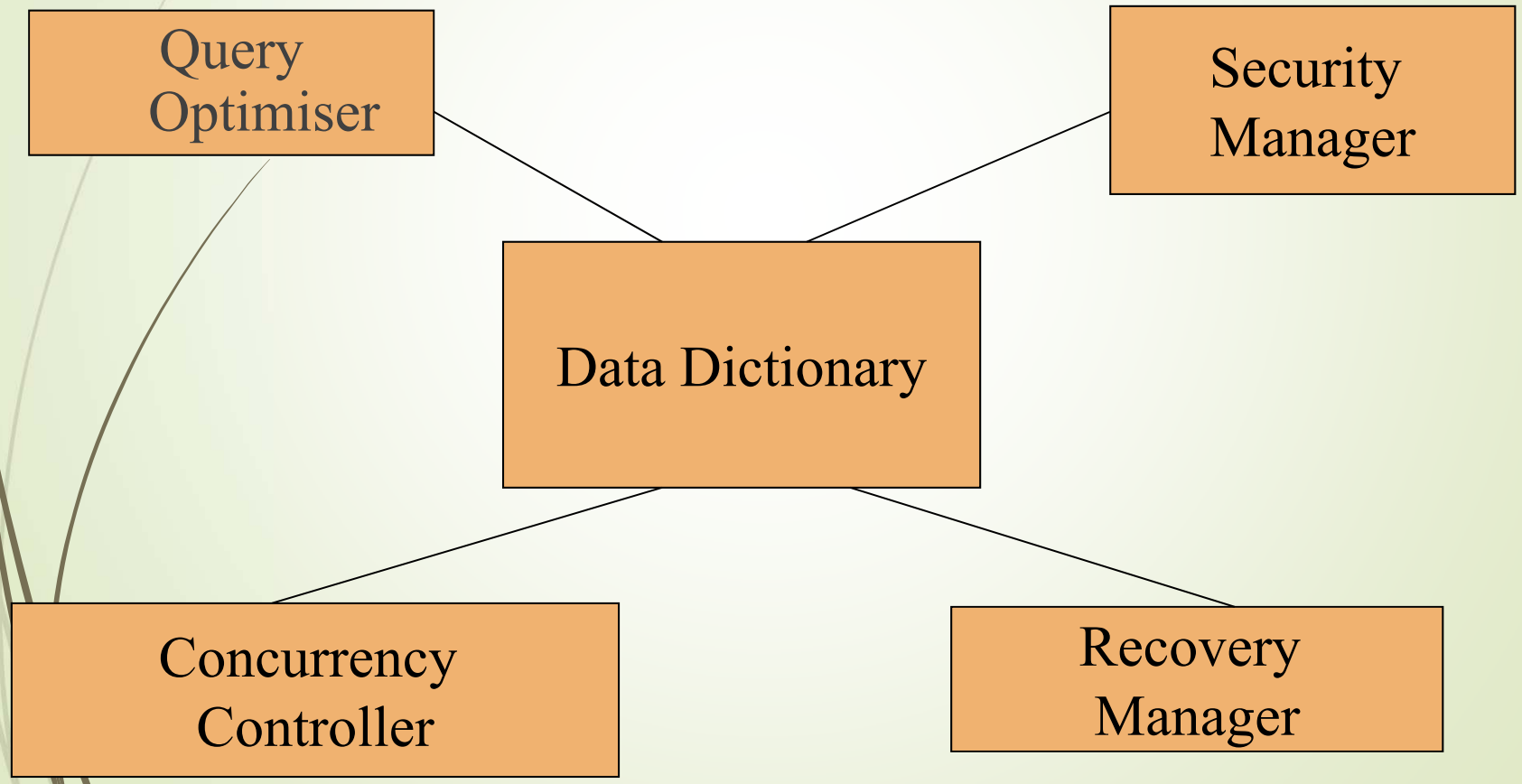
Administrator vs. Developer

- The DBA is the sole authority for allocating system-wide resources (disk space usage, auditing, etc)
- However, there are many areas of overlap in responsibility between the DBA and Developers

Who has Primary Responsibility for each Activity?

