Concordia University
Computer Science and Software Engineering
COMP353: Databases
Winter 2018
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Introduction to Databases and SQL

What is a Database?

- A database is a collection of data that exists over a long period of time (*Persistent storage*)
- This collection should be logically coherent and have some inherent meaning, typically about an enterprise ➔ it may not be a random pile of data

Examples of Databases

- List of names, addresses, and phone numbers of your friends
- Information about employees, departments, salaries, managers, etc. in a COMPANY
- Information about students, courses, grades, professors, etc. in a UNIVERSITY
- Information about books, users, etc. in a LIBRARY

Database Management System (DBMS)

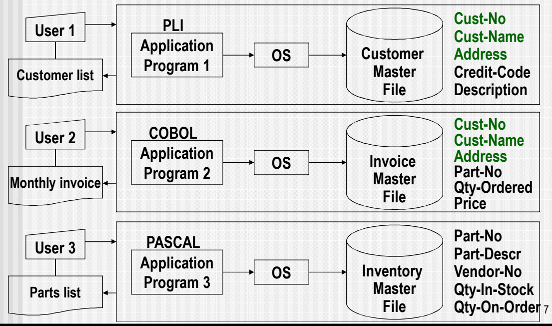
- A DBMS is a complex software package developed to *store* and "*manage*" databases
- Note the distinction between DB, DBS, and DBMS:

Database system = **Database** + **DBMS**

What does a DBMS provide?

- Supports convenient, efficient, and secure *access and manipulation of large amounts of data*
- *(high-level) Programming interface*: Gives users the ability to create, *query,* and *modify* the data
- *Persistent storage*: Supports the storage of data *over a long period of time*
- *Transaction management and recovery*: Controls access to shared data from multiple, simultaneous users with properties Atomicity, Consistency, Isolation, Durability (ACID)

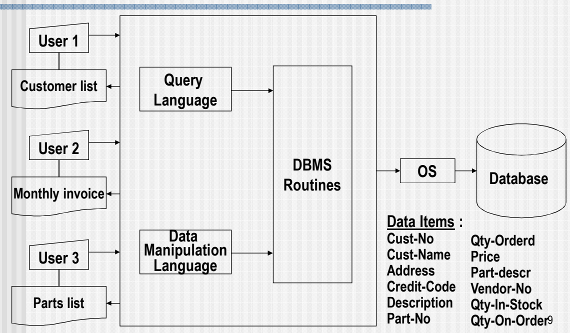
File Processing Systems (FPS)



Disadvantages of FPS

- Redundancy of data: Identical data are distributed over various files – a major source of problems
  - Waste of storage space: When the same field is stored in several files, the required storage space is needlessly high ➔ high storage cost
  - Multiple updates: One field may be updated in one file but not in others ➔ inconsistency and lack of data integrity and hence potential conflicting reports
  - Multiple programming languages: Dealing with several programming languages which are often not user friendly ➔ high system maintenance cost

Database Systems



Advantages of Databases

- Minimize data redundancy and avoid inconsistency

  They provide:
- Concurrent access to shared data
- Centralized control over data management
- Security and authorization
- Integrity and reliability
- Data abstraction and independence

Aspects of Database Studies

- Modeling and design of databases ✓
- Database programming ✓
- DBMS implementation

  The first two aspects are studied in COMP 353

  The third one is studied in COMP 451

What is this course about?

- A database is a "collection of data." This data is managed by a DBMS
- Databases are essential today to support *commercial, engineering,* and *scientific applications.*
- They are at the core of many scientific investigations.
- Their power comes from a rich body of knowledge and technology developed over several decades
- In this course, we study fundamental concepts, techniques, and tools for *database design* and *programming*.
- In **COMP451**, we study details of DB *implementation*

A quick test!

- Which one of the following is the main source of the problems in file processing systems, addressed by databases?
  - A. Waste of storage space.
  - B. Update anomalies, which result in lack of data integrity.
  - C. Data redundancy.
  - D. Data inconsistency.

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Data Modeling and Database Design

An Overview

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Types of Data Models

- A Data Model is a collection of concepts, describing
  - data and relationships among data
  - data semantics and data constraints
- Entity-Relationship (ER) Model √
- Relational Model √
- Object-Oriented Data Model (ODL) √
- Logical Data Model (Datalog) √
- Earlier "record" based Data Models
  - Network
  - Hierarchical

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Relational Model

- Data is organized in relations (tables)

  The user should/need not be concerned with the underlying storage data structure.
- Relational database schema:
  - Set of table names – $D = \{R_1,\ldots,R_n\}$
  - Set of attributes for each table – $R_i = \{A_1,\ldots,A_k\}$
- Examples of tables:
  - Account= {accNum, branchNam, amount, customerId}
  - Movie= {title, year, director, studio}

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Relational Model

- Most widely used model
  - Vendors: Oracle, IBM, Informix, Microsoft, Sybase, etc.
- Competitor: object-oriented model
  - ObjectStore, Postgres, etc.
- Another approach: *object-relational model*

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Objectives of Database Systems

- A DB system should be ***simple***, so that many users with little skills could interact with the system **conveniently**
- It should be ***complex***, so that many (complex) queries and transactions could be handled/processed **efficiently**

But these objectives are contradictory!
So how to achieve both?

