Views (Virtual Tables) in SQL

Database Design

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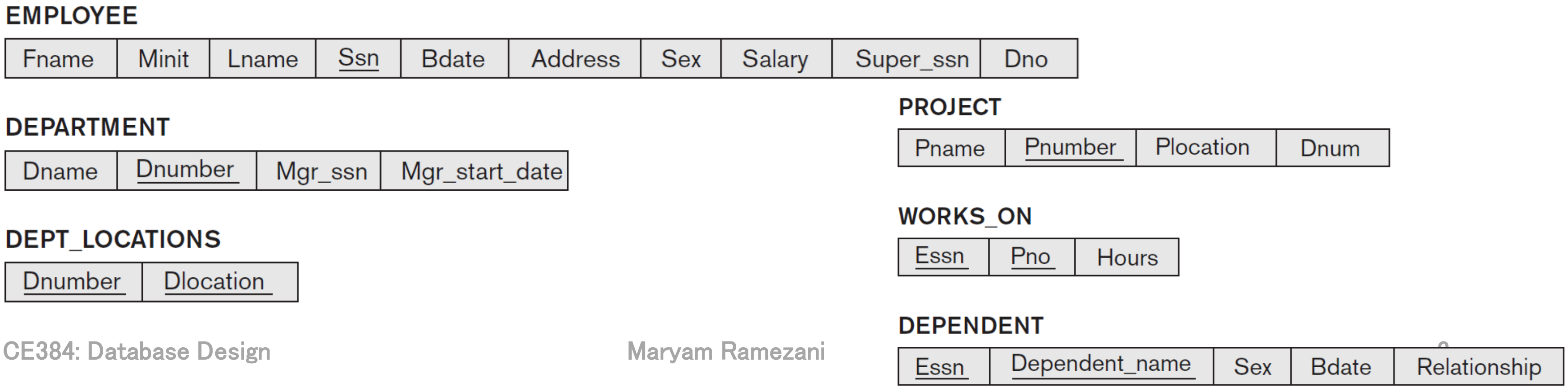
Introduction

Concept of view

- We may frequently issue queries that retrieve the employee name and the project names that the employee works on. Rather than having to specify the join of the three tables EMPLOYEE, WORKS_ON, and PROJECT every time we issue this query, we can define a view that is specified as the result of these joins. Then we can issue queries on the view, which are specified as single table retrievals rather than as retrievals involving two joins on three tables. We call the EMPLOYEE, WORKS_ON, and PROJECT tables the defining tables of the view.



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Concept of view

- A **view** in SQL terminology is a single table that is derived from other tables.
- These other tables can be *base tables* or previously defined views.
- A view does not necessarily exist in physical form; it is considered to be a **virtual table**, in contrast to **base tables**, whose tuples are always physically stored in the database.
  - This limits the possible update operations that can be applied to views, but it does not provide any limitations on querying a view.
- We can think of a view as a way of specifying a table that we need to reference frequently, even though it may not exist physically.
- The view is given a (virtual) table name (or view name), a list of attribute names, and a query to specify the contents of the view.
- If none of the view attributes results from applying functions or arithmetic operations, we do not have to specify new attribute names for the view, since they would be the same as the names of the attributes of the defining tables in the default case.

Specification of Views in SQL

```
CREATE VIEW      WORKS_ON1
AS SELECT        Fname, Lname, Pname, Hours
     FROM        EMPLOYEE, PROJECT, WORKS_ON
     WHERE       Ssn = Essn AND Pno = Pnumber;
```

WORKS_ON1

Fname	Lname	Pname	Hours

```
SELECT      Fname, Lname
FROM        WORKS_ON1
WHERE       Pname = 'ProductX';
```

```
DROP VIEW      WORKS_ON1;
```

```
CREATE VIEW      DEPT_INFO(Dept_name, No_of_emps, Total_sal)
AS SELECT        Dname, COUNT (*), SUM (Salary)
     FROM        DEPARTMENT, EMPLOYEE
     WHERE       Dnumber = Dno
     GROUP BY    Dname;
```

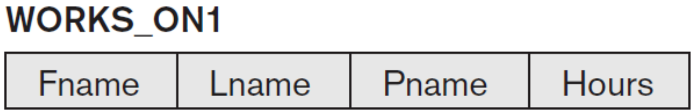
DEPT_INFO

Dept_name	No_of_emps	Total_sal

Query on View

- SQL query on a view is in the same way we specify queries on base tables:
  - Example: retrieve the last name and first name of all employees who work on the ‘ProductX’ project
  - QV1:

```
SELECT Fname, Lname
FROM WORKS_ON1
WHERE Pname = ‘ProductX’;
```



WORKS_ON1

Fname	Lname	Pname	Hours

View Properties

- ❑ Advantages:
  - ○ Simplify the specification of certain queries.
  - ○ Used as a security and authorization mechanism (End of this slide!)

- ❑ A view is supposed to be always up-to-date; if we modify the tuples in the base tables on which the view is defined, the view must automatically reflect these changes. Hence, the view does not have to be realized or materialized at the time of view definition but rather at the time when we specify a query on the view.
- ❑ It is the responsibility of the DBMS and not the user to make sure that the view is kept up-to-date.

