Business Analytics and Data Driven Decision Making

Introduction to Datawarehouse Modelling & Basics of SQL

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AGENDA

Agenda

- Dataware house Models
- Introduction to Structured Query Language (SQL)
  - Select Clause
  - Aggregation
  - Group By
  - String Functions
- Join Relations and Types of Joins

Learning Objective

- Understand the structure of relations/tables suitable for (Visual) analysis
- Understand use of SQL for reporting
- **Strong understanding of GROUP BY concept for aggregations**
- **I don’t expect that you will remember syntax !**

Literature

- This lecture will use examples and illustrations for the following books.

Silberschatz, A., Korth, H., Sudarshan, S. Database System Concepts. 7th Edition. McGraw-Hill Education. ISBN13: 9780078022159

Jukic, N. (2019). Database systems: Introduction to databases and data warehouses.

DATAWARE HOUSE / REPORTING SCHEMAS FOR DATA

Operational vs Analytical Information

- Operational Information
  - Transactional database storing day to day operations
  - Result of individual transactions i.e. Sales, Purchases, Logs, Conversations
- Analytical Information
  - To support data analysis tasks
  - Transformed from operational databases

Operational vs Analytical Information

- Data Makeup Differences.
  - Summarized data
  - Granularity of time span
- Technical Differences.
  - Redundancy allowed.
  - Less frequent updates and access.
- Functional Differences.
  - Consumed by decision makers.
  - Organized and structured around subject of analysis

MEMBERS DATABASE

MEMBER

MemberID	MemberName	MemberGender	MLevelID	DateMembershipPaid	ValidUntil
111	Joe	M	A	1/1/2020	1/1/2021
222	Sue	F	B	1/1/2020	1/1/2021
333	Pam	F	A	1/2/2020	1/2/2021
...	...	...	...	...	...

MEMBERSHIP LEVEL

MLevelID	MLevelType	MLevelFee	MLevelDescription
A	Gold	$100	Includes the Pool Usage
B	Basic	$50	No Pool Usage

NONMEMBERS DATABASE

NONMEMBER DAILY VISIT

DVisitTID	DVisitLevelID	DVisitDate	DVisitorGender
11xx22	YP	1/1/2020	M
11xx23	NP	1/2/2020	M
11xx24	YP	1/2/2020	F
...	...	...	...

NONMEMBER VISIT LEVEL

DVisitLevelID	DVisitLevelFee	DVisitLevelType
YP	$15	With Pool Usage
NP	$10	Without Pool Usage

Figure 7.1 Application-oriented databases serving the Vitality Health Club Visits and Payments Application

on

Jukic, N. (2019). Database systems: Introduction to databases and data warehouses.

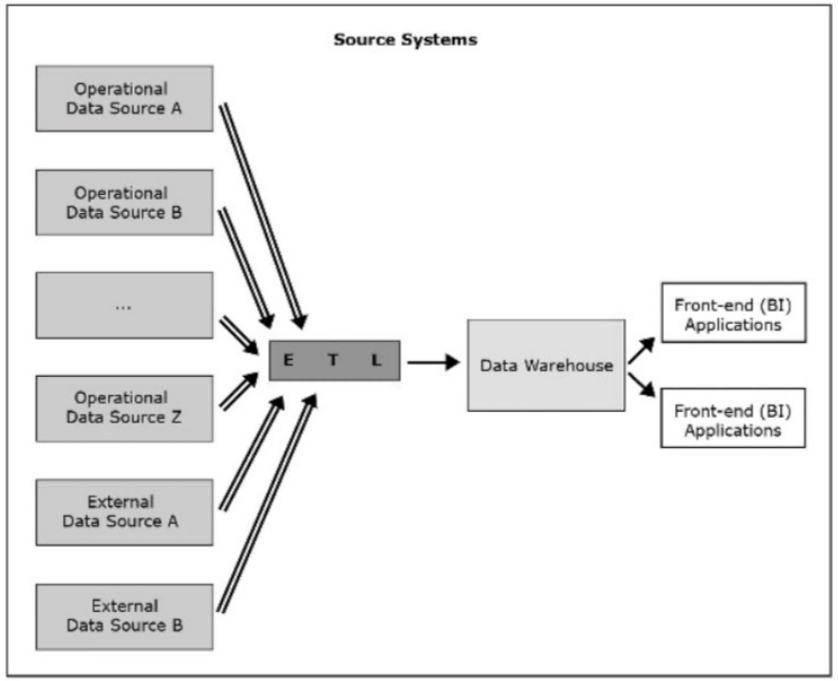
REVENUE

RevenueRecordID	Date	GeneratedBy	ClientGender	Pool Use Included in Purchase	Amount
1000	1/1/2020	Member	M	Yes	$100
1001	1/1/2020	Member	F	No	$50
1002	1/1/2020	Nonmember	M	Yes	$15
1003	1/2/2020	Member	F	Yes	$100
1004	1/2/2020	Nonmember	M	No	$10
1005	1/2/2020	Nonmember	F	Yes	$15
...				...	...

