

**NOVA**

**IMS**

Information  
Management  
School

# Storing and Retrieving Data

Lecture 2

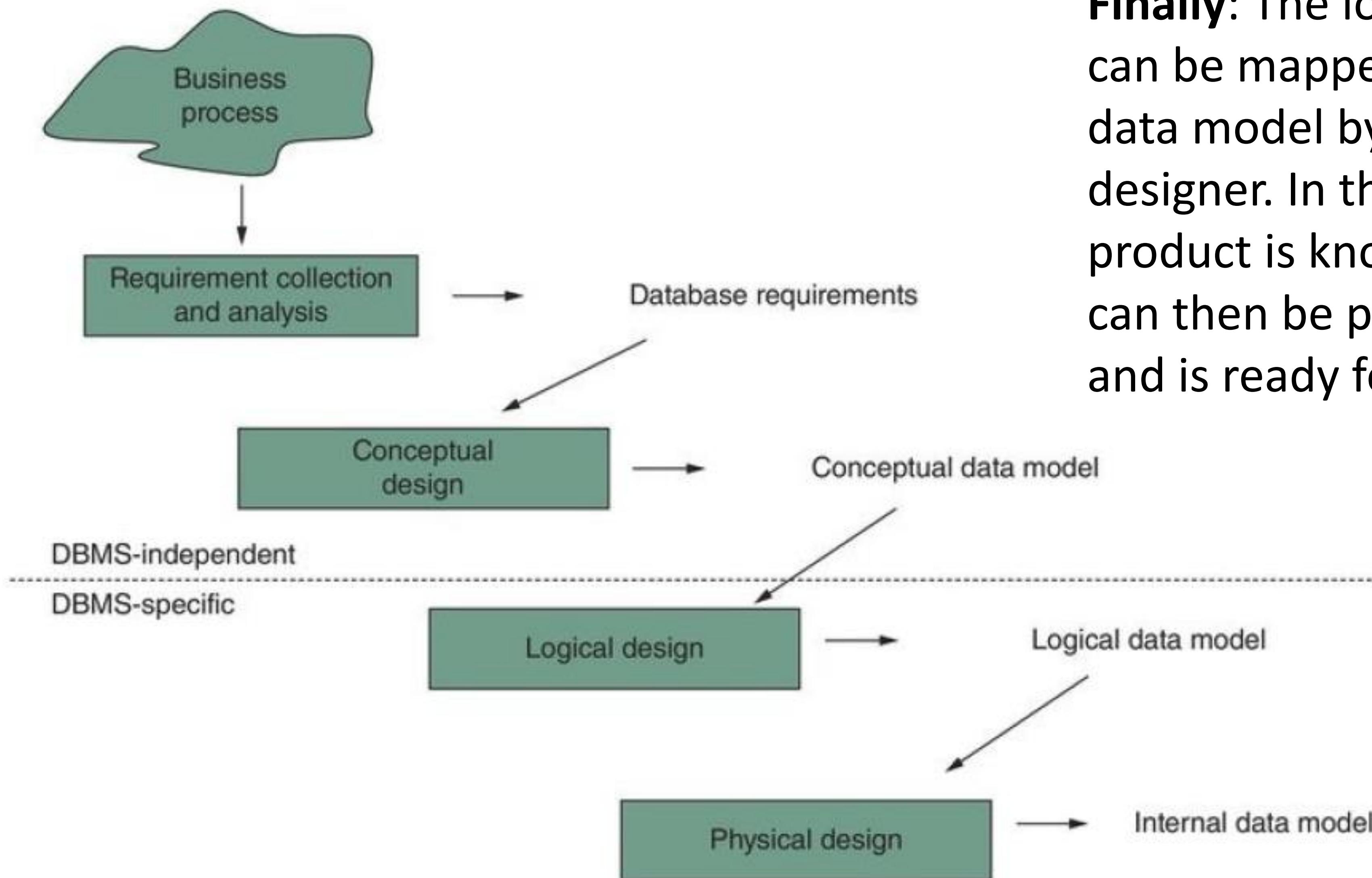
Database modelling

Lecturer: Mijail Naranjo Zolotov  
Email: mijail.naranjo@novaims.unl.pt

# Previous class

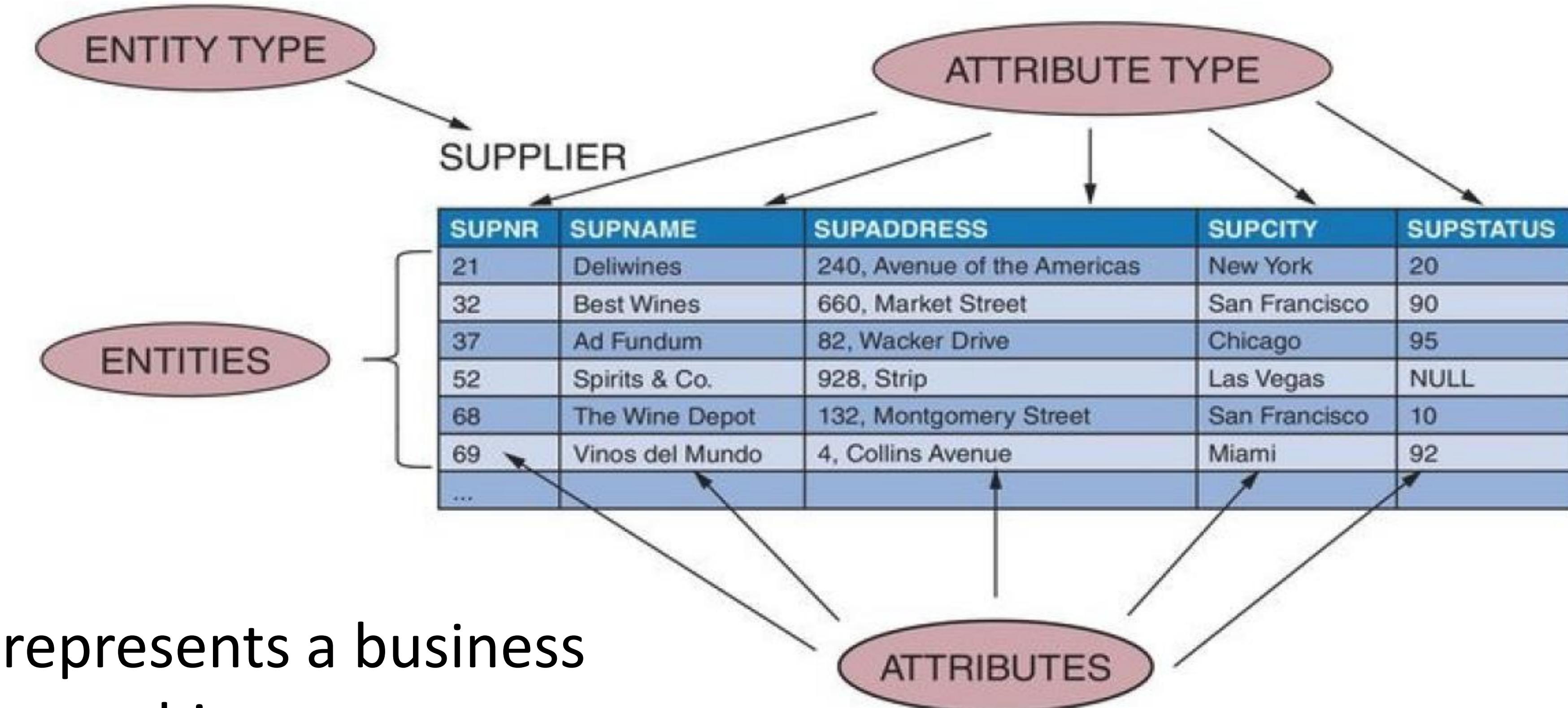


# The database design process



**Finally:** The logical data model can be mapped to an internal data model by the database designer. In this step, the DBMS product is known. The database can then be populated with data and is ready for use.

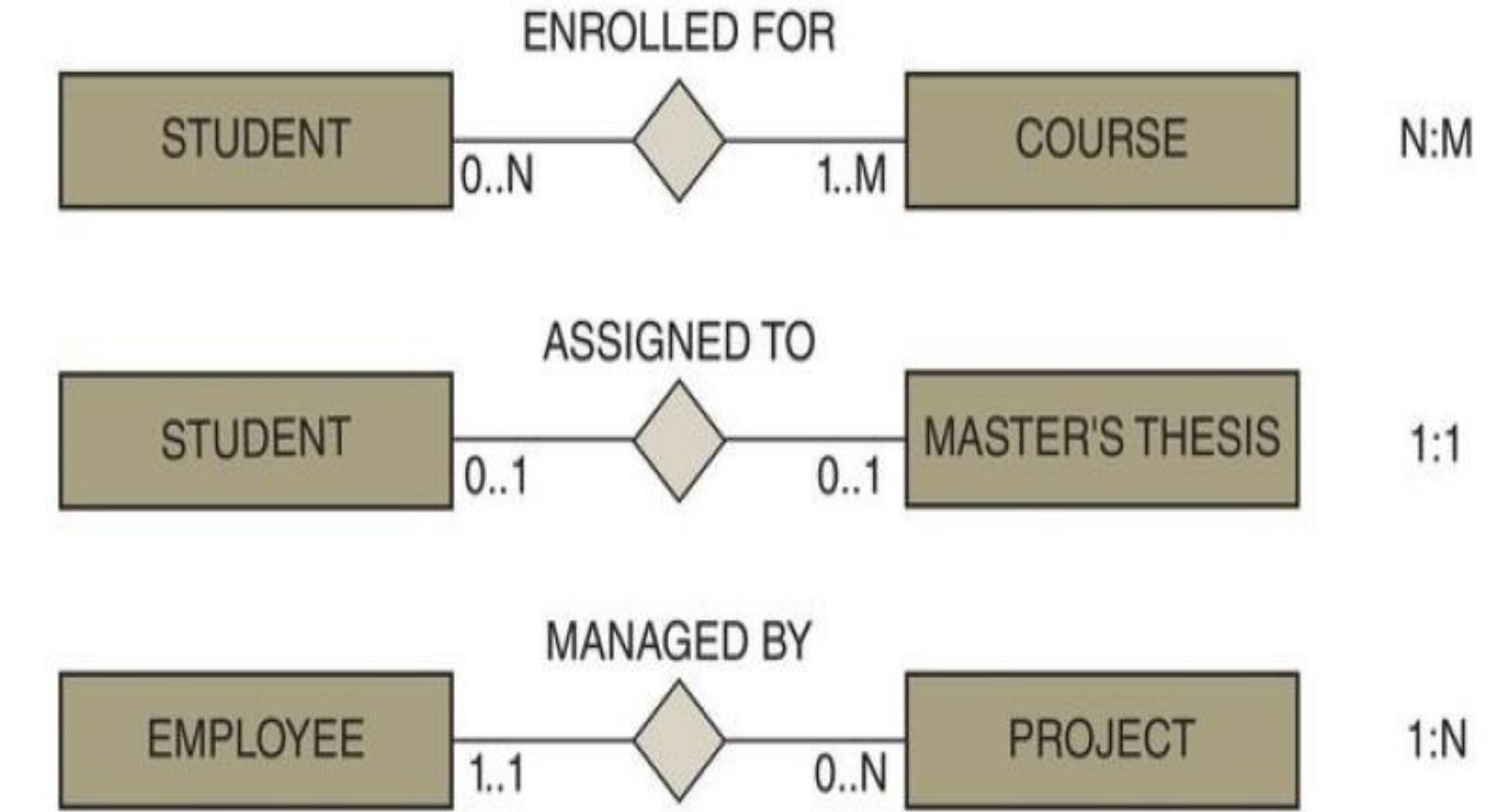
# The entity relationship model



An **ENTITY TYPE** represents a business concept with an unambiguous meaning to a particular set of users.  
Examples?

# Cardinalities

Every relationship type can be characterized in terms of its cardinalities, which specify the minimum or maximum number of relationship instances that an individual entity can participate in.

