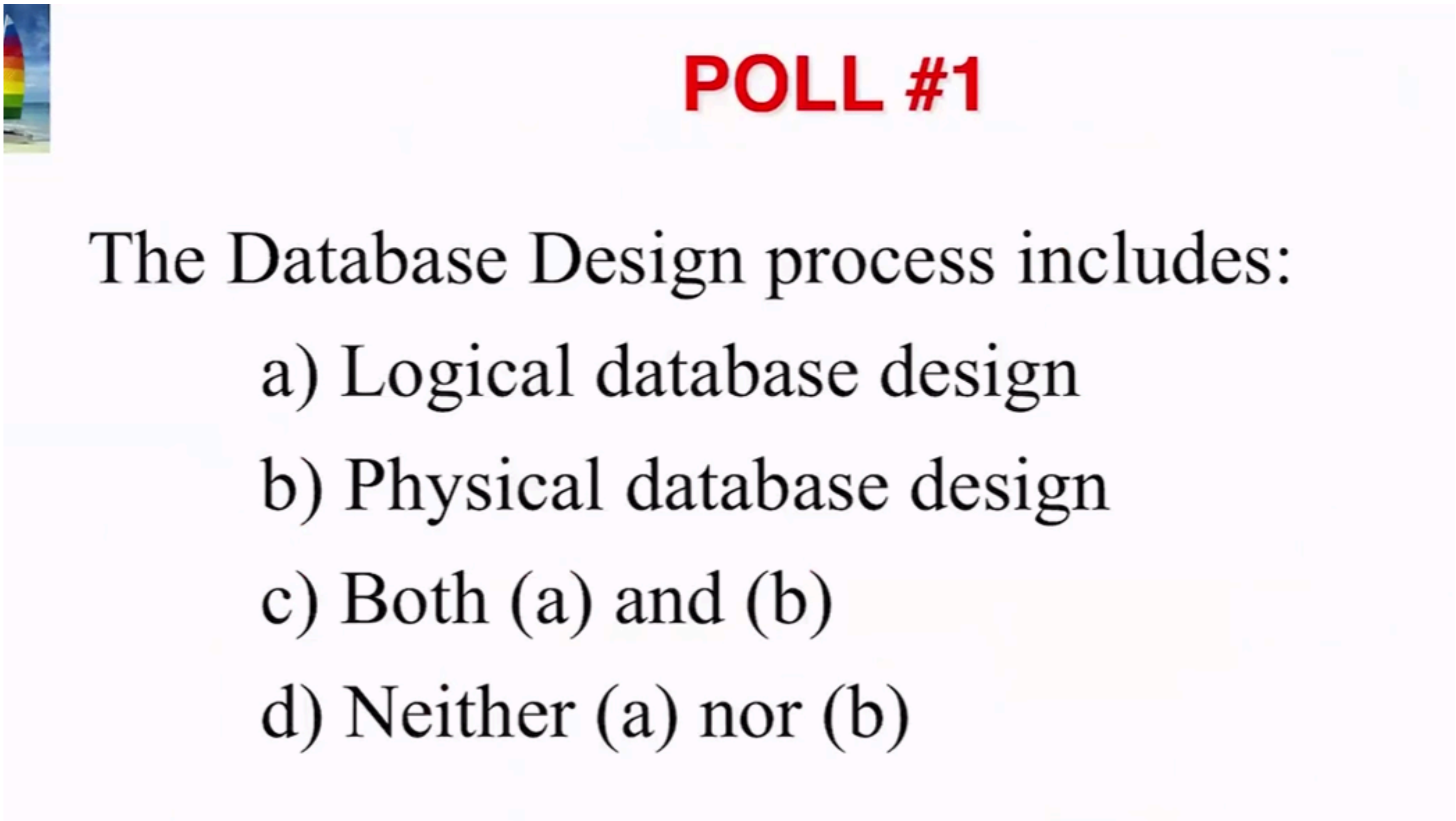
Topic 1 Polls



POLL #1

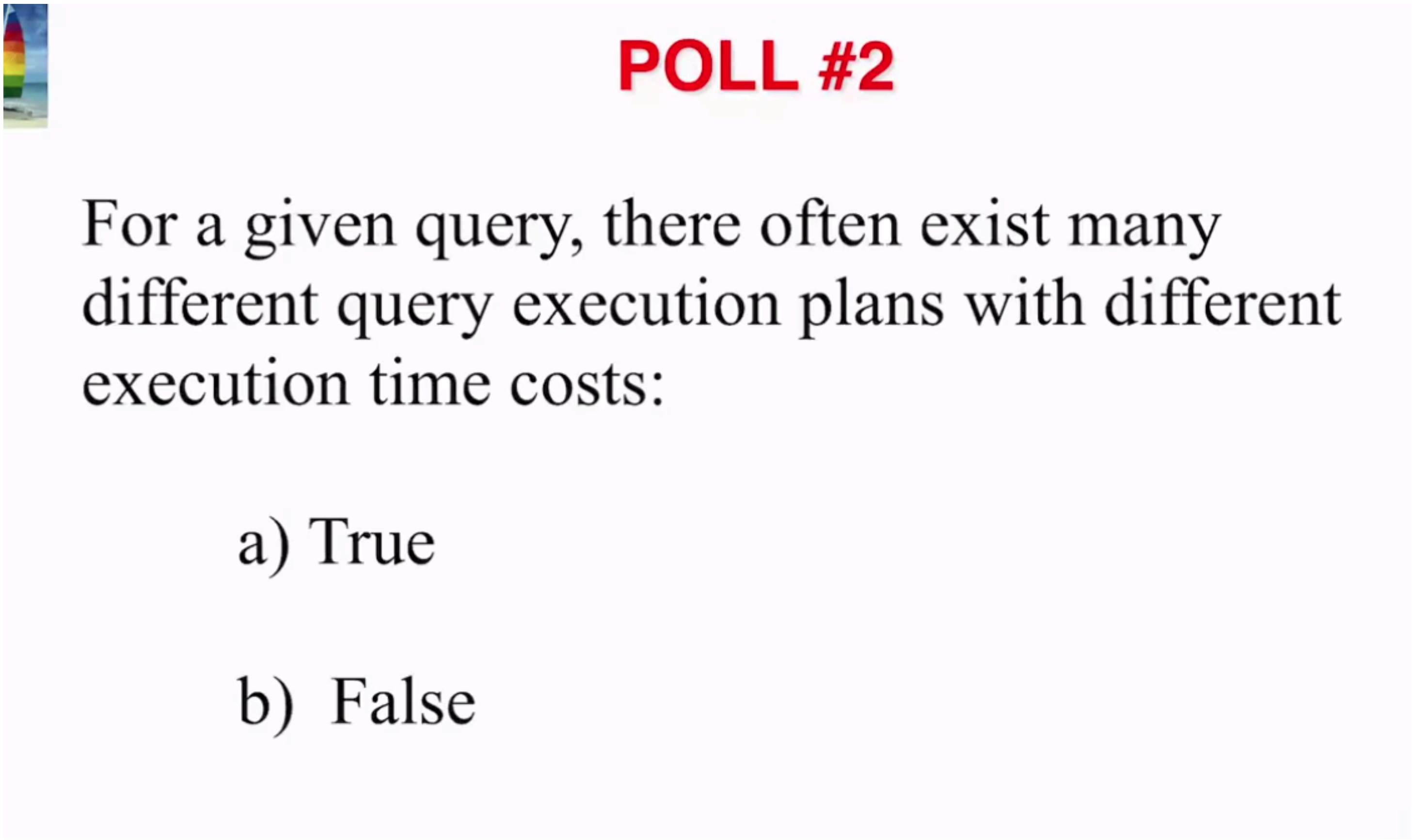
The Database Design process includes:

a) Logical database design

b) Physical database design

c) Both (a) and (b)

d) Neither (a) nor (b)

