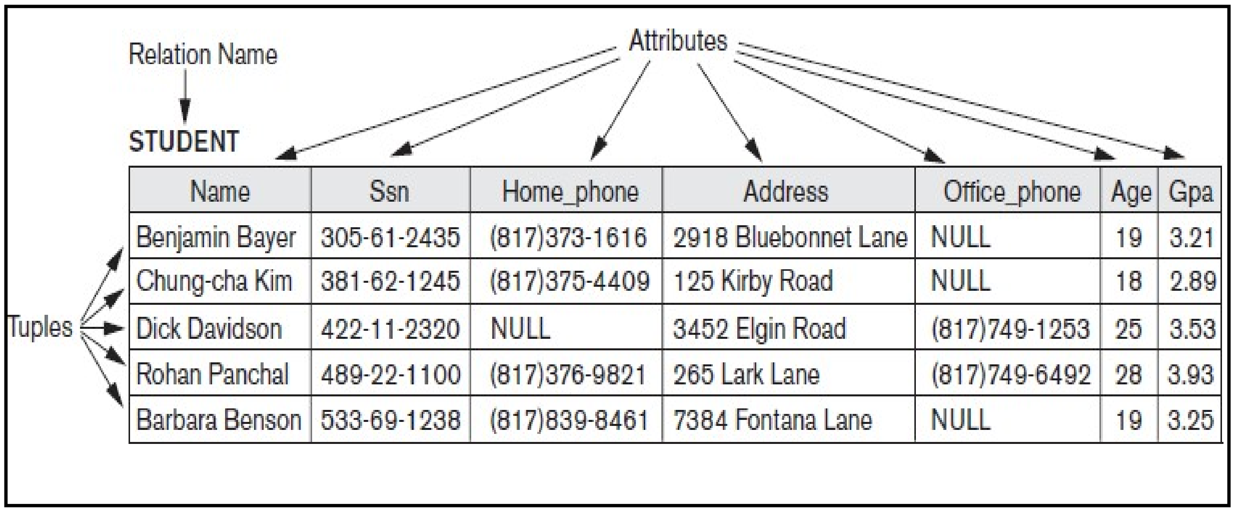
UNIT 2
The Relational Data Model and Relational Database Constraints

In the formal relational model terminology, a row is called a *tuple,* a column header is called an *attribute,* and the table is called a *relation.* The data type describing the types of values that can appear in each column is represented by a *domain.*

Domains, Attributes, Tuples, and Relations

A **domain** *D* is a set of atomic values. By **atomic** we mean that each value in the domain is indivisible as far as the formal relational model is concerned.
A **relation schema** *R*, denoted by *R*(*A*1, *A*2, ...,A*n*), is made up of a relation name *R* and a list of attributes, *A*1, *A*2, ..., *An*.
Each **attribute** *Ai* is the name of a role played by some domain *D* in the relation schema *R*. *D* is called the **domain** of *Ai* and is denoted by **dom**(**A**i*).*
A relation schema is used to *describe* a relation, *R* is called the **name** of this relation.
The **degree** (or **arity**) of a relation is the number of attributes *n* of its relation schema.
A relation of degree seven, which stores information about university students, would contain seven attributes describing each student. as follows:
The terms **relation intension** for the schema *R* .
Relation extension for a relation state *r*(*R*) are also commonly used.

STUDENT(Name, Ssn, Home_phone, Address, Office_phone, Age, Gpa).



Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	(817)373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	(817)375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	(817)749-1253	25	3.53
Rohan Panchal	489-22-1100	(817)376-9821	265 Lark Lane	(817)749-6492	28	3.93
Barbara Benson	533-69-1238	(817)839-8461	7384 Fontana Lane	NULL	19	3.25

A relation (or relation state) *r*(*R*) is a **mathematical relation** of degree *n* on the domains dom(*A*1), dom(*A*2), ..., dom(*An*), which is a **subset** of the **Cartesian product** (denoted by x) of the domains that define *R*:

$$r(R) \subseteq (\mathrm{dom}(A_1) \times \mathrm{dom}(A_2) \times \ldots \times \mathrm{dom}(A_n))$$

Informal Terms	**Formal Terms**
Table	Relation
Column	Attribute/Domain
Row	Tuple
Values in a column	Domain
Table Definition	Schema of a Relation
Populated Table	Extension

Characteristics of Relations

Ordering of Tuples in a Relation. A relation is defined as a *set* of tuples.

Mathematically, elements of a set have *no order* among them; hence, tuples in a relation do not have any particular order. In other words, a relation is not sensitive to the ordering of tuples.
Tuple ordering is not part of a relation definition because a relation attempts to representfacts at a logical or abstract level.

Ordering of Values within a Tuple and an Alternative Definition of a Relation.
At a more abstract level, the order of attributes and their values is *not* that important as long as the correspondence between attributes and values is maintained. An **alternative definition** of a relation can be given, making the ordering of values in a tuple *unnecessary.*

Values and NULLs in the Tuples. Each value in a tuple is an **atomic** value Hence, composite and multivalued attributes are not allowed. This model is sometimes called the **flat relational model**.
An important concept is that of NULL values, which are used to represent the values of attributes that may be unknown or may not apply to a tuple. A special value, called NULL, is used in these cases.

Interpretation (Meaning) of a Relation.
The relation schema can be interpreted as a declaration or a type of **assertion**. For example, the schema of the **STUDENT** relation- in general, a student entity has a Name, USN,Home_phone, Address, Office_phone, Age, and Gpa.

Each tuple in the relation can then be interpreted as a **fact** or a particular instance of the assertion.

Notice that some relations may represent facts about *entities,* whereas other relations may represent facts about *relationships.*

Relational Model Notation:
R(A1, A2, ..., An) is a relational schema of degree *n* denoting that there is a relation *R* having as its attributes *A1, A2, ...,* A_n.
By convention, *Q*, *R*, and *S* denote relation names.

By convention, *q*, *r*, and *s* denote relation states. For example, *r(R)* denotes one possible state of relation *R*. If *R* is understood from context, this could be written, more simply, as *r*.
By convention, *t*, *u*, and *v* denote tuples.

The "dot notation" *R***.***A* (e.g., STUDENT**.**Name) is used to qualify an attribute name, usually for the purpose of distinguishing it from a same-named attribute in a different relation (e.g., DEPARTMENT**.**Name).

Relational Model Constraints and Relational Database Schemas
There are generally many restrictions or **constraints** on the actual values in a database state. These constraints are derived from the rules in the miniworld that the database represents.
Domain Constraints
Domain constraints specify that within each tuple, the value of each attribute *A* must be an atomic value from the domain dom(*A*).
The data types associated with domains typically include standard numeric data types for integers (such as short integer, integer, and long integer) and real numbers (float and double precision float). Characters, Booleans, fixed-length strings, and variable-length strings are also available, as are date, time, timestamp, and money, or other special data types. Other possible domains may be described by a subrange of values from a data type or as an enumerated data type in which all possible values are explicitly listed.

Key Constraints and Constraints on NULL Values

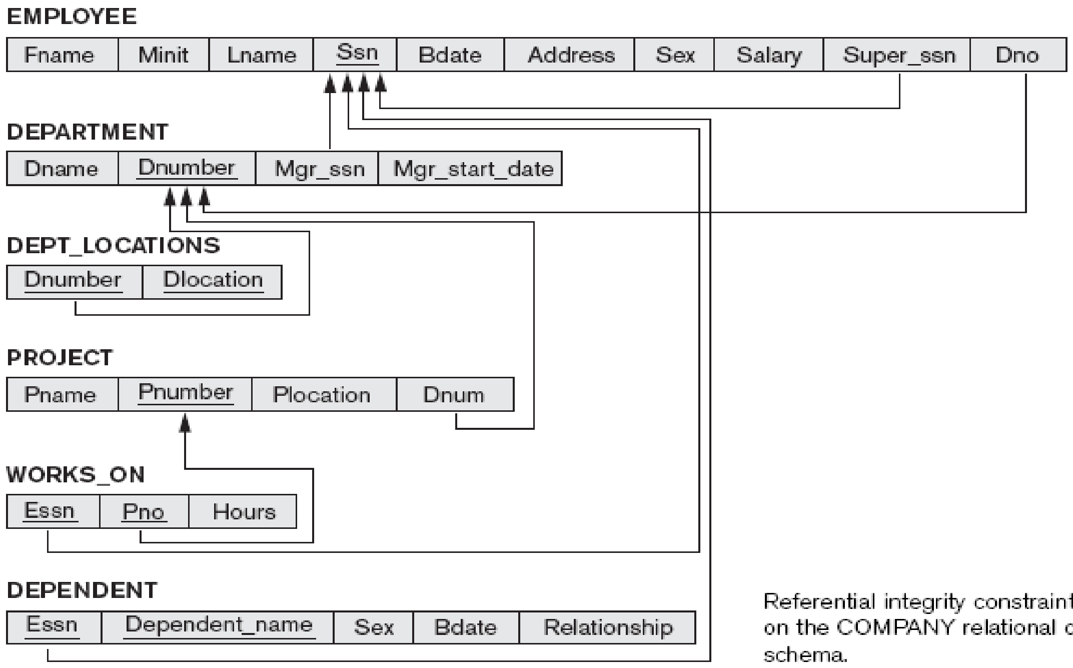
A *relation* is defined as a *set of tuples*. By definition,all elements of a set are distinct, hence- all tuples in a relation must also be distinct.
*There are other **subsets of attributes** of a relation schema R with the property that no two tuples in any relation state r of R should have the same combination of values for these attributes.*
Suppose that we denote one such subset of attributes by SK,then for any two *distinct* tuples *t*1 and *t*2 in a relation state *r* of *R*, we have the constraint that:
$t1[SK] \neq t2[SK]$

Integrity, Referential Integrity, and Foreign Keys
The **entity integrity constraint** states that no primary key value can be NULL. This is because the primary key value is used to identify individual tuples in a relation.

Having NULL values for the primary key implies that we cannot identify some tuples. For example, if two or more tuples had NULL for their primary keys, we may not be able to distinguish them if we try to reference them from other relations.

The **referential integrity constraint** is specified between two relations and is used to maintain the consistency among tuples in the two relations. the referential integrity constraint states that a tuple in one relation that refers to another relation must refer to an *existing tuple* in that relation.

The attribute Dno of EMPLOYEE gives the department number for which each employee works; hence, its value in every EMPLOYEE tuple must match the Dnumber value of some tuple in the DEPARTMENT relation.



Referential integrity constraints displayed on the COMPANY relational database schema.

We can *diagrammatically display referential integrity constraints* by drawing a **directed arc** from each foreign key to the relation it references. For clarity, the arrowhead may point to the primary key of the referenced relation.

The types of constraints we discussed so far may be called **state constraints** because they define the constraints that a *valid state* of the database must satisfy.

<u>Update Operations, Transactions, and Dealing with Constraint Violations</u>

The operations of the relational model can be categorized into *retrievals* and *updates.*

There are three basic operations that can change the states of relations in the database:***Insert, Delete, and Update (or Modify).***

They insert new data, delete old data, or modify existing data records.
Insert is used to insert one or more new tuples in a relation,
Delete is used to delete tuples.
Update (or **Modify**) is used to change the values of some attributes in existing tuples.
Whenever these operations are applied, the integrity constraints specified on the relational database schema should not be violated.

The Insert Operation

The **Insert** operation provides a list of attribute values for a new tuple *t* that is to be inserted into a relation *R.*

Domain constraints can be violated if an attribute value is given that does not appear in the corresponding domain or is not of the appropriate data type. Key constraints can be violated if a key value in the new tuple t already exists in another tuple in the relation r(R). Entity integrity can be violated if any part of the primary key of the new tuple t is NULL. Referential integrity can be violated if the value of any foreign key in t refers to a tuple that does not exist in the referenced relation.

The Delete Operation

The **Delete** operation can violate only referential integrity. This occurs if the tuple being deleted is referenced by foreign keys from other tuples in the database.

The Update Operation

The **Update** (or **Modify**) operation is used to change the values of one or more attributes in a tuple (or tuples) of some relation *R*. It is necessary to specify a condition on the attributes of the relation to select the tuple (or tuples) to be modified.

The relational algebra is very important for several reasons. First, it provides a formal foundation for relational model operations. Second, and perhaps more important, it is used as a basis for implementing and optimizing queries in the query processing and optimization modules that are integral parts of relational database management systems (RDBMSs), Third, some of its concepts are incorporated into the SQL standard query language for RDBMSs.

