Deconstructing Clusters for High End Biometric Applications

NSF CCF-0621434
June 2007-2009

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University of Notre Dame
5 August 2007

Data Intensive Abstractions for High End Biometric Applications

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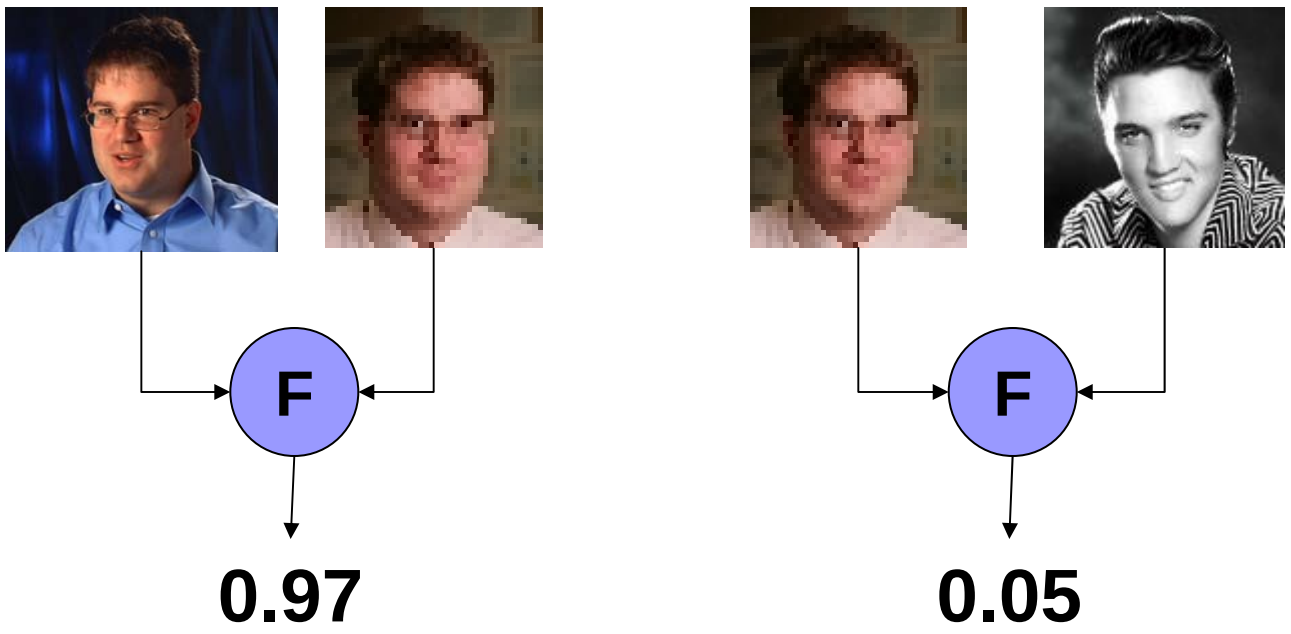
The Problem:

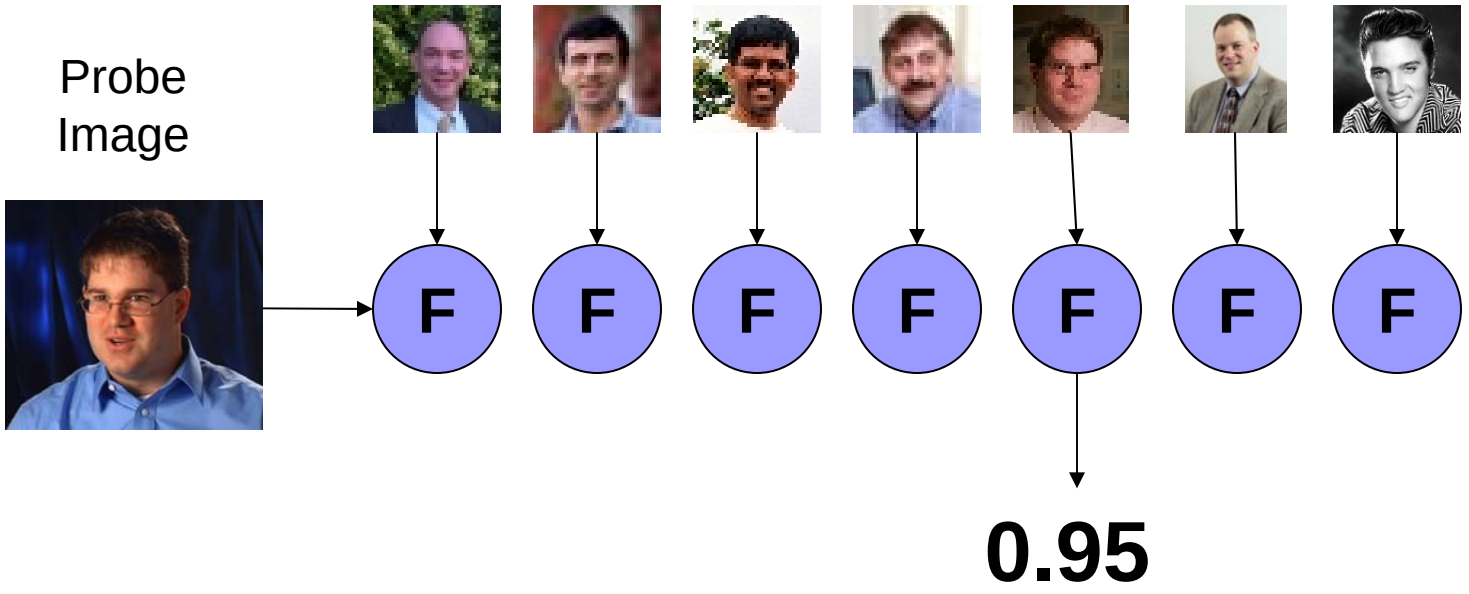
- It is far too easy for an ambitious user of a large batch system to submit large workloads that cripple a system's network or I/O capacity.
- Why does this happen?
  - The user does not know (or care) how to tune the workload for the given environment.
  - The system does not know (in advance) the workload structure and has few tools for shaping the load.
- Solution: Introduce ***abstractions*** that describe both data and CPU needs, allowing the system to partition, optimize, and predict workloads.