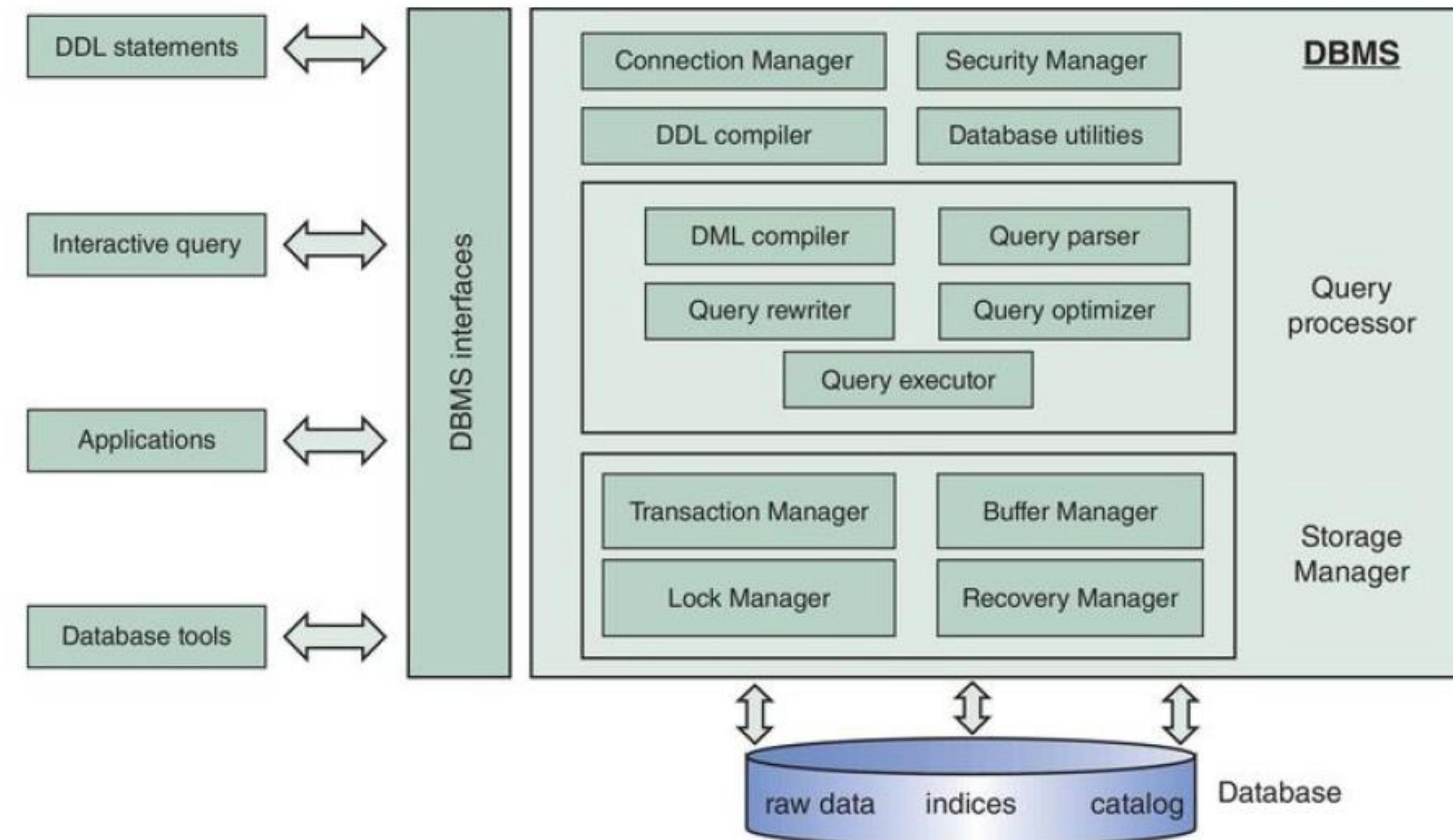


Example: A student is **enrolled for** 1 or M courses

- DBMS Architecture
- Entity Relationship Diagram (ERD)
- Crow's foot notation

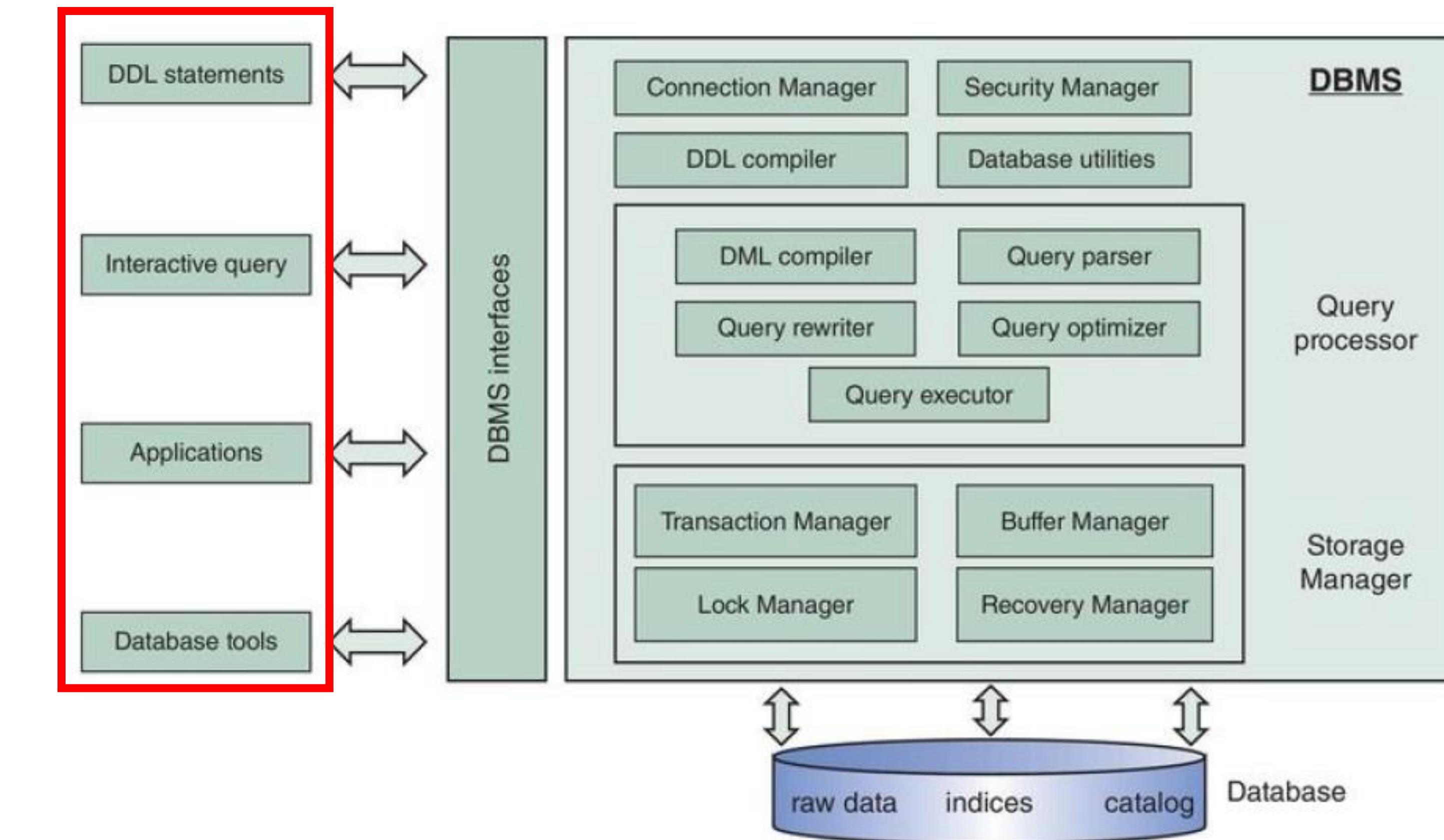
# DBMS Architecture

# Architecture of a DBMS



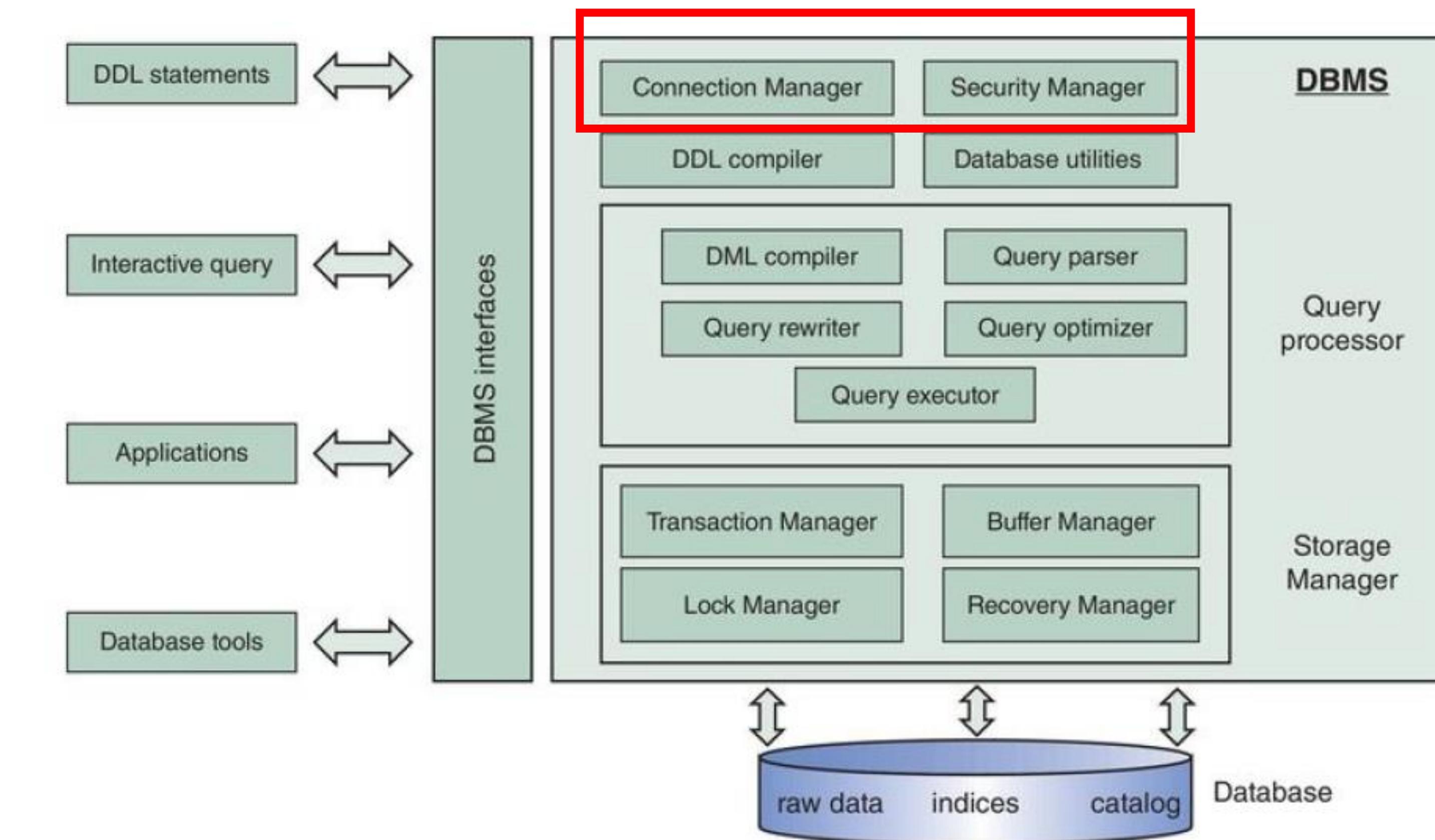
# Architecture of a DBMS

Various ways of interacting with the DBMS. Command line interface, form-base interface, tools to maintain of fine-tune the DBMS.



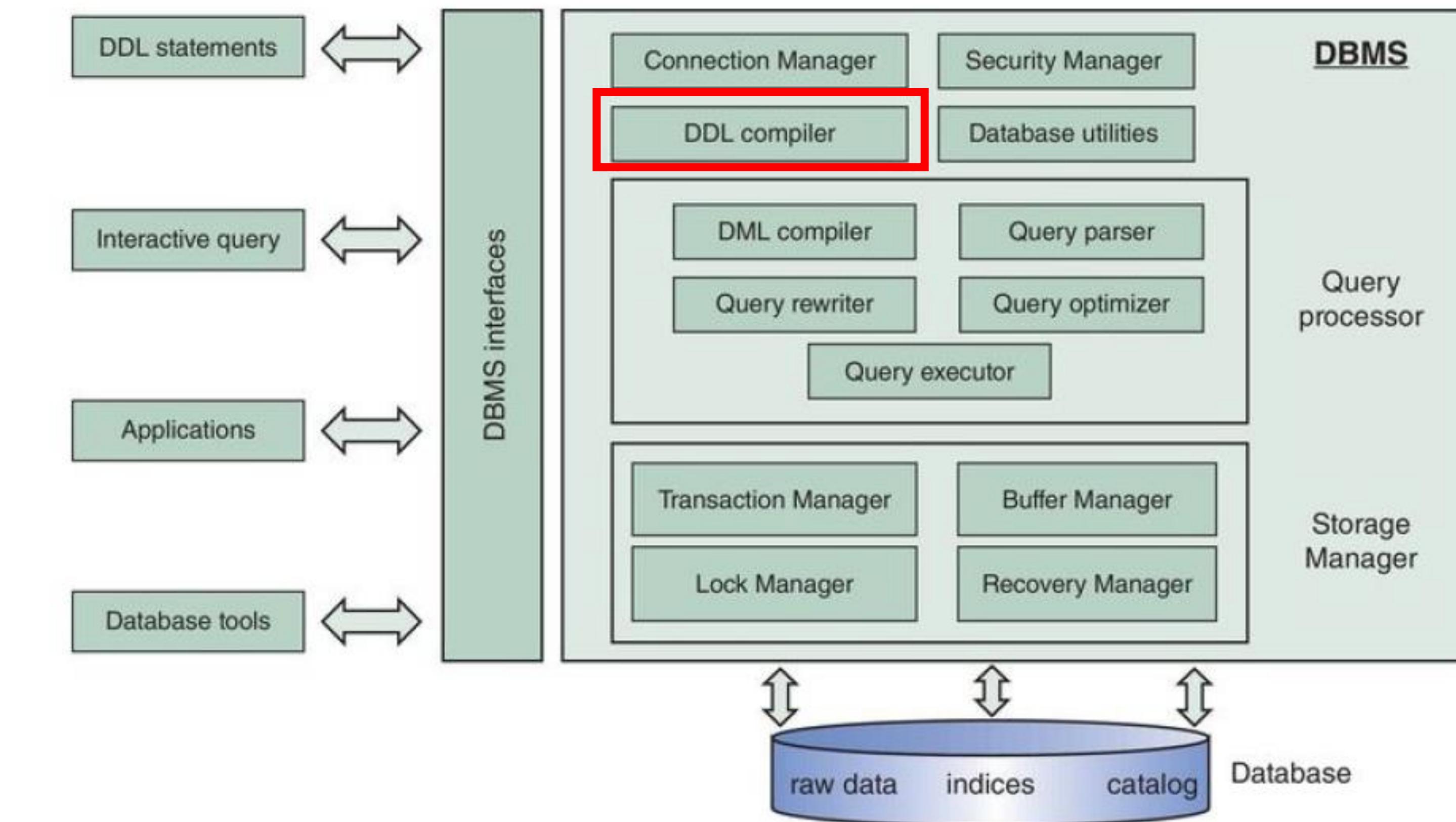
# Architecture of a DBMS

The **connection manager** provides facilities to set-up a database connection. It can be set-up locally or through a network. The **security manager** verifies whether a user has the right privileges to execute the database actions required.



