CS525: Advanced Database Organization

Notes 1: Introduction to DBMS Implementation

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Slides: adapted from a course taught by Hector Garcia-Molina, Stanford

Core Terminology Review

- Data
    - any information worth preserving, most likely in electronic form
- Database
    - organized collection of interrelated data that models some aspect of the real-world.
- Query
    - an operation that extracts specified data from the database.
- Relation
    - an organization of data into a two-dimensional table, where rows (tuples) represent basic entities or facts of some sort, and columns (attributes) represent properties of those entities.
- Schema
    - a description of the structure of the data in a database, often called “metadata”

Database Management System (DBMS)

- A DBMS is software that allows applications to store and analyze information in a database.
- A general-purpose DBMS is designed to allow the definition, creation, querying, update, and administration of databases.

Advanced Database Organization?

- =Database Implementation
- =How to implement a database system
- and have fun doing it ;-)

What do you want from a DBMS?

- Keep data around (persistent)
- Answer questions (queries) about data
- Update data

Isn’t Implementing a Database System Simple?

- Relation ⇒ Statements ⇒ Results

Introduction the MEGATRON 3000 Database Management System

- “Imaginary” database System
- The latest from MEGATRON Labs
- Incorporates latest relational technology
- UNIX compatible
- Lightweight & cheap!

MEGATRON 3000 Implementation Details

- MEGATRON 3000 uses the file system to store its relations
- Relations stored in files (ASCII)
- Use a separate file per entity/relation.
- The application has to parse the files each time they want to read/update records.
  - e.g., relation Students($name,id,dept$) is in /usr/db/Students
  - The file Students has one line for each tuple.
  - Values of components of a tuple are stored as a character string, separated by special marker character #

```
Smith   #  123  #  CS
Jonson  #  522  #  EE

           .
```

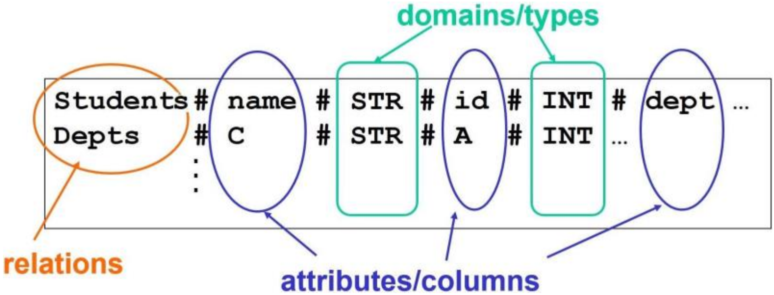
MEGATRON 3000 Implementation Details

- The database schema is stored in a special file
- Schema file (ASCII) in /usr/db/schema
  - For each relation, the file schema has a line beginning with that relation name, in which attribute names alternate with types.
  - The character # separates elements of these lines.

```
Students  #  name  #  STR  #  id  #  INT  #  dept ...
Depts     #   C    #  STR  #  A   #  INT  ...

                           .
```

MEGATRON 3000 Implementation Details



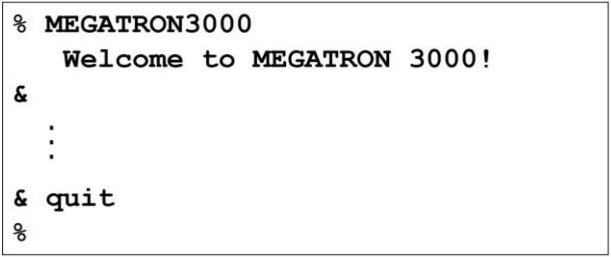
domains/types

```
Students # name # STR # id # INT # dept ...
Depts    # C    # STR # A  # INT ...
         :
         :
```

relations

attributes/columns

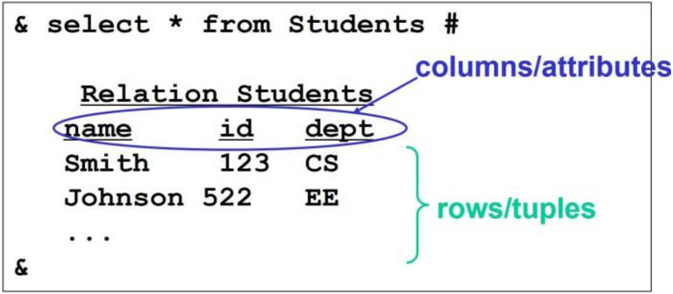
MEGATRON 3000 Sample Sessions



```
% MEGATRON3000
   Welcome to MEGATRON 3000!
&
     .
     .
     .
& quit
%
```

- We are now talking to the MEGATRON 3000 user interface, to which we can type SQL queries in response to the Megatron prompt (&).

