INNOVATION

DATABASE ADMINISTRATION

T1. Database Server Architecture

C1: DBMS Internal Organization and SQL Processing

Plan

- 1. Overview on DBMS operational structures
  - 1.1. Database Server Generic Functions and Services
  - 1.2. Generic Memory Structures
  - 1.3. Generic Data Query Processing
- 2. Oracle Database Server Internals
  - 2.1 Oracle Instance: background processes and internal memory structures
  - 2.2 SQL Processing [Select, Update, Commit Phrases]
  - 2.3 Oracle specific storage structures
  - 2.4 Table storage
  - 2.5 Index storage
  - 2.6 Partitioning

1. Database Server Internal Organization Structures

- 1.1. Management Structures [what]
  - Generic services and functions.
- 1.2. Internal Organization Structures [who]
  - Memory Structures:
    - persistent memory (disks);
    - internal memory (active memory, caches).
  - I/O Operations - data transfer operation from/to persistent storage to/from active memory.
- 1.3. Operating DBMS. Data query processing flow [how]
  - SQL processing with I/O memory operations and in-memory processing.

1.1 Management services of DBMSs

- *Data and access management services*:
  - physical storage management;
  - I/O operation management;
  - internal memory management;
  - data query processor (SQL processor/runtime: compiling, execution plan generation, execute and coordinate I/O ops. etc.).
- *User/client Session management services*:
  - security management;
  - session management:
    - state manager for parallel sessions;
  - transaction management:
    - concurrent access manager and locking system manager.

Management services

- *Log and Recovery services* (database change/version management):
  - database change log management;
  - database backup management;
  - database recovery and restore.
- *Auditing and Monitoring services*:
  - database activity management (db object states, performance stats);
  - dynamic warning services;
  - auto-management or proactive management.

1.2 Internal organization structures: Persistent storage

- ***Physical Tables*** – storing table rows or table entries grouped into physical pages.
- ***Indexes*** – storing interconnected access-keys building access paths to reach table-rows-pointers used to access source tables by:
  - non-leaf (branch) pages storing associations between access-key and index-entry-pointers chained in tree-like access paths from root-page down to leaf-pages;
  - leaf pages storing associations between access-key and table-row-pointers.

Internal organization structures: active memory
Caching or transient memory

- **Data pages** (with table/index rows) could reside in two memory spaces:
  - active or transient memory space (internal memory);
  - inactive or persistent memory space (internal storage).

- **Active memory** consists in some caching systems with specialized buffers (at least) for:
  - data buffers storing table and index data pages;
  - transactional log buffers.