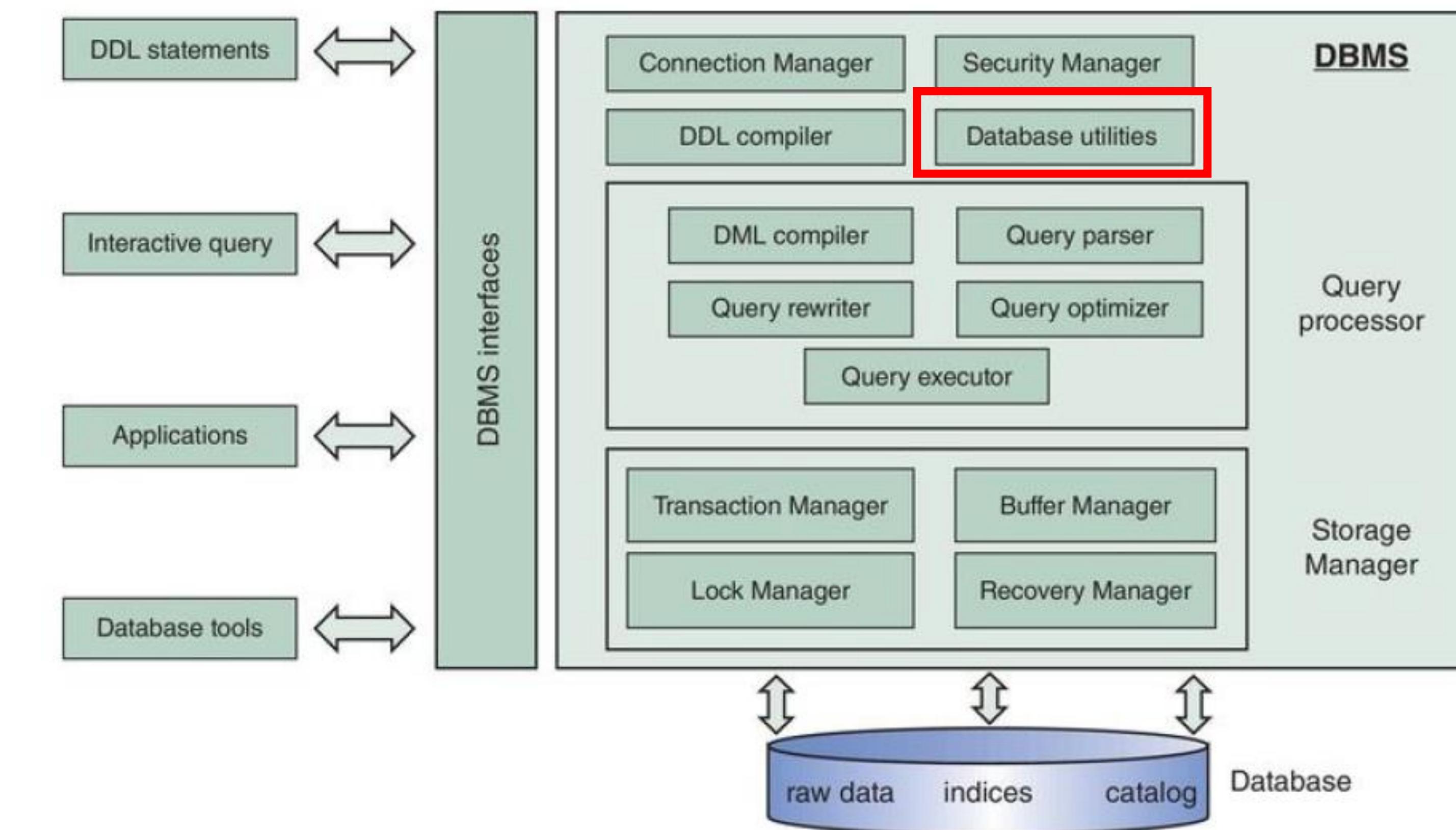
# Architecture of a DBMS

The **Data Definition Language (DDL) compiler** compiles the data definitions specified in DDL. Most relational databases use SQL as their DDL.



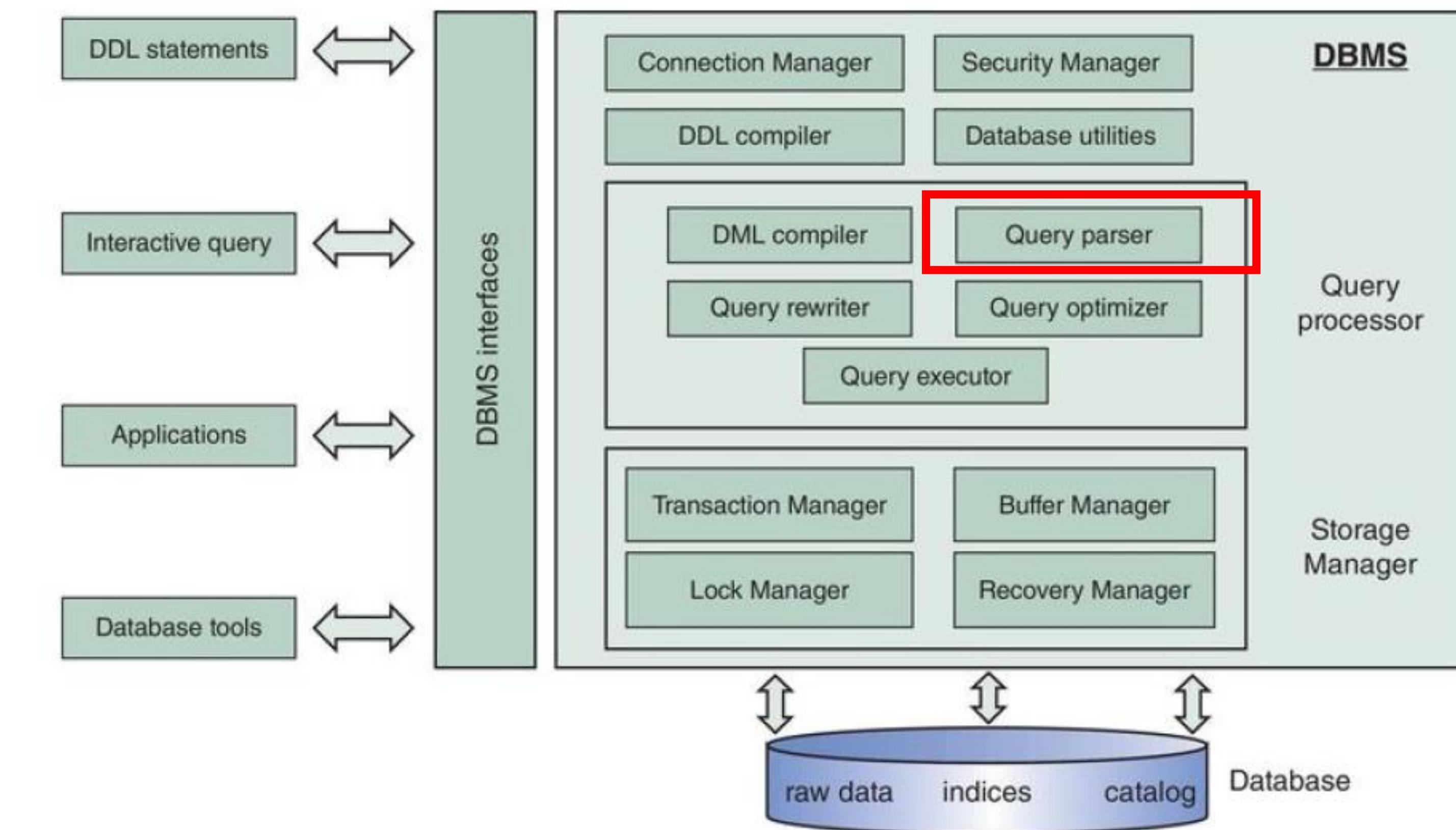
# Architecture of a DBMS

Various utilities, example: A loading utility (load data from a variety of sources), reorganization utility (reorganizes the data), user management utilities (support the creation of user groups or accounts), etc.



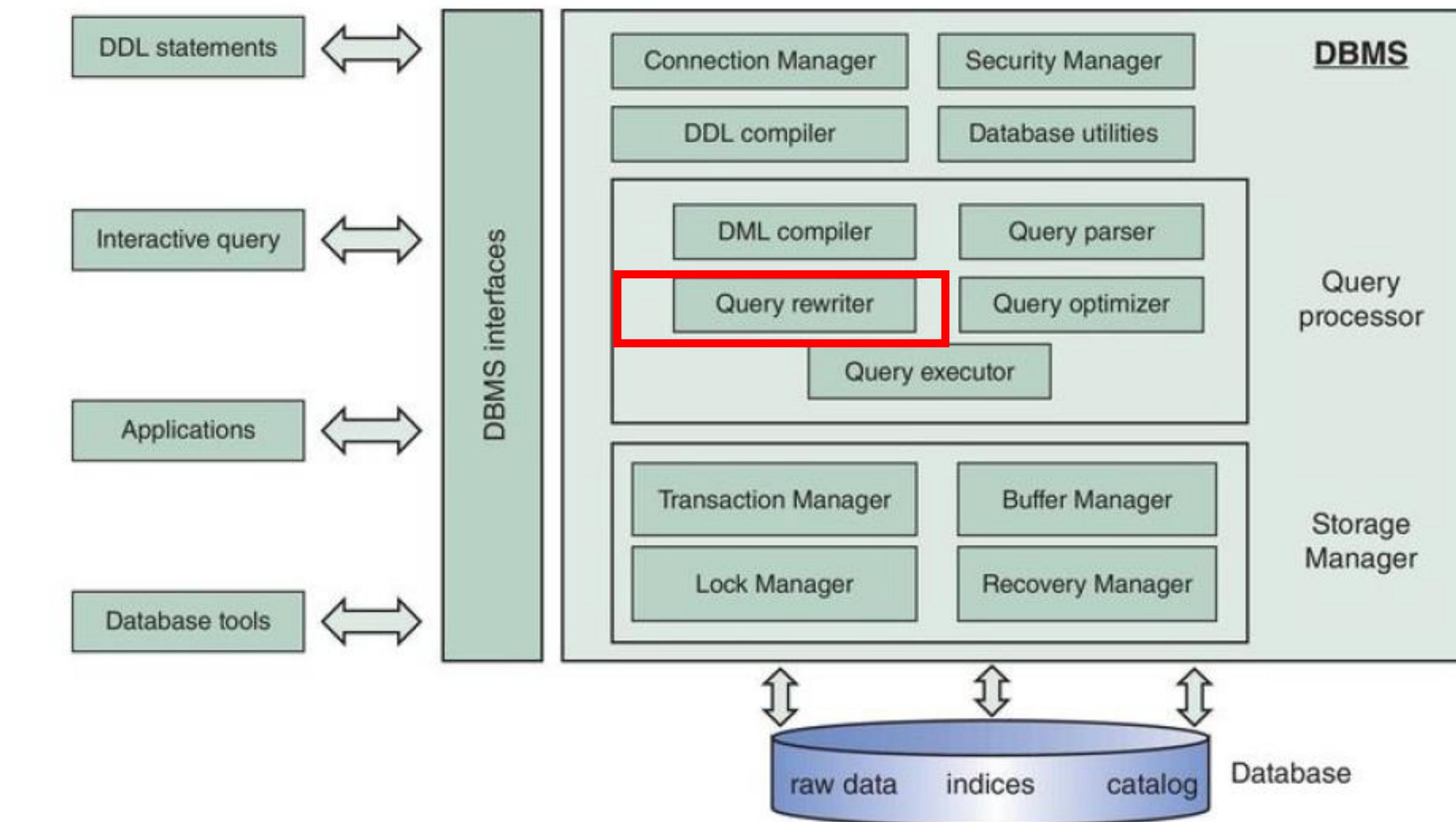
# Architecture of a DBMS

The **query parser** parses the query into an *internal representation format* that can then be further evaluated by the system. It checks the query for syntactical and semantical correctness.



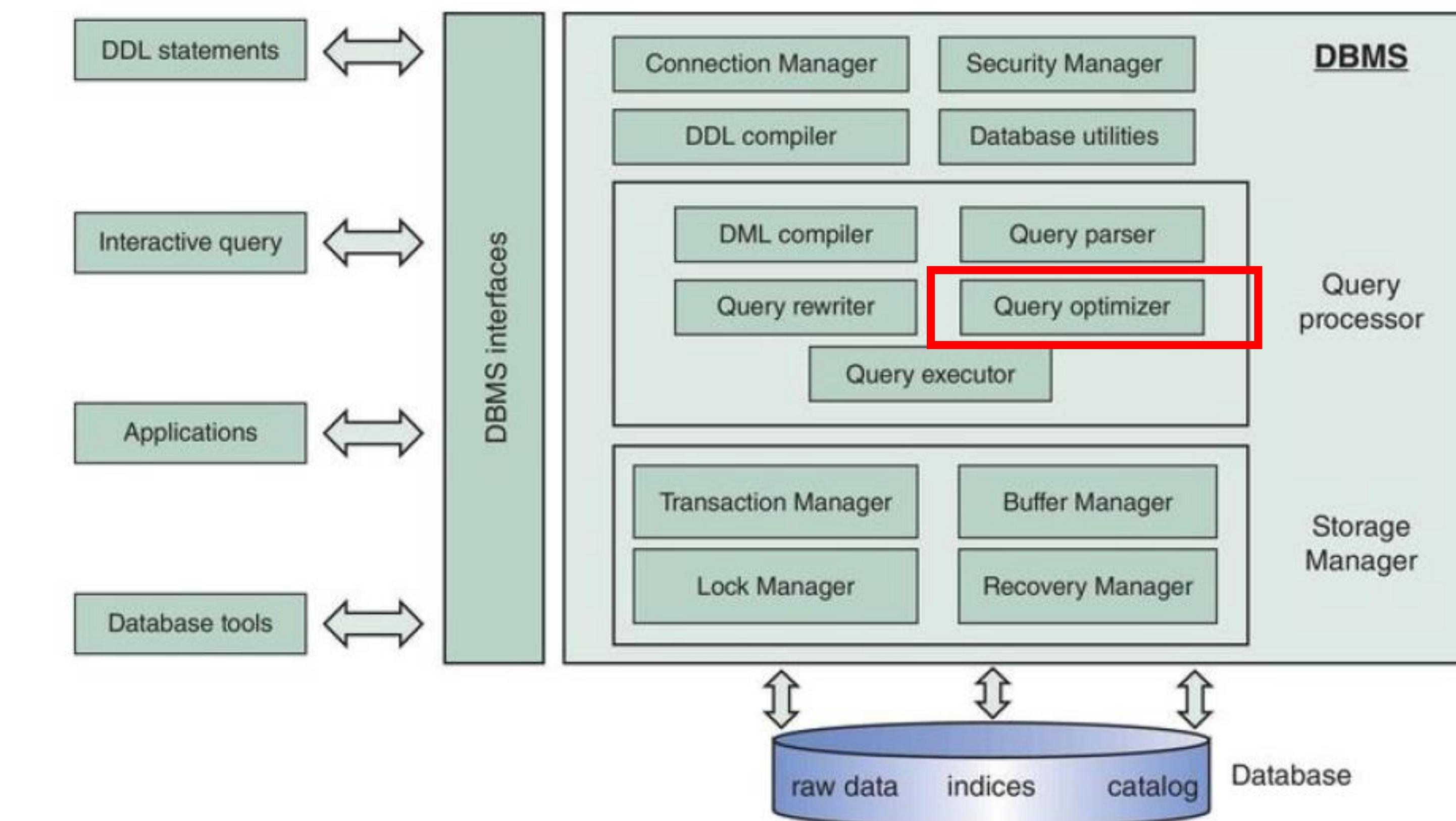
# Architecture of a DBMS

The **query rewriter** optimizes the query, independently of the current database state. It simplifies it using a set of predefined rules and heuristics that are DBMS-specific.



