Carnegie Mellon University

Intro to Database Systems (15-445/645)

# Lecture #02

# Modern SQL


**SPRING 2024** ❯❯ Prof. Jignesh Patel

# LAST CLASS

We introduced the Relational Model as the superior data model for databases.

We then showed how Relational Algebra is the building blocks that will allow us to query and modify a relational database.

# SQL HISTORY

In 1971, IBM created its first relational query language called SQUARE.

IBM then created "SEQUEL" in 1972 for IBM System R prototype DBMS.

→ Structured English Query Language

IBM releases commercial SQL-based DBMSs:

→ System/38 (1979), SQL/DS (1981), and DB2 (1983).

Q2. Find the average salary of employees in the Shoe Department.

$$AVG\,(\,{}_{SAL}EMP'_{DEPT}\,('SHOE'))$$

Mappings may be *composed* by applying one mapping to the result of another, as illustrated by Q3.

Q3. Find those items sold by departments on the second floor.

$${}_{ITEM}SALES_{DEPT} \circ {}_{DEPT}LOC_{FLOOR}\,(2)$$

The floor '2' is first mapped to the departments located there, and then to the items which they sell. The range of the inner mapping must be compatible with the domain of the outer mapping, but they need not be identical, as illustrated by Q4.

# SQL HISTORY

ANSI Standard in 1986. ISO in 1987

→ Structured Query Language

Current standard is **SQL:2023**

→ **SQL:2023** → Property Graph Queries, Muti-Dim. Arrays

→ **SQL:2016** → JSON, Polymorphic tables

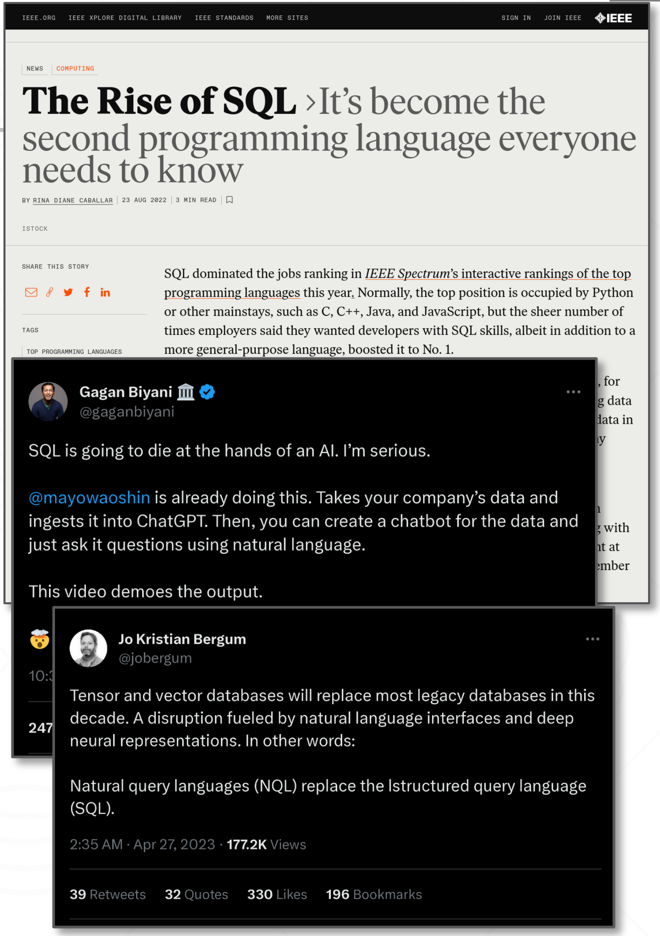
→ **SQL:2011** → Temporal DBs, Pipelined DML

→ **SQL:2008** → Truncation, Fancy Sorting

→ **SQL:2003** → XML, Windows, Sequences, Auto-Gen IDs.

→ **SQL:1999** → Regex, Triggers, OO

The minimum language syntax a system needs to say that it supports SQL is [SQL-92](SQL-92).



# RELATIONAL LANGUAGES

Data Manipulation Language (DML)
Data Definition Language (DDL)
Data Control Language (DCL)

Also includes:
→ View definition
→ Integrity & Referential Constraints
→ Transactions

Important: SQL is based on **bags** (duplicates) not **sets** (no duplicates).