Unary Operations that operate on single relations.

JOIN and other complex **binary operations**, which operate on two tables by combining related tuples (records) based on *join conditions.*

Unary Relational Operations:

SELECT and PROJECT

The SELECT Operation:

The SELECT operation is used to choose a *subset* of the tuples from a relation that satisfies a **selection condition.**

In general, the SELECT operation is denoted by

$$\boxed{\sigma_{\text{<selection condition>}}(R)}$$

where the symbol σ (sigma) is used to denote the SELECT operator and the selection condition is a Boolean expression (condition) specified on the attributes of relation *R*.

The Boolean expression specified in <selection condition> is made up of a number of **clauses** of the form

<attribute name> <comparison op> <constant value>

or

<attribute name> <comparison op> <attribute name>

where <attribute name> is the name of an attribute of *R*, <comparison op> is normally one of the operators {=, <, >, ≥,≤,≠ }, and <constant value> is a constant value from the attribute domain.

Clauses can be connected by the standard Boolean operators ***and, or, not***

$$\sigma_{Dno=4}(\text{EMPLOYEE})$$
$$\sigma_{Salary>30000}(\text{EMPLOYEE})$$

Similarly, $\sigma_{Dno=4 \text{ AND } Salary>25000}(\text{EMPLOYEE})$

```
SELECT      *
FROM        EMPLOYEE
WHERE       Dno=4 AND Salary>25000;
```

The **PROJECT** operation, on the other hand, selects certain *columns* from the table and discards the other columns. If we are interested in only certain attributes of a relation, we use the PROJECT operation to *project* the relation over these attributes only.

$$\boxed{\pi_{Lname, Fname, Salary}(\text{EMPLOYEE})}$$

The general form of the PROJECT operation is

$$\boxed{\pi_{\text{<attribute list>}}(R)}$$

where π (pi) is the symbol used to represent the PROJECT operation, and <attribute list> is the desired sublist of attributes from the attributes of relation *R*.
The result of the PROJECT operation has only the attributes specified in <attribute list> *in the same order as they appear in the list*. Hence, its **degree** is equal to the number of attributes in <attribute list>.

The PROJECT operation *removes any duplicate tuples*, so the result of the PROJECT operation is a set of distinct tuples, and hence a valid relation. This is known as **duplicate elimination**.

πSex, Salary(EMPLOYEE)

```
SELECT      DISTINCT Sex, Salary
FROM        EMPLOYEE
```

Sequences of Operations and the RENAME Operation
A single relational algebra expression, also known as an **in-line expression**, as follows:

$$\pi_{\text{Fname, Lname, Salary}}(\sigma_{\text{Dno}=5}(\text{EMPLOYEE}))$$

shows the result of this in-line relational algebra expression.

Alternatively, we can explicitly show the sequence of operations, giving a name to each intermediate relation, as follows:

$$\text{DEP5\_EMPS} \leftarrow \sigma_{\text{Dno}=5}(\text{EMPLOYEE})$$
$$\text{RESULT} \leftarrow \pi_{\text{Fname, Lname, Salary}}(\text{DEP5\_EMPS})$$

It is sometimes simpler to break down a complex sequence of operations by specifying intermediate result relations than to write a single relational algebra expression.
We can also use this technique to **rename** the attributes.

We can also define a formal **RENAME** operation—which can rename either the relation name or the attribute names, or both—as a unary operator. The general RENAME operation when applied to a relation *R* of degree *n* is denoted by any of the following three forms:

$$\rho_{S(B1, B2, \ldots, Bn)}(R) \quad \text{or} \quad \rho_S(R) \quad \text{or} \quad \rho_{(B1, B2, \ldots, Bn)}(R)$$

Relational Algebra Operations from Set Theory

The UNION, INTERSECTION, and MINUS Operations

Several set theoretic operations are used to merge the elements of two sets in various ways, including **UNION**, **INTERSECTION**, and **SET DIFFERENCE** (also called **MINUS** or **EXCEPT**)
the three operations UNION, INTERSECTION, and SET DIFFERENCE on two union-compatible relations *R* and *S* as follows:

■ **UNION:** The result of this operation, denoted by $R \cup S$, is a relation that includes all tuples that are either in *R* or in *S* or in both *R* and *S*. Duplicate tuples are eliminated.
■ **INTERSECTION:** The result of this operation, denoted by $R \cap S$, is a relation that includes all tuples that are in both *R* and *S*.
■ **SET DIFFERENCE** (or **MINUS**): The result of this operation, denoted by $R - S$, is a relation that includes all tuples that are in *R* but not in *S*.

Notice that both UNION and INTERSECTION are *commutative operations*; that is, $R \cup S = S \cup R$ and $R \cap S = S \cap R$

Both UNION and INTERSECTION can be treated as *n*-ary operations applicable to any number of relations because both are also *associative operations;* that is,
$R \cup (S \cup T) = (R \cup S) \cup T$ and $(R \cap S) \cap T = R \cap (S \cap T)$

The MINUS operation is *not commutative;* that is, in general,
$R - S \neq S - R$
INTERSECTION can be expressed in terms of union and set difference as follows:
$R \cap S = ((R \cup S) - (R - S)) - (S - R)$

The set operations UNION, INTERSECTION, and MINUS.

(a) STUDENT

Fn	Ln
Susan	Yao
Ramesh	Shah
Johnny	Kohler
Barbara	Jones
Amy	Ford
Jimmy	Wang
Ernest	Gilbert

INSTRUCTOR

Fname	Lname
John	Smith
Ricardo	Browne
Susan	Yao
Francis	Johnson
Ramesh	Shah

(a) Two union-compatible relations.

(b)

Fn	Ln
Susan	Yao
Ramesh	Shah
Johnny	Kohler
Barbara	Jones
Amy	Ford
Jimmy	Wang
Ernest	Gilbert
John	Smith
Ricardo	Browne
Francis	Johnson

(b) STUDENT ∪ INSTRUCTOR.

(c)

Fn	Ln
Susan	Yao
Ramesh	Shah

(c) STUDENT ∩ INSTRUCTOR.

(d)

Fn	Ln
Johnny	Kohler
Barbara	Jones
Amy	Ford
Jimmy	Wang
Ernest	Gilbert

(d) STUDENT – INSTRUCTOR.

(e)

Fname	Lname
John	Smith
Ricardo	Browne
Francis	Johnson

(e) INSTRUCTOR – STUDENT.

The CARTESIAN PRODUCT (CROSS PRODUCT) Operation

the **CARTESIAN PRODUCT** operation—also known as **CROSS PRODUCT** or **CROSS JOIN**—which is denoted by ×. This is also a binary set operation, but the relations on which it is applied do *not* have to be union compatible.

In general, the result of $R(A1, A2, \ldots, An) \times S(B1, B2, \ldots, Bm)$ is a relation Q with degree $n + m$ attributes $Q(A1, A2, \ldots, An, B1, B2, \ldots, Bm)$, in that order. The resulting relation Q has one tuple for each combination of tuples—one from R and one from S.

Retrieve a list of names of each female employee‘s dependents

$\text{FEMALE\_EMPS} \leftarrow \sigma_{\text{Sex}=\text{'F'}}(\text{EMPLOYEE})$

$\text{EMPNAMES} \leftarrow \pi_{\text{Fname, Lname, Ssn}}(\text{FEMALE\_EMPS})$

$\text{EMP\_DEPENDENTS} \leftarrow \text{EMPNAMES} \times \text{DEPENDENT}$

$\text{ACTUAL\_DEPENDENTS} \leftarrow \sigma_{\text{Ssn}=\text{Essn}}(\text{EMP\_DEPENDENTS})$

$\text{RESULT} \leftarrow \pi_{\text{Fname, Lname, Dependent\_name}}(\text{ACTUAL\_DEPENDENTS})$

Binary Relational Operations:JOIN and DIVISION

The JOIN Operation

The **JOIN** operation, denoted by $\bowtie$,is used to combine *related tuples* from two relations into single ―longer‖ tuples.
To illustrate JOIN, suppose that we want to retrieve the name of the manager of each department.
To get the manager‘s name, we need to combine each department tuple with the employee tuple whose Ssn value matches the Mgr_ssn value in the department tuple.

$$\text{DEPT\_MGR} \leftarrow \text{DEPARTMENT} \bowtie_{\text{Mgr\_ssn=Ssn}} \text{EMPLOYEE}$$
$$\text{RESULT} \leftarrow \pi_{\text{Dname, Lname, Fname}}(\text{DEPT\_MGR})$$

Note that Mgr_ssn is a foreign key of the DEPARTMENT relation that references Ssn, the primary key of the EMPLOYEE relation. This referential integrity constraint plays a role in having matching tuples in the referenced relation EMPLOYEE.

DEPT_MGR

Dname	Dnumber	Mgr_ssn	. . .	Fname	Minit	Lname	Ssn	. . .
Research	5	333445555	. . .	Franklin	T	Wong	333445555	. . .
Administration	4	987654321	. . .	Jennifer	S	Wallace	987654321	. . .
Headquarters	1	888665555	. . .	James	E	Borg	888665555	. . .

Result of the JOIN operation DEPT_MGR ← DEPARTMENT $\bowtie_{\text{Mgr_ssn=Ssn}}$EMPLOYEE.

The general form of a JOIN operation on two relations5 $R(A1, A2, \ldots, An)$ and $S(B1,B2, \ldots, Bm)$ is

$$R \bowtie_{\text{<join condition>}} S$$

A general join condition is of the form <condition> **AND** <condition> **AND**…**AND** <condition> where each <condition> is of the form *Ai ΘBj*, *Ai* is an attribute of *R*, *Bj* is an attribute of *S*, *Ai* and *Bj* have the same domain, and Θ(theta) is one of the comparison operators {=, <, <=, >, >=, ≠}.
A JOIN operation with such a general join condition is called a **THETA JOIN**.

The DIVISION Operation

The DIVISION operation, denoted by ÷, is useful for a special kind of query that sometimes occurs in database applications.
Q: Retrieve the names of employees who work on all the projects that 'John Smith' works on.
To express this query using the DIVISION operation, proceed as follows. First, retrieve the list of project numbers that ‗John Smith‘ works on in the intermediate relation SMITH_PNOS:

using the DIVISION operation retrieve the list of project numbers that ‗John Smith‘ works on in the intermediate relation SMITH_PNOS:

$$\text{SMITH} \leftarrow \sigma_{\text{Fname='John' AND Lname='Smith'}}(\text{EMPLOYEE})$$
$$\text{SMITH\_PNOS} \leftarrow \pi_{\text{Pno}}(\text{WORKS\_ON} \bowtie_{\text{Essn=Ssn}} \text{SMITH})$$

create a relation that includes a tuple <Pno, Essn> whenever the employee whose Ssn is Essn works on the project whose number is Pno in the intermediate relation SSN_PNOS:

$$\text{SSN\_PNOS} \leftarrow \pi_{\text{Essn, Pno}}(\text{WORKS\_ON})$$

Finally, apply the DIVISION operation to the two relations, which gives the desired employees‘ Social Security numbers:

$$\text{SSNS(Ssn)} \leftarrow \text{SSN\_PNOS} \div \text{SMITH\_PNOS}$$
$$\text{RESULT} \leftarrow \pi_{\text{Fname, Lname}}(\text{SSNS} * \text{EMPLOYEE})$$

The DIVISION operation. (a) Dividing SSN_PNOS by SMITH_PNOS. (b) $T \leftarrow R \div S$.

