An Introduction to Databases

- Today: Relational databases; SQL
- Introduction to Microsoft Access
- Designing a Relational DB
- Building MS Access Applications

1

Outline: Databases

- The Relational Abstraction
  - Tables of data
  - Operations on tables
- Extracting data from Databases: Queries, SQL
- Computer Representation of Databases: Indexes
- DBMS

2

Chrysanthos Dellarocas.

What is a Database

- An abstraction for storing and retrieving related pieces of data
- Many different kinds of databases have been proposed
  - hierarchical, network, etc.
  - each kind supports a different abstract model for organizing data
  - in this class, we will only explain relational databases
    - sets of tables of related data

3

Example DB: Fortune 500 Companies

- company

compname	sales	assets	netincome	empls	indcode	yr
allied	9115000	13271000	-279000	143800	37	85
boeing	9035000	7593000	292000	95700	37	82
...						

- industry codes

indcode	indname
42	pharmaceuticals
44	computers
...	

4

Chrysanthos Dellarocas.

The Relational Abstraction

- Information is in tables
  - Also called (base) relations
- Columns define attributes
  - Also called fields or domains
- Rows define records
  - Also called tuples
- Cells contain values
  - All cells in column have information of same type
    - e.g., integer, floating point, text, date

5

Operating on Databases: SQL

- Every abstraction needs an interface through which users invoke abstract operations
  - graphical interface
  - language
- Structured Query Language
- Has all those operations
- We'll focus only on queries
  - Query = question
  - Extract some data from one or more tables to answer a particular question

6

Chrysanthos Dellarocas.

The Select Statement

- **Every select statement yields a table of values as output**
  - **Sometimes there's only one row in the table!**

select	columns and/or expressions
from	tables
where	conditions on the rows
group by	group rows together
having	conditions on the groups
order by	order the rows
into temp	save results of query in a temporary table

7

Display Company Data

```
SELECT *
    FROM company;
```

8

Chrysanthos Dellarocas.

Choose Columns

- Choosing a subset of columns is sometimes called "project" operation
- Display company name and income for each year
- `SELECT compname, netincome, yr`
  `FROM company;`

compname	netincome	yr
allied	-279000	85
boeing	292000	82
...		

9

Choose Rows

- Find performance data for 1984 for boeing

```
SELECT compname, netincome, yr
  FROM company
  WHERE yr = 84 AND compname = “boeing”;
```

- Which companies lost money in 1984?

10

Chrysanthos Dellarocas.

Compute Columns

- Find return on assets for each year

```
SELECT compname, yr,
(netincome/assets) AS roa
  FROM company;
```

- Nice names for output columns
  - Name following computed column (e.g., roa) will be used to name output column
- Find company-years with roa of more than 15%

11

Sorting

- Can sort output by contents of a column
  - sort in ascending or descending order
  - sort by more than one column (second one breaks ties)
- Sort companies by 1984 profits

```
SELECT compname, netincome
  FROM company
  WHERE yr = 84
  ORDER BY netincome DESC;
```

- Sort companies by 1984 return on assets

12

Chrysanthos Dellarocas.

Aggregates

- Can make calculations on entire columns
  - sum, avg, max, min, count
- How many apparel companies are in database and what are their total sales for 1984?

```
SELECT Count(*) AS number,
       Sum(sales) AS totalsales
  FROM company
  WHERE indcode = 40 and yr = 84;
```

  - returns a table with just one row!
- What is average percent roa for apparel companies in 1984?

13

Grouping and Aggregates

- Each different value for the group by fields defines a new group
- One row of output is produced for each group
- Several rows may belong to same group
  - Aggregate those using aggregation operator
- Compute total sales by all companies for each year

```
SELECT yr,
       Sum(sales) AS totalsales
  FROM company
  GROUP BY yr;
```

yr	totalsales
82	575837090
83	612820552
84	721430558
85	744115766

14

Chrysanthos Dellarocas.

