# Advanced topics

SQL language

# SQL Language: Advanced Topics

- Views
- Transactions
- Access control
- Index management
- Physical design

# Views

Advanced Topics

# The concept of view

- A view is a *“virtual"* table
    - the content (tuples) is defined by means of an SQL query on the database
        - the content of the view depends on the content of the other tables present in the database
    - the content is *not* memorized physically in the database
        - it is recalculated every time the view is used by executing the query that defines it
- A view is an object of the database
    - it can be used in queries as if it were a table
- If the query refers to a view, it has to be reformulated by the DBMS before execution
- This operation is carried out automatically
    - the references to the view are substituted by its definition

# Example n.1: definition of the view

- Definition of the view *small suppliers*
  - the suppliers that have fewer than 3 employees are considered "small suppliers"
- The view "small suppliers"
  - contains the code, name, number of employees and city of the suppliers that have fewer than 3 employees.

Name of the views

```
CREATE VIEW SMALL_SUPPLIERS AS

SELECT SId, SName, #Employees, City
FROM   S
WHERE #Employees<3;
```

Query associated with the view

# Example n.1: query

- View the code, name, employee number and city of “small suppliers” in London
- The query can be answered without using views

```
SELECT *
FROM   S
WHERE #Employees<3 AND City=‘London’;
```

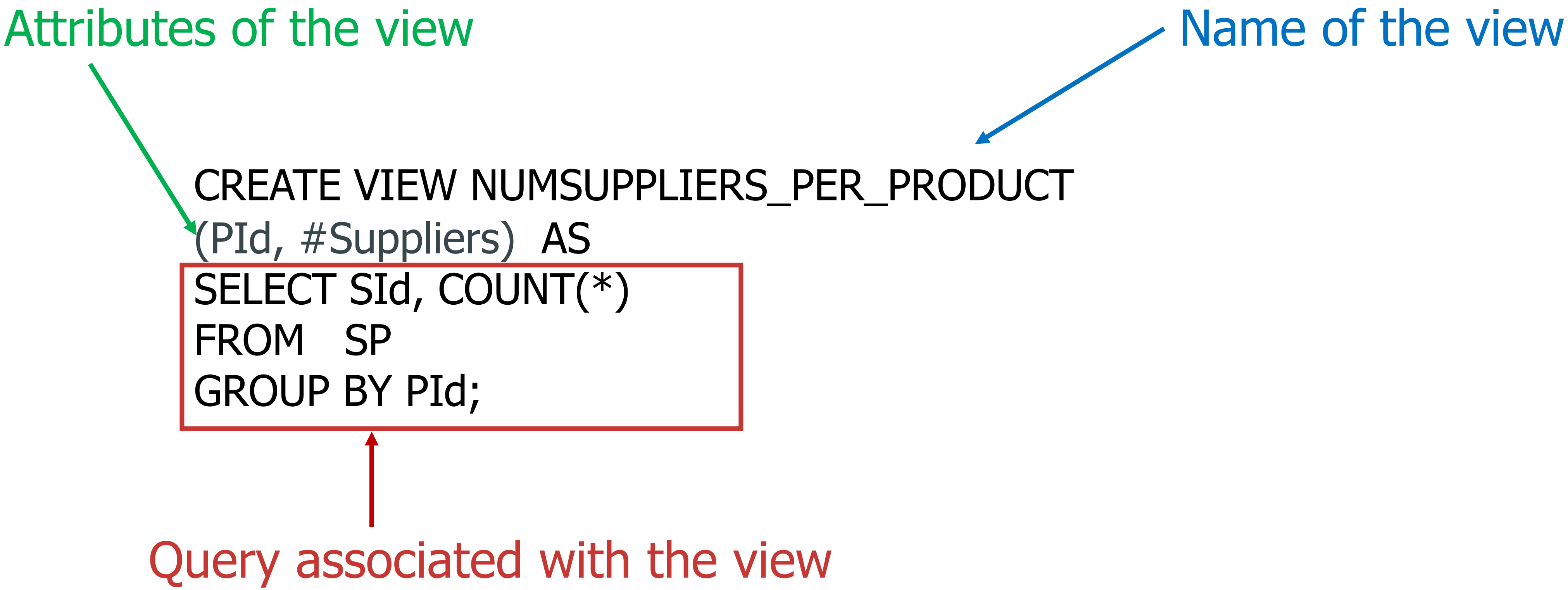
- The query can be answered using the view defined previously

```
SELECT *
FROM   SMALL_SUPPLIERS
WHERE City=‘London’;
```

