Chapter 4: Intermediate SQL

Database System Concepts, 6th Ed.

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Chapter 4: Intermediate SQL

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

Joined Relations

- **Join operations** take two relations and return as a result another relation.
- A join operation is a Cartesian product followed by Selection.
- The join operations are typically used as subquery expressions in the **from** clause

- Relation *course*

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

- Relation *prereq*

course_id	*prereq_id*
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

course ⋈ *prereq*

course_id	*title*	*dept_name*	*credits*	*prere_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101

- Observe that

  prereq information is missing for CS-315 and

  course information is missing for CS-437

Figure 4.01: The Student Relation

ID	*name*	*dept_name*	*tot_cred*
00128	Zhang	Comp. Sci.	102
12345	Shankar	Comp. Sci.	32
19991	Brandt	History	80
23121	Chavez	Finance	110
44553	Peltier	Physics	56
45678	Levy	Physics	46
54321	Williams	Comp. Sci.	54
55739	Sanchez	Music	38
70557	Snow	Physics	0
76543	Brown	Comp. Sci.	58
76653	Aoi	Elec. Eng.	60
98765	Bourikas	Elec. Eng.	98
98988	Tanaka	Biology	120

Figure 4.02: The Takes relation

ID	*course_id*	*sec_id*	*semester*	*year*	*grade*
00128	CS-101	1	Fall	2009	A
00128	CS-347	1	Fall	2009	A-
12345	CS-101	1	Fall	2009	C
12345	CS-190	2	Spring	2009	A
12345	CS-315	1	Spring	2010	A
12345	CS-347	1	Fall	2009	A
19991	HIS-351	1	Spring	2010	B
23121	FIN-201	1	Spring	2010	C+
44553	PHY-101	1	Fall	2009	B-
45678	CS-101	1	Fall	2009	F
45678	CS-101	1	Spring	2010	B+
45678	CS-319	1	Spring	2010	B
54321	CS-101	1	Fall	2009	A-
54321	CS-190	2	Spring	2009	B+
55739	MU-199	1	Spring	2010	A-
76543	CS-101	1	Fall	2009	A
76543	CS-319	2	Spring	2010	A
76653	EE-181	1	Spring	2009	C
98765	CS-101	1	Fall	2009	C-
98765	CS-315	1	Spring	2010	B
98988	BIO-101	1	Summer	2009	A
98988	BIO-301	1	Summer	2010	*null*

Figure 4.03: The result of student join takes on student.ID = takes.ID with second occurrence pf ID omitted

ID	*name*	*dept_name*	*tot_cred*	*course_id*	*sec_id*	*semester*	*year*	*grade*
00128	Zhang	Comp. Sci.	102	CS-101	1	Fall	2009	A
00128	Zhang	Comp. Sci.	102	CS-347	1	Fall	2009	A-
12345	Shankar	Comp. Sci.	32	CS-101	1	Fall	2009	C
12345	Shankar	Comp. Sci.	32	CS-190	2	Spring	2009	A
12345	Shankar	History	32	CS-315	1	Spring	2010	A
12345	Shankar	Finance	32	CS-347	1	Fall	2009	A
19991	Brandt	Music	80	HIS-351	1	Spring	2010	B
23121	Chavez	Physics	110	FIN-201	1	Spring	2010	C+
44553	Peltier	Physics	56	PHY-101	1	Fall	2009	B-
45678	Levy	Physics	46	CS-101	1	Fall	2009	F
45678	Levy	Physics	46	CS-101	1	Spring	2010	B+
45678	Levy	Physics	46	CS-319	1	Spring	2010	B
54321	Williams	Comp. Sci.	54	CS-101	1	Fall	2009	A-
54321	Williams	Comp. Sci.	54	CS-190	2	Spring	2009	B+
55739	Sanchez	Music	38	MU-199	1	Spring	2010	A-
76543	Brown	Comp. Sci.	58	CS-101	1	Fall	2009	A
76543	Brown	Comp. Sci.	58	CS-319	2	Spring	2010	A
76653	Aoi	Elec. Eng.	60	EE-181	1	Spring	2009	C
98765	Bourikas	Elec. Eng.	98	CS-101	1	Fall	2009	C-
98765	Bourikas	Elec. Eng.	98	CS-315	1	Spring	2010	B
98988	Tanaka	Biology	120	BIO-101	1	Summer	2009	A
98988	Tanaka	Biology	120	BIO-301	1	Summer	2010	*null*

Additional Join Operations

- **Join operations** take two relations and return as a result another relation.
- **Join condition** – defines which tuples in the two relations match, and what attributes are present in the result of the join
  - Natural 이 붙는경우, on <predicate> 이 붙는 경우, using이 붙는경우
- **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.