MEGATRON 3000 Sample Sessions



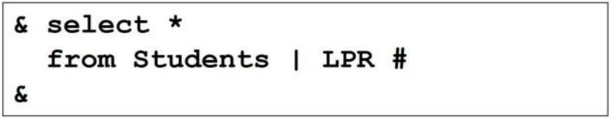
```
& select * from Students #

    Relation Students
   name        id    dept
   Smith       123   CS
   Johnson 522       EE
   ...
&
```

- A # ends a query

Megatron 3000 Sample Sessions

- Execute a query and send the result to printer

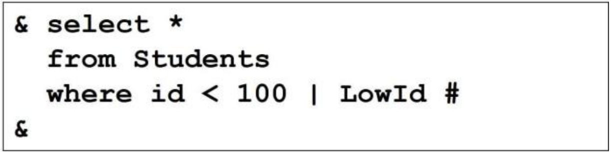


```
& select *
  from Students | LPR #
&
```

- Result sent to LPR (printer).

Megatron 3000 Sample Sessions

- Execute a query and store the result in a new file



```
& select *
  from Students
  where id < 100 | LowId #
&
```

- New relation LowId created.

How MEGATRON 3000 Executes Queries

- To execute

```
SELECT * FROM R WHERE <condition>
```

1. Read schema to get attributes of R
2. Check validity of condition
3. Display attributes of R as the header
4. Read file R; for each line:
    a. Check condition
    b. If TRUE, display the line as tuple

Megatron 3000 Query Execution

- To execute

```
SELECT * FROM R WHERE <condition> | T
```

1. Process select as before but omit Step 3
2. Write results to new file T
3. Append new line to dictionary usr/db/schema

Megatron 3000 Query Execution

- Consider a more complicated query, one involving a join of two relations R, S
- To execute

```sql
SELECT A,B FROM R,S WHERE <condition>
```

1. Read schema to get R,S attributes
2. Read R file, for each line r:
    - a. Read S file, for each line s:
        1. Create join tuple r & s
        2. Check condition
        3. If TRUE, Display $r, s[A, B]$

What's wrong with MEGATRON 3000 DBMS?

- DBMS is not implemented like our imaginary MEGATRON 3000
- Described implementation is inadequate for applications involving significant amount of data or multiple users of data
- Partial list of problems follows

What's wrong with MEGATRON 3000 DBMS?

- Tuple layout on disk is inadequate with no flexibility when the database is modified
- e.g., change String from *CS* to *CSDept* in one Students tuple, we have to rewrite the entire file
  - ASCII storage is expensive
  - Deletions are expensive

What's wrong with MEGATRON 3000 DBMS?

- Search expensive; no indexes
  - e.g., cannot find tuple with given key quickly
  - Always have to read full relation

What’s wrong with Megatron 3000 DBMS?

- Brute force query processing
- e.g.,

```
SELECT * FROM R,S WHERE R.A = S.A and S.B > 1000
```

  - Much better if use index to select tuples that satisfy condition (Do select using S.B >1000 first)
  - More efficient join (sort both relations on A and merge)

What's wrong with MEGATRON 3000 DBMS?

- No buffer manager
  - There is no way for useful data to be buffered in main memory; all data comes off the disk, all the time
  - e.g., need caching.

What's wrong with MEGATRON 3000 DBMS?

- No concurrency control
  - Several users can modify a file at the same time with unpredictable results.

What's wrong with MEGATRON 3000 DBMS?

- No reliability
- e.g., in case of error/crash, say, power failure or leave operations half done
  - Can lose data

What's wrong with MEGATRON 3000 DBMS?

- No security
- e.g., file system security is coarse
    - Unable to restrict access, say, to some fields of a relation and not others

What's wrong with MEGATRON 3000 DBMS?

- No application program interface (API)
  - e.g., how can a payroll program get at the data?

What's wrong with MEGATRON 3000 DBMS?

- Cannot interact with other DBMSs.

What's wrong with MEGATRON 3000 DBMS?

- No GUI

This Course

- Introduce students to better way of building a database management systems.

Reading assignment

- Refresh your memory about basics of the relational model and SQL
  - from your earlier course notes
  - from some textbook
  - http://cs.iit.edu/~cs425/schedule.html

Next

Notes 2: Hardware