Chapter 4: Intermediate SQL

Outline

Joined Relation
SQL Data Types and Schemas
Integrity Constraints
Views
Indexes
Transactions
Authorization

Joined Relations

Join operations take two relations and return as a result another relation.

Join 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.

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

Join Conditions	
natural	自然连接
on < predicate>	条件连接
using $(A_1, A_1, \ldots, A_n)$	等值连接

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

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

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*

Right Outer Join

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

select count(*)
from *course* **natural right outer join** *prereq*
where *prereq_id* is null;

Full Outer Join

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 – Examples

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 – Examples

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

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

date, time functions:

current_date(), current_time()

year(x), month(x), day(x), hour(x), minute(x), second(x)

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)

MySQL BLOB datatypes:

- **TinyBlob** : 0 ~ 255 bytes.
- **Blob**: 0 ~ 64K bytes.
- **MediumBlob** : 0 ~ 16M bytes.
- **LargeBlob** : 0 ~ 4G bytes.

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.

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

foreign key

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, …, A_m)

The unique specification states that the attributes *A*1, *A*2, … *A*m form a super key (× 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".

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, restricted**

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 ?

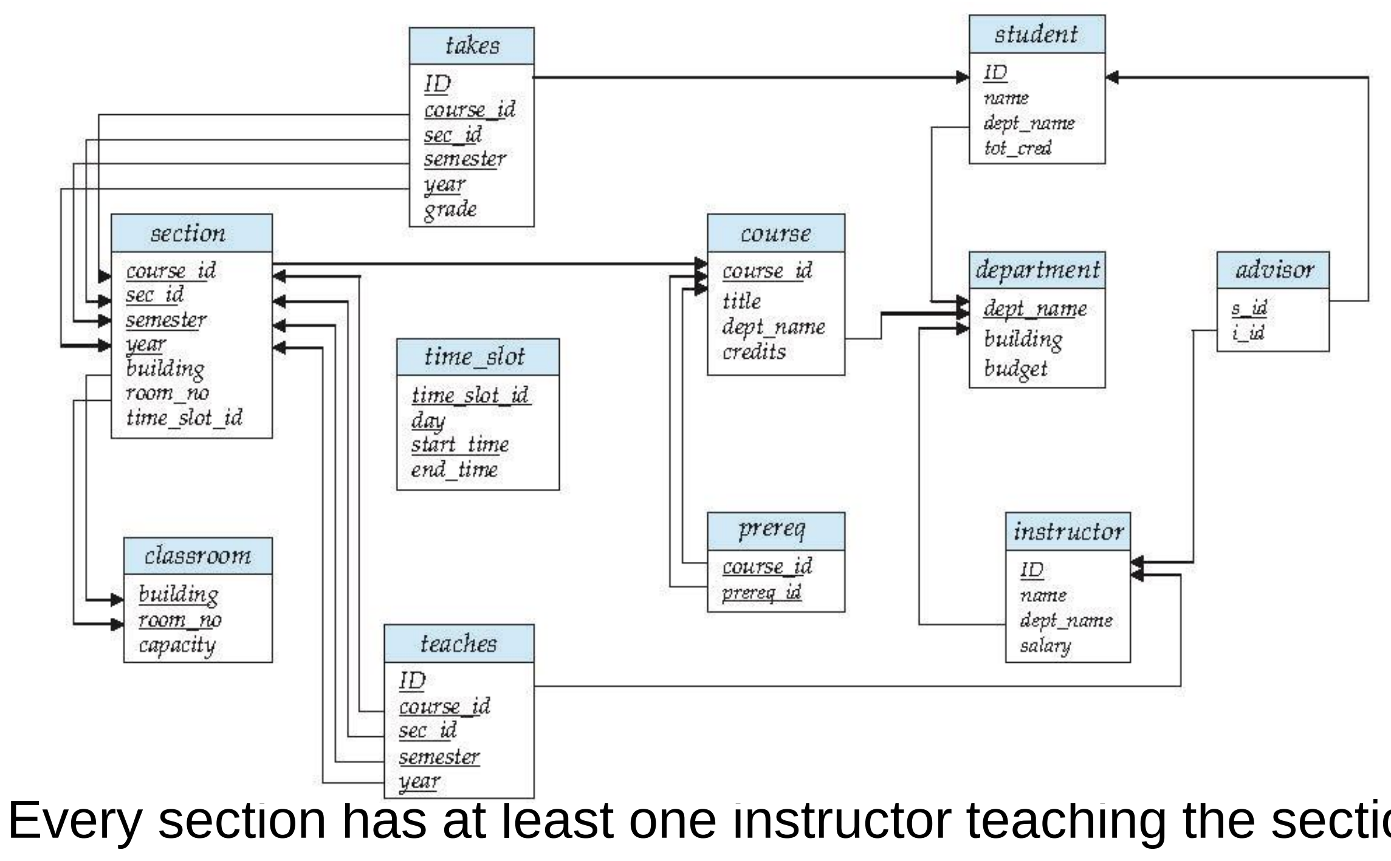
insert father and mother of a person before inserting person

