



Chapter 4: Intermediate SQL

Database System Concepts, 6th Ed.

©Silberschatz, Korth and Sudarshan

See www.db-book.com for conditions on re-use



Chapter 4: Intermediate SQL

- Join Expressions
- Views
- Transactions
- Integrity Constraints
- SQL Data Types and Schemas
- Authorization



Joined Relations

- **基本语义:** **Join operations** take two relations and return as a result another relation.
 - A join operation is a Cartesian product which requires that tuples in the two relations match (under some condition). It also specifies the attributes that are present in the result of the join
- **用途:** The join operations are typically used as subquery expressions in the **from** clause



Join operations – Example

■ Relation *course*

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

■ Relation *prereq*

<i>course_id</i>	<i>prereq_id</i>
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

■ Observe that

prereq information is missing for CS-315 and
course information is missing for CS-347



Outer Join

- **扩展目的**: An extension of the join operation that avoids loss of information.
- **基本语义**: Computes the join and then adds tuples from one relation that does not match tuples in the other relation to the result of the join.
 - Uses *null* values.



Left Outer Join

- *course* **natural left outer join** *prereq*

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

<i>course_id</i>	<i>prereq_id</i>
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>	<i>prere_id</i>
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	<i>null</i>



Right Outer Join

- *course* **natural right outer join** *prereq*

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

<i>course_id</i>	<i>prereq_id</i>
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>	<i>prere_id</i>
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-347	<i>null</i>	<i>null</i>	<i>null</i>	CS-101



连接运算规则

- **Join operations** take two relations and return as a result another relation.
 - typically used as subquery expressions in the **from** clause
- **结果集依赖于**
 - **Join condition** – defines which tuples in the two relations **match**, and what attributes are present in the result of the join.

<i>Join types</i>	<i>Join Conditions</i>
inner join left outer join right outer join full outer join	natural on <predicate> using (A_1, A_1, \dots, A_n)

- **Join type** – defines how tuples in each relation that do **not match** any tuple in the other relation (based on the join condition) are treated.



Full Outer Join

- *course* **natural full outer join** *prereq*

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

<i>course_id</i>	<i>prereq_id</i>
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>	<i>prere_id</i>
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	<i>null</i>
CS-347	<i>null</i>	<i>null</i>	<i>null</i>	CS-101



Joined Relations – Examples

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

- **course inner join prereq on**
course.course_id = prereq.course_id

<i>course_id</i>	<i>prereq_id</i>
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>	<i>prereq_id</i>	<i>course_id</i>
BIO-301	Genetics	Biology	4	BIO-101	BIO-301
CS-190	Game Design	Comp. Sci.	4	CS-101	CS-190

- What is the difference between the above, and a natural join?

- **course left outer join prereq on**
course.course_id = prereq.course_id

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>	<i>prereq_id</i>	<i>course_id</i>
BIO-301	Genetics	Biology	4	BIO-101	BIO-301
CS-190	Game Design	Comp. Sci.	4	CS-101	CS-190
CS-315	Robotics	Comp. Sci.	3	<i>null</i>	<i>null</i>



Joined Relations – Examples

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

- ***course* natural right outer join *prereq***

<i>course_id</i>	<i>prereq_id</i>
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

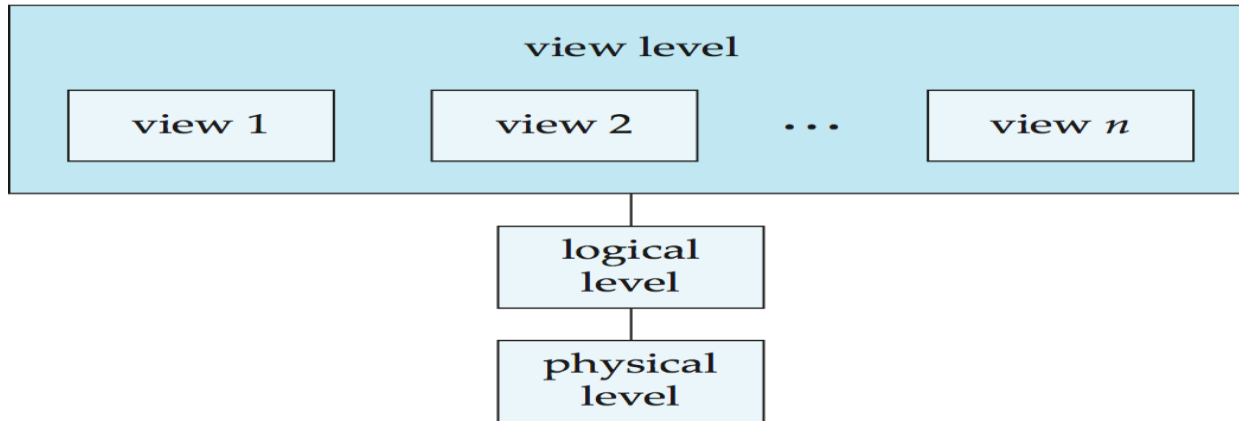
<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>	<i>prere_id</i>
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-347	<i>null</i>	<i>null</i>	<i>null</i>	CS-101

