CS 525
Advanced Distributed Systems
Spring 2010

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Old Wine: Stale or Vintage?

April 27, 2010

A comparison of approaches to large-scale data analysis

A. Pavlo et al
SIGMOD 2009

(there is also a shorter paper in CACM, Jan 2010)

Databases vs. Clouds

- Basic Question: Why use MapReduce (MR), when parallel databases have been around for decades and have been successful?
- Written by experts in databases research, including those who defined relational DBs many decades ago.
- Some in databases community felt they might be hurt by these new-fangled cloud computing paradigms which were just reiventing the wheel

Relational Database

- Consists of schemas
  - Employee schema, Company schema
- Schema = table consisting of tuples
  - <Employee name, company> <Company name, number of employees>
- Tuple = consists of multiple fields, including primary key, foreign key, etc.
  - <Employee name, company>
- SQL queries run on multiple schemas very efficiently

Parallel DB is similar to MR

Parallel DBs = parallelize query operation across multiple servers

- Parallel DBs: data processing consists of 3 phases
  - E.g., consider: joining two tables T1 and T2
    1. Filter T1 and T2 parallelly (~ Map)
    2. Distribute the larger of T1 and T2 across multiple nodes, then broadcast the other Ti to all nodes (~Shuffle)
    3. Perform join at each node, and store back answers (~Reduce)
- Parallel DBs used in the paper: DBMS-X and Vertica
- MR representative: Hadoop

Advantages of Parallel DBs over MR

- Schema Support: more structured storage of data
  - Really needed?
- Indexing: e.g., B-trees
  - Really needed? What about BigTable?
- Programming model: more expressive
  - What about Hive and Pig Latin?
- Execution strategy: push data instead of pull (as in MR)
  - They argue it reduces bottlenecks
    - Really? What about the network I/O bottleneck?

Load Times

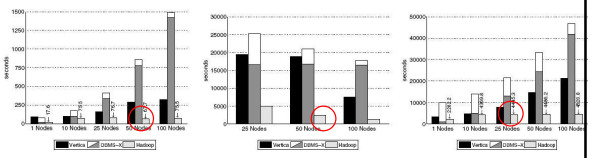


Figure 1: Load Times – Grep Task Data Set (535MB/node)

Figure 2: Load Times – Grep Task Data Set (1TB/cluster)

Figure 3: Load Times – UserVisits Data Set (20GB/node)

- The cost of "structured schema" and "indexing"
- Data loaded on nodes sequentially! (implementation artifact?)
- Are these operations really needed?

Actual Execution

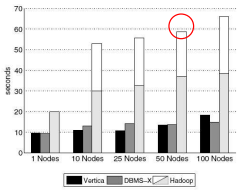


Figure 4: Grep Task Results – 535MB/node Data Set

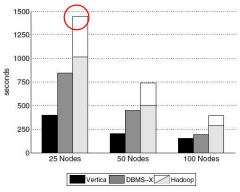


Figure 5: Grep Task Results – 1TB/cluster Data Set

- Hadoop always seems worst
  - Overhead rises linearly with data stored per node
- Vertica is best
  - Aggressive compression
  - More effective as more data stored per node

Other Tasks

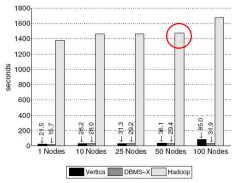


Figure 9: Join Task Results

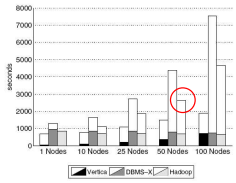


Figure 10: UDF Aggregation Task Results

- MR was never built for Join!
  - What about MapReduce-Merge?
- UDF does worst because of row-by-row interaction of DB and input file which is outside DB
  - How common is this in parallel DBs?

What have we learnt?

- Load time advantage is in 1000s of seconds for MR, while execution time disadvantage is in 10s of seconds
  - Means what?
- Pre-processing cuts down on processing time
  - E.g., selection task: Vertica and DBMS-X already use an index on pageRank column
  - No reason why we can't do this preprocessing using MR!
- MapReduce is better matched to on-demand computations, while parallel DBs are better for repeated computations.