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 to transaction end.

Complex Check Clauses

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



Every section has at least one instructor teaching the section.

check ((*course_id, sec_id, semester, year)* **in**
(**select** *course_id, sec_id, semester, year* **from** *teaches*))

Complex Check Clauses

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

Alternative: triggers

assertion

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

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'*))

Views

A **view** provides a mechanism to hide certain data from the view of certain users.

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
```

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 the names of 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 another view

```
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';
```

View Expansion

Expand use of a view in a query:

```
select course_id, room_number
from physics_fall_2009
where building= 'Watson';
→
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';
→
select course_id, 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'
            and building= 'Watson';
```

Update of a View

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

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

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

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

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?

Most SQL implementations allow updates only on simple views(updatable 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.

*Materialized Views

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.

Example:

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

select *dept_name*
from *departments_total_salary*
where total_salary > (select avg(total_salary) from *departments_total_salary);*

* View and Logical Data Indepencence

If relation **S(a, b, c)** is split into two sub relations **S1(a,b)** and **S2(a,c)**
How to realize the logical data independence?

1) create table S1 …;
   create table S2 …;
2) insert into S1 select a, b from S;
   insert into S2 select a, c from S;
3) drop table S;
4) create view S(a,b,c) as select a,b,c from S1 natural join S2;

select * from S where … → select * from S1 natural join S2 where …

insert into S values (1 ,2,3) → insert into S1 values (1, 2);
                                insert into S2 values (1 ,3);

Indexes

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*

Transactions

Unit of work (NONE or ALL)

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 MySQL:
- >**SET AUTOCOMMIT=0;**
- In SQL:1999, can use: **begin atomic** …. **end**
  - Not supported on most databases

Transactions

Transaction example :

SET AUTOCOMMIT=0;
UPDATE account **SET** balance=balance -100 **WHERE** ano='1001';
UPDATE account **SET** balance=balance+100 **WHERE** ano='1002';
COMMIT;