Figure 7.2 A subject-oriented database for the analysis of the subject revenue

Components of Analytical Database Systems / Warehouse

- Source Systems. i.e. Operational Databases, external data streams.
- ETL Processes for Data transformation and storage into Datawares.
- Dataware house / Structured schematic of data for analysis is a repository of analytical data.



Jukic, N. (2019). Database systems: Introduction to databases and data warehouses.

Modelling of Analytical Databases

- Dimensional Modeling
  - is a data design methodology used for designing subject oriented analytical databases.
  - Consists of two types of tables connected in different structures
    - Dimentional Tables
    - Fact Tables

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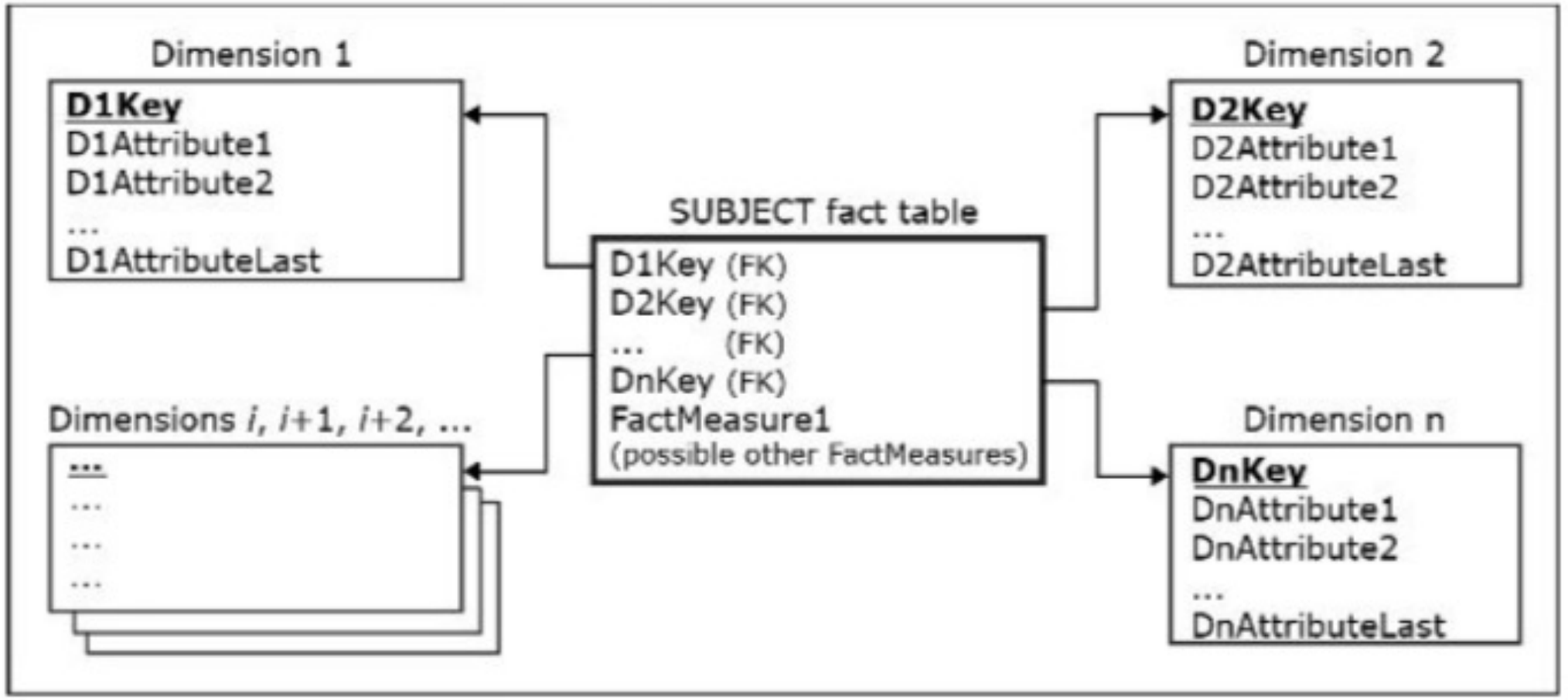
Modelling of Analytical Databases



Jukic, N. (2019). Database systems: Introduction to databases and data warehouses.