- ***course* full outer join *prereq* using (*course_id*)**

<i>course_id</i>	<i>title</i>	<i>dept_name</i>	<i>credits</i>	<i>prereq_id</i>
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	<i>null</i>
CS-347	<i>null</i>	<i>null</i>	<i>null</i>	CS-101



Levels of Abstraction



- **Physical level:** describes how a record (e.g., customer) is stored.
- **Logical level:** describes data stored in database, and the relationships among the data.
- **View level:** describes only part of the entire database.
The system may provide many views for the same database.



Views

- **针对情况**: In some cases, it is **not** desirable for all users to **see the entire logical model** (that is, all the actual relations stored in the database.)
 - Consider a person who needs to know an instructors name and department, **but not** the salary. This person should see a relation described, in SQL, by

```
select ID, name, dept_name  
from instructor
```

- **解决方法**: A **view** provides a mechanism to **hide** certain data from the view of certain users.
- **定义**: Any relation that is **not of the logical model** but is made **visible to a user** as a “virtual relation” is called a **view**.



View Definition

- **定义语法**: A view is defined using the **create view** statement which has the form

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

where <query expression> is any legal SQL expression. The view name is represented by *v*.

- **效果**: Once a view is defined, the view name can be used to refer to the **virtual relation** that the view generates.
 - View definition is **not the same as** creating a new relation by evaluating the query expression
 - Rather, a view definition causes the saving of an expression; the expression is **substituted** into queries using the view.



Example Views

- A view of instructors without their salary

create view *faculty* **as**

select *ID, name, dept_name*
from *instructor*

- Find all instructors in the Biology department

select *name*
from *faculty*
where *dept_name* = 'Biology'

- Create a view of department salary totals

create view *departments_total_salary*(*dept_name, total_salary*) **as**
select *dept_name, sum (salary)*
from *instructor*
group by *dept_name*;



Views Defined Using Other Views

- **create view** *physics_fall_2009* **as**
 select *course.course_id, sec_id, building, room_number*
 from *course, section*
 where *course.course_id = section.course_id*
 and *course.dept_name = 'Physics'*
 and *section.semester = 'Fall'*
 and *section.year = '2009';*
- **create view** *physics_fall_2009_watson* **as**
 select *course_id, room_number*
 from *physics_fall_2009*
 where *building = 'Watson';*



View Expansion

- Expand use of a view in a query/another view

```
create view physics_fall_2009 as  
  select course.course_id, sec_id, building, room_number  
  from course, section  
  where course.course_id = section.course_id  
        and course.dept_name = 'Physics'  
        and section.semester = 'Fall'  
        and section.year = '2009';
```

```
create view physics_fall_2009_watson as  
  select course_id, room_number  
  from physics_fall_2009  
  where building = 'Watson';
```

```
create view physics_fall_2009_watson as  
  (select course_id, room_number  
  from (select course.course_id, building, room_number  
        from course, section  
        where course.course_id = section.course_id  
              and course.dept_name = 'Physics'  
              and section.semester = 'Fall'  
              and section.year = '2009')  
  where building = 'Watson';
```



视图依赖

- One view may be used in the expression defining another view
- A view relation v_1 is said to *depend directly* on a view relation v_2 if v_2 is used in the expression defining v_1
- A view relation v_1 is said to *depend on* view relation v_2 if either v_1 depends directly to v_2 or there is a path of dependencies from v_1 to v_2
- A view relation v is said to be *recursive* if it depends on itself.



