

Master e-business and ICT Management

Database

SQL



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Supplier and part database

S#	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens

S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S1	P4	200
S1	P5	100
S1	P6	100
S2	P1	300
S2	P2	400
S3	P2	200
S4	P2	200
S4	P4	300
S4	P5	400


P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

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Supplier and part database

- **Relational model**
 - part base table
 - supplier base table
 - supply base table, that puts a relation between parts and suppliers which supply parts
- **Primary key** (record identifier)
 - part: P#
 - supplier: S#
 - supply: (S#,P#)




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SQL language

- It is a language to define the relational database structure and to access and update data
- It is suitable for
 - *interactive operations*
 - *embedded instructions*
 - a host language contains SQL instructions. These instructions differ from host language instructions by means of syntactic artifices




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SQL language

- SQL is a level set language
 - operations and results are set of data
- SQL expresses queries in declarative way
 - the abstraction level is higher than programming languages
 - queries specify the properties of the result, not the way to obtain it
 - queries are translated by the query optimizer into the procedural language internal to the DBMS
 - the programmer should focus on readability, not on efficiency




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SQL language

- The name is an acronym for Structured Query Language
- It is a language to manage relational database
 - **DDL (Data Definition Language)** is the language which supports the definition or declaration of database objects (e.g., tables, indexes)
 - **DML (Data Manipulation Language)** is the language which supports the manipulation or processing of data





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Data Definition Language

- **CREATE TABLE**: base table definition
- **ALTER TABLE**: alteration of a base table structure
- **DROP TABLE**: base table deletion
- **CREATE INDEX**: index creation
- **DROP INDEX**: index deletion


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CREATE TABLE


CREATE TABLE <base-table-name>
(*column-definition* [, *column-definition*]);
column-definition::=*column-name* *type-name* [NOT NULL]


Example. Create the supplier base table.

S#	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens

```


CREATE TABLE S
(S#      CHAR(5)      NOT NULL,
SNAME   CHAR(20)     NOT NULL,
STATUS  SMALLINT     NOT NULL,
CITY    CHAR(15)     NOT NULL,
PRIMARY KEY (S#)
);
    
```


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Definition of supplier and part database

```
CREATE TABLE S (S# CHAR(5) NOT NULL,  
SNAME CHAR(20) NOT NULL,  
STATUS SMALLINT NOT NULL,  
CITY CHAR(15) NOT NULL,  
PRIMARY KEY (S#));  
  
CREATE TABLE P (P# CHAR(6) NOT NULL,  
PNAME CHAR(20) NOT NULL,  
COLOR CHAR(6) NOT NULL,  
WEIGHT SMALLINT NOT NULL,  
CITY CHAR(15) NOT NULL,  
PRIMARY KEY (P#));  
  
CREATE TABLE SP (S# CHAR(5) NOT NULL,  
P# CHAR(6) NOT NULL,  
QTY INTEGER NOT NULL,  
PRIMARY KEY (S#,P#),  
FOREIGN KEY (S#) REFERENCES S,  
FOREIGN KEY (P#) REFERENCES P);
```




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ALTER TABLE

- The following “alterations” are supported
 - A new column can be added
 - A new default can be defined for an existing column (replacing the previous one, if any)
 - An existing column default can be deleted
 - An existing column can be deleted
 - A new integrity constraint can be specified
 - An existing integrity constraint can be deleted



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ALTER TABLE

ALTER TABLE <base-table-name>
ADD column-name data-type;


Example. Add the column DISCOUNT to supplier base table.

S#	SNAME	STATUS	CITY	DISCOUNT
S1	Smith	20	London	
S2	Jones	10	Paris	
S3	Blake	30	Paris	
S4	Clark	20	London	
S5	Adams	30	Athens	

ALTER TABLE S
ADD DISCOUNT SMALLINT;



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DROP TABLE

DROP TABLE <base-table-name>;


- indexes and views, defined on base-table-name, are also deleted

Example. Delete the supplier base table.