I/O Transfer Operations

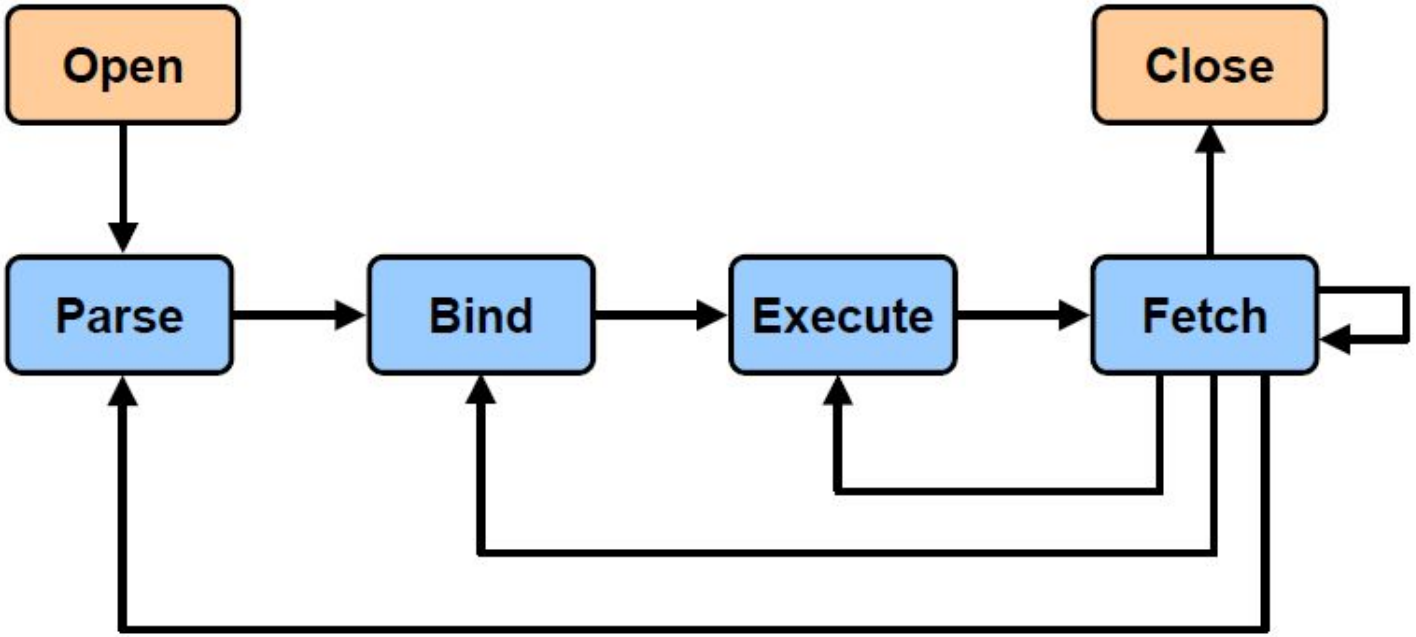
Read/Write Operations

- **I/O Operations**:
  - ensure data **availability**: transferring data pages from persistent storage to internal active buffers;
  - ensure data **durability**: saving data from active buffers to persistent storage.
- **I/O operations** consist in 2 main categories:
  - **random** operations: starting with random search to locate (first) data page from internal storage (disk) and loading it into active memory (expensive access op.);
  - **sequential** operations: loading next sequential data pages beyond first page location (a more efficient access op.).

1.3. SQL Processing

- Stages:
  - **SQL phrase compiling**:
    - syntactic and semantic analysis;
    - execution plan generation;
      - determine eligible access path;
      - evaluate access path;
      - determine temporary cursors;
      - determine processing operations on temporary cursors;
  - **plan execution***;*
  - **sending query execution results**.

SQL Statement Processing Phases



2. ORACLE Database Server Internals

- 2.1 Structures of Oracle Instance
  - Server Processes
  - Background Processes
  - Internal Memory
- 2.2 Oracle Instance life cycle
  - Starting and stopping stages
  - Oracle Instance Data Query Processing
- 2.3 Oracle Database Storage Structures
  - Data Files
  - Tablespaces
  - Blocks and extents
  - Data Segments

2.1 Oracle Instance Structures: *Processes*

- **Server Processes:**
  - user/client session management;
  - pairing with client application processes;
  - SQL processing flow control;
- **Background processes:**
  - I/O operation management, working with data files, operation logs, log archives (DBWR, LGWR, ARCH);
  - versioning and data file synchronization with database current state (CHKP, SMON);
  - controlling concurrent data access (LOCKn);
  - monitoring consistency and recovering of database state (SMON);
  - monitoring server processes and resource allocation (PMON).