(a)

SSN_PNOS

Essn	Pno
123456789	1
123456789	2
666884444	3
453453453	1
453453453	2
333445555	2
333445555	3
333445555	10
333445555	20
999887777	30
999887777	10
987987987	10
987987987	30
987654321	30
987654321	20
888665555	20

SMITH_PNOS

Pno
1
2

SSNS

Ssn
123456789
453453453

(b)

R

A	B
a1	b1
a2	b1
a3	b1
a4	b1
a1	b2
a3	b2
a2	b3
a3	b3
a4	b3
a1	b4
a2	b4
a3	b4

S

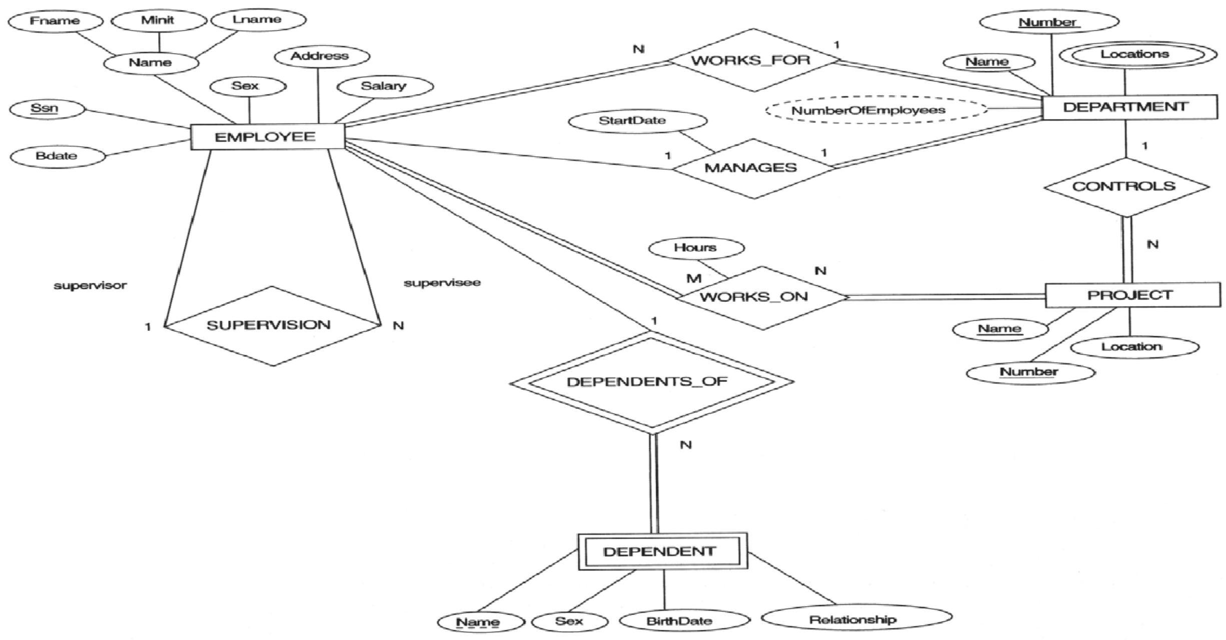
A
a1
a2
a3

T

B
b1
b4

ER-to-Relational Mapping Algorithm

Step 1: Mapping of Regular Entity Types
Step 2: Mapping of Weak Entity Types
Step 3: Mapping of Binary 1:1 Relation Types
Step 4: Mapping of Binary 1:N Relationship Types.
Step 5: Mapping of Binary M:N Relationship Types.
Step 6: Mapping of Multivalued attributes.
Step 7: Mapping of N-ary Relationship Types.



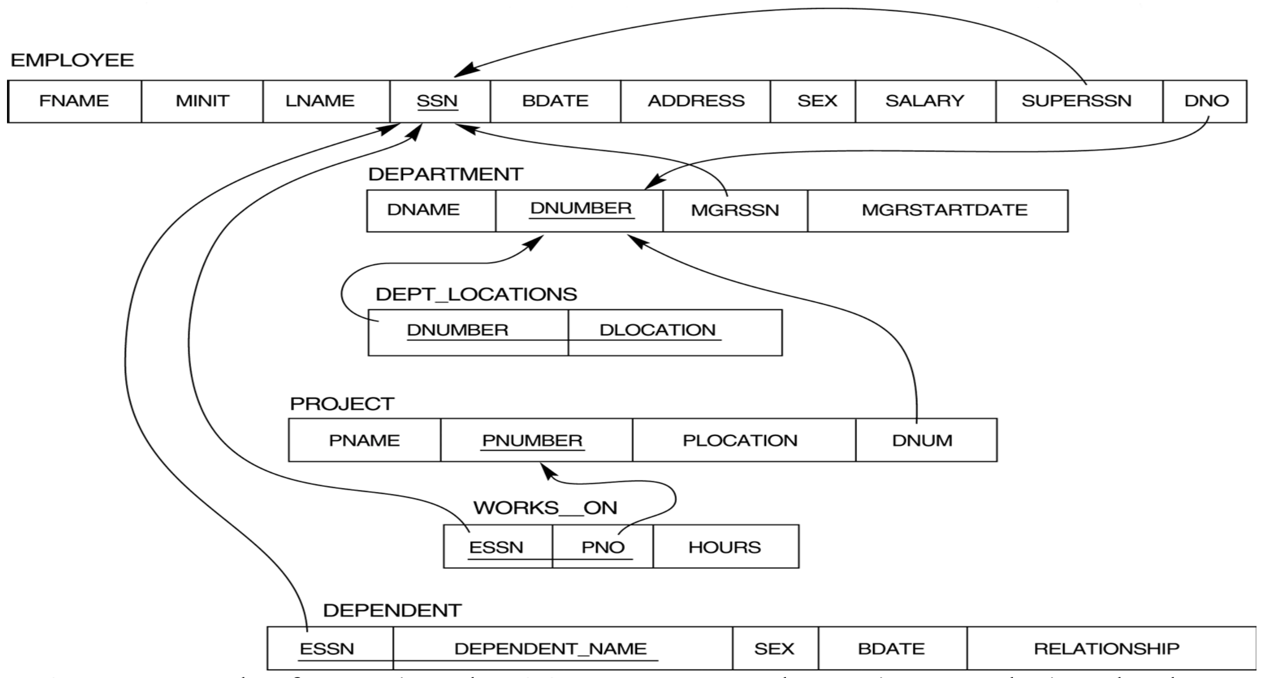


FIGURE : Result of mapping the COMPANY ER schema into a relational schema

Step 1: Mapping of Regular Entity Types.
For each regular (strong) entity type E in the ER schema, create a relation R that includes all the simple attributes of E.
Choose one of the key attributes of E as the primary key for R. If the chosen key of E is composite, the set of simple attributes that form it will together form the primary key of R.
Example: EMPLOYEE, DEPARTMENT, and PROJECT are the regular entities in the ER diagram. SSN, DNUMBER, and PNUMBER are the primary keys for the relations EMPLOYEE, DEPARTMENT, and PROJECT respectively.

Step 2: Mapping of Weak Entity Types
For each weak entity type W in the ER schema with owner entity type E, create a relation R and include all simple attributes of W as attributes of R.
Example: Create the relation DEPENDENT in this step to correspond to the weak entity type DEPENDENT. Include the primary key SSN of the EMPLOYEE relation as a foreign key attribute of DEPENDENT (renamed to ESSN).

The primary key of the DEPENDENT relation is the combination {ESSN, DEPENDENT_NAME} because DEPENDENT_NAME is the partial key of DEPENDENT.
Step 3: Mapping of Binary 1:1 Relation Types
For each binary 1:1 relationship type R in the ER schema, identify the relations S and T that correspond to the entity types participating in R.
Example: 1:1 relation MANAGES is mapped by choosing the participating entity type DEPARTMENT to serve in the role of S, because its participation in the MANAGES relationship type is total.
Step 4: Mapping of Binary 1:N Relationship Types.
For each regular binary 1:N relationship type R, identify the relation S that represent the participating entity type at the N-side of the relationship type.
Example: 1:N relationship types WORKS_FOR, CONTROLS, and SUPERVISION in the figure. For WORKS_FOR we include the primary key DNUMBER of the DEPARTMENT relation as foreign key in the EMPLOYEE relation and call it DNO.
Step 5: Mapping of Binary M:N Relationship Types.
For each regular binary M:N relationship type R, *create a new relation* S to represent R.
Include as foreign key attributes in S the primary keys of the relations that represent the participating entity types; *their combination will form the primary key* of S.
Example: The M:N relationship type WORKS_ON from the ER diagram is mapped by creating a relation WORKS_ON in the relational database schema. The primary keys of the PROJECT and EMPLOYEE relations are included as foreign keys in WORKS_ON and renamed PNO and ESSN, respectively.
Attribute HOURS in WORKS_ON represents the HOURS attribute of the relation type. The primary key of the WORKS_ON relation is the combination of the foreign key attributes {ESSN, PNO}.

Step 6: Mapping of Multivalued attributes.
For each multivalued attribute A, create a new relation R. This relation R will include an attribute corresponding to A, plus the primary key attribute K-as a foreign key in R-of the relation that represents the entity type of relationship type that has A as an attribute.
Example: The relation DEPT_LOCATIONS is created. The attribute DLOCATION represents the multivalued attribute LOCATIONS of DEPARTMENT, while DNUMBER-as foreign key-represents the primary key of the DEPARTMENT relation. The primary key of R is the combination of {DNUMBER, DLOCATION}.
Step 7: Mapping of N-ary Relationship Types.
For each n-ary relationship type R, where n>2, create a new relationship S to represent R.
Example: The relationship type SUPPY in the ER below. This can be mapped to the relation SUPPLY shown in the relational schema, whose primary key is the combination of the three foreign keys {SNAME, PARTNO, PROJNAME}

Consider the following schema:
Suppliers(*sid:* integer, *sname:* string, *address:* string)
Parts(*pid:* integer, *pname:* string, *color:* string)
Catalog(*sid:* integer, *pid:* integer, *cost:* real)

1. **Find the *names* of suppliers who supply some red part.**

$$\pi_{sname}(\pi_{sid}((\pi_{pid}\sigma_{color='red'}Parts) \bowtie Catalog) \bowtie Suppliers)$$

SQL: SELECT S.sname
FROM Suppliers S, Parts P, Catalog C
WHERE P.color=‗red' AND C.pid=P.pid AND C.sid=S.sid

2. **Find the *sids* of suppliers who supply some red or green part.**

$$\pi_{sid}(\pi_{pid}(\sigma_{color='red' \vee color='green'}Parts) \bowtie catalog)$$

SQL:SELECT C.sid
FROM Catalog C, Parts P
WHERE (P.color = ‗red' OR P.color = ‗green')
AND P.pid = C.pid

3. **Find the *sids* of suppliers who supply some red part or are at 221 Packer Street.**

$$\rho(R1, \pi_{sid}((\pi_{pid}\sigma_{color='red'}Parts) \bowtie Catalog))$$

$$\rho(R2, \pi_{sid}\sigma_{address='221PackerStreet'}Suppliers)$$

$$R1 \cup R2$$

```
SELECT S.sid
FROM Suppliers S
WHERE S.address = _221 Packer street‘
OR S.sid IN ( SELECT C.sid
FROM Parts P, Catalog C
WHERE P.color=‘red‘ AND P.pid = C.pid )
```

4. **Find the *sid*s of suppliers who supply some red part and some green part**.

$$\rho(R1, \pi_{sid}((\pi_{pid}\sigma_{color='red'}Parts) \bowtie Catalog))$$
$$\rho(R2, \pi_{sid}((\pi_{pid}\sigma_{color='green'}Parts) \bowtie Catalog))$$
$$R1 \cap R2$$

```
SELECT C.sid
FROM Parts P, Catalog C
WHERE P.color = _red‘ AND P.pid = C.pid
AND EXISTS ( SELECT P2.pid
FROM Parts P2, Catalog C2
WHERE P2.color = _green‘ AND C2.sid = C.sid
AND P2.pid = C2.pid )
```

5. **Find the *sid*s of suppliers who supply every part.**

$$(\pi_{sid,pid}Catalog)/(\pi_{pid}Parts)$$

```
SELECT C.sid
FROM Catalog C
WHERE NOT EXISTS (SELECT P.pid
FROM Parts P
WHERE NOT EXISTS (SELECT C1.sid
FROM Catalog C1
WHERE C1.sid = C.sid
        AND C1.pid = P.pid))
```

6. **Find the *sid*s of suppliers who supply every red part.**

$$(\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color='red'}Parts)$$

```
SELECT C.sid
FROM Catalog C
WHERE NOT EXISTS (SELECT P.pid
FROM Parts P
WHERE P.color = _red‘
AND (NOT EXISTS (SELECT C1.sid
FROM Catalog C1
WHERE C1.sid = C.sid AND
        C1.pid = P.pid)))
```

7. **Find the *sid*s of suppliers who supply every red or green part.**

$$(\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color='red' \vee color='green'}Parts)$$

```
SELECT C.sid
FROM Catalog C
WHERE NOT EXISTS (SELECT P.pid
FROM Parts P
WHERE (P.color = _red‘ OR P.color = _green‘)
AND (NOT EXISTS (SELECT C1.sid
FROM Catalog C1
WHERE C1.sid = C.sid AND
        C1.pid = P.pid)))
```

8. **Find the *sid*s of suppliers who supply every red part or supply every green part.**

$$\rho(R1, ((\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color='red'}Parts)))$$
$$\rho(R2, ((\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color='green'}Parts)))$$
$$R1 \cup R2$$

```
SELECT C.sid
FROM Catalog C
WHERE (NOT EXISTS (SELECT P.pid
FROM Parts P
WHERE P.color = _red‘ AND
(NOT EXISTS (SELECT C1.sid
FROM Catalog C1
WHERE C1.sid = C.sid AND
C1.pid = P.pid))))
OR ( NOT EXISTS (SELECT P1.pid
FROM Parts P1
WHERE P1.color = _green‘ AND
(NOT EXISTS (SELECT C2.sid
FROM Catalog C2
WHERE C2.sid = C.sid AND
        C2.pid = P1.pid))))
```

9. Find pairs of *sid*s such that the supplier with the first *sid* charges more for some part than the supplier with the second *sid*.