# TODAY'S AGENDA

Aggregations + Group By

String / Date / Time Operations

Output Control + Redirection

Window Functions

Nested Queries

Lateral Joins

Common Table Expressions

# EXAMPLE DATABASE

**student(sid,name,login,gpa)**

| sid | name | login | age | gpa |
|---|---|---|---|---|
| 53666 | RZA | rza@cs | 44 | 4.0 |
| 53688 | Bieber | jbieber@cs | 27 | 3.9 |
| 53655 | Tupac | shakur@cs | 25 | 3.5 |

**enrolled(sid,cid,grade)**

| sid | cid | grade |
|---|---|---|
| 53666 | 15-445 | C |
| 53688 | 15-721 | A |
| 53688 | 15-826 | B |
| 53655 | 15-445 | B |
| 53666 | 15-721 | C |

**course(cid,name)**

| cid | name |
|---|---|
| 15-445 | Database Systems |
| 15-721 | Advanced Database Systems |
| 15-826 | Data Mining |
| 15-799 | Special Topics in Databases |

# AGGREGATES

Functions that return a single value from a bag of tuples:

`AVG(col)`→ Return the average col value.

`MIN(col)`→ Return minimum col value.

`MAX(col)`→ Return maximum col value.

`SUM(col)`→ Return sum of values in col.

`COUNT(col)`→ Return # of values for col.

# AGGREGATES

Aggregate functions can (almost) only be used in the **SELECT** output list.

*Get # of students with a "@cs" login:*

```
SELECT COUNT(login) AS cnt
  FROM student WHERE login LIKE '%@cs'
```

# AGGREGATES

Aggregate functions can (almost) only be used in the **SELECT** output list.

*Get # of students with a "@cs" login:*

```
SELECT COUNT(login) AS cnt
  FROM student WHERE login LIKE '%@cs'
```

```
SELECT COUNT(*) AS cnt
  FROM student WHERE login LIKE '%@cs'
```

# AGGREGATES

Aggregate functions can (almost) only be used in the **SELECT** output list.

*Get # of students with a "@cs" login:*

```
SELECT COUNT(login) AS cnt
```

```
SELECT COUNT(*) AS cnt
```

```
SELECT COUNT(1) AS cnt
  FROM student WHERE login LIKE '%@cs'
```

# AGGREGATES

Aggregate functions can (almost) only be used in the **SELECT** output list.

*Get # of students with a "@cs" login:*

```
SELECT COUNT(login) AS cnt
```

```
SELECT COUNT(*) AS cnt
```

```
SELECT COUNT(1) AS cnt
```

```
SELECT COUNT(1+1+1) AS cnt
  FROM student WHERE login LIKE '%@cs'
```

# MULTIPLE AGGREGATES

*Get the number of students and their average GPA that have a "@cs" login.*

```
SELECT AVG(gpa), COUNT(sid)
  FROM student WHERE login LIKE '%@cs'
```

| AVG(gpa) | COUNT(sid) |
|---|---|
| 3.8 | 3 |

# DISTINCT AGGREGATES

**COUNT**, **SUM**, **AVG** support **DISTINCT** modifier.

→ Caveat: COUNT(*) does not support the DISTINCT modifier.

*Get the number of unique students that have an "@cs" login.*

```
SELECT COUNT(DISTINCT login)
  FROM student WHERE login LIKE '%@cs'
```

| COUNT(DISTINCT login) |
|---|
| 3 |

# AGGREGATES

Output of other columns outside of an aggregate is undefined.

*Get the average GPA of students enrolled in each course.*

```
SELECT AVG(s.gpa), e.cid
  FROM enrolled AS e JOIN student AS s
    ON e.sid = s.sid
```

| AVG(s.gpa) | e.cid |
|---|---|
| 3.86 | ??? |

# GROUP BY

Project tuples into subsets and calculate aggregates against each subset.

```
SELECT AVG(s.gpa), e.cid
  FROM enrolled AS e JOIN student AS s
    ON e.sid = s.sid
 GROUP BY e.cid
```

| e.sid | s.sid | s.gpa | e.cid |
|---|---|---|---|
| 53435 | 53435 | 2.25 | 15-721 |
| 53439 | 53439 | 2.70 | 15-721 |
| 56023 | 56023 | 2.75 | 15-826 |
| 59439 | 59439 | 3.90 | 15-826 |
| 53961 | 53961 | 3.50 | 15-826 |
| 58345 | 58345 | 1.89 | 15-445 |

| AVG(s.gpa) | e.cid |
|---|---|
| 2.46 | 15-721 |
| 3.39 | 15-826 |
| 1.89 | 15-445 |

# GROUP BY

Non-aggregated values in **SELECT** output clause must appear in **GROUP BY** clause.

```
SELECT AVG(s.gpa), e.cid, s.name
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid
 GROUP BY e.cid
```

# GROUP BY

Non-aggregated values in **SELECT** output clause must appear in **GROUP BY** clause.

```
SELECT AVG(s.gpa), e.cid, s.name
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid
 GROUP BY e.cid
```

# GROUP BY

Non-aggregated values in **SELECT** output clause must appear in **GROUP BY** clause.

```
SELECT AVG(s.gpa), e.cid, s.name
  FROM enrolled AS e JOIN student AS s
    ON e.sid = s.sid
 GROUP BY e.cid, s.name
```

# HAVING

Filters results based on aggregation computation.