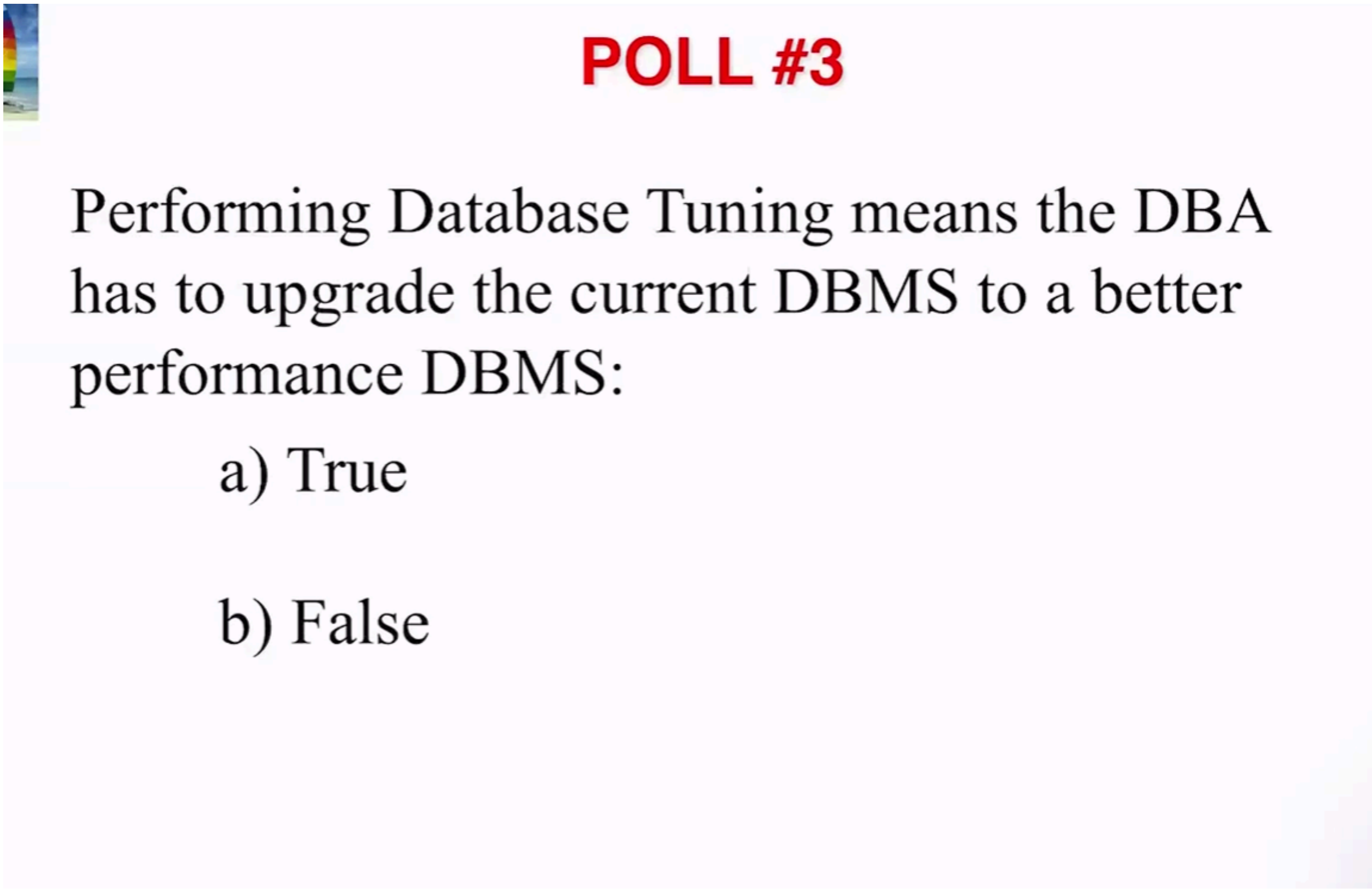


POLL #2

For a given query, there often exist many different query execution plans with different execution time costs:

a) True

b) False



POLL #3

Performing Database Tuning means the DBA has to upgrade the current DBMS to a better performance DBMS:

a) True

b) False

Lecture 1

Topic 1: Basic Concepts of a Database Management System

What is a database?