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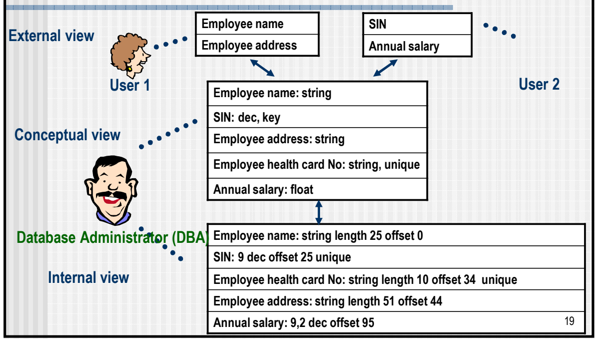
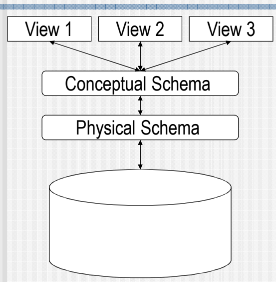
Three Views of Data



Three Views / Levels of Data

- **Internal (physical) level**
  A block of consecutive bytes actually holding the data
- **Conceptual (logical) level**
  type emp = record
  SIN : integer;
  name : string;
  address : string;
  salary : real;
  healthCard : string;
  end
- **External (logical) level**
  View 1 : (emp.name, emp.address)
  View 2 : (emp.SIN, emp.salary)

Levels of Abstraction in DB's



- Views describe how users "see" the data
- Conceptual schema defines logical structure
- Physical schema describes the storage structure of data and the indexes

Abstraction is achieved through describing each level in terms of a schema using a particular data model

Schemas at different levels of abstraction

- View (or External users): are typically determined during requirements analysis (often defined as views over some of the concepts in the logical DB schema)
- Conceptual (or Logical) Schema: an outcome of a database design (a main focus in this course)
- Physical Schema: storage and index structures associated with relations

Schemas and Instances

- A database *instance* is the current content of the DB
- A database *schema* is the structure of the data (relations/classes), described in some suitable data model

e.g. relation:

Students {sid, name, department, dob, address} rep. as a *set* or
Students (sid, name, department, dob, address) as a *tuple*

Students

sid	*name*	*department*	*dob*	*address*
1112223	John Smith	CS	12-01-82	22 Pine, #1203
2223334	Ali Brown	EE	31-08-73	2000 St. Marc
3334445	Sana Kordi	CS	23-11-79	1150 Guy

Data Independence

- Defn: the ability to modify definition of schema at one level without affecting the schema definition(s) at a higher level
  - Achieved through the use of three levels of data abstraction
- Logical Data Independence
  - Ability to modify logical schema without causing application programs to be rewritten
  - E.g., adding new fields to a record or changing the type of a field
- Physical Data Independence
  - Ability to modify physical schema without causing the conceptual schema or the applications to be modified, i.e., *the possibility of having separate schemas at the physical and conceptual levels*
  - E.g., changing a file structure from sequential to direct access

DBMS Implementation

Overview

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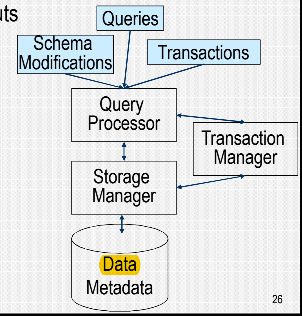
Architecture of a DBMS

- There are 3 types of inputs to DBMS:
  - Queries
  - Transactions, i.e., data Modifications
  - Schema Creations/ Modifications



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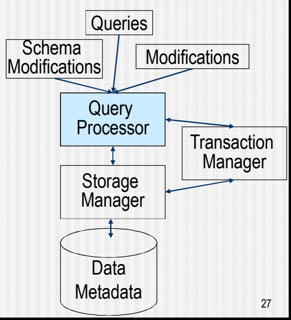
Architecture of a DBMS

- The **query processor** handles:
  - Queries
  - Modifications (of both data and schema)
- The job of the **query processor + query optimizer** (QO) is
  - To find the "best" plan to process the query
  - To issue commands to storage/buffer manager



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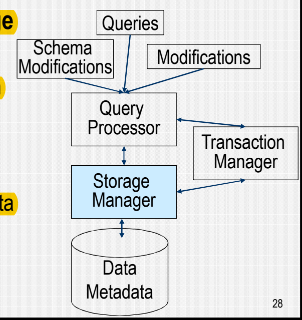
Architecture of a DBMS

- The job of the **storage manager** is
  - To obtain information requested **from** the data storage
  - To modify the information **to** the data storage when requested.



