CptS 451- Introduction to Database Systems

SQL : Views and Indexes

(DMS Ch-25.8)

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World Class. Face to Face.

Topics

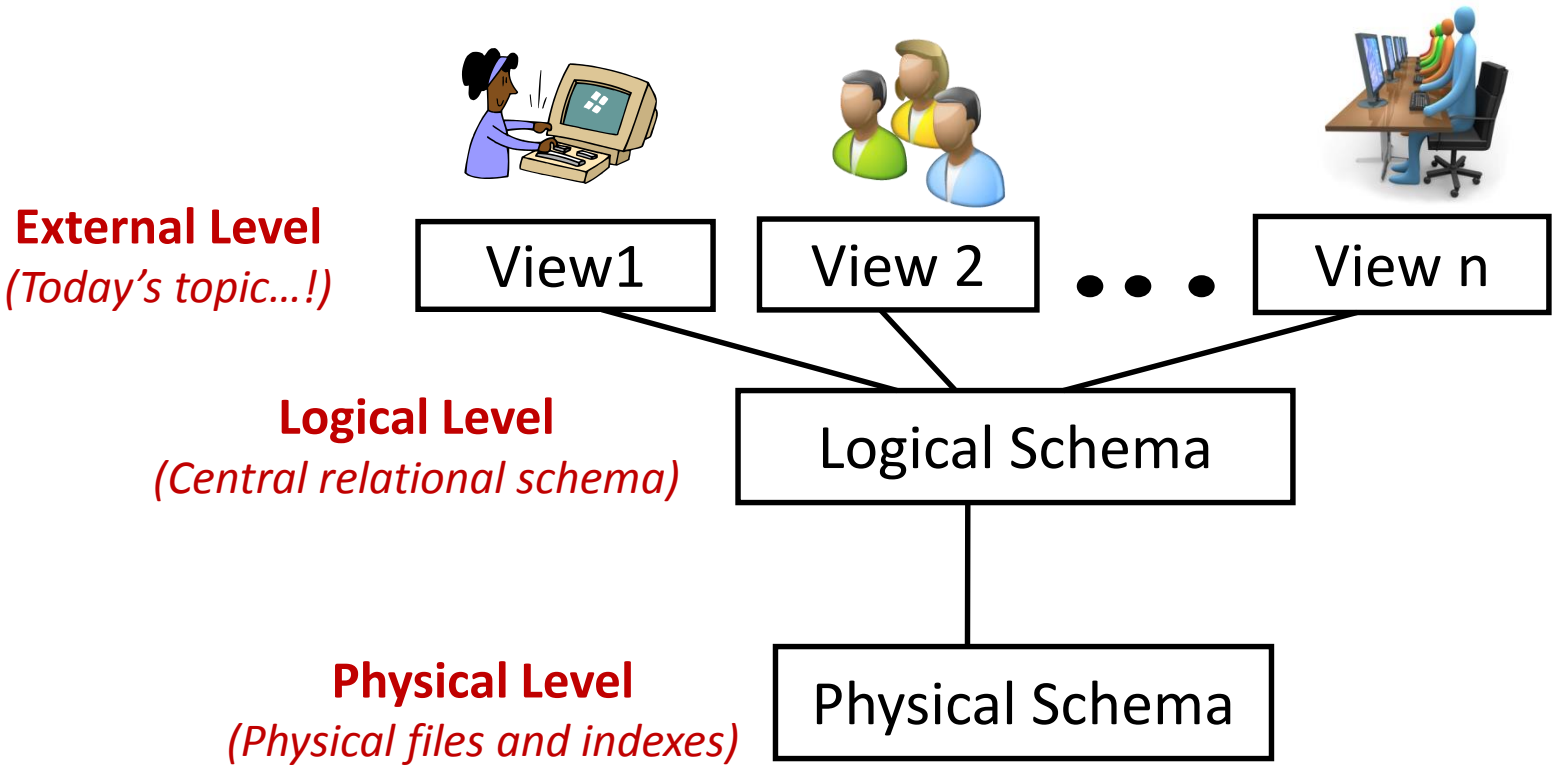
- SQL Views
- Indexes in SQL

SQL Views & Security

- Outline
  - The three-schema architecture
  - View definitions and query execution
  - Views and updates
  - View updates using triggers
  - Views for data independence