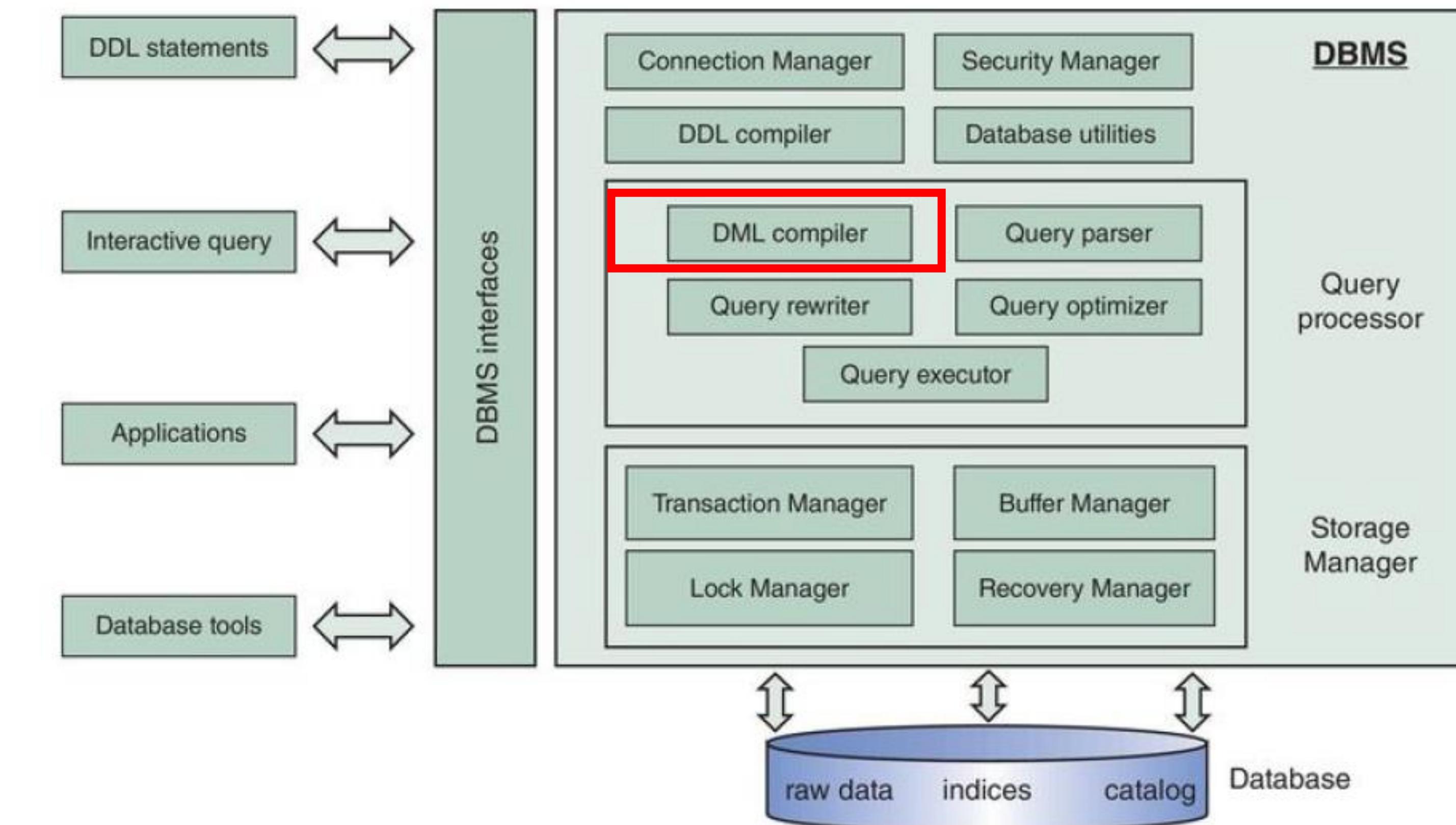
# Architecture of a DBMS

The **query optimizer** optimizes the query based upon the current database state. It can make use of predefined indexes that are part of the internal data model and provide quick access to the data.



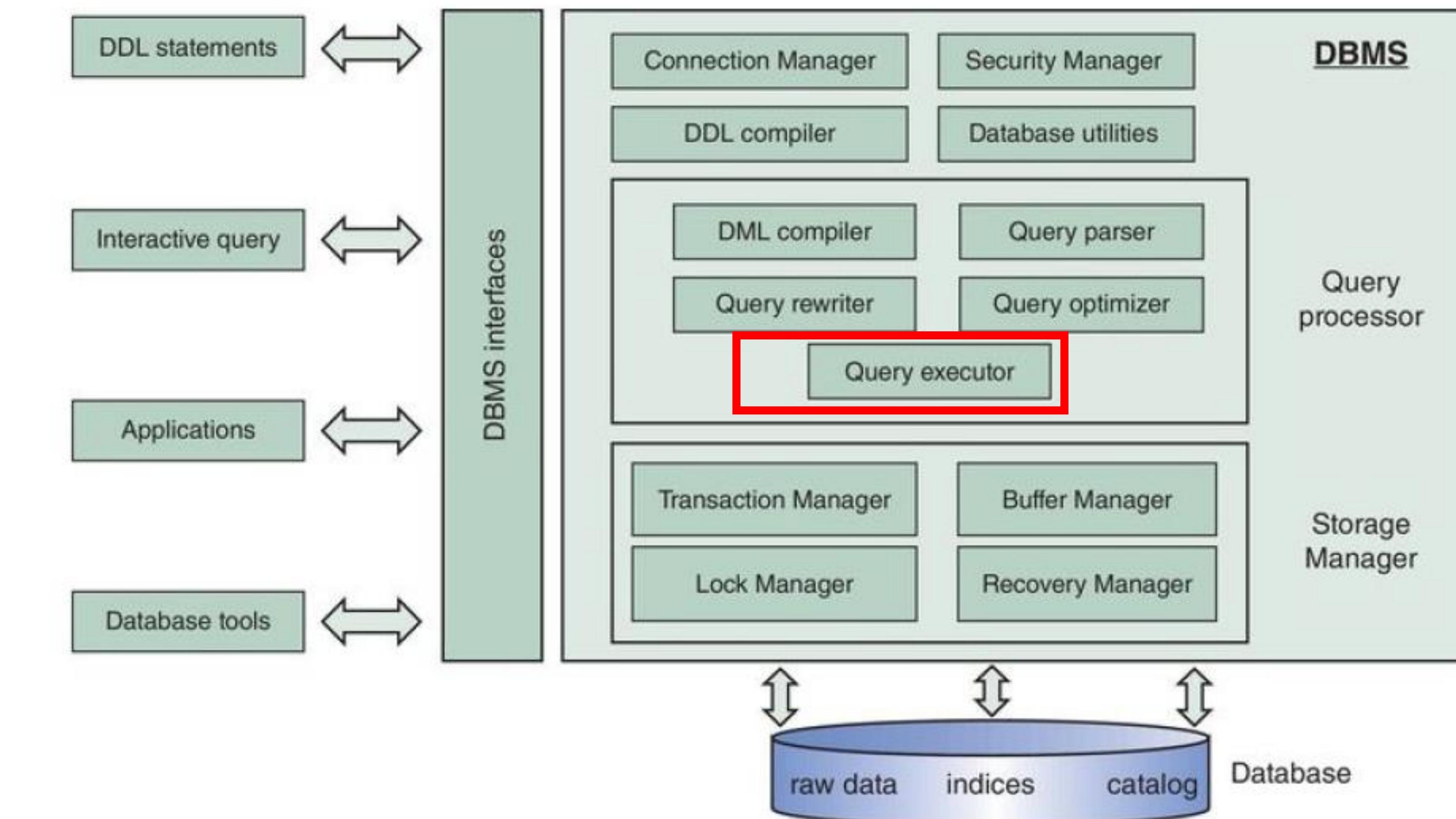
# Architecture of a DBMS

The Data Manipulation Language (DML) compiler compiles the data manipulation statements specified in DML.



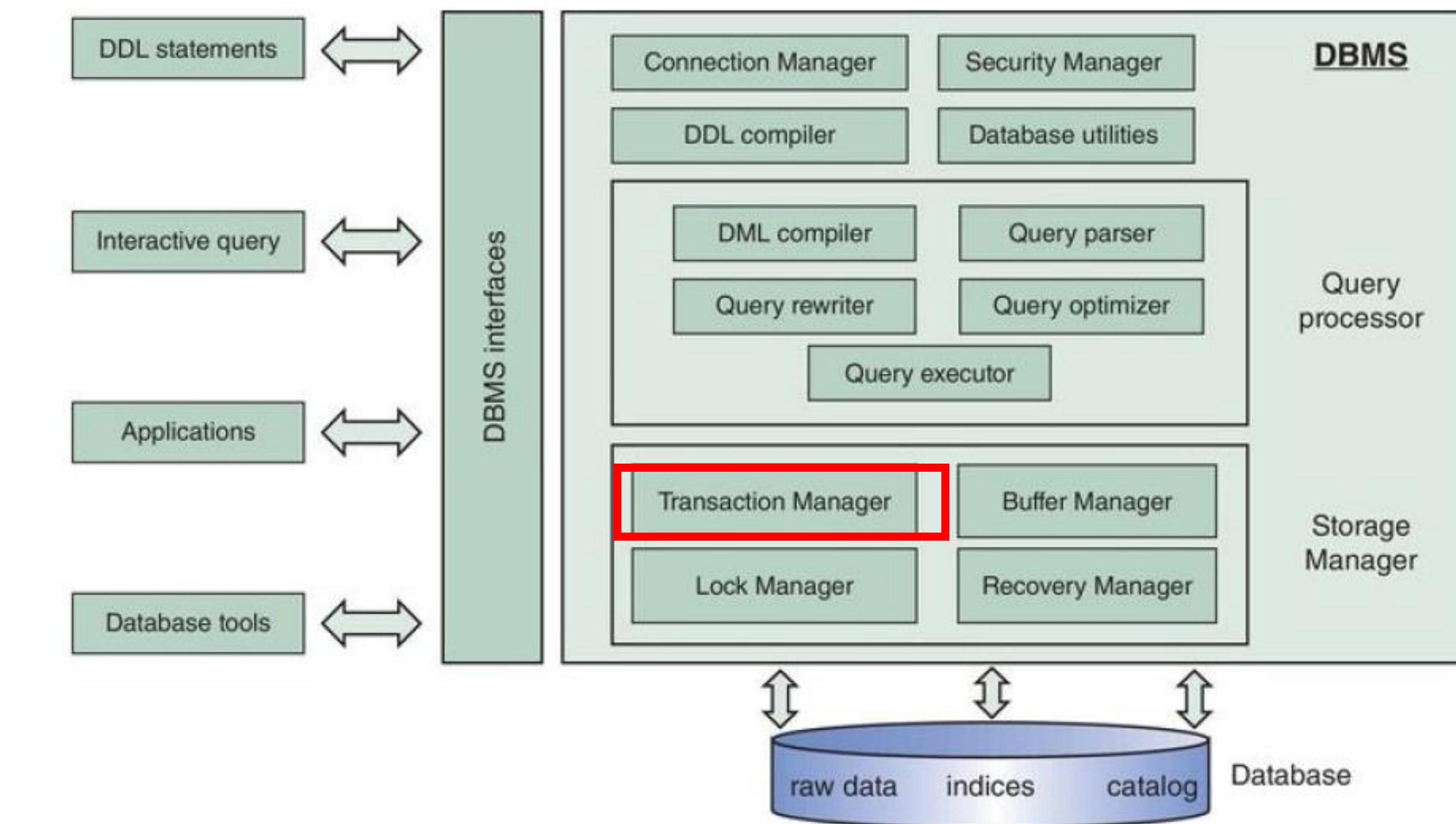
# Architecture of a DBMS

The **query executor** takes care of the actual execution by calling on the storage manager to retrieve the data requested



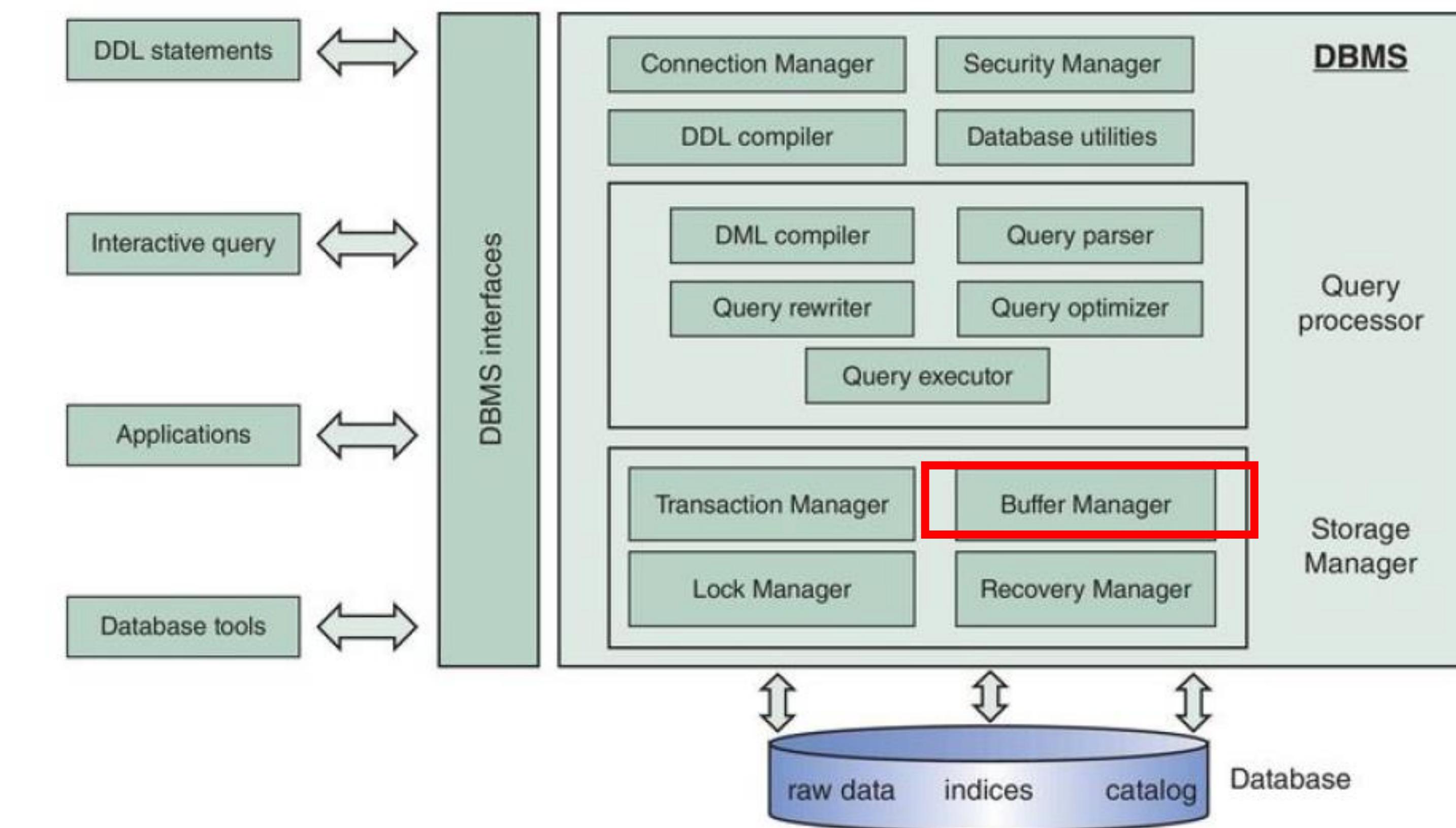
# Architecture of a DBMS

The **transaction manager** supervises the execution of database transactions.  
Remember, a database transaction is a sequence of read/write operations considered to be an atomic unit.