UPDATE account **SET** balance=balance -200 **WHERE** ano='1003';
UPDATE account **SET** balance=balance+200 **WHERE** ano='1004';
COMMIT;

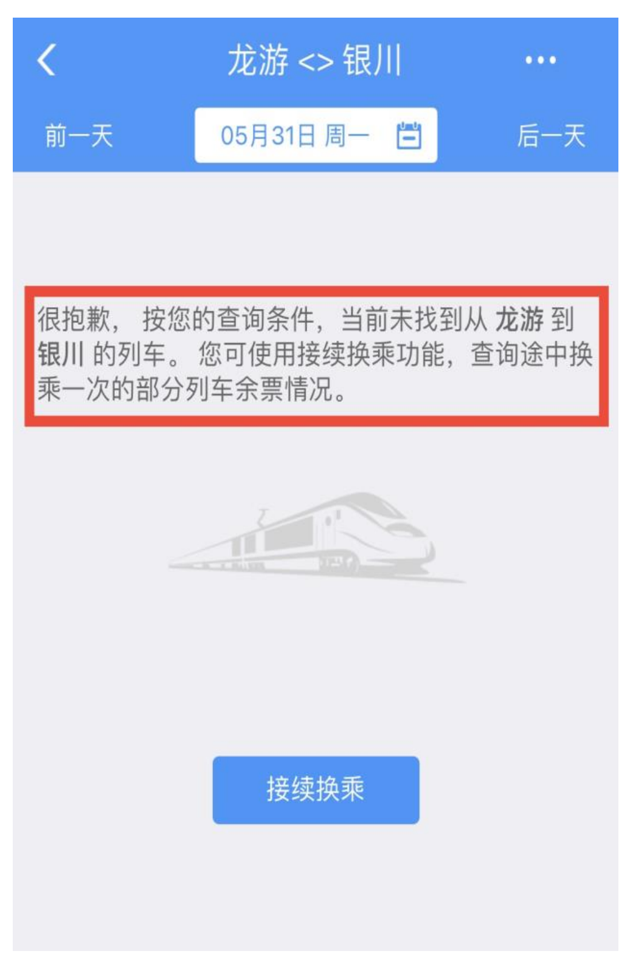
UPDATE account **SET** balance=balance+balance*2.5%;
COMMIT;

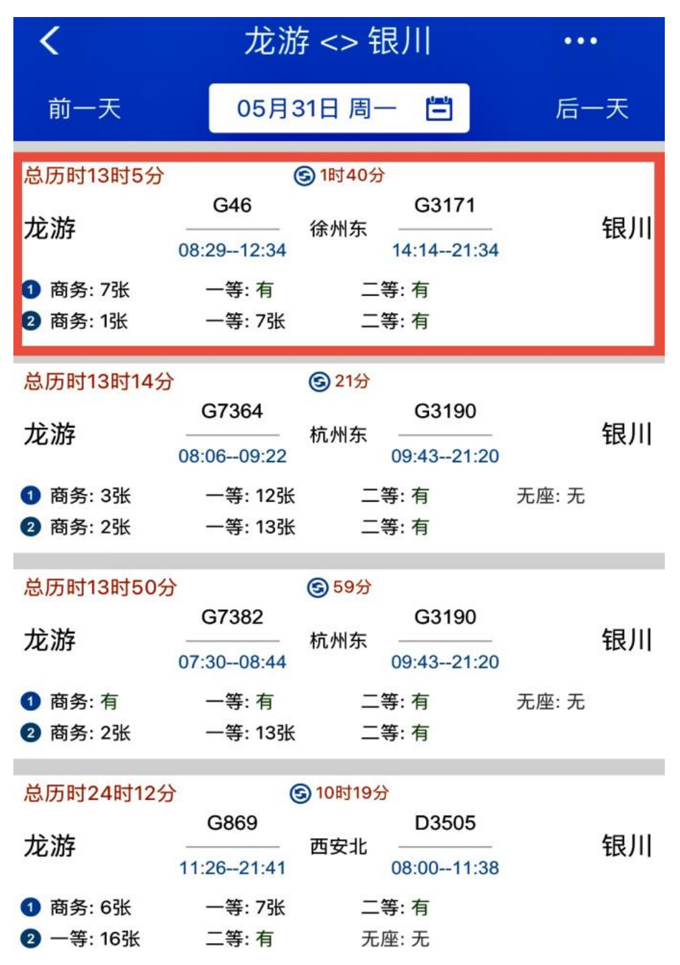
Transaction Examples

中国铁路12306
12306 CHINA RAILWAY

Transaction Boundaries

Booking one ticket vs multiple tickets?


龙游 <> 银川
前一天 05月31日 周一 后一天
很抱歉，按您的查询条件，当前未找到从 龙游 到 银川 的列车。您可使用接续换乘功能，查询途中换乘一次的部分列车余票情况。
接续换乘

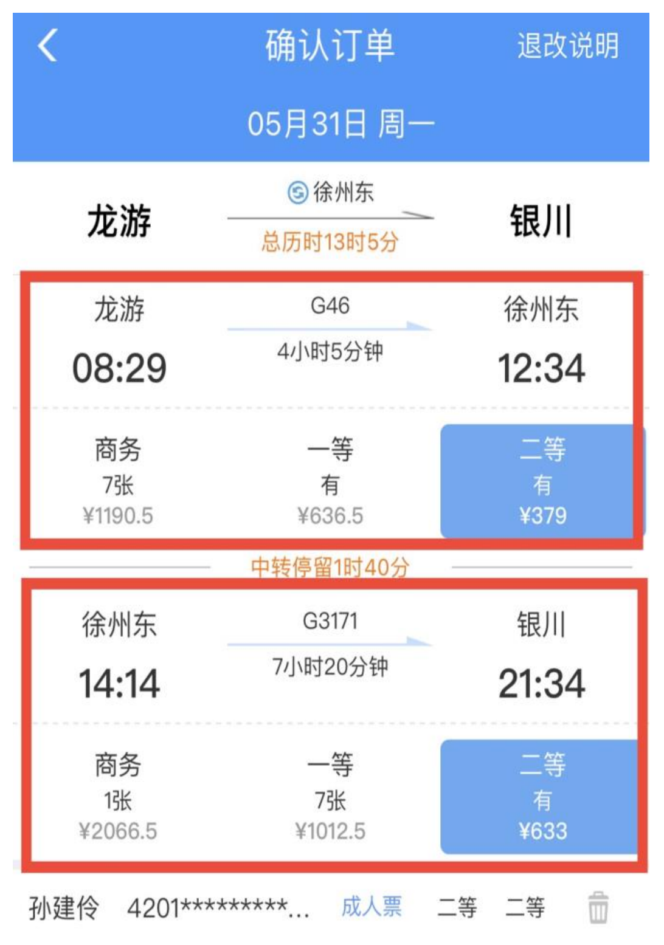

龙游 <> 银川
前一天 05月31日 周一 后一天

总历时13时5分 1时40分
龙游 G46 08:29--12:34 徐州东 G3171 14:14--21:34 银川
1 商务: 7张 一等: 有 二等: 有
2 商务: 1张 一等: 7张 二等: 有

总历时13时14分 21分
龙游 G7364 08:06--09:22 杭州东 G3190 09:43--21:20 银川
1 商务: 3张 一等: 12张 二等: 有 无座: 无
2 商务: 2张 一等: 13张 二等: 有

总历时13时50分 59分
龙游 G7382 07:30--08:44 杭州东 G3190 09:43--21:20 银川
1 商务: 有 一等: 有 二等: 有 无座: 无
2 商务: 2张 一等: 13张 二等: 有

总历时24时12分 10时19分
龙游 G869 11:26--21:41 西安北 D3505 08:00--11:38 银川
1 商务: 6张 一等: 7张 二等: 有
2 一等: 16张 二等: 有 无座: 无

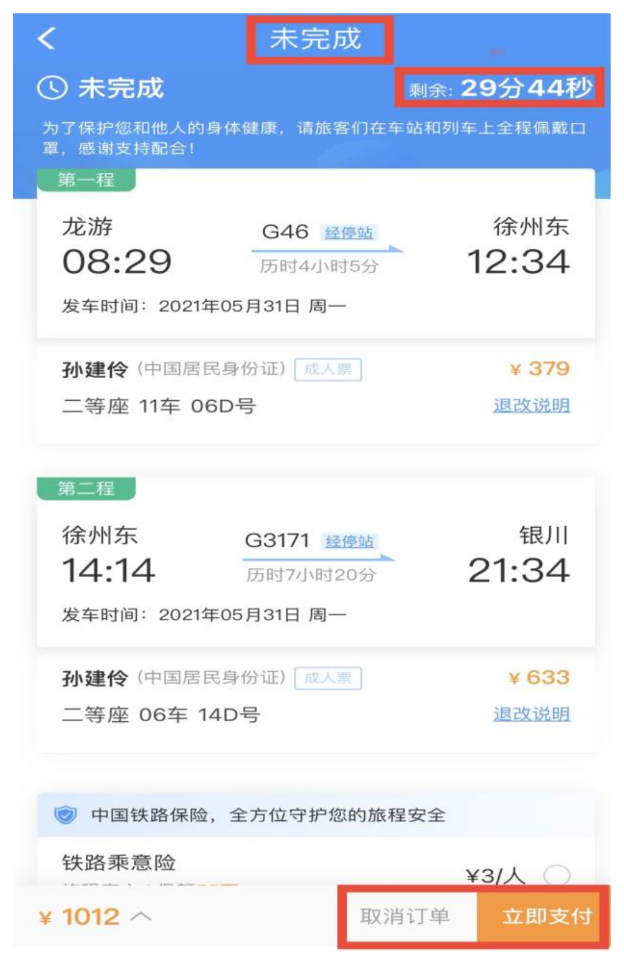

确认订单 退改说明
05月31日 周一
龙游 徐州东 总历时13时5分 银川
龙游 G46 徐州东
08:29 4小时5分钟 12:34
商务 7张 ¥1190.5 | 一等 有 ¥636.5 | 二等 有 ¥379
中转停留1时40分
徐州东 G3171 银川
14:14 7小时20分钟 21:34
商务 1张 ¥2066.5 | 一等 7张 ¥1012.5 | 二等 有 ¥633
孙建伶 4201*********... 成人票 二等 二等

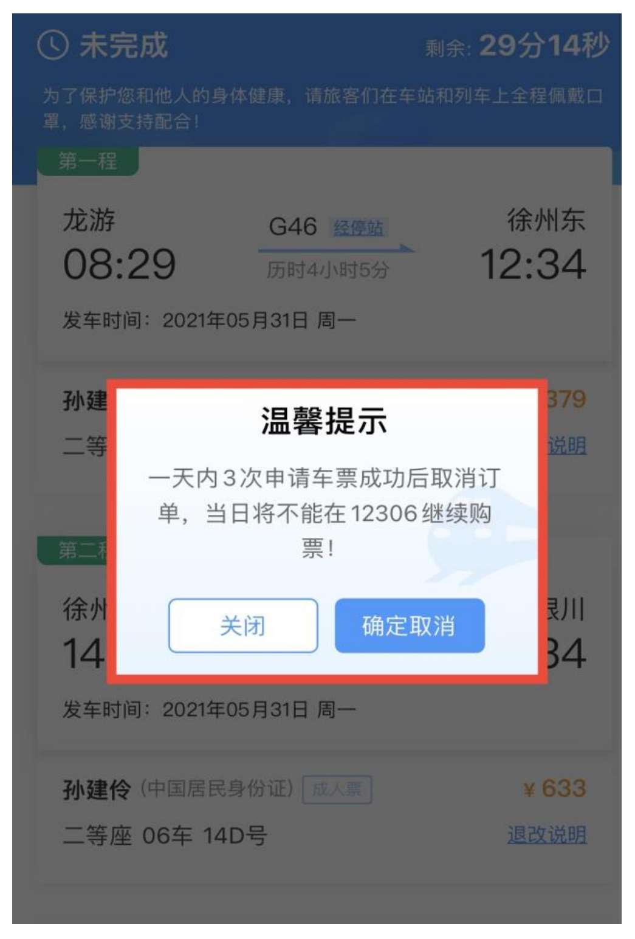
Transaction Examples

中国铁路12306
12306 CHINA RAILWAY

Transaction Boundaries

Booking tickets & paying order - combining vs separating ?


未完成
未完成 剩余: 29分44秒
为了保护您和他人的身体健康，请旅客们在车站和列车上全程佩戴口罩，感谢支持配合！