Like a **WHERE** clause for a **GROUP BY**

```
SELECT AVG(s.gpa) AS avg_gpa, e.cid
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid
   AND avg_gpa > 3.9
 GROUP BY e.cid
```

# HAVING

Filters results based on aggregation computation.

Like a **WHERE** clause for a **GROUP BY**

```
SELECT AVG(s.gpa) AS avg_gpa, e.cid
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid
   AND avg_gpa > 3.9
 GROUP BY e.cid
```

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```
SELECT AVG(s.gpa) AS avg_gpa, e.cid
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid
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 HAVING avg_gpa > 3.9;
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```

# HAVING

Filters results based on aggregation computation.

Like a **WHERE** clause for a **GROUP BY**

```
SELECT AVG(s.gpa) AS avg_gpa, e.cid
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid
 GROUP BY e.cid
 HAVING AVG(s.gpa) > 3.9;
```

| AVG(s.gpa) | e.cid |
|---|---|
| 3.75 | 15-415 |
| 3.950000 | 15-721 |
| 3.900000 | 15-826 |

# HAVING

Filters results based on aggregation computation.

Like a **WHERE** clause for a **GROUP BY**

```
SELECT AVG(s.gpa) AS avg_gpa, e.cid
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid
 GROUP BY e.cid
 HAVING AVG(s.gpa) > 3.9;
```

| AVG(s.gpa) | e.cid |
|---|---|
| 3.75 | 15-415 |
| 3.950000 | 15-721 |
| 3.900000 | 15-826 |

→

| avg_gpa | e.cid |
|---|---|
| 3.950000 | 15-721 |

# STRING OPERATIONS

| | String Case | String Quotes |
|---|---|---|
| **SQL-92** | **Sensitive** | **Single Only** |
| Postgres | Sensitive | Single Only |
| MySQL | Insensitive | Single/Double |
| SQLite | Sensitive | Single/Double |
| MSSQL | Sensitive | Single Only |
| Oracle | Sensitive | Single Only |

*SQL-92*
```
WHERE UPPER(name) = UPPER('TuPaC')
```

*MySQL*
```
WHERE name = "TuPaC"
```

# STRING OPERATIONS

**LIKE** is used for string matching.

String-matching operators

→ **'%'** Matches any substring (including empty strings).

→ **'_'** Match any one character

```
SELECT * FROM enrolled AS e
 WHERE e.cid LIKE '15-%'
```

```
SELECT * FROM student AS s
 WHERE s.login LIKE '%@c_'
```

# STRING OPERATIONS

SQL-92 defines string functions.

→ Many DBMSs also have their own unique functions

Can be used in either output and predicates:

```
SELECT SUBSTRING(name,1,5) AS abbrv_name
  FROM student WHERE sid = 53688
```

```
SELECT * FROM student AS s
 WHERE UPPER(s.name) LIKE 'KAN%'
```

# STRING OPERATIONS

SQL standard defines the **||** operator for concatenating two or more strings together.

*SQL-92*
```
SELECT name FROM student
 WHERE login = LOWER(name) || '@cs'
```

*MSSQL*
```
SELECT name FROM student
 WHERE login = LOWER(name) + '@cs'
```

*MySQL*
```
SELECT name FROM student
 WHERE login = CONCAT(LOWER(name), '@cs')
```

# DATE/TIME OPERATIONS

Operations to manipulate and modify DATE/TIME attributes.

→ Can be used in both output and predicates.

→ Support/syntax varies wildly…

**Demo: Get the # of days since the beginning of the year.**

| Database | SQL |
|---|---|
| SQLite3 | `SELECT CAST(julianday(CURRENT_TIMESTAMP) - julianday ('2024-01-01') AS INT) AS DaysSinceYearStart;` |
| MySQL | `SELECT DATEDIFF(CURRENT_TIMESTAMP, '2024-01-01') AS DaysSinceYearStart;` |
| PostgreSQL | `SELECT EXTRACT(DAY FROM CURRENT_TIMESTAMP - '2024-01-01') AS DaysSinceYearStart;` |
| DuckDB | `SELECT (CURRENT_DATE - '2024-01-01'::DATE) AS DaysSinceYearStart;` |

# OUTPUT REDIRECTION

Store query results in another table:

→ Table must not already be defined.

→ Table will have the same # of columns with the same types as the input.

*SQL-92*

```
SELECT DISTINCT cid INTO CourseIds
  FROM enrolled;
```

*MySQL*

```
CREATE TABLE CourseIds (
  SELECT DISTINCT cid FROM enrolled);
```

# OUTPUT REDIRECTION

Store query results in another table:

→ Table must not already be defined.

→ Table will have the same # of columns with the same types as the input.