Application Context: Biometrics

- **Goal: Design robust face comparison function.**

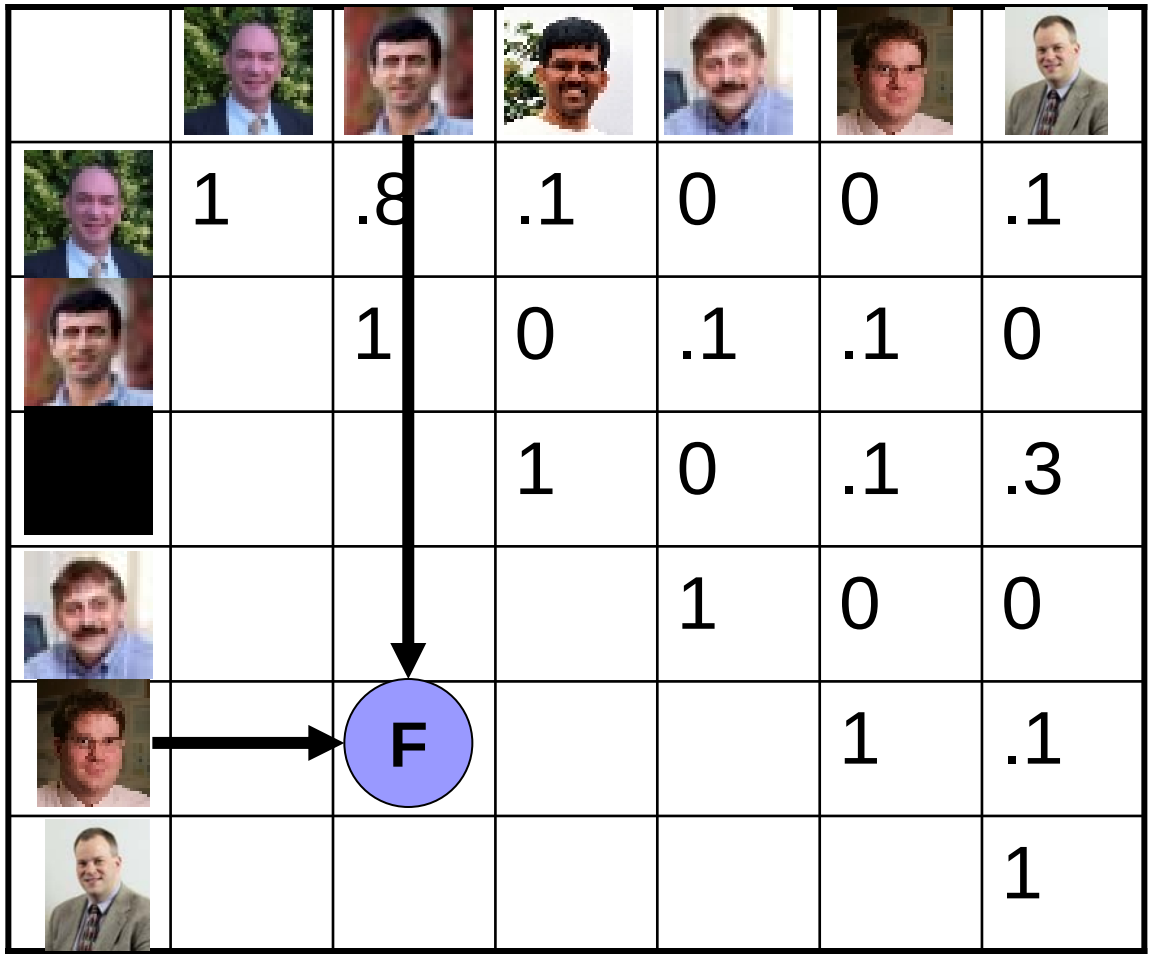


Application of Biometrics



- **Challenge: Make it work on non-ideal images with different orientation, expression, lighting...**
- **Question: How to systematically evaluate F?**

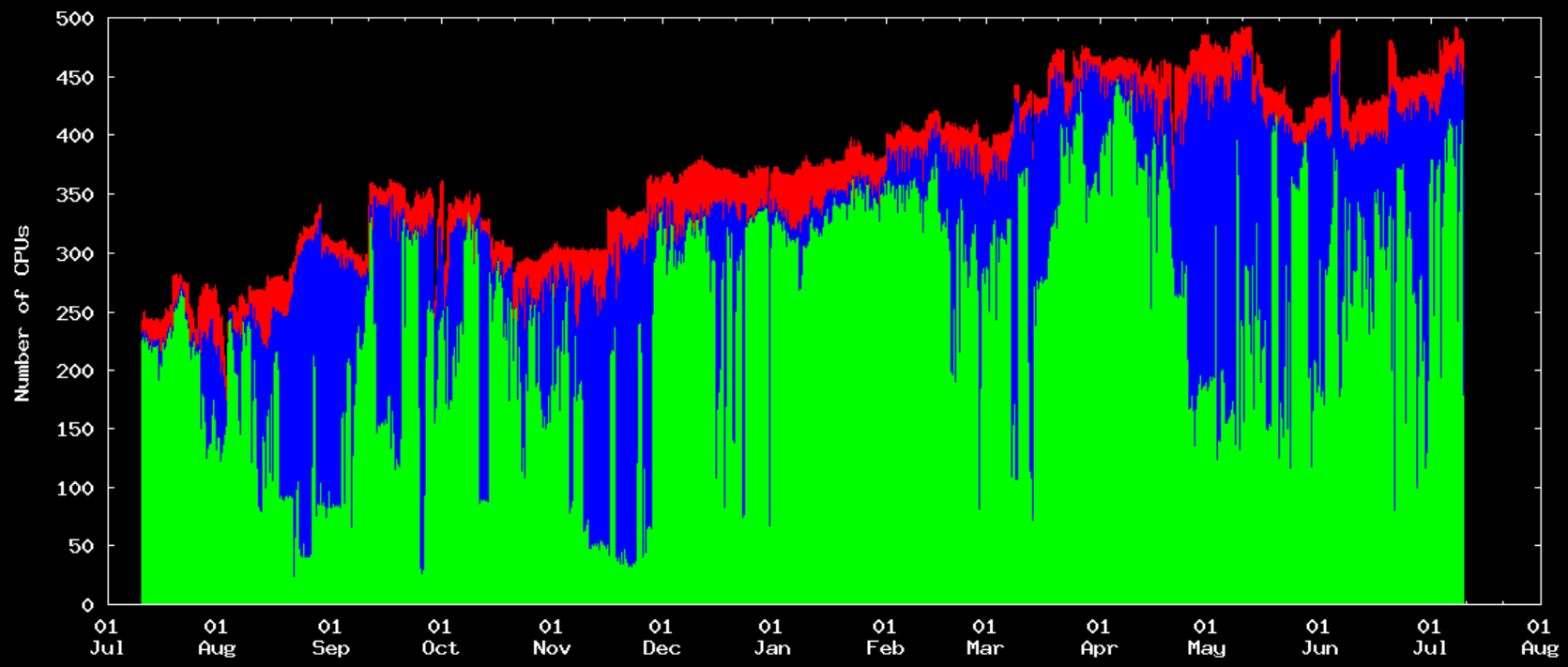
All-Pairs Image Comparison



Current Workload:
4000 images
256 KB each
10s per F
(five days)