Analysis Data Models Schema Types

- Star Schema
  - One fact table for subject of analysis. i.e. Sales
  - Multiple Dimension table according to required analysis
- Snowflake Schema
  - One fact table like Star Schema
  - Normalized (Redundancy removed) expanded dimension table(s)
- Fact Constellation Schema
  - Multiple Fact tables to support analysis of multiple subjects
  - Dimensions are re-used

Jukic, N. (2019). Database systems: Introduction to databases and data warehouses.

REGION

RegionID	RegionName
C	Chicagoland
T	Tristate

INCLUDES

ProductID	TID	Quantity
1X1	T111	1
2X2	T222	1
3X3	T333	5
1X1	T333	1
4X4	T444	1
2X2	T444	2
4X4	T555	4
5X5	T555	2
6X6	T555	1

VENDOR

VendorID	VendorName
PG	Pacific Gear
MK	Mountain King

STORE

StoreID	StoreZip	RegionID
S1	60600	C
S2	60605	C
S3	35400	T

CATEGORY

CategoryID	CategoryName
CP	Camping
FW	Footwear

SALESTRANSACTION

TID	CustomerID	StoreID	TDate
T111	1-2-333	S1	1-Jan-2020
T222	2-3-444	S2	1-Jan-2020
T333	1-2-333	S3	2-Jan-2020
T444	3-4-555	S3	2-Jan-2020
T555	2-3-444	S3	2-Jan-2020

CUSTOMER

CustomerID	CustomerName	CustomerZip
1-2-333	Tina	60137
2-3-444	Tony	60611
3-4-555	Pam	35401

PRODUCT

ProductID	ProductName	ProductPrice	VendorID	CategoryID
1X1	Zzz Bag	$100	PG	CP
2X2	Easy Boot	$70	MK	FW
3X3	Cosy Sock	$15	MK	FW
4X4	Dura Boot	$90	PG	FW
5X5	Tiny Tent	$150	MK	CP
6X6	Biggy Tent	$250	MK	CP

Figure 8.3 Data records for the ZAGI Retail Company Sales Department Database shown in Figure 8.2

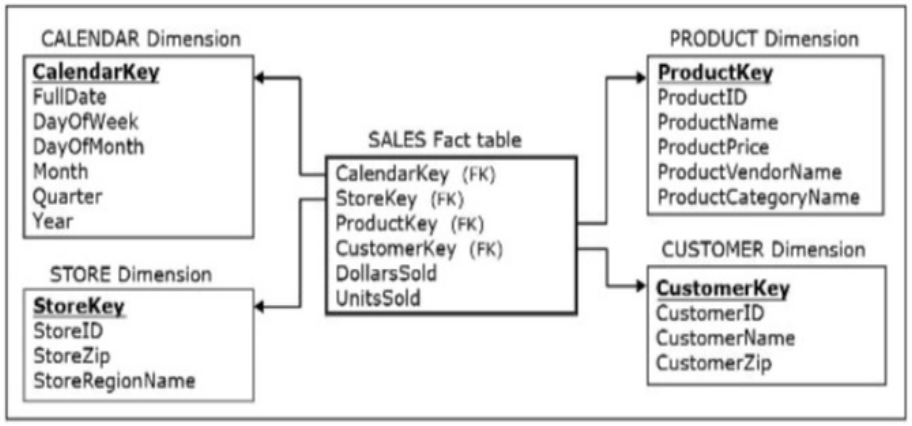
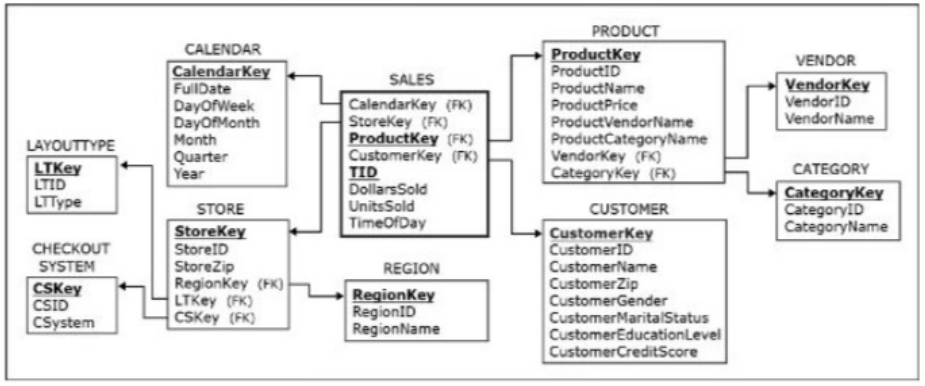