View Properties

- If we do not need a view anymore, we can use the DROP VIEW command to dispose of it.
  - Example: DROP VIEW WORKS_ON1

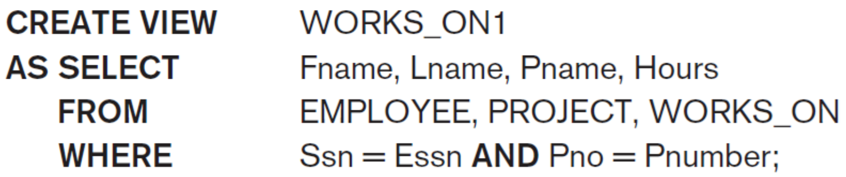
View Implementation in DBMs

View Implementation

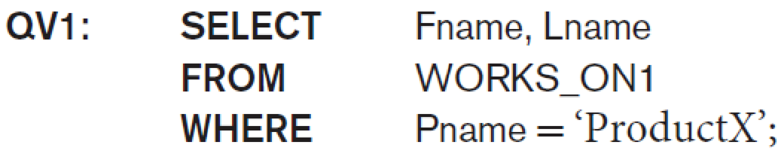
- How a DBMS can efficiently implement a view for efficient querying?
  - It is complex!
  - Two main approaches have been suggested:
    - Query modification
    - View materialization

Query modification (View Computation)

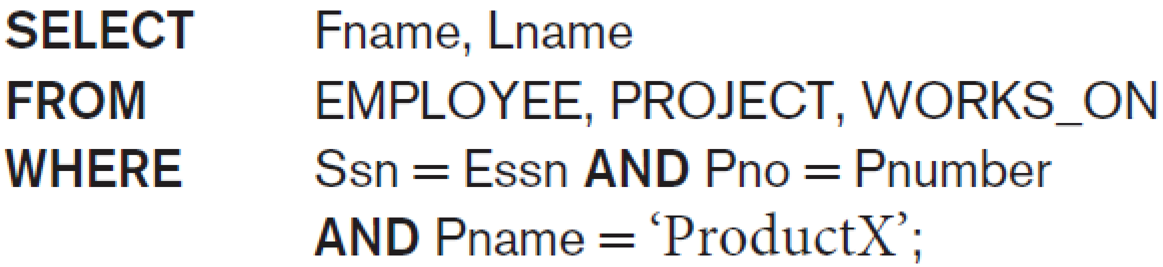
- Involves modifying or transforming the view query (submitted by the user) into a query on the underlying base tables.



```
CREATE VIEW     WORKS_ON1
AS SELECT       Fname, Lname, Pname, Hours
     FROM       EMPLOYEE, PROJECT, WORKS_ON
     WHERE      Ssn = Essn AND Pno = Pnumber;
```

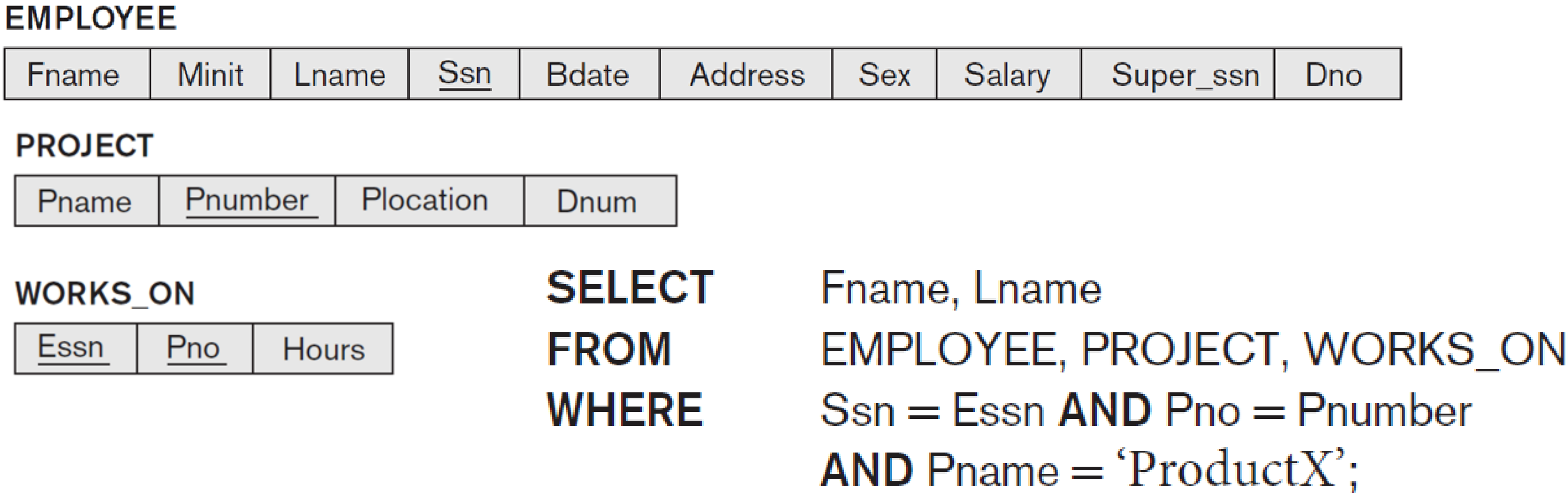


```
QV1:     SELECT     Fname, Lname
         FROM       WORKS_ON1
         WHERE      Pname = 'ProductX';
```



```
SELECT     Fname, Lname
FROM       EMPLOYEE, PROJECT, WORKS_ON
WHERE      Ssn = Essn AND Pno = Pnumber
           AND Pname = 'ProductX';
```