*SQL-92*

```
SELECT DISTINCT cid INTO CourseIds
  FROM
```

```
CREATE
  SELECT DISTINCT cid FROM enrolled);
```

*Postgres*

```
SELECT DISTINCT cid
  INTO TEMPORARY CourseIds
  FROM enrolled;
```

# OUTPUT REDIRECTION

Insert tuples from query into another table:

→ Inner **SELECT** must generate the same columns as the target table.

→ DBMSs have different options/syntax on what to do with integrity violations (e.g., invalid duplicates).

*SQL-92*

```
INSERT INTO CourseIds
(SELECT DISTINCT cid FROM enrolled);
```

# OUTPUT CONTROL

## ORDER BY <column*> [ASC|DESC]

→ Order the output tuples by the values in one or more of their columns.

```
SELECT sid, grade FROM enrolled
 WHERE cid = '15-721'
 ORDER BY grade
```

| sid | grade |
|---|---|
| 53123 | A |
| 53334 | A |
| 53650 | B |
| 53666 | D |

# OUTPUT CONTROL

## ORDER BY <column*> [ASC|DESC]

→ Order the output tuples by the values in one or more of their columns.

```
SELECT sid, grade FROM enrolled
 WHERE cid = '15-721'
 ORDER BY grade
```

# OUTPUT CONTROL

## ORDER BY <column*> [ASC|DESC]

→ Order the output tuples by the values in one or more of their columns.

```
SELECT sid, grade FROM enrolled
 WH
 OR
```

```
SELECT sid, grade FROM enrolled
 WHERE cid = '15-721'
 ORDER BY 2
```

# OUTPUT CONTROL

## ORDER BY <column*> [ASC|DESC]

→ Order the output tuples by the values in one or more of their columns.

```
SELECT sid, grade FROM enrolled
 WH
 OR
```

```
SELECT sid, grade FROM enrolled
 WHERE cid = '15-721'
 ORDER BY 2
```

```
SELECT sid FROM enrolled
 WHERE cid = '15-721'
 ORDER BY grade DESC, sid ASC
```

| sid |
|---|
| 53666 |
| 53650 |
| 53123 |
| 53334 |

# OUTPUT CONTROL

**FETCH {FIRST|NEXT} <count> ROWS**

**OFFSET <count> ROWS**

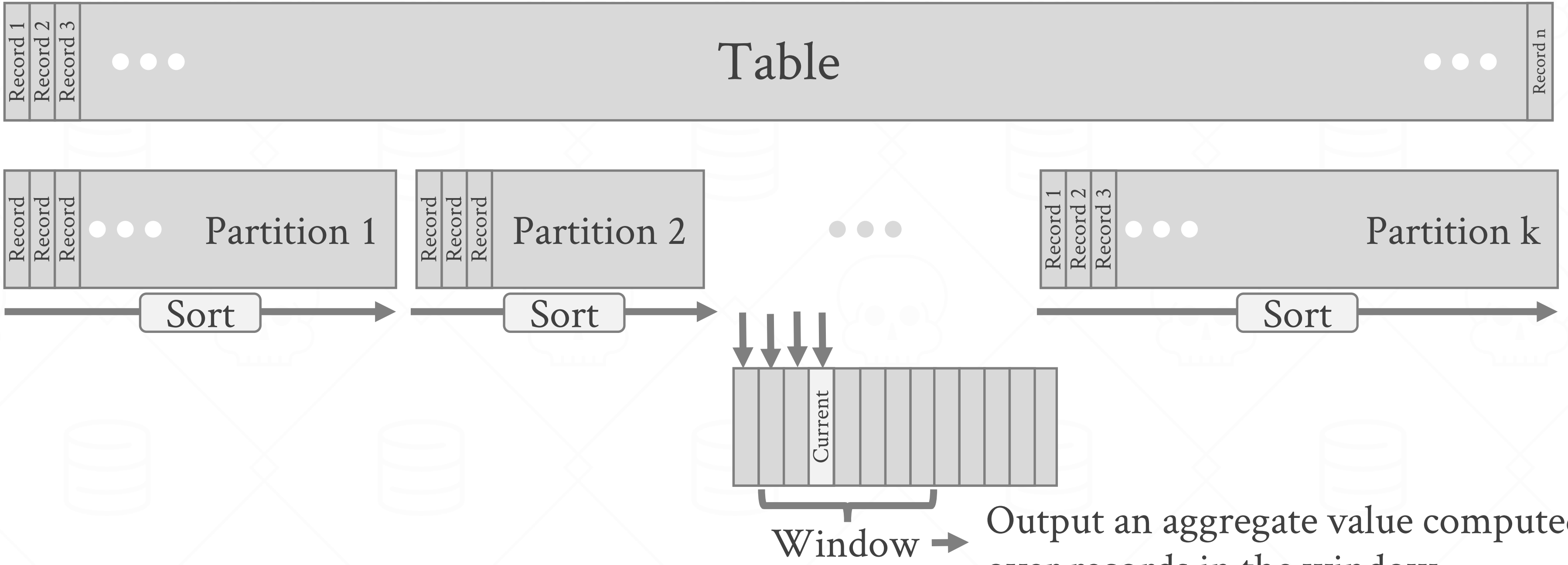
- → Limit the # of tuples returned in output.
- → Can set an offset to return a "range"

```sql
SELECT sid, name FROM student
 WHERE login LIKE '%@cs'
FETCH FIRST 10 ROWS ONLY;
```

```sql
SELECT sid, name FROM student
 WHERE login LIKE '%@cs'
 ORDER BY gpa
OFFSET 10 ROWS
FETCH FIRST 10 ROWS WITH TIES;
```

