

CS 4604: Introduction to Database Management Systems

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Lecture #4: SQL---Part 2

Overview - detailed - SQL

- DML
- other parts:
 - views
 - modifications
 - joins
 - DDL
 - constraints

VIEWS

Views

- A view is a relation that does not exist physically.
- A view is defined by a query over other relations (tables and/or views).
- Just like a table, a view can be
 - queried: the query processor replaces the view by its definition.
 - used in other queries.
- Unlike a table, a view cannot be updated unless it satisfies certain conditions.

Example: View Definition

- `CREATE VIEW ViewName AS Query;`
- Suppose we want to perform a set of queries on those students who have taken courses both in the computer science and the mathematics departments.

Example: View Definition

- Suppose we want to perform a set of queries on those students who have taken courses both in the computer science and the mathematics departments.
- Let us create a view to store the PIDs of these students and the CS-Math course pairs they took.

```
CREATE VIEW CSMathStudents AS
```

```
  SELECT T1.StudentPID, T1.Number AS CSNum, T2.Number AS  
  MathNum
```

```
  FROM Take AS T1, Take AS T2
```

```
  WHERE (T1.StudentPID = T2.StudentPID)
```

```
    AND (T1.DeptName = ' CS' )
```

```
    AND (T2.DeptName = ' Math' );
```

Querying Views

- Query a view as if it were a base table.
- How many students took both CS and Math courses?

```
SELECT COUNT(StudentPID)  
FROM CSMathStudents
```

Querying Views

- Just replace view by its definition

```
SELECT COUNT(StudentPID)
FROM CSMathStudents
```

```
SELECT COUNT(StudentPID)
FROM
  (SELECT T1.StudentPID, T1.Number AS CSNum,
    T2.Number AS MathNum
  FROM Take AS T1, Take AS T2
  WHERE (T1.StudentPID = T2.StudentPID)
    AND (T1.DeptName = ' CS' )
    AND (T2.DeptName = ' Math' ));
```



Modifying Views

- What does it mean to modify a view?
- How is tuple deletion from a view executed?
- Can we insert a tuple into a view? Where will it be inserted, since a view does not physically exist?
- Can we insert tuples into any view? SQL includes rules that specify which views are updatable.

Deleting Views

- `DROP VIEW CSMathStudents;`
- Like a Symbolic Link: only the view definition is deleted

Deleting Tuples from Views

- Delete tuples for students taking 'CS 4604'.
DELETE FROM CSMathStudents
WHERE (CSNum = 4604);
- Deletion is executed as if were executing
DELETE FROM Take
WHERE (Number = 4604); 
- Incorrect: non-CS tuples where (Number = 4604) will be deleted.

Deleting Tuples from Views

- Tuples only seen in the view should be deleted!
- Add conditions to the WHERE clause

```
DELETE FROM CSMathStudents  
WHERE (CSNum = 4604) AND (DeptName = 'CS');
```

Inserting tuples into Views

- Again, passed through to the underlying relation

```
INSERT INTO CSMathStudents
```

```
VALUES ('123-45-6789', 4604, 8811);
```

- But Take schema is (PID, Number, Dept)
 - what should dept values be?
 - NULL?

Then it is not part of CSMathStudents!

Inserting tuples into Views

- CREATE VIEW CSStudents AS
SELECT StudentPID, Number
FROM Take
WHERE (DeptName = 'CS');
- INSERT INTO CSStudents
VALUES ('123-45-6789', 4604);

Works?