Discussion Points

- Performance vs. Complexity: does the study account for this tradeoff?
  - Which is more complex: RDB's or MR?
- "It is not clear how many MR users really need 1000 nodes." (page 2)
  - What do you think?
  - What about shared Hadoop services?

On death, taxes, and the convergence of peer to peer and Grid Computing

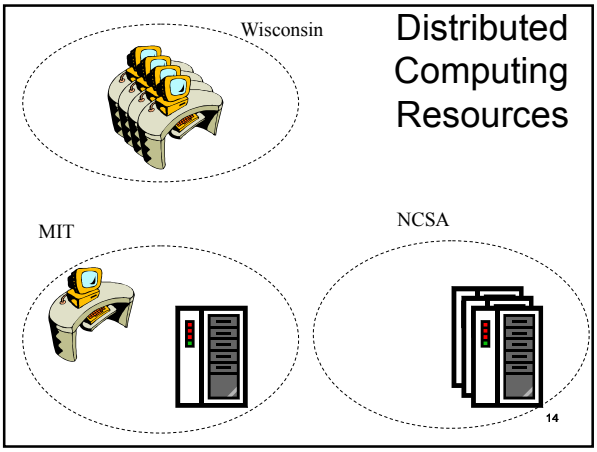
I. Foster et al

IPTPS 2003

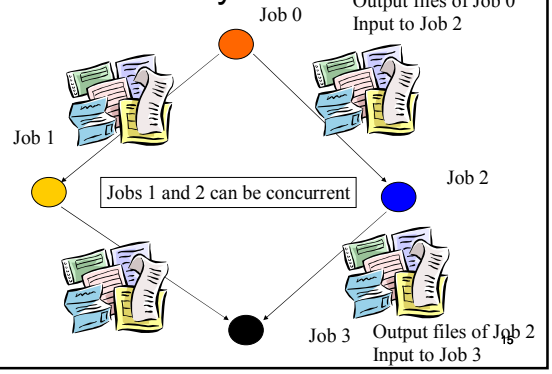
Context

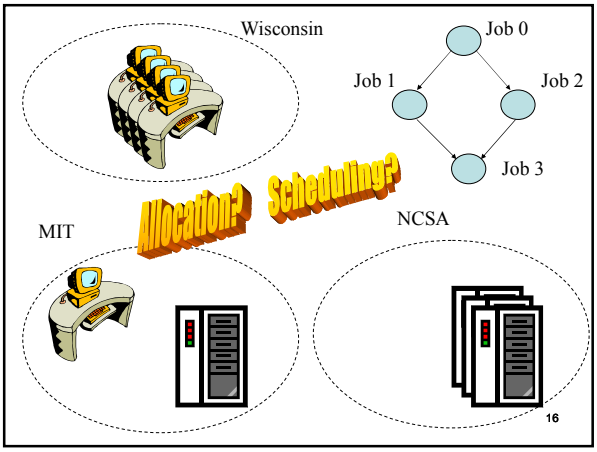
- Written by the "father" of Grid Computing (Ian Foster)
- Written in an era where p2p was very active research area
- Grid computing was very active
- P2P and Grid communities were separate
  - Different researchers and conferences with not much interaction between them
- Cloud computing had not yet emerged