DROP TABLE S;



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INDEXES - Creation

```
CREATE [UNIQUE] INDEX <index-name> ON  
<base-table-name>(column-name [,column-name]);
```

- UNIQUE option specified than only one record can assume a given value


Examples.

```
CREATE UNIQUE INDEX XS ON S (S#);  
CREATE UNIQUE INDEX XP ON P (P#);  
CREATE UNIQUE INDEX XSP ON SP (S#,P#);
```


The violation of the unique option prevents the operation

```
CREATE INDEX XSC ON S (CITY);
```

Since many records can do reference to the same city,
UNIQUE option is not specified



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INDEXES – Deleting


```
DROP INDEX index-name;
```

Example. Delete XSC index.

```
DROP INDEX XSC;
```




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Data Manipulation Language

- **SELECT** – retrieval data (querying database)
- **INSERT** – inserting new data
- **UPDATE** – changing existing data
- **DELETE** – deleting exiting data




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Query

```
SELECT [DISTINCT] column(s)  
FROM table(s)  
[WHERE condition  
[GROUP BY column(s)  
[HAVING condition ]  
[ORDER BY column(s)];
```



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Data manipulation

Example. Find the code and status relating to suppliers in Paris.


```
SELECT S#, STATUS
FROM S
WHERE CITY='Paris';
```


S base table

S#	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens

Result

S#	STATUS
S2	10
S3	30


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SELECT with DISTINCT

DISTINCT – Remove duplicates

Example. Find distinct supplied parts.


```
SELECT DISTINCT P#
FROM SP;
```


SP base table

S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S1	P4	200
S1	P5	100
S1	P6	100
S2	P1	300
S2	P2	400
S3	P2	200
S4	P2	200
S4	P4	300
S4	P5	400

Result

P#
P1
P2
P3
P4
P5
P6


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Extraction of all information

Example. Find all the information relating to parts.

```
SELECT *
FROM P;
```


```
SELECT P.P#, P.NAME, P.COLOR, P.WEIGHT, P.CITY
FROM P;
```


P base table

P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

Result

P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London


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Ordering

- The ORDER BY clause, at the end of the query, orders the rows of the result


```
ORDER BY Ordering-Attribute [asc|desc]
{, Ordering-Attribute [asc|desc]}
```


Example. Extract the content of the part base table in descending order of name and color.

```
SELECT *
FROM P
ORDER BY PNAME DESC,
        COLOR DESC;
```

Result

P#	PNAME	COLOR	WEIGHT	CITY
P4	Screw	Red	14	London
P3	Screw	Blue	17	Rome
P1	Nut	Red	12	London
P6	Cog	Red	19	London
P5	Cam	Blue	12	Paris
P2	Bolt	Green	17	Paris


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ORDER BY

Example. Get p# of all parts in descending order of p#.

```
SELECT P#
FROM P
ORDER BY P# DESC;
```

Without DESC
↓
Implicit order is ASCENDING


↑
DESCENDING

P base table


P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

Result

P#
P6
P5
P4
P3
P2
P1



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Search with Ordering (1)

Example. Find all the information relating to parts. The result needs to be ordered in descending order of weight and ascending order of name.


```
SELECT P#, PNAME, COLOR, WEIGHT, CITY
FROM P
ORDER BY WEIGHT DESC, PNAME;
```

P base table


P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

Result

P#	PNAME	COLOR	WEIGHT	CITY
P6	Cog	Red	19	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Hut	Red	12	London



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Search with Ordering (2)

Example. For each part find p# and weight expressed in gram. Order the result based on weight expressed in gram.


```
SELECT P#, WEIGHT*454 AS PESO
FROM P
ORDER BY PESO;
```


P base table

P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

Result

P#	PESO
P1	5448
P5	5448
P4	6356
P2	7718
P3	7718
P6	8626


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Qualified search (Predicate conjunction)

Example. Find s# relating to suppliers in Paris with status greater than 20.


```
SELECT S#
FROM S
WHERE CITY='Paris' AND STATUS>20;
```


S base table

S#	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens

Result

S#
S3


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Queries (1)

1. Find s# and status relating to suppliers in Paris. Order the result with respect to status.


```
SELECT S#, STATUS  
FROM S  
WHERE CITY='Paris'  
ORDER BY STATUS DESC;
```

2. Find s# and status relating to suppliers in Paris or in London.

```
SELECT S#, STATUS  
FROM S  
WHERE CITY='Paris' OR CITY='London';
```




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Queries (2)

3. Find s# and status relating to suppliers without buildings in Paris.

```
SELECT S#, STATUS  
FROM S  
WHERE CITY<>'Paris';
```