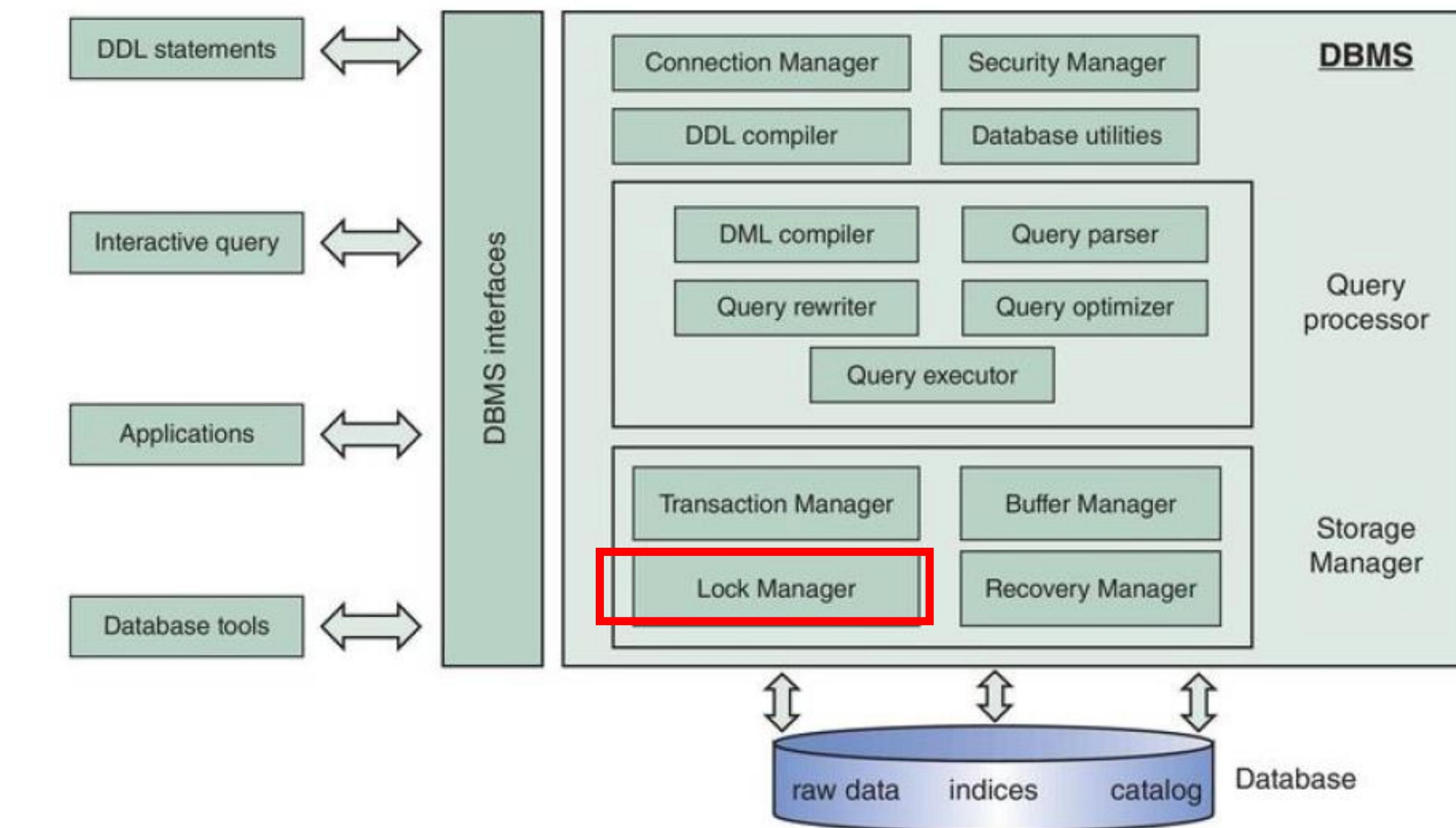
# Architecture of a DBMS

The **buffer manager** is responsible for managing the buffer memory of the DBMS. The DBMS checks first the memory when data need to be retrieved. Retrieving data from the buffer is significantly faster than retrieving them from external disk-based storage.



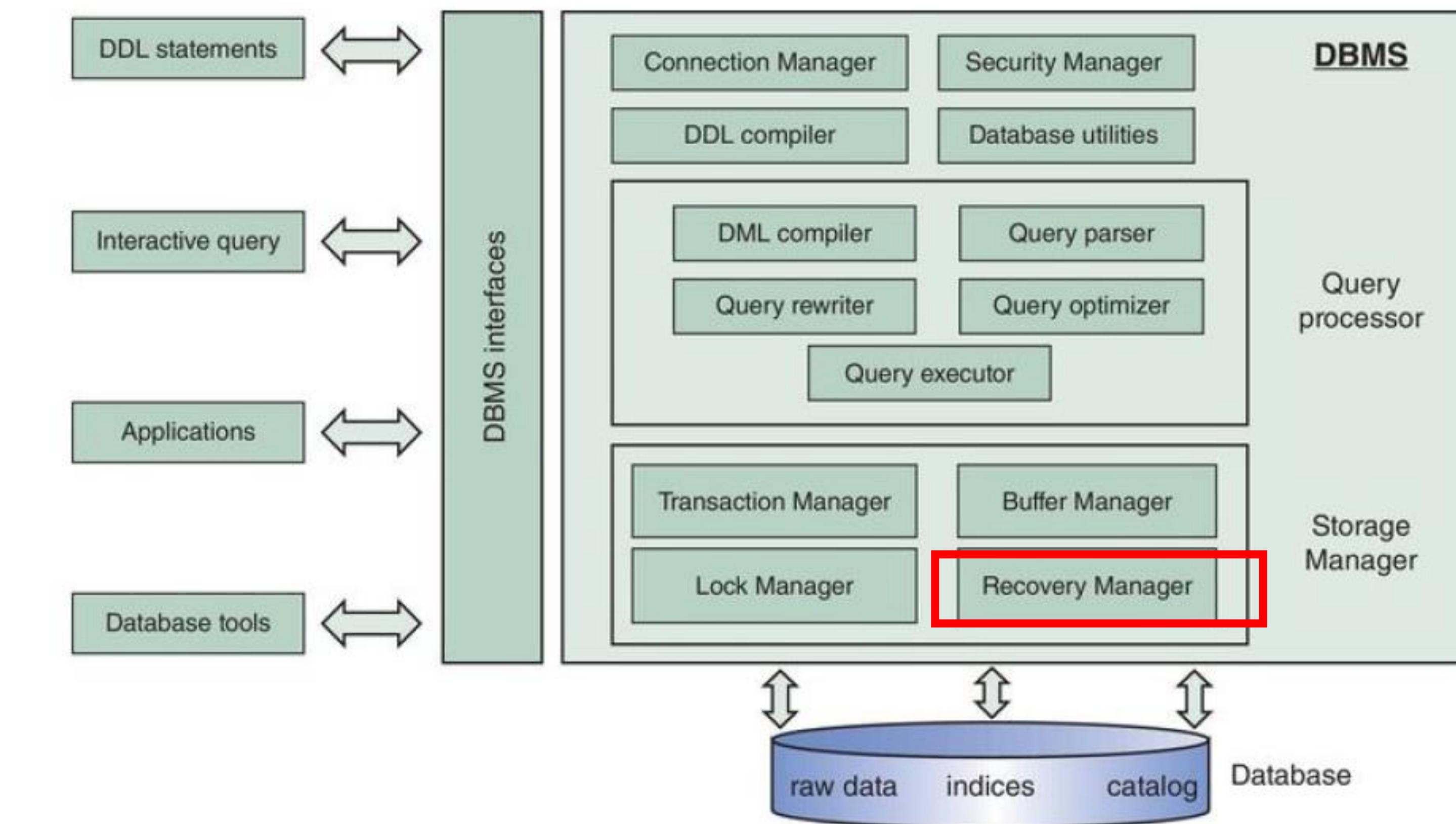
# Architecture of a DBMS

The **lock manager** is an essential component for providing concurrency control, which ensures data integrity at all times.



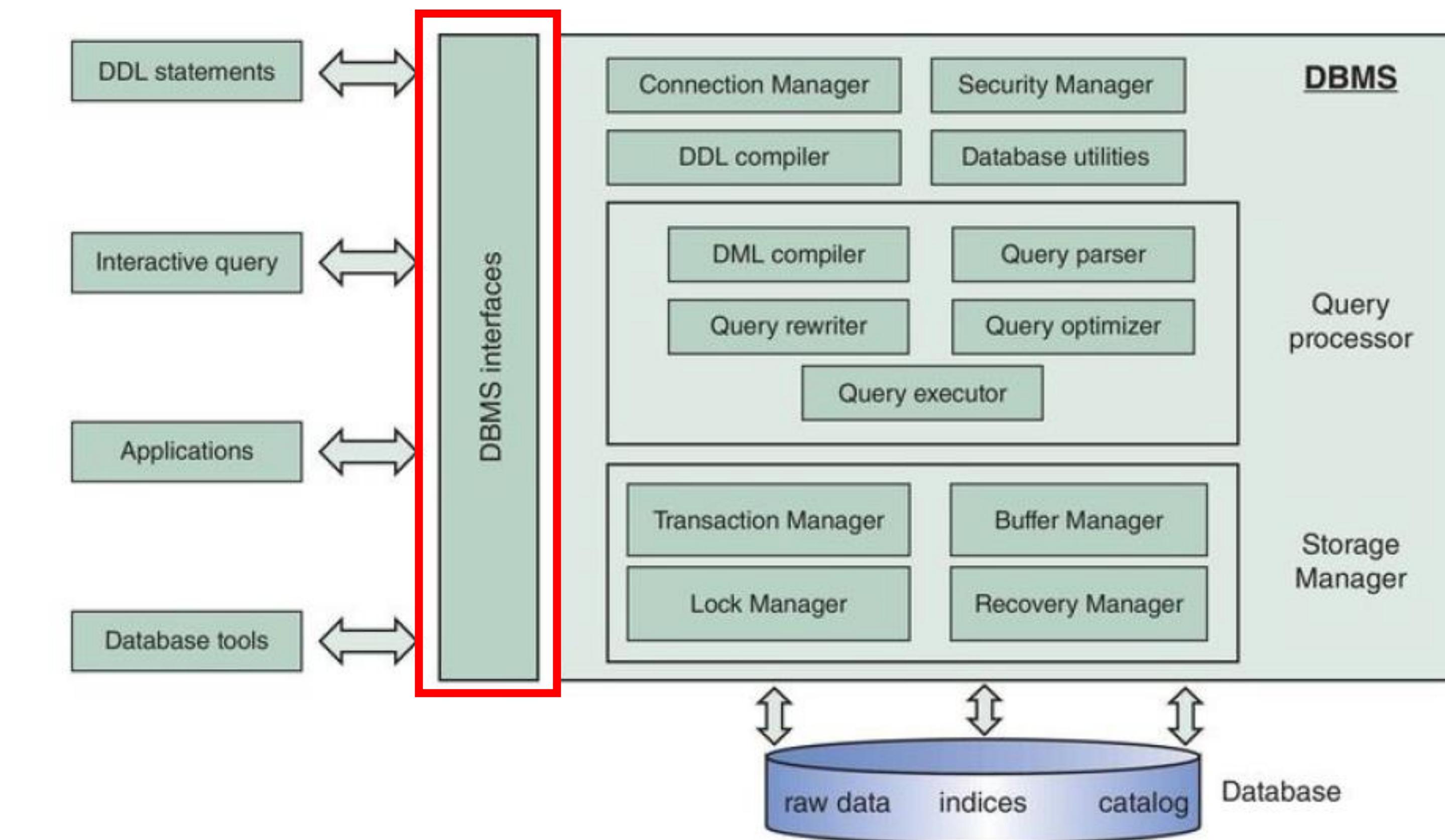
# Architecture of a DBMS

The **recovery manager** supervises the correct execution of database transactions. It keeps track of all database operations in a **logfile** and will be called upon to undo actions of aborted transactions or during crash recovery.



# Architecture of a DBMS

A DBMS needs to interact with various parties, such as a database designer, a database administrator, an application, or even an end-user (Ex. APIs)



## Review question

Fill in the gaps in the following sentences:

When, during crash recovery, aborted transactions need to be undone, that is a task of the ...A...

The part of the storage manager that guarantees the ACID properties is the ...B...

