Database@Duke

CPS 300: Introduction to Graduate Study

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Announcements

- Homework (due in two weeks)
  - Write (or update) your resume/CV
  - Put up (or update) your homepage on http://www.cs.duke.edu/~*yourlogin*/
    - Have your resume/CV available in HTML or PDF for download
- Next session (Oct. 21): Prof. Xiaobai Sun on scientific computing research

Common misconceptions

- Database people are SQL freaks!
- Database systems have gone commercial for more than 40 years! What else is there to research?
- Database is a business application. *Narrow. Boring.*

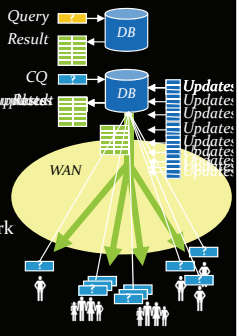
Rebuttal 1

Misconception: *Database people are SQL freaks!*

- We are true believers of the importance of abstraction and semantics (which are far more important than syntax)
- Rising human costs and increasing system complexities only make this importance grow over time
- Looking for the "right" high-level abstraction for emerging applications continues to be an active area of research

ProSem

- One-time query over a static snapshot of database
- Continuous query over an input update stream
- Scalability challenges
  - Too much data
  - Too many continuous queries
  - Results needed all over the network



Rebuttal 2

Misconception: *Database systems have gone commercial for more than 40 years! What else is there to research?*

- (BTW, Relatively few changes to SQL over the years = we really got the abstraction right!)
- Stuff underneath the hood has been and will be changing a lot ⇒ must adapt to new technology trends
- Besides, much of database research has gone beyond relational databases to data management in general…

Data processing on SSDs

- Solid State Drives promise much faster and "greener" data access than hard disks
  - Random reads are just as fast as sequential reads
  - Overwriting data is much, much slower than reads and writes that do not overwrite
- Many assumptions made in the design of the data structures, algorithms, and software architecture of databases are now invalid!

Rebuttal 3

Misconception: *Database is a business application. Narrow. Boring.*

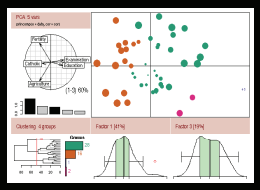
- We do anything data-intensive these days—be it commercial, scientific, or societal
  - Web, sensor networks, data-driven system management, data-intensive statistical computing, computational journalism, etc.
- We collaborate a lot with other computer scientists
  - E.g., Pankaj Agarwal, Jeff Chase, Kamesh Munagala
- And statisticians, ecologists, immunologists…
- And researchers from leading industry research labs

Sensors in Duke Forest

- Use wireless sensor networks to study how environment affects tree growth in Duke forest
- Model-based data suppression and model-driven data analysis and recovery

RIOT

- R: a popular open-source language/environment for statistical computing
  - Seriously challenged by big-data problems
- RIOT
  - Attains efficiency without explicit user intervention
    - Smarter I/Os, parallelism
  - Runs legacy code with little or minimal modification
  - Blurs the boundary between host language and backend processing



Additional resources

- CPS 116: undergrad-level database course, for acquiring more background
  - Focuses on using data management systems and techniques effectively
  - Relational; XML; fundamentals of database system internals; overview of various topics
- CPS 216: grad-level database course, as gateway to research
  - Focuses on building database systems and developing new, scalable data processing techniques
  - Principles and internals of database and massive data-intensive systems; selection of latest research topics
  - You will find it useful/interesting even if you are not a database student

Additional resources (cont'd)

- CPS 296: topics (vary across offerings)
  - CPS 296.1 this coming Spring (*Database and Programming Languages: Crossing the Chasm*) will explores new abstractions and techniques for building data-driven and data-intensive applications
    - Handling impedance mismatches between programming paradigms
    - Abstractions and primitives for data parallelism
    - New, data-centric declarative languages for domains such as networking and system management
- Monthly dbgroup meetings to discuss new research developments and trends
  - Watch for my email announcement

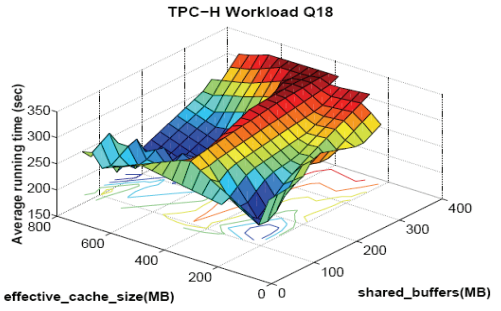
Research in My Group

- Experiment-driven system management
- Big-data processing and Cloud computing
- Querying a system (diagnosis, forecasting, …)

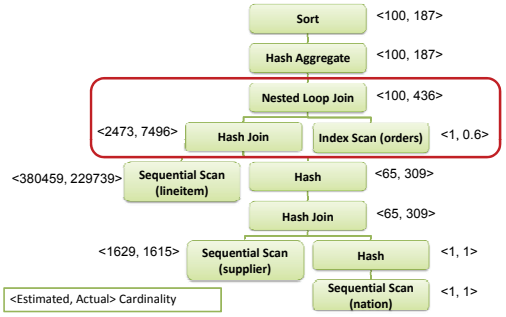
- Graduate students I work with at Duke:
  - Nedyalko Borisov
  - Azbayar Demberel (Jeff Chase's student)
  - Herodotos Herodotou
  - Harold Lim (Jeff Chase's student)
  - Risi Thonangi (Jun Yang's student)
  - Vamsidhar Thummala