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Query with JOIN

- This type of query searches a set of data in two or more base tables
- It performs a cartesian product of a set of base tables listed
- The result table is composed by all possible rows r, where r is obtained linking together one row of the first table, one for the second, ... , one of the last table
- All rows, which do not satisfy conditions expressed in WHERE, are removed from the result table


Example. Find the name of suppliers which supply the P2 part

```
SELECT SNAME
FROM S, SP
WHERE S.S#=SP.S# and P#='P2';
```

↑
Join condition



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Query with JOIN

Example. Find names of suppliers which supply at least a red part


```
SELECT SNAME
FROM S, SP, P
WHERE S.S#=SP.S# AND P.P#=SP.P#
AND P. Color='red';
```

If in the FROM clause there are N base tables → At least N-1 Join Conditions

DISTINCT is necessary to remove duplicate



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Query with JOIN

Example. Find the pairs of s# relating to suppliers with building in the same city.

```
SELECT SX.S#, SY.S#
FROM S AS SX, S AS SY
WHERE SX.CITY=SY.CITY AND SX.S#<>SY.S# ;
```

Result (a)


SX.S#	SY.S#
S1	S1
S1	S4
S2	S2
S2	S3
S3	S2
S3	S3
S4	S1

Result (b)

SX.S#	SY.S#
S1	S1
S1	S4
S2	S2
S2	S3
S3	S2
S3	S3
S4	S1

DBG
M

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Aggregate function

- The result of an aggregate query depends on the consideration of sets of rows
- SQL-2 offers five aggregate operators
 - **COUNT** – counts elements of a column
 - **SUM** – sums values of a column
 - **AVG** – value average of a column
 - **MAX** – maximum value in a column
 - **MIN** – minimum value in a column

DBG
M

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Operator COUNT


- COUNT returns the number of rows or distinct values

`COUNT (<*| distinct | all Attribute-List>)`

- Function argument may be preceded by DISTINCT
- COUNT(*) counts the number of base table rows



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Operator COUNT


- 1. Get the number of rows of S base table.*

```
SELECT COUNT(*)  
FROM S;
```
- 2. Get the number of suppliers which provide at least one supply.*


```
SELECT COUNT(DISTINCT S#)  
FROM SP;
```
- 3. Get the number of suppliers which supply the P2 part.*

```
SELECT COUNT(*)  
FROM SP  
WHERE P#='P2';
```
- 4. Get the total number of supplied parts relating to P2 part.*

```
SELECT SUM(QTY)  
FROM SP  
WHERE P#='P2';
```




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SUM, AVERAGE, MAXIMUM, MINIMUM

< SUM | MAX | MIN | AVG >
([distinct | all] Attribute-Expression >)

- SUM and AVG are applied on numeric values
- Function argument may be preceded by DISTINCT



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AVG, SUM, MAXIMUM, MINIMUM

- Find the average quantity of all supplied parts.


```
SELECT AVG(QTY) as AvgQ  
FROM SP;
```
- Find the total quantity of all supplied parts.

```
SELECT SUM(QTY) as TotQ  
FROM SP;
```
- Find the maximum and the minimum weight of all parts.

```
SELECT MAX(WEIGHT) as MaxW,  
MIN(WEIGHT) as MinW  
FROM P;
```



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GROUP BY queries

- Queries may apply aggregate operators to subsets of rows

Example. For each part get the total number of supplied parts. (Find the total supplied quantity for all supplied parts)

*SELECT P#, SUM(QTY)
FROM SP
GROUP BY P#;*


SP base table

S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S1	P4	200
S1	P5	100
S1	P6	100
S2	P1	300
S2	P2	400
S3	P2	200
S4	P2	200
S4	P4	300
S4	P5	400


S#	P#	QTY
S1	P1	300
S2	P1	300
S1	P2	200
S2	P2	400
S3	P2	200
S4	P2	200
S1	P3	400
S1	P4	200
S4	P4	300
S1	P5	100
S4	P5	400
S1	P6	100

Result

P#	...
P1	600
P2	1000
P3	400
P4	500
P5	500
P6	100



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Group predicate: HAVING

- When conditions are on the result of an aggregate operator, it is necessary to use the **HAVING** clause

Example. For each part, with at least 500 supplied pieces, get the total supplied quantity.

