Extreme Computing

Admin and Overview

Course Staff

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Informatics Forum 4.21

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Website

`http://www.inf.ed.ac.uk/teaching/courses/exc`

Mailing List

`exc-students at inf.ed.ac.uk` is populated when you enroll.

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$\Longrightarrow$ Check website for announcements, especially first two weeks.

Assessment

25% Assignment 1
25% Assignment 2
50% Exam in May ☹ (December ☺ for visitors)

Don't start the assignments yet; they are being updated.

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Solve the assignments on your own. Don't share code.
Exam is closed book.

- **Lectures** Online, subject to revision.
- **Labs** Practice on a cluster. Not marked.
- **Papers** Linked from the website.
- **Books** Don't buy them. They're in the library:
  Data-Intensive Text Processing with MapReduce
  Hadoop: The Definitive Guide.

The exam is based on the lectures. Reading may help digestion.

Labs

Get familiar with the tools and ask questions.

Three weeks starting 3 October.

Currently 4 groups, actual number depends on enrollment.

Unix Command Line

We assume you know the Unix command line (typically bash).

If you don't know what this does

```
tar cz . | ssh server "cd $PWD && tar xz"
```

then work through the Unix material here:
http://www.ed.ac.uk/information-services/help-consultancy/is-skills/catalogue/program-op-sys-catalogue/unix1

Programming Languages

We do not require a particular programming language.[1]

Examples are mostly Python and Java, with occasional C++.

[1] Besides the aforementioned Unix command line.

FAQ

1. Assignment extension requests go to the Informatics Teaching Organisation. I do not decide.
2. We don't take attendance, including at labs.
3. Visiting from Caltech? I'll fill out Lauren Stolper's form.

Core Course Content

- Working with big data
- Cluster computing with 10,000 machines
- How to pass a Google interview[2]
- How commercial services like Amazon Web Services and Microsoft Azure work

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Not Part of the Course

- How to program (expected)
- Unix command line (learn it yourself)
- Mobile phones or Internet of things
- Exotic hardware

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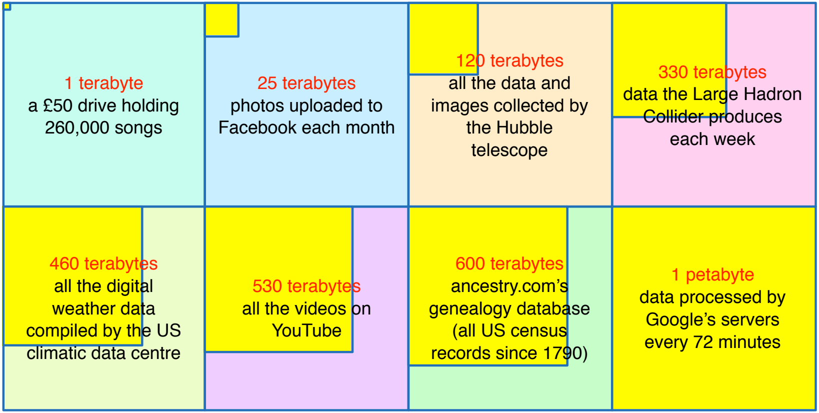
Petabytes


1 terabyte
a £50 drive holding 260,000 songs
25 terabytes
photos uploaded to Facebook each month
120 terabytes
all the data and images collected by the Hubble telescope
330 terabytes
data the Large Hadron Collider produces each week
460 terabytes
all the digital weather data compiled by the US climatic data centre
530 terabytes
all the videos on YouTube
600 terabytes
ancestry.com's genealogy database (all US census records since 1790)
1 petabyte
data processed by Google's servers every 72 minutes

Backblaze: 270TB, one machine, £9531

Applications

Government	Demographics, communication
Large Hadron Collider	15 PB/year
Fraud detection	Did your debit card work?
Social media	Who to follow?
Search	Can I borrow a copy of the web?
Online advertising	Placement, tracking, pricing

High performance and low latency

How quickly does data move around the network?
Examples

- High-frequency trading: put machines next to the exchange
- Simulating physical systems
- Amazon (2007): sales decrease 1% for every 100ms increase in load time
- Google (2006): increasing page load time by 0.5 second produces a 20% drop in traffic
- Google rankings include load time

Topics

Big Data

Cloud Computing Infrastructure

MapReduce and Hadoop

Beyond MapReduce

Fault Tolerance and Replication

Virtualisation

NoSQL

BASE vs ACID

BitTorrent

Data warehousing

Data streams

What is big data?

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Big data is relative: not the same for Google and Informatics.
Sometimes Google's big data is our small data! [Brants et al, 2007]

Scientific Challenges of Big Data

Hard to understand and visualize

Tools often fail: need new algorithms

Models may not scale
Models that do scale may not show gains anymore

Curating Scientific Data

- Effectiveness of medicine across multiple studies
- Evolution of language over years
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Is it reproducible?