$\rho(R1, Catalog)$

$\rho(R2, Catalog)$

$\pi_{R1.sid,R2.sid}(\sigma_{R1.pid=R2.pid \wedge R1.sid \neq R2.sid \wedge R1.cost > R2.cost}(R1 \times R2))$

SELECT C1.sid, C2.sid
FROM Catalog C1, Catalog C2
WHERE C1.pid = C2.pid AND C1.sid = C2.sid
AND C1.cost > C2.cost

10. Find the *pid*s of parts supplied by at least two different suppliers.

$\rho(R1, Catalog)$

$\rho(R2, Catalog)$

$\pi_{R1.pid}\sigma_{R1.pid=R2.pid \wedge R1.sid \neq R2.sid}(R1 \times R2)$

SELECT C.pid
FROM Catalog C
WHERE EXISTS (SELECT C1.sid
FROM Catalog C1
WHERE C1.pid = C.pid AND C1.sid != C.sid)

11. Find the Supplier names of the suppliers who supply a red part that costs less than 100 dollars.

$\pi_{sname}(\pi_{sid}((\sigma_{color='red'}Parts) \bowtie (\sigma_{cost<100}Catalog)) \bowtie Suppliers)$

12. Find the Supplier names of the suppliers who supply a red part that costs less than 100 dollars and a green part that costs less than 100 dollars.

$(\pi_{sname}((\sigma_{color='red'}Parts) \bowtie (\sigma_{cost<100}Catalog) \bowtie Suppliers)) \cap$

$(\pi_{sname}((\sigma_{color='green'}Parts) \bowtie (\sigma_{cost<100}Catalog) \bowtie Suppliers))$

13. Find the Supplier ids of the suppliers who supply a red part that costs less than 100 dollars and a green part that costs less than 100 dollars.

$(\pi_{sid}((\sigma_{color='red'}Parts) \bowtie (\sigma_{cost<100}Catalog) \bowtie Suppliers)) \cap$

$(\pi_{sid}((\sigma_{color='green'}Parts) \bowtie (\sigma_{cost<100}Catalog) \bowtie Suppliers))$

14. Find the Supplier names of the suppliers who supply a red part that costs less than 100 dollars and a green part that costs less than 100 dollars.

$\pi_{sname}((\pi_{sid,sname}((\sigma_{color='red'}Parts) \bowtie (\sigma_{cost<100}Catalog) \bowtie Suppliers)) \cap$

$(\pi_{sid,sname}((\sigma_{color='green'}Parts) \bowtie (\sigma_{cost<100}Catalog) \bowtie Suppliers)))$

UNIT – 2

SQL – 1: *SQL Data Definition and Data Types; Specifying basic constraints in SQL; Schema change statements in SQL; Basic queries in SQL; More complex SQL Queries.*

The name **SQL** is presently expanded as Structured Query Language. Originally, SQL was called SEQUEL (Structured English QUEry Language) and was designed and implemented at IBM Research as the interface for an experimental relational database system called SYSTEM R.

SQL is now the standard language for commercial relational DBMSs. A joint effort by the American National Standards Institute (ANSI) and the International Standards Organization (ISO) has led to a standard version of SQL (ANSI 1986), called SQL-86 or SQL1.

SQL is a comprehensive database language: It has statements for data definitions, queries, and updates. Hence, it is both a DDL *and* a DML.

SQL Data Definition and Data Types SQL uses the terms **table**, **row**, and **column** for the formal relational model terms *relation*, *tuple*, and *attribute*, respectively.We will use the corresponding terms interchangeably.

The main SQL command for data definition is the **CREATE** statement,which can be used to create schemas, tables (relations), and domains (as well as other constructs such as views, assertions, and triggers).

Schema and Catalog Concepts in SQL Early versions of SQL did not include the concept of a relational database schema;

all tables (relations) were considered part of the same schema. An **SQL schema** is identified by a **schema name**, and includes an **authorization identifier** to indicate the user or account who owns the schema, as well as **descriptors** for *each element* in the schema.

Schema **elements** include tables, constraints, views, domains, and other constructs (such as authorization grants) that describe the schema. For example, the following statement creates a schema called COMPANY, owned by the user with authorization identifier 'Jsmith'.

Note that each statement in SQL ends with a semicolon. **CREATE SCHEMA** COMPANY **AUTHORIZATION** 'Jsmith';

In general, not all users are authorized to create schemas and schema elements. The privilege to create schemas, tables, and other constructs must be explicitly granted to the relevant user accounts by the system administrator or DBA.

The CREATE TABLE Command in SQL

The **CREATE TABLE** command is used to specify a new relation by giving it a name and specifying its attributes and initial constraints. The attributes are specified first, and each attribute is given a name, a data type to specify its domain of values, and any attribute constraints, such as NOT NULL.

The key, entity integrity, and referential integrity constraints can be specified within the CREATE TABLE statement after the attributes are declared, or they can be added later using the ALTER TABLE command.

For example, by writing

CREATE TABLE *COMPANY.EMPLOYEE* (..............);
rather than
CREATE TABLE EMPLOYEE (EID VARCHAR(10),........................); as shown above ,
we can explicitly (rather than implicitly) make the EMPLOYEE table part of the COMPANY schema.
The relations declared through CREATE TABLE statements are called ***Base Tables*** (or base relations).

This means that the relation and its tuples are actually created and stored as a file by the DBMS ***Attribute Data Types and Domains in SQL .***

The basic **data types** available for attributes include ***numeric, character string, bit string, Boolean, date, and time.***

Numeric data types include integer numbers of various sizes (*INTEGER or INT, and SMALLINT*) and floating-point (real) numbers of various precision *(FLOAT or REAL, and DOUBLE PRECISION)*. Formatted numbers can be declared by using *DECIMAL(i,j)—or DEC(i,j) or NUMERIC(i,j).*

Character-string data types are either fixed length—*CHAR(n) or CHARACTER(n)*, where *n* is the number of characters—or varying length—*VARCHAR(n) or CHAR VARYING(n) or CHARACTER VARYING(n)*, where *n* is the maximum number of characters.

Another variable-length string data type called CHARACTER **LARGE OBJECT** or CLOB is also available to specify columns that have large text values, such as documents. The CLOB maximum length can be specified in kilobytes (K), megabytes (M), or gigabytes (G). For example, CLOB(20M) specifies a maximum length of 20 megabytes.

Bit-string data types are either of fixed length *n*—BIT(*n*)—or varying length—BIT VARYING(*n*), where *n* is the maximum number of bits. The default for *n*, the length of a character string or bit string, is 1.

Boolean data type has the traditional values of TRUE or FALSE. In SQL, because of the presence of NULL values, a three-valued logic is used, so a third possible value for a Boolean data type is UNKNOWN.

DATE data type has ten positions, and its components are YEAR, MONTH, and DAY in the form YYYY-MM-DD.

The **TIME** data type has at least eight positions, with the components HOUR, MINUTE, and SECOND in the form **HH:MM:SS**.

A **timestamp** data type (TIMESTAMP) includes the DATE and TIME fields, plus a minimum of six positions for decimal fractions of seconds and an optional WITH TIME ZONE qualifier. example, TIMESTAMP '2008-09-27 09:12:47.648302'.

Another data type related to **DATE, TIME,** and **TIMESTAMP** is the **INTERVAL** data type.

This specifies an **interval**—a *relative value* that can be used to increment or decrement an absolute value of a date, time, or timestamp.

Intervals are qualified to be either YEAR/MONTH intervals or DAY/TIME intervals.

Specifying Constraints in SQL These include *key and referential integrity constraints, restrictions on attribute domains and NULLs and constraints* on individual tuples within a relation.

Specifying Attribute Constraints and Attribute Defaults Because SQL allows NULLs as attribute values, a *constraint* NOT NULL may be specified if NULL is not permitted for a particular attribute.

It is also possible to define a *default value* for an attribute by appending the clause **DEFAULT** <value> to an attribute definition. The default value is included in any new tuple if an explicit value is not provided for that attribute.

Ex: **CREATE TABLE** EMPLOYEE (Ssn varchar(10),Ename varchar(10),salary integer,address varchar(10),……. Dno INT **NOT NULL DEFAULT** 1, **CONSTRAINT** EMPPK **PRIMARY KEY** (Ssn), **CONSTRAINT** EMPSUPERFK **FOREIGN KEY** (Super_ssn) **REFERENCES** EMPLOYEE(Ssn) **ON DELETE** SET NULL **ON UPDATE** CASCADE, **CONSTRAINT** EMPDEPTFK **FOREIGN KEY**(Dno) **REFERENCES** DEPARTMENT(Dnumber) **ON DELETE** SET DEFAULT **ON UPDATE** CASCADE);

Another type of constraint can restrict attribute or domain values using the **CHECK** clause following an attribute or domain definition.

For example, suppose that department numbers are restricted to integer numbers between 1 and 20; then, we can change the attribute declaration of Dnumber in the DEPARTMENT table to the following:

*Dnumber INT **NOT NULL CHECK** (Dnumber > 0 **AND** Dnumber < 21);*

Specifying Key and Referential Integrity Constraints Because keys and referential integrity constraints are very important, there are special clauses within the CREATE TABLE statement to specify them.

For example, the primary key of DEPARTMENT can be specified as follows (instead of the way it is specified in Figure): *Dnumber INT **PRIMARY KEY**; We can specify RESTRICT, CASCADE, SET NULL or SET DEFAULT on referential integrity constraints (foreign keys)*

CREATE TABLE DEPT (DNAME VARCHAR(10) NOT NULL, DNUMBER INTEGER NOT NULL, MGRSSN CHAR(9), MGRSTARTDATE CHAR(9), PRIMARY KEY (DNUMBER), FOREIGN KEY (MGRSSN) REFERENCES EMP ON DELETE SET DEFAULT ON UPDATE CASCADE);

Specifying Constraints on Tuples Using CHECK :

other *table constraints* can be specified through additional CHECK clauses at the end of a CREATE TABLE statement. These can be called **tuple-based** constraints because they apply to each tuple *individually* and are checked whenever a tuple is inserted or modified.

Ex: CREATE TABLE statement for the DEPARTMENT table to make sure that a manager's start date is later than the department creation date. ***CHECK (Dept_create_date <= Mgr_start_date);***

Delete a Table or Database
To delete a table (the table structure, attributes, and indexes will also be deleted):

- **DROP TABLE** table_name

To delete a database:

- **DROP DATABASE** database_name

Truncate a Table
What if we only want to get rid of the data inside a table, and not the table itself? Use the **TRUNCATE TABLE** command (deletes only the data inside the table):

- **TRUNCATE TABLE** table_name

The ALTER Command
The definition of a base table or of other named schema elements can be changed by using the ALTER command.
For base tables, the possible *alter table actions* include adding or dropping a column (attribute), changing a column definition, and adding or dropping table constraints.
To drop a column, we must choose either CASCADE or RESTRICT for drop behavior. If CASCADE is chosen, all constraints and views that reference the column are dropped automatically from the schema, along with the column. If RESTRICT is chosen, the command is successful only if no views or constraints (or other elements) reference the column.
ALTER TABLE COMPANY.EMPLOYEE **DROP ADDRESS CASCADE;**
It is also possible to alter a column definition by dropping an existing default clause or by defining a new default clause. The following examples illustrate this clause:
ALTER TABLE COMPANY.DEPARTMENT **ALTER MGRSSN DROP DEFAULT;**
ALTER TABLE COMPANY.DEPARTMENT ALTER MGRSSN SET DEFAULT "333445555";
One can also change the constraints specified on a table by adding or dropping a constraint. To be dropped, a constraint must have been given a name when it was specified. For example, to drop the constraint named EMPSUPERFK in Figure 8.2 from the EMPLOYEE relation, we write:
ALTER TABLE **EMPLOYEE**
DROP CONSTRAINT EMPSUPERFK CASCADE;
The **ALTER TABLE** statement is used to add or drop columns in an existing table.