Three-Layer Schema Architecture

- Three levels of schemas



Views

- A view is a relation defined in terms of stored tables (called base tables) and other views.
- Two kinds:
  1. Virtual = not stored in the database; just a query for constructing the relation.
  2. Materialized = actually constructed and stored.

View Examples

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Dept(dno, dname, mgr)

dno	dname	mgr
111	Sells	Alice
222	Toys	Lisa
333	Electronics	Mary

- **Example-1**: Employees in the "Purchasing" department.
  - Their names, salaries, departments, and managers

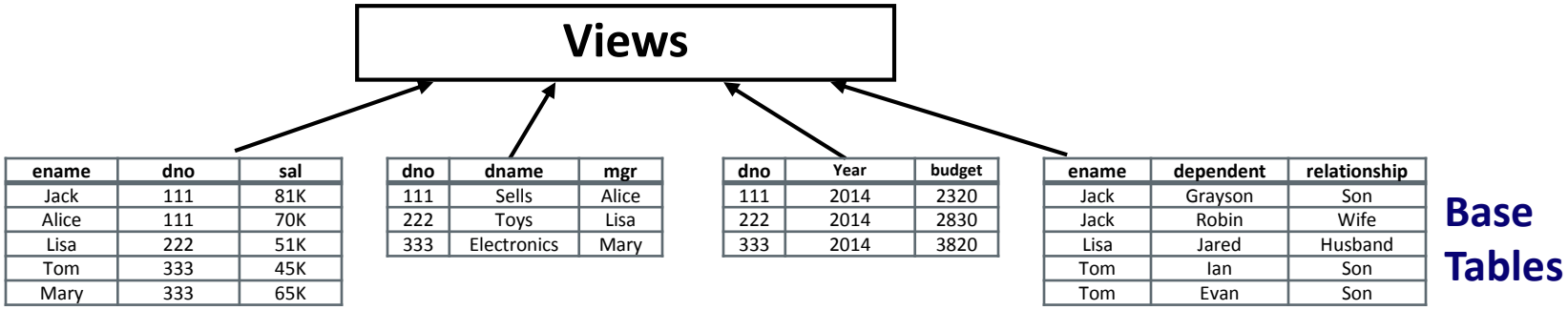
```
CREATE VIEW  PurchEmpInfo AS
        SELECT ename, sal, Emp.dno, mgr
        FROM  Emp, Dept
        WHERE  Emp.dno = Dept.dno AND dname = 'Purchasing';
```

Views

- SQL syntax:

  Virtual: CREATE VIEW <name> AS <query>;

  Materialized: CREATE VIEW [MATERIALIZED]<name> AS <query>;



ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

dno	dname	mgr
111	Sells	Alice
222	Toys	Lisa
333	Electronics	Mary

dno	Year	budget
111	2014	2320
222	2014	2830
333	2014	3820

ename	dependent	relationship
Jack	Grayson	Son
Jack	Robin	Wife
Lisa	Jared	Husband
Tom	Ian	Son
Tom	Evan	Son

Base Tables

- The uses of "views" include:
  - Provide *logical data independence*
  - Serve as a unit of access control for security purposes
  - Simplify common/complex queries by predefining useful "tables"
  - Tailor DB schema to meet the needs of different applications

View Examples

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Dept(dno, dname, mgr)

dno	dname	mgr
111	Sells	Alice
222	Toys	Lisa
333	Electronics	Mary

- **Example-1**: Employees in the "Purchasing" department.
  - Their names, salaries, departments, and managers

```
CREATE VIEW PurchEmpInfo AS
        SELECT ename, sal, Emp.dno, mgr
        FROM  Emp, Dept
        WHERE  Emp.dno = Dept.dno AND dname = 'Purchasing';
```