Figure 8.4 A dimensional model for an analytical database for the ZAGI Retail Company, whose subject of analysis is sales



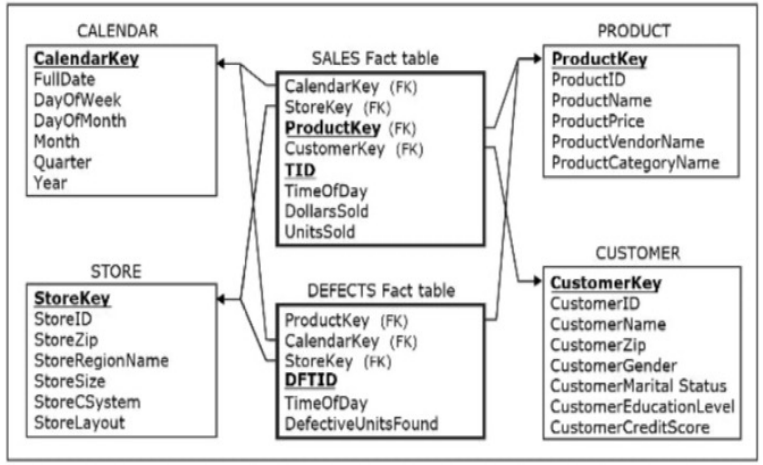


Figure 8.19 An expanded dimensional model with two subjects

REGION

RegionID	RegionName
C	Chicagoland
T	Tristate

INCLUDES

ProductID	TID	Quantity
1X1	T111	1
2X2	T222	1
3X3	T333	5
1X1	T333	1
4X4	T444	1
2X2	T444	2
4X4	T555	4
5X5	T555	2
6X6	T555	1

VENDOR

VendorID	VendorName
PG	Pacific Gear
MK	Mountain King

STORE

StoreID	StoreZip	RegionID
S1	60600	C
S2	60605	C
S3	35400	T

CATEGORY

CategoryID	CategoryName
CP	Camping
FW	Footwear

SALESTRANSACTION

TID	CustomerID	StoreID	TDate
T111	1-2-333	S1	1-Jan-2020
T222	2-3-444	S2	1-Jan-2020
T333	1-2-333	S3	2-Jan-2020
T444	3-4-555	S3	2-Jan-2020
T555	2-3-444	S3	2-Jan-2020

CUSTOMER

CustomerID	CustomerName	CustomerZip
1-2-333	Tina	60137
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3-4-555	Pam	35401

PRODUCT

ProductID	ProductName	ProductPrice	VendorID	CategoryID
1X1	Zzz Bag	$100	PG	CP
2X2	Easy Boot	$70	MK	FW
3X3	Cosy Sock	$15	MK	FW
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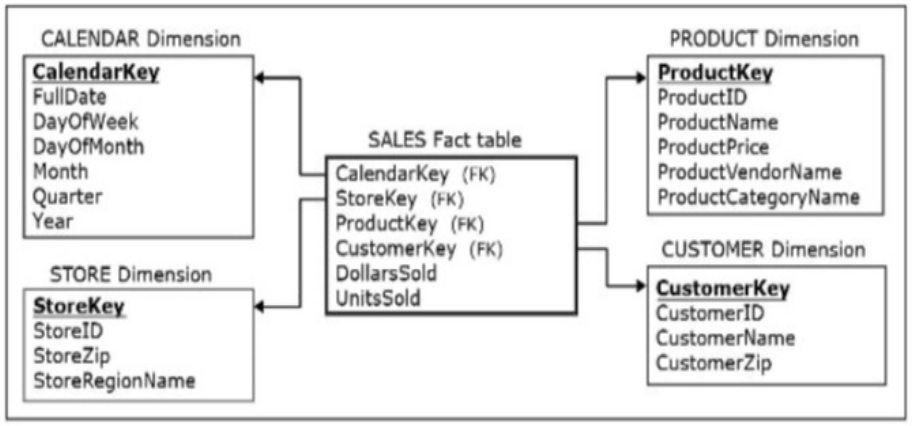