- Preserving large data sets is hard. Who will pay?
- Who owns it?
- Privacy versus data retention

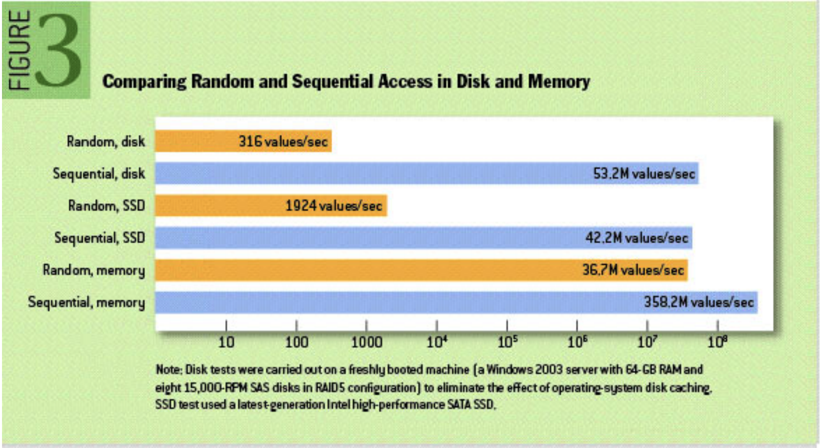
Repeated Observations

- Mobile phone location reports
- Twitter posts
- Every Google search
- Every web page

$$\implies \text{Challeges:}$$

- Storage: disk performance/reliability
- Efficient access and analysis

Disk Performance

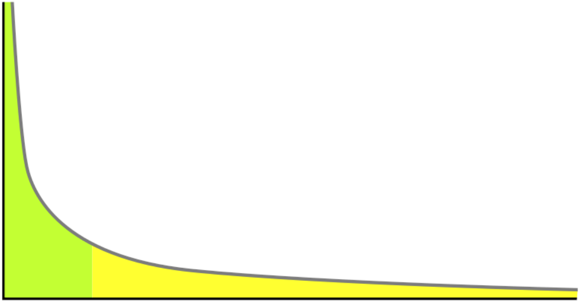


Sequential access impacts algorithm choice:

	Complexity	Access
Hash table	$O(n)$	Random
Merge sort	$O(n \log n)$	Sequential batches

Constant factors matter: merge sort is faster on disk.

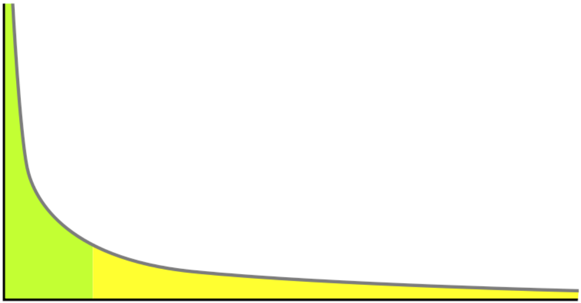
Power Law



Big data often follows a power law.

Modelling the head (e.g. common words) is easier, but unrepresentative.
Handling the tail is harder (e.g. selling all books, not just top 100).

Power Law



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The machine responsible for "the" will take longer.

Challenge: Load Balancing

Distributed computing is a natural way to tackle big data.
MapReduce tries to balance work over nodes in a cluster.

- Head of power law goes to one or two nodes $\Longrightarrow$ slow
- Tail balanced over nodes $\Longrightarrow$ fast

Power laws can turn parallel algorithms into sequential algorithms.

Economics of Servers: Own or Rent?

Many machines operate at 30% capacity.

Own

- Security
- Full control, customized hardware
- Tune for latency- or time-critical tasks
- Cheaper if machines will be used all the time

Rent

- Pay for servers, storage, and bandwidth by usage/hour
- Scale up to many servers when needed
- Compute is another commodity like electricity

Supercomputers

A pile of Linux boxes in the same room, with a fast network.

Top 2 (according to top500.org):

1. Tiahne-2 (China) $390 million, 33 TFLOP/s, 3,120,000 cores.
2. Titan (US) $97 million, 17 TFLOP/s, 560,640 cores.

Cost per hour, assuming 10 year life:

Tianhe-2	$4,110
Titan	$1,107

And that's not counting electicity, staff, maintenance, etc.

Provisioning

Web traffic changes: time of day, shopping seasons, news, link from major site

High traffic $\rightarrow$ more machines
Low traffic $\rightarrow$ save cost

Target (US Retailer)

Website `target.com` is hosted on Amazon Web Services
Busiest shopping day in 2009: 28 November
Day `target.com` went offline: 28 November

Data lock-in and third-party control

Some provider hosts our data:

- But we can only access it using proprietary (non-standard) APIs
- Lock-in makes customers vulnerable to price increases and dependent upon the provider

Providers may control our data in unexpected ways:

- July 2009: Amazon remotely remove books from Kindles
- Twitter prevents exporting tweets more than 3200 posts back
- Facebook locks user-data in
- August 2010: Google drops Google Wave

Privacy and Security

Laundry list of breaches:

- Ashley Madison hack
- US government HR database leaks, including security clearance
- Customer data: TJX, Carphone Warehouse, Target, Health insurers

- What if your cloud provider is hacked?
- Who has access? The government? Which governments?

Need for privacy guarantees and measures.

Summary: Big Data

- Scalable algorithms
- Tools for cluster computing
- Cloud providers and how they work