A Brief History of Big Data

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Big data is a broad term for data sets so large or complex that traditional data processing applications are inadequate.

—*Wikipedia*

Once there was only small data...

A classic amount of “small” data

Find a tasty appetizer – Easy!

Find something to use up these oranges – grumble…

What if….

Less sophisticated is sometimes better…

"Chronologically" or "geologically" organized.
Familiar to some of you at tax time.

Get all articles from 2007.

Get all papers on "fault tolerance"
– grumble and cough

Indexing will determine your individual performance.
Teamwork can scale that up.

The culmination of centuries...

Find books on Modern Physics (DD# 539)

Find books by Wheeler

where he isn't the first author – grumble…

Your only hope…

Then data started to grow.

1956 IBM Model 350

5 MB of data!

But still pricey. $

Better think about what you want to save.

And finally got **BIG**.

8TB for $130

Whys:

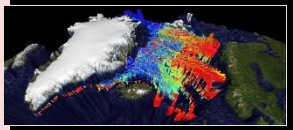
Storage got cheap
So why not keep it all?
Today data is a hot commodity $
And we got better at generating it

= Facebook
Deep Learning
IoT
Science...

10 TB *

Pan-STARRS

Genome sequencers
(Wikipedia Commons)



Horniman museum:
http://www.horniman.ac.uk

Wikipedia Commons

http://www.arctic.noaa.gov/report11/biodiv_whales_walrus.html

**Actually, a silly estimate. The original referen[illegible]ntions a more accurate 208TB, and in 2013 the digital collection alone was 3PB.*

A better sense of biggish

Size

- 1000 Genomes Project
  - AWS hosted
  - 260TB
- Common Crawl
  - Hosted on Bridges
  - 300-800TB+

Throughput

- Square Kilometer Array
  - Building now
  - Exabyte of raw data/day – compressed to 10PB
- Internet of Things (IoT) / motes
  - Endless streaming

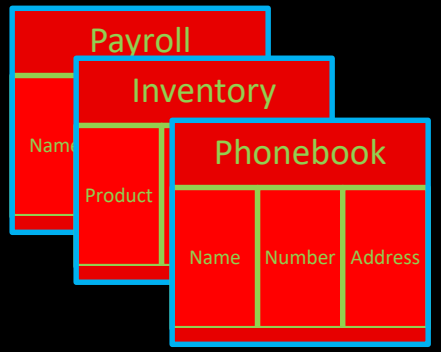
Records

- GDELT (Global Database of Events, Language, and Tone) (also soon to be hosted on Bridges)
  - Only about 2.5TB per year, but...
  - 250M rows and 59 fields (BigTable)
  - *"during periods with relatively little content, maximal translation accuracy can be achieved, with accuracy linearly degraded as needed to cope with increases in volume in order to ensure that translation always finishes within the 15 minute window…. and prioritizes the highest quality material, accepting that lower-quality material may have a lower-quality translation to stay within the available time window."*

Good Ol' SQL couldn't keep up.

MySQL PostgreSQL Oracle SQLite

```
SELECT  NAME, NUMBER, FROM PHONEBOOK
```



Why it *wasn't* fashionable:

- Schemas set in stone:
  - Need to define before we can add data
  - Not a fit for *agile development*

    "What do you mean we didn't plan to keep logs of everyone's heartbeat?"

- Queries often require accessing multiple indexes and joining and sorting multiple tables

- Sharding isn't trivial

- Caching is tough
  - ACID (Atomicity,Consistency,Isolation,Durability) in a *Transaction* is costly.

So we gave up: Key-Value

Redis, Memcached, Amazon DynamoDB, Riak, Ehcache

```
GET foo
```

- Certainly agile (no schema)
- Certainly scalable (linear in most ways: hardware, storage, cost)
- Good hash might deliver fast lookup
- Sharding, backup, etc. could be simple
- Often used for “session” information: online games, shopping carts

```
GET cart:joe:15~4~7~0723
```

foo	bar
2	fast
6	0
9	0
0	9
text	pic
1055	stuff
bar	foo

How does a pile of unorganized data solve our problems?

Sure, giving up ACID buys us a lot performance, but doesn't our crude organization cost us something? Yes, but remember these guys?

This is what they look like today.

NoSQL

It turns out this *NoSQL* approach can benefit from some old-fashioned organization. Let's look at what types of structure take us beyond simple key-value:

- Document
- Column
- Graph
- DataFrames
- Analysis / Machine Learning

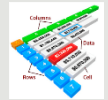
Document


```
GET foo
```

- Value must be an object the DB can understand
- Common are: XML, JSON, Binary JSON and nested thereof
- This allows server side operations on the data

```
GET plant=daisy
```

- Can be quite complex: Linq query, JavaScript function
- Different DB's have different update/staleness paradigms

foo	
2	<CATALOG> <PLANT> <COMMON>Bloodroot</COMMON> <BOTANICAL>Sanguinaria canadensis</BOTANICAL> <ZONE>4</ZONE> <LIGHT>Mostly Shady</LIGHT> <PRICE>$2.44</PRICE> <AVAILABILITY>031599</AVAILABILITY> </PLANT> <PLANT> <COMMON>Columbine</COMMON> <BOTANICAL>Aquilegia canadensis</BOTANICAL> <ZONE>3</ZONE> <LIGHT>Mostly Shady</LIGHT> <PRICE>$9.37</PRICE> <AVAILABILITY>030699</AVAILABILITY> </PLANT>
6	JSON
9	XML
0	Binary JSON
bar	JSON XML
12	XML XML