Query modification (View Computation)



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

```
SELECT    Fname, Lname
FROM      EMPLOYEE, PROJECT, WORKS_ON
WHERE     Ssn = Essn AND Pno = Pnumber
          AND Pname = 'ProductX';
```

- Disadvantage:

  Inefficient for views defined via complex queries that are time-consuming to execute, especially if multiple view queries are going to be applied to the same view within a short period of time

View Implementation

- How a DBMS can efficiently implement a view for efficient querying?
  - It is complex!
  - Two main approaches have been suggested:
    - Query modification
    - View materialization

View Materialization

- Involves physically creating a temporary or permanent view table when the view is first queried or created and keeping that table on the assumption that other queries on the view will follow.

- Efficient strategy for automatically updating the view table when the base tables are updated? **incremental update** have been developed for this purpose, where the DBMS can determine what new tuples must be inserted, deleted, or modified in a materialized view table when a database update is applied to one of the defining base tables.

View Materialization

- The view is generally kept as a materialized (physically stored) table as long as it is being queried.
- If the view is not queried for a certain period of time, the system may then automatically remove the physical table and recompute it from scratch when future queries reference the view.
- Application: For Data mining goals!

Materialized View Example

```
CREATE MATERIALIZED VIEW user_purchase_summary AS SELECT
  u.id as user_id,
  COUNT(*) as total_purchases,
  SUM(CASE when p.status = 'cancelled' THEN 1 ELSE 0 END) as cancelled_purchases
FROM users u
JOIN purchases p ON p.user_id = u.id;
```

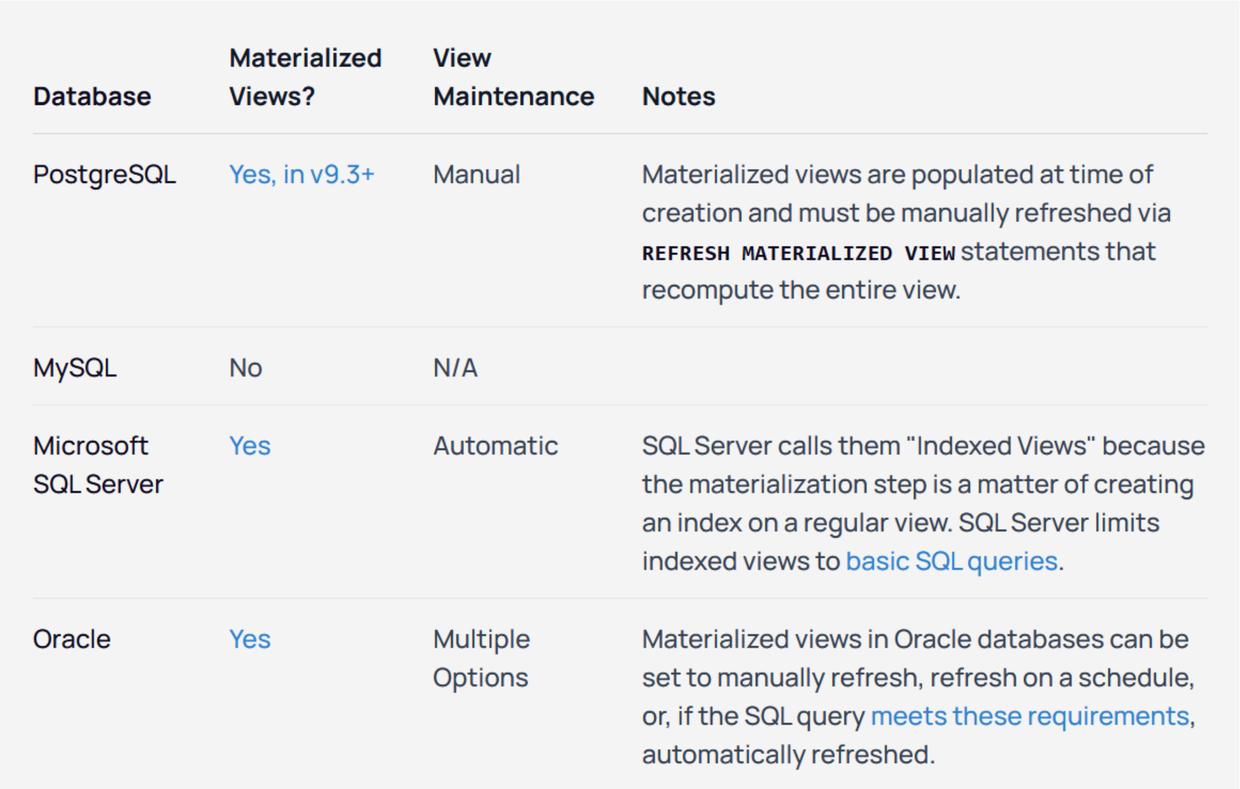
When executed, this statement instructs the database to:

- Execute the SELECT query within the materialized view definition.
- Cache the results in a new “virtual” table named user_purchase_summary
- Save the original query so it knows how to update the materialized view in the future.