- **ALTER TABLE** table_name **ADD** column_name datatype
- **ALTER TABLE** table_name **DROP COLUMN** column_name
- **ALTER TABLE** table_name **MODIFY COLUMN** column_name
- **ALTER TABLE** table_name **RENAME** newtablename

Note: Some database systems don't allow the dropping of a column in a database table (DROP COLUMN column_name).

Person:

LastName	FirstName	Address
Kumar	Kiran	RR Nagar

Example
To add a column named "City" in the "Person" table:
ALTER TABLE Person **ADD** City varchar(30);
Result:

LastName	FirstName	Address	City
Kumar	Kiran	RR nagar	

Example
To drop the "Address" column in the "Person" table:
ALTER TABLE Person **DROP COLUMN** Address;
Result:

LastName	FirstName	City
Kumar	Kiran	Bangalore

The INSERT INTO Statement
The INSERT INTO statement is used to insert new rows into a table.

Syntax: **INSERT INTO** table_name **VALUES** (value1, value2,....)

We can also specify the columns for which you want to insert data:

INSERT INTO *table_name (column1, column2,...)***VALUES** *(value1, value2,....)*

Insert a New Row

LastName	FirstName	Address	City
Kumar	Kiran	Rr nagr	bangalore

And this SQL statement:
INSERT INTO *Persons* ***VALUES*** *('Rao', 'Praveen', 'RajajiNagar', 'Bangalore')*
Will give this result:

LastName	FirstName	Address	City
Kumar	Kiran	Rr nagr	bangalore
Rao	Praveen	RajajiNgar	Bangalore

Insert Data in Specified Columns:

INSERT INTO *Persons* ***(LastName, Address)VALUES (' Shetty ', ' banashankari ')***
Will give this result:

LastName	**FirstName**	**Address**	**City**
Kumar	Kiran	Rr nagr	bangalore
Rao	Praveen	RajajiNgar	Bangalore
Shetty		**banashankari**	

The Update Statement
The UPDATE statement is used to modify the data in a table.
Syntax:

```
UPDATE table_name
SET column_name = new_value
WHERE column_name = some_value;
```

Person:

LastName	**FirstName**	**Address**	**City**
Kumar	Kiran	Rr nagr	bangalore
Rao	Praveen	RajajiNgar	Bangalore
Shetty		banashankari	

Update one Column in a Row
We want to add a first name to the person with a last name of " Shetty ":

```
UPDATE Person SET FirstName = '  pradeep '
WHERE LastName = '  shetty ';
```

Result:

LastName	**FirstName**	**Address**	**City**
Kumar	Kiran	Rr nagr	bangalore
Rao	Praveen	RajajiNgar	Bangalore
Shetty	Pradeep	banashankari	

Update several Columns in a Row
We want to change the address and add the name of the city:

```
UPDATE Person
SET  City = 'Tumkur'
WHERE LastName = 'shetty';
```

Result:

LastName	FirstName	Address	City
Kumar	Kiran	Rr nagr	bangalore
Rao	Praveen	RajajiNgar	Bangalore
Shetty	Pradeep	banashankari	Tumkur

The Delete Statement
The DELETE statement is used to delete rows in a table.
Syntax:

```
DELETE FROM table_name
WHERE column_name = some_value
```

Person:

LastName	FirstName	Address	City
Kumar	Kiran	Rr nagr	bangalore
Rao	Praveen	RajajiNgar	Bangalore
Shetty	Pradeep	banashankari	Tumkur

Delete a Row
"Pradeep Shetty" is going to be deleted:

```
DELETE
FROM Person
WHERE LastName = 'shetty'
```

LastName	FirstName	Address	City
Kumar	Kiran	Rr nagr	bangalore
Rao	Praveen	RajajiNgar	Bangalore

Delete All Rows
It is possible to delete all rows in a table without deleting the table. This means that the tablestructure, attributes, and indexes will be intact:

DELETE FROM table_name;
or
DELETE * FROM table_name;

LastName	FirstName	Address	City

Try this: ***SELECT * from Person;***

Examples:
The employee JONES is transfered to the department 20 as a manager and his salary is increased by 1000:

```
UPDATE EMP set
JOB = 'MANAGER', DEPTNO = 20, SAL = SAL +1000
where ENAME = 'JONES';
```

• All employees working in the departments 10 and 30 get a 15% salary increase.

```
UPDATE EMP set
SAL = SAL * 1.15 where DEPTNO in (10,30);
```

```
UPDATE EMP set
SAL = (select min(SAL) from EMP
where JOB = 'MANAGER')
where JOB = 'SALESMAN' and DEPTNO = 20;
```

Explanation: The query retrieves the minimum salary of all managers. This value then is assigned to all salesmen working in department 20.

Joining Relations
Comparisons in the where clause are used to combine rows from the tables listed in the from clause.
Example: In the table EMPLOYEE only the numbers of the departments are stored, not their name. For each salesman, we now want to retrieve the name as well as the number and the name of the department where he is working:

```
SELECT ENAME, E.DEPTNO, DNAME
FROM EMP E, DEPT D
WHERE E.DEPTNO = D.DEPTNO
AND JOB = 'SALESMAN';
```

Explanation: E and D are table aliases for EMP and DEPT, respectively. The computation of the query result occurs in the following manner (without optimization):
1. Each row from the table EMP is combined with each row from the table DEPT (this operationis called Cartesian product). If EMP contains m rows and DEPT contains n rows, we thus get **n x m** rows.
2. From these rows those that have the same department number are selected (where E.DEPTNO = D.DEPTNO).
3. From this result finally all rows are selected for which the condition JOB = 'SALESMAN' holds.

In this example the joining condition for the two tables is based on the equality operator "=".
The columns compared by this operator are called join columns and the join operation is called an **equijoin**.
Any number of tables can be combined in a select statement.
Example: For each project, retrieve its name, the name of its manager, and the name of the department where the manager is working:

```
select ENAME, DNAME, PNAME
from EMP E, DEPT D, PROJECT P
where E.EMPNO = P.MGR
and D.DEPTNO = E.DEPTNO;
```

It is even possible to join a table with itself:
Example: List the names of all employees together with the name of their manager:

```
select E1.ENAME, E2.ENAME
from EMP E1, EMP E2
where E1.MGR = E2.EMPNO;
```

Explanation: The join columns are MGR for the table E1 and EMPNO for the table E2.
The equijoin comparison is E1.MGR = E2.EMPNO.
The Comparison Operators
IN:which compares a value *v* with a set (or multiset) of values V and evaluates to TRUE if *v* is one of the elements in V.
The **= ANY** (or **= SOME**) operator returns **TRUE** if the value *v* is equal to some *value* in the set V and is hence equivalent to IN.
The keywords **ANY** and **SOME** have the same meaning. Other operators that can be combined with ANY (or SOME) include >,>=, <, <=, and < >. The keyword ALL can also be combined with each of these operators.
For example, the comparison condition *(v* > ALL V) returns TRUE if the value *v* is greater than *all* the values in the set (or multiset) V.

Retrieve all employees who are working in department 10 and who earn at least as much as any (i.e., at least one) employee working in department 30:

```
SELECT *
FROM emp
WHERE sal >= ANY
                   (SELECT sal
                    FROM emp
                    WHERE deptno = 30)
    AND deptno = 10;
```

List all employees who are not working in department 30 and who earn more than all employees working in department 30:

```
Select * from EMP
where SAL > all
(select SAL from EMP
where DEPTNO = 30)
and DEPTNO <> 30;
```

For all and any, the following equivalences hold:
in : = any
not in : <> all or != all
Often a query result depends on whether certain rows do (not) exist in (other) tables. Such type of queries is formulated using the exists operator.
Example: List all departments that have no employees:

```
select  * from DEPT
where not exists
(select *from EMP
where DEPTNO = DEPT.DEPTNO);
```

Basic Retrieval Queries in SQL

SQL has one basic statement for retrieving information from a database.
The SELECT-FROM-WHERE clause Structure of Basic SQL Queries

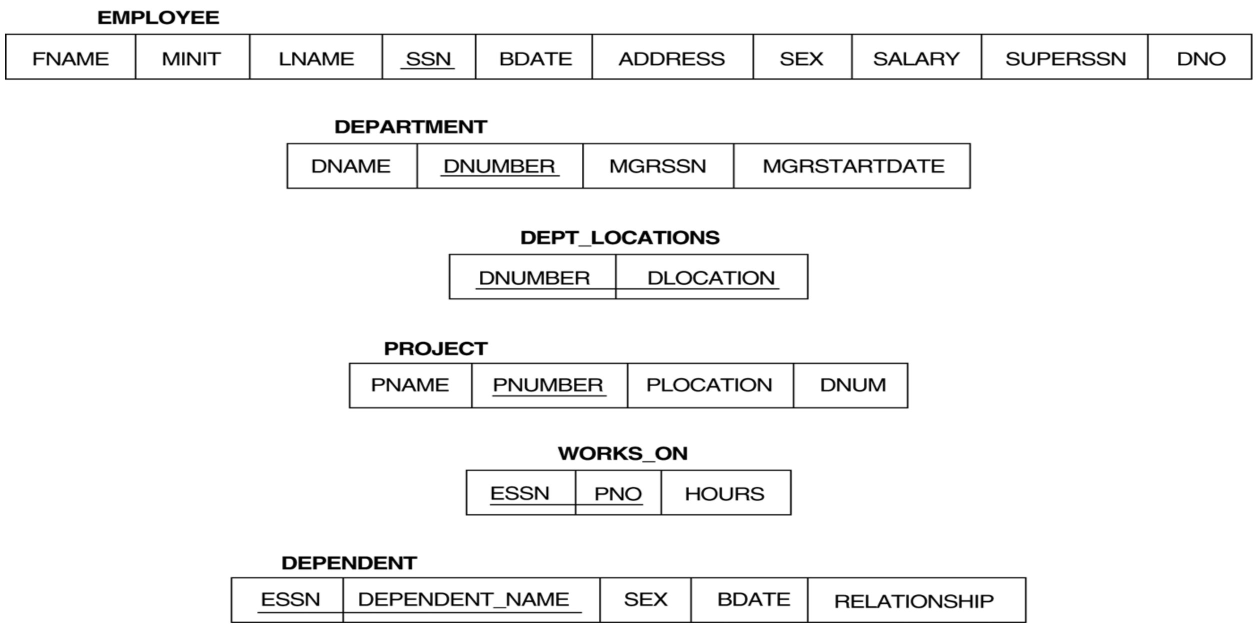
The basic form of the SELECT statement, sometimes called a **mapping** or a **select-from-where block**, is formed of the three clauses SELECT, FROM, and WHERE and has the following form:

SELECT <*attribute list*>
FROM <*table list*>
WHERE <*condition*>;

where ***<attribute list>*** is a list of attribute names whose values are to be retrieved by the query.
<table list> is a list of the relation names required to process the query.
<condition> is a conditional (Boolean) expression that identifies the tuples to be retrieved by the query.

In SQL, the basic logical comparison operators for comparing attribute values with one another and with literal constants are =, <, <=, >, >=, and <>.

These correspond to the relational algebra operators =, <, ≤, >, ≥, and ≠, respectively, The main syntactic difference is the ***not equal*** operator.


EMPLOYEE
FNAME MINIT LNAME SSN BDATE ADDRESS SEX SALARY SUPERSSN DNO
DEPARTMENT
DNAME DNUMBER MGRSSN MGRSTARTDATE
DEPT_LOCATIONS
DNUMBER DLOCATION
PROJECT
PNAME PNUMBER PLOCATION DNUM
WORKS_ON
ESSN PNO HOURS
DEPENDENT
ESSN DEPENDENT_NAME SEX BDATE RELATIONSHIP

CONSIDER THE FOLLOWING DETAILS:

EMPLOYEE(Fname,Minit,Lname,SSN,Bdate,Address,Sex,Salary,SuperSSN,Dno)
DEPARTMENT(Dname,Dnumber,MgrSSN,MgrStartDate)
DEPT_LOCATIONS(Dnumber,Dlocation)
PROJECT(Pname,pnumber,plocation,dnum)
WORKS_ON(essn,pno,hrs)
DEPENDENT(essn,dependentname,sex,bdate,relationship)

SQL Queries:

Query : Retrieve the birthdate and address of the employee whose name is 'John S Peter'.