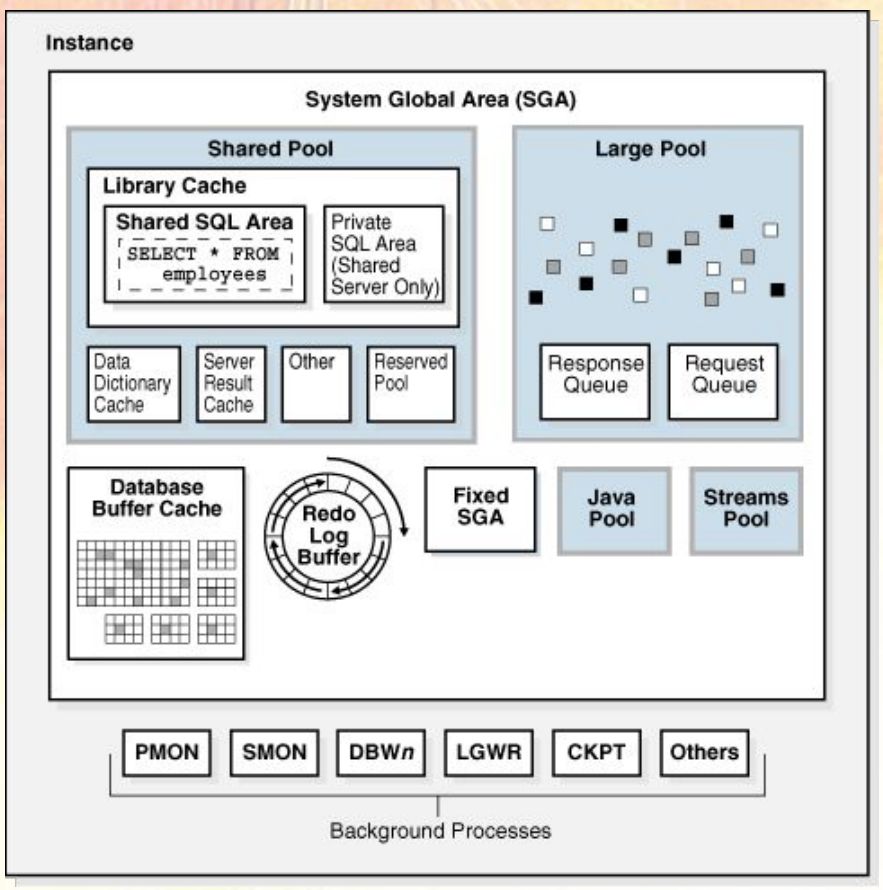
Oracle Instance Structures: *Active Memory*

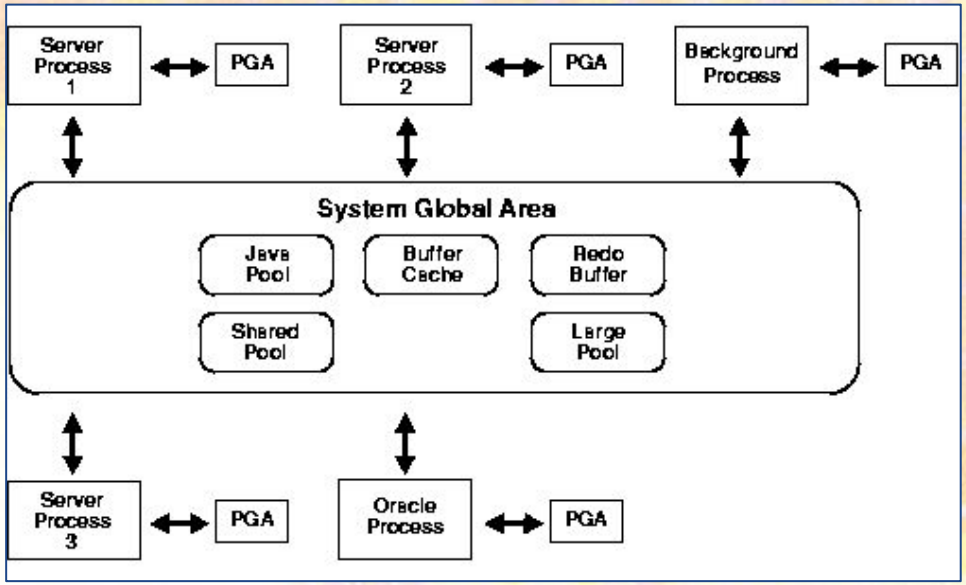
- **Oracle buffer-cache system** consists in:
  - shared memory **SGA -** System Global Area:
    - database buffer cache;
    - redo log buffer;
    - shared pool - buffering SQL processing artifacts:
      - storing SQL text and execution plan into library cache;
      - storing catalog data invoked in SQL compilation phase into data dictionary cache;
  - private/program exclusive memory **PGA** - Private/Program Global Area:
    - private memory space for each individual active session.