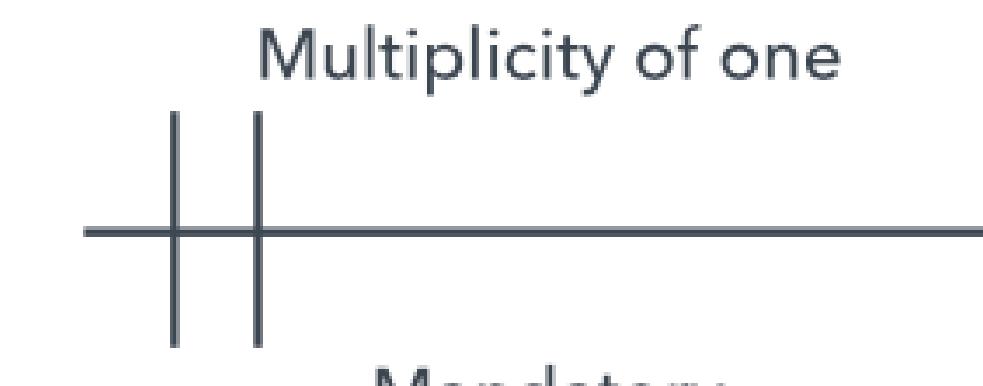
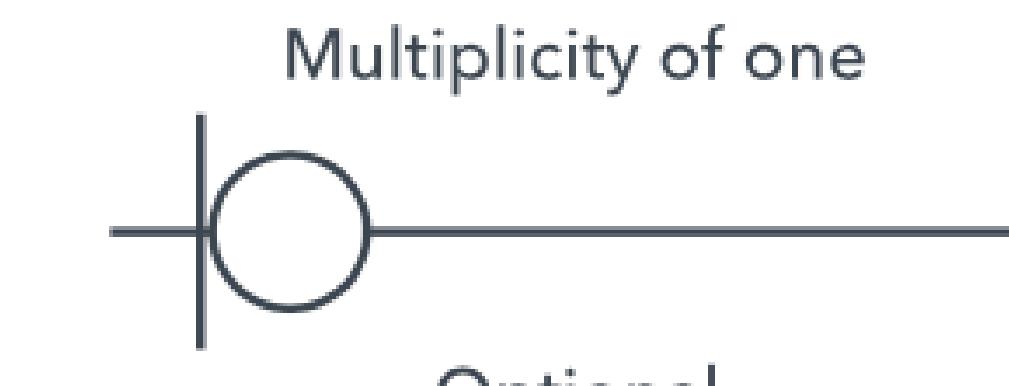
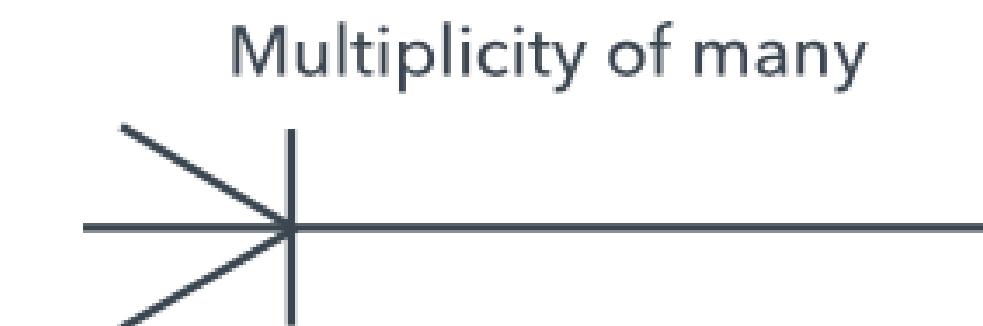
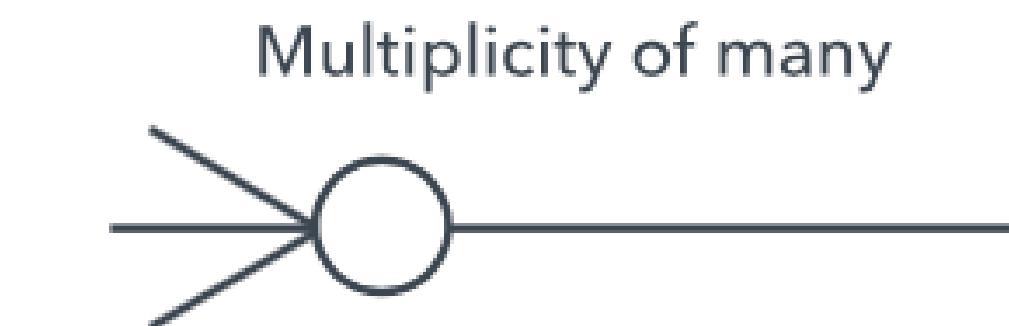
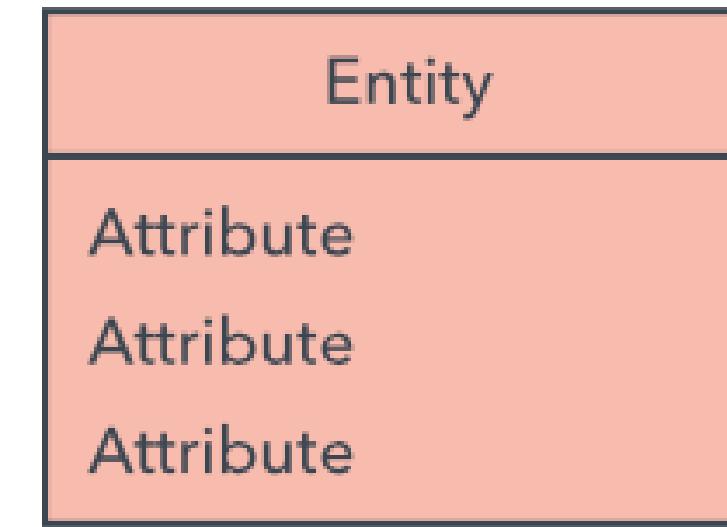
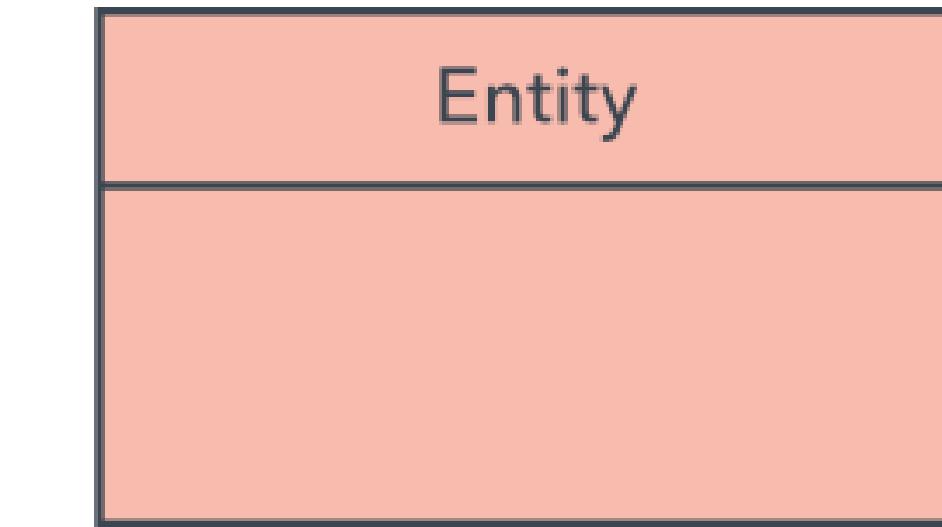
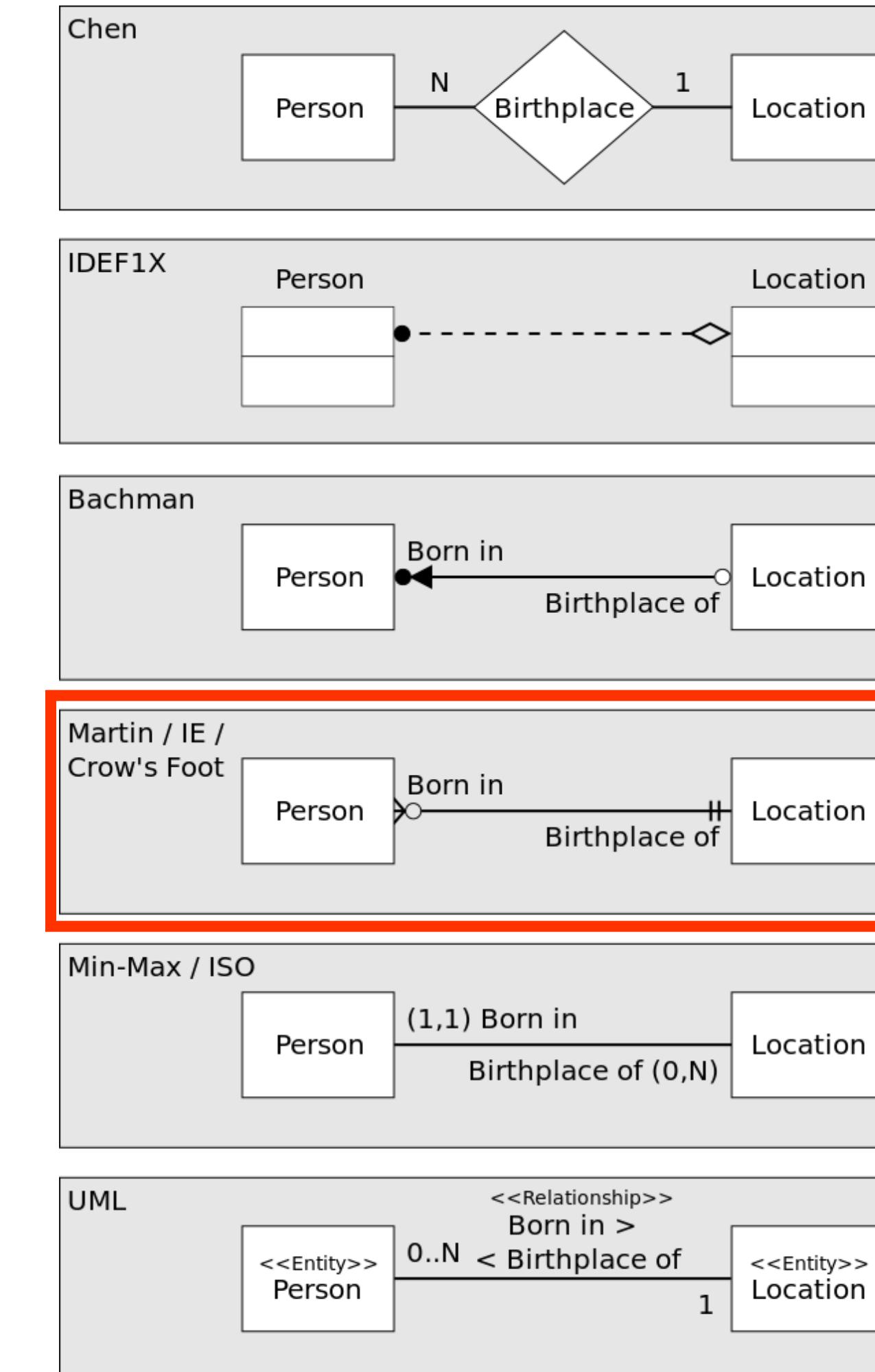
- a.** A: lock manager, B: recovery manager.
- b.** A: lock manager, B: lock manager.
- c.** A: recovery manager, B: buffer manager.
- d.** A: recovery manager, B: transaction manager.

# Relational Modelling

# Entity Relationship Diagram (ERD)



# Different types of Notations for the ERD



# CROW's foot notation



Gordon Everest proposed the Crow's Foot notation in a 1976 paper. Several development methodologies enhanced the notation in the 1980s. Most Computer-Aided Software Engineering (CASE) tools support some variation of the Crow's Foot notation.

Source: Mannino, M. V. (2019). *Database design, application development, and administration*. 7<sup>th</sup> edition. Chicago Business Press

# CROW's foot notation - Illustrating Basic Symbols

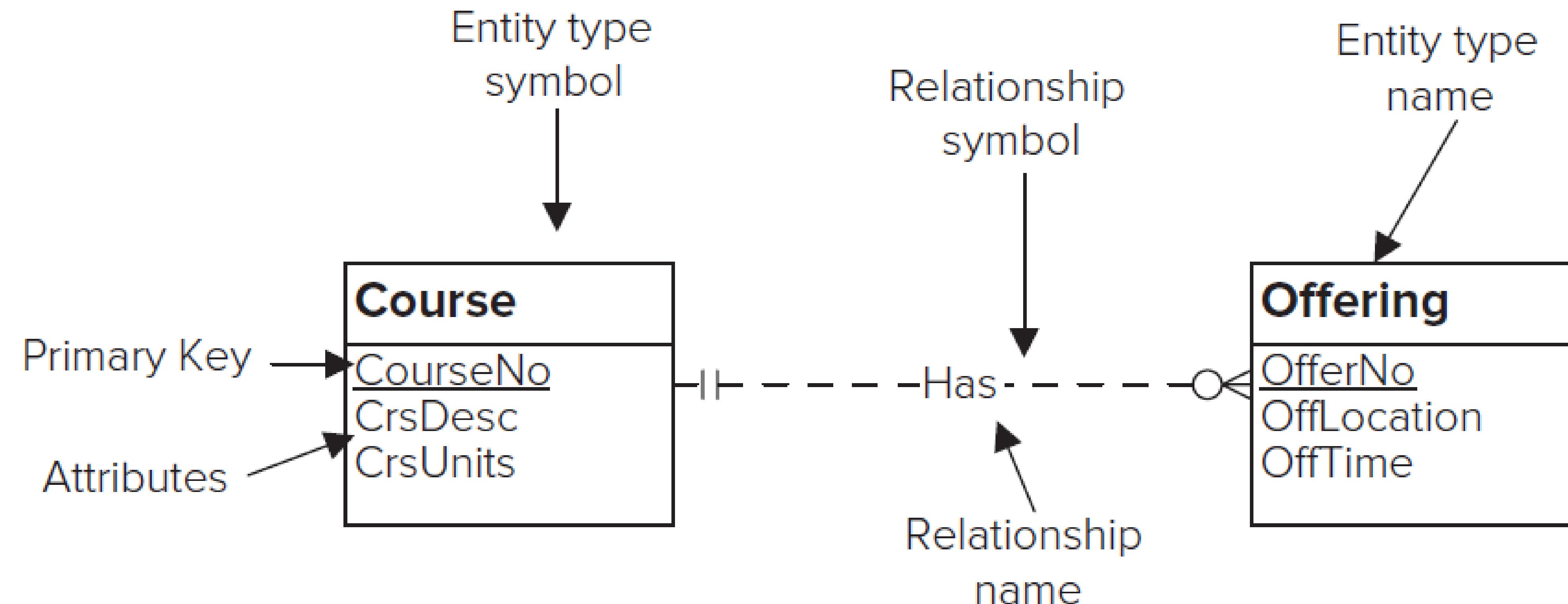
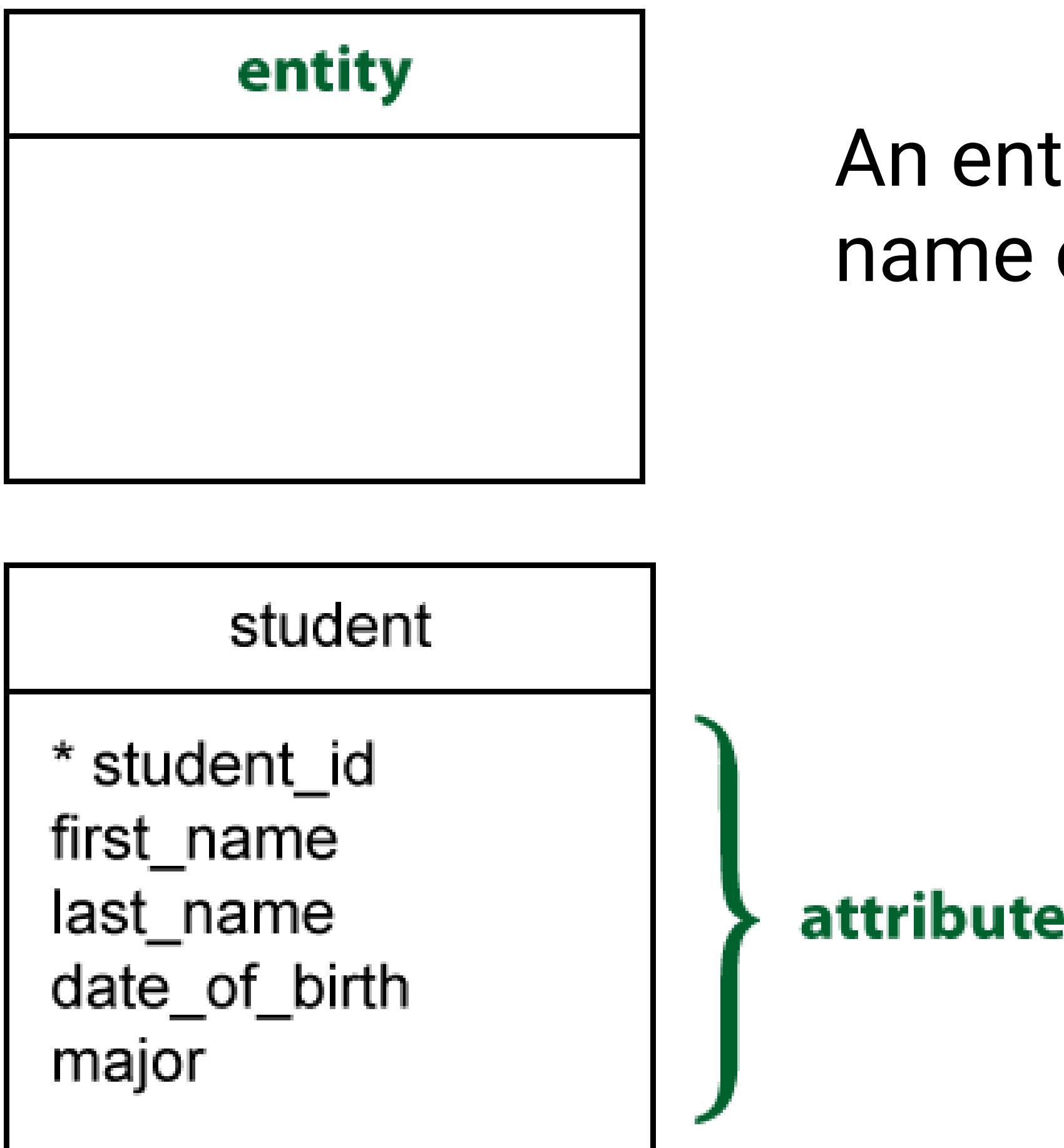