SELECT BDATE, ADDRESS
FROM EMPLOYEE
WHERE FNAME='John'
AND MINIT='S'
AND LNAME='Peter';

Query: Retrieve the name and address of all employees who work for the 'Research' department.

SELECT FNAME, LNAME, ADDRESS
FROM EMPLOYEE, DEPARTMENT
WHERE DNAME='Research'
AND DNUMBER=DNO ;

Query : For every project located in 'bangalore', list the project number, the controlling department number, and the department manager's last name, address, and birthdate.

SELECT PNUMBER, DNUM, LNAME, BDATE, ADDRESS
FROM PROJECT, DEPARTMENT, EMPLOYEE
WHERE DNUM=DNUMBER AND MGRSSN=SSN
AND
PLOCATION='Indiranagar‘;

Ambiguous Attribute Names, Aliasing,Renaming, and Tuple Variables

In SQL, the same name can be used for two (or more) attributes as long as the attributes are in *different relations.* If this is the case, and a multitable query refers to two or more attributes with the same name, we *must* **qualify** the attribute name with the relation name to prevent ambiguity.

This is done by *prefixing* the ***relation name to the attribute name*** and separating the two by a ***period***.
The Dno and Lname attributes of the EMPLOYEE relation were called Dnumber and Name, and the Dname attribute of DEPARTMENT was also called Name. then, to prevent ambiguity.
We must prefix the attributes Name and Dnumber in Q1A to specify which ones we are referring to, because the same attribute names are used in both relations:
Query 1A: Retrieve the name and address of all employees who work for the 'Research' department.
SELECT Fname, EMPLOYEE.Name, Address
FROM EMPLOYEE, DEPARTMENT
WHERE DEPARTMENT.Name=‘Research’
AND DEPARTMENT.Dnumber=EMPLOYEE.Dnumber;

Fully qualified attribute names can be used for clarity even if there is no ambiguity in attribute names. We can also create an *alias* for each table name to avoid repeated typing of long table names .

Query: Retrieve the name and address of all employees who work for the 'Research' department.
SELECT EMPLOYEE.Fname, EMPLOYEE.LName, EMPLOYEE.Address
FROM EMPLOYEE, DEPARTMENT
WHERE DEPARTMENT.DName=‘Research’
AND DEPARTMENT.Dnumber=EMPLOYEE.Dno;

Query :For each employee, retrieve the employee’s first and last name and the first and last name of his or her immediate supervisor.

SELECT E.Fname, E.Lname, S.Fname, S.Lname
FROM EMPLOYEE **AS** E,
EMPLOYEE **AS** S **WHERE** E.Super_ssn=S.Ssn;

In this case, we are required to declare alternative relation names E and S, called **aliases** or **tuple variables**.

Q:Retrieve the name and address of all employees who work for the 'Research' department.
SELECT Fname, Lname, Address
FROM EMPLOYEE, DEPARTMENT
WHERE Dname='Research' **AND** Dnumber=Dno;

SELECT E.Fname, E.LName, E.Address
FROM EMPLOYEE E, DEPARTMENT D
WHERE D.DName='Research' **AND** D.Dnumber=E.Dno; (preffered)

Unspecified WHERE Clause and Use of the Asterisk

A *missing* WHERE clause indicates no condition on tuple selection. hence, *all tuples* of the relation specified in the FROM clause qualify and are selected for the query result.

If more than one relation is specified in the FROM clause and there is no WHERE clause, then the CROSS PRODUCT—*all possible tuple combinations*—of these relations is selected.

Select all EMPLOYEE Ssns

SELECT Ssn
FROM EMPLOYEE;

Select all EMPLOYEE Ssns and all combinations of EMPLOYEE Ssn and DEPARTMENT Dname in the database.

SELECT Ssn, Dname **FROM** EMPLOYEE, DEPARTMENT;

It is extremely important to specify every selection and join condition in the WHERE clause; if any such condition is overlooked, incorrect and very large relations may result.

OTHER EXAMPLES:

- **SELECT** * **FROM** EMPLOYEE **WHERE** Dno=5;

- **SELECT** * **FROM** EMPLOYEE, DEPARTMENT
  WHERE Dname='Research' **AND** Dno=Dnumber;

- **SELECT** * **FROM** EMPLOYEE, DEPARTMENT;

the keyword **DISTINCT** in the SELECT clause, meaning that only distinct tuples should remain in the result.

In general, a query with SELECT DISTINCT eliminates duplicates, whereas a query with SELECT ALL does not.

Q:Retrieve the salary of every employee

SELECT ALL Salary
FROM EMPLOYEE;
Q:Retrieve the salary of every employee and all distinct salary values

SELECT DISTINCT Salary

FROM EMPLOYEE;

SQL has directly incorporated some of the set operations from mathematical *set theory*, which are also part of relational algebra.

There are set union **(UNION),** set difference (**EXCEPT**) and set intersection (**INTERSECT**) operations.

The relations resulting from these set operations are sets of tuples, that is, *duplicate tuples are eliminated from the result.* These set operations apply only to *union-compatible relations*, so we must make sure that the two relations on which we apply the operation have the same attributes and that the attributes appear in the same order in both relations.

SQL supports three set operators which have the pattern:
<query 1> <*set operator*> <query 2>
The set operators are:
• **UNION [ALL:**] returns a table consisting of all rows either appearing in the result of **<query 1>** or in the result of **<query 2>.**
Duplicates are automatically eliminated unless the clause all is used.

• **INTERSECT** returns all rows that appear in both results <query 1> and <query 2>.

• **MINUS** returns those rows that appear in the result of <query 1> but not in the result of <query 2>.

(a)

R	A
	a1
	a2
	a2
	a3

S	A
	a1
	a2
	a4
	a5

(b)

T	A
	a1
	a1
	a2
	a2
	a2
	a3
	a4
	a5

(c)

T	A
	a2
	a3

(d)

T	A
	a1
	a2

(a) Two tables, R(A) and S(A).
(b) R(A) UNION ALL S(A). (c) R(A) EXCEPT ALL S(A). (d) R(A) INTERSECT ALL S(A).

SQL also has corresponding multiset operations, which are followed by the keyword ALL (UNION ALL, EXCEPT ALL, INTERSECT ALL). Their results are multisets (duplicates are not eliminated). The behavior of these operations is illustrated by the examples in Figure .

The below example illustrates the use of UNION.

Q. Make a list of all project numbers for projects that involve an employee whose last name is 'Smith', either as a worker or as a manager of the department that controls the project.

(**SELECT DISTINCT** Pnumber **FROM** PROJECT, DEPARTMENT, EMPLOYEE
WHERE Dnum=Dnumber **AND** Mgr_ssn=Ssn **AND** Lname='Smith')
UNION
(**SELECT DISTINCT** Pnumber **FROM** PROJECT, WORKS_ON, EMPLOYEE
WHERE Pnumber=Pno **AND** Essn=Ssn **AND** Lname='Smith');

The first SELECT query retrieves the projects that involve a 'Smith' as manager of the department that controls the project, and the second retrieves the projects that involve a 'Smith' as a worker on the project.

Substring Pattern Matching and Arithmetic Operators In this section we discuss several more features of SQL. The first feature allows comparison conditions on only parts of a character string, using the **LIKE** comparison operator. This can be used for string **pattern matching**. Partial strings are specified using two reserved characters: % replaces an arbitrary number of zero or more characters, and the underscore (_) replaces a single character.

Q. Retrieve all employees whose address is Houston, Texas.

SELECT Fname, Lname
FROM EMPLOYEE
WHERE Address **LIKE** '%Houston%';

Q . Find all employees who were born during the 1950s.

SELECT Fname, Lname
FROM EMPLOYEE
WHERE Bdate **LIKE** '_ _ 5 _ _ _ _ _ _ _';
Another feature allows the use of arithmetic in queries. The standard arithmetic operators for addition (+), subtraction (–), multiplication (*), and division (/) can be applied to numeric values or attributes with numeric domains.

Q . Show the resulting salaries if every employee working on the 'ProductX' project is given a 10 percent raise.

SELECT E.Fname, E.Lname, 1.1 * E.Salary **AS** Increased_sal
FROM EMPLOYEE **AS** E, WORKS_ON **AS** W, PROJECT **AS** P
WHERE E.Ssn=W.Essn **AND** W.Pno=P.Pnumber **AND** P.Pname='ProductX';

Another comparison operator, which can be used for convenience, is **BETWEEN Query .**

Q.Retrieve all employees in department 5 whose salary is between $30,000 and $40,000.

SELECT *
FROM EMPLOYEE
WHERE (Salary **BETWEEN** 30000 **AND** 40000) **AND** Dno = 5;
*The condition (Salary **BETWEEN** 30000 **AND** 40000) in above is equivalent to the condition ((Salary >= 30000) **AND** (Salary <= 40000)).*

Ordering of Query Results SQL allows the user to order the tuples in the result of a query by the values of one or more of the attributes that appear in the query result, by using the **ORDER BY** clause.

Q . Retrieve a list of employees and the projects they are working on, ordered by department and, within each department, ordered alphabetically by last name, then first name.

SELECT D.Dname, E.Lname, E.Fname, P.Pname
FROM DEPARTMENT D, EMPLOYEE E, WORKS_ON W,PROJECT P
WHERE D.Dnumber= E.Dno
AND E.Ssn= W.Essn
AND W.Pno= P.Pnumber
ORDER BY D.Dname, E.Lname, E.Fname;

The keyword **ASC** can be used to specify ascending order explicitly.
For example, if we want descending alphabetical order on Dname and ascending order on Lname, Fname, the ORDER BY clause of can be written as
ORDER BY D.Dname **DESC**, E.Lname **ASC**, E.Fname **ASC**

Summary of Basic SQL Retrieval Queries A *simple* retrieval query in SQL can consist of up to four clauses, but only the first two—**SELECT** and **FROM**—are mandatory. The clauses are specified in the following order, with the clauses between square brackets [...] being optional:

SELECT <attribute list>
FROM <table list>
[**WHERE** <condition>]
[**ORDER BY** <attribute list>];

The SELECT clause lists the attributes to be retrieved, and the FROM clause specifies all relations (tables) needed in the simple query. The WHERE clause identifies the conditions for selecting the tuples from these relations, including join conditions if needed. ORDER BY specifies an order for displaying the results of a query.

Comparisons Involving NULL and Three-Valued Logic SQL has various rules for dealing with NULL values. NULL is used to represent a missing value, but that it usually has one of three different interpretations—value *unknown* (exists but is not known), value *not available* (exists but is purposely withheld), or value *not applicable* (the attribute is undefined for this tuple). Consider the following examples to illustrate each of the meanings of NULL.

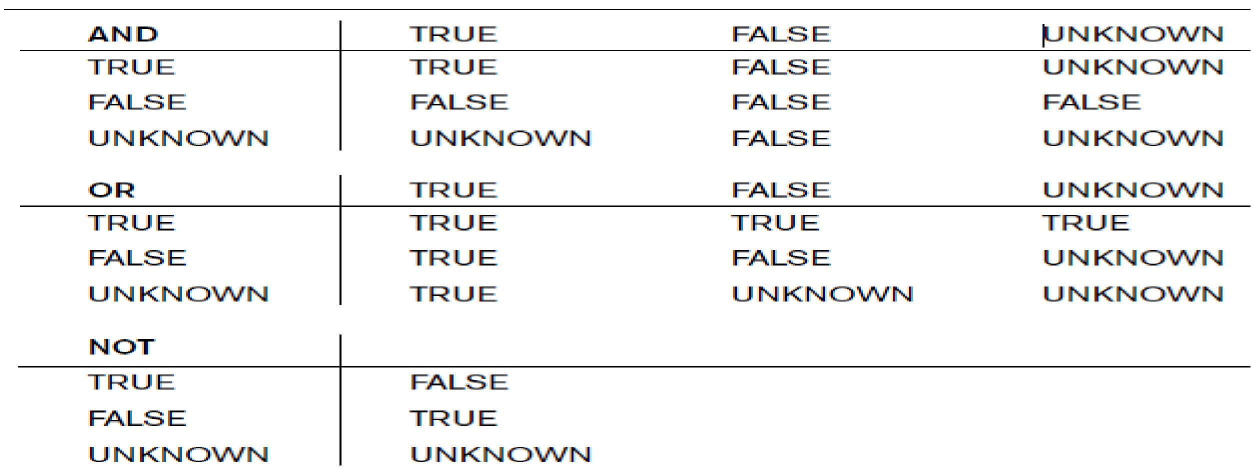
1. Unknown value. A person's date of birth is not known, so it is represented by NULL in the database.

