Database Systems

Lecture 12:
Advanced SQL (part 2)

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based on the slides of the course book

Outline

- Accessing SQL From a Programming Language
- Functions
- **Triggers**
- Advanced Aggregation Features
- OLAP

Triggers

- A **trigger** is a statement that is executed automatically by the system as a side effect of a modification to the database.
- To design a trigger mechanism, we must:
  - Specify the conditions under which the trigger is to be executed.
  - Specify the actions to be taken when the trigger executes.
- Triggers introduced to SQL standard in SQL:1999, but supported even earlier using non-standard syntax by most databases.
  - Syntax illustrated here may not work exactly on your database system; check the system manuals

Triggering Events and Actions in SQL

- Triggering event can be **insert**, **delete** or **update**
- Triggers on update can be restricted to specific attributes
  - For example, **after update of** *takes* **on** *grade*
- Values of attributes before and after an update can be referenced
  - **referencing old row as :** for deletes and updates
  - **referencing new row as :** for inserts and updates
- Triggers can be activated before an event, which can serve as extra constraints. For example, convert blank grades to null.

Trigger Example: Using set Statement

```
create trigger setnull before update on takes
referencing new row as nrow
for each row
when (nrow.grade = ' ')
begin atomic
    set nrow.grade = null;
end;
```

Trigger Example:
to Maintain Referential Integrity

```
create trigger timeslot_check1 after insert on section
referencing new row as nrow
for each row
when (nrow.time_slot_id not in (
            select time_slot_id
            from time_slot)) /* time_slot_id not present in time_slot */
begin
   rollback
end;

create trigger timeslot_check2 after delete on timeslot
referencing old row as orow
for each row
when (orow.time_slot_id not in (
            select time_slot_id
            from time_slot) /* last tuple for time_slot_id deleted from time_slot */
   and orow.time_slot_id in (
            select time_slot_id
            from section)) /* and time_slot_id still referenced from section*/
begin
   rollback
end;
```

Trigger Example: to Maintain credits_earned value

```
create trigger credits_earned after update of takes on (grade)
referencing new row as nrow
referencing old row as orow
for each row
when nrow.grade <> 'F' and nrow.grade is not null
    and (orow.grade = 'F' or orow.grade is null)
begin atomic
    update student
    set tot_cred= tot_cred+
            (select credits
             from course
             where course.course_id= nrow.course_id)
    where student.id = nrow.id;
end;
```

Figure 5.9 Using a trigger to maintain *credits_earned* values.

Disabling Triggers

- Triggers can be disabled or enabled;
  - by default they are enabled when they are created.
- Triggers can be disabled by:

  alter trigger *trigger_name* **disable**

  disable trigger *trigger_name*

- A trigger that has been disabled can be enabled again.

- A trigger can instead be dropped, which removes it permanently, by:

  drop trigger *trigger_name*

When Not To Use Triggers

- Triggers were used earlier for tasks such as
  - Maintaining summary data (e.g., total salary of each department)
  - Replicating databases by recording changes to special relations (called **change** or **delta** relations) and having a separate process that applies the changes over to a replica
- There are better ways of doing these now:
  - Databases today provide built in materialized view facilities to maintain summary data
  - Databases provide built-in support for replication
- Encapsulation facilities can be used instead of triggers in many cases
  - Define methods to update fields
  - Carry out actions as part of the update methods instead of through a trigger

When Not To Use Triggers

- Risk of unintended execution of triggers, for example, when
  - Loading data from a backup copy
  - Replicating updates at a remote site
  - Trigger execution can be disabled before such actions.
- Other risks with triggers:
  - Error leading to failure of critical transactions that set off the trigger
  - Cascading execution

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Ranking

- Suppose we are given a relation
  student_grades(ID, GPA)
  giving the grade-point average of each student

- Goal: finding the rank of each student.

- Ranking can be done using basic SQL aggregation, but resultant query is very inefficient

```
select ID, (1 + (select count(*)
                 from student_grades B
                 where B.GPA > A.GPA)) as s_rank
from student_grades A
order by s_rank;
```

Ranking

- Ranking is done in conjunction with an order by specification.

select *ID*, **rank**() **over** (**order by** *GPA* **desc) as** *s_rank*
from *student_grades*
order by *s_rank*

- NOTE: the extra **order by** clause is needed to get them in sorted order

Ranking

- Two possible approaches for ranking
  - Leaving gaps: (default)

    e.g. if 2 students have the same top GPA, both have rank 1, and the next rank is 3
  - Without gaps: (using **dense_rank)**

    so next dense rank would be 2

Ranking with Partitions

- Ranking can be done within partition of the data.