第一程
龙游 08:29 G46 经停站 历时4小时5分 徐州东 12:34
发车时间: 2021年05月31日 周一
孙建伶 (中国居民身份证) 成人票 ¥ 379
二等座 11车 06D号 退改说明
第二程
徐州东 14:14 G3171 经停站 历时7小时20分 银川 21:34
发车时间: 2021年05月31日 周一
孙建伶 (中国居民身份证) 成人票 ¥ 633
二等座 06车 14D号 退改说明
中国铁路保险，全方位守护您的旅程安全
铁路乘意险 ¥3/人
¥ 1012 取消订单 立即支付


未完成 剩余: 29分14秒
温馨提示
一天内3次申请车票成功后取消订单，当日将不能在12306继续购票！
关闭 确定取消

ACID Properties

A **transaction** is a unit of program execution that accesses and possibly updates various data items.To preserve the integrity of data the database system must ensure:

Atomicity. Either all operations of the transaction are properly reflected in the database or none are.

Consistency. Execution of a transaction in isolation preserves the consistency of the database.

Isolation. Although multiple transactions may execute concurrently, each transaction must be unaware of other concurrently executing transactions. Intermediate transaction results must be hidden from other concurrently executed transactions.

- That is, for every pair of transactions T_i and T_j, it appears to T_i that either T_j, finished execution before T_i started, or T_j started execution after T_i finished.

Durability. After a transaction completes successfully, the changes it has made to the database persist, even if there are system failures.

Enables use of the CREATE VIEW statement.

Authorization(授权)

Forms of authorization on parts of the database:

- **Select** - 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

- **Resources（MySQL：Create）** - allows creation of new relations.