Databases have the following properties:

- Repository of interrelated data.
- Efficient environment for fast queries with minimal resource usage.
- Accessible via application programs for data access and modification.

Why don't we just use file systems to store all of the data?

Design Principles

- **Redundancy, Inconsistency**
  Multiple file formats often lead to duplicated information without built-in constraints. Implementing these constraints must be done manually in applications like Java, JS, or Python.
- **Separation of Concerns**
  Database integrity can suffer without clear separation. For instance, preventing negative values (e.g., `GPA > 0`) should be enforced in the database, not just in application code.

Functionality of pre-existing DBMSes

- **Concurrent access by multiple users**
  Uncontrolled access can lead to data inconsistencies, such as conflicts when two users edit the same data. DBMSs use **concurrency control** to manage this.
- **Security concerns**
  A pre-existing DBMS allows easier control of access to sensitive data.
- **Graceful failures**
  Modern DBMSs only update data if an operation is successful. Without a DBMS, this would need to be manually coded, risking partial updates if a failure occurs.

Levels of Abstraction

These are written in order of lowest level to highest level.

- **Physical level**
  Describes how records are stored (e.g., hash files, sequential files).
- **Logical level**
  Defines data relationships and data types.
- **View level**
  Application programs interact with the DBMS.
  - Security: Conceals information through application interfaces (e.g., JDBC).
  - Abstracts data type details; SQL queries are written as **procedures** in SQL, which can be accessed via libraries like JDBC in Java applications.

Lecture 2

Data Models

A set of **tools** for describing:

- Data via data types
- Relationships between data
- Semantics, including schema and table design
- Constraints (e.g., prevent negative integers, enforce fixed string lengths)

Relational Model

- **Table:** A set of columns (attributes) with each row representing values.
- **Columns:** Attributes of a table.
- **Rows:** Values corresponding to each column.

Data Definition Language (DDL)

The language for defining tables in a DBMS, with SQL being the most common.

Data Dictionary

- Generated by a **DDL compiler**; contains table "templates."
- Templates include **metadata** such as:
    - **Integrity constraints**
        - Primary key
        - Data type constraints
        - Database schema (attributes and relationships, not data)
    - **Permissions**
        - Who can modify or read the data?