# WINDOW FUNCTIONS

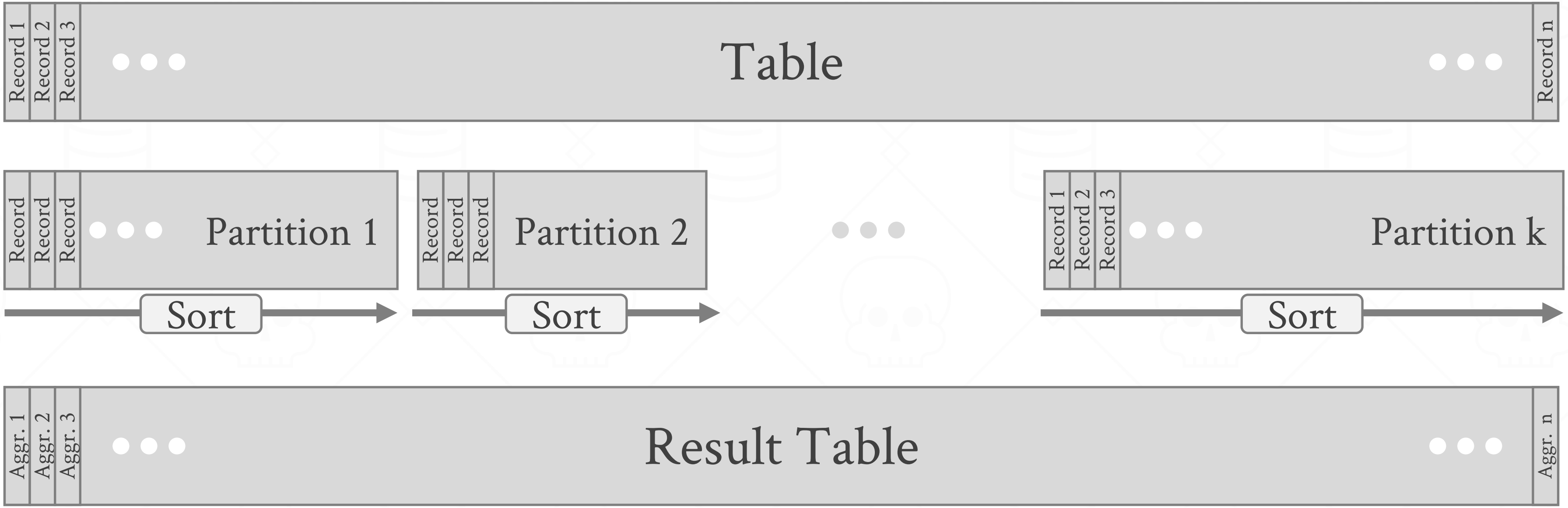
Conceptual execution: Partition data → sort each partition → for each record create a window → compute an answer for each window.




Output an aggregate value computed over records in the window.

# WINDOW FUNCTIONS

Conceptual execution: Partition data → sorts each partition → for each record, creates a window → computes an answer for each window.



# WINDOW FUNCTIONS

## Aggregation functions:

→ Anything that we discussed earlier

## Special window functions:

→ **ROW_NUMBER()**→ # of the current row

→ **RANK()**→ Order position of the current row.

| sid | cid | grade | row_num |
|---|---|---|---|
| 53666 | 15-445 | C | 1 |
| 53688 | 15-721 | A | 2 |
| 53688 | 15-826 | B | 3 |
| 53655 | 15-445 | B | 4 |
| 53666 | 15-721 | C | 5 |

```
SELECT *, ROW_NUMBER() OVER () AS row_num
  FROM enrolled
```

# WINDOW FUNCTIONS

The **OVER** keyword specifies how to group together tuples when computing the window function.

| cid | sid | row_number |
|---|---|---|
| 15-445 | 53666 | 1 |
| 15-445 | 53655 | 2 |
| 15-721 | 53688 | 1 |
| 15-721 | 53666 | 2 |
| 15-826 | 53688 | 1 |