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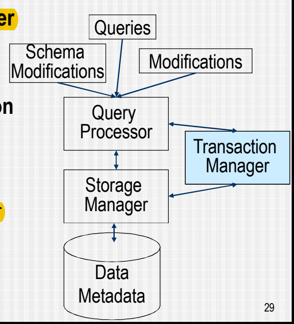
Architecture of a DBMS

- The **transaction manager** is responsible for the **consistency** of the data
- The job of the **transaction manager** is to ensure:
  - several queries running simultaneously do not "interfere" with each other
  - Integrity of the data data even if there is a power failure (*Recovery system*)



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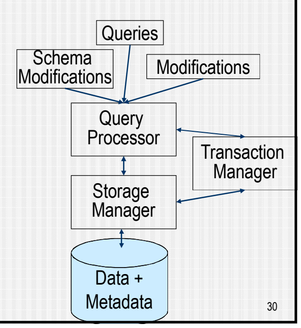
Architecture of a DBMS

- A representation of data and other relevant information on disk
- It contains:
  - Data
  - Metadata



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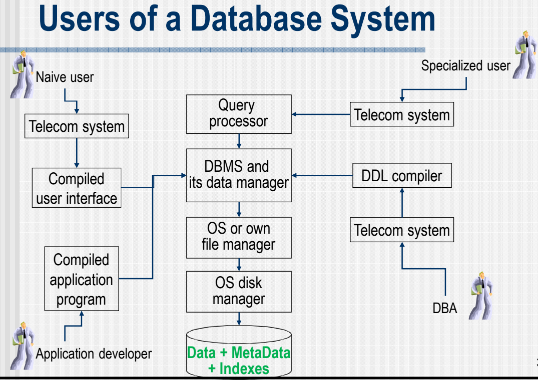
Users of a Database System



Database Programming

Overview

Database Languages

- A Database Management System (DBMS) provides two types of languages, which may also be viewed as components of the DBMS language:
  - Data Definition Language (DDL)
    - Language (notation) for *defining* a database schema
    - It includes syntax for declaring tables, indexes, views, constraints, etc.)
  - Data Manipulation Language (DML)
    - Language for *accessing* and *manipulating* the data (organized/stored according to the appropriate data model)

Query Languages

- Commercial:
  - SQL√
- Theoretical/Abstract:
  - Relational Algebra √
  - Relational Calculus
  - Datalog √

SQL

- Developed originally at IBM in 1976
  - First standard: SQL-86
  - Second standard: SQL-92
  - Latest standard: SQL-99, or SQL3, well over 1,000 pages of document
- De-facto standard of the relational database world; replaced all other DB languages
- The SQL query language components:
  - DDL
  - DML

Simple SQL Queries

- A SQL query has a form:

  SELECT . . .
  FROM . . .
  WHERE . . . ;
- The **SELECT** clause indicates which attributes should appear in the output.
- The **FROM** gives the relation(s) the query refers to
- The **WHERE** clause is a Boolean expression indicating which tuples are of interest.
- A query result is a **bag**, in general
- A query result is **unnamed**.

Example SQL Query

- Relation schema:
  Course (<u>courseNumber</u>, name, noOfCredits)
- Query:
  Find all the courses stored in the database
- Query in SQL:
  SELECT ∗
  FROM Course;

Note: " ∗ " means **all** attributes in the **relation(s)** involved.

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Example SQL Query

- Relation schema:
  Movie (<u>title</u>, <u>year</u>, length, filmType)
- Query:
  Find the titles of all movies stored in the database
- Query in SQL:
  SELECT title
  FROM Movie;

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Example SQL Query

- Relation schema:
  Student (<u>ID</u>, firstName, lastName, address, GPA)
- Query:
  Find the ID of every student whose GPA is more than 3
- Query in SQL:
  SELECT ID
  FROM Student
  WHERE GPA > 3;

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Example SQL Query

- Relation schema:
  Student (<u>ID</u>, firstName, lastName, address, GPA)
- Query:
  Find the ID and last name of every student with first name 'John', who has a GPA > 3
- Query in SQL:
  SELECT ID, lastName
  FROM Student
  WHERE firstName = 'John' **AND** GPA > 3;