- The view SMALL_SUPPLIERS is used like a table

# Example n.2: definition of the view

- Definition of the view *number of suppliers per product*
  - The view contains the product code and the number of different suppliers providing it



Attributes of the view

Name of the view

```
CREATE VIEW NUMSUPPLIERS_PER_PRODUCT
(PId, #Suppliers)  AS
SELECT SId, COUNT(*)
FROM   SP
GROUP BY PId;
```

Query associated with the view

# Advantages of views

- Simplification of queries
  - by breaking down a complex query into subqueries associated with the views
- Security management
  - it is possible to introduce different privacy protection mechanisms for each user or group
    - access authorization is associated with the view
    - each user, or group, accesses the database only via views that are appropriate for the operation they are authorized to carry out
- Database mainteinance and evolution
  - If a database is restructured, it is possible to change the views
    - it is not necessary to re-formulate the queries written before the restructuring and present in the applications that have already been developed

# Creation of views

```
CREATE VIEW ViewName [(AttributList) ]
AS SQLquery;
```

- If the names of the attributes of a view are not specified
  - use those present in the SQL query SELECT
- Attribute names have to be specified if
  - they represent the result of an internal function
  - they represent the result of an expression
  - they are constant
  - two columns (from different tables) have the same name

# Cancelling views

```
DROP VIEW ViewName;
```

- Cancelling a table that a view refers to can have various effects
    - automatic elimination of the associated views
    - automatic invalidation of the associated views
    - prohibition to execute the operation of cancelling the table
- the effect depends on the specific DBMS

# Updating views

- It is possible to update the data in a view *only* for some types of views
- Only views in which a single row of each table corresponds to a single row of the view can be updated (Standard SQL-92)
  - univocal correspondence between the tuple of the view and the tuple of the table on which it is defined
  - it is possibile to propagate without ambiguity the changes made to the view to each table on which it is defined
- *It is not possible to update* a view which in the outermost block of the query that defines it:
  - does not contain the primary key of the table on which it is defined
  - contains joins that represent one-to-many or many-to-many matches
  - contains aggregated functions
  - contains the DISTINCT keyword
- Some non-updatable views can become updatable by modifying the SQL expression associated with the view
  - it may be necessary to reduce the information content of the view

# Example n.1

- View SUPPLIER_CITY

```
CREATE VIEW SUPPLIER_CITY AS
SELECT SId, City
FROM   S;
```

# Example n.1: insertion

- Insertion in SUPPLIER_CITY of

('S10', 'Rome')

➡ corresponds to the insertion in S of

('S10',NULL,NULL,'Rome')

- the attributes SName, #Employees have to admit the value NULL

# Example n.1: deletion

- Deletion from SUPPLIER_CITY of

  ('S1', 'London')

  ➡ corresponds to the deletion from S of

  ('S1', 'Smith',20,'London')

  - identification of the tuple to delete is enabled by the primary key

# Example n.1: update

- update in SUPPLIER_CITY of

(‘S1’, ‘London’) to (‘S1’, ‘Milan’)

➡ update in S of

(‘S1’, ‘Smith’,20,‘London’) to (‘S1’, ‘Smith’,20,‘Milan’)

- identification of the tuple to be updated is enabled by the primary key

# Example n.1: updating

- The view SUPPLIER_CITY *can be updated*
  - each tuple of the view corresponds to a single tuple of table S
  - the changes carried out on the view can be propagated to the table on which it is defined

# Example n.2

- View NUMEMPLOYEE_CITY

```
CREATE VIEW NUMEMPLOYEE_CITY AS
SELECT DISTINCT #Employees, City
FROM   S;
```

# Esempio n.2: insertion

- Insertion in NUMEMPLOYEE_CITY of

(40, ‘Rome’)

➡ it is impossible to insert in S

(NULL, NULL, 40, ‘Rome’)

  - the value of the primary key is missing

# Example n.2: deletion

- Deletion from NUMEMPLOYEE_CITY of

(20, ‘London’)

  - several  tuples are associated with the pair  (20, ‘London’)
    - Which tuple has to be deleted from S?