Future Workload:
60000 images
1MB each
1s per F
(three months)

CPU Utilization for the Last Year



340318 (10%) **CPU-Hours Used by Owner**

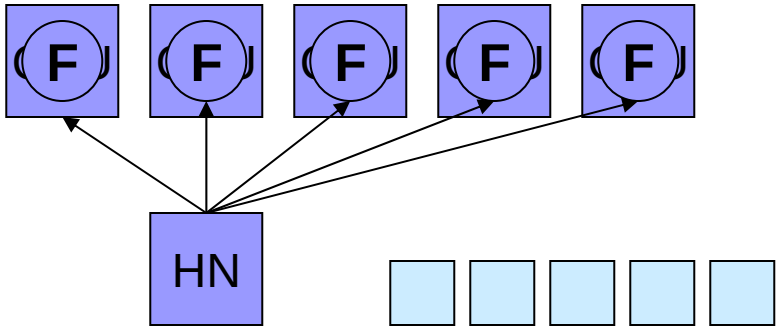
1064540 (32%) **CPU-Hours Used by Condor**

1868979 (57%) **CPU-Hours Unused**

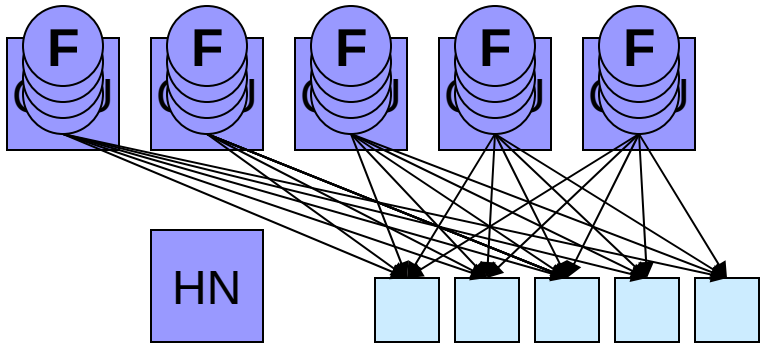
3273837 (100%) **CPU-Hours Total**

Non-Expert User Using 500 CPUs

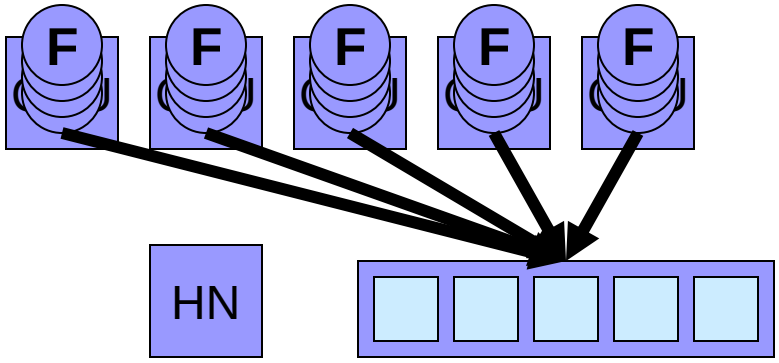
Try 1: Each F is a batch job.
Failure: Dispatch latency >> F runtime.



Try 2: Each row is a batch job.
Failure: Too many small ops on FS.



Try 3: Bundle all files into one package.
Failure: Everyone loads 1GB at once.

