CPS 216: Data-intensive Computing Systems

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Let us first see what a relational database system is.
Data Management

User/Application

Query

Query

Query

Data

DataBase Management System (DBMS)
Example: At a Company

Query 1: Is there an employee named “Nemo”?
Query 2: What is “Nemo’s” salary?
Query 3: How many departments are there in the company?
Query 4: What is the name of “Nemo’s” department?
Query 5: How many employees are there in the “Accounts” department?

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>DeptID</th>
<th>Salary</th>
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<tr>
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<td>Nemo</td>
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<td>Dory</td>
<td>156</td>
<td>79K</td>
<td></td>
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<tr>
<td>40</td>
<td>Gill</td>
<td>89</td>
<td>76K</td>
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<td>52</td>
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<td>85K</td>
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<tr>
<td>156</td>
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Employee

Department
Data Management System (DBMS)

High-level Query Q

Answer

DBMS

Translates Q into best execution plan for current conditions, runs plan

Data
Example: Store that Sells Cars

Owners of Honda Accords who are <= 23 years old

Filter (Make = Honda and Model = Accord)

Join (Cars.OwnerID = Owners.ID)

Filter (Age <= 23)

<table>
<thead>
<tr>
<th>Make</th>
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<th>ID</th>
<th>Name</th>
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<table>
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<tbody>
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<tr>
<td>156</td>
<td>Dory</td>
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</table>
**Data Base Management System (DBMS)**

- **High-level Query Q**
- **Answer**
- Translates Q into best execution plan for current conditions, runs plan

- Keeps data safe and correct despite failures, concurrent updates, online processing, etc.
A Brief History

Relational database management systems

Time

1975-1985
1985-1995
1995-2005
2005-2010
2020

Assumptions and requirements changed over time

Semi-structured and unstructured data (Web)

Hardware developments

Developments in system software

Changes in data sizes
Big Data: How much data?

- Google processes 20 PB a day (2008)
- Wayback Machine has 3 PB + 100 TB/month (3/2009)
- eBay has 6.5 PB of user data + 50 TB/day (5/2009)
- Facebook has 36 PB of user data + 80-90 TB/day (6/2010)
- CERN’s LHC: 15 PB a year (any day now)
- LSST: 6-10 PB a year (~2015)

640K ought to be enough for anybody.

From http://www.umiacs.umd.edu/~jimmylin/
eBay Analytics Technology Highlights

>50 TB/day of new, incremental data >100k data elements
>150^10 new records/day

>50 PB/day Processed
>50k chains of logic >5000 business users & analysts

Active/Active

24x7x365 Always online

turning over a TB every 5 seconds

Millions of queries/day

99.98+% Availability Near-Real-time

From: http://www.cs.duke.edu/smdb10/
NEW REALITIES

The quest for knowledge used to begin with grand theories.

Now it begins with massive amounts of data.

Welcome to the Petabyte Age.

From: http://db.cs.berkeley.edu/jmh/
Greenplum parallel DB
- 42 Sun X4500s ("Thumper") each
  with:
  - 48 500GB drives
  - 16GB RAM
  - 2 dual-core Opterons
- Big and growing
  - 200 TB data (mirrored)
  - Fact table of 1.5 trillion rows
  - Growing 5TB per day
  - 4-7 Billion rows per day

Also extensive use of R and Hadoop

Yahoo! runs a 4000 node Hadoop cluster (probably the largest).
Overall, there are 38,000 nodes running Hadoop at Yahoo!

From: http://db.cs.berkeley.edu/jmh/

As reported by FAN, Feb, 2009
A SCENARIO FROM FAN

How many female WWF fans under the age of 30 visited the Toyota community over the last 4 days and saw a Class A ad?

How are these people similar to those that visited Nissan?

Open-ended question about statistical densities (distributions)

From: http://db.cs.berkeley.edu/jmh/
MULTILINGUAL DEVELOPMENT

- SQL or MapReduce
- Sequential code in a variety of languages
  - Perl
  - Python
  - Java
  - R
- Mix and Match!

From: http://db.cs.berkeley.edu/jmh/
The Next Gen = Cloud Computing

I can develop and deploy quickly in a Cloud!

I can do my job from anywhere!

We can Back Up our data center in the cloud!
What we will cover

• Principles of query processing (35%)
  – Indexes
  – Query execution plans and operators
  – Query optimization

• Data storage (15%)
  – Databases Vs. Filesystems (Google/Hadoop Distributed FileSystem)
  – Data layouts (row-stores, column-stores, partitioning, compression)

• Scalable data processing (40%)
  – Parallel query plans and operators
  – Systems based on MapReduce
  – Scalable key-value stores
  – Processing rapid, high-speed data streams

• Concurrency control and recovery (10%)
  – Consistency models for data (ACID, BASE, Serializability)
  – Write-ahead logging
Course Logistics

- Web: http://www.cs.duke.edu/courses/fall11/cps216
- TA: Rozemary Scarlat
- Books:
  - (Recommended) *Hadoop: The Definitive Guide*, by Tom White
  - *Cassandra: The Definitive Guide*, by Eben Hewitt
- Grading:
  - Project 25% (Hopefully, on Amazon Cloud!)
  - Homeworks 25%
  - Midterm 25%
  - Final 25%
Projects + Homeworks (50%)

• Project 1 (Sept to late Nov):
  1. Processing collections of records: Systems like Pig, Hive, Jaql, Cascading, Cascalog, HadoopDB
  2. Matrix and graph computations: Systems like Rhipe, Ricardo, SystemML, Mahout, Pregel, Hama
  3. Data stream processing: Systems like Flume, FlumeJava, S4, STREAM, Scribe, STORM
  4. Data serving systems: Systems like BigTable/HBase, Dynamo/Cassandra, CouchDB, MongoDB, Riak, VoltDB

• Project 1 will have regular milestones. The final report will include:
  1. What are properties of the data encountered?
  2. What are concrete examples of workloads that are run? Develop a benchmark workload that you will implement and use in Step 5.
  3. What are typical goals and requirements?
  4. What are typical systems used, and how do they compare with each other?
  5. Install some of these systems and do an experimental evaluation of 1, 2, 3, & 4

• Project 2 (Late Nov to end of class). Of your own choosing. Could be a significant new feature added to Project 1

• Programming assignment 1 (Due third week of class ~Sept 16)
• Programming assignment 2 (Due fifth week of class ~Sept 30)
• Written assignments for major topics