*SELECT P#, SUM(QTY)
FROM SP
GROUP BY P#
HAVING SUM(QTY)>=500;*


SP base table

S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S1	P4	200
S1	P5	100
S1	P6	100
S2	P1	300
S2	P2	400
S3	P2	200
S4	P2	200
S4	P4	300
S4	P5	400


S#	P#	QTY
S1	P1	300
S2	P1	300
S1	P2	200
S2	P2	400
S3	P2	200
S4	P2	200
S1	P3	400
S1	P4	200
S4	P4	300
S1	P5	100
S4	P5	400
S1	P6	100

Result

P#	...
P1	600
P2	1000
P4	500
P5	500



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Group predicate: HAVING

- Only predicates containing aggregate operators should appear in the argument of the having clause
- Having for the group by is like where for the table rows

Example. Get p# supplied by more than one supplier.

SP base table


S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S1	P4	200
S1	P5	100
S1	P6	100
S2	P1	300
S2	P2	400
S3	P2	200
S4	P2	200
S4	P4	300
S4	P5	400


S#	P#	QTY
S1	P1	300
S2	P1	300
S1	P2	200
S2	P2	400
S3	P2	200
S4	P2	200
S1	P3	400
S1	P4	200
S4	P4	300
S1	P5	100
S4	P5	400
S1	P6	100

```
SELECT P#
FROM SP
GROUP BY P#
HAVING COUNT(*)>1;
```

Result

P#
P1
P2
P4
P5


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Exercises (1)

The following relations are given (primary keys are underlined):
 JOURNAL (CodJ, NameJ, Editor)
 ARTICLE (CodA, Title, Topic, CodJ)

Write the following SQL queries

- (a) Find journal names which have published at least an article based on 'motorcycling' topic.
- (b) Find journal names which publish motorcycling articles or motor racing articles.
- (c) Find journal names which have published at least 2 motorcycling articles.
- (d) Find journal names which have published a motorcycling article (only one).


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Solutions (1a)

(a)


```
SELECT DISTINCT NameJ
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodJ
AND Topic='motorcycling';
```

(b)

```
SELECT NameJ
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodJ
AND (Topic='motorcycling' OR Topic='motor racing');
```



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Solutions (1b)

(c)


```
SELECT NameJ
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodR AND Topic='motorcycling'
GROUP BY JOURNAL.CodJ, NameJ
HAVING COUNT(*)>1;
```

(d)

```
SELECT NameJ
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodJ AND Topic='motorcycling'
GROUP BY JOURNAL.CodJ, NameJ
HAVING COUNT(*)=1
```



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Exercises (2)


The following relations are given (primary keys are underlined):
JOURNAL (CodJ, NameJ, Editor)
ARTICLE (CodA, Title, Topic, CodJ)

Write the following SQL queries

- (a) Find editors which have published at least an article based on 'motorcycling' topic.
- (b) Find editors which publish motorcycling articles or motor racing articles.
- (c) Find editors which have published at least 2 motorcycling articles.
- (d) Find editors which have published a motorcycling article (only one).



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Solutions (2a)

(a)


```
SELECT DISTINCT Editor
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodJ
AND Topic='motorcycling';
```

(b)

```
SELECT DISTINCT Editor
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodJ
AND (Topic='motorcycling' OR Topic='motor racing');
```




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Solutions (2b)

(c) SELECT Editor
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodJ AND Topic='motorcycling'
GROUP BY Editor
HAVING COUNT(*)>1;

(d) SELECT Editore
FROM JOURNAL, ARTICLE
WHERE JOURNAL.CodJ=ARTICLE.CodJ AND Topic='motorcycling'
GROUP BY Editor
HAVING COUNT(*)=1



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Verbatim search

It is performed by means of **LIKE constructor**
column-name LIKE char-string-const

- `_` means any characters
- `%` means any sequence of n characters

Example. Find all the information relating to parts whose name starts with c.


```
SELECT P.*
FROM P
WHERE P.PNAME LIKE 'c%';
```

P base table


P#	PNAME	COLOR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

Result

P#	PNAME	COLOR	WEIGHT	CITY
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London




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Verbatim search

- ADDRESS contains the 'Berkeley' string
ADDRESS LIKE '%Berkeley%'
- S# is exactly of 3 characters and the first one is 'S'
S# LIKE 'S_ _'
- PNAME is longer or equal to 4 characters and the last fourth is 'c'
PNAME LIKE '%c_ _ _'
- CITY does not contain 'E'
CITY NOT LIKE '%E%'