Join types
inner join
left outer join
right outer join
full outer join

Join Conditions
natural
on <predicate>
using $(A_1, A_1, \ldots, A_n)$

- Outer Join
  - An extension of the join operation that avoids loss of information.
  - Computes the join and then adds tuples form one relation that does not match tuples in the other relation to the result of the join.
  - Uses *null* values.

Left Outer Join

- Relation *course*

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

- Relation *prereq*

course_id	*prereq_id*
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

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

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

Figure 4.04: Result of student natural_left_outer_join takes

ID	*name*	*dept_name*	*tot_cred*	*course_id*	*sec_id*	*semester*	*year*	*grade*
00128	Zhang	Comp. Sci.	102	CS-101	1	Fall	2009	A
00128	Zhang	Comp. Sci.	102	CS-347	1	Fall	2009	A-
12345	Shankar	Comp. Sci.	32	CS-101	1	Fall	2009	C
12345	Shankar	Comp. Sci.	32	CS-190	2	Spring	2009	A
12345	Shankar	History	32	CS-315	1	Spring	2010	A
12345	Shankar	Finance	32	CS-347	1	Fall	2009	A
19991	Brandt	Music	80	HIS-351	1	Spring	2010	B
23121	Chavez	Physics	110	FIN-201	1	Spring	2010	C+
44553	Peltier	Physics	56	PHY-101	1	Fall	2009	B-
45678	Levy	Physics	46	CS-101	1	Fall	2009	F
45678	Levy	Physics	46	CS-101	1	Spring	2010	B+
45678	Levy	Physics	46	CS-319	1	Spring	2010	B
54321	Williams	Comp. Sci.	54	CS-101	1	Fall	2009	A-
54321	Williams	Comp. Sci.	54	CS-190	2	Spring	2009	B+
55739	Sanchez	Music	38	MU-199	1	Spring	2010	A-
70557	Snow	Physics	0	*null*	*null*	*null*	*null*	*null*
76543	Brown	Comp. Sci.	58	CS-101	1	Fall	2009	A
76543	Brown	Comp. Sci.	58	CS-319	2	Spring	2010	A
76653	Aoi	Elec. Eng.	60	EE-181	1	Spring	2009	C
98765	Bourikas	Elec. Eng.	98	CS-101	1	Fall	2009	C-
98765	Bourikas	Elec. Eng.	98	CS-315	1	Spring	2010	B
98988	Tanaka	Biology	120	BIO-101	1	Summer	2009	A
98988	Tanaka	Biology	120	BIO-301	1	Summer	2010	*null*

Right Outer Join

- Relation *course*

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

- Relation *prereq*

course_id	*prereq_id*
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

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

course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-347	*null*	*null*	*null*	CS-101

Figure 4.05:Result of takes natural_right_outer_join student

ID	*course_id*	*sec_id*	*semester*	*year*	*grade*	*name*	*dept_name*	*tot_cred*
00128	CS-101	1	Fall	2009	A	Zhang	Comp. Sci.	102
00128	CS-347	1	Fall	2009	A-	Zhang	Comp. Sci.	102
12345	CS-101	1	Fall	2009	C	Shankar	Comp. Sci.	32
12345	CS-190	2	Spring	2009	A	Shankar	Comp. Sci.	32
12345	CS-315	1	Spring	2010	A	Shankar	History	32
12345	CS-347	1	Fall	2009	A	Shankar	Finance	32
19991	HIS-351	1	Spring	2010	B	Brandt	Music	80
23121	FIN-201	1	Spring	2010	C+	Chavez	Physics	110
44553	PHY-101	1	Fall	2009	B-	Peltier	Physics	56
45678	CS-101	1	Fall	2009	F	Levy	Physics	46
45678	CS-101	1	Spring	2010	B+	Levy	Physics	46
45678	CS-319	1	Spring	2010	B	Levy	Physics	46
54321	CS-101	1	Fall	2009	A-	Williams	Comp. Sci.	54
54321	CS-190	2	Spring	2009	B+	Williams	Comp. Sci.	54
55739	MU-199	1	Spring	2010	A-	Sanchez	Music	38
70557	*null*	*null*	*null*	*null*	*null*	Snow	Physics	0
76543	CS-101	1	Fall	2009	A	Brown	Comp. Sci.	58
76543	CS-319	2	Spring	2010	A	Brown	Comp. Sci.	58
76653	EE-181	1	Spring	2009	C	Aoi	Elec. Eng.	60
98765	CS-101	1	Fall	2009	C-	Bourikas	Elec. Eng.	98
98765	CS-315	1	Spring	2010	B	Bourikas	Elec. Eng.	98
98988	BIO-101	1	Summer	2009	A	Tanaka	Biology	120
98988	BIO-301	1	Summer	2010	*null*	Tanaka	Biology	120