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WHERE clause

- The expressions that may follow **WHERE** are conditions
  - Standard comparison operators Θ includes { =, <>, <, >, <=, >= }
  - The values that may be compared include constants and attributes of the relation(s) mentioned in **FROM** clause
    - Simple expression
      - **A** *op Value*
      - **A** *op* **B**

      where **A**, **B** are attributes and *op* is a comparison operator
  - We may also apply the usual arithmetic operators, +,-,*,/, etc. to numeric values before comparing them
    - **(year - 1930) * (year - 1930) < 100**
  - The result of a comparison is a Boolean value, **TRUE** or **FALSE**
  - Boolean expressions can be combined by the logical operators **AND**, **OR**, and **NOT**

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Example SQL Query

- Relation schema:
  Movie (<u>title</u>, <u>year</u>, length, filmType)
- Query:
  Find the titles of all color movies produced in 1990
- Query in SQL:
  SELECT title
  FROM Movie
  WHERE filmType = 'color' **AND** year = 1990;

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Example SQL Query

- Relation schema:
  Movie (<u>title</u>, <u>year</u>, length, filmType)
- Query:
  Find the titles of color movies that are either made after 1970 or are less than 90 minutes long
- Query in SQL:
  SELECT title
  FROM Movie
  WHERE (year > 1970 **OR** length < 90) **AND** filmType = 'color';
- Note the precedence rules, when parentheses are absent:
  AND takes precedence over **OR**, and
  NOT takes precedence over **AND** and **OR**

Products and Joins

- SQL has a simple way to "couple" relations in one query
  - How? By "listing" the relevant relation(s) in the **FROM** clause
- All the relations in the **FROM** clause are coupled through **Cartesian product** (shown as $\times$ in algebra notation)

Cartesian Product

- From Set Theory:
  - The **Cartesian Product** of two sets **R** and **S** is the set of **all** pairs (**a, b**) such that: **a** $\in$ **R** and **b** $\in$ **S**.
  - Denoted as **R** $\times$ **S**
  - Note:
    - In general, **R** $\times$ **S** $\neq$ **S** $\times$ **R**

A quick test!

- Let R(A_1,…,A_n) be a relation schema and *r be any* instance of R. Suppose *r* has *m* tuples. Which of the following is the number of ways in which *r* may be represented in the relational model?

  A. m * n

  B. 2^m

  C. m! * n!

  D. 2^n

Example

Instance R:

A	B
1	2
3	4

Instance S:

B	C	D
2	5	6
4	7	8
9	10	11

R x S:

A	R.B	S.B	C	D
1	2	2	5	6
1	2	4	7	8
1	2	9	10	11
3	4	2	5	6
3	4	4	7	8
3	4	9	10	11

Example

Instance of Student:

ID	firstName	lastName	GPA	Address
111	Joe	Smith	4.0	45 Pine av.
222	Sue	Brown	3.1	71 Main st.
333	Ann	Johns	3.7	39 Bay st.

Instance of Course:

courseNumber	name	noOfCredits
Comp352	Data structures	3
Comp353	Databases	4

SELECT * FROM Student, Course;

ID	firstName	lastName	GPA	Address	courseNumber	name	noOfCredits
111	Joe	Smith	4.0	45 Pine av.	Comp352	Data structures	3
111	Joe	Smith	4.0	45 Pine av.	Comp353	Databases	4
222	Sue	Brown	3.1	71 Main st.	Comp352	Data structures	3
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Example

Instance of Student:

ID	firstName	lastName	GPA	Address
111	Joe	Smith	4.0	45 Pine av.
222	Sue	Brown	3.1	71 Main st.
333	Ann	Johns	3.7	39 Bay st.

Instance of Course:

courseNumber	name	noOfCredits
Comp352	Data structures	3
Comp353	Databases	4

SELECT ID, courseNumber
FROM Student, Course;

ID	courseNumber
111	Comp352
111	Comp353
222	Comp352
222	Comp353
333	Comp352
333	Comp353

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Example

- Relation schemas:
  - **Student** (<u>ID</u>, firstName, lastName, address, GPA)
  - **Ugrad** (<u>ID</u>, major)
- Query:
  - Find "all" information about every undergraduate student
- We try first by computing the Cartesian product (×)
  - **SELECT** * **FROM** Student, Ugrad;

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Example

Instance of Student:

ID	firstName	lastName	GPA	Address
111	Joe	Smith	4.0	45 Pine av.
222	Sue	Brown	3.1	71 Main st.
333	Ann	Johns	3.7	39 Bay st.