View Expansion过程

- **作用:** A way to define the **meaning** of views defined in terms of other views.
- Let view v_1 be defined by an expression e_1 that may itself contain uses of view relations.
- View expansion of an expression repeats the following replacement step:
 - repeat**
 - Find any view relation v_i in e_1
 - Replace the view relation v_i by the expression defining v_i
 - until** no more view relations are present in e_1
- As long as the view definitions **are not recursive**, this loop will terminate



Update of a View

- Add a new tuple to *faculty* view which we defined earlier

insert into *faculty* values ('30765', 'Green', 'Music');

This insertion must be represented by the insertion of the tuple

('30765', 'Green', 'Music', null)

into the *instructor* relation

create view *faculty* as
select *ID*, *name*, *dept_name*
from *instructor*

<i>instructor</i>	
<u><i>ID</i></u>	
<i>name</i>	
<i>dept_name</i>	
<i>salary</i>	



Some Updates cannot be Translated Uniquely

- **create view** *instructor_info* as
 select *ID, name, building*
 from *instructor, department*
 where *instructor.dept_name= department.dept_name;*
- **insert into** *instructor_info* **values** ('69987', 'White', 'Taylor');
 - ▶ which department, if multiple departments in Taylor?
 - ▶ what if no department is in Taylor?
- Most SQL implementations allow updates only on **simple views**
 - The **from** clause has only one database relation.
 - The **select** clause contains only attribute names of the relation, and does not have any expressions, aggregates, or **distinct** specification.
 - Any attribute not listed in the **select** clause can be set to null
 - The query does not have a **group** by or **having** clause.



And Some Not at All

- **create view** *history_instructors* **as**
 select *
 from *instructor*
 where *dept_name*= 'History';
- What happens if we insert ('25566', 'Brown', 'Biology', 100000) into *history_instructors*?



Materialized Views

- **Materializing a view(物化视图)**: create a physical table containing all the tuples in the result of the query defining the view
- If relations used in the query are updated, the materialized view result becomes out of date
 - Need to **maintain** the view, by updating the view whenever the underlying relations are updated.



Transactions

- Unit of work
- Atomic transaction
 - either fully executed or rolled back as if it never occurred
- Isolation from concurrent transactions
- Transactions begin implicitly
 - Ended by **commit work** or **rollback work**
- But default on most databases: each SQL statement commits automatically
 - Can turn off auto commit for a session (e.g. using API)
 - In SQL:1999, can use: **begin atomic end**
 - ▶ Not supported on most databases



Integrity Constraints

- Integrity constraints 是指数据库实例必须满足的条件.
 - A checking account must have a balance greater than \$10,000.00
 - A salary of a bank employee must be at least \$4.00 an hour
 - A customer must have a (non-null) phone number



Integrity Constraints on a Single Relation

- **not null**
- **primary key**
- **unique**
- **check** (P), where P is a predicate



Not Null and Unique Constraints

■ not null

- Declare *name* and *budget* to be **not null**

name **varchar(20) not null**

budget **numeric(12,2) not null**

■ unique (A_1, A_2, \dots, A_m)

- The unique specification states that the attributes A_1, A_2, \dots, A_m form a candidate key.
- Candidate keys are permitted to be null (in contrast to primary keys).



The check clause

■ **check** (P)

where P is a predicate

Example: ensure that semester is one of fall, winter, spring or summer:

```
create table section (  
    course_id varchar (8),  
    sec_id varchar (8),  
    semester varchar (6),  
    year numeric (4,0),  
    building varchar (15),  
    room_number varchar (7),  
    time_slot id varchar (4),  
    primary key (course_id, sec_id, semester, year),  
    check (semester in ('Fall', 'Winter', 'Spring', 'Summer'))  
);
```