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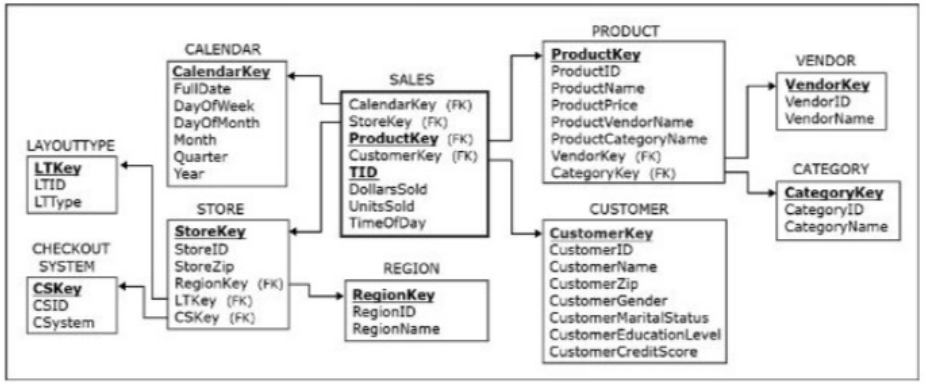

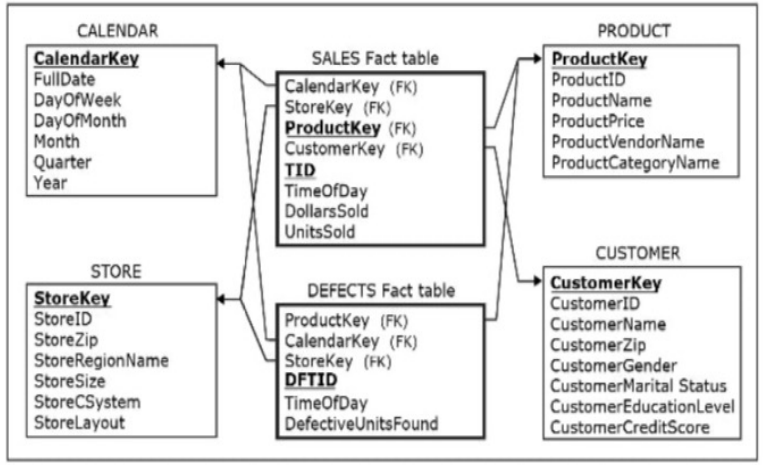

Figure 8.19 An expanded dimensional model with two subjects

SQL QUERIES

Basic Query Structure

- A typical SQL query has the form:

select $A_1, A_2, ..., A_n$

from $r_1, r_2, ..., r_m$

where P

  - A_i represents an attribute
  - R_i represents a relation
  - P is a predicate.
- The result of an SQL query is a relation.

SELECT Clause

- The **select** clause lists the attributes desired in the result of a query
  - corresponds to the projection operation of the relational algebra
- Example: find the names of all instructors:

  select *name*

  from *instructor*
- NOTE: SQL names are case insensitive (i.e., you may use upper- or lower-case letters.)
  - E.g., *Name* ≡ *NAME* ≡ *name*
  - Some people use upper case wherever we use bold font.

SELECT Clause – Duplicate elimination

- SQL allows duplicates in relations as well as in query results.
- To force the elimination of duplicates, insert the keyword **distinct** after select**.**
- Find the department names of all instructors, and remove duplicates

select distinct *dept_name* **from** *instructor*

SELECT Clause – literal output

- An asterisk in the select clause denotes “all attributes”

  select *

  from *instructor*

- An attribute can be a literal with no **from** clause

  select ‘437’

  - Results is a table with one column and a single row with value “437”
  - Can give the column a name using: **select** ‘437’ **as** *FOO*

- An attribute can be a literal with **from** clause

  select ‘A’

  from *instructor*

  - Result is a table with one column and *N* rows (number of tuples in the *instructors* table), each row with value “A”