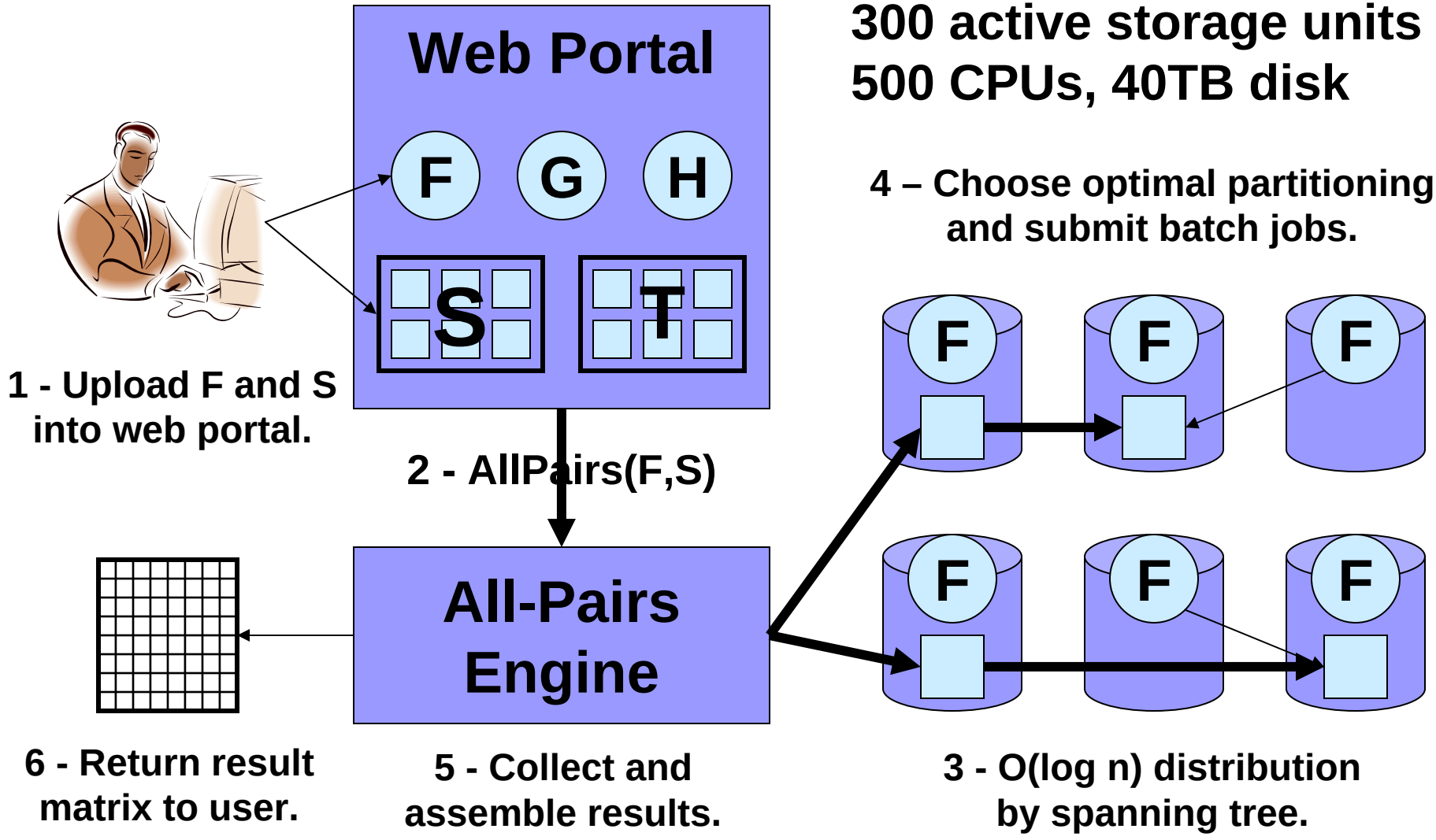


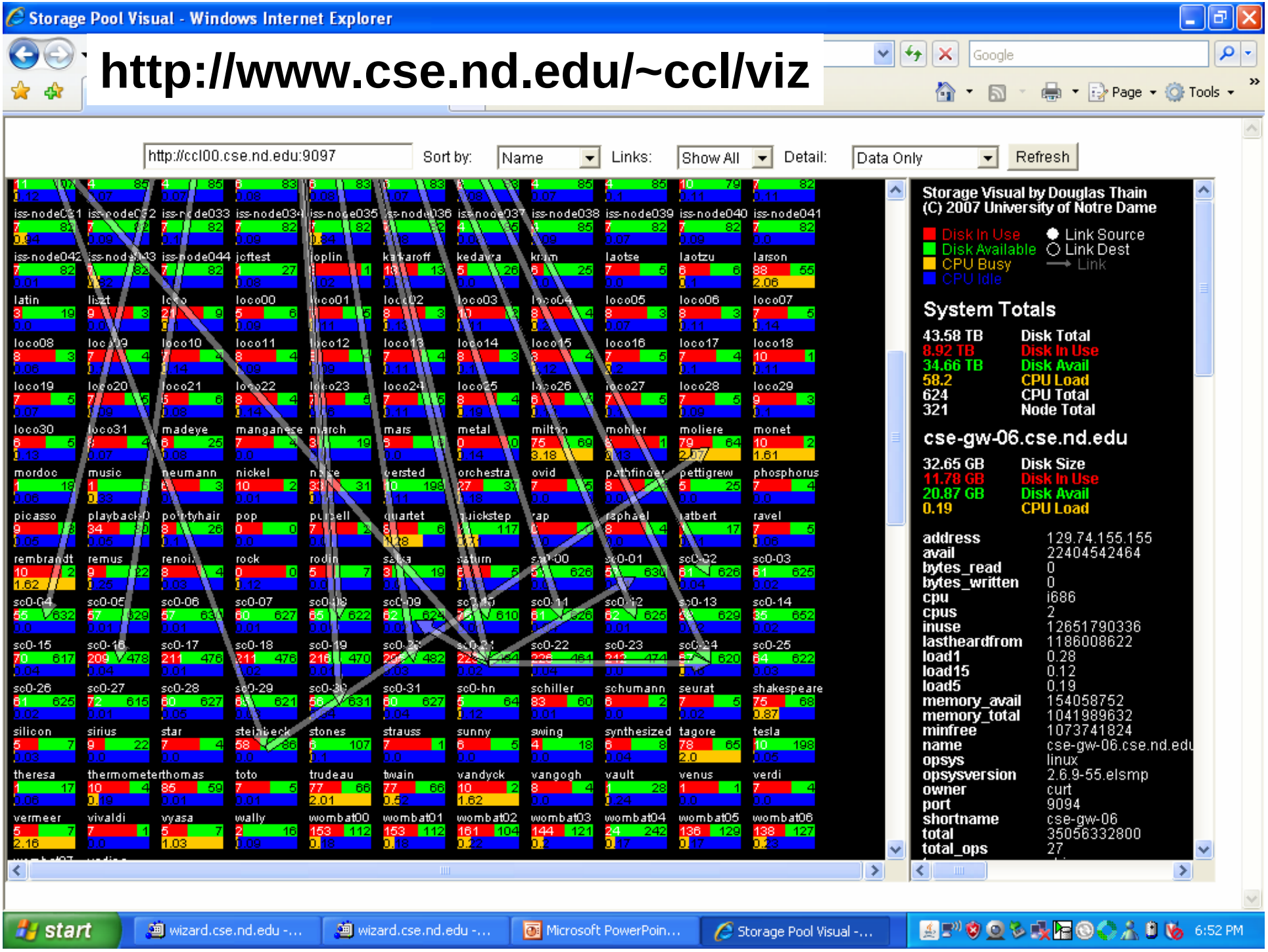
Try 4: User gives up and attempts
to solve an easier or smaller problem.

Solution: The All-Pairs Abstraction

- All-Pairs:
  - For a set S and a function F:
  - Compute F(Si,Sj) for all Si and Sj in S.
- The end user provides:
  - Set S: A bunch of files.
  - Function F: A self-contained program.
- The computing system determines:
  - Optimal decomposition in time and space.
  - Which (and how many) resources to employ.
  - What to do when failures occur.

All Pairs Production System




Storage Pool Visual - Windows Internet Explorer
http://www.cse.nd.edu/~ccl/viz
http://ccl00.cse.nd.edu:9097
Sort by:
Name
Links:
Show All
Detail:
Data Only
Refresh
Storage Visual by Douglas Thain
(C) 2007 University of Notre Dame
Disk In Use
Disk Available
CPU Busy
CPU Idle
Link Source
Link Dest
Link
System Totals
43.58 TB Disk Total
8.92 TB Disk In Use
34.66 TB Disk Avail
58.2 CPU Load
624 CPU Total
321 Node Total
cse-gw-06.cse.nd.edu
32.65 GB Disk Size
11.78 GB Disk In Use
20.87 GB Disk Avail
0.19 CPU Load
address 129.74.155.155
avail 22404542464
bytes_read 0
bytes_written 0
cpu i686
cpus 2
inuse 12651790336
lastheardfrom 1186008622
load1 0.28
load15 0.12
load5 0.19
memory_avail 154058752
memory_total 1041989632
minfree 1073741824
name cse-gw-06.cse.nd.edu
opsys linux
opsysversion 2.6.9-55.elsmp
owner curt
port 9094
shortname cse-gw-06
total 35056332800
total_ops 27
start
wizard.cse.nd.edu -...
wizard.cse.nd.edu -...
Microsoft PowerPoin...
Storage Pool Visual -...
6:52 PM