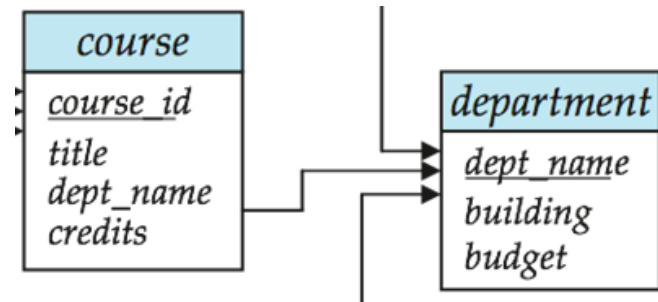
Referential Integrity

- Ensures that a value that appears in one relation for a given set of attributes also appears for a certain set of attributes in another relation.
 - Example: If “Biology” is a department name appearing in one of the tuples in the *instructor* relation, then there exists a tuple in the *department* relation for “Biology”.
- 外键引用完整性: Let A be a set of attributes. Let R and S be two relations that contain attributes A and where A is the primary key of S. A is said to be a **foreign key** of R if for any values of A appearing in R these values also appear in S.



Cascading Actions in Referential Integrity

- **create table** *course* (
 course_id **char**(5) **primary key**,
 title **varchar**(20),
 dept_name **varchar**(20) **references** *department*
)
- **create table** *course* (
 ...
 dept_name **varchar**(20),
 foreign key (*dept_name*) **references** *department*
 on delete cascade
 on update cascade,
 ...
)
- alternative actions to cascade: **set null, set default**





Integrity Constraint Violation During Transactions

■ E.g.

```
create table person (  
    ID char(10),  
    name char(40),  
    mother char(10),  
    father char(10),  
    primary key ID,  
    foreign key father references person,  
    foreign key mother references person)
```

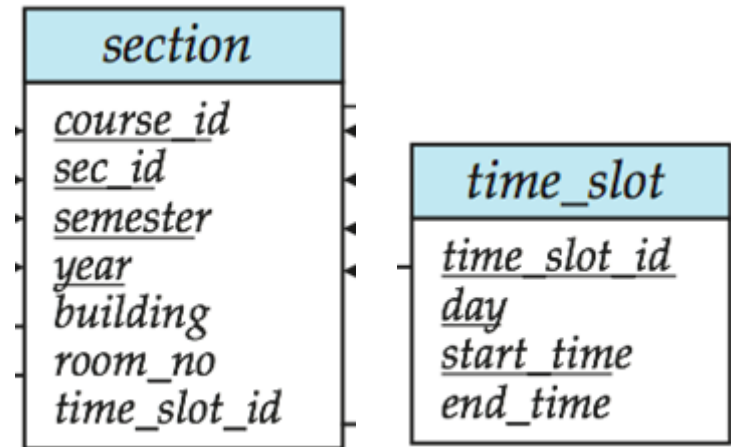
- How to insert a tuple without causing constraint violation ?
 - insert father and mother of a person before inserting person
 - OR, set father and mother to null initially, update after inserting all persons
 - ▶ (not possible if father and mother attributes declared to be **not null**)
 - OR defer constraint checking



Complex Check Clauses

- **check** (*time_slot_id* in (**select** *time_slot_id* from *time_slot*))

- why not use a foreign key here?



- Unfortunately: subquery in check clause not supported by pretty much any database

- Alternative: triggers (later)

- **create assertion** <assertion-name> **check** <predicate>;

- Also not supported by anyone



Built-in Data Types in SQL

- **date**: Dates, containing a (4 digit) year, month and date
 - Example: **date** '2005-7-27'
- **time**: Time of day, in hours, minutes and seconds.
 - Example: **time** '09:00:30' **time** '09:00:30.75'
- **timestamp**: date plus time of day
 - Example: **timestamp** '2005-7-27 09:00:30.75'
- **interval**: period of time
 - Example: **interval** '1' day
 - Subtracting a date/time/timestamp value from another gives an interval value
 - Interval values can be added to date/time/timestamp values



Index Creation

- **create table** *student*
(*ID* **varchar** (5),
name **varchar** (20) **not null**,
dept_name **varchar** (20),
tot_cred **numeric** (3,0) **default** 0,
primary key (*ID*))
- **create index** *studentID_index* **on** *student*(*ID*)
- Indices are data structures used to speed up access to records with specified values for index attributes
 - e.g. **select** *
 from *student*
 where *ID* = '12345'

can be executed by using the index to find the required record, without looking at all records of *student*

More on indices in Chapter 11



User-Defined Types

- **create type** construct in SQL creates user-defined type

create type *Dollars* as numeric (12,2) final

- **create table** *department*
(*dept_name* **varchar** (20),
building **varchar** (15),
budget *Dollars*);