Use **PARTITION BY** to specify group.

```
SELECT cid, sid,
    ROW_NUMBER() OVER (PARTITION BY cid)
  FROM enrolled
 ORDER BY cid
```

# WINDOW FUNCTIONS

You can also include an **ORDER BY** in the window grouping to sort entries in each group.

```
SELECT *,
    ROW_NUMBER() OVER (ORDER BY cid)
  FROM enrolled
 ORDER BY cid
```

# WINDOW FUNCTIONS

*Find the student with the second highest grade for each course.*

**Group tuples by cid**
**Then sort by grade**

```
SELECT * FROM (
  SELECT *, RANK() OVER (PARTITION BY cid
            ORDER BY grade ASC) AS rank
    FROM enrolled) AS ranking
 WHERE ranking.rank = 2
```

# WINDOW FUNCTIONS

*Find the student with the second highest grade for each course.*

**Group tuples by cid**
**Then sort by grade**

```
SELECT * FROM (
  SELECT *, RANK() OVER (PARTITION BY cid
            ORDER BY grade ASC) AS rank
    FROM enrolled) AS ranking
 WHERE ranking.rank = 2
```

# NESTED QUERIES

Invoke a query inside of another query to compose more complex computations.

→ They are often difficult to optimize for the DBMS to optimize due to correlations.

→ Inner queries can appear (almost) anywhere in query.

Outer Query →

```
SELECT name FROM student WHERE
 sid IN (SELECT sid FROM enrolled)
```

← Inner Query

# NESTED QUERIES

*Get the names of students in '15-445'*

```
SELECT name FROM student
 WHERE ...
```

***sid in the set of people that take 15-445***

# NESTED QUERIES

*Get the names of students in '15-445'*

```
SELECT name FROM student
 WHERE ...
   SELECT sid FROM enrolled
    WHERE cid = '15-445'
```

# NESTED QUERIES

*Get the names of students in '15-445'*

```
SELECT name FROM student
 WHERE sid IN (
   SELECT sid FROM enrolled
    WHERE cid = '15-445'
 )
```

# NESTED QUERIES

*Get the names of students in '15-445'*

```
SELECT name FROM student
 WHERE sid IN (
   SELECT sid FROM enrolled
    WHERE cid = '15-445'
 )
```

# NESTED QUERIES

**ALL**→ Must satisfy expression for all rows in the sub-query.

**ANY**→ Must satisfy expression for at least one row in the sub-query.

**IN**→ Equivalent to '**=ANY()**'.

**EXISTS**→ At least one row is returned without comparing it to an attribute in the outer query.

# NESTED QUERIES

*Get the names of students in '15-445'*

```
SELECT name FROM student
 WHERE sid = ANY(
   SELECT sid FROM enrolled
    WHERE cid = '15-445'
 )
```

# NESTED QUERIES

*Find student record with the highest id that is enrolled in at least one course.*

```
SELECT MAX(e.sid), s.name
  FROM enrolled AS e, student AS s
 WHERE e.sid = s.sid;
```

This won't work in SQL-92. It runs in SQLite, but not Postgres or MySQL (v8 with strict mode).

# NESTED QUERIES

*Find student record with the highest id that is enrolled in at least one course.*

```
SELECT sid, name FROM student
 WHERE ...
```

***"Is the highest enrolled sid"***

# NESTED QUERIES

*Find student record with the highest id that is enrolled in at least one course.*

```
SELECT sid, name FROM student
 WHERE sid =
   (SELECT MAX(sid) FROM enrolled)
```

| sid | name |
|---|---|
| 53688 | Bieber |

# NESTED QUERIES

*Find student record with the highest id that is enrolled in at least one course.*

```
SELECT sid, name FROM student
 WHERE sid =
   (SELECT MAX(sid) FROM enrolled)
```

# NESTED QUERIES

*Find all courses that have no students enrolled in it.*

```
SELECT * FROM course
 WHERE ...
```

***"with no tuples in the enrolled table"***

| cid | name |
|---|---|
| 15-445 | Database Systems |
| 15-721 | Advanced Database Systems |
| 15-826 | Data Mining |
| 15-799 | Special Topics in Databases |

| sid | cid | grade |
|---|---|---|
| 53666 | 15-445 | C |
| 53688 | 15-721 | A |
| 53688 | 15-826 | B |
| 53655 | 15-445 | B |
| 53666 | 15-721 | C |

# NESTED QUERIES

*Find all courses that have no students enrolled in it.*

```
SELECT * FROM course
 WHERE NOT EXISTS(
   SELECT * FROM enrolled
    WHERE course.cid = enrolled.cid
)
```

| cid | name |
|---|---|
| 15-799 | Special Topics in Databases |

# NESTED QUERIES

*Find all courses that have no students enrolled in it.*

```
SELECT * FROM course
 WHERE NOT EXISTS(
   SELECT * FROM enrolled
    WHERE course.cid = enrolled.cid
)
```

| cid | name |
|---|---|
| 15-799 | Special Topics in Databases |

# LATERAL JOINS

The **LATERAL** operator allows a nested query to reference attributes in other nested queries that precede it.