View Materialization DBMS Update Strategies

- Different strategies as to when a materialized view is updated are possible:
  - Immediate update strategy updates a view as soon as the base tables are changed
  - Lazy update strategy updates the view when needed by a view query
  - Periodic update strategy updates the view periodically (in the latter strategy, a view query may get a result that is not up-to-date).

How do materialized views work in specific databases?



Database	Materialized Views?	View Maintenance	Notes
PostgreSQL	Yes, in v9.3+	Manual	Materialized views are populated at time of creation and must be manually refreshed via `REFRESH MATERIALIZED VIEW` statements that recompute the entire view.
MySQL	No	N/A	
Microsoft SQL Server	Yes	Automatic	SQL Server calls them "Indexed Views" because the materialization step is a matter of creating an index on a regular view. SQL Server limits indexed views to basic SQL queries.
Oracle	Yes	Multiple Options	Materialized views in Oracle databases can be set to manually refresh, refresh on a schedule, or, if the SQL query meets these requirements, automatically refreshed.

User Commands on View

User Command on View

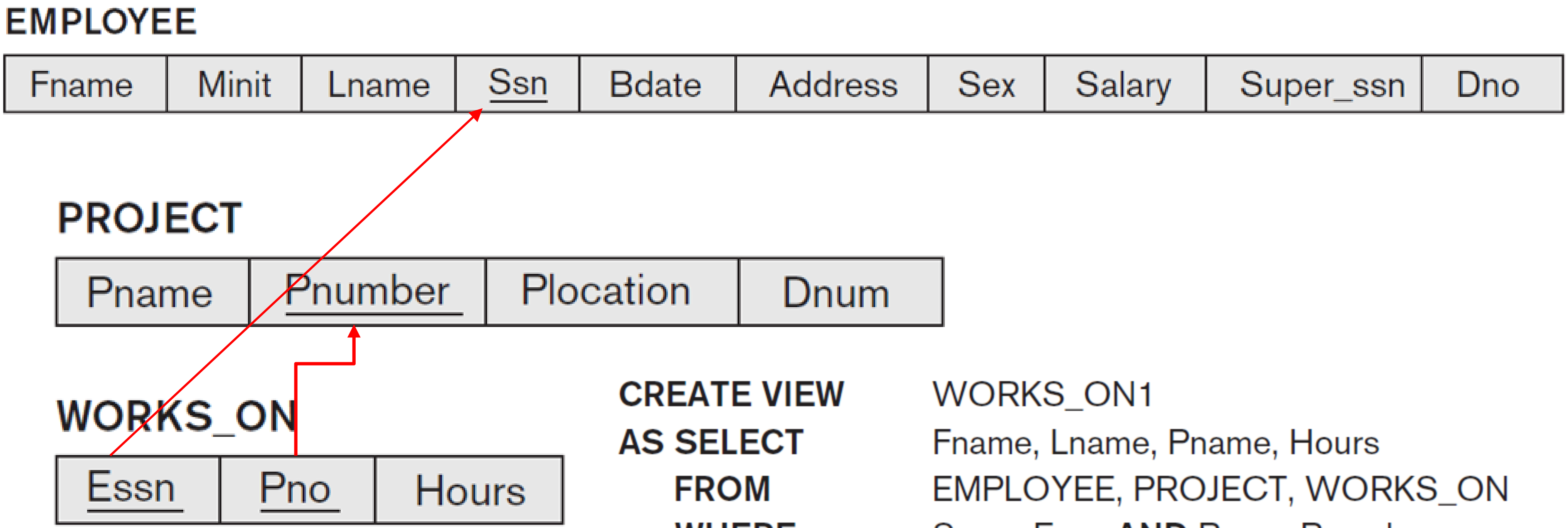
- ❑ A user can always issue a retrieval query against any view.
- ❑ Issuing an INSERT, DELETE, or UPDATE command on a view table is in many cases not possible.
- ❑ An update on a view defined on a single table without any aggregate functions can be mapped to an update on the underlying base table under certain conditions.
- ❑ For a view involving joins, an update operation may be mapped to update operations on the underlying base relations in multiple ways. Hence, it is often not possible for the DBMS to determine which of the updates is intended.

Updatable and Non Updatable View

- Updatable: Can be updated but has problems in some cases.
- Non Updatable: Can not convert external to conceptual.

- View can be defined on:
  - One base table:
    - Key Preserving: view has primary key of base table: OK with some problems.
    - Non Key Preserving: NO
    - View has aggregated columns: NO
  - More than one base table: In practice non updatable but updatable in theory.