Instance of Ugrad:

ID	major
111	CS
333	EE

SELECT * **FROM** Student, Ugrad;

ID	firstName	lastName	GPA	Address	ID	major
111	Joe	Smith	4.0	45 Pine av.	111	CS
111	Joe	Smith	4.0	45 Pine av.	333	EE
222	Sue	Brown	3.1	71 Main st.	111	CS
222	Sue	Brown	3.1	71 Main st.	333	EE
333	Ann	Johns	3.7	39 Bay st.	111	CS
333	Ann	Johns	3.7	39 Bay st.	333	EE

Only the green tuples should be in the query result. How to pick them only?

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Example

Instance of Student:

ID	firstName	lastName	GPA	Address
111	Joe	Smith	4.0	45 Pine av.
222	Sue	Brown	3.1	71 Main st.
333	Ann	Johns	3.7	39 Bay st.

Instance of Ugrad:

ID	major
111	CS
333	EE

SELECT *
FROM Student, Ugrad
WHERE Student.ID = Ugrad.ID;

ID	firstName	lastName	GPA	Address	ID	major
111	Joe	Smith	4.0	45 Pine av.	111	CS
333	Ann	Johns	3.7	39 Bay st.	333	EE

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Join in SQL

- The above query is an example of **Join** operation
- There are different kinds of joins, which we will studyl
- To join relations $R_1, \ldots, R_n$ in SQL:
  - List all these relations in the **FROM** clause
  - Express the conditions in the **WHERE** clause in order to get the "desired" **join**

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Joining Relations

- Relation schemas:
  - **Movie** (<u>title</u>, <u>year</u>, length, filmType)
  - **Owns** (<u>title</u>, <u>year</u>, <u>studioName</u>)
- Query: Find title, length, and studio name of every movie
- Query in SQL:
  - **SELECT** Movie.title, Movie.length, Owns.studioName
  - **FROM** Movie, Owns
  - **WHERE** Movie.title = Owns.title **AND** Movie.year = Owns.year;

Question: Is Owns in Owns.studioName necessary?

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Joining Relations

- Relation schemas:
  - **Movie** (title, year, length, filmType)
  - **Owns** (title, year, studioName)
- Query:
  - Find the title and length of every movie produced by Disney studio.
- Query in SQL:

```
SELECT Movie.title, length
FROM Movie, Owns
WHERE Movie.title = Owns.title AND
      Movie.year = Owns.year AND studioName = 'Disney';
```

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Joining Relations

- Relation schemas:
  - **Movie** (title, year, length, filmType)
  - **Owns** (title, year, studioName)
  - **StarsIn** (title, year, starName)
- Query:
  - Find the title and length of Disney movies with JR as an actress.
- Query in SQL:

```
SELECT Movie.title, Movie.length
FROM Movie, Owns, StarsIn
WHERE Movie.title = Owns.title AND Movie.year = Owns.year
  AND Movie.title = StarsIn.title AND Movie.year = StarsIn.year
  AND studioName = 'Disney' AND starName = 'JR';
```

Example

Movie

title	year	length	filmType
T1	1990	124	color
T2	1991	144	color

Owns

title	year	studioName
T1	1990	Disney
T2	1991	MGM

StarsIn

title	year	starName
T1	1990	JR
T2	1991	JR

title	length
T1	124

```
SELECT Movie.title, Movie.length
FROM Movie, Owns, StarsIn
WHERE Movie.title = Owns.title AND Movie.year =
   Owns.year AND  Movie.title = StarsIn.title AND
   Movie.year = StarsIn.year AND studioName = 'Disney'
   AND starName = 'JR';
```

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Aggregation in SQL

- SQL provides 5 operators that can be applied to a column of a relation in order to produce some kind of "summary"
- These operators are called ***aggregations***
- They are used in a **SELECT** clause and often applied to a scalar-valued attribute (column) or an expression in general.

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Aggregation Operators

- **SUM**
  - Returnes the sum of values in the column
- **AVG**
  - Returns the average of values in the column
- **MIN**
  - Returns the least value in the column
- **MAX**
  - Returns the greatest value in the column
- **COUNT**
  - Returns the number of values in the column, including the duplicates, unless the keyword **DISTINCT** is used explicitly

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Example

- Relation schema:
  - **Exec**(name, address, cert#, netWorth)
- Query:
  - Find the average net worth of the movie executives
- Query in SQL:
  - **SELECT AVG**(netWorth)
  - **FROM** Exec;
    - The sum of "all" values in the column **netWorth** divided by the number of these values
    - In general, if a value ***v*** appears ***n*** times in the column, it contributes the value ***n*v*** to computing the average

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Example

- Relation schema:

  Exec (name, address, cert#, netWorth)
- Query:

  How many movie executives are there in the Exec relation?
- Query in SQL:

  SELECT COUNT(*)

  FROM Exec;
  - The use of * as a parameter is unique to **COUNT**;

    Its use for other aggregation operations makes no sense.