- "Find the rank of students within each department."

  select *ID*, *dept_name*,
  rank () **over** (**partition by** *dept_name* **order by** *GPA* **desc**)
  as *dept_rank*
  from *dept_grades*
  order by *dept_name*, *dept_rank*;

- Ranking is done *after* applying **group by** clause/aggregation

Top *n* Items

- Can be used to find top-n results
  - More general than the **limit** *n* clause supported by many databases, since it allows top-n within each partition

Other Ranking Functions

- **percent_rank**
  - within partition, if partitioning is done

  - Having *n* tuples in a partition and the rank *r* for the target tuple
  - *percent_rank = (r-1)/(n-1)*

Other Ranking Functions

- **cume_dist** (cumulative distribution)
  - fraction of tuples with preceding values
  - Having n tuples in a partition and p tuples with ordering value preceding or equal to the the target tuple
  - *cume_dist = p/n*

Other Ranking Functions

- **row_number**
  - Sorting the rows and giving each row a unique number corresponding to its position in the sort order
  - Non-deterministic in presence of duplicates

    (different rows with the same ordering value would get different random row numbers)

Other Ranking Functions

- **ntile**:
  - For a given constant *n*, the ranking the function *ntile*(*n*) takes the tuples in each partition in the specified order, and divides them into *n* buckets with equal numbers of tuples.
  - E.g.,

select *ID*, **ntile**(4) **over** (**order by** *GPA* **desc**) **as** *quartile*
from *student_grades;*

Other Ranking Functions

- SQL:1999 permits the user to specify **nulls first** or **nulls last**

select *ID*,
rank ( ) **over** (**order by** *GPA* **desc nulls last**) **as** *s_rank*
from *student_grades*

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Data Analysis and OLAP

- **Online Analytical Processing (OLAP)**
  - Interactive analysis of data, allowing data to be summarized and viewed in different ways in an online fashion (with negligible delay)
- Is used for **multidimensional data** (data that can be modeled as dimension attributes and measure attributes)
  - **Measure attributes**
    - measure some value
    - can be aggregated upon
    - e.g., the attribute *number* of the *sales* relation
  - **Dimension attributes**
    - define the dimensions on which measure attributes (or aggregates there of) are viewed
    - e.g., attributes *item_name, color,* and *size* of the *sales* relation

Example sales relation

item_name	*color*	*clothes_size*	*quantity*
skirt	dark	small	2
skirt	dark	medium	5
skirt	dark	large	1
skirt	pastel	small	11
skirt	pastel	medium	9
skirt	pastel	large	15
skirt	white	small	2
skirt	white	medium	5
skirt	white	large	3
dress	dark	small	2
dress	dark	medium	6
dress	dark	large	12
dress	pastel	small	4
dress	pastel	medium	3
dress	pastel	large	3
dress	white	small	2
dress	white	medium	3
dress	white	large	0
shirt	dark	small	2
shirt	dark	medium	6
...	...	...	...
...	...	...	...

Cross Tabulation of *sales* by *item_name* and *color*

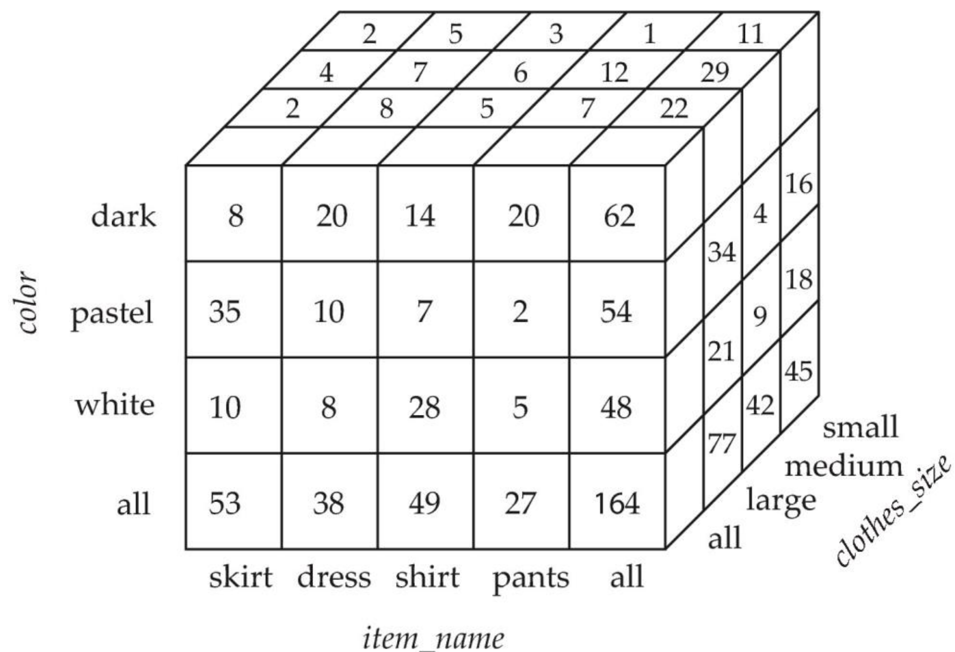
clothes_size **all**

item_name \ *color*	dark	pastel	white	total
skirt	8	35	10	53
dress	20	10	5	35
shirt	14	7	28	49
pants	20	2	5	27
total	62	54	48	164

- The table above is an example of a **cross-tabulation** (**cross-tab**), also referred to as a **pivot-table**.
  - Values for one of the dimension attributes form the row headers
  - Values for another dimension attribute form the column headers
  - Other dimension attributes are listed on top
  - Values in individual cells are (aggregates of) the values of the dimension attributes that specify the cell.