CCL Grid Portal - Windows Internet Explorer

http://cclbuild03.cse.nd.edu:9090/all_pairs.php

CCL Grid Portal

Welcome dthain

My Account Logout

Site Menu

- Home
- Grid Status
- Grid Queue
- Grid Users

Members

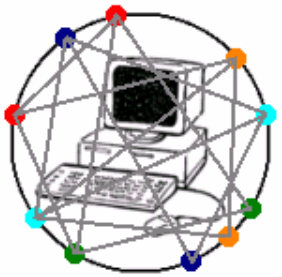
- Submit Job
- My Jobs
- Set Management
- Function Management
- Blend File Management

Admin

- All Jobs
- All Sets
- All Functions
- All Blend Files
- User Accounts

Cooperative Computing Lab

More Computers... Less Wait



Job Categories:

- All Pairs more info
  - Set Management
  - Function Management
- Render Blender more info
  - Blend File Management

allpairs-dthain-3:

Implementation: Stable

First Set: 1000gallery

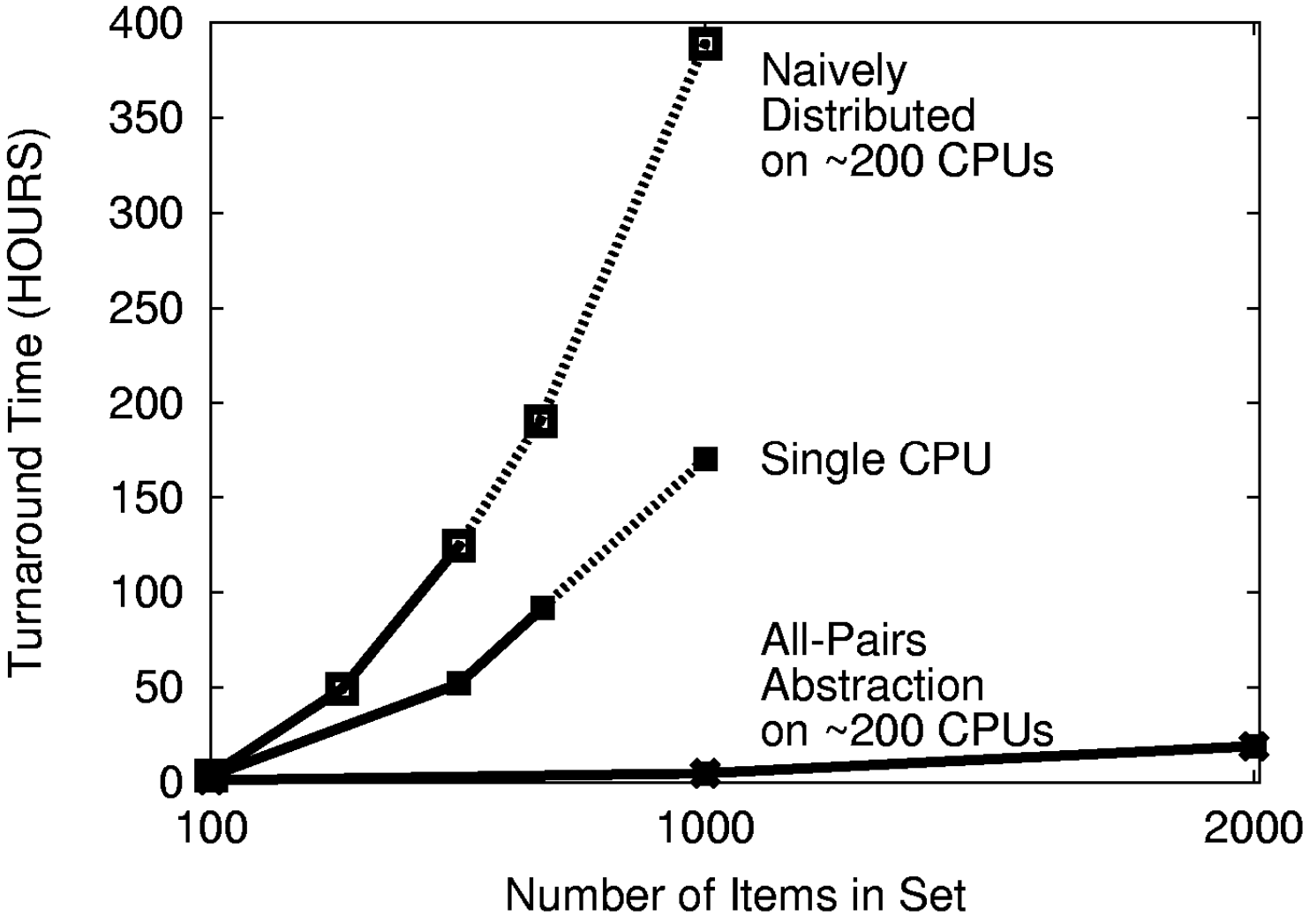
Second Set: 1000gallery

Function: ICPKD

Reset Submit Job

start | Microsoft PowerPoint ... | CCL Grid Portal - Win... | wizard.cse.nd.edu - ... | 10:45 AM