Oracle Instance Structures: *Oracle Files*

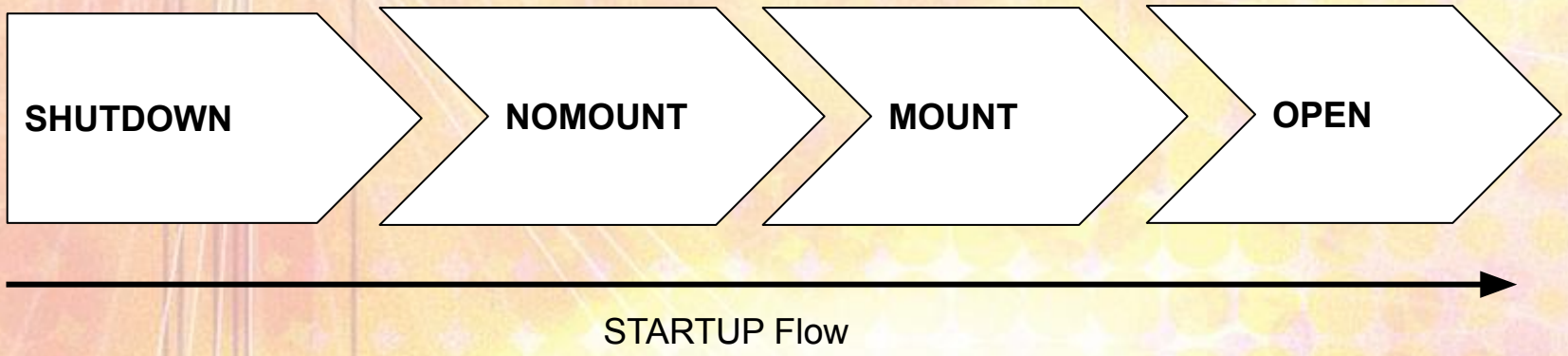
- Data Files
- Log Files
- Control Files
- Parameter Files
- Archive Log Files

Oracle Instance Functional Structures



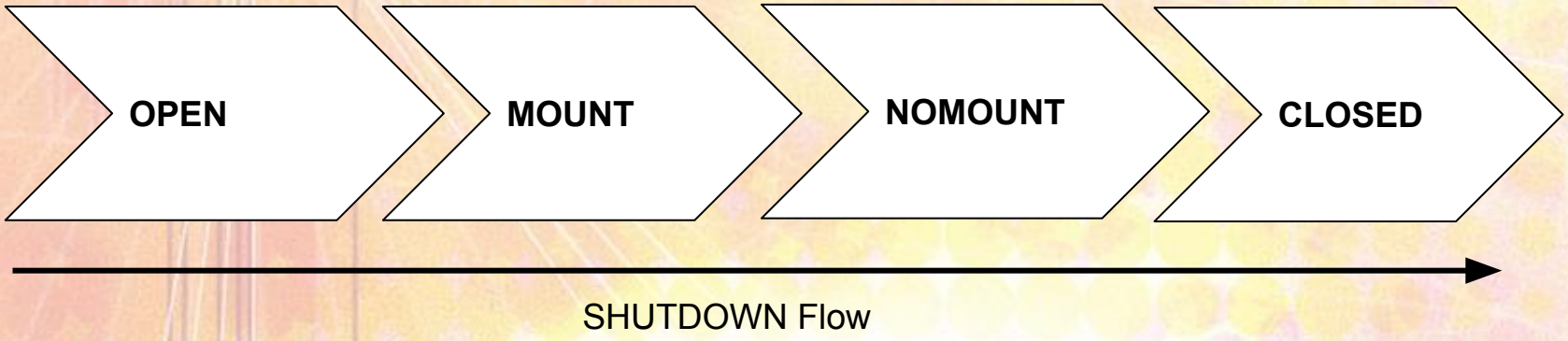


2.2 Instance Lifecycle and SQL Processing



- SHUTDOWN
- NOMOUNT: open/read parameter file;
- MOUNT: open/read control file;
- OPEN: open/read data files.

Stopping Oracle Instance



- OPEN: instance is up, synchronizing and closing data files;
- MOUNT: synchronizing and closing control files;
- NOMOUNT: closing buffers and releasing processes;
- CLOSED: all files are closed, all memory structures are down.