Full Outer Join

- Relation *course*

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

- Relation *prereq*

course_id	*prereq_id*
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

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

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

Joined Relations – on <predicate> 이 붙는 경우

- Relation *course*

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

- Relation *prereq*

course_id	*prereq_id*
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

- *course* **inner join** *prereq*

  on *course.course_id = prereq.course_id*

course_id	*title*	*dept_name*	*credits*	*prereq_id*	*course_id*
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*

course_id	*title*	*dept_name*	*credits*	*prereq_id*	*course_id*
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	*null*	*null*

Joined Relations – natural, using이 붙는 경우

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

course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-347	*null*	*null*	*null*	CS-101

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

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

Views

- 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*

- A **view** provides a mechanism to hide certain data from the view of certain users.
- Any relation that is not of the conceptual model but is made visible to a user as a "virtual relation" is called a **view**.

View Definition

- 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.*

- 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*;

instructor

ID	*name*	*dept_name*	*salary*
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000

Views Defined Using Other Views

- 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
  - 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 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

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';

Figure 2.02: The Course relation

course_id	*title*	*dept_name*	*credits*
BIO-101	Intro. to Biology	Biology	4
BIO-301	Genetics	Biology	4
BIO-399	Computational Biology	Biology	3
CS-101	Intro. to Computer Science	Comp. Sci.	4

Figure 2.06: The Section relation

course_id	*sec_id*	*semester*	*year*	*building*	*room_number*	*time_slot_id*
BIO-101	1	Summer	2009	Painter	514	B
BIO-301	1	Summer	2010	Painter	514	A
CS-101	1	Fall	2009	Packard	101	H
CS-101	1	Spring	2010	Packard	101	F
CS-190	1	Spring	2009	Taylor	3128	E

- View Expansion

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');

Update of a View

- Faculty view on instructor relation

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

- Add a new tuple to *faculty* view

  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

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.

Figure 4.07: Relations instructor and department after insertion of tuples

ID	*name*	*dept_name*	*salary*
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000
69987	White	*null*	*null*

instructor

dept_name	*building*	*budget*
Biology	Watson	90000
Comp. Sci.	Taylor	100000
Elec. Eng.	Taylor	85000
Finance	Painter	120000
History	Painter	50000
Music	Packard	80000
Physics	Watson	70000
null	Taylor	*null*

department

Some view updates are not at all possible for translation to relation

- Instructor (ID, name, department, salary)

- **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

- **Some DBMS allows view relations to be stored**

```
CREATE MATERIALIZED VIEW MV_MY_VIEW
REFRESH FAST START WITH SYSDATE
    NEXT SYSDATE + 1
        AS SELECT * FROM <table_name>;
```

- **Materialized view**: create a physical table containing all the tuples in the result of the query defining the view
- Materialzed view is kept up-to-date
  - 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 guard against accidental damage to the database, by ensuring that authorized changes to the database do not result in a loss of data consistency.
  - 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

SQL Statements for Integrity 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, …, A_m)
  - The attributes *A*1, *A*2, … *A*m form a candidate key.
  - Candidate keys are permitted to be null (in contrast to primary keys)

- **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”.
  - 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.
  - instructor relation의 dept_name는 department relation의 name중에서 값을 가져야 하고 (referential integrity), instructor relation의 dept_name은 foreign key라고 한다

Cascading Actions in Referential Integrity

- **create table** *course* (
  course_id **char**(5) **primary key**,
  title **varchar**(20),
  dept_name **varchar**(20),
  primary key (course_id)
  foreign key (*dept_name*) **references** *department*
  on delete cascade
  on update cascade,
  . . .
)

dept_name	*building*	*budget*
Biology	Watson	90000
Comp. Sci.	Taylor	100000
Elec. Eng.	Taylor	85000
Finance	Painter	120000
History	Painter	50000
Music	Packard	80000
Physics	Watson	70000
null	Painter	*null*

department

- If the first tuple in the department relation is deleted, delete all courses of Biology department
- If the Biology department updated the department name into “Bio Technology” department, update the course tuples of Biology department
- alternative actions to cascade: **set null**, **set default**

Integrity Constraint Violation During Transactions

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
    - set constraints <constraint-list> deferred

Complex Check Clauses and Assertions

- Every section has at least one instructor teaching the section.