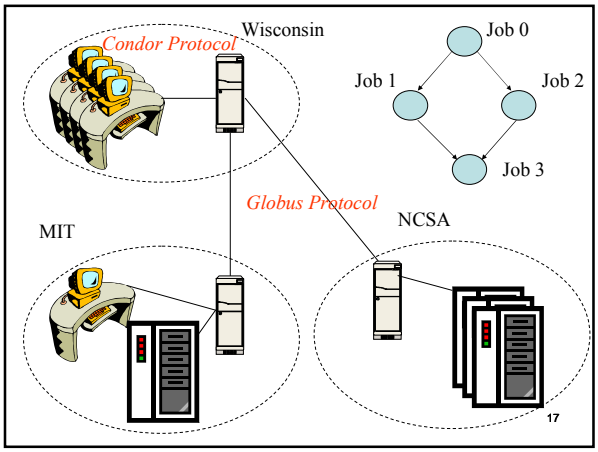
Distributed Computing Resources



An Application Coded by a Physicist

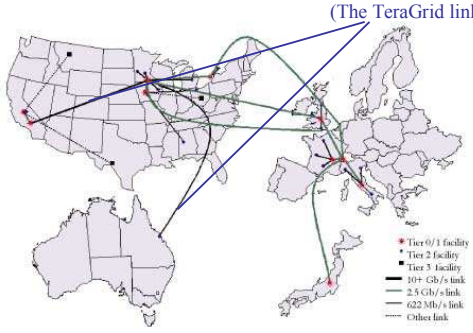






The Grid Recently

Some are 40Gbps links!
(The TeraGrid links)

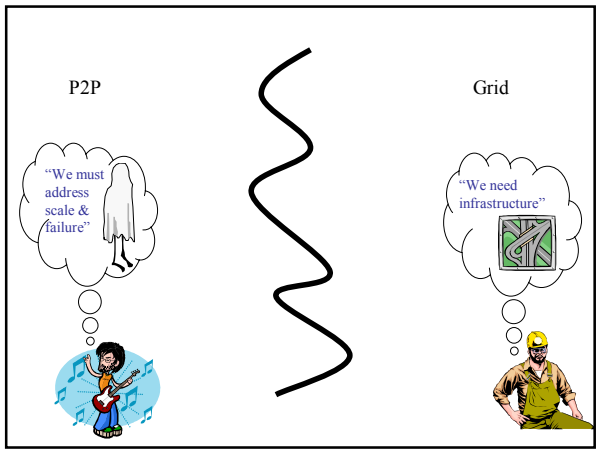


"A parallel Internet"

Some Things Grid Researchers Consider Important

- Single sign-on: collective job set should require once-only user authentication
- Mapping to local security mechanisms: some sites use Kerberos, others using Unix
- Delegation: credentials to access resources inherited by subcomputations, e.g., job 0 to job 1
- Community authorization: e.g., third-party authentication

- For clouds, you need to additionally worry about failures, scale, on-demand nature, and so on.



Definitions

Grid
- "Infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities" (1998)
- "A system that coordinates resources not subject to centralized control, using open, general-purpose protocols to deliver nontrivial QoS" (2002)

P2P
- "Applications that takes advantage of resources at the edges of the Internet" (2000)
- "Decentralized, self-organizing distributed systems, in which all or most communication is symmetric" (2002)

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525: (good legal applications without intellectual fodder)

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525: (clever designs without good, legal applications)

Grid versus P2P - Pick your favorite

Applications

Grid
- Often complex & involving various combinations of
  - Data manipulation
  - Computation
  - Tele-instrumentation
- Wide range of computational models, e.g.
  - Embarrassingly ||
  - Tightly coupled
  - Workflow
- Consequence
  - Complexity often inherent in the application itself

P2P
- Some
  - File sharing
  - Number crunching
  - Content distribution
  - Measurements
- Legal Applications?
- Consequence
  - Low Complexity

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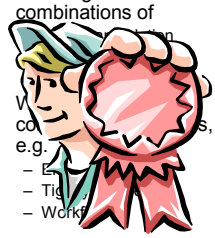

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Clouds:

Scale and Failure

Grid
- Moderate number of entities
  - 10s institutions, 1000s users
- Large amounts of activity
  - 4.5 TB/day (D0 experiment)
- Approaches to failure reflect assumptions
  - E.g., centralized components

P2P
- V. large numbers of entities

FastTrackC	4,277,745
iMesh	1,398,532
eDonkey	500,289
DirectConnect	111,454
Blubster	100,266
FileNavigator	14,400
Ares	7,731

(www.slyck.com, 2/19/'03)
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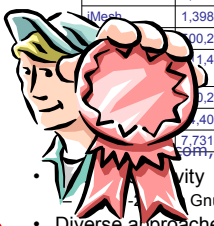

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Clouds:

Services and Infrastructure

Grid
- Standard protocols (Global Grid Forum, etc.)
- De facto standard software (open source Globus Toolkit)
- Shared infrastructure (authentication, discovery, resource access, etc.)