SQL

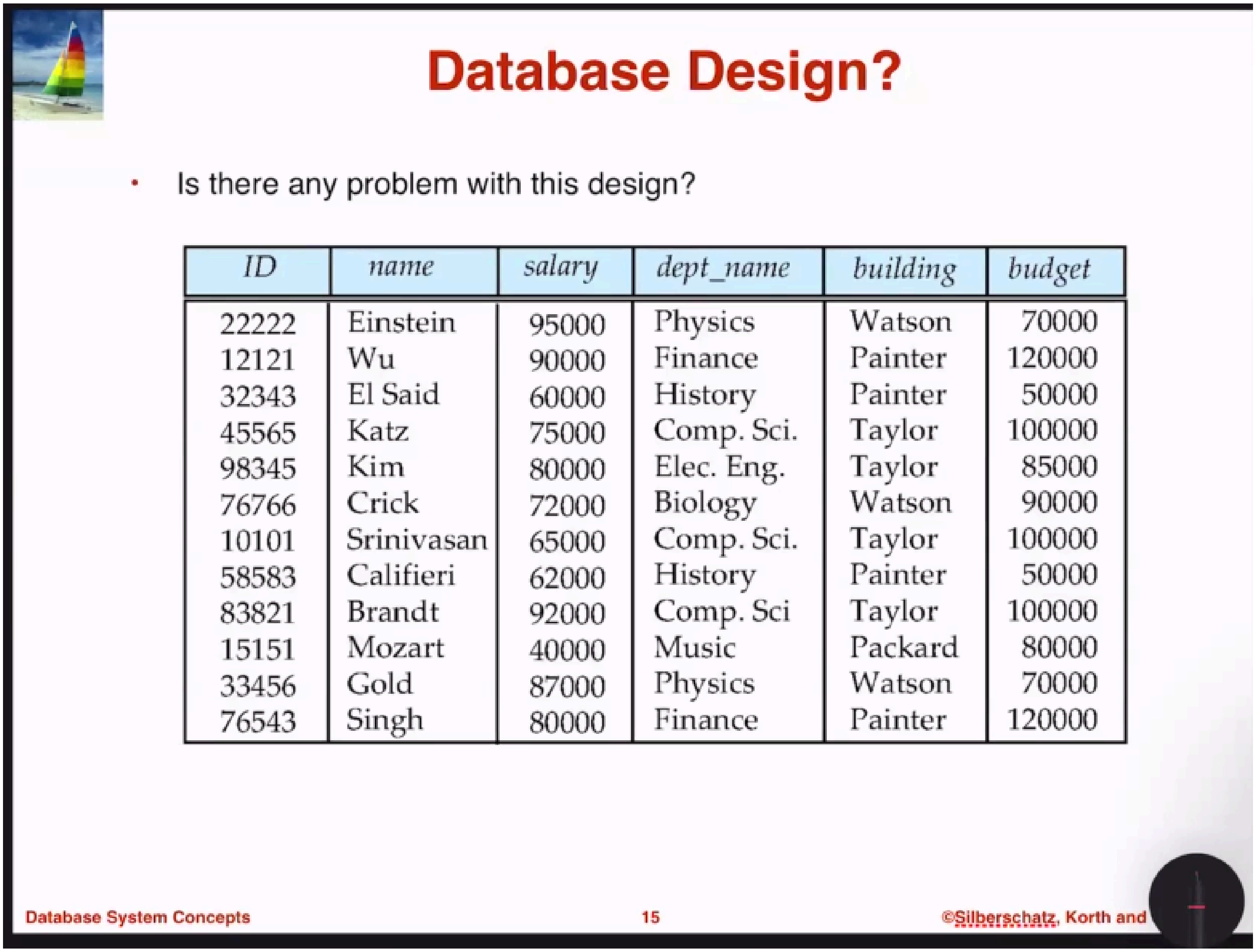
SQL Table Creation

```sql
create table instructor (
  ID char(5),
  name varchar(20),
  dept_name varchar(20),
  salary numeric(8,2)
)
```

SQL Retrievals

```sql
select name
from instructor
where instructor.ID = 22222
```

Database Design



Database Design?

- Is there any problem with this design?

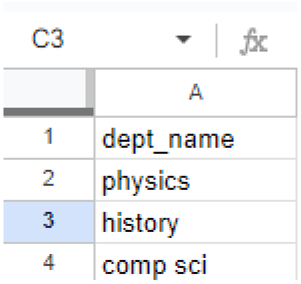
ID	*name*	*salary*	*dept_name*	*building*	*budget*
22222	Einstein	95000	Physics	Watson	70000
12121	Wu	90000	Finance	Painter	120000
32343	El Said	60000	History	Painter	50000
45565	Katz	75000	Comp. Sci.	Taylor	100000
98345	Kim	80000	Elec. Eng.	Taylor	85000
76766	Crick	72000	Biology	Watson	90000
10101	Srinivasan	65000	Comp. Sci.	Taylor	100000
58583	Califieri	62000	History	Painter	50000
83821	Brandt	92000	Comp. Sci	Taylor	100000
15151	Mozart	40000	Music	Packard	80000
33456	Gold	87000	Physics	Watson	70000
76543	Singh	80000	Finance	Painter	120000

Database System Concepts 15 ©Silberschatz, Korth and

Problem: Data redundancy in the `dept_name` column (e.g., "Physics" appearing multiple times). Modifying a department name requires changing it everywhere, making this design inefficient, though it supports queries like:

```
select name
from table1
where dept_name = "Physics"
```