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Nested queries

- It is a query nested in an other query
- It is introduced by the IN predicate
- Internal query is executed before than the external query


Example. Find supplier names which supply P2 part.

```
SELECT SNAME
FROM S
WHERE S# IN (SELECT S#
FROM SP
WHERE P#='P2');
```


Membership operator

Result

SNAME
Smith
Jones
Blake
Clark



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Nested queries


- The last query is equivalent to the following join


```
SELECT S.SNAME
FROM S,SP
WHERE S.S#=SP.S# AND SP.P#='P2';
```
- For the example database, it is possible to write the query using a predefined set of data


```
SELECT SNAME
FROM S
WHERE S# IN ('S1','S2','S3','S4');
```



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Nested queries

Example. Find supplier names which supply at least a red part.


```
SELECT SNAME
FROM S
WHERE S# IN (SELECT S#
FROM SP
WHERE P# IN (SELECT P#
FROM P
WHERE COLOR='Red')));
```

Codes of suppliers of red parts


Codes of red products

Result

SNAME
Smith
Jones
Clark



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Nested queries


Example. Find codes of suppliers which work in the same city of 'S1'.

```
SELECT S#
FROM S
WHERE CITY = (SELECT CITY
              FROM S
              WHERE S#='S1');
```


If we know that the returned value is only one, it is possible to use = or > ... instead of IN.

Result

S#
S1
S4



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Nested query

Example. Find s# of all suppliers which have status value smaller than the maximum status stored in the supplier base table.


```
SELECT S#
FROM S
WHERE STATUS < (SELECT MAX(STATUS)
               FROM S);
```

S base table


S#	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens

Result

S#
S1
S2
S4



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Query with EXISTS

Example. Find the name of suppliers which supply the 'P2' part.

```
SELECT SNAME
FROM S
WHERE EXISTS (SELECT *
              FROM SP
              WHERE S# = S.S# AND P# = 'P2');
```

EXISTS expression (SELECT * FROM ...) is true if and only if the result of the SELECT is different from empty set.


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Query with NOT EXISTS

Example. Find the name of suppliers which do not supply the 'P2' part.

```
SELECT SNAME
FROM S
WHERE NOT EXISTS (SELECT *
                  FROM SP
                  WHERE S# = S.S# AND P# = 'P2');
```

S base table


S#	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens


SP base table

S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S1	P4	200
S1	P5	100
S1	P6	100
S2	P1	300
S2	P2	400
S3	P2	200
S4	P2	200
S4	P4	300
S4	P5	400

Result

Adams
SNAME



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Query with NOT IN

Example. Find the name of suppliers which do not supply the 'P2' part.

```
SELECT SNAME
FROM S
WHERE S# NOT IN (SELECT S#
                 FROM SP
                 WHERE P# = 'P2');
```




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Query with NOT EXISTS

Example. Find the name of suppliers with supply all parts.

```
SELECT SNAME
FROM S
WHERE NOT EXISTS (SELECT *
                 FROM P
                 WHERE NOT EXISTS (SELECT *
                                   FROM SP
                                   WHERE S# = S.S#
                                   AND P# = P.P#));
```



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Query with NOT EXISTS


Example. Find the code of suppliers which supply at least all parts supplied by S2.

The search can be divided into steps


- Find all the part codes supplied by the S2 supplier

```
SELECT P#  
FROM SP  
WHERE S# = 'S2';
```

- With CREATE TABLE and INSERT it is possible to save such data into a TEMP base table
- Next, we search all the suppliers which supply such parts




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Query with NOT EXISTS

Example. Find the code of suppliers which supply at least all the product supplied by S2.

```
SELECT DISTINCT S#  
FROM SP SPX  
WHERE NOT EXISTS (SELECT *  
FROM TEMP  
WHERE NOT EXISTS (SELECT *  
FROM SP SPY  
WHERE SPY.S# = SPX.S#  
AND SPY.P# = TEMP.P#));
```



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Query with UNION


Given two sets A and B

A UNION B

- is the set of objects such that
- if x belongs to A or belongs to B or belongs to both sets
- x belongs to (A UNION B)
- duplicates are deleted