Domains

- **create domain** construct in SQL-92 creates user-defined domain types

```
create domain person_name char(20) not null
```

- Types and domains are similar. Domains can have constraints, such as **not null**, specified on them.
- **create domain** *degree_level* **varchar**(10)
constraint *degree_level_test*
check (**value in** ('Bachelors', 'Masters', 'Doctorate'));



Large-Object Types

- Large objects (photos, videos, CAD files, etc.) are stored as a *large object*.
 - **blob**: binary large object -- object is a large collection of uninterpreted binary data (whose interpretation is left to an application outside of the database system)
 - **clob**: character large object -- object is a large collection of character data
 - When a query returns a large object, a pointer is returned rather than the large object itself.



Authorization

Forms of authorization on parts of the database:

- **Read** - allows reading, but not modification of data.
- **Insert** - allows insertion of new data, but not modification of existing data.
- **Update** - allows modification, but not deletion of data.
- **Delete** - allows deletion of data.

Forms of authorization to modify the database schema

- **Index** - allows creation and deletion of indices.
- **Resources** - allows creation of new relations.
- **Alteration** - allows addition or deletion of attributes in a relation.
- **Drop** - allows deletion of relations.



Authorization Specification in SQL

- The **grant** statement is used to confer authorization
 - grant** <privilege list>
on <relation name or view name> **to** <user list>
 - <user list> is:
 - ▶ a user-id
 - ▶ **public**, which allows all valid users the privilege granted
 - ▶ A role (more on this later)
- 注意以下几点
 - Granting a privilege on a **view** does **not imply** granting any privileges on the **underlying relations**.
 - The grantor of the privilege must already hold the privilege on the specified item (or be the database administrator).



Privileges in SQL

- **select**: allows read access to relation, or the ability to query using the view
 - Example: grant users U_1 , U_2 , and U_3 **select** authorization on the *instructor* relation:
grant select on instructor to U_1 , U_2 , U_3
- **insert**: the ability to insert tuples
- **update**: the ability to update using the SQL update statement
- **delete**: the ability to delete tuples.
- **all privileges**: used as a short form for all the allowable privileges



Revoking Authorization in SQL

- The **revoke** statement is used to revoke authorization.

revoke <privilege list>

on <relation name or view name> **from** <user list>

- Example:

revoke select on *branch* **from** U_1, U_2, U_3

- 注意以下几点

- <privilege-list> may be **all** to revoke all privileges the revokee may hold.
- If <revokee-list> includes **public**, all users lose the privilege except those granted it explicitly.
- If the **same privilege** was granted twice to the same user by **different grantees**, the user may retain the privilege after the revocation.
- All privileges that depend on the privilege being revoked are also revoked.



Roles

■ 语句

- **create role** instructor;
- **grant** *instructor* **to** Amit;

■ Privileges can be granted to roles:

- **grant select on** *takes* **to** *instructor*;

■ Roles can be granted to users, as well as to other roles

- **create role** *teaching_assistant*
- **grant** *teaching_assistant* **to** *instructor*;
 - ▶ *Instructor* inherits all privileges of *teaching_assistant*

■ Chain of roles

- **create role** *dean*;
- **grant** *instructor* **to** *dean*;
- **grant** *dean* **to** Satoshi;



Authorization on Views

- **create view** *geo_instructor* **as**
(**select** *
from *instructor*
where *dept_name* = 'Geology');
- **grant select on** *geo_instructor* **to** *geo_staff*
- Suppose that a *geo_staff* member issues
 - **select** *
from *geo_instructor*,
- What if
 - *geo_staff* does not have permissions on *instructor*?
 - creator of view did not have some permissions on *instructor*?



Other Authorization Features

- **references** privilege to create foreign key
 - **grant reference** (*dept_name*) **on** *department* **to** Mariano;
 - why is this required?
- transfer of privileges
 - **grant select on** *department* **to** Amit **with grant option**;
 - **revoke select on** *department* **from** Amit, Satoshi **cascade**;
 - **revoke select on** *department* **from** Amit, Satoshi **restrict**;
- Etc. read Section 4.6 for more details we have omitted here.



End of Chapter 4

Database System Concepts, 6th Ed.

©Silberschatz, Korth and Sudarshan

See www.db-book.com for conditions on re-use