DATABASE SYSTEM PRINCIPLE
– INTERMEDIATE SQL

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OBJECTIVES

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

JOINED RELATIONS

- **Join operations**连接谓词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
- The join operations are typically used as subquery expressions in the **from** clause

JOIN OPERATIONS – EXAMPLE

- 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

- Observe that

  prereq information is missing for CS-315 and

  course information is missing for CS-437

OUTER JOIN外连接

- 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 : preserves tuples only in the relation named before (to the left of) the operation.
- right outer join
- full outer join

LEFT OUTER JOIN

```
select *
from course natural left outer join 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
CS-315	Robotics	Comp. Sci.	3	*null*

RIGHT OUTER JOIN

```
select *
from course natural right outer join 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
CS-347	*null*	*null*	*null*	CS-101

FULL OUTER JOIN

```
select *
from course natural full outer join 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
CS-315	Robotics	Comp. Sci.	3	*null*
CS-347	*null*	*null*	*null*	CS-101

JOINED RELATIONS

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

JOINED RELATIONS

Join types	*Join Conditions*
inner join	**natural**
left outer join	**on** <predicate>
right outer join	**using** $(A_1, A_1, \ldots, A_n)$
full outer join	

JOINED RELATIONS – EXAMPLES

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

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

JOINED RELATIONS – EXAMPLES

- 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*	*prere_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 – EXAMPLES

- *course* **natural right outer join** *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
CS-347	*null*	*null*	*null*	CS-101

JOINED RELATIONS – EXAMPLES

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

course_id	*title*	*dept_name*	*credits*	*prere_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

OUTER JOIN: ON V.S. WHERE

- select *

from student left outer join takes on student. ID = takes. ID

- select *

from student left outer join takes on true

- where student. ID = takes. ID

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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*

VIEWS

- 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

- 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’

EXAMPLE VIEWS

- 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';

VIEWS DEFINED USING OTHER VIEWS

- **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_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';
```

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

- 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

- A view of instructors without their salary

  create view *faculty* **as**

  select *ID*, *name*, *dept_name*

  from *instructor*

UPDATE OF A VIEW (CONT.,)

- 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

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?

SOME UPDATES CANNOT BE TRANSLATED UNIQUELY

- 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**.**

UPDATE OF A VIEW – 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物化视图

- **Materializing a view**
  - 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
  - Materialized view maintenance 物化视图维护

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TRANSACTIONS事务

- Unit of work
- Atomic transaction: either fully executed or rolled back as if it never occurred
- Isolation from concurrent transactions
- Transactions begin implicitly隐式地: 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

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INTEGRITY CONSTRAINTS完整性约束

- 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

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** ($A_1, A_2, \ldots, A_m$)
  - The unique specification states that the attributes *A*1, *A*2, … *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参照完整性

- 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.

CASCADING级联 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*)

INTEGRITY CONSTRAINT VIOLATION DURING TRANSACTIONS (CONT.,)

- 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延迟 constraint checking: initially deferred

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 触发器
- **create assertion** <assertion-name> **check** <predicate>;
  - **assertion** 断言
  - Also not supported by anyone

COMPLEX CHECK CLAUSES – ASSERTION: CASE

```
create assertion credits_earned_constraint check
(not exists (select ID
             from student
             where tot_cred <> (select sum(credits)
             from takes natural join course
             where student.ID= takes.ID
                   and grade is not null and grade<> 'F' )
```

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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'

BUILT-IN DATA TYPES IN SQL

- Functions of Time
  - current_date
  - current_time
  - localtime
  - lurrent_timestamp
  - localtimestamp

BUILT-IN DATA TYPES IN SQL

- **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

DEFAULT VALUES

```
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));
```

```
insert into student(ID, name, dept_name)
        values ('12789', 'Newman', 'Comp. Sci.');
```

INDEX CREATION创建索引

- **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*)

INDEX CREATION创建索引 （CONT.,）

- 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*

LARGE-OBJECT TYPES

- Large objects (photos, videos, CAD files, etc.) are stored as a large object
  - clob: character data
  - blob: binary data
- locator for a large object定位器

book_review **clob**(10KB)
image **blob**(10MB)
movie **blob**(2GB)

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);

USER-DEFINED TYPES

- create type
- drop type
- alter type

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'));

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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.

AUTHORIZATION

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授予 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)

AUTHORIZATION SPECIFICATION IN SQL (CONT.,)

- 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收回 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

REVOKING AUTHORIZATION IN SQL (CONT.,)

- <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角色

- **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*

ROLES (CONT.,)

- 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*

AUTHORIZATION ON VIEWS

- 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**;

SUMMARY

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Q&A?

THANKS !

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