View Examples

- **Example-2**: Employees in the Purchasing department.
  - Their names, salaries, and managers

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Dept(dno, dname, mgr)

dno	dname	mgr
111	Sells	Alice
222	Toys	Lisa
333	Electronics	Mary

Some attributes can be dropped (e.g., dno) and others renamed (e.g., mgr)

SellsEmpInfo (ename,sal, manager)

ename	sal	manager
Jack	81K	Alice
Alice	70K	Alice

```
CREATE VIEW PurchEmpInfo AS
        SELECT ename, sal, mgr AS manager
        FROM  Emp, Dept
        WHERE  Emp.dno = Dept.dno AND dname = 'Purchasing';
```

View Examples

- **Example-3**: A department summary for managers to use
  - Department dno s, number of employees and average salaries.

```
CREATE VIEW DeptSummary AS
    SELECT d.dno, COUNT (*) as headcnt, AVG(e.sal) as avgsal
    FROM  Dept d, Emp e
    WHERE  e.dno = d.dno
    GROUP BY d.dno;
```

deptSummary(dno, dname, mgr, headcnt, avgsal)

dno	headcnt	avgsal
111	2	70K
222	1	80K
333	2	65K

- With this view, managers don't have to be looking at multiple tables, doing joins, doing aggregations, etc.

Views for Data Independence

- Make existing programs compatible with DB schema changes
  - *Ex:* Emp(emp, dno, sal), Dept(dno, dname, mgr)
    (All applications currently use this old schema)
  - Suppose for some reason we change the schema to:
    E(emp, deptno , sal), D(deptno, dname, mgr)
    (Old applications will not work with this new schema!)
  - Solution: using views, recreate the **old** schema from the **new** schema

CREATE VIEW Emp(ename, dno, sal) AS …
CREATE VIEW Dept(dno, dname, mgr) AS …

→ *Now old applications and queries will still run (modulo updates)!*

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Dept(dno, dname, mgr)

dno	dname	mgr
111	Sells	Alice
222	Toys	Lisa
333	Electronics	Mary

Views for Data Independence (cont.)

Old schema

Queries

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Dept(dno, dname, mgr)

dno	dname	mgr
111	Sells	Alice
222	Toys	Lisa
333	Electronics	Mary

New schema

Queries

CREATE VIEW Emp(ename, dno, sal) AS
SELECT ename, deptno, sal FROM E;

CREATE VIEW Dept(dno, dname, mgr) AS
SELECT deptno, dname, mgr FROM D;

Emp (ename, deptno, sal)

ename	deptno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Dept(deptno, dname, mgr)

deptno	dname	mgr
111	Sells	Alice
222	Toys	Lisa
333	Electronics	Mary

Queries on Views

- Views can be used just like other tables in queries

```
SELECT ename,manager
FROM  SellsEmpInfo
WHERE  sal>=35000;
```

```
SELECT dno, avgsal
FROM DeptSummary
WHERE  headcnt>1;
```

- How does the system answer a query on views?
  - "Replace" it (using view definitions) to get a query over base relations

←(*Note:* FROM clause may contain subqueries!)

```
SELECT S_emp.ename, S_emp.manager
FROM (SELECT ename, sal, mgr as manager
        FROM  Emp, Dept
        WHERE  Emp.dno = Dept.dno AND dname = 'Sells')  AS S_emp
        WHERE S_emp.sal>= 35000;
```

Queries on Views

- Note that views can be layered on other views (and so on)…
  - Example:

```
CREATE VIEW costlyDepts AS
    SELECT dno, headcnt, avgsal, headcnt*avgsal AS spending
    FROM  deptSummary
    WHERE  avgsal >= 70000;
```

costlyDepts(dno, headcnt, avgsal, spending)

dn0	headcnt	avgsal	spending
222	2	70K	140K
111	1	80K	80K

Modifying Views

- How can we modify a view if it is supposedly virtual?
  - INSERT, DELETE, UPDATE
- Many views cannot be modified, as we will soon see
- Some views can be modified (called updatable views)
  - Example:

    INSERT INTO SellsEmpInfo VALUES ('Pete', 111);

Modifications on Views


```
CREATE TABLE Emp(
    ename char(20) PRIMARY KEY,
    dno   int,
    sal   float default 0);
```

```
CREATE VIEW SellsEmpInfo AS
    SELECT ename, dno
    FROM Emp
    WHERE dno = 111;
```

```
INSERT INTO SellsEmpInfo VALUES ('Pete', 111);
```

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K
Pete	111	0

SellsEmpInfo(ename, dno)

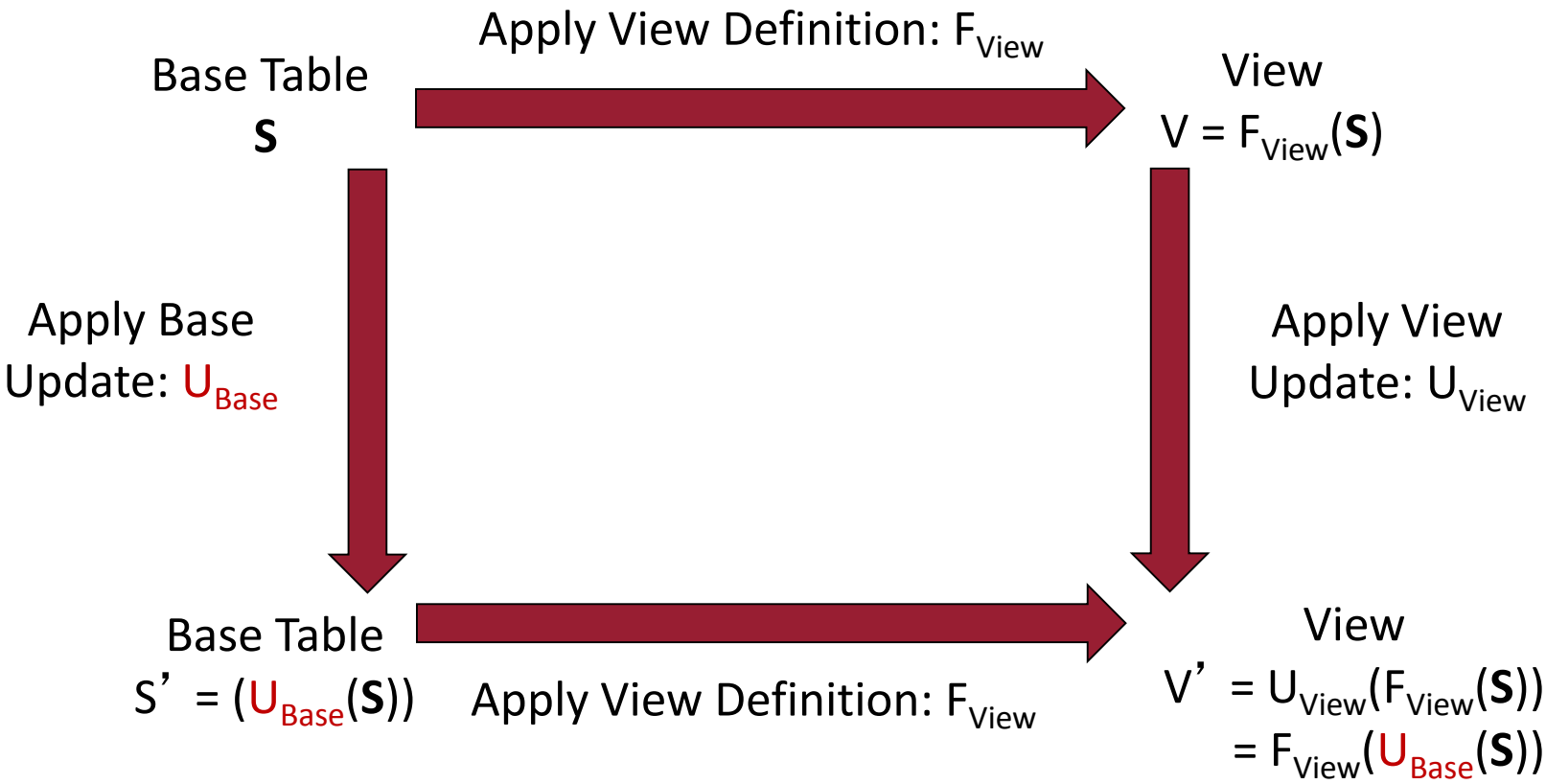
ename	dno
Jack	111
Alice	111
Pete	111

- Insertion of a tuple into a view
  - Insertion of corresponding tuple(s) into its base table(s)
  - Missing column values lead to insertion of NULL or default values
  - The inserted base tuple(s) should generate the new view tuple(s)!

Modifying Views

- Updatable views:
  - An updatable view **V(R)'s** definition must satisfy certain requirements (SQL92):
    - FROM: Consists of one occurrence of R (and no other relations)
    - WHERE: Does not involve R in a subquery
    - SELECT: Includes "enough" attributes, has only simple field references (no arithmetic expressions or aggregates), and not DISTINCT
    - No GROUP BY or HAVING clauses
  - A modification of V is translated to a corresponding modification of R
  - Note: Some vendors support more or less in this area

Principles of Updatable Views



Modifications on Views


```
CREATE TABLE Emp(
    ename char(20) PRIMARY KEY,
    dno   int,
    sal   float default 0);
```

```
CREATE VIEW SellsEmpInfo AS
      SELECT ename
      FROM Emp
      WHERE dno = 111;
```

```
INSERT INTO SellsEmpInfo VALUES ('Pete');
```

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Pete	????	0

SellsEmpInfo(ename)

ename
Jack
Alice

Pete