Initial Results on Real Workload



Optimizing One Abstraction

- Challenges of Scaling in the Real World
  - User assertions are unreliable. Measure F runtime, file sizes, network and disk speeds via sampling.
  - Managing real limits: sockets, jobs, file size, dirs.
  - Comprehending and reacting to inline errors.
- Make it portable across architectures.
  - Multi-core, cluster, campus grid, national grid
- Deploy with new applications.
  - Data mining - Document comparison.
  - Bioinformatics – DNA sequence similarity.

Broader Goal: Suite of Abstractions

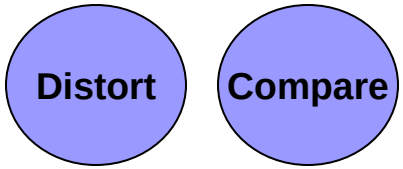
- A complete high level data-intensive programming environment that for high throughput processing of data sets on parallel computation and storage.
- Super Data Cluster =
  - Abstractions +
  - Object Storage +
  - Active Storage +
  - Databases +
  - Functional Language

Data Intensive Programming

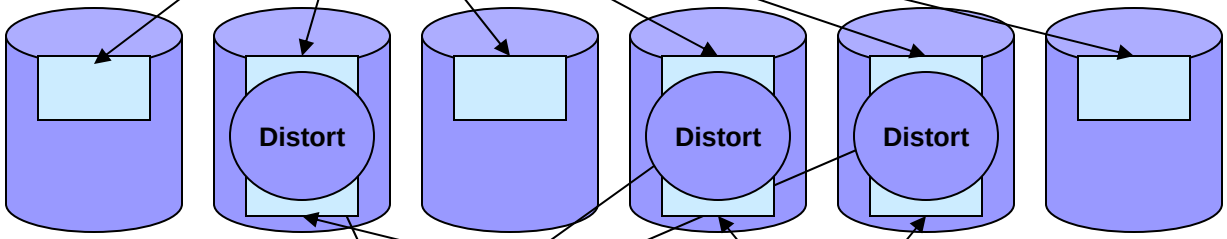
metadata database

name	sex	height	file
Fred	M	5.9	125
Betty	F	5.6	246
Harry	M	6.2	982

function library



active storage cluster

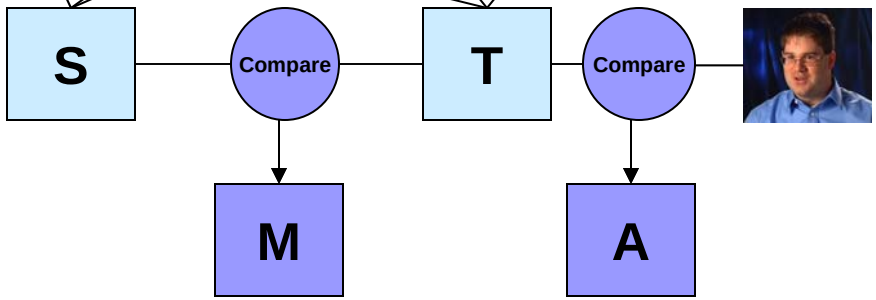


S = select males > 5 feet tall

T = apply(S, Distort)

M = allpairs(S, T, Compare)

A = rank(T, P, Compare)



- Project began June 2007.
- Personnel
  - Douglas Thain (PI) – Grid Computing
  - Patrick Flynn (co-PI) – Biometrics
  - Christopher Moretti – All Pairs Engine
  - Jared Bulosan – Web Portal (REU)
  - Brandon Rich – High Level Language
  - (Hire second grad student fall 2007)
- Publications
  - “Challenges in Executing Data Intensive Biometric Workloads on a Desktop Grid”, Christopher Moretti, Timothy Faltemier, Douglas Thain, and Patrick J. Flynn, Workshop on Large-Scale and Volatile Desktop Grids March 2007.
  - “All-Pairs: An Abstraction for Data Intensive Grid Computing”, Christopher Moretti, Jared Bulosan, and Douglas Thain, IEEE Grid, September 2007.
  - Used by Ph.D. Thesis: Tim Faltemier, “Robust 3D Face Recognition”, 2007.

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