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

  - Unfortunately: subquery in check clause not supported by pretty much any DBMS
  - Alternative: triggers (later)

- Assertion is a predicate expressing condition that we wish the database always to satisfy

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

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 and Domains

- **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*);

- **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.

- Attributes having large objects

  book_review clob(10KB)

  image blob(10MB)

  movie blob(2GB)

Authorization

Forms of authorization on data in 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.

Forms of Authorization ➔ Privilege List

Authorization Specification in SQL

- The **grant** statement is used to confer authorization

  grant <privilege list>

  on <relation name or view name>

  to <user list>

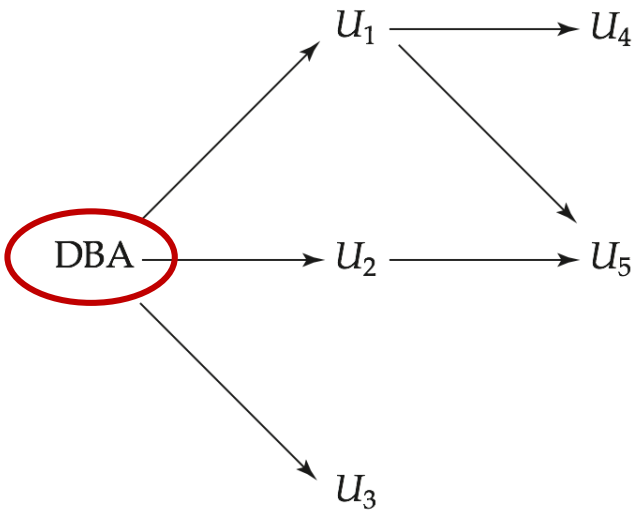
- <user list> is:
  - **user-id**
  - **public**, which allows all valid users the privilege granted
  - **A role** (more on this later)
- Granting a privilege on a view does not imply granting any privileges on the underlying relations.
- The grantor of the privilege must already hold the privilege 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

Figure 4.10: Authorization-grant graph



Revoking Authorization in SQL

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

  revoke <privilege list>

  on <relation name or view name>

  from <user list>

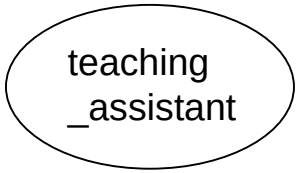
- Example:

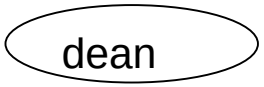
  revoke select on *branch* **from** U_1, U_2, U_3

- <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 (Group rather than Individual)

- **Role = Virtual Group of Persons**
- **create role** instructor_group;
- **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

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000
69987	White	*null*	*null*

instructor

- **Geology학과의 geo_staff이 있다고 하자**
- **create view** *geo_instructor* **as**
  (**select** *
  from *instructor*
  where *dept_name* = 'Geology');
- **Suppose** the creator of *geo_instructor issues*

  grant select on *geo_instructor* **to** *geo_staff*

  geo_staff
- **Suppose** that a *geo_staff* member issues
  - **select** *
    from *geo_instructor*;
- 이경우 geo_staff이 instructor relation에 대해서 query 권한이 없고, geo_instructor view를 만든 사람이 instructor relation에 대해서 권한이 없다면 ➔ geo_staff은 geo_instructor view에 query를 할수 없다.
  - geo_instructor view에 대한 query를 하기 위해서는 instructor에 대해서 query를 해야 하므로

Other Authorization Features

- Authorization of schema modification
  - **grant reference** (*dept_name*) **on** *department* **to** Mariano;
  - Mario는 새로운 relation을 define하면서 attribute를 department relation의 dept_name을 foreign key의 domain으로 선언할수 있다

- Grant grant-privileges vs Revoke grant-privileges
  - **Privilege를 받은 user들이 다른 user들에게 grant privilege를 행사**
    - **grant select on** *department* **to** Amit **with grant option**;
  - **User에게 grant했던 privilege를 revoke하고 다른 user들에게 privilege가 grant되었었다면 cascadingly revoke**
    - **revoke select on** *department* **from** Amit, Satoshi **cascade**;
  - **User에게 grant했던 privilege만를 revoke 하도록 restrict**
    - **revoke select on** *department* **from** Amit, Satoshi **restrict**;

- Etc. read Section 4.6 for more details we have omitted here.