- **Alteration** - allows addition or deletion of attributes in a relation.
- **Drop** - allows deletion of relations.
- **Index** - allows creation and deletion of indices.
- **Create view（MySQL）** – allows creation of views.

Authorization Specification in SQL

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

grant <privilege list> // privilege：权限

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)

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

grant select on *instructor* **to** U_1, U_2, U_3

grant select on *department* **to** *public*

grant update *(budget)* **on** *department* **to** *U1,U2*

grant all privileges on department to U_1

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

create role instructor;

grant *instructor* **to Amit;**

Privileges can be granted to roles:

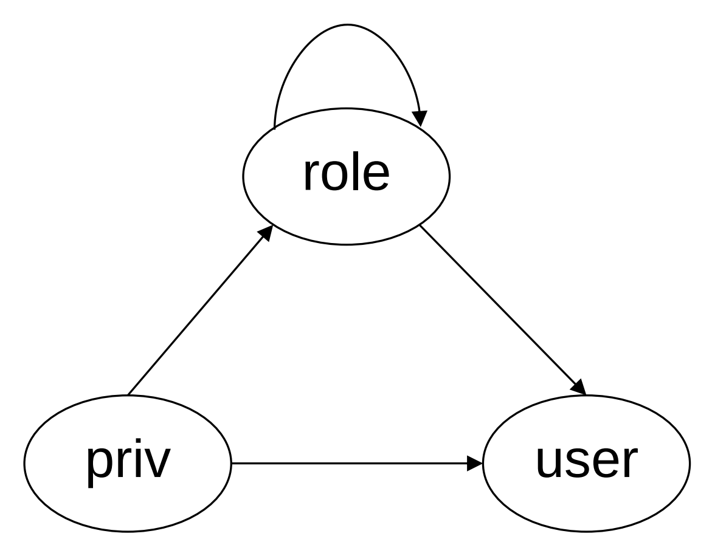
- **grant select on** *takes* **to** *instructor*;

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');

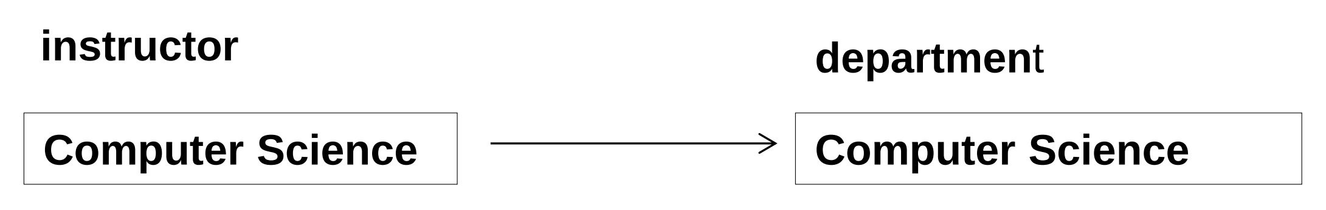
grant select on *geo_instructor* **to** *geo_staff*

Other Authorization Features

references privilege to create foreign key

grant reference (*dept_name*) **on** *department* **to** Mariano;

why is this required?



Other Authorization Features

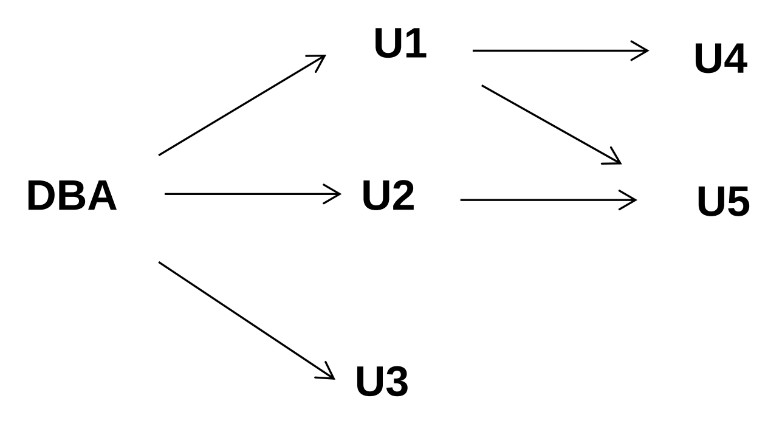
transfer of privileges

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**;

revoke grant option for select on *department* **from** Amit；



End of Chapter 4