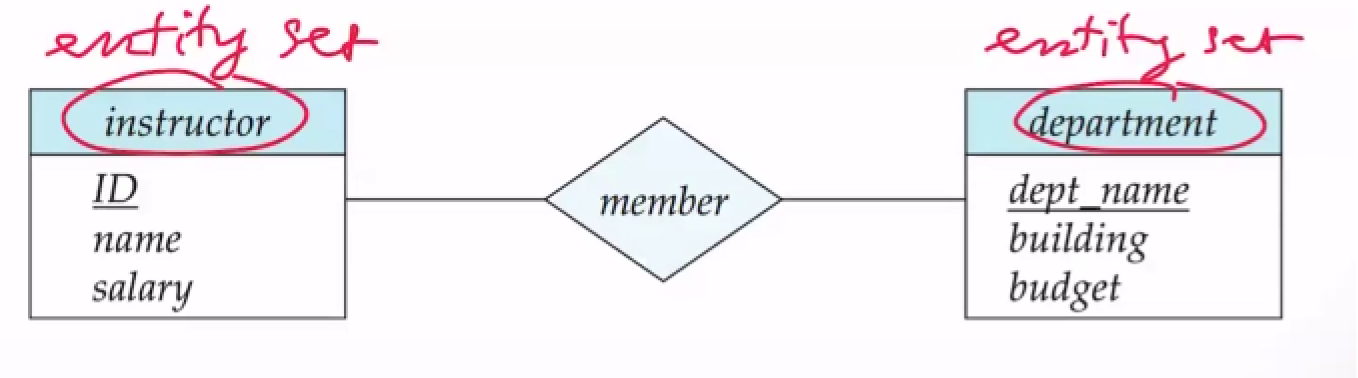
Proposed Solution: Create a `department` table to store `dept_name` uniquely.



	A
1	dept_name
2	physics
3	history
4	comp sci

Response: Redundancy still exists in the `budget` column. Separating `dept_name` risks losing essential relationships for queries.