SELECT Clause – Embedded Arithmetic Operations

- The **select** clause can contain arithmetic expressions involving the operation, +, –, ∗, and /, and operating on constants or attributes of tuples.
  - The query:

    select *ID, name, salary/12*

    from *instructor*

    would return a relation that is the same as the *instructor* relation, except that the value of the attribute *salary* is divided by 12.
  - Can rename "s*alary/12"* using the **as** clause:

    select *ID, name, salary/12* **as** *monthly_salary*

WHERE Clause

- The **where** clause specifies conditions that the result must satisfy
  - Corresponds to the selection predicate of the relational algebra.
- To find all instructors in Comp. Sci. dept

  select *name*

  from *instructor*

  where *dept_name = '*Comp. Sci.'
- Comparison results can be combined using the logical connectives **and, or,** and **not**
  - To find all instructors in Comp. Sci. dept with salary > 80000

    select *name.* **from** *instructor* **where** *dept_name = '*Comp. Sci.' **and** *salary* > 80000

FROM Clause

- The **from** clause lists the relations involved in the query
  - Corresponds to the Cartesian product operation of the relational algebra.
- Find the Cartesian product *instructor X teaches*

  select ∗

  from *instructor, teaches*

  - generates every possible instructor – teaches pair, with all attributes from both relations.
  - For common attributes (e.g., *ID*), the attributes in the resulting table are renamed using the relation name (e.g., *instructor.ID*)
- Cartesian product not very useful directly, but useful combined with where-clause condition (selection operation in relational algebra).

Cartesian Product

instructor

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000

teaches

ID	course_id	sec_id	semester	year
10101	CS-101	1	Fall	2009
10101	CS-315	1	Spring	2010
10101	CS-347	1	Fall	2009
12121	FIN-201	1	Spring	2010
15151	MU-199	1	Spring	2010
22222	PHY-101	1	Fall	2009

Inst.ID	name	dept_name	salary	teaches.ID	course_id	sec_id	semester	year
10101	Srinivasan	Comp. Sci.	65000	10101	CS-101	1	Fall	2009
10101	Srinivasan	Comp. Sci.	65000	10101	CS-315	1	Spring	2010
10101	Srinivasan	Comp. Sci.	65000	10101	CS-347	1	Fall	2009
10101	Srinivasan	Comp. Sci.	65000	12121	FIN-201	1	Spring	2010
10101	Srinivasan	Comp. Sci.	65000	15151	MU-199	1	Spring	2010
10101	Srinivasan	Comp. Sci.	65000	22222	PHY-101	1	Fall	2009
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
12121	Wu	Finance	90000	10101	CS-101	1	Fall	2009
12121	Wu	Finance	90000	10101	CS-315	1	Spring	2010
12121	Wu	Pinance	90000	10101	CS-347	1	Fall	2009
12121	Wu	Pinance	90000	12121	FIN-201	1	Spring	2010
12121	Wu	Finance	90000	15151	MU-199	1	Spring	2010
12121	Wu	Pinance	90000	22222	PHY-101	1	Fall	2009
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…

Silberschatz, A., Korth, H., Sudarshan, S. Database System Concepts. 7th Edition. McGraw-Hill Education. ISBN13: 9780078022159

Examples

- Find the names of all instructors who have taught some course and the course_id

  select *name, course_id*

  from *instructor , teaches*

  where *instructor.ID = teaches.ID*

- Find the names of all instructors in the Art department who have taught some course and the course_id

  select *name, course_id*

  from *instructor , teaches*

  where *instructor.ID = teaches.ID* ***and*** *instructor. dept_name =* 'Art'

String Operations

- SQL includes a string-matching operator for comparisons on character strings. The operator **like** uses patterns that are described using two special characters:
  - percent (%). The % character matches any substring.
  - underscore (_). The _ character matches any character.
- Find the names of all instructors whose name includes the substring “dar”.
- **se**l**ect** *name*

  from *instructor*

  where *name* **like** '%dar%'

String Operations

- Patterns are case sensitive.
- Pattern matching examples:
  - ‘Intro%’ matches any string beginning with “Intro”.
  - ‘%Comp%’ matches any string containing “Comp” as a substring.
  - ‘_ _ _’ matches any string of exactly three characters.
  - ‘_ _ _ %’ matches any string of at least three characters.

- SQL supports a variety of string operations such as
  - concatenation (using “||”)
  - converting from upper to lower case (and vice versa)
  - finding string length, extracting substrings, etc.