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Example

- Relation schema:

  Exec (name, address, cert#, netWorth)
- Query:

  How many different names are there in the Exec relation?
- Query in SQL:

  SELECT COUNT (**DISTINCT** name)

  FROM Exec;
  - In query processing time, the system first eliminates the duplicates from the column name, and then counts the number of present values

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Aggregation -- Grouping

- To answer a query, we may need to "group"the tuples according to the values of some other column(s)
- Example: Suppose we want to find:

  Total length in minutes of movies produced by each studio:

  Movie(title, year, length, filmType, studioName, producerC#)
- We must group the tuples in the *Movie* relation according to their *studio*, and then find the sum of the *lengths* within each group. The result displayed would look like:

studio	SUM(length)
Disney	12345
MGM	54321
…	…

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Aggregation - Grouping

- Relation schema:

  Movie(title, year, length, filmType, studioName, producerC#)
- Query: What is the total length in minutes produced by each studio?
- Query formulated/expressed in SQL:

  SELECT studioName, **SUM**(length)

  FROM Movie

  GROUP BY studioName;
  - Whatever aggregation used in the **SELECT** clause will be applied only within groups
  - Only those attributes mentioned in the **GROUP BY** clause may appear unaggregated in the **SELECT** clause
  - Can we use GROUP BY without using aggregation?

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Aggregation -- Grouping

- Relation schema:

  Movie(title, year, length, filmType, studioName, producerC#)

  Exec(name, address, cert#, netWorth)
- Query:

  For each producer (name), list the total length of the films produced
- Query in SQL:

  SELECT Exec.name, **SUM**(Movie.length)

  FROM Exec, Movie

  WHERE Movie.producerC# = Exec.cert#

  GROUP BY Exec.name;

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A rule about null values!

- Nulls are counted when grouping but ignored when aggregating.

  Example: Consider the instance below of R(A,B).

  Which one of the following tuples will *not* be in the output?

Select A, Sum(B)
From R
Group By A;

A	B
null	1
2	1
null	null
3	2
2	3
1	null

A. (null, null)
B. (2,4)
C. (1,null)
D. (null,1)

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A rule about null values!

- The answer:

Select A, Sum(B)
From R
Group By A;

A	B
null	1
2	1
null	null
3	2
2	3
1	null

√ (null, null)
- (2,4)
- (1,null)
- (null,1)

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Another test!

- Consider again the same instance of R(A,B) containing the tuples: (null,1), (2,1), (null, null), (3,2), (2,3), and (1,null). Which of the following tuples will be in the result of the query below?

Select A, Sum(B)
From R
Where B<>2
Group By A;

A. (null, 0)
B. (1,null)
C. (2,3)
D. (2,4)

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Answer!

- Consider an instance of R(A,B) with the tuples (null,1), (2,1), (null, null), (3,2), (2,3), and (1,null). Which one of the following tuples will be present in the result of the query below?

Select A, Sum(B)
From R
Where B<>2
Group By A;

null	1
2	1
2	3

- (null, 0)
- (1,null)
- (2,3)

√ (2,4)

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Aggregation – HAVING clause

- We might be interested in not all but some groups of tuples that satisfy certain conditions
- We can follow a **GROUP BY** clause with a **HAVING** clause
- **HAVING** is followed by some conditions about the group
- We can ***not*** use a **HAVING** clause without **GROUP BY**

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Aggregation – HAVING clause

- Relation schema:
  Movie (title, year, length, filmType, studioName, producerC#)
  Exec(name, address, cert#, netWorth)
- Query:
  For those producers who made at least one film prior to 1930, list the total length of the films produced
- Query in SQL:
  SELECT Exec.name, **SUM**(Movie.length)
  FROM Exec, Movie
  WHERE producerC# = cert#
  GROUP BY Exec.name
  HAVING MIN(Movie.year) < 1930;

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Aggregation – HAVING clause

- This query chooses the group based on the property of **each group**
  SELECT Exec.name, **SUM**(Movie.length)
  FROM Exec, Movie
  WHERE producerC# = cert#
  GROUP BY Exec.name
  HAVING MIN(Movie.year) < 1930;
- Consider the following query which chooses the movies based on the property of **each movie tuple**:
  SELECT Exec.name, **SUM**(Movie.length)
  FROM Exec, Movie
  WHERE producerC# = cert# **AND** Movie.year < 1930
  GROUP BY Exec.name;