Entity-Relationship Model



Relationship Set

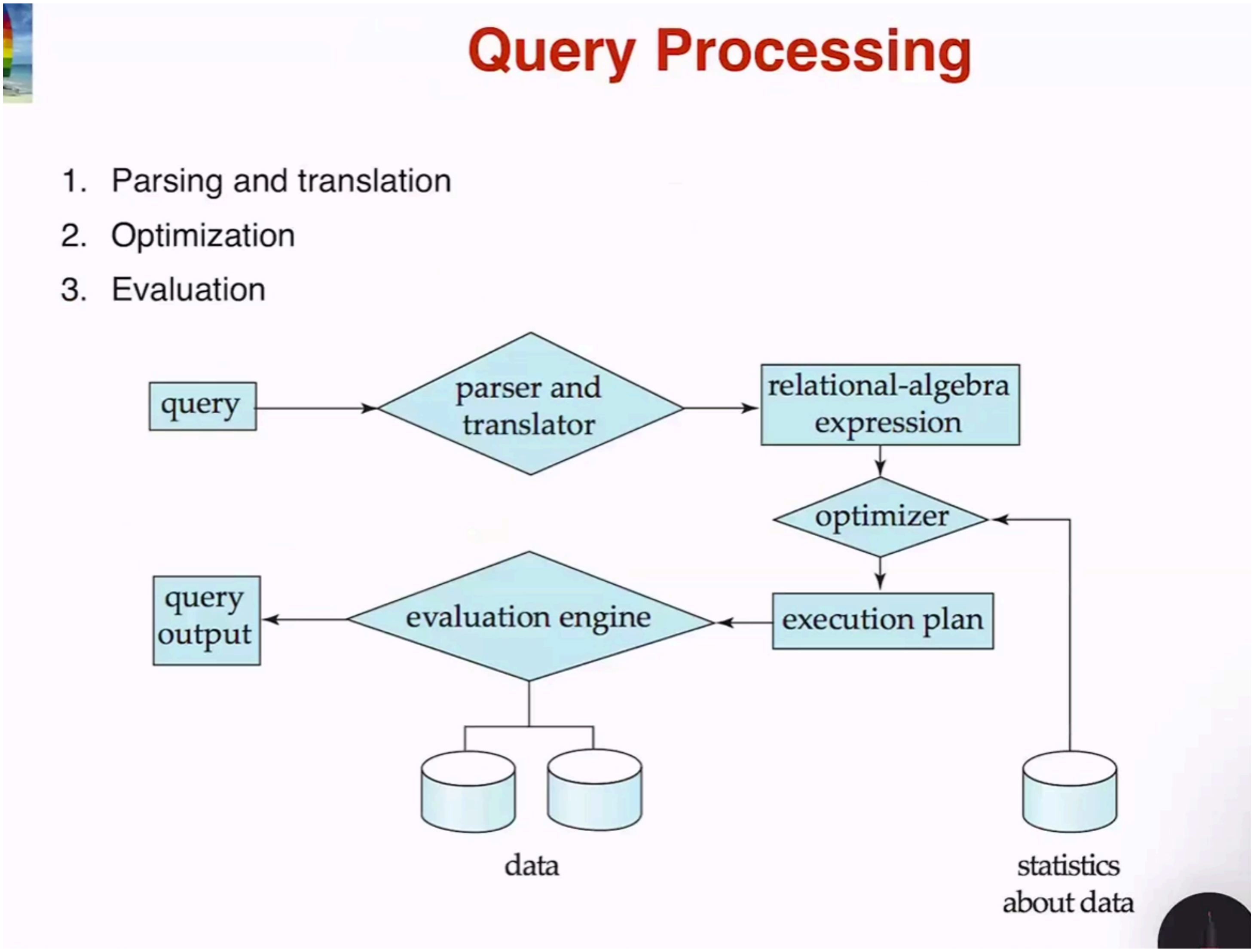
- Represented by a diamond; typically tables in SQL.

Entity Set

- Represented by a rectangle.
- Primary key is a unique identifier; non-underlined attributes are normal.
- Also represented as tables in SQL.

Query Processing

1. Parsing and translation
2. Query optimization
   - Creates an execution plan, choosing the one with the smallest execution time.
3. Query evaluation



Query Processing

1. Parsing and translation
2. Optimization
3. Evaluation

Transaction Management

Transaction: A set of operations performing one logical function in the DB application.

Purpose

Transaction management component:

- Ensures graceful failure if a query fails.

Concurrency control manager:

- Maintains database consistency during concurrent updates.

Database Administrator (DBA)