More examples

- **Compute total sales by all companies for each year**

```
SELECT yr, Sum(sales) AS totalsales
  FROM company
  GROUP BY yr;
```

- **Compute total sales for each company**

- **What are the leading industries in total sales for 1984?**

15

Joins

- **Combine rows from one table with rows from another**
- **Usually join on some common column**
  - Don't combine rows unless their value in the common column is the same
  - Where clause says the common column must be same in each table
- **Find the industry name for each company**

```
SELECT company.compname AS compname,
  codes.indname AS industry
   FROM company, codes
   WHERE company.indcode = codes.indcode;
```

compname	*industry*
allied	aerospace
boeing	aerospace
...	

16

Chrysanthos Dellarocas.

Example DB: Fortune 500 Companies

- **company**

compname	sales	assets	netincome	empls	indcode	yr
allied	9115000	13271000	-279000	143800	37	85
boeing	9035000	7593000	292000	95700	37	82
...						

- **industry codes**

indcode	indname
42	pharmaceuticals
44	computers
...	

17

Database Representations

- **Requirements:**
  - **Minimize disk space taken by database**
  - **Enable fast retrieval of records with desired properties**
- **Main ideas:**
  - **Store tables as sequential files**
    - **within each table records can be stored in any order**
  - **Augment those tables with indexes to accelerate retrieval**

18

Indexes

- Like a book index, it says where to find things
- Indexes can make queries run faster
- To understand indexes we have to break the abstraction barrier
  - How are tables stored?
    - Assume they are stored sequentially, one row after the other
      - Each row takes a fixed number of bytes of storage
  - How are queries processed?

19

Example

```
SELECT *
    FROM company
    WHERE indcode = 42;
```

- Suppose know nothing about order of records in company
  - check each record in sequence
    - if indcode = 42, put it into output table
- Suppose know records stored in ascending order by indcode
  - How will this help?
- So why not sort the records by indcode to make this query go faster?

20

Chrysanthos Dellarocas.

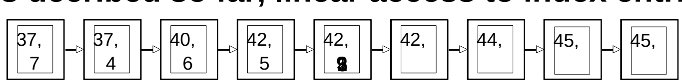
Index on indcode

- Each index entry is an (indcode, record position) pair
- Leave the storage of the records alone
- Sort the index entries in increasing order by indcode
- Can store several indices (e.g., on indcode, on assets, etc.)
  - Requires less space than keeping several sorted copies of the actual tables
- Can we do even better?
  - Can we skip directly to index entries for indcode 42?

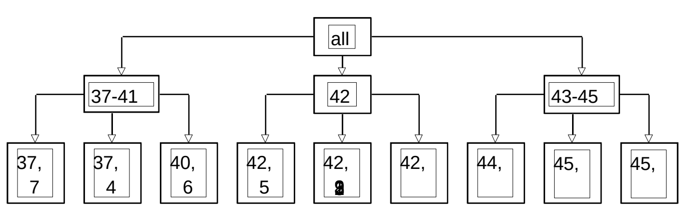
21

Linear vs. Tree Indices

- As decribed so far, linear access to index entries



- Tree access to index entries



- Now can avoid looking at first three index entries and last three

22

Chrysanthos Dellarocas.

More on Trees

- That was a trinary tree
  - Each node had three "children"
  - Three is called the breadth
- Often use binary trees
  - Each node has ____ children
- Binary trees give fast access—if they are "balanced"
- If one "branch" of the tree is a lot heavier (has more nodes), lose benefit
- B-trees are trees that are guaranteed to stay pretty balanced, even as you add new nodes
- Most indices are implemented with some variation on B-trees

23

DBMS

- A Database Management System (DBMS) maintains the abstraction
  - Translates relational tables from/to internal representation
  - Implements operations on relational tables
    - Creates/Modifies tables
    - Inserts/Deletes data
    - Runs queries
    - ...
- Usually, DBMS builds on top of the OS-provided abstraction of files to store tables
  - this is an example of abstraction layering

24

Chrysanthos Dellarocas.