Example



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

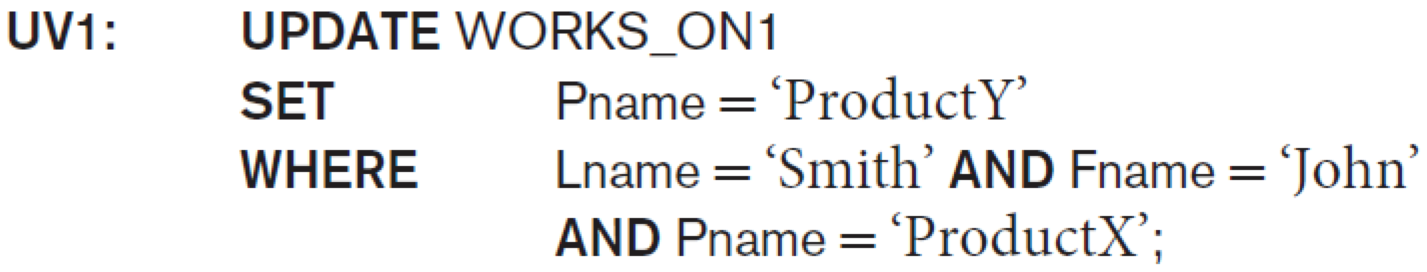
```
CREATE VIEW     WORKS_ON1
AS SELECT       Fname, Lname, Pname, Hours
     FROM       EMPLOYEE, PROJECT, WORKS_ON
     WHERE      Ssn = Essn AND Pno = Pnumber;
```

WORKS_ON1

Fname	Lname	Pname	Hours

Updating a view defined on multiple tables

- Challenge 1: Consider the WORKS_ON1 view, and suppose that we issue the command to update the PNAME attribute of 'John Smith' from 'ProductX' to 'ProductY'.



```
UV1:    UPDATE WORKS_ON1
        SET       Pname = 'ProductY'
        WHERE     Lname = 'Smith' AND Fname = 'John'
                  AND Pname = 'ProductX';
```

Updating a view defined on multiple tables

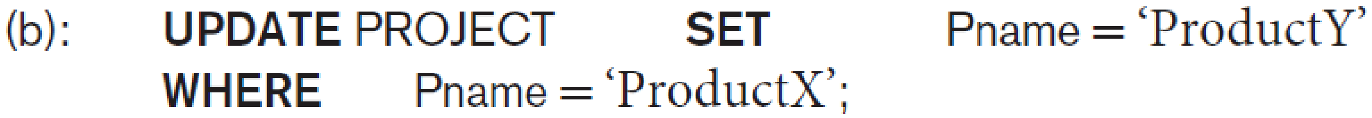
- ❑ Two possible updates on the base relations corresponding to the view update operation in UV1:

```
(a):    UPDATE WORKS_ON
        SET       Pno =     ( SELECT Pnumber
                              FROM      PROJECT
                              WHERE     Pname = 'ProductY' )
        WHERE     Essn IN   ( SELECT    Ssn
                              FROM      EMPLOYEE
                              WHERE     Lname = 'Smith' AND Fname = 'John' )
                  AND
                  Pno =     ( SELECT    Pnumber
                              FROM      PROJECT
                              WHERE     Pname = 'ProductX' );
```

relates 'John Smith' to the 'ProductY' PROJECT tuple instead of the 'ProductX' PROJECT tuple and is the most likely desired update.

Updating a view defined on multiple tables

- Two possible updates on the base relations corresponding to the view update operation in UV1:

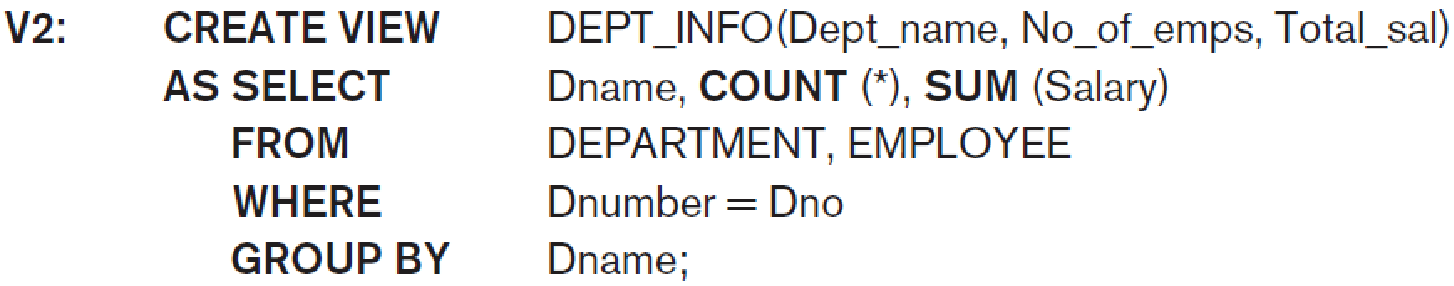


```
(b):    UPDATE PROJECT      SET         Pname = 'ProductY'
        WHERE     Pname = 'ProductX';
```

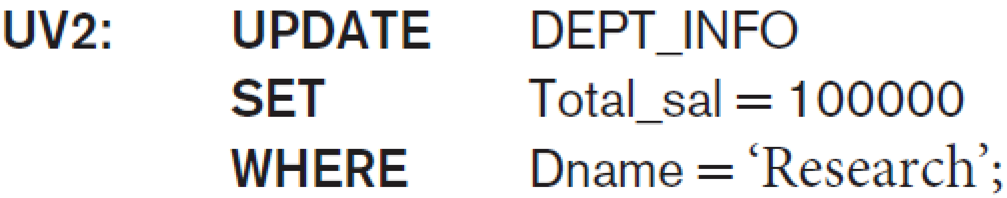
(b) Would also give the desired update effect on the view, but it accomplishes this by changing the name of the 'ProductX' tuple in the PROJECT relation to 'ProductY'. It is quite unlikely that the user who specified the view update UV1 wants the update to be interpreted as in (b), since it also has the side effect of changing all the view tuples with Pname = 'ProductX'.