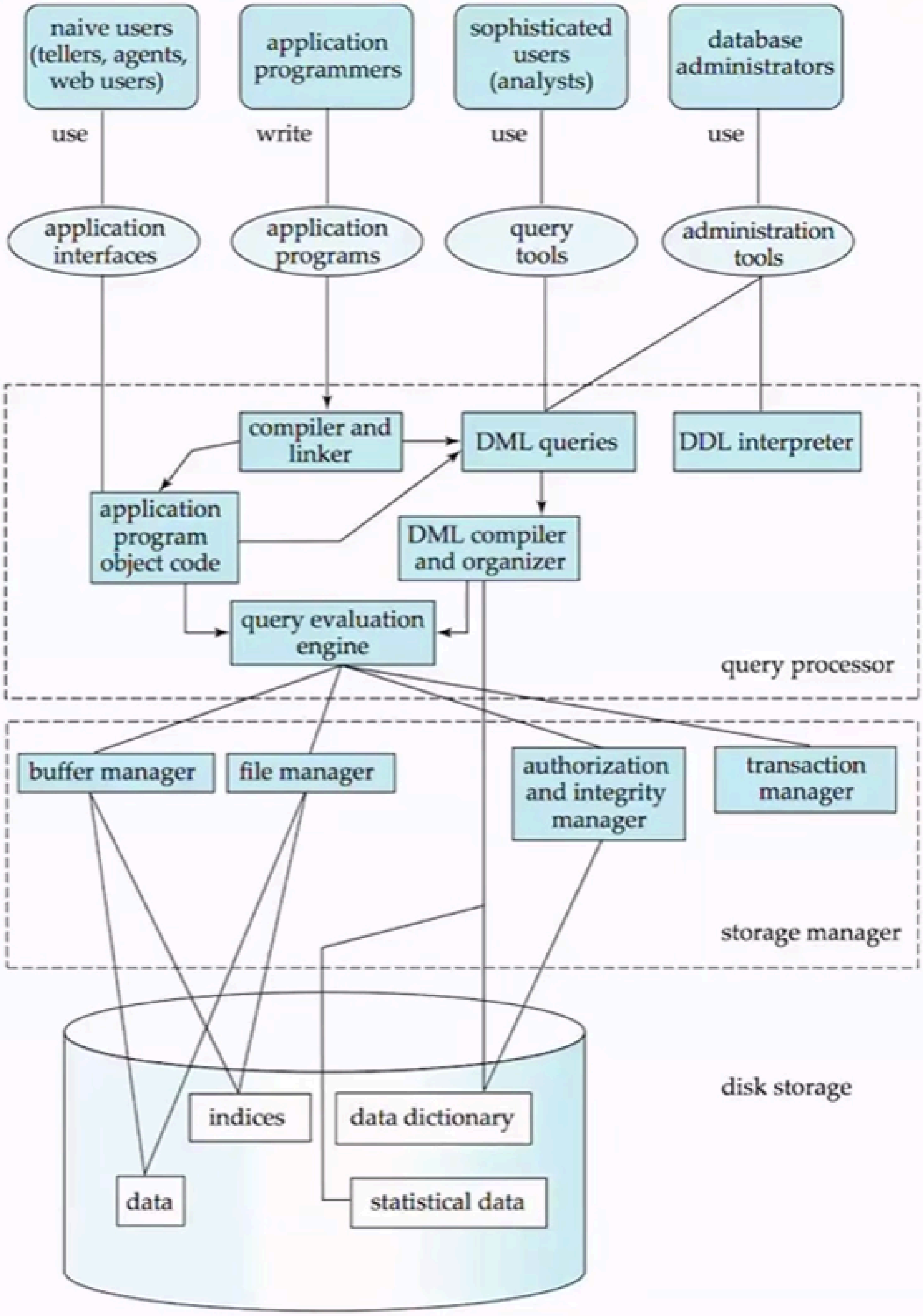
Responsible for:

- Defining schema (tables for relationships and entities).
- Defining logical and physical storage structure.
- Authorizing user access and modification permissions.
- Maintaining the DB (backups, optimizations, upgrades).
- Monitoring database performance.

Overview of the abstractions previously listed

Some sections remain unexplained, but DBA, query processing, storage manager, and disk storage aspects have been covered.

Database System Internals



Lecture 3

Database architecture

- **Centralized** *(the focus here)*: A single server stores the database, accessible from various devices.
- **Parallel (multi-processor)**: The database is stored on multiple units for concurrent query processing.
- **Distributed**: Parts of the database exist on multiple servers, but altogether are still one database.

When not to use a DBMS

Sometimes, a file system is preferable.

- **Overhead**
    - Concurrency control, recovery, and integrity checks are resource-intensive.
    - High entry barriers: employee training, software licenses, hardware costs.
    - A DBMS is a comprehensive package for general operations; many tools may go unused.
- **Additional problems**
    - Poor design or maintenance of the database can create issues absent in file system implementations.

Other Indications

- The database and application are simple, well-defined, and stable.
- Time-critical applications may require faster query responses than a general DBMS can provide, favoring file systems.
- Only one user, or multi-user access doesn't impact the filesystem.

Overall, handling data doesn't always necessitate a DBMS.