Wide Column Stores

Google BigTable


```
SELECT Name, Occupation FROM People WHERE key IN (199, 200, 207);
```

- No predefined schema
- Can think of this as a 2-D key-value store: the value may be a key-value store itself
- Different databases aggregate data differently on disk with different optimizations

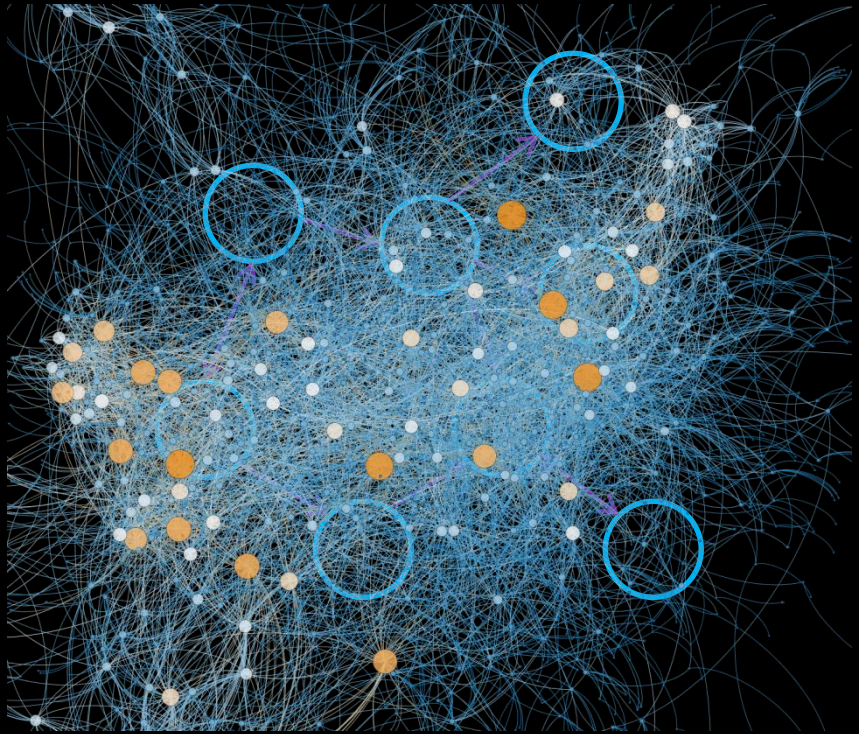
Key			
Joe	**Email:** joe@gmail	**Web:** www.joe.com	
Fred	**Phone:** 412-555-3412	**Email:** fred@yahoo.com	**Address:** 200 S. Main Street
Julia	**Email:** julia@apple.com		
Mac	**Phone:** 214-555-5847		

Graph

Neo4j Titan, GEMS

- Great for semantic web
- Great for graphs 

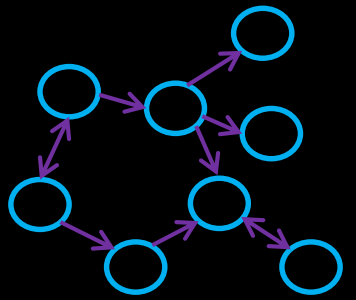
- Can be hard to visualize
- Serialization can be difficult
- Queries more complicated



From *PDX Graph Meetup*

Queries

SPARQL, Cypher



SPARQL (W3C Standard)

- Uses Resource Description Framework format (triple store)
- RDF Limitations
  - No named graphs
  - No quantifiers or general statements
    - “Every page was created by some author”
    - “Cats meow”
- Requires a schema (RDFS) to define rules
    - "The object of ‘homepage’ must be a Document.“

```
SELECT ?name ?email
WHERE {
          ?person a foaf:Person.
          ?person foaf:name ?name.
          ?person foaf:mbox ?email.
}
```

Cypher (Neo4J only)

- No longer proprietary
- Stores whole graph, not just triples
- Allows for named graphs
- …and general Property Graphs (edges and nodes may have values)

```
SMATCH (Jack:Person
  { name:‘Jack Nicolson’})-[:ACTED_IN]-(movie:Movie)
RETURN movie
```

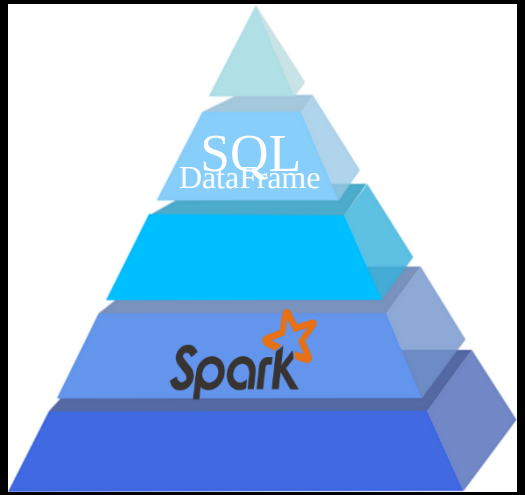
Hadoop & Spark

Frameworks for Data