→ You can think of it like a **for** loop that allows you to invoke another query for each tuple in a table.

```
SELECT * FROM
  (SELECT 1 AS x) AS t1,
  LATERAL (SELECT t1.x+1 AS y) AS t2;
```

| t1.x | t2.y |
|---|---|
| 1 | 2 |

# LATERAL JOIN

*Calculate the number of students enrolled in each course and the average GPA. Sort by enrollment count in descending order.*

```
SELECT * FROM course AS c,
```

*For each course:*

- *Compute the # of enrolled students*

*For each course:*

- *Compute the average gpa of enrolled students*

# LATERAL JOIN

*Calculate the number of students enrolled in each course and the average GPA. Sort by enrollment count in descending order.*

```
SELECT * FROM course AS c,
  LATERAL (SELECT COUNT(*) AS cnt FROM enrolled
             WHERE enrolled.cid = c.cid) AS t1,
  LATERAL (SELECT AVG(gpa) AS avg FROM student AS s
              JOIN enrolled AS e ON s.sid = e.sid
             WHERE e.cid = c.cid) AS t2;
```

# LATERAL JOIN

*Calculate the number of students enrolled in each course and the average GPA. Sort by enrollment count in descending order.*

```
SELECT * FROM course AS c,
  LATERAL (SELECT COUNT(*) AS cnt FROM enrolled
             WHERE enrolled.cid = c.cid) AS t1,
  LATERAL (SELECT AVG(gpa) AS avg FROM student AS s
              JOIN enrolled AS e ON s.sid = e.sid
             WHERE e.cid = c.cid) AS t2;
```

# LATERAL JOIN

*Calculate the number of students enrolled in each course and the average GPA. Sort by enrollment count in descending order.*

```
SELECT * FROM course AS c,
  LATERAL (SELECT COUNT(*) AS cnt FROM enrolled
             WHERE enrolled.cid = c.cid) AS t1,
  LATERAL (SELECT AVG(gpa) AS avg FROM student AS s
              JOIN enrolled AS e ON s.sid = e.sid
             WHERE e.cid = c.cid) AS t2;
```

# LATERAL JOIN

*Calculate the number of students enrolled in each course and the average GPA. Sort by enrollment count in descending order.*

| cid | name | cnt | avg |
|---|---|---|---|
| 15-445 | Database Systems | 2 | 3.75 |
| 15-721 | Advanced Database Systems | 2 | 3.95 |
| 15-826 | Data Mining | 1 | 3.9 |
| 15-799 | Special Topics in Databases | 0 | null |

```
SELECT * FROM course AS c,
  LATERAL (SELECT COUNT(*) A
                WHERE enrolled.cid = c.cid) AS t1,
  LATERAL (SELECT AVG(gpa) AS avg FROM student AS s
                 JOIN enrolled AS e ON s.sid = e.sid
                WHERE e.cid = c.cid) AS t2;
```

# COMMON TABLE EXPRESSIONS

Provides a way to write auxiliary statements for use in a larger query.

→ A table variable with the lifespan for just that query.

Alternative to nested queries and views.

→ Makes long queries modular

```
WITH cteName AS (
   SELECT 1
)
SELECT * FROM cteName
```

# COMMON TABLE EXPRESSIONS

You can bind/alias output columns to names before the **AS** keyword.

```
WITH cteName (col1, col2) AS (
   SELECT 1, 2
)
SELECT col1 + col2 FROM cteName
```

# COMMON TABLE EXPRESSIONS

*Find student record with the highest id that is enrolled in at least one course.*