Activity/User Type	Developer	DBA
Database Design		
Data Structure Definition		
Recovery Policy		
Design and Implementation of Concurrency Control Policies		
Application Tuning		
Enrolment of Users		

Database Architecture



Interactions between Components

Lets look at a typical scenario

1. Query is parsed
2. Table and column names sent by QO to the DD
3. DD validates names, sends a message to the SM
4. SM validates access rights
5. DD now replies to QO
6. QO generates a plan for execution and sends messages to CC for obtaining locks
7. As transaction executes it writes information in the rollback segments maintained by the Recovery Manager

Performance Issues

- Two main factors:
  1. Processing time at the CPU
  2. Data retrieval time at the disk
- Data retrieval time >> Processing time
- Thus major objective is to minimise data retrieval (I/O) costs

Performance Issues - Compression

- Data retrieval costs minimised by *clustering* and/or *compressing* data
- Compression can be achieved by replacing large data fields by a coding scheme that takes up less space
- This will typically be used for a table with large-sized text fields
- These fields can be replaced by codes which reference the original text values in a lookup table

Clustering — Oracle's Solution

- Oracle clusters data at the physical level into *data blocks*

Q) What happens when data (table) size > data block size?

A)

- This is precisely what Oracle does!

Oracle's Storage Structures — Extents

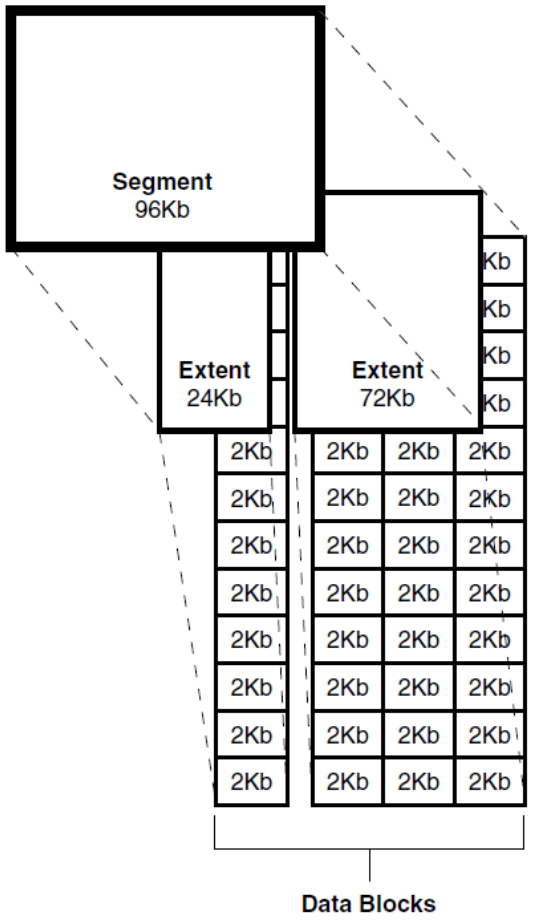
- Oracle organises data blocks that are accessed together into a single contiguous unit called an extent
- Thus when creating a table you specify the size of the extent
- When the table size exceeds the size of the extent, Oracle obtains another extent
- However there is no guarantee that the next extent is contiguous with the previous one

Extents...

- Oracle allows the designer to specify the size of the first (initial) and subsequent (*next*) extents
- For a table that would be expected to grow linearly with time, the size of the *initial* and *next* extents would be the same