Image Source: Mannino, M. V. (2005). *Database design, application development, and administration*. 7<sup>th</sup> edition. Chicago Business Press

# CROW's foot notation - Notation



An entity is represented by a rectangle, with its name on the top. The name is singular.

The attribute(s) that uniquely distinguishes an instance of the entity is the identifier.

Image Source: <https://www.vertabelo.com/blog/crow-s-foot-notation/>

# CROW's foot notation - Notation

Relationships have two indicators.

The **first one** refers to the maximum number of times that an instance of one entity can be associated with instances in the related entity.

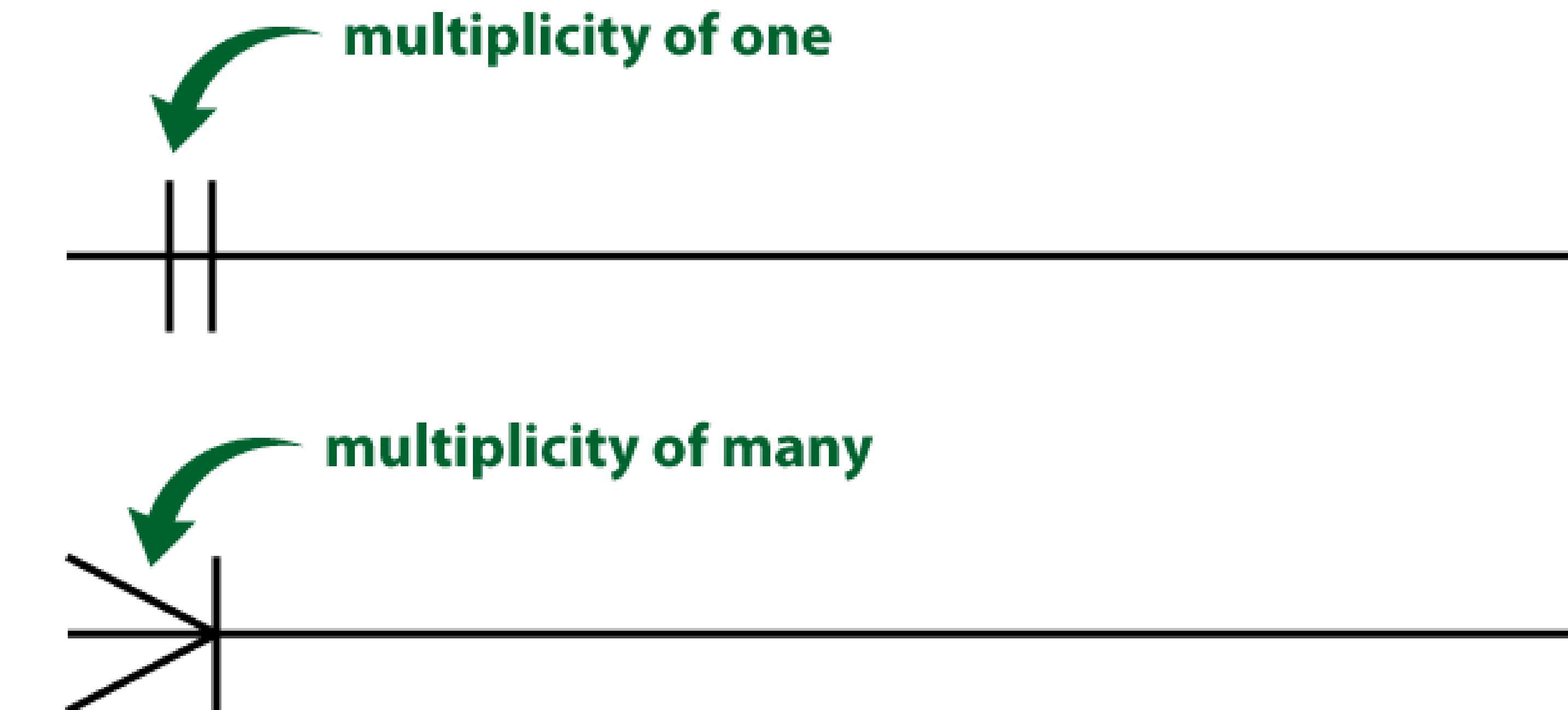


Image Source: <https://www.vertabelo.com/blog/crow-s-foot-notation/>

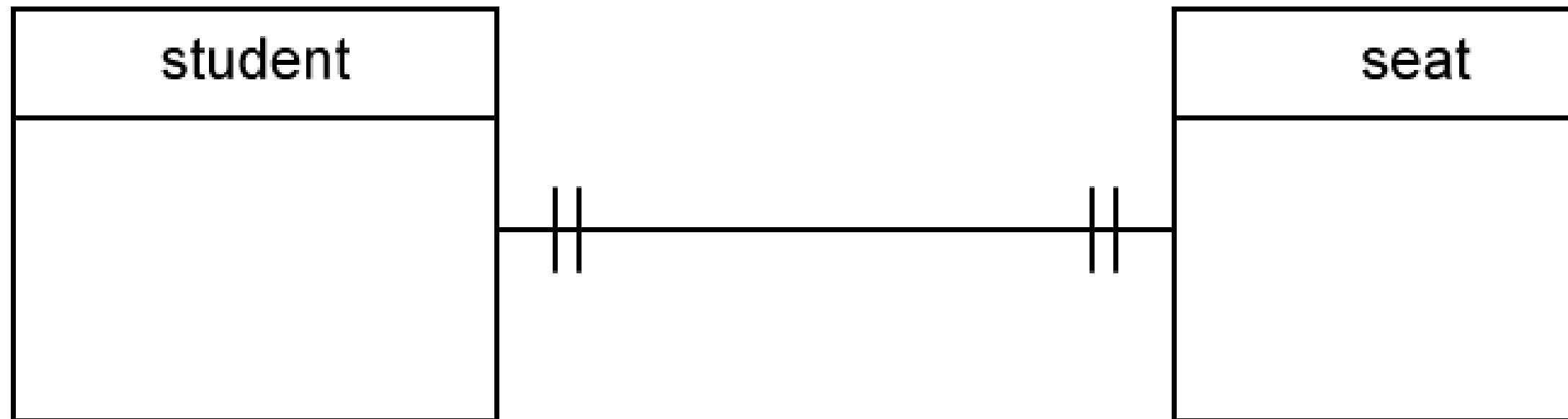
# CROW's foot notation - Notation

The **second one** describes the minimum number of times one instance can be related to others. It can be zero or one, and optional or mandatory.

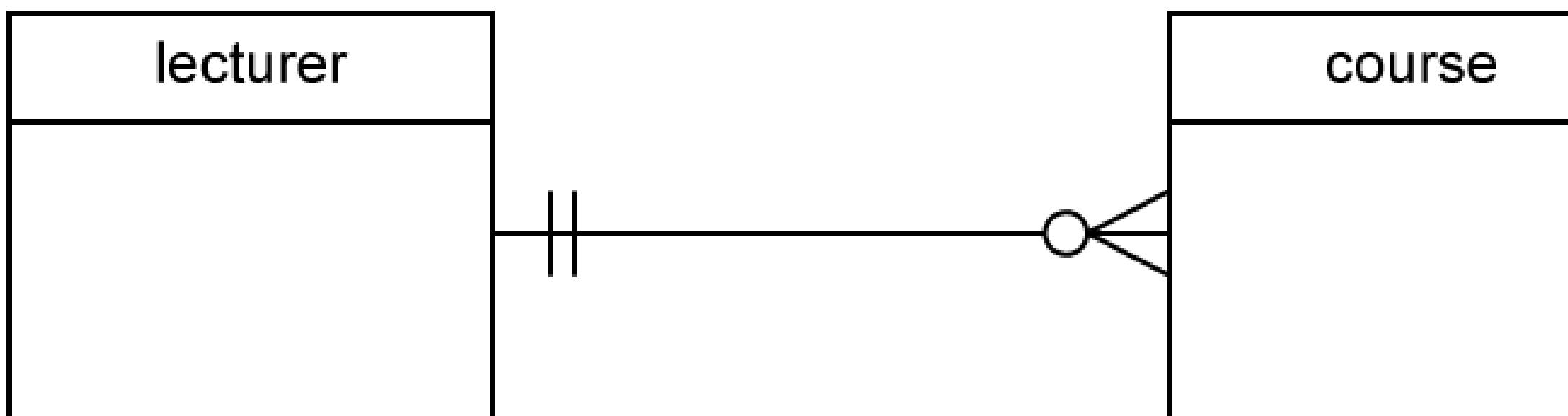


Image Source: <https://www.vertabelo.com/blog/crow-s-foot-notation/>

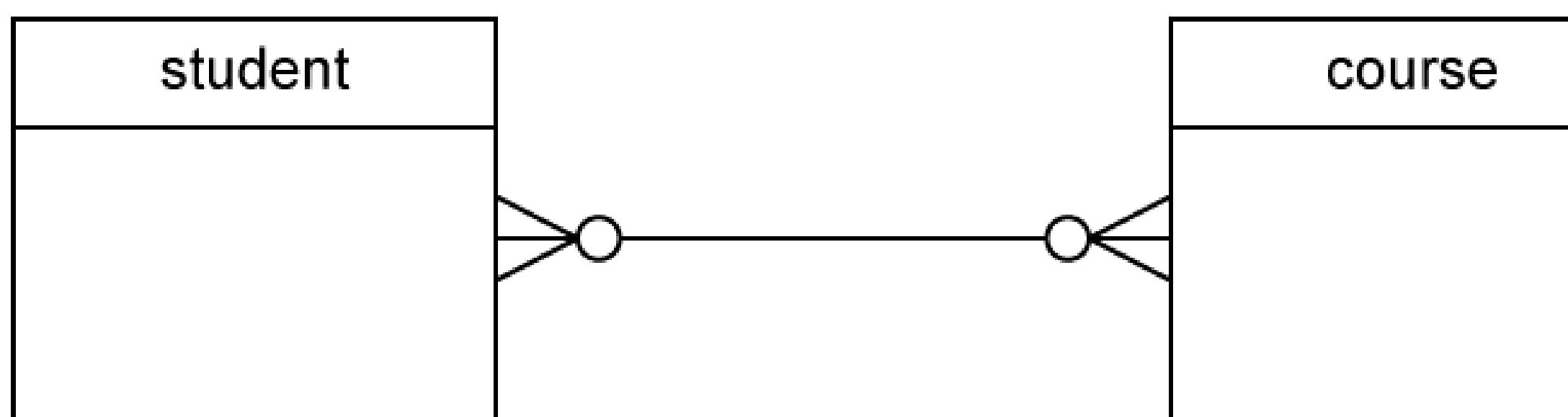
# CROW's foot notation - Examples



One-to-one



One-to-many



Many-to-many

Image Source: <https://www.vertabelo.com/blog/crow-s-foot-notation/>

# CROW's foot notation - Examples

Work in pairs: Consider the following entity types for a patient appointment system:

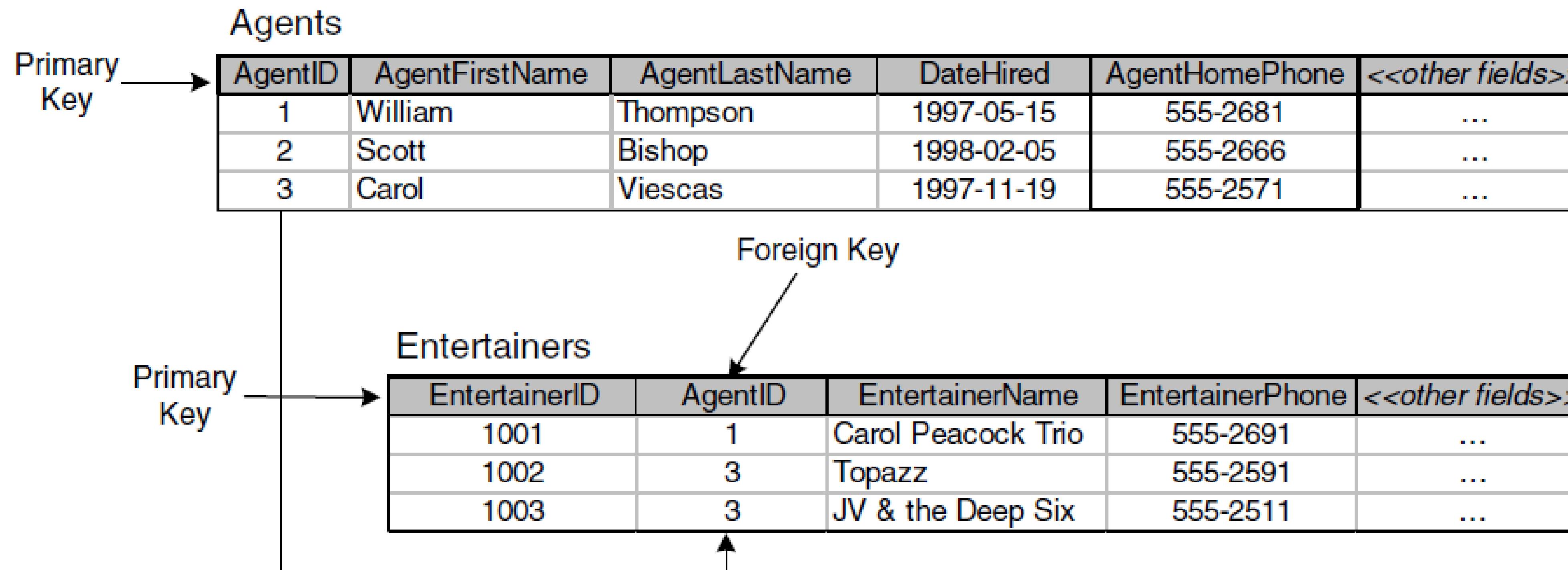
- Doctor
- Appointment
- Bill
- Payment
- Patient
- Insurance\_company

Draw an entity relationship diagram (ERD) with crow's foot notation.  
Several solutions can be valid

<http://www2.cs.uregina.ca/~bernatja/crowsfoot.html>

# From ERD to Tables

## Primary Keys - Unique Identifier of Records in each Table



## Foreign Keys - Establish relationships between tables

## Table A


# One to One

# Table B

The image consists of a 5x4 grid of colored squares. The top row contains four dark gray squares. The second row contains four light gray squares. The third row contains one orange square on the far left, followed by three white squares. The fourth and fifth rows are entirely white.

# Relational Databases - Relationships

Example:

Agents					
AgentID	AgentFirstName	AgentLastName	DateOfHire	AgentHomePhone	<<other fields>>
1	William	Thompson	1997-05-15	555-2681	...
2	Scott	Bishop	1998-02-05	555-2666	...
3	Carol	Viescas	1997-11-19	555-2571	...

Compensation		
Salary	CommissionRate	<<other fields>>
\$35,000.00	4.00%	...
\$27,000.00	4.00%	...
\$30,000.00	5.00%	...

to each Agent is linked one and only one Row in Compensation Table

# Relational Databases - Relationships

**Table A**


# One to Many



## Table B

A 4x4 grid of gray squares. The first row contains four dark gray squares. The second row contains one light gray square followed by three white squares. The third row contains two light gray squares followed by two white squares. The fourth row contains three white squares followed by one light gray square. A small orange arrow points from the bottom-left towards the second row.

# Relational Databases - Relationships

## Example:

The diagram illustrates a relationship between two tables: **Entertainers** and **Engagements**.

**Entertainers** table:

EntertainerID	EntertainerName	EntertainerPhone	<<other fields>>
1001	Carol Peacock Trio	555-2691	...
1002	Topazz	555-2591	...
1003	JV & the Deep Six	555-2511	...

**Engagements** table:

EngagementID	EntertainerID	CustomerID	StartDate	EndDate	<<other fields>>
5	1003	10006	2007-09-11	2007-09-14	...
7	1002	10004	2007-09-11	2007-09-18	...
10	1003	10005	2007-09-17	2007-09-26	...
12	1001	10014	2007-09-18	2007-09-26	...

to each Entertainer can be linked multiple rows in Engagements,  
but each Engagement is only linked to a single Entertainer

# Relational Databases - Relationships

**Table A**


# Many to Many



## Table B

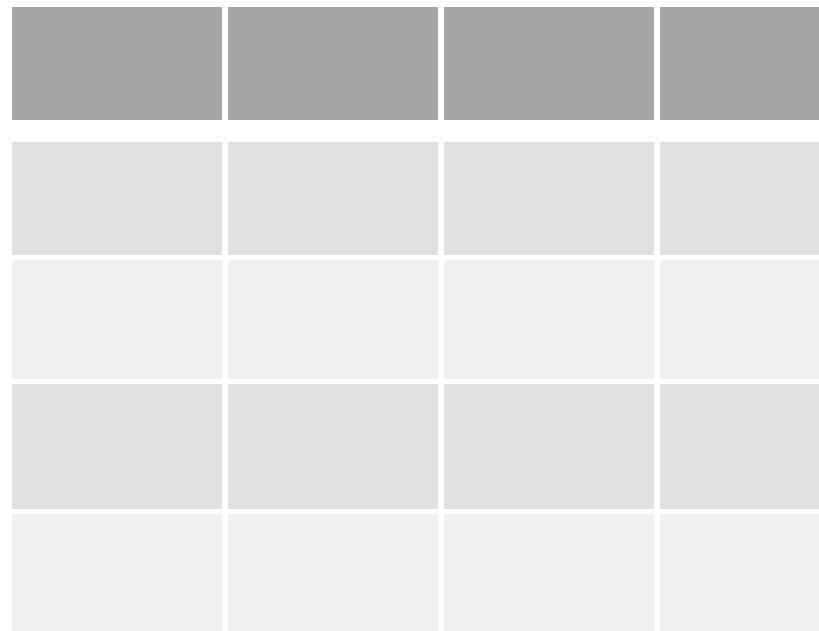
A 5x4 grid of colored squares. The colors transition from dark gray in the top row to light gray in the middle rows, and finally to medium gray in the bottom row. A small orange arrow points from the bottom-left corner of the first row towards the center of the grid.

# Relational Databases - Relationships

Problem: how to create a database structure with a many-to-many relationship type?

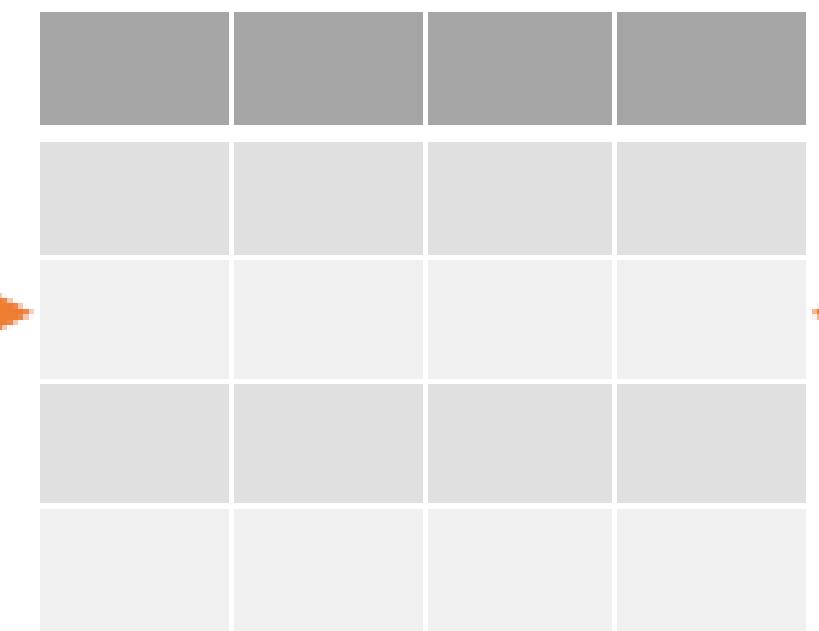
# Relational Databases - Relationships

**Table A**



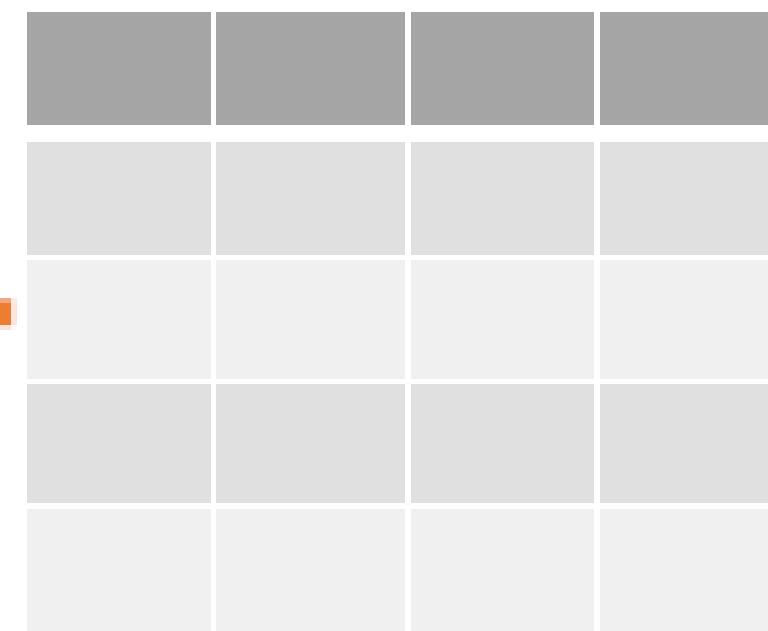
**One to Many**

**Linking Table**



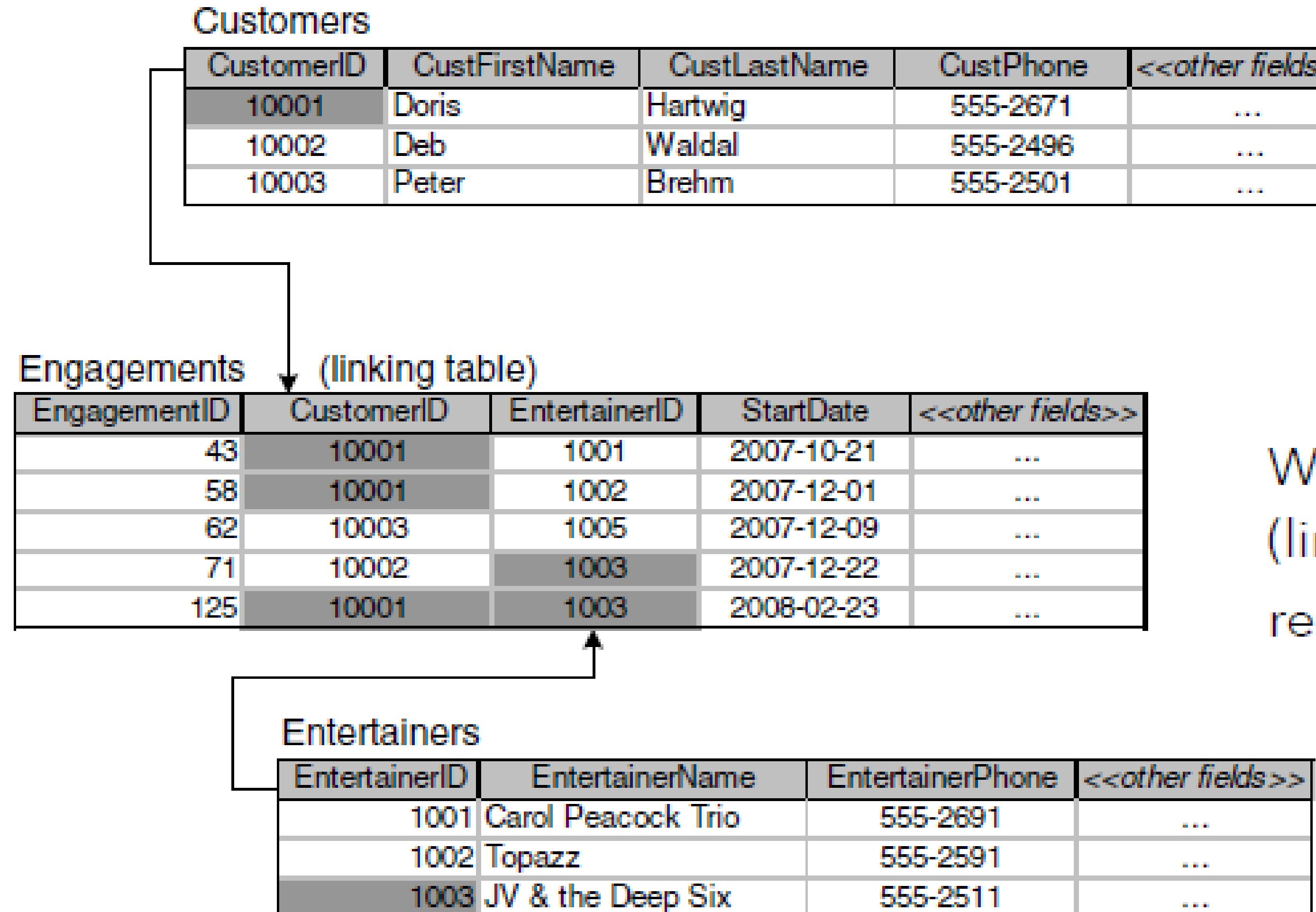
**One to Many**

**Table B**



# Relational Databases - Relationships

Example:



We create an additional table (linking table) with one to many relationships with the original tables

# Quick quiz

<https://b.socrative.com/login/student/>

Room: SRD2024



**Quiz Time**

**Let's have  
some fun!**

# END OF LECTURE 2

## Acreditações e Certificações



UNIGIS



A3ES



Double Degree  
Master Course in  
Information Systems  
Management



eduniversal



Computing  
Accreditation  
Commission

Instituto Superior de Estatística e Gestão de Informação  
Universidade Nova de Lisboa