Chapter 4: Intermediate SQL

Edited by Radhika Sukapuram

Database System Concepts, 6th Ed.

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**.
  - No two instructors must have the same ID
  - Every dept_name in the *course* relation must have a matching dept_name in the *department* relation
  - 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**

  Primary keys do not need to be explicitly declared **not null**
- **unique** (A_1, A_2, …, 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

- 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”.

Referential integrity contd.

- 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.
  - if for any values of A appearing in R these values also appear in S, A is said to be a
  - **foreign key** of R
- In general, a referential integrity constraint does not require A to be a primary key of S

Referential integrity in SQL: direct support

- By default, a foreign key references a primary key attribute of another table

create table *course (*
  course_id **char**(5) **primary key**,
  title **varchar**(20),
  dept_name **varchar**(20) **references** *department /** foreign key */
)

- A list of attributes *A* of the referenced relation can be specified explicitly
  - *A* must be declared a candidate key using a **unique** constraint or a **primary key** constraint – MySQL version dependent

Cascading Actions in Referential Integrity

- When a referential-integrity constraint is violated, the normal procedure is to reject the action that caused the violation.
- Alternatively

create table *course* (
…
dept_name **varchar**(20),
foreign key (*dept_name*) **references** *department*
        on delete cascade
        on update cascade,
. . .
)

- **on delete cascade** will work when you delete a tuple in *department*
- alternative actions to cascade: **set null**, **set default**

Integrity Constraint Violation

- 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 (not supported in many databases)

Complex Check Clauses

- **create table** *section* (

  ……..

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

  - The condition has to be checked when
    - a tuple is inserted or modified in *section* and
    - when the relation *time_slot* changes
- In general, how is this different from a foreign key ?
- Unfortunately: subquery in check clause not supported by pretty much any database
  - Alternative: triggers (later)

Assertions

- An **assertion** is a predicate expressing a condition that we wish the database to satisfy always.
- Domain and referential integrity constraints are special forms of assertions
- The following constraint can be expressed using assertions, but not using domain / referential integrity constraints:
  - For each tuple in the *student* relation, the value of the attribute *tot_cred* must equal the sum of credits of courses that the student has completed successfully.
- An assertion is tested for validity – often time consuming
- Therefore not supported in many RDBMs

Assertions contd.

- **create assertion** <assertion-name> **check** (<predicate>);
- **Example**

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

Additional 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

- Many queries reference only a small proportion of the records in a table.
- Inefficient for the system to read every record
- An **index** on an attribute of a relation is
  - a data structure that allows the database system to find those tuples in the relation that have a specified value for that attribute efficiently
  - without scanning through all the tuples of the relation.
- We create an index with the **create index** command

  create index <name> **on** <relation-name> (attribute);

Index Creation contd.

- **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*)

  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 later

Large-Object Types

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

User-Defined Types

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

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

- Example:

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

User-Defined Types contd.

- Strong type checking
- A value of type *Rupees* assigned to a value of type *Dollars* results in compile-time error
- What about (*department.budget* + 20) ?
  - **cast** (*department.budget* **to** numeric(12,2))
  - How to save the result back into *Rupees* ?

Domains

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

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

- Example for a constraint:

  create domain *degree_level* **varchar**(10)
  constraint *degree_level_test*
  check (**value in** ('Bachelors', 'Masters', 'Doctorate'));

Domains contd.

- Types and domains - differences
  - Domains can have constraints, such as **not null**
  - Domains can have **default** values for variables
  - Domains are *not* strongly typed – what is the implication ?

Authorization

- We may assign a user several forms of authorizations on parts of the database (related to data).
  - **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.
- Each of these types of authorizations is called a **privilege**.
- We may authorize the user
  - all, none, or a combination of these types of privileges
  - on specified parts of a database, such as a relation or a view.

Authorization (Cont.)