2. Unavailable or withheld value. A person has a home phone but does not want it to be listed, so it is withheld and represented as NULL in the database.

3. Not applicable attribute. An attribute LastCollegeDegree would be NULL for a person who has no college degrees because it does not apply to that person.

It is often not possible to determine which of the meanings is intended; for example, a NULL for the home phone of a person can have any of the three meanings. Hence, SQL does not distinguish between the different meanings of NULL.
In general, each individual NULL value is considered to be different from every other NULL value in the various database records. When a NULL is involved in a comparison operation, the result is considered to be UNKNOWN (it may be TRUE or it may be FALSE). Hence, SQL uses a three-valued logic with values TRUE, FALSE, and UNKNOWN instead of the standard two-valued (Boolean) logic with values TRUE or FALSE. It is therefore necessary to define the results (or truth values) of three-valued logical expressions when the logical connectives AND, OR, and NOT are used.

Logical Connectives in Three-Valued Logic



AND	TRUE	FALSE	UNKNOWN
TRUE	TRUE	FALSE	UNKNOWN
FALSE	FALSE	FALSE	FALSE
UNKNOWN	UNKNOWN	FALSE	UNKNOWN

OR	TRUE	FALSE	UNKNOWN
TRUE	TRUE	TRUE	TRUE
FALSE	TRUE	FALSE	UNKNOWN
UNKNOWN	TRUE	UNKNOWN	UNKNOWN

NOT	
TRUE	FALSE
FALSE	TRUE
UNKNOWN	UNKNOWN

SQL allows queries that check whether an attribute value is **NULL**. Rather than using = or <> to compare an attribute value to NULL, SQL uses the comparison operators **IS** or **IS NOT**.

Q,Retrieve the names of all employees who do not have supervisors.

SELECT Fname, Lname
FROM EMPLOYEE
WHERE Super_ssn **IS** NULL;

Nested Queries, Tuples, and Set/Multiset Comparisons:
A nested query is a query that has another query embedded within it. The embedded query is called a subquery.

The embedded query can of course be a nested query itself; thus queries that have very deeply nested structures are possible. Some queries require that existing values in the database be fetched and then used in a comparison condition. Such queries can be conveniently formulated by using **nested queries**, which are complete select-from-where blocks within the WHERE clause of another query. That other query is called the **outer query**.

```
SELECT DISTINCT Pnumber
FROM PROJECT
WHERE Pnumber IN ( SELECT Pnumber
                   FROM PROJECT, DEPARTMENT, EMPLOYEE
                   WHERE Dnum=Dnumber AND Mgr_ssn=Ssn
                    AND Lname='Smith' ) OR Pnumber
                    IN
                   (SELECT Pno
                    FROM WORKS_ON, EMPLOYEE
                    WHERE Essn=Ssn AND Lname='Smith' );
```

If a nested query returns a single attribute *and* a single tuple, the query result will be a single (scalar) value. In such cases, it is permissible to use = instead of IN for the comparison operator.

SQL allows the use of **tuples** of values in comparisons by placing them within parentheses. To illustrate this, consider the following query:

```
SELECT DISTINCT Essn
FROM WORKS_ON
 WHERE (Pno, Hours) IN
                   ( SELECT Pno, Hours
                     FROM WORKS_ON
                     WHERE Essn='123456789' );
```

This query will select the Essns of all employees who work the same (project, hours) combination on some project that employee 'John Smith' (whose Ssn ='123456789') works on. In this example, the IN operator compares the subtuple of values in parentheses (Pno, Hours) within each tuple in WORKS_ON with the set of type-compatible tuples produced by the nested query.

An example is the following query, which returns the names of employees whose salary is greater than the salary of all the employees in department 5:

```
SELECT Lname, Fname
FROM EMPLOYEE
WHERE Salary > ALL ( SELECT Salary
                     FROM EMPLOYEE
                     WHERE Dno=5 );
```

Correlated Nested Queries In the nested queries seen thus far, *the inner subquery has been completely independent of the outer query*. In general, the inner subquery could depend on the row currently being examined in the outer query

Q. Retrieve the name of each employee who has a dependent with the same first name and is the same sex as the employee.

```
SELECT E.Fname, E.Lname
FROM EMPLOYEE AS E
WHERE E.Ssn IN
             ( SELECT Essn
              FROM DEPENDENT AS D
              WHERE E.Fname=D.Dependent_name
                      AND
                     E.Sex=D.Sex );
```

Q: Retrieve the name of each employee who has a dependent with the same first name as the employee.

```
SELECT E.FNAME, E.LNAME
FROM EMPLOYEE AS E
WHERE E.SSN IN (SELECT ESSN
               FROM DEPENDENT
               WHERE ESSN=E.SSN AND E.FNAME=DEPENDENT_NAME)
```

or

```
Q: SELECT E.FNAME, E.LNAME
FROM EMPLOYEE E, DEPENDENT D
WHERE E.SSN=D.ESSN AND E.FNAME=D.DEPENDENT_NAME ;
```

The **CONTAINS** operator compares two *sets of values* , and returns TRUE if one set contains all values in the other set (reminiscent of the *division* operation of algebra).

Q: Retrieve the name of each employee who works on *all* the projects controlled by department number 5.

```
SELECT FNAME,LNAME
FROM EMPLOYEE
WHERE ( (SELECT PNO
              FROM WORKS_ON
WHERE SSN=ESSN)
CONTAINS
               (SELECT PNUMBER
                FROM PROJECT
                 WHERE DNUM=5) )
```

In the above method, the second nested query which is not correlated with the outer query, retrieves the project numbers of all projects controlled by department 5.
The first nested query, which is correlated, retrieves the project numbers on which the employee works, which is different *for each employee tuple* because of the correlation.

The EXISTS and NOT EXISTS Functions in SQL

The EXISTS function in SQL is used to check whether the result of a correlated nested query is *empty* (contains no tuples) or not.

The result of EXISTS is a Boolean value **TRUE** if the nested query result contains at least one tuple, or **FALSE** if the nested query result contains no tuples.

Q. Retrieve the name of each employee who has a dependent with the same first name and is the same sex as the employee.

```
SELECT E.Fname, E.Lname
FROM EMPLOYEE  E
WHERE E.Ssn IN ( SELECT Essn
                  FROM DEPENDENT  D
                 WHERE E.Fname=D.Dependent_name  AND E.Sex=D.Sex );
```

Or

```
SELECT E.Fname, E.Lname
FROM EMPLOYEE  E, DEPENDENT  D
 WHERE E.Ssn=D.Essn AND E.Sex=D.Sex AND E.Fname=D.Dependent_name;
```

Or

```
Q: SELECT E.Fname, E.Lname
FROM EMPLOYEE AS E
WHERE EXISTS
( SELECT *
FROM DEPENDENT AS D
WHERE E.Ssn=D.Essn AND E.Sex=D.Sex AND E.Fname=D.Dependent_name);
```

EXISTS and NOT EXISTS are typically used in conjunction with a correlated nested query.

Q. Retrieve the names of employees who have no dependents.

```
 SELECT Fname, Lname
FROM EMPLOYEE
WHERE NOT EXISTS ( SELECT *
                   FROM DEPENDENT
                     WHERE Ssn=Essn );
```

In above correlated nested query retrieves all DEPENDENT tuples related to a particular EMPLOYEE tuple. If *none exist,* the EMPLOYEE tuple is selected because the **WHERE**-clause condition will evaluate to **TRUE** in this case. We can explain Query as follows:

For each EMPLOYEE tuple, the correlated nested query selects all DEPENDENT tuples whose Essn value matches the EMPLOYEE Ssn, if the result is empty, no dependents are related to the employee, so we select that EMPLOYEE tuple and retrieve its Fname and Lname.

Q. List the names of managers who have at least one dependent.

```
SELECT Fname, Lname
FROM EMPLOYEE
WHERE EXISTS ( SELECT *
               FROM DEPENDENT
               WHERE Ssn=Essn )AND
                                  EXISTS ( SELECT *
                                           FROM DEPARTMENT
                                           WHERE Ssn=Mgr_ssn );
```

It is possible to write the above query by using single nested query or without using nested query.

Q :Retrieve the name of each employee who works on all *the projects controlled by department number 5 (it* can be written using EXISTS and NOT EXISTS in SQL systems.)

```
SELECT Fname, Lname
FROM EMPLOYEE
WHERE NOT EXISTS ( ( SELECT Pnumber
                     FROM PROJECT
                     WHERE Dnum=5) EXCEPT
                                         ( SELECT Pno
                                           FROM WORKS_ON
                                           WHERE Ssn=Essn) );
```

or

```
SELECT FNAME, LNAME
FROM EMPLOYEE
WHERE ( (SELECT PNO
         FROM WORKS_ON
         WHERE SSN=ESSN)
 CONTAINS
        (SELECT PNUMBER
         FROM PROJECT
         WHERE DNUM=5) );
```

Or

```
SELECT Lname, Fname
FROM EMPLOYEE
WHERE NOT EXISTS ( SELECT *
                   FROM WORKS_ON B
                   WHERE ( B.Pno IN ( SELECT Pnumber
                                      FROM PROJECT
                                      WHERE Dnum=5 ) AND
                        NOT EXISTS ( SELECT *
                                     FROM WORKS_ON C
                           WHERE C.Essn=Ssn AND C.Pno=B.Pno )));
```

Aggregate Functions in SQL:

Aggregate functions are used to summarize information from multiple tuples into a single-tuple summary.

Grouping is used to create subgroups of tuples before summarization. Grouping and aggregation are required in many database applications.

A number of built-in aggregate functions exist: **COUNT**, **SUM**, **MAX**, **MIN**, and **AVG**.

The COUNT function returns the number of tuples or values as specified in a query. The functions **SUM, MAX, MIN, and AVG** can be applied to a set or multiset of numeric values and return, respectively, the sum, maximum value, minimum value, and average (mean) of those values.

These functions can be used in the SELECT clause or in a HAVING clause (which we introduce end of the topic).

The functions MAX and MIN can also be used with attributes that have nonnumeric domains if the domain values have a *total ordering* among one another.

Q. Find the sum of the salaries of all employees, the maximum salary, the minimum salary, and the average salary.

SELECT SUM (Salary), **MAX** (Salary), **MIN** (Salary), **AVG** (Salary)
FROM EMPLOYEE;

Q. Find the sum of the salaries of all Research department employees, the maximum salary, the minimum salary, and the average salary.

SELECT SUM (Salary), **MAX** (Salary), **MIN** (Salary), **AVG** (Salary)
FROM (EMPLOYEE **JOIN** DEPARTMENT **ON** Dno=Dnumber)
WHERE Dname='Research';

Q. Retrieve the total number of employees in the company

SELECT COUNT (*) **FROM** EMPLOYEE;

Q; Retrieve the total number of employees in the company and the number of employees in the 'Research' department .

SELECT COUNT (*)
FROM EMPLOYEE, DEPARTMENT
WHERE DNO=DNUMBER **AND** DNAME='Research';

Here the *asterisk (*) refers to the rows (tuples*), so **COUNT (*)** returns the number of rows in the result of the query. We may also use the *COUNT function to count values in a column rather than tuples, as in the next example.*

Q . Count the number of distinct salary values in the database.