Ordering the Tuples

- List in alphabetic order the names of all instructors

  select distinct *name*

  from *instructor*

  order by *name*

- We may specify **desc** for descending order or **asc** for ascending order, for each attribute; ascending order is the default.
  - Example: **order by** *name* **desc**
- Can sort on multiple attributes
  - Example: **order by** *dept_name, name*

WHERE Clause predicates

- SQL includes a **between** comparison operator
- Example: Find the names of all instructors with salary between $90,000 and $100,000 (that is, ≥ $90,000 and ≤ $100,000)

  select *name*

  from *instructor*

  where *salary* **between** 90000 **and** 100000

SET Operations

- Find courses that ran in Fall 2009 or in Spring 2010
  - (**select** *course_id* **from** *section* **where** *sem* = 'Fall' **and** *year* = 2009)

    union

    (**select** *course_id* **from** *section* **where** *sem* = 'Spring' **and** *year* = 2010)
- Find courses that ran in Fall 2009 and in Spring 2010
  - (**select** *course_id* **from** *section* **where** *sem* = 'Fall' **and** *year* = 2009)

    intersect

    (**select** *course_id* **from** *section* **where** *sem* = 'Spring' **and** *year* = 2010)
- Find courses that ran in Fall 2009 but not in Spring 2010
  - (**select** *course_id* **from** *section* **where** *sem* = 'Fall' **and** *year* = 2009)

    except

    (**select** *course_id* **from** *section* **where** *sem* = 'Spring' **and** *year* = 2010)

NULL Values

- It is possible for tuples to have a null value, denoted by *null*, for some of their attributes
- *null* signifies an unknown value or that a value does not exist.
- The result of any arithmetic expression involving *null* is *null*

  Example: 5 + *null* returns null
- The predicate **is null** can be used to check for null values.

  Example: Find all instructors whose salary is null

  select *name*

  from *instructor*

  where *salary* **is null**

AGGREGATE Functions

- These functions operate on the multiset of values of a column of a relation, and return a value
- **avg:** average value

  min: minimum value

  max: maximum value

  sum: sum of values

  count: number of values

AGGREGATE Functions

- Find the average salary of instructors in the Computer Science department
  - **select avg** (*salary*)

    from *instructor*

    where *dept_name*= ’Comp. Sci.’;
- Find the total number of instructors who teach a course in the Spring 2010 semester
  - **select count** (**distinct** *ID*)

    from *teaches*

    where *semester* = ’Spring’ **and** *year* = 2010;
- Find the number of tuples in the *course* relation
  - **select count** (*)

    from *course*;

AGGREGATE Functions – Group BY

- Find the average salary of instructors in each department
- Attributes in **select** clause outside of aggregate functions must appear in **group by** list

select *dept_name*,

avg (*salary*) **as** *avg_salary*

from *instructor*

group by *dept_name*;

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

dept_name	*salary*
Biology	72000
Comp. Sci.	77333
Elec. Eng.	80000
Finance	85000
History	61000
Music	40000
Physics	91000

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AGGREGATE Functions – Having Clause

- Find the names and average salaries of all departments whose average salary is greater than 42000

  select *dept_name*, **avg** (*salary*)
  from *instructor*
  group by *dept_name*
  having avg (*salary*) > 42000;

- **Note**: predicates in the **having** clause are applied after the formation of groups whereas predicates in the **where** clause are applied before forming groups

AGGREGATE and NULL Values

- Total all salaries

  select sum (*salary*)

  from *instructor*

  - Above statement ignores null amounts
  - Result is *null* if there is no non-null amount

- All aggregate operations except **count(*)** ignore tuples with null values on the aggregated attributes
- What if collection has only null values?
  - count returns 0
  - all other aggregates return null

SET Membership and Sub Queries

- Find courses offered in Fall 2009 and in Spring 2010

```
select distinct course_id
from section
where semester = 'Fall' and year= 2009 and
        course_id in (select course_id
                      from section
                      where semester = 'Spring' and year= 2010);
```

- Find courses offered in Fall 2009 but not in Spring 2010

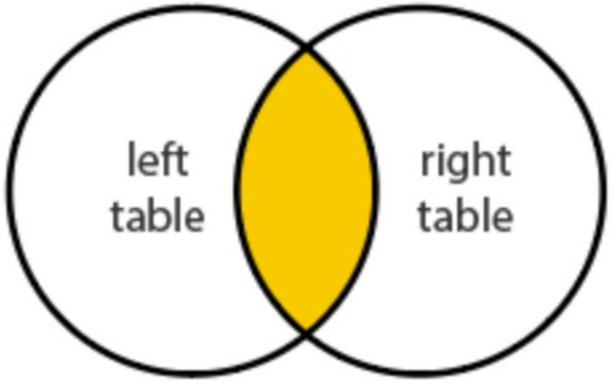
```
select distinct course_id
from section
where semester = 'Fall' and year= 2009 and
        course_id  not in (select course_id
                           from section
                           where semester = 'Spring' and year= 2010);
```