- Insertion of a tuple into this view
  - Not allowed: What would we insert into Emp.dno? → View not updatable!
  - The DBMS isn't "smart" enough to "know" that the inserted dno value should be 111
  - If dno was inserted as NULL, the new view tuple ("Pete") would not be generated

View Updates Using Triggers

- Remember triggers: ECA rules
  - Event: INSERT, DELETE, UPDATE
  - Condition: WHEN <some condition on table>
  - Action: Some operation
- Use INSTEAD OF triggers on views
  - Specify what to do in case of an update of the view, e.g.:

```
CREATE TRIGGER sellsEmpInsert
INSTEAD OF INSERT on SellsEmpInfo
REFERENCING NEW ROW AS NewRow
FOR EACH ROW
INSERT INTO Emp (ename, dno)
        VALUES (NewRow.ename, 111);
```

Deletes from Updatable Views

- When deleting tuples from a view, system should delete all tuples from base table(s) that can potentially produce the deleted view tuples (and only those tuples, of course)
- Example:

```
DELETE FROM SellsEmpInfo
WHERE ename = 'Jack';
```

will be translated to:

```
DELETE FROM Emp
WHERE ename = 'Jack' AND dno = 111;
```

```
CREATE VIEW SellsEmpInfo AS
    SELECT ename, dno
    FROM Emp
    WHERE dno = 111;
```

SellsEmpInfo(ename, dno)

ename	dno
Jack	111
Alice	111

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	81K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Updates to Updatable Views

- Will update all tuples in the base relations that produce the updated tuples in the view
- Example:

```
CREATE VIEW SellsEmpInfo AS
SELECT ename, dno, sal
FROM Emp
WHERE dno = 111;
```

```
UPDATE sellsEmpInfo SET sal = sal * 0.9
WHERE ename = 'Jack'
```

will be translated to:

```
UPDATE Emp SET sal = sal * 0.9
WHERE ename = 'Jack' AND dno = 111;
```