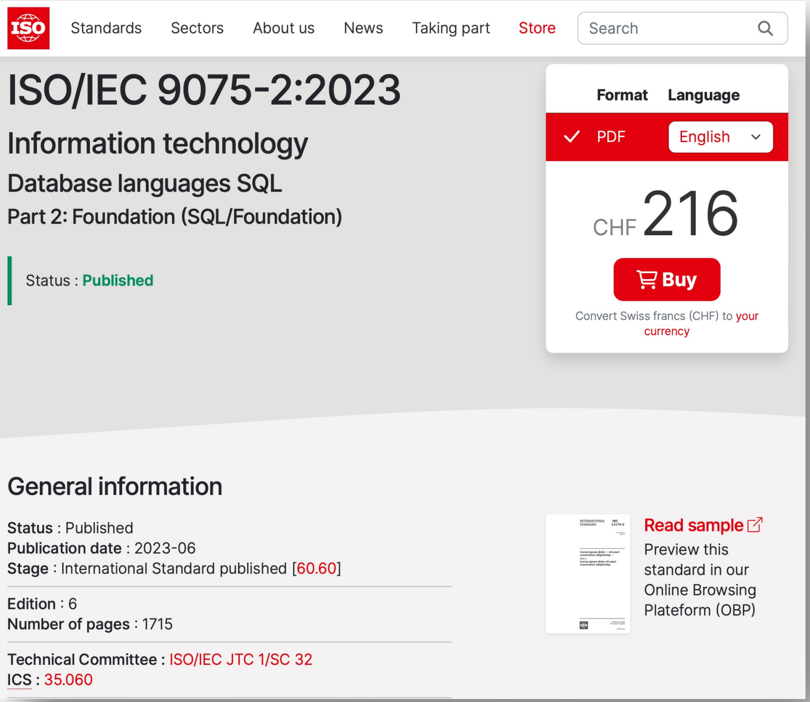
```
WITH cteSource (maxId) AS (
   SELECT MAX(sid) FROM enrolled
)
SELECT name FROM student, cteSource
 WHERE student.sid = cteSource.maxId
```

# OTHER NOTES ABOUT SQL

Identifiers (e.g. table and column names) are case-insensitivity. Makes it harder for applications that care about case (e.g. use CamelCased names).

→ One often sees quotes around names, e.g. SELECT "ArtistList.firstName". Ugly!

The standard itself is behind a paywall ☹



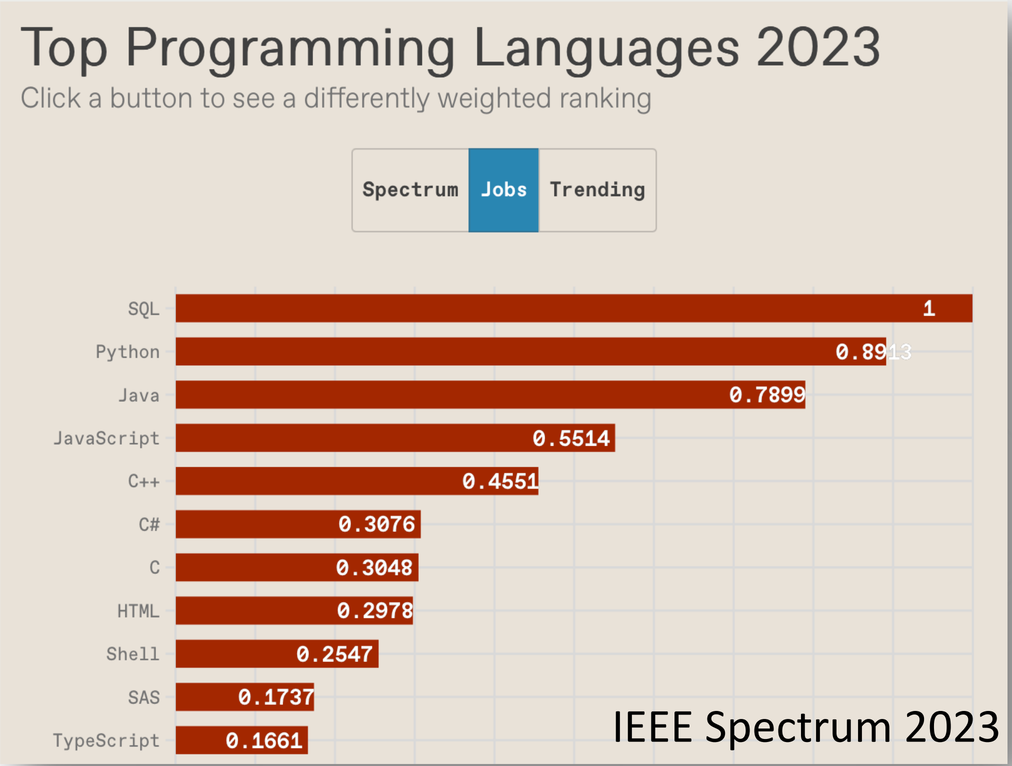
# CONCLUSION

SQL is "hot" language.

→ Lots of NL2SQL tools, but writing SQL is not going away.

→ These tools can aid in writing SQL.

You should (almost) always strive to compute your answer as a single SQL statement.




IEEE Spectrum 2023

# HOMEWORK #1

Write SQL queries to perform basic data analysis.

Write the queries locally using SQLite + DuckDB.

Submit them to Gradescope

You can submit multiple times and use your best score.

**Due: Feb 02, 2024 @ 11:59pm**

https://15445.courses.cs.cmu.edu/spring2024/homework1

# NEXT CLASS

Storage Management