Updating a view defined on multiple tables

- Challenge 2: Some view updates may not make much sense; for example, modifying the Total_sal attribute of the DEPT_INFO view does not make sense because Total_sal is defined to be the sum of the individual employee salaries. This incorrect request is shown as UV2:



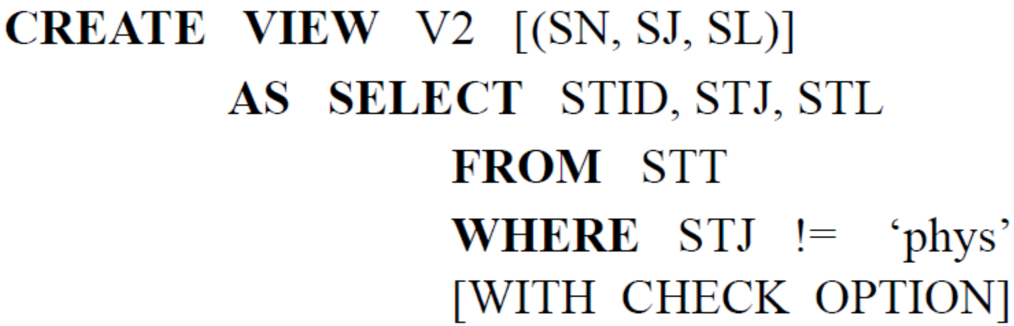
```
V2:     CREATE VIEW     DEPT_INFO(Dept_name, No_of_emps, Total_sal)
        AS SELECT       Dname, COUNT (*), SUM (Salary)
           FROM         DEPARTMENT, EMPLOYEE
           WHERE        Dnumber = Dno
           GROUP BY     Dname;
```



```
UV2:    UPDATE     DEPT_INFO
        SET        Total_sal = 100000
        WHERE      Dname = ‘Research’;
```

Notes

- In SQL, the clause WITH CHECK OPTION should be added at the end of the view definition if a view is to be updated by INSERT, DELETE, or UPDATE statements.



```
CREATE  VIEW  V2  [(SN, SJ, SL)]
        AS  SELECT  STID, STJ, STL
                FROM  STT
                WHERE  STJ  !=  'phys'
                [WITH  CHECK  OPTION]
```

- This allows the system to reject operations that violate the SQL rules for view updates. The full set of SQL rules for when a view may be modified by the user are more complex than the rules stated earlier.

View Example

V2

SN	SL	SJ
888	ms	math
444	bs	comp
⋮	⋮	

STT

STID	STNAME	STLEV	STMJR	STD
777	st7	bs	phys	d11
888	st8	ms	math	d12
444	st4	bs	comp	d14
⋮	⋮	⋮	⋮	⋮

```
CREATE  VIEW  V2  [(SN, SJ, SL)]
              AS  SELECT  STID, STMJR, STLEV
                      FROM  STT
                      WHERE  STMJR  !=  'phys'
                      [WITH  CHECK  OPTION]
```

View – Delete by User

```
DELETE FROM V2
          WHERE SN=‘444’
```

```
DELETE FROM STT
          WHERE STID=‘444’  AND  STMJR != ‘phys’
```

- Any single row operation is ok! This is a single row because we have STID the primary key in the condition of query!
- The row is deleted, and any other user will not have this row in his view!

View – Delete by User

```
DELETE FROM V2
        WHERE SL=‘ms’
```

```
DELETE FROM STT
        WHERE STLEV=‘ms’  AND  STMJR != ‘phys’
```

- This is not a single row, because we don’t have primary key in query condition. Many rows in STT may be deleted.
- The request is rejected by the DBMS!

View – Delete by User

```
CREATE VIEW V3
        AS SELECT DISTINCT STNAME, STMJR
        FROM STT
```

```
DELETE FROM V3
        WHERE STNAME=‘a’
```

✖ Rejected by the DBMS!

View – Update by User

```
UPDATE V2
        SET SJ=‘IT’
        WHERE SN=‘444’
```

```
UPDATE STT
        SET STMJR=‘IT’
        WHERE STID=‘444’ ’  AND  STMJR != ‘phys’
```

View – Update by User

```
UPDATE V2
        SET SJ=‘phys’
        WHERE SN=‘888’
```

```
UPDATE STT
        SET STMJR=‘phys’
        WHERE STID=‘888’ ’  AND  STMJR != ‘phys’
```

✖

Rejected because of WITH CHECK OPTION

If there was not WITH CHECK OPTION, what happened?

```
SELECT V2.*  FROM V2
```

No row with 888 key in view! :D

Summarized updating a view by user

- Generally, a view update is feasible when only one possible update on the base relations can accomplish the desired update operation on the view.
- Whenever an update on the view can be mapped to more than one update on the underlying base relations, it is usually not permitted.