# Example n.2: update

- Update in NUMEMPLOYEE_CITY of

(20, ‘London’) to (30, ‘Rome’)

➧Several tuples are associated with the pair (20, ‘London’)

  - Which tuple has to be updated in S?

# Example n.2: updating

- The view NUMEMPLOYEE_CITY *cannot be updated*
  - the primary key of table S is not present in the view
    - the insertion of new tuples in the view cannot be propagated to S
  - some tuples of the view correspond to several tuples in the table S
    - the association between the tuples in the view and the tuples in the table is ambiguous
    - it is not possible to propagate the changes carried out on the tuples of the view to the tuples of the table on which it is defined

# Example n.3: non-updatable view

```
CREATE VIEW SUPPLIER_LONDON AS
SELECT *
FROM S
WHERE City=‘London’;
```

- The view is non-updatable
  - it does not explicitly select the primary key of table S
- It is sufficient to replace the symbol “*” with the name of the attributes

# Example 4: non-updatable view

```
CREATE VIEW BEST_SUPPLIER (SId, SName) AS
SELECT DISTINCT SId, SName
FROM  S, SP
WHERE S.SId = SP.SId AND Qty >100;
```

- The view is not updatable
  - there is a join
  - the DISTINCT keyword is present

# Example n.4: changed view

```
CREATE VIEW BEST_SUPPLIER (SId, SName) AS
SELECT SId, SName
FROM   S
WHERE SId IN (SELECT SId
    FROM   SP
    WHERE Qty>100);
```

- The view is updatable
  - the join was removed using the IN operator
  - the keyword DISTINCT is no longer necessary

It is not always possible to rewrite the query to make the view updatable

# Transaction

Advanced Topics

# Transaction

- A transaction is necessary when several users can simultaneously access the data
- It provides efficient mechanisms to
  - manage competing access to data
  - recovery after a malfunction
- It is a logical unit of work, which cannot be further broken down
  - a sequence of data modification operations (SQL statements) that takes the database from one consistent state to another consistent state
  - there is no need to maintain consistency in intermediate states
- A system that makes a mechanism available for the definition and execution of transactions is called a transactional system
- The DBMS contains architecture blocks that offer transaction management services

# Beginning a transaction

- To define the beginning of a transaction, the SQL language uses the instruction
    - START TRANSACTION
- Usually the instruction to begin a transaction is omitted
    - the beginning is implicit for
        - the first SQL instruction of the programme that accesses the database
        - the first SQL instruction following the instruction   ending the previous transaction

# Ending a transaction

- The SQL language has instructions for defining the end of a transaction
  - Transaction successful
    - COMMIT [WORK]
    - the action associated with the instruction is called *commit*
  - Transaction failed
    - ROLLBACK [WORK]
    - the action associated with the instruction is called *abort*

# Commit

- Action executed when a transaction ends with success
- The database is in a new (final) correct state
- The changes to the data executed by the transaction become
  - permanent
  - visibile to other users

# Rollback

- Action executed when a transaction ends because of an error
  - for example, an error in application
- All the operations modifying the data executed during the transaction are “cancelled”
- The database returns to the state prior to the beginning of the transaction
  - the data is visible again to the other users

# Example

- Transfer the sum of 100
  - from current account number IT92X0108201004300000322229
  - to current account number IT32L0201601002410000278976

```
START TRANSACTION;

UPDATE Account
    SET Balance= Balance - 100
    WHERE IBAN='IT92X0108201004300000322229';

UPDATE Account
    SET Balance = Balance + 100
    WHERE IBAN= 'IT32L0201601002410000278976';

COMMIT;
```

# Properties of transactions

- The principal properties of transactions are
  - Atomicity
  - Consistency
  - Isolation
  - Durability
- They are summarized by the English acronym *ACID*

# Atomicity

- A transaction is an indivisible unit (atom) of work
  - all the operations contained in the transaction have to be executed
  - or none of the operations contained in the transaction have to be executed
    - the transaction has no effect on the database
- The database cannot remain in an intermediate state during the processing of a transaction

# Consistency

- The execution of a transaction has to take the database
  - from an initial state of consistency (correct)
  - to a final state of consistency
- Correctness is verified by integrity constraints defined on the database
- When there is a violation of the integrity constraint the system intervenes
  - to abort the transaction
  - or to modify the state of the database by eliminating the violation of the constraint