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Order By

- The SQL statements/queries we looked at so far return an **unordered** *relation/bag. What if we want the result displayed in a certain order?*

  Movie (title, year, length, filmType, studioName, producerC#)

```
SELECT Exec.name, SUM(Movie.length)
FROM Exec, Movie
WHERE producerC# = cert#
GROUP BY Exec.name
HAVING MIN(Movie.year) < 1930
ORDER BY Exec.name ASC;
```

In general:
ORDER BY A **ASC**, B **DESC**, C **ASC;**

Database Modifications

- **SQL & Database Modifications?**
  - We now look at SQL statements that do not return tuples, but rather ***change the state (content) of the database***
- There are three types of such statements/transactions:
  - **Insert** tuples into a relation
  - **Delete** certain tuples from a relation
  - **Update** values of certain attributes of certain existing tuples

  These types of operations that modify the database content are *referred to as* ***transactions***

Insertion

- The insertion statement consists of:
  - The keyword **INSERT INTO**
  - The name of a relation ***R***
  - A parenthesized list of attributes of the relation ***R***
  - The keyword **VALUES**
  - A tuple expression, that is, a parenthesized list of concrete values, one for each attribute in the attribute list
- The form of an insert statement:

  INSERT INTO $R(A_1, \ldots, A_n)$ **VALUES** $(v_1, \ldots, v_n)$ **;**

  - This command inserts the tuple $(v_1,\ldots,v_n)$ to table ***R***, where v_i *is the value of* attribute A_i, for $i = 1,\ldots,n$

Insertion

- Relation schema:

  StarsIn (title, year, starName)
- Update the database:

  Add "Sydney Greenstreet" to the list of stars of *The Maltese Falcon*
- In SQL:

  INSERT INTO StarsIn (title,year, starName)

  VALUES('The Maltese Falcon', 1942, 'Sydney Greenstreet');

  Another formulation of this query:

  INSERT INTO StarsIn

  VALUES('The Maltese Falcon', 1942, 'Sydney Greenstreet');

Insertion

- The previous insertion statement was "simple" in that it added just **one** tuple into a relation
- Instead of using *explicit* values for one tuple, we can request a **set** of tuples to be inserted. For this we define, in a *subquery*, the set of tuples from an existing relation
- This subquery replaces the keyword **VALUES** and the tuple expression in the **INSERT** statement

Insertion

- Database schema:

  Studio(name, address, presC#**)**

  Movie(title, year, length, filmType, studioName, producerC#)
- Update the database:

  Add to **Studio,** all studio names mentioned in the **Movie** relation
- **Note**: If the list of attributes in an "insert" statement does not include all the attributes of the relation, the tuple created will have the **default** value for each missing attribute
- Since there is no way to determine an **address** or a **presC#** for a studio tuple, **NULL** will be used for these attributes.

Insertion

- Database schema:
  Studio(name, address, presC#**)**
  Movie(title, year, length, filmType, studioName, producerC#)
- Update the database:
  Add to **Studio,** all studio names mentioned in the **Movie** relation
- In SQL:

```
INSERT INTO Studio(name)
SELECT DISTINCT studioName
FROM Movie
WHERE studioName NOT IN (SELECT name
                         FROM Studio);
```


Deletion

- A delete statement consists of :
  - The keyword **DELETE FROM**
  - The name of a relation ***R***
  - The keyword **WHERE**
  - A condition
- The syntax of the delete statement:
  DELETE FROM *R* WHERE <condition**>;**
  - The effect of executing this statement is that "every tuple" in relation ***R*** satisfying the condition will be deleted from ***R***
  - Note: unlike the INSERT, we MAY need a WHERE clause here

Deletion

- Relation schema:
  StarsIn(title, year, starName)
- Update:
  Delete the tuple that says**:**
  Sydney Greenstreet was a star in *The Maltese Falcon*
- In SQL:

```
DELETE FROM StarIn
WHERE title = 'The Maltese Falcon' AND
      starName = 'Sydney Greenstreet';
```


Deletion

- Relation schema:
  Exec(name, address, cert#, netWorth)
- Update:
  Delete every movie executive whose net worth is < $10,000,000
- In SQL:

```
DELETE FROM Exec
WHERE netWorth < 10,000,000;
```

Anything wrong here?!