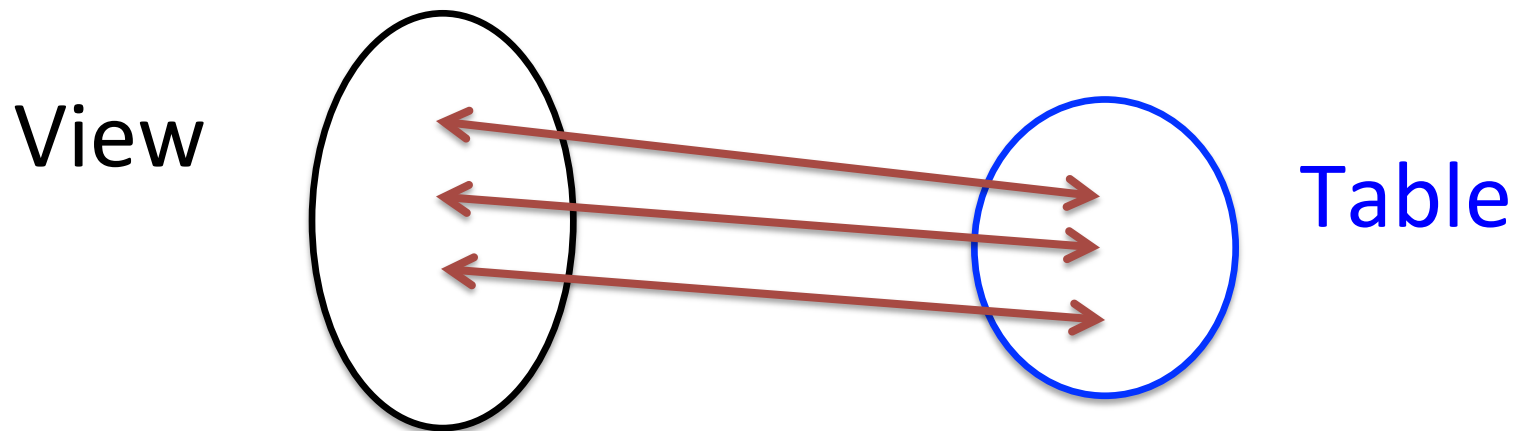
Same
Problem

Inserting tuples into Views

- Include DeptName in the view's schema
- CREATE VIEW CSStudents AS
SELECT StudentPID, DeptName, Number
FROM Take
WHERE (DeptName = 'CS');
- INSERT INTO CSStudents
VALUES ('123-45-6789', 'CS', 4604)

Updatable Views

- The idea is that there must be a one-one relationship between rows in the view and the rows in the underlying table



Updatable Views

**EXTRA: NOT
IN EXAM**

SQL:92 standard:

- Defined by selecting/projecting some attributes from one relation R
- R may itself be an updatable view.
- Use `SELECT` and not `SELECT DISTINCT`.
- `FROM` clause can contain only one occurrence of R and must not contain any other relation.
- NO aggregation operations

Materialized Views

- Two kinds:
 - 1. *Virtual*** = not stored in the database; just a query for constructing the relation.
 - 2. *Materialized*** = actually constructed and stored.

WHY?

- Some views may be frequently used in queries.
- It may be efficient to materialize such a view, i.e., maintain its value at all times as a physical table

Declaring Views

- Declare by:
`CREATE [MATERIALIZED] VIEW <name> AS <query>;`
- Default is virtual.

Maintaining Materializing Views

**EXTRA: NOT
IN EXAM**

- Cost?
 - Re-computing it when the underlying tables change
 - Materialized view may be much larger than original relations, e.g., in the case of joins

Maintaining Materialized Views

**EXTRA: NOT
IN EXAM**

- CREATE MATERIALIZED VIEW CSStudents AS
SELECT StudentPID, DeptName, Number
FROM Take
WHERE (DeptName = 'CS');
- When?
 - Insertion/deletion/update of Take
- Cost?
 - Insertion of tuple: Insert tuple into CSStudents only if new tuple has DeptName = 'CS'
 - Same for Deletion
 - Update? Delete followed by an Insert...

Maintaining Materialized Views

**EXTRA: NOT
IN EXAM**

- Key idea is that many materialized views can be updated incrementally.
- More info: Sections 25.9, and 25.10.1 from the textbook (~3 pages total)

MODIFICATIONS, JOINS, DDL

Reminder: mini-U db

STUDENT		
<u>Ssn</u>	Name	Address
123	smith	main str
234	jones	forbes ave

CLASS		
<u>c-id</u>	c-name	units
4602	s.e.	2
4603	o.s.	2

TAKES

<u>SSN</u>	<u>c-id</u>	grade
123	4613	A
234	4613	B

DML - insertions etc

insert into student

values (“123”, “smith”, “main”)

insert into student(ssn, name, address)

values (“123”, “smith”, “main”)

DML - insertions etc

bulk insertion: how to insert, say, a table of
'foreign-student' s, in bulk?

DML - insertions etc

bulk insertion:

insert into student

select ssn, name, address

from foreign-student

DML - deletion etc

delete the record of 'smith'

DML - deletion etc

delete the record of 'smith' :

```
delete from student  
  where name= 'smith'
```

(careful - it deletes ALL the 'smith' s!)