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Query with UNION

Example. Find the code of parts which weight more than 16 or are supplied by S2 supplier, or both events are true.

```
SELECT P#  
FROM P  
WHERE WEIGHT > 16  
UNION  
SELECT P#  
FROM SP  
WHERE S# = 'S2';
```




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UPDATE

UPDATE table-name
SET column = expression
[, column = expression]
[WHERE condition];

- All table records in *table-name*, which satisfy the condition, are updated according to the *column = expression* in the *SET clause*




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Updating of a single record

```
UPDATE P
SET COLOR = 'Yellow', WEIGHT=WEIGHT+12, CITY = NULL,
WHERE P# = 'P1';
```

- The updating is executed only for the record associated to P1 code



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Multiple Updating


Example. Update the status of all suppliers in London to double of their current status.

```
UPDATE S
  SET STATUS = 2 * STATUS
  WHERE CITY = 'London'
```

- The updating is executed for all records which satisfy the specified condition




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Updating with nested query

Example. Set to 0 the quantity supplied by all suppliers in London.

```
UPDATE SP
  SET QTY = 0
  WHERE 'London' = (SELECT CITY
                    FROM S
                    WHERE S.S# = SP.S#);
```



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Updating of many tables


Example. Update the code of S2 and S9 suppliers.

```
UPDATE S
  SET S# = 'S9'
    WHERE S# = 'S2';
UPDATE SP
  SET S# = 'S9'
    WHERE S# = 'S2';
```

- An UPDATE instruction can update only a table
- There is an integrity problem after the updating of supplier base table
- To guarantee the integrity it is necessary to perform the updating of both tables



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DELETE instruction


```
DELETE FROM table-name
  [WHERE condition];
```

- All records which satisfy the condition are deleted from *table-name*

Example. Delete all supplies.

```
DELETE FROM SP;
```

- SP base table has been emptied



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Record deleting

Example. Delete the record corresponding to S1 supplier.

```
DELETE FROM S  
WHERE S# = 'S1';
```

ATTENTION: if SP base table contains reference to S1, the database loses its integrity

Example. Delete all suppliers in Madrid.

```
DELETE FROM S  
WHERE CITY = 'Madrid';
```



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Deleting with nested query

Example. Delete all sales by suppliers in London.

```
DELETE FROM SP  
WHERE 'London' = (SELECT CITY  
FROM S  
WHERE S.S# = SP.S#);
```



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INSERT instruction


Two cases:

```
INSERT INTO table-name  
[(column [,column]...)]  
VALUES (constant [, constant] ...)
```

```
INSERT INTO table-name  
[(column [,column] ...)]  
SELECT ... FROM ... WHERE ... ;
```




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Inserting of only one record

```
INSERT INTO P (P#, CITY, WEIGHT)  
VALUES ('P7', 'Athens', 24);
```

- A new record is build for P7 part
- NAME and COLOR are initialized to NULL (Attention to CREATE TABLE statement)



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Inserting of only one record


Example. Insert P8 part (name: Sprocket, color: Pink, Weight: 12, city: Nice).

```
INSERT INTO P  
VALUES ('P8','Sprocket','Pink',12,'Nice');
```

- When attribute list is omitted, the statement is equivalent to specify all the attributes according to the creation order of columns in the base table



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Inserting of only one record


Example. Insert a new supply with S20 supplier, P20 part and quantity equal to 1000.

```
INSERT INTO SP (S#, P#, QTY)  
VALUES ('S20','P20',1000);
```

ATTENTION: it is necessary than P20 and S20 exist in S and P respectively (integrity problem)




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Inserting of many records

Example. For each part find the code and the corresponding supplied quantity, saving the result into the database.

```
CREATE TABLE TEMP  
  (P# CHAR(6),  
   TOTQTY INTEGER);  
  
INSERT INTO TEMP (P#, TOTQTY)  
  (SELECT P#, SUM(QTY) FROM SP  
   GROUP BY P#);
```




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Inserting of many records

- SELECT returns data which are immediately inserted into TEMP base table
- TEMP base table is available for next elaborations
- At the end TEMP table can be deleted

```
DROP TABLE TEMP ;
```




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Integrity constraints in SQL-92

- Constraints are conditions that must be verified by every database instance
 - Intra-relational constraints
 - Inter-relational constraints
 - Assertions




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Intra-relational constraints