# Isolation

- The execution of a transaction is independent from the simultaneous execution of other transactions
- The effects of a transaction are not visible by other transactions until the transaction is terminated
    - the visibility of unstable intermediate states is avoided
        - an intermediate state can be aborted by a subsequent rollback
        - in case of  a rollback, it would be necessary to rollback the other transactions that have observed the intermediate state (domino effect)

# Durability

- The effect of a transaction that has executed a commit is memorized permanently
  - the changes to the data carried out by a transaction ending successfully are permanent after a commit
- It guarantees the reliability of the operations of data modification
  - the DBMS provides mechanisms for recovery to the correct state of the database after a malfunction has occurred

# Access control

Advanced topics

# Data security

- Protection of data from
  - unauthorized readers
  - alteration or destruction
- The DBMS provides protection tools which are defined by the database administrator (DBA)
- Security control verifies that users are authorized to execute the operations they request
- Security is guaranteed through a set of constraints
  - specificied by the DBA in an appropriate language
  - memorized in the data dictionary system

# Resources

- Any component of the database scheme is a resource
  - table
  - view
  - attribute in a table or view
  - domain
  - procedure
  - …
- Resources are protected by the definition of *access privileges*

# Access privileges

- Describe access rights to system resources
- SQL provides very flexible access control mechanisms for specifying
  - the resources users can access
  - the resources that have to remain private

# Privileges: characteristics

- Each privilege is characterized by the following information
    - the resource it refers to
    - the type of privilege
        - describes the action allowed on the resource
    - the user granting the privilege
    - the user receiving the privilege
    - the faculty to transmit the privilege to other users

# Types of privileges

- INSERT
  - enables the insertion of a new object in the resource
  - valid for tables and views
- UPDATE
  - enables updating the value of an object
  - valid for tables, views and attributes
- DELETE
  - enables removal of objects from the resource
  - valid for tables and views
- SELECT
  - enables using the resource in a query
  - valid for tables and views
- REFERENCES
  - enables referring to a resource in the definition of a table scheme
  - can be associated with tables and attributes
- USAGE
  - enables use of the resource (e.g. a new type of data) in the definition of new schemas

# Resource creator privileges

## Resource creator

- When a resource is created, the system grants all privileges over that resource to the user that created it
- Only the resource creator has the privilege to eliminate a resource (DROP) and modify a scheme (ALTER)
  - the privilege to eliminate and modify a resource cannot be granted to any other user

## System administrator

- The system administrator (user system) possesses all priviles over all the resources

# Management of privileges in SQL

- Privileges are granted or revoked using SQL instructions
  - GRANT
    - grants privileges over a resource to one or more users
  - REVOKE
    - revokes privileges granted to one or more users

# GRANT

GRANT *PrivilegeList* ON *ResourceName*
TO *UserList*
[WITH GRANT OPTION]

- *PrivilegeList*
  - specifies the list of privileges
  - ALL PRIVILEGES
    - Keyword for identifying all privileges
- *ResourceName*
  - specifies the resource for which the privilege is granted
- *UserList*
  - Specifies the users who are granted the privilege
- WITH GRANT OPTION
  - faculty to transfer the privilege to other users

# Examples

```
GRANT ALL PRIVILEGES
ON P TO Smith, Singh
```

- Users Smith and Singh are granted all privileges for table P

```
GRANT SELECT ON S TO Smith
WITH GRANT OPTION
```

- User Smith is granted the privilege to SELECT in table S
- User Smith has the faculty to grant the privilege to other users

# REVOKE

```
REVOKE PrivilegeList ON ResourceName
FROM UserList
[RESTRICT|CASCADE]
```

- Can remove
  - all the privileges that have been granted
  - a subset of privileges granted
- RESTRICT
  - the command must not be executed if revoking the user's privileges entails revoking other privileges
    - Example: the user has received the privileges with the GRANT OPTION and has propagated the privileges to other users
  - default value
- CASCADE
  - revokes also all the privileges which have been propagated
    - generates a chain reaction
  - for each privilege revoked
    - all granted privileges are revoked in a cascade
    - all database elements which have been created exploiting these privileges are removed

# Examples

REVOKE UPDATE ON P FROM White

- User White’s privilege to UPDATE table P is revoked
  - the command is not executed if it entails revoking the privilege of other users