Note: Some researchers have suggested that the DBMS have a certain procedure for choosing one of the possible updates as the most likely one. Some researchers have developed methods for choosing the most likely update, whereas other researchers prefer to have the user choose the desired update mapping during view definition. But these options are generally not available in most commercial DBMSs

View – Insert by User

```
INSERT  INTO  V2
             VALUES (‘555’, ‘chem’, ‘bs’)

INSERT  INTO  STT
             VALUES (‘555’, ?, ‘chem’, ‘bs’, ?)
```

- ❑ The request is rejected, if the hidden columns has NOT NULL constraint.
- ❑ If STID is a primary key and ‘555’ was inserted in STT table before but is hidden in view, then the request is rejected.
- ❑ Inserting value VALUES (‘555’, ‘phys’, ‘bs’) is rejected because of [WITH CHECK OPTION].

View with Aggregated Columns

- It is non updatable in practice and theory

V4

PN	SQ
P1	100
P2	210
P3	80

```
CREATE VIEW V4 (PN, SQ)
        AS SELECT P#, SUM(QTY)
        FROM SP
        GROUP BY P#
```

SP

S#	P#	QTY
S1	P1	100
S1	P2	140
S2	P3	80
S2	P2	70

```
DELETE FROM V4   ✖
       WHERE PN=‘p2’
```

Summarized inserting into view by user

A user can not insert data into view with a single defining table if:

- ❑ Having [WITH CHECK OPTION] and conflict with the constraints.
- ❑ Violation of the UNIQUENESS constraint of primary key.
- ❑ Violation of the NOT NULL constraint

Conclusion in Practical

- **A view with a single defining table is updatable if:**
  - (1) the view attributes contain the primary key of the base relation
  - (2) All the other attributes of base table do not have the NOT NULL constraint or has the default values
  - (3) View query does not have Distinct in the select.
  - (4) View query does not have group by or having.

- Views defined on multiple tables using joins are generally not updatable.
- Views defined using grouping and aggregate functions are not updatable.

Theory:
Update View of Multiple Table

Multiple Table

- As practically view of multiple base tables is not updatable, but when is it theoretically acceptable?
  - Cartesian Product ×
  - Join on two primary keys PK–PK
  - Join on primary and foreign keys PK–FK
  - Join on two foreign keys which are referenced to primary key of another table FK–FK
  - Join on two non–key columns of two tables without any relationship NK–NK
  - Union
  - Intersect
  - Except

Multiple Table Example

V5

STID	STNAME	STLEV	STMJR	STDEID
777	st7	bs	phys	d11
888	st8	ms	math	d12
444	st4	bs	comp	d14
⋮	⋮	⋮	⋮	⋮

```
CREATE VIEW V5
          AS SELECT   *
          FROM ST1  NATURAL JOIN  ST2
```

ST1

STID	STNAME	STLEV
777	st7	bs
888	st8	ms
444	st4	bs
⋮	⋮	⋮

ST2

STID	STMJR	STDEID
777	phys	d11
888	math	d12
444	comp	d14
⋮	⋮	⋮

Multiple Table PK–PK

```
INSERT INTO V5
          VALUES (‘999’, ‘St9’, ‘chem’, ‘bs’, ‘D15’)
```

```
INSERT INTO ST1
          VALUES (‘999’, ‘St9’, ‘bs’)

INSERT INTO ST2
          VALUES (‘999’, ‘chem’, ‘D15’)
```

Multiple Table PK–FK

STT

STID	STNAME	STLEV	STMJR	STD
777	st7	bs	phys	d11
888	st8	ms	math	d12
444	st4	bs	comp	d14
⋮	⋮	⋮	⋮	⋮

STCOT

STID	COURSE	GRADE
777	40280	19
888	40567	20
444	40232	15
⋮	⋮	⋮

Multiple Table PK–FK

```
CREATE VIEW V6
        AS SELECT STT.STID, STT.NAME, STCOT.COURSE,STCOT.GRADE
        FROM STT JOIN STCOT


INSERT INTO V6
        VALUES (‘9212345’, ‘Amir’, ‘40638’, 15)

INSERT INTO STT
        VALUES (‘9212345’, ‘Amir’, ?, ?, ?)

INSERT INTO STCOT
        VALUES (‘9212345’, ‘40638’, 15)
```

***Insert one row in STCOT (table having foreign key!)**

***If the student is not in table STT then it will be inserted.**

Multiple Table PK-FK

```
CREATE VIEW V6
        AS SELECT STT.STID, STT.NAME, STCOT.COURSE,STCOT.GRADE
        FROM STT JOIN STCOT
```

```
Delete from V6
        where STID=‘9212345’ and NAME= ‘Amir’ and STCOT= ‘40638’ and GRADE=15)
```

Delete from STCOT
What about STT? Affect on other tables and view?

Union

Create view v7 as select * from T1 union select * from T2

- ❑ Insert row: into both or one of T1 or T2.
- ❑ Delete row: delete from both T1 and T2.
- ❑ Update row: update both in T1 and T2.