Deletion

- Relation schema:
  Studio(name, address, presC#**)**
  Movie(title, year, length, filmType, studioName, producerC#)
- Update:
  Delete from **Studio,** those studios not mentioned in **Movie**
  (i.e., we don't want to have non-productive studios!!)
- In SQL:

```
DELETE FROM Studio
WHERE name NOT IN (SELECT StudioName
                   FROM Movie);
```


Update

- Update statement consists of**:**
  - The keyword **UPDATE**
  - The name of a relation ***R***
  - The keyword **SET**
  - A list of formulas, each of which will assign a value to an attribute of ***R***
  - The keyword **WHERE**
  - A condition
- The syntax of the update statement:
  UPDATE *R* SET <new-value assignments> **WHERE** <condition>**;**

Update

- Database schema:
  Studio(name, address, presC#)
  Exec(name, address, cert#, netWorth)
- Update:
  Modify table **Exec** by attaching the title **'Pres. '** in front of the name of every movie executive who is also the president of some studio
- In SQL:

```
UPDATE Exec
SET name = 'Pres. ' || name          ← this line performs the update
WHERE cert# IN (SELECT presC#
                FROM Studio);
```

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Defining Database Schema

- SQL includes two types of statements:
  - DML
  - DDL
- So far we looked at the DML part to specify or modify the relation/database instances.
- The DDL part allows us to define or modify the relation/database schemas.

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Defining Database Schema

- To create a table in SQL:
  - **CREATE TABLE** *name* (list of elements);
    - Principal elements are *attributes* and their *types*, but declarations of key and constraints may also appear
  - Example:

```
CREATE TABLE Star (
    name CHAR(30),
    address VARCHAR(255),
    gender CHAR(1),
    birthdate DATE
);
```

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Defining Database Schema

- To delete a table from the database:
  - **DROP TABLE** *name*;
- Example:
  DROP TABLE Star;

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Data types

- **INT** or **INTEGER**
- **REAL** or **FLOAT**
- **DECIMAL**(n, d) -- **NUMERIC**(n, d)
  - **DECIMAL**(6, 2), e.g., 0123.45
- **CHAR**(n)/**BIT**(B) fixed length character/bit string
  - Unused part is padded with the "pad character", denoted as ⊥
- **VARCHAR**(n) / **BIT VARYING**(n) variable-length strings up to **n** characters
- Oracle also uses **VARCHAR2**(n), which is truly varying length;
  Since **VARCHAR** uses fixed array with end-marker, it is not followed any longer in Oracle.

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Data types (cont'd)

- **SQL2 Syntax for:**
  -- Time: 'hh:mm:ss[.ss...]'
  -- Date: 'yyyy-mm-dd' (m =0 or 1)
- Example:
  CREATE TABLE Days(d DATE);
  INSERT INTO Days **VALUES**('2012-12-23');

- **Note 1:** In **Oracle**, the default format of date is 'dd-mon-yy', e.g.,
  INSERT INTO Days **VALUES**('22-jan-18');
- **Note 2:** The Oracle function **to_date** converts a specified format into default, e.g.,
  INSERT INTO Days **VALUES (to_date(**'2018-01-22', 'yyyy-mm-dd'**));**

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Altering Relation Schemas

- **Adding Columns**
  - Add an attribute to an existing relation **R:**

    ALTER TABLE R ADD <column declaration>;
- **Example:** **Add attribute phone to table Star**
  - **ALTER TABLE** Star **ADD** phone CHAR(16);
- **Removing Columns**
  - Remove an attribute from a relation **R** using DROP:
  - **ALTER TABLE** *R* **DROP COLUMN <***column_name***>;**
- **Example:** **Remove column phone from Star**
  - **ALTER TABLE** Star **DROP COLUMN** phone**;**

Note: Can't drop a column, if it is the only column

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Attribute Properties

- We can assert that the value of an attribute A to be:
  - **NOT NULL**
    - Then every tuple must have a "real" value (not null) for this attribute
  - **DEFAULT** *value*
    - Null is the default value for every attribute
    - However, we can consider/define any value we wish as the default for a column, when we create a table.

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Attribute Properties

CREATE TABLE Star (
name **CHAR**(30),
address **VARCHAR**(255),
gender **CHAR**(1) **DEFAULT** '?',
birthdate **DATE NOT NULL**);

- Example: Add an attribute with a default value:
  - **ALTER TABLE** Star **ADD** phone **CHAR**(16) **DEFAULT** 'unlisted';
- **INSERT INTO** Star(name, birthdate) **VALUES** ('Sally' ,'0000-00-00')

name	address	gender	birthdate	phone
Sally	**NULL**	**?**	**0000-00-00**	**unlisted**

- **INSERT INTO** Star(name, phone) **VALUES** ('Sally', '333-2255');
  - this insertion op. fails since the value for birthdate is not given, since Null was disallowed by the user

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Attribute Properties

To add default value after an attribute is defined:

- **ALTER TABLE** Star **ALTER** phone **SET DEFAULT** 'no-phone';
- **In Oracle:**

  ALTER TABLE Star **MODIFY** phone **DEFAULT** 'no-phone';

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