Relationship between Data Blocks, Extents and Segments

Figure 2–1 The Relationships Among Segments, Extents, and Data Blocks



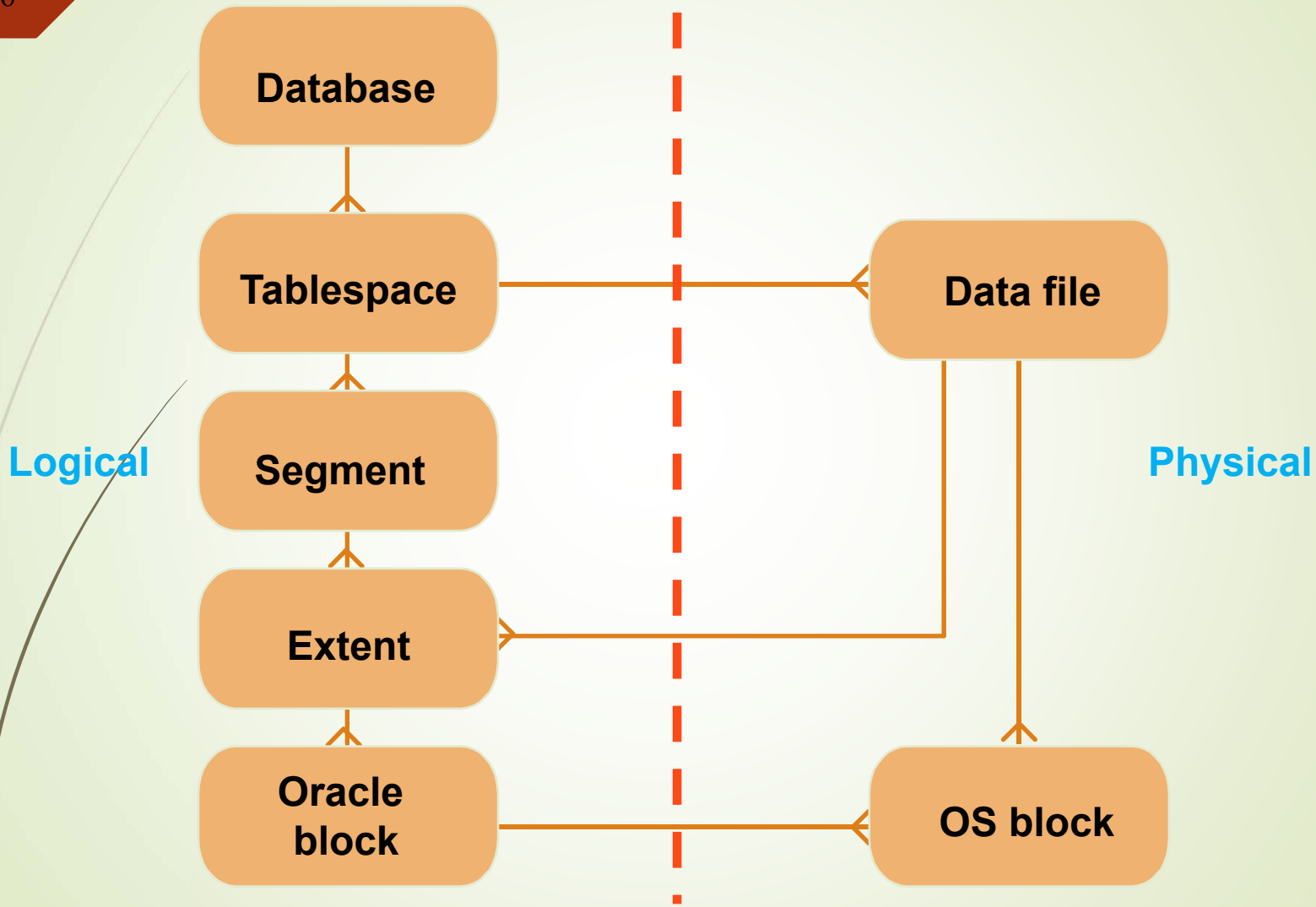
Oracle's Storage Structures — Segments

- Segments are collections of extents that belong to one logical unit – e.g. a table
- In general there four types of segments:
  1. Table
  2. Index
  3. Rollback (for Recovery)
  4. Temporary (to store intermediate results, e.g. during sorting)