*

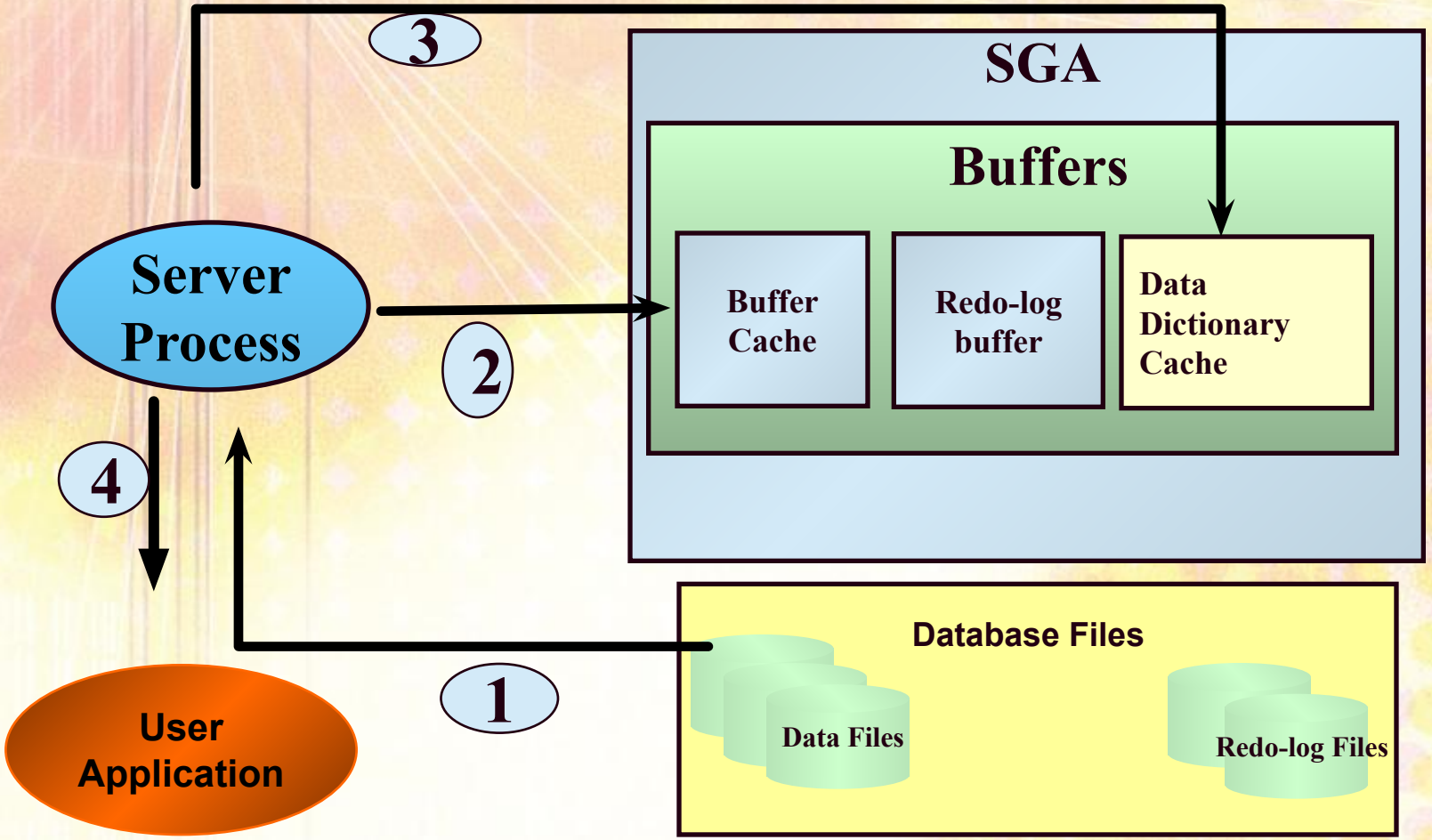
*

Practice C1_P1

Script	Topics
C1_P1.1.sqlplus_startup.sql C1_P1.2.start-ORCL11GR2.bat C1_P1.3.stop-ORCL11GR2.bat	Shutdown and Startup process
C1_P1.4.Memory_SGA_PGA_Config.sql	Oracle Instance Memory Parameters

SELECT Query Processing/Execution

```
SELECT * FROM angajati WHERE marca=7369 FOR UPDATE...
```



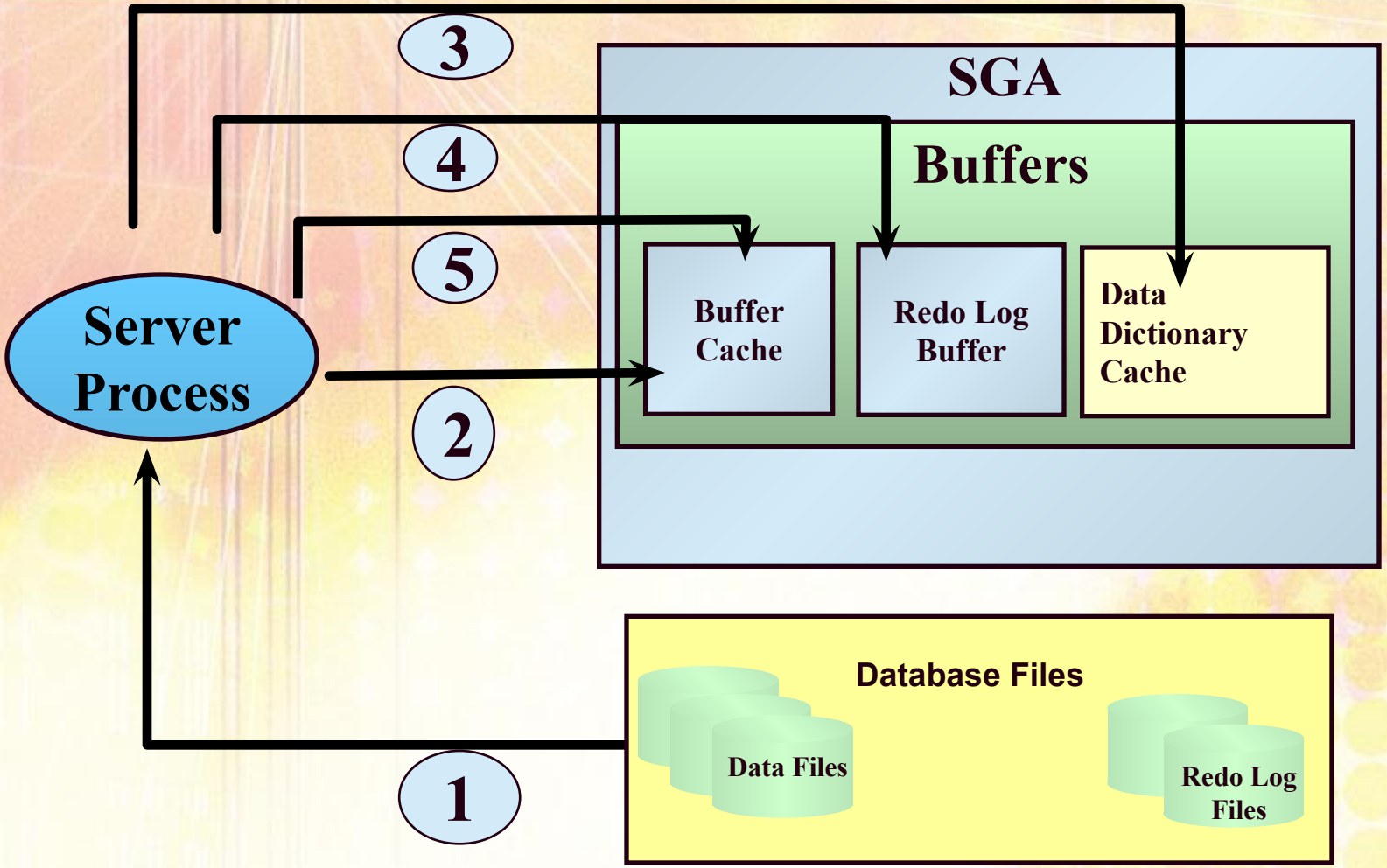
SQL Query Processing

- Preparing steps:
  - *establishing disk location to read table rows* – determining block addresses (physical addresses);
  - *checking data blocks availability in buffer cache*.

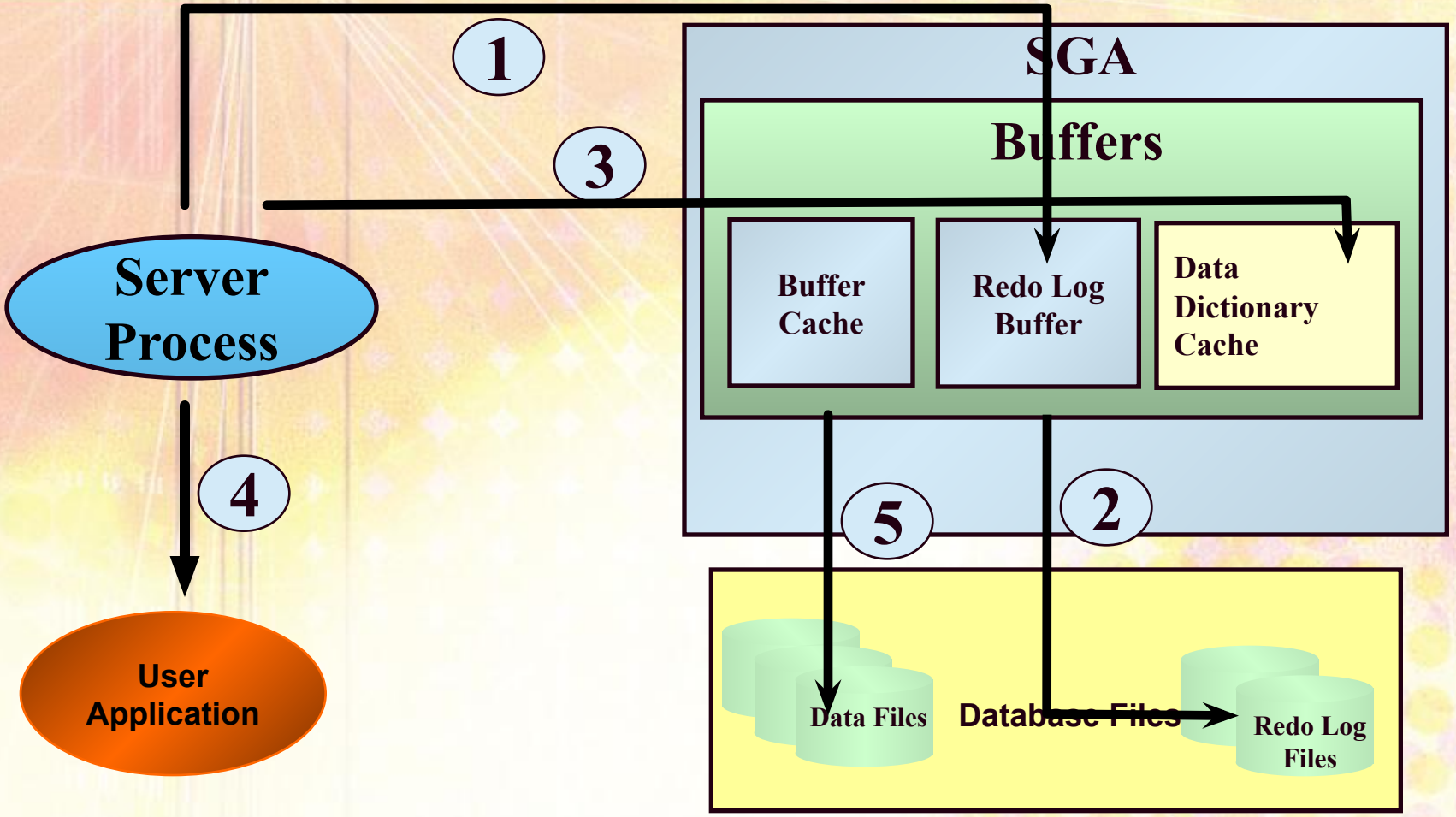
1. Read data blocks from data files.
2. Transfer data blocks into buffer cache.
3. Set locks in data dictionary (FOR UPDATE clause).
4. Send result set to user application.