TYPES OF JOINS

JOIN in Relational Databases

- A SQL JOIN combines records from two Tables
- A JOIN is used to locate related records from tables
- A query may contain zero, one or multiple JOIN operations
- There are following commonly used types of Joins
  - INNER JOIN
  - LEFT JOIN
  - RIGHT JOIN

INNER JOIN



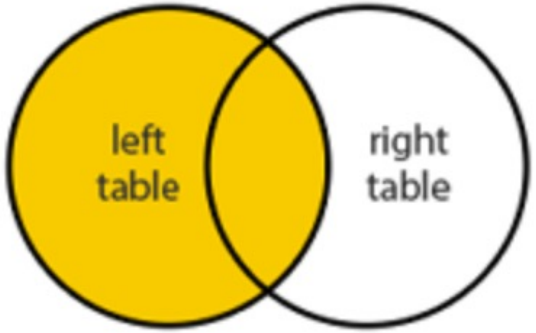
- SELECTS records with the matching values in both tables
  - **Example:**

    select * **from** *student* **join** *takes* **on** *student.ID* = *takes.ID*;

    or

    S**elect** * **from** *student*, *takes* **where** *student.ID* = *takes.ID*;

LEFT (OUTER) JOIN

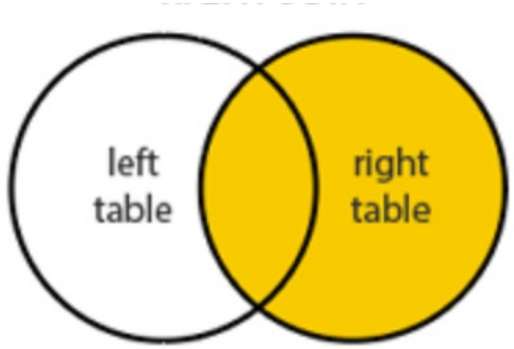


- The **left outer join** preserves tuples only in the relation named before (to the left of) the **left outer join** operation

Example: Get a list of student who did not take a course

```
select *
from student s left join takes t
on s.id=t.id where t.id is null;
```

LEFT (OUTER) JOIN



- The **right outer join** is symmetric to the **left outer join**
- Tuples from the right-hand- side relation that do not match any tuple in the left-hand-side relation are padded with nulls
-

Example: Get a list of student who did not take a course

```
select *
from takes t
right join student s on s.id=t.id
 Where s.ID is null
```

VIEWS

Views

- In some cases, it is not desirable for all users to see the entire logical model

  (that is, all the actual relations stored in the database.)
- Consider a person who needs to know an instructors name and department, but not the salary. This person should see a relation described, in SQL, by

  select *ID*, *name*, *dept_name*

  from *instructor*
- A **view** provides a mechanism to hide certain data from the view of certain users.
- Any relation that is not of the conceptual model but is made visible to a user as a “virtual relation” is called a **view**.
- Views are widely used to provide access for Visual Dashboards.

Views

- A view is defined using the **create view** statement which has the form

  create view *v* **as** < query expression >

  - where <query expression> is any legal SQL expression. The view name is represented by *v.*
- Once a view is defined, the view name can be used to refer to the virtual relation that the view generates.
- View definition is not the same as creating a new relation by evaluating the query expression
  - Rather, a view definition causes the saving of an expression; the expression is substituted into queries using the view.
- A view in some cases and under some conditions be used for updates however Views should best be used for data fetch and Reporting Only and not for insertion or update

Views

- A view of instructors without their salary

  create view *faculty* **as**

  select *ID*, *name*, *dept_name*

  from *instructor*

- Find all instructors in the Biology department

  select *name*

  from *faculty*

  where *dept_name* = 'Biology'

- Create a view of department salary totals

  create view *departments_total_salary*(*dept_name*, *total_salary*) **as**

  select *dept_name*, **sum** (*salary*)

  from *instructor*

  group by *dept_name*;

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THANK YOU