REVOKE SELECT
ON S FROM Red CASCADE

- User Red’s privilege to SELECT table S is revoked
- User Red had received the privilege through GRANT OPTION
  - if Red has propagated the privilege to other users, the privilege is revoked in cascade
  - if Red has created a view using the SELECT privilege, the view is removed

# Concept of role

- The role is an access profile
  - Defined by its set of privileges
- Each user has a defined role
  - it enjoys the privileges associated with that role
- Advantages
  - access control is more flexible
    - a user can have different roles at different times
  - it simplifies administration
    - an access profile need not be defined at the moment of its activation
    - it is easy to define new user profiles

# CREATE ROLE

CREATE ROLE *RoleName*

- Definition of role privileges and user roles
  - instruction GRANT
- A user can have different roles at different times
  - dynamic association of a role with a user

    SET ROLE *RoleName*

# Index management

Advanced Topics

# Physical data organization

- In a relational DBMS the data are represented as collections of records memorized in one or more files
  - the physical organization of the data in a file influences the time required to access the information
  - each physical data organization makes some operations efficient and others cumbersome
- There is no physical data organization that is efficient for any type of data reading and writing

# Indexes

- *Indexes* are the accessory physical structures provided by the relational DBMS to improve the efficiency of data access operations
  - indexes are implemented using different types of physical structures
    - trees
    - hash tables
- The instructions for managing the indexes are not part of standard  SQL

# Index definition in SQL

- SQL language provides the following instructions for defining indexes
  - to create an index
    - CREATE INDEX
  - to delete an index
    - DROP INDEX
- The instructions for the management of indexes are not part of standard SQL

# CREATE INDEX

CREATE INDEX *NomeIndice*
ON *NomeTabella (ElencoAttributi)*

- The order in which the attributes appear in *AttributeList is important*
- the order of the index keys is
  - first on the basis of the first attribute in *AttributeList*
  - equal in value to the first attribute on the values of the second attribute
  - and so on, in order, until the last attribute

! Use the minimum number of attributes, usually one

# Example

- Creation of an index on the attribute Residence of the table EMPLOYEE

```
CREATE INDEX ResidenceIndex
ON EMPLOYEE (Surname, Residence)
```

- The index is jointly defined on the two attributes
- The index keys are ordered
    - first on the basis of the value of the attribute  Surname
    - of equal value to the attribute Surname, on the value of the attribute Name

# DROP INDEX

DROP INDEX *NomeIndice*

- Eliminate the index with the name *IndexName*
- This command is used when
  - the index is no longer utilized
  - the improvement in performance is insufficient
    - reduced reduction in response time for the queries
    - slowing down of updates due to index maintenance

# Physical design

Advanced Topics

# Physical design: input data

- Logical scheme of the database
- Characteristics of the chosen DBMS
  - physically available options
    - physical memory structures
    - indexes
- Data volumes
  - cardinality of tables
  - cardinality and distribution of the attribute values domain
- Estimate of application load
  - most important queries and their frequency
  - most important updating operations and their frequency
  - response time requirements for important queries/updates

# Physical design: result

- Physical scheme of the database
  - physical organization of tables
  - indexes
- Memorization and operating parameters
  - Initial file sizes, expansion possibilities, free space at outset, ...

# Procedure

- Physical design is carried out empirically, using a trial and error approach
  - there are no reference methodologies
- Characterization of the application load
  - for each important query it is necessary to define
    - access relationships
    - attributes to be viewed
    - attributes involved in selections/joins
    - degree of selectivity of selection conditions
  - for each important update it is necessary to define
    - type of update (Insertion, cancellation, modification)
    - relation to any attributes involved
    - degree of selectivity of selection conditions

# Procedure: choices to be made

- Choices to be made
  - physical structuring of the files containing the tables
- choice of  attributes to index
  - driven by estimating applicative load and data volume
  - definition of type for each index
  - e.g. hash or B-tree
- any variations of the scheme
  - horizontal partitioning in the secondary memory
  - denormalization of tables
    - used in data warehouses

# Tuning

- If the result is not satisfactory
  - *Tuning*, adding and removing indexes
- This is a procedure guided by the availability of tools that enable
  - verification of the execution plan adopted by the chosen DBMS
    - the execution plan defines the sequence of activities carried out by the DBMS to execute a query
      - data access methods
      - join methods
  - assess the execution cost of various alternatives