Response Surfaces

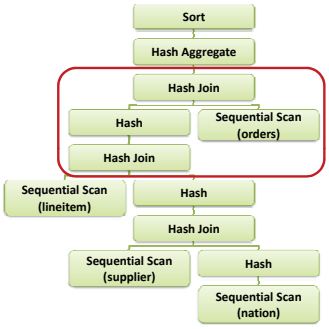
- TPC-H 4 GB database, 1 GB memory, Query 18



Plan Selected by Query Optimizer



Better Plan



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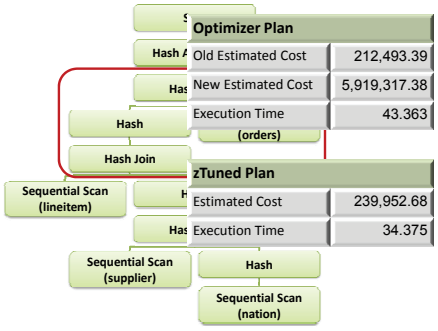
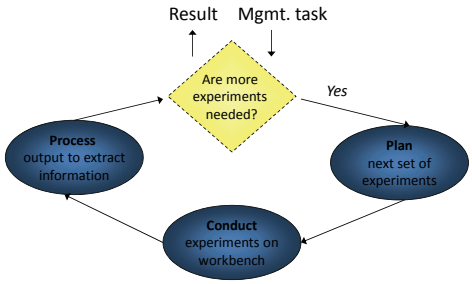
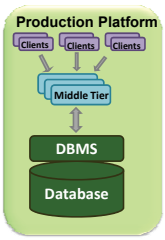


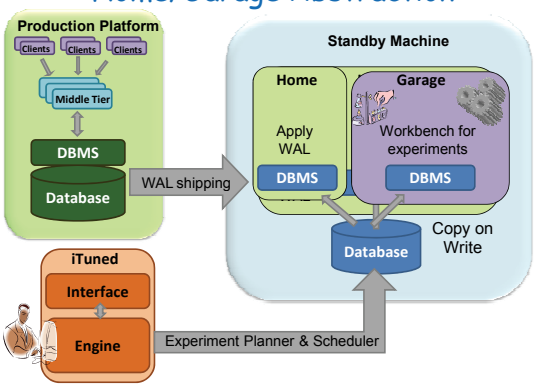
Experiment-driven Management



Where to Run Experiments?



Home/Garage Abstraction



Workbench API

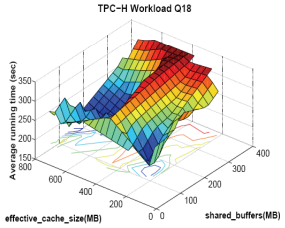
Operation in API	Time (seconds)	Description
Create Container	610	Create a new garage (one time process)
Clone Container	17	Clone a garage from already existing one
Boot Container	19	Boot garage from halt state
Halt Container	2	Stop garage and release resources
Reboot Container	2	Reboot the garage
Snapshot-R DB (5GB, 20GB)	7, 11	Create read-only snapshot of the database
Snapshot-RW DB (5GB, 20GB)	29, 62	Create read-write snapshot of database

Experiment-driven Mgmt: Why Now?

- Trend 1: Increasing use of data management platforms by unsophisticated users
  - Web 2.0, Facebook apps, …
- Trend 2: Good admins scarce and expensive
- Trend 3: Cheap, pay-as-you-go resources with cloud computing

Back of the Envelope Calculation

- DBAs cost $300/day; Consultants cost $100/hr
- 1 Day of experiments give a wealth of info.
  - TPC-H, TPC-W, RUBiS workloads; 10-30 conf. params



- Cost of running these experiments for 1 day on Amazon Web Serv.
  - Server: $10/day
  - Storage: $0.4/day
  - I/O: $5/day
  - TOTAL: $15/day

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Big Data

- Metrics on eBay's main Teradata data warehouse include:
  - **>2 petabytes of user data**
  - **10s of 1000s of users**
  - **Millions of queries per day**
  - 72 nodes
  - >140 GB/sec of I/O, or **2 GB/node/sec at peak**
  - 100s of production databases being fed in
- Metrics on eBay's Greenplum data warehouse/mart:
  - **6.5 petabytes of user data**
  - **17 trillion records**
  - **150 billion new records/day ➔ 50 terabytes/day**
  - 96 nodes
  - **200 MB/node/sec** of I/O
  - 4.5 petabytes of storage, 70% compression
  - A small number of concurrent users

Two Schools in Big Data Processing

- The world born from Parallel Databases
  - Teradata, Oracle RAC, HP's NeoView, …
  - New kids on the block: AsterData, Greenplum, …
- The world born from Google's MapReduce
  - Hadoop (originally from Yahoo!)
  - HDFS (originally from Yahoo!)
  - Hive (Facebook)
  - Pig (Yahoo!)
  - …

Tons of Interesting Problems

- Efficient query processing over MapReduce
- Query should go on even if nodes fail
- Tuning, problem diagnosis, …
- Elastic computing
- Data partitioning, placement, and rebalancing
- Adaptive processing
- Scheduling
- …

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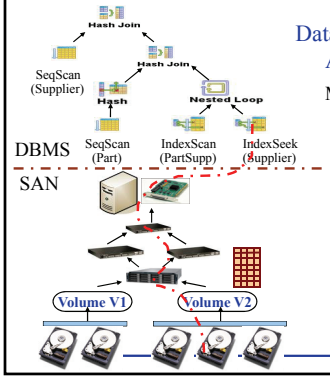
Databases on SANs



Database often run on Storage Area Networks

Makes problem diagnosis hard