DML - update etc

record the grade 'A' for ssn=123 and course 4604

update takes

set grade="A"

where ssn="123" and c-id="4604"

(will set to "A" ALL such records)

DML - joins

so far: 'INNER' joins, eg:

```
select ssn, c-name  
from takes, class  
where takes.c-id = class.c-id
```

DML - joins

Equivalently:

```
select ssn, c-name
```

```
from takes join class on takes.c-id = class.c-id
```


Joins

```
select [column list]
from table_name
      [inner | {left | right | full} outer ] join
      table_name
      on qualification_list
where...
```

Reminder: mini-U db

STUDENT		
<u>Ssn</u>	Name	Address
123	smith	main str
234	jones	forbes ave

CLASS		
<u>c-id</u>	c-name	units
4602	s.e.	2
4603	o.s.	2

TAKES

<u>SSN</u>	<u>c-id</u>	grade
123	4613	A
234	4613	B

Inner join

TAKES

<u>SSN</u>	<u>c-id</u>	grade
123	4613	A
234	4613	B

CLASS

<u>c-id</u>	c-name	units
4613	s.e.	2
4613	o.s.	2

<u>SSN</u>	<u>c-name</u>
123	s.e
234	s.e

o.s.: gone!

Outer join

TAKES

<u>SSN</u>	<u>c-id</u>	grade
123	4613	A
234	4613	B

CLASS

<u>c-id</u>	c-name	units
4613	s.e.	2
4613	o.s.	2

<u>SSN</u>	<u>c-name</u>
123	s.e
234	s.e.
null	o.s.



Outer join

select ssn, c-name

from takes **right outer join** class **on** takes.c-
id=class.c-id

<u>SSN</u>	<u>c-name</u>
123	s.e
234	s.e.
null	o.s.



Outer join

- **left outer join**
- **right outer join**
- **full outer join**
- **natural join**

Null Values

- **null** -> unknown, or inapplicable, (or ...)
- Complications:
 - 3-valued logic (true, false and *unknown*).
 - **null = null** : false!!

Overview - detailed - SQL

- DML
- other parts:
 - views
 - modifications
 - joins
 - **DDL**
 - constraints

Data Definition Language

```
create table student  
(ssn char(9) not null,  
  name char(30),  
  address char(50),  
primary key (ssn) )
```

Data Definition Language

```
create table r( A1 D1, ..., An Dn,  
  integrity-constraint1,  
  ...  
  integrity-constraint-n)
```

Data Definition Language

Domains:

- **char(n), varchar(n)**
- **int, numeric(p,d), real, double precision**
- **float, smallint**
- **date, time**

Data Definition Language

delete a table: difference between

drop table student

delete from student

Data Definition Language

modify a table:

```
alter table student drop address
```

```
alter table student add major char(10)
```

CONSTRAINTS

Data Definition Language

integrity constraints:

- **primary key**
- **foreign key**
- **check(P)**

Data Definition Language

create table takes

(**ssn char(9) not null,**

c-id char(5) not null,

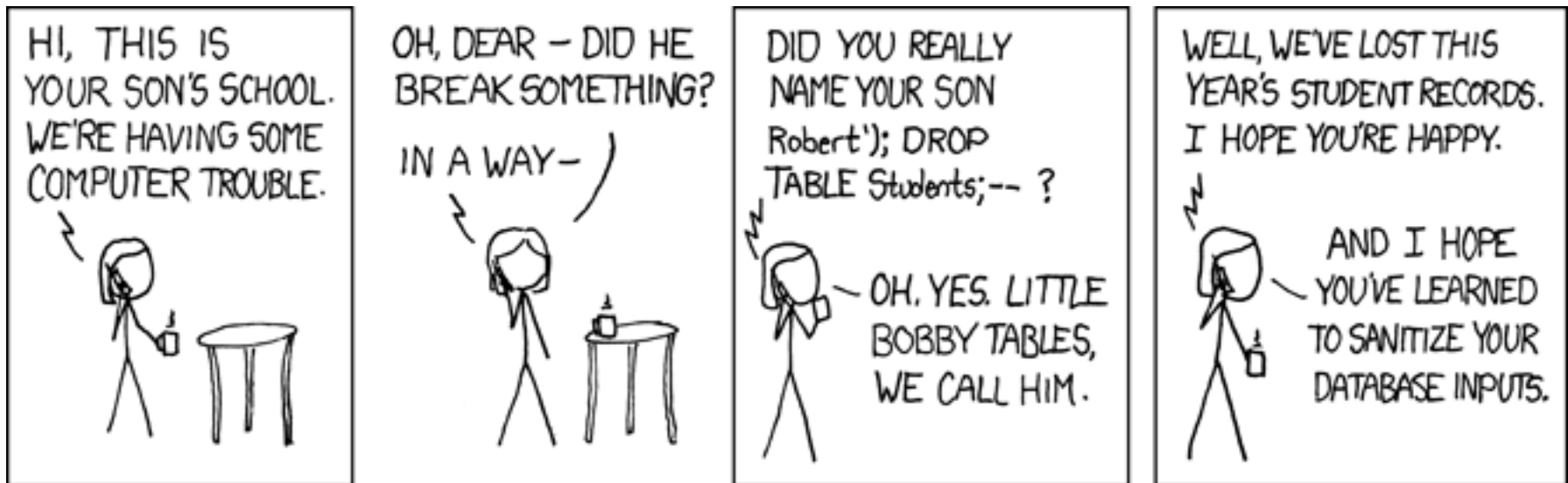
grade char(1),

primary key (ssn, c-id),

check grade in ("A", "B", "C", "D", "F"))

Maintaining Integrity of Data

- Data is **dirty**.
- How does an application ensure that a database modification does not corrupt the tables?



Maintaining Integrity of Data

- Data is **dirty**.
- How does an application ensure that a database modification does not corrupt the tables?
- Two approaches:
 - Application programs check that database modifications are consistent.
 - Use the features provided by SQL.

Integrity Checking in SQL

- PRIMARY KEY and UNIQUE constraints.
- FOREIGN KEY constraints.
- Constraints on attributes and tuples.
- Triggers (schema-level constraints).

- How do we express these constraints?
- How do we check these constraints?
- What do we do when a constraint is violated?

Keys in SQL

- A set of attributes S is a key for a relation R if every pair of tuples in R **disagree on at least one attribute** in S .
- Select one key to be the **PRIMARY KEY**; declare other keys using **UNIQUE**.

Primary Keys in SQL

- Modify the schema of Students to declare PID to be the key.
 - CREATE TABLE Students(
 PID VARCHAR(8) **PRIMARY KEY**,
 Name CHAR(20), Address VARCHAR(255));
- What about Courses, which has two attributes in its key?
 - CREATE TABLE Courses(Number integer, DeptName:
 VARCHAR(8), CourseName VARCHAR(255), Classroom
 VARCHAR(30), Enrollment integer,
 PRIMARY KEY (Number, DeptName)
);

Effect of Declaring PRIMARY KEYS

- Two tuples in a relation cannot agree on all the attributes in the key. DBMS will reject any action that inserts or updates a tuple in violation of this rule.
- A tuple cannot have a NULL value in a key attribute.

Other Keys in SQL

- If a relation has other keys, declare them using the UNIQUE keyword.
- Use UNIQUE in exactly the same places as PRIMARY KEY.
- There are two differences between PRIMARY KEY and UNIQUE:
 - A table may have **only one PRIMARY KEY** but more than one set of attributes declared UNIQUE.
 - A tuple **may have NULL values in UNIQUE** attributes.

Enforcing Key Constraints

- Upon which actions should an RDBMS enforce a key constraint?
- Only tuple update and insertion.
- RDBMS searches the tuples in the table to find if any tuple exists that agrees with the new tuple on all attributes in the primary key.
- To speed this process, an RDBMS automatically creates an efficient search index on the primary key.
- User can instruct the RDBMS to create an index on one or more attributes

Foreign Key Constraints

- **Referential integrity constraint:** in the relation Teach (that “connects” Courses and Professors), if Teach relates a course to a professor, then a tuple corresponding to the professor **must** exist in Professors.
- How do we express such constraints in Relational Algebra?
- Consider the Teach(ProfessorPID, Number, DeptName) relation.

every non-NULL value of ProfessorPID in Teach must be a valid ProfessorPID in Professors.

- **RA** $\pi_{\text{ProfessorPID}}(\text{Teach}) \subseteq \pi_{\text{PID}}(\text{Professors})$.

Referential Integrity constraints

‘foreign keys’ - eg:

create table takes(
 ssn **char(9) not null,**

c-id **char(5) not null,**

grade **integer,**

primary key(ssn, c-id),

foreign key ssn **references** student,

foreign key c-id **references** class)

Referential Integrity constraints

...

foreign key ssn references student,
foreign key c-id references class)

Effect:

- expects that ssn to exist in ‘student’ table
- blocks ops that violate that - how??
 - insertion?
 - deletion/update?