SELECT COUNT (**DISTINCT** Salary)
FROM EMPLOYEE;
Q: Retrieve the names of all employees who have two or more dependents

```
Q: SELECT Lname, Fname
FROM EMPLOYEE
WHERE ( SELECT COUNT (*)
        FROM DEPENDENT
        WHERE Ssn=Essn ) >= 2;
```

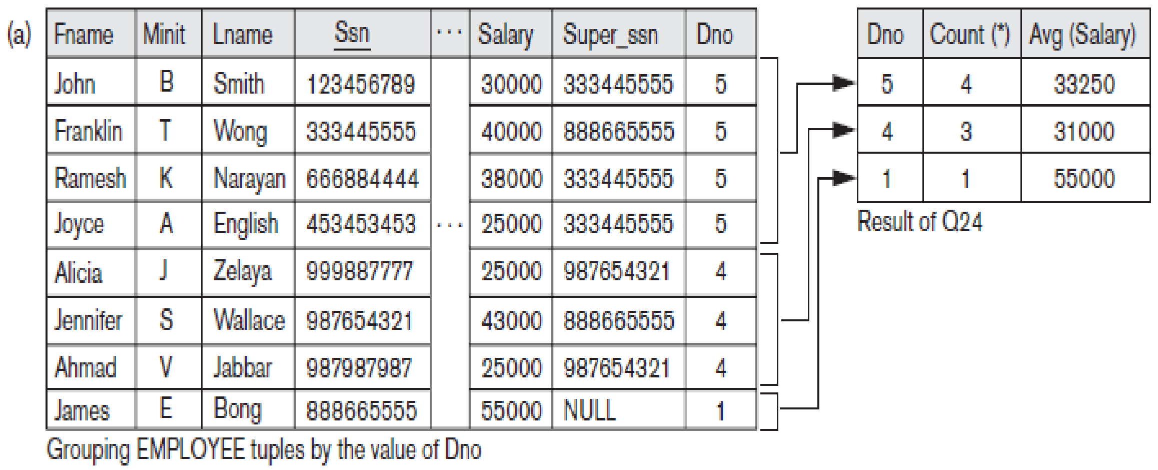
The correlated nested query counts the number of dependents that each employee has. If this is greater than or equal to two, the employee tuple is selected.

Grouping: The GROUP BY and HAVING Clauses

The GROUP BY clause specifies the grouping attributes, which should *also appear in the SELECT clause,* so that the value resulting from applying each aggregate function to a group of tuples appears along with the value of the grouping attribute(s).

Q. For each department, retrieve the department number, the number of employees in the department, and their average salary.
SELECT Dno, **COUNT** (*), **AVG** (Salary)
FROM EMPLOYEE **GROUP BY** Dno;

Figure
Results of GROUP BY



(a)

Fname	Minit	Lname	Ssn	. . .	Salary	Super_ssn	Dno
John	B	Smith	123456789		30000	333445555	5
Franklin	T	Wong	333445555		40000	888665555	5
Ramesh	K	Narayan	666884444		38000	333445555	5
Joyce	A	English	453453453	. . .	25000	333445555	5
Alicia	J	Zelaya	999887777		25000	987654321	4
Jennifer	S	Wallace	987654321		43000	888665555	4
Ahmad	V	Jabbar	987987987		25000	987654321	4
James	E	Bong	888665555		55000	NULL	1

Grouping EMPLOYEE tuples by the value of Dno

Dno	Count (*)	Avg (Salary)
5	4	33250
4	3	31000
1	1	55000

Result of Q24

Q. For each project, retrieve the project number, the project name, and the number of employees who work on that project.

SELECT Pnumber, Pname, **COUNT** (*)
FROM PROJECT, WORKS_ON
WHERE Pnumber=Pno
GROUP BY Pnumber, Pname;

The above Query shows how we can use a join condition in conjunction with GROUP BY.
In this case, the grouping and functions are applied *after* the joining of the two relations. SQL provides a **HAVING** clause, which can appear in conjunction with a **GROUP BY** clause, for this purpose.
HAVING provides a condition on the summary information regarding the group of tuples associated with each value of the grouping attributes. Only the groups that satisfy the condition are retrieved in the result of the query.

Q. For each project *on which more than two employees work,* retrieve the project number, the project name, and the number of employees who work on the project.

SELECT Pnumber, Pname, **COUNT** (*)
FROM PROJECT, WORKS_ON
WHERE Pnumber=Pno
GROUP BY Pnumber, Pname
HAVING COUNT (*) > 2;

the HAVING clause serves to choose *whole groups.*

Q . For each project, retrieve the project number, the project name, and the number of employees from department 5 who work on the project.
SELECT Pnumber, Pname, **COUNT** (*)
FROM PROJECT, WORKS_ON, EMPLOYEE
WHERE Pnumber=Pno **AND** Ssn=Essn **AND** Dno=5
GROUP BY Pnumber, Pname;

Q. For each department that has more than five employees, retrieve the department number and the number of its employees who are making more than $40,000.
SELECT Dnumber, **COUNT** (*)
FROM DEPARTMENT, EMPLOYEE
WHERE Dnumber=Dno **AND** Salary>40000 **AND**
(**SELECT** Dno
FROM EMPLOYEE
GROUP BY Dno
HAVING COUNT (*) > 5)

A retrieval query in ***SQL can consist of up to six clauses***, but only the first two— **SELECT and FROM—are mandatory**.

The query can span several lines, and is ended by a semicolon. Query terms are separated by spaces, and parentheses can be used to group relevant parts of a query in the standard way.

The clauses are specified in the following order, with the clauses between square brackets [...] being optional:

```
SELECT <attribute and function list>
FROM <table list>
[ WHERE <condition> ]
[ GROUP BY <grouping attribute(s)> ]
[ HAVING <group condition> ]
[ ORDER BY <attribute list> ];
```

The SELECT clause lists the attributes or functions to be retrieved.

The FROM clause specifies all relations (tables) needed in the query, including joined relations, but not those in nested queries.

The WHERE clause specifies the conditions for selecting the tuples from these relations, including join conditions if needed.

GROUP BY specifies grouping attributes, whereas HAVING specifies a condition on the groups being selected rather than on the individual tuples.

The built-in aggregate functions COUNT, SUM, MIN, MAX, and AVG are used in conjunction with grouping, but they can also be applied to all the selected tuples in a query without a GROUP BY clause. *Finally, ORDER BY specifies an order for displaying the result of a query.*

In general, there are numerous ways to specify the same query in SQL. This flexibility in specifying queries has advantages and disadvantages. The main advantage is that users can choose the technique with which they are most comfortable when specifying a query. For example, many queries may be specified with join conditions in the WHERE clause, or by using joined relations in the FROM clause, or with some form of nested queries and the IN comparison operator. Some users may be more comfortable with one approach, whereas others may be more comfortable with another. From the programmer's and the system's point of view regarding query optimization, it is generally preferable to write a query with as little nesting and implied ordering as possible. The disadvantage of having numerous ways of specifying the same query is that this may confuse the user, who may not know which technique to use to specify particular types of queries. Another problem is that it may be more efficient to execute a query specified in one way than the same query specified in an alternative way. Ideally, this should not be the case: The DBMS should process the same query in the same way regardless of how the query is specified. But this is quite difficult in practice, since each DBMS has different methods for processing queries specified in different ways.

Sailors(<u>sid</u>: integer, sname: string, rating: integer, age: real);
Boats(<u>bid</u>: integer, bname: string, color: string);
Reserves(<u>sid:</u> integer<u>, bid</u>: integer, day: date).

Find all information of sailors who have reserved boat number 103.
SELECT S.*
FROM Sailors S, Reserves R
WHERE S.sid = R.sid AND R.bid = 103;
Or
SELECT **Sailors.***
FROM Sailors, Reserves
WHERE Sailors.sid = Reserves.sid AND Reserves.bid = 103;
**** can be used if you want to retrieve all columns.***

Find the names of sailors who have reserved a red boat, and list in the order of age.
SELECT S.sname, S.age
FROM Sailors S, Reserves R, Boats B
WHERE S.sid = R.sid AND R.bid = B.bid AND B.color = 'red'
ORDER BY S.age
ORDER BY S.age [ASC] (default)
ORDER BY S.age DESC

Find the names of sailors who have reserved at least one boat.
SELECT sname
FROM Sailors S, Reserves R
WHERE S.sid = R.sid
The join of Sailors and Reserves ensure that for each select sname, the sailor has made some reservation.
Find the ids and names of sailors who have reserved two different boats on the same day.
SELECT DISTINCT S.sid, S.sname
FROM Sailors S, Reserves R1, Reserves R2
WHERE S.sid = R1.sid AND S.sid = R2.sid
AND R1.day = R2.day AND R1.bid <> R2.bid;
Using Expressions and Strings in the SELECT Command.
SELECT sname, age, rating + 1 as sth
FROM Sailors
WHERE 2* rating – 1 < 10 AND sname like **'B_%b';**
SQL provides for pattern matching through LIKE operator, along with the use of symbols:
% (which stands for **zero or more** arbitrary characters) and
_ (which stands for **exactly one**, arbitrary, characters)

Union, Intersect and Except
Note that Union, Intersect and Except can be used on only two tables that are **union-compatible**,
that is, have the same number of columns and the columns, taken in order, have the same types.
Ex. Find the ids of sailors who have reserved a red boat or a green boat.
SELECT R.sid
FROM Boats B, Reserves R
WHERE R.bid = B.bid AND B.color = 'red'
UNION
SELECT R2.sid
FROM Boats B2, Reserves R2
WHERE R2.bid = B2.bid AND B2.color = 'green'

The default for UNION queries is that **duplicates *are* eliminated**. To retain duplicates, use UNION ALL.
Replace UNION with **UNION ALL**.
Replace UNION with **INTERSECT**.
Replace UNION with **EXCEPT**.
<u>Nested Query</u>
IN and **NOT IN**
EXISTS and **NOT EXISTS**
UNIQUE and **NOT UNIQUE**
op ANY
op ALL
Find the names of sailors who have reserved boat 103.
SELECT S.sname
FROM Sailors S
WHERE S.sid **IN** (SELECT R.sid
FROM Reserves R
WHERE R.bid = 103)
The inner subquery has been completely independent of the outer query.
(Correlated Nested Queries)
SELECT S.sname
FROM Sailors S
WHERE **EXISTS** (SELECT *
FROM Reserves R
WHERE R.bid = 103
AND **R.sid = S.sid**)
The inner query depends on the row that is currently being examined in the outer query.
Find the name and the age of the youngest sailor.
SELECT S.sname, S.age
FROM Sailors S
WHERE S.age **<= ALL** (SELECT age
FROM Sailors)

Find the names and ratings of sailor whose rating is better than some sailor called Horatio.

SELECT S.sname, S.rating
FROM Sailors S
WHERE S.rating **> ANY** (SELECT S2.rating
FROM Sailors S2
WHERE S2.sname = 'Horatio')

Note that **IN** and **NOT IN** are equivalent to **= ANY** and **<> ALL**, respectively.

Find the names of sailors who have reserved all boats.

SELECT S.sname
FROM Sailors S
WHERE **NOT EXISTS** ((SELECT B.bid
FROM Boats B)
EXCEPT
(SELECT R.bid
FROM Reserves R
WHERE **R.sid = S.sid**))

An alternative solution:

SELECT S.sname
FROM Sailors S
WHERE **NOT EXISTS** (SELECT B.bid
FROM Boats B
WHERE **NOT EXISTS** (SELECT R.bid
FROM Reserves R
WHERE R.bid = B.bid
AND **R.sid = S.sid**))

Aggregation Operators

Count the number of different sailor names.

SELECT COUNT(DISTINCT S.sname)
FROM Sailors S

Calculate the average age of all sailors.

SELECT AVG(s.age)
FROM Sailors S

Find the name and the age of the youngest sailor.

SELECT S.sname, S.age
FROM Sailors S
WHERE S.age = (SELECT MIN(S2.age)
FROM Sailors S2)

SELECT [DISTINCT] select-list
FROM from-list
WHERE qualification
GROUP BY grouping-list
HAVING group-qualification

Find the average age of sailors for each rating level.

```
SELECT S.rating, AVG(S.age) AS avg_age
FROM Sailors S
GROUP BY S.rating;
```

Find the average age of sailors for each rating level that has at least two sailors.

```
SELECT S.rating, AVG(S.age) AS avg_age
FROM Sailors S
GROUP BY S.rating
HAVING COUNT(*) > 1;
```

Sailors

Sid	Sname	Rating	Age
22	Dustin	7	45
29	Brutus	1	33
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35
64	Horatio	7	35
71	Zorba	10	16
74	Horatio	9	40
85	Art	3	25.5
95	Bob	3	63.5

Boats

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Reserves

sid	bid	day
22	101	1998-10-10
22	102	1998-10-10
22	103	1998-10-8
22	104	1998-10-7
31	102	1998-11-10
31	103	1998-11-6
31	104	1998-11-12
64	101	1998-9-5
64	102	1998-9-8
74	103	1998-9-8

An example shows difference between WHERE and HAVING:

```
SELECT S.rating, AVG(S.age) as avg_age
FROM Sailors S
WHERE S.age >=40
GROUP BY S.rating
```

Rating	avg_age
3	63.5
7	45
8	55.5

```
SELECT S.rating, AVG(S.age) as avg_age
FROM Sailors S
GROUP BY S.rating
HAVING AVG(S.age) >= 40
```

Rating	avg_age
3	44.5
7	40
8	40.5