DML Query Processing - UPDATE

```
UPDATE angajati SET sal=sal*1.1 WHERE marca=7369
```



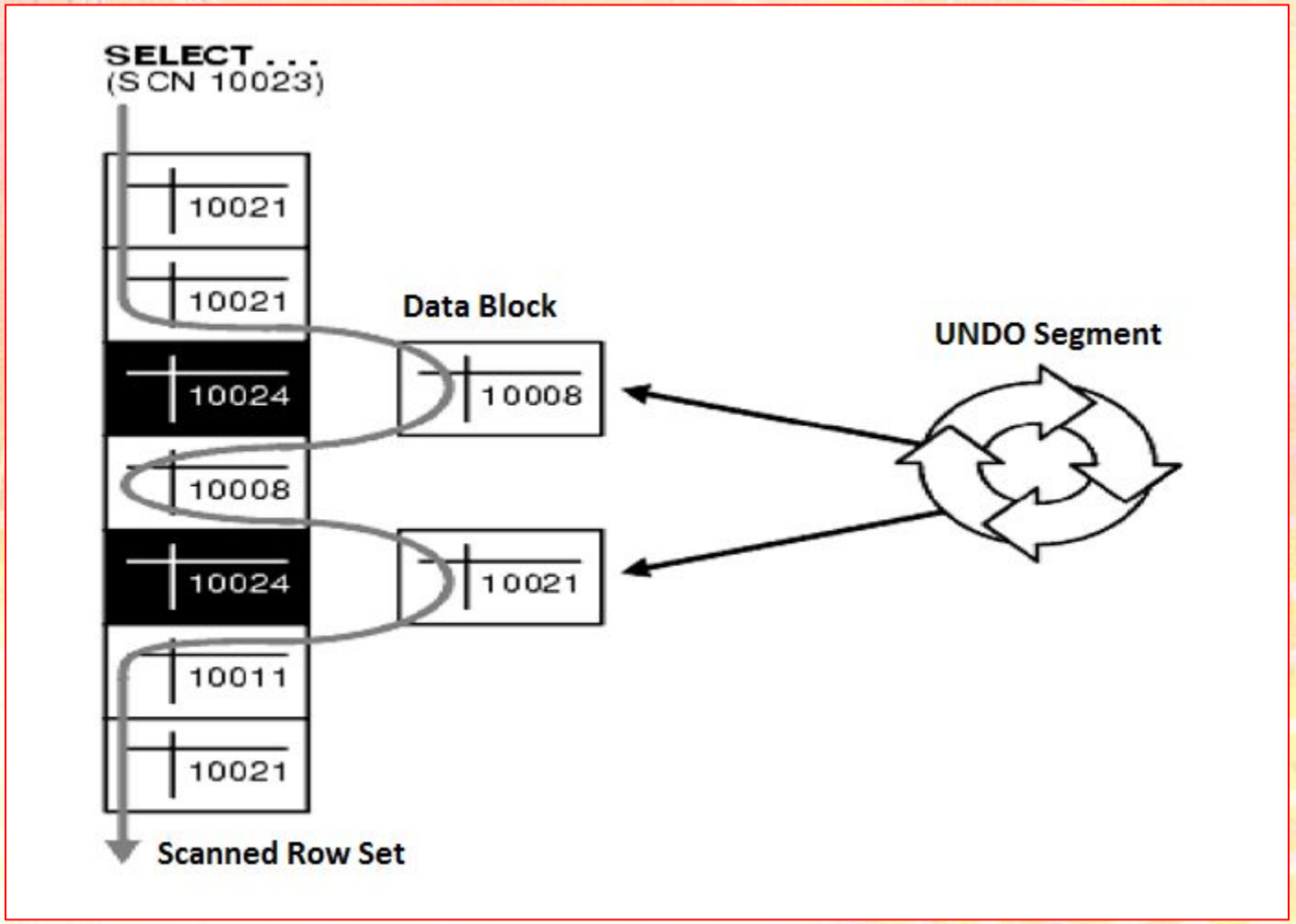
COMMIT Processing



Other support structures for SQL Query Processing

- **Redo-log files/groups:**
  - record user transactions
- **Undo segments:**
  - record database states before DML changes.

UNDO segments role in SELECT query processing



Practice C1_P2

Script	Topics
C1_P2.1.Base_Schema_CREATE_USER.sql C1_P2.2.Base_Schema_CREATE_TABLE_HEAP.sql C1_P2.3.Base_Schema_INSERT.sql	Create test schema and initial data objects
C1_P2.4.Buffers_Content_SELECT_STAT.sql	Instance Internal Buffers: statistics and configuration SQL Activity

References

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