- 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 - data

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

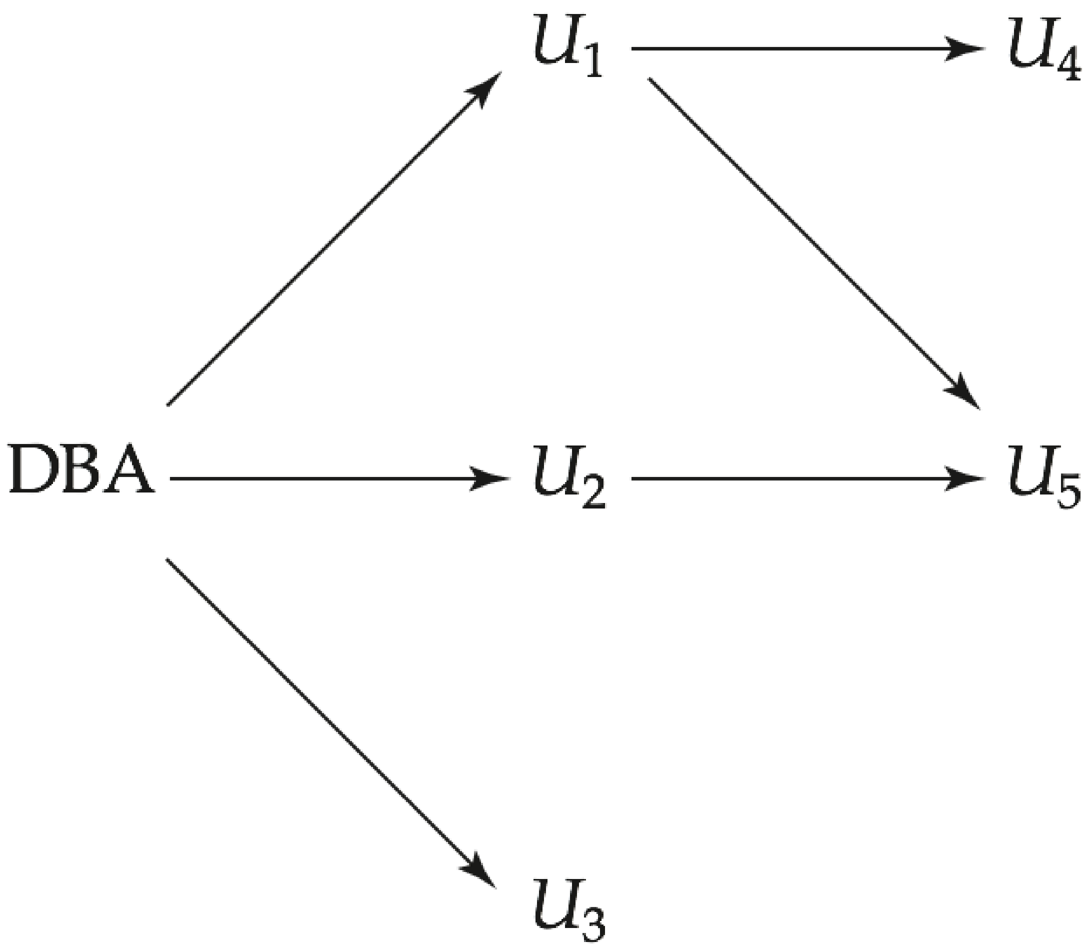
  grant <privilege list> **on** <relation or view > **to** <user list>
- <user list> is:
  - a user-id
  - **public**, which allows all valid users the privilege granted
  - A role (more on this later)
- Example:
  - **grant select on** *department* **to** Amit, Satoshi
- Granting a privilege on a view 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 - data

- **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 all or some attributes of tuples
- **update**: the ability to update all or some attributes
- **delete**: the ability to delete tuples.
- **all privileges**: used as a short form for all the allowable privileges

Authorization-Grant Graph



Transfer of privileges:
grant select on *department* **to** *U1* **with grant option**;

Revoking Authorization in SQL

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

  revoke <privilege list> **on** <relation or view> **from** <user list>

- Example:

  revoke select on *student* **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 – view and underlying relations

Roles

- A **role** is a way to distinguish among various users
  - denotes what these users can access/update in the database.
  - No need to give individual authorizations
- To create a role we use:

  create a role <name>
- Example:
  - **create role** instructor
- Once a role is created we can assign “users” to the role using:
  - **grant** <role> **to** <users>

Roles Example

- **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 --geo_staff* is a role
- 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

- transfer of privileges
  - **grant select on** *department* **to** Amit **with grant option**;
  - **revoke select on** *department* **from** Amit, Satoshi **cascade**;
    - Revocation will cascade (default behavior)
  - **revoke select on** *department* **from** Amit, Satoshi **restrict**;
    - An error if there are cascading revocations
  - And more!

Authorizations on schema

- Primitive: Only the owner can carry out any modification to the schema
- **references** privilege to declare foreign keys while creating a relation
  - **grant reference** (*dept_name*) **on** *department* **to** Mariano;
  - Now Mariano can create a foreign key in r referencing *department*
  - why is this a privileged operation ?

End of Chapter 4

Edited by Radhika Sukapuram

Database System Concepts, 6th Ed.

Figure 4.01

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

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

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*

Figure 4.04

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*

Figure 4.05

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

Figure 4.07

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