Requirements for FOREIGN KEYS

- If a relation R declares that some of its attributes refer to foreign keys in another relation S , then these attributes **must** be declared UNIQUE or PRIMARY KEY in S .
- Values of the foreign key in R must appear in the referenced attributes of some tuple in S .

Enforcing Referential Integrity

- **Three** policies for maintaining referential integrity.
- **Default policy:** reject violating modifications.
- **Cascade policy:** mimic changes to the referenced attributes at the foreign key.
- **Set-NULL policy:** set appropriate attributes to NULL.

Default Policy for Enforcing Referential Integrity

- **Reject** violating modifications. There are **four cases**.
 - Insert a new Teach tuple whose ProfessorPID is not NULL and is not the PID of any tuple in Professors.
 - Update the ProfessorPID attribute in a tuple in Teach to a value that is not the PID value of any tuple in Professors.
 - Delete a tuple in Professors whose PID value is the ProfessorPID value for one or more tuples in Teach.
 - Update the PID value of a tuple in Professors when the old PID value is the value of ProfessorPID in one or more tuples of Teach.

Cascade Policy for Enforcing Referential Integrity

- Only applies to deletions of or updates to tuples in the referenced relation (e.g., Professors).
- If we delete a tuple in Professors, delete all tuples in Teach that refer to that tuple.
- If we update the PID value of a tuple in Professors from p_1 to p_2 , update all value of ProfessorPID in Teach that are p_1 to p_2 .

Set-NULL Policy for Enforcing Referential Integrity

- Also applies only to deletions of or updates to tuples in the referenced relation (e.g., Professors).
- If we delete a tuple in Professors, set the ProfessorPID attributes of all tuples in Teach that refer to the deleted tuple to NULL.
- If we update the PID value of a tuple in Professors from p1 to p2, set all values of ProfessorPID in Teach that are p1 to NULL

Referential Integrity constraints in SQL

...

foreign key ssn references student
on delete cascade
on update cascade,

...

- -> eliminate all student enrollments
- other options (set to null, to default etc)

Constraining Attributes and Tuples

- SQL also allows us to specify constraints on attributes in a relation and on tuples in a relation.
 - Disallow courses with a maximum enrollment greater than 100.
 - A chairperson of a department must teach at most one course every semester.
- How do we express such constraints in SQL?
- How can we change our minds about constraints?
- A simple constraint: NOT NULL
 - Declare an attribute to be NOT NULL after its type in a CREATE TABLE statement.
 - Effect is to disallow tuples in which this attribute is NULL.

Attribute-Based CHECK Constraints

- Disallow courses with a maximum enrollment greater than 100.
- CREATE TABLE Courses(...
Enrollment INT CHECK (Enrollment <= 100) ...);
- The condition can be any condition that can appear in a WHERE clause.
- CHECK statement may use a subquery to mention other attributes of the same or other relations.
- An attribute-based CHECK constraint is checked **only when the value of that attribute changes.**

Tuple-Based CHECK Constraints

- Tuple-based CHECK constraints are checked whenever a tuple is **inserted into or updated in a relation**.
- A chairperson of a department teaches at most one course in any semester.

```
CREATE TABLE Teach(...  
    CHECK ProfessorPID NOT IN  
        ((SELECT ProfessorPID FROM Teach)  
        INTERSECT  
        (SELECT ChairmanPID FROM Departments)  
        )  
    );
```

Weapons for IC:

- assertions
 - **create assertion** <assertion-name> **check** <predicate>
- triggers (~ assertions with ‘teeth’)
 - on operation, if condition, then action

Assertions: Example

- Can't have more courses than students ('Pigeonhole Principle')

```
CREATE ASSERTION FewStudents CHECK (  
  (SELECT COUNT(*) FROM Students) <=  
  (SELECT COUNT(*) FROM Courses)  
);
```

Triggers: Motivation

- triggers (~ assertions with ‘teeth’)
 - on operation, if condition, then action

Triggers - example

```
define trigger zerograde on update takes  
(if new takes.grade < 0  
  then takes.grade = 0)
```


Triggers - discussion

- more complicated: “managers have higher salaries than their subordinates” - a trigger can automatically boost mgrs salaries
- triggers: tricky (infinite loops...)

OK, what could have been done?