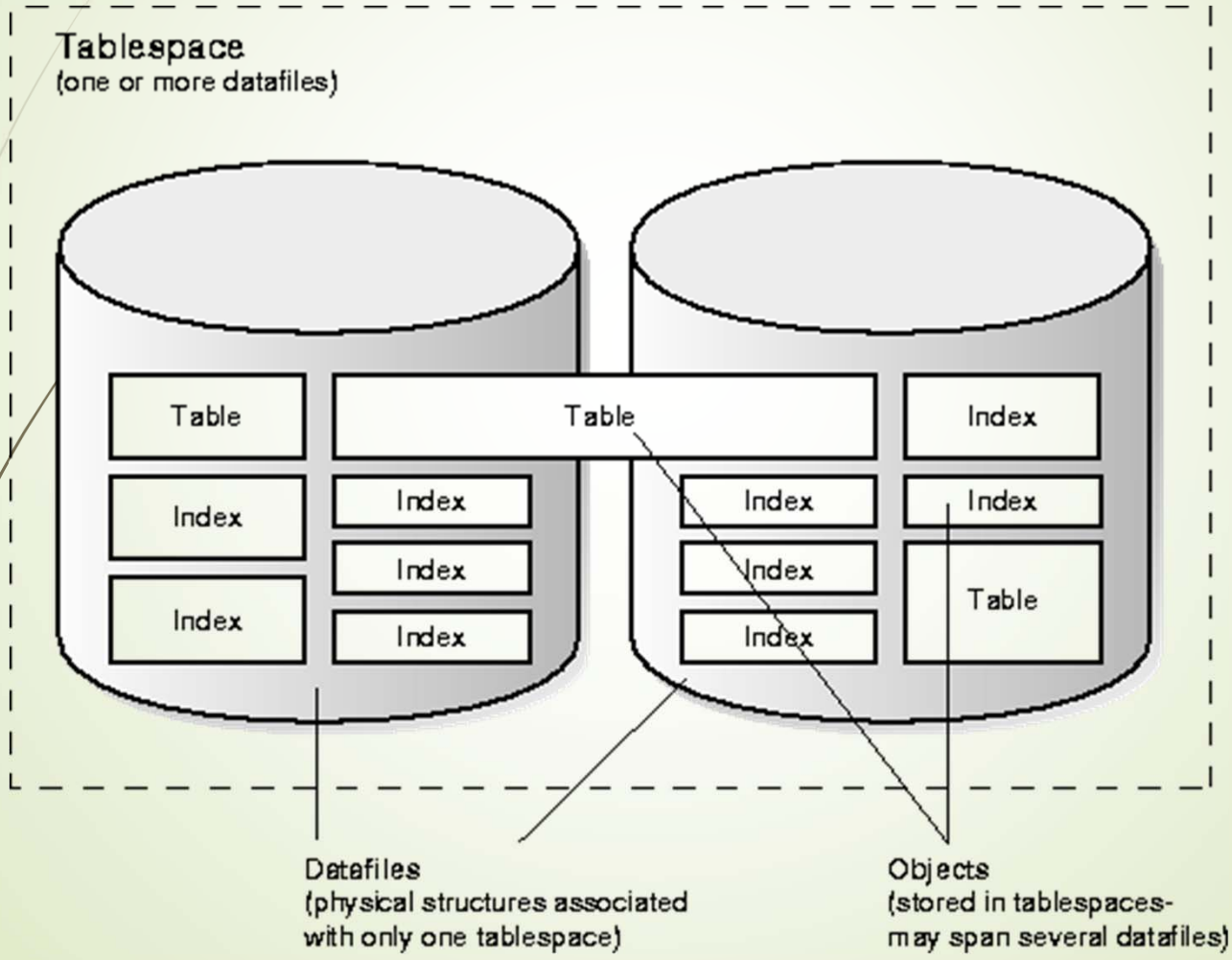
Oracle's Storage Structures — Tablespaces

- A database is divided into logical storage units called tablespaces.
- Each tablespace in an ORACLE database is comprised of one or more operating system files called data files.
- A tablespace's data files physically store the associated database data on disk

DATABASE STORAGE HIERARCHY



Tablespaces and Datafiles



Logical Structure versus Physical Structure

- Logical structures
  - composed of orderly groupings of information that allow you to manipulate and access related data.
  - cannot be viewed outside the database.
- Physical structures
  - composed of operating system components,
  - have a physical name and location.