Intersect

Create view v8 as select * from T1 intersect select * from T2

- ❑ Insert row: insert into both T1 and T2.
- ❑ Delete row: delete from T1 or T2.
- ❑ Update row: update both in T1 and T2.

Except

Create view v9 as select * from T1 except select * from T2

- ❑ Insert row: insert into T1 and check not be in T2.
- ❑ Delete row: delete from T1
- ❑ Update row: update in T1 and check not be in T2.

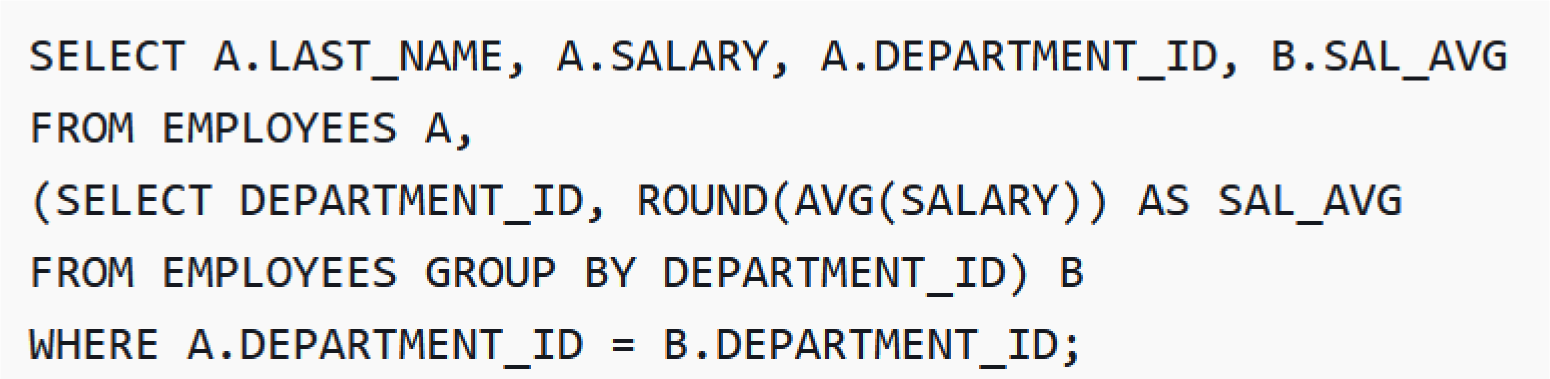
In-line View

Inline View

- It is also possible to define a view table in the FROM clause of an SQL query. This is known as an in-line view. In this case, the view is defined within the query itself.
- Inline views refer to a SELECT statement located in the FROM clause of secondary SELECT statement. Inline views can help make complex queries simpler by removing compound calculations or eliminating join operations while condensing several separate queries into a single simplified query.

Inline View

- PostgreSQL semantics may refer to inline views as Subselect or as Subquery
- ERROR: subquery in FROM must have an alias. This is because in PostgreSQL the use of aliases is mandatory. The following example uses B as an alias.

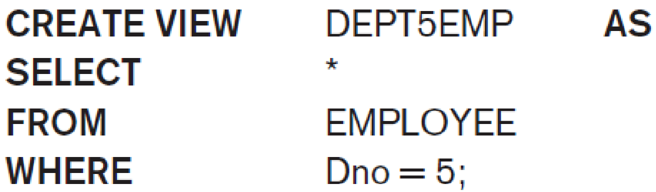


```
SELECT A.LAST_NAME, A.SALARY, A.DEPARTMENT_ID, B.SAL_AVG
FROM EMPLOYEES A,
(SELECT DEPARTMENT_ID, ROUND(AVG(SALARY)) AS SAL_AVG
FROM EMPLOYEES GROUP BY DEPARTMENT_ID) B
WHERE A.DEPARTMENT_ID = B.DEPARTMENT_ID;
```

Authorization Mechanisms with View

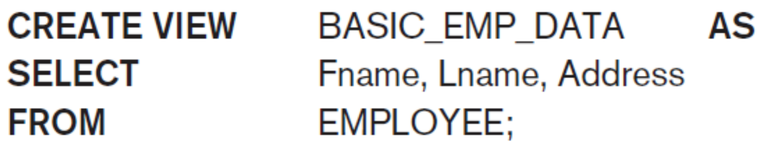
Views as Authorization Mechanisms

- Creating an appropriate view and granting certain users access to the view and not the base tables, they would be restricted to retrieving only the data specified in the view.
  - Access to specific rows



```
CREATE VIEW     DEPT5EMP     AS
SELECT          *
FROM            EMPLOYEE
WHERE           Dno = 5;
```

  - Access to specific columns



```
CREATE VIEW     BASIC_EMP_DATA     AS
SELECT          Fname, Lname, Address
FROM            EMPLOYEE;
```

Conclusion

- Advantages:
  - Simplify the specification of certain queries.
  - Used as a security and authorization mechanism (for columns & rows)
    - Data sharing
    - Hidden Data
  - Data Independence (Next Topic!)
  - Good for data mining and reporting

Conclusion

- Disadvantages:
  - Not good when system is single user!
  - Not good when user needs to run updatable commands.
  - Overhead for converting query to base table queries