- Intra-relational constraints involve a single relation
 - not null (on single attributes)
 - unique: permits the definition of keys
 - for single attributes
 - unique, after the domain
 - for multiple attributes
 - unique (Attribute {, Attribute })
 - primary key: defines the primary key (once for each table; implies not null)
 - check




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Example of intra-relational constraints

- Each pair of S# and P# uniquely identifies each supply
 - S# CHAR(6)
 - P# CHAR(6)
 - unique(S#,P#)
- Note the difference with the following (stricter) definition which can be used in base tables S and P
 - S# char(6) not null unique
 - P# char(6) not null unique




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Check clause

- It can be used to express arbitrary constraints during schema definition
- Check (*Condition*)
- *Condition* is what can appear in a where clause (including nested queries)

```
CREATE TABLE SP (  
    S# CHAR(6) NOT NULL,  
    P# CHAR(6) NOT NULL,  
    QTY INTEGER  
    CHECK(QTY IS NOT NULL AND QTY>0),  
    PRIMARY KEY (S#,P#));
```




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Inter-relational constraints

- Constraints may take into account several relations
 - references and foreign key permit the definition of referential integrity constraints
 - for single attributes
 - references after the domain
 - for multiple attributes
 - foreign key (Attribute {, Attribute })
 - references ...
 - It is possible to associate reaction policies to violations of referential integrity




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Reaction policies

- Reactions operate on the internal table, after changes to the external table
- Violations may be introduced by
 - updates on the referred attribute
 - row deletions
- Reactions
 - cascade: propagate the change
 - set null: nullify the referring attribute
 - set default: assign the default value to the referring attribute
 - no action: forbid the change on the external table
- Reactions may depend on the event
 - on < delete | update >
 - < cascade | set null | set default | no action >




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Example of inter-relational constraint

```
CREATE TABLE SP (  
    S# CHAR(6) NOT NULL,  
    P# CHAR(6) NOT NULL,  
    QTY INTEGER  
        CHECK(QTY IS NOT NULL AND QTY > 0),  
    PRIMARY KEY (S#,P#),  
    FOREIGN KEY (S#) REFERENCES S(S#)  
        ON DELETE NO ACTION  
        ON UPDATE CASCADE,  
    FOREIGN KEY(P#) REFERENCES P(P#)  
        ON DELETE NO ACTION  
        ON UPDATE CASCADE);
```




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Assertions

- Assertions permit the definition of constraints outside of table definitions
- Useful in many situations (e.g., to express generic inter relational constraints)
- An assertion associates a name to a check clause
 - create assertion *AssertionName* check (*Condition*)



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Example of Assertion

- Constraint: each part can be supplied by at most 10 different suppliers

```
CREATE ASSERTION TooManyS
CHECK (NOT EXISTS
      (SELECT * FROM SP
       GROUP BY P#
       HAVING COUNT(DISTINCT S#)>10))
DEFERRABLE
INITIALLY DEFERRED;
```



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Transactional System

- A system capable of providing
 - the definition and execution of transactions on behalf of multiple
 - concurrent applications




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Transactions

- An elementary unit of work performed by an application, with specific features for what concerns correctness, robustness and isolation
- Each transaction is encapsulated within two commands
 - begin transaction (bot)
 - end transaction (eot)
- Within a transaction, one of the commands below is executed (exactly once)
 - commit work (commit)
 - rollback work (abort)




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ACID Properties of Transactions (1)

- **A**tomicity
 - A transaction is an atomic unit of work
 - It cannot leave the database in an intermediate state
 - a fault or error prior to commit causes the UNDO of the work made earlier
 - A fault or error after the commit may require the REDO of the work made earlier, if its effect on the database state is not guaranteed
- **C**onsistency
 - Consistency amounts to requiring that the transaction does not violate any integrity constraint
 - Integrity constraint verification can be
 - Immediate: during the transaction (the operation causing the violation is rejected)
 - Deferred: at the end of the transaction (if some integrity constraint is violated, the entire transaction is rejected)



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ACID Properties of Transactions (2)

- Isolation
 - Isolation requires that any transaction executes independently from the execution of all other concurrent transactions [isolation requires that the concurrent execution of a collection of transaction yields to the same result as an arbitrary sequential execution of the same transactions]
- Durability (Persistence)
 - Durability requires that the effect of a transaction that has successfully committed be not lost (the effect will “last forever”)