Consequences
- Reusable services
- Large developer & user communities
- Interoperability & code reuse

P2P
- Each application defines & deploys completely independent "infrastructure"
- JXTA, BOINC, XtremWeb?
- Efforts started to define common APIs, albeit with limited scope to date

Consequences
- New (albeit simple) install per application
- Interoperability & code reuse not achieved

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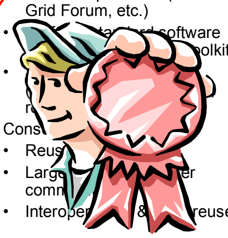

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Clouds:

Coolness Factor

Grid

P2P

Coolness Factor

Grid

P2P

Clouds:

Summary: Grid and P2P

1) Both are concerned with the same general problem
   - Resource sharing within virtual communities
2) Both take the same general approach
   - Creation of overlays that need not correspond in structure to underlying organizational structures
3) Each has made genuine technical advances, but in complementary directions
   - “Grid addresses infrastructure but not yet scale and failure”
   - “P2P addresses scale and failure but not yet infrastructure”
4) Complementary strengths and weaknesses => room for collaboration (Ian Foster at UChicago)

Has this already happened? Are clouds where it has happened?

(Inspired by)

2 P2P or Not 2 P2P

M. Roussopoulos et al

IPTPS 2004

Should I build a P2P solution to…?

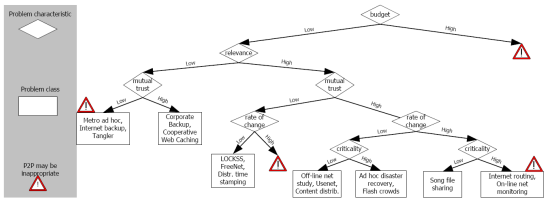

Fig. 1. A decision tree for analyzing the suitability of a P2P solution to a problem. Diamonds indicate decision points. Boxes contain problems or specifi c P2P solutions to problems. A warning sign over a particular box indicates that the box is a 'trouble spot'; a P2P solution for the problems in that box may be inappropriate. In some cases, we include particular P2P solutions (e.g., Tangler) and explain in the text how those solutions overcome the diffi culties of their box.

Challenges for you

- Can you build a similar decision tree for cloud problems?
  - Function of
    - data sizes involved
    - computation and I/O involved
    - usage characteristics (streaming vs. batch)
- Can you extend this to a choice between parallel DBs and MR?

(Inspired by)

Scooped Again

J. Ledlie et al
IPTPS 2004

Killer apps!

- Computer Scientists invented the Internet
- What is the killer app for the Internet?
  - The Web
- Who designed the Web?
  - Not Computer Scientists!

- Computer Scientists invented p2p systems
- What is the killer app for p2p?
  - File sharing
- Who designed the killer app?
  - Not Computer Scientists!

Can we build them?

- Wireless/Ad-hoc networks
  - Killer app: social networks?
- Computer Scientists invented datacenters and cloud services…
  - The story continues?
- Sensor networks?

- Some opine that Computer Scientists have never been good at building killer applications
- What do you think?

Next 2 Lectures

- No more reviews after today! (Yay!)
- But please attend lectures

- Thursday: Structure of Networks
  - Area that crosses into non-CS areas
- Next Tuesday: Wrap-up
  - Closure for course
- Last office hours will be next Tuesday

CS525 Course Evaluations

- Main purpose: to evaluate how useful this course was to you (and to get your feedback that will help improve future versions of the course)
- I won't see these evaluations until after you see your grades
- Fill them online (ICES has/will send you instructions)
- Optional Instructor Questions (please write answers on reverse side)
  - **Item**: Should the course projects remain open or be assigned like Machine Problems?
  - **Item**: How much has the peer reviews helped with respect to your project? State any positives and/or negatives you see.
- You will be able to fill out course evaluations online until next week, but don't forget!