Logical Structure

- The logical structure of an Oracle database includes
  - Schema objects
  - Data blocks
  - Extents
  - Segments
  - Tablespaces

Physical Structure

- Every database has one or more physical datafiles.
- The Physical Structure of an Oracle database includes:
  - Data Files
  - Redo log Files
  - Control Files

Physical Structure…

- Data Files: contain all the database data, and can be associated with only one database.
- Redo Log files: primary function is to record all changes made to data.
  - The information in a redo log file is used only to recover the database from a system or media failure
- Control File: contains entries that specify the physical structure of the database, such as:
  - Database name
  - Names and locations of datafiles and redo log files
  - Time stamp of database creation.

Using Tablespaces

- Oracle uses a SYSTEM tablespace to store internal information such as the Data Dictionary
- User tables can also be stored in SYSTEM but this is not recommended
- Mutiple tablespaces give users better performance and flexibility

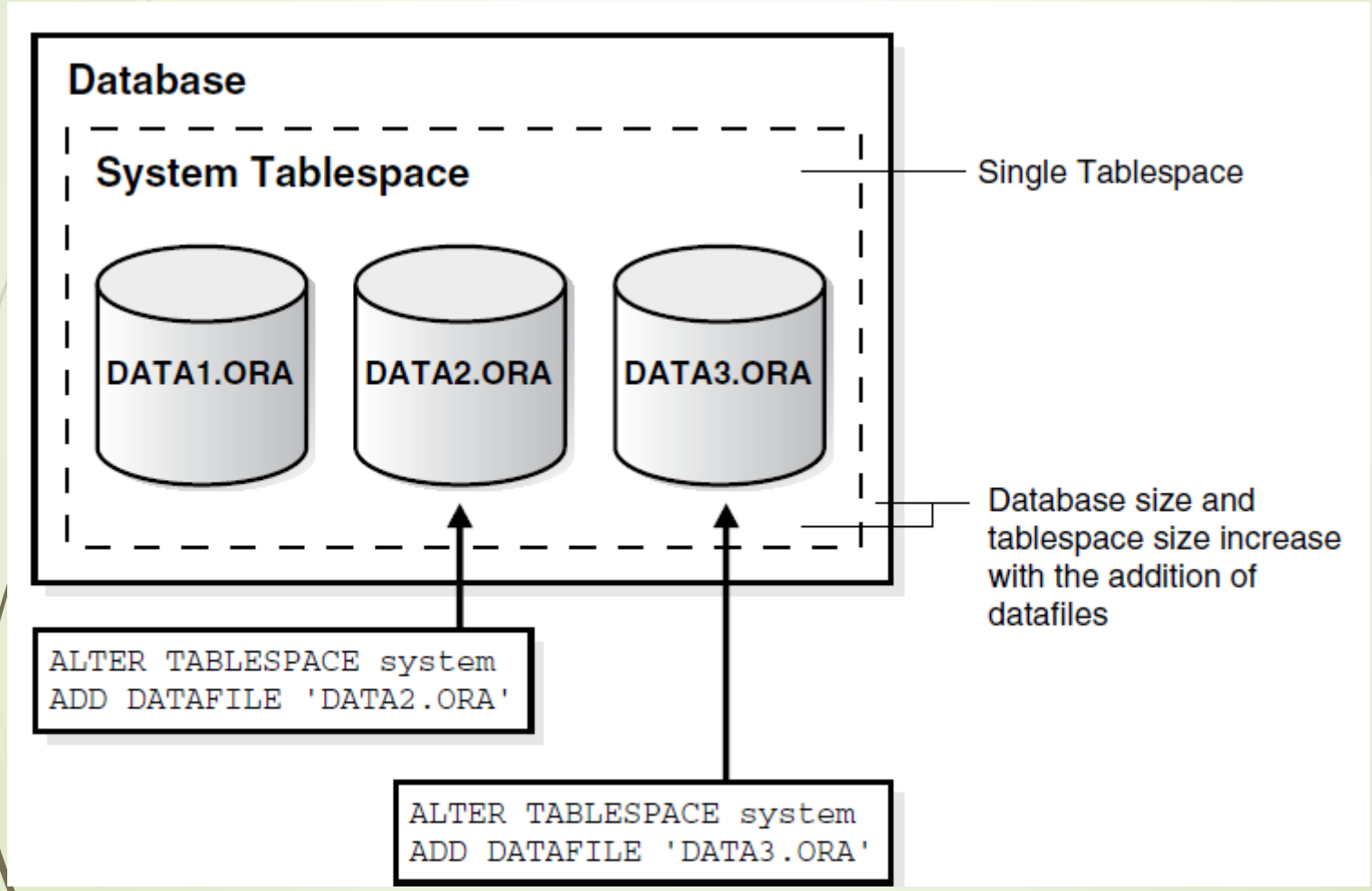
Advantages of Multiple Tablespaces

1. Control over space quotas for users
2. Better control over data availability by taking individual tablespaces online or offline
3. Perform partial database backup or recovery
4. Parallelise Queries by partitioning tables and allocating them to separate tablespaces
5. Reduce contention between objects by allocating them to separate tablespaces