SellsEmpInfo(ename, dno,sal)

ename	dno	sal
Jack	111	72.9K
Alice	111	70K

Emp (ename, dno, sal)

ename	dno	sal
Jack	111	72.9K
Alice	111	70K
Lisa	222	51K
Tom	333	45K
Mary	333	65K

Materialized Views

- CREATE MATERIALIZED VIEW <name> AS <query>;
- *Ex:* CREATE MATERIALIZED VIEW deptSummary AS … ;

- Problem: each time a base table changes, the materialized view may change.
  - Cannot afford to re-compute the view with each change.
- Solution: A number of policy options are available
  - Incremental maintainance → continual consistency
  - Periodic maintenance → e.g., refresh every 24 hours

Example: A Data Warehouse

- Wal-Mart stores every sale at every store in a database.
- Overnight, the sales for the day are used to update a *data warehouse* which includes materialized views of the sales.
- The warehouse is used by analysts to predict trends and move goods to where they are selling best.

Other Aspects of Views

- Dropping views
  - DROP VIEW <name>;
  - *Ex:* DROP VIEW sellsEmpInfo;
  - Base tables are NOT affected in any way
  - May impact other views/applications

Indexes in SQL

Indexes

- Index : data structure used to speed access to tuples of a relation, given values of one or more attributes.
- For example:
  - a hash index, or
  - a balanced search tree with giant nodes (a full disk page) called a B+ tree.

Declaring Indexes

- No standard!
- Typical syntax:

```
CREATE INDEX dnoInd ON Dept(dno);
CREATE INDEX empInd ON Emp(ename,dept);
```

Using Indexes

- Assume relation R has an index on attributes A1, A2. Given the values v1,v2 for A1,A2; the index takes us to only those tuples that have v1,v2.
- **Example**:

```
CREATE INDEX empInd ON Emp(ename,dno);
```

```
SELECT ename, dno, sal
FROM Emp
WHERE ename='Jack' AND dno = 111;
```

1. Use empInd to get all the employees whose names are "Jack" and that work in department 111
2. Then return the names, department numbers and salaries of those employees.

Using Indexes (cont.)

- **Example**:

```
CREATE INDEX dnoInd ON Emp(dno);
```

```
CREATE INDEX empInd ON Emp(ename);
```

```
SELECT ename, dno, sal
FROM Emp
WHERE ename='Jack' AND dno = 111;
```

Using Indexes (cont.)

- **Example**:

```
CREATE INDEX dnoInd ON Dept(dno);
```

```
CREATE INDEX empDnoInd ON Emp(ename,dno);
```

```
SELECT ename, Emp.dno, sal, mgr
FROM Emp, Dept
WHERE ename='Jack' AND Emp.dno=Dept.dno;
```

1. Use empDnoInd to get all the employees whose names are "Jack".
2. Use dnoInd to get the departments whose dno s match the tuples in step1.
3. Perform the join on tuples from step1 and 2.
4. Then return the names, department numbers, salaries, and managers of those employees.

Database Tuning

- A major problem in making a database run fast is deciding which indexes to create.
- Benefit: An index speeds up queries that can use it.
- Tradeoff: An index slows down all modifications (INSERT,DELETE,UPDATE) on its relation because the index must be modified too.

Useful Indexes

- Often, the most useful index on a relation is an index on the relation's key.
  - The keys are usually used frequently in queries
  - Since each tuple has a unique value for the key, the search on index returns either nothing or a single tuple.
    - i.e., a single page access
- On some occasions, an index can be effective, even if the index is not on a key
  - If the attribute is almost a key, i.e., only a few tuples share the same value for the index attribute(s).
  - If the tuples are clustered (on disk) based on the index attribute(s).

Best Indexes to Create

- Will come later:
  - Query execution
  - Query optimization

SQL

- Go update your resumes, adding “SQL” to your list of “languages spoken”…!