Data Cube

- A **data cube** is a multidimensional generalization of a cross-tab
- Can have *n* dimensions; we show 3 below
- Cross-tabs can be used as views on a data cube



Online Analytical Processing Operations

- **Pivoting:** changing the dimensions used in a cross-tab is called
- **Slicing:** creating a cross-tab for fixed values only
  - Sometimes called **dicing**, particularly when values for multiple dimensions are fixed.

Cross Tabulation With Hierarchy

- The following table can be achieved using natural join with another table specifying item_names and category

clothes_size: **all**

category	*item_name*	*color*				
		dark	pastel	white	total	
womenswear	skirt	8	8	10	53	
	dress	20	20	5	35	
	subtotal	28	28	15		88
menswear	pants	14	14	28	49	
	shirt	20	20	5	27	
	subtotal	34	34	33		76
total		62	62	48		164

Cross Tabulation With Hierarchy

- Cross-tabs can be easily extended to deal with hierarchies
- Can drill down or roll up on a hierarchy
  - roll up: moving from finer granularity to coarser-granularity (by the mean of aggregation)
  - drill down: moving from coarser-granularity to finer granularity (must be generated from original data)

Relational Representation of Cross-tabs

- Cross-tabs can be represented as relations
  - We use the value **all** is used to represent aggregates.
  - The SQL standard actually uses null values in place of **all** despite confusion with regular null values.

item_name	*color*	*clothes_size*	*quantity*
skirt	dark	**all**	8
skirt	pastel	**all**	35
skirt	white	**all**	10
skirt	**all**	**all**	53
dress	dark	**all**	20
dress	pastel	**all**	10
dress	white	**all**	5
dress	**all**	**all**	35
shirt	dark	**all**	14
shirt	pastel	**all**	7
shirt	White	**all**	28
shirt	**all**	**all**	49
pant	dark	**all**	20
pant	pastel	**all**	2
pant	white	**all**	5
pant	**all**	**all**	27
all	dark	**all**	62
all	pastel	**all**	54
all	white	**all**	48
all	**all**	**all**	164

Extended Aggregation to Support OLAP

- The **cube** operation computes union of **group by**’s on every subset of the specified attributes
- Example relation for this section
  sales(*item_name, color, clothes_size, quantity*)
- E.g. consider the query

  select *item_name, color, size,* **sum**(*number*)
  from *sales*
  group by cube(*item_name, color, size*)

  This computes the union of eight different groupings of the *sales* relation:

  { (*item_name, color, size*), (*item_name, color*),
  (*item_name, size*), (*color, size*),
  (*item_name*), (*color*),
  (*size*), ( ) }

  where ( ) denotes an empty **group by** list.
- For each grouping, the result contains the null value for attributes not present in the grouping.

Extended Aggregation

- The **rollup** construct generates union on every prefix of specified list of attributes

- E.g.,

  select *item_name*, *color*, *size*, **sum**(*number*)
  from *sales*
  group by rollup(*item_name, color, size*)

  Generates union of four groupings:

  { (*item_name, color, size*), (*item_name, color*), (*item_name*), ( ) }

Extended Aggregation

- Rollup can be used to generate aggregates at multiple levels of a hierarchy.
- E.g., suppose table *itemcategory*(*item_name, category*) gives the category of each item. Then

  select *category, item_name*, **sum**(*number*)
  from *sales, itemcategory*
  where *sales.item_name = itemcategory.item_name*
  group by rollup(*category, item_name*)

  would give a hierarchical summary by *item_name* and by *category.*

Extended Aggregation

- Multiple rollups or cubes can be used in a single group by clause
  - Each generates set of group by lists, cross product of sets gives overall set of group by lists

- E.g.,

  select *item_name, color, size*, **sum**(*number*)
  from *sales*
  group by rollup(*item_name*), **rollup**(*color, size*)

  generates the groupings

  {item_name, ()} X {(color, size), (color), ()}

  = { (*item_name, color, size*), (*item_name, color*), (*item_name*), (*color, size*), (*color*), ( ) }

OLAP Implementation

- The earliest OLAP systems used multidimensional arrays in memory to store data cubes, and are referred to as **multidimensional OLAP (MOLAP)** systems.

- OLAP implementations using only relational database features are called **relational OLAP (ROLAP)** systems

- Hybrid systems, which store some summaries in memory and store the base data and other summaries in a relational database, are called **hybrid OLAP (HOLAP)** systems.

OLAP Implementation

- Early OLAP systems precomputed *all* possible aggregates in order to provide online response
  - Space and time requirements for doing so can be very high
    - 2^n combinations of **group by**
- Several optimizations available for computing multiple aggregates
  - It suffices to precompute some aggregates, and compute others on demand from one of the precomputed aggregates
    - Can compute aggregate on (*item_name, color*) from an aggregate on (*item_name, color, size*)
      - is cheaper than computing it from scratch

The picture can't be displayed.

Questions?