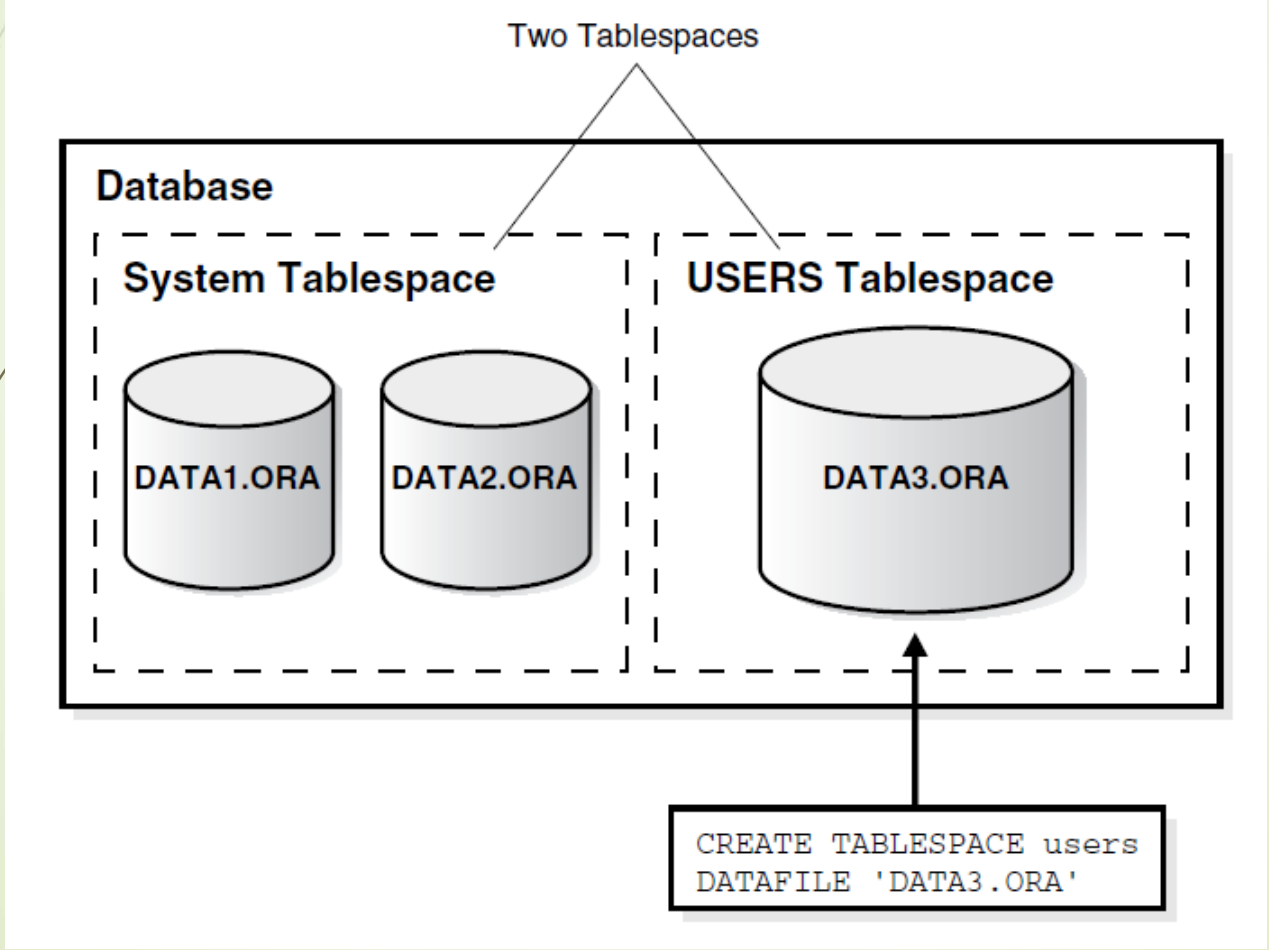
Controlling Database Size

- Tablespaces can be used to control database size in three ways:
  1. Adding a new datafile to an existing tablespace
  2. Adding a new tablespace
  3. Allowing datafiles to grow dynamically
- Choice made by DBA depending on circumstances

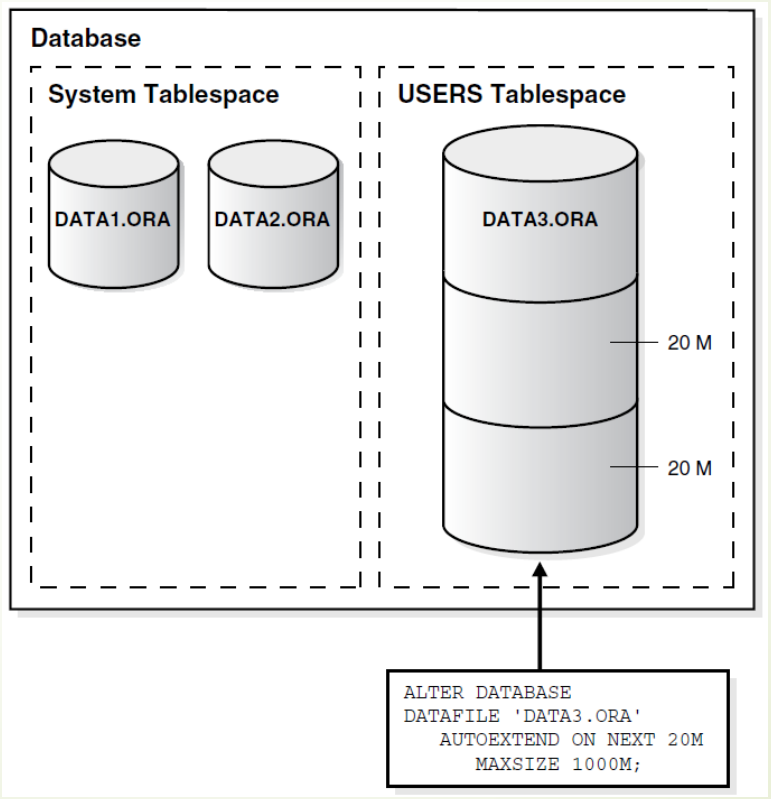
1. Adding a Datafile to a tablespace



2. Adding a new tablespace



3. Allowing datafiles to grow dynamically



Oracle's Space Management

- Oracle maintains a list of free blocks for each tablespace
- When a new extent (N blocks) is required, Oracle uses the following algorithm:
  1. Search for N+1 contiguous blocks (N, if N <5).
  2. If an exact match is not found then Oracle searches for M contiguous blocks, where M > N

     If M < N+5, then ALL blocks are allocated to new extent

     If M > N+5, allocate N to new extent and return remainder to free list
  3. If neither 1 or 2 applies, Oracle coalesces adjacent blocks (used) to release space and obtain more free blocks

References

- Oracle 11g Database Concepts – Chapters 1, 2, & 3
- Oracle 11g Administrator's Guide Chapter 8
- Chapter on Physical Database Design in "Modern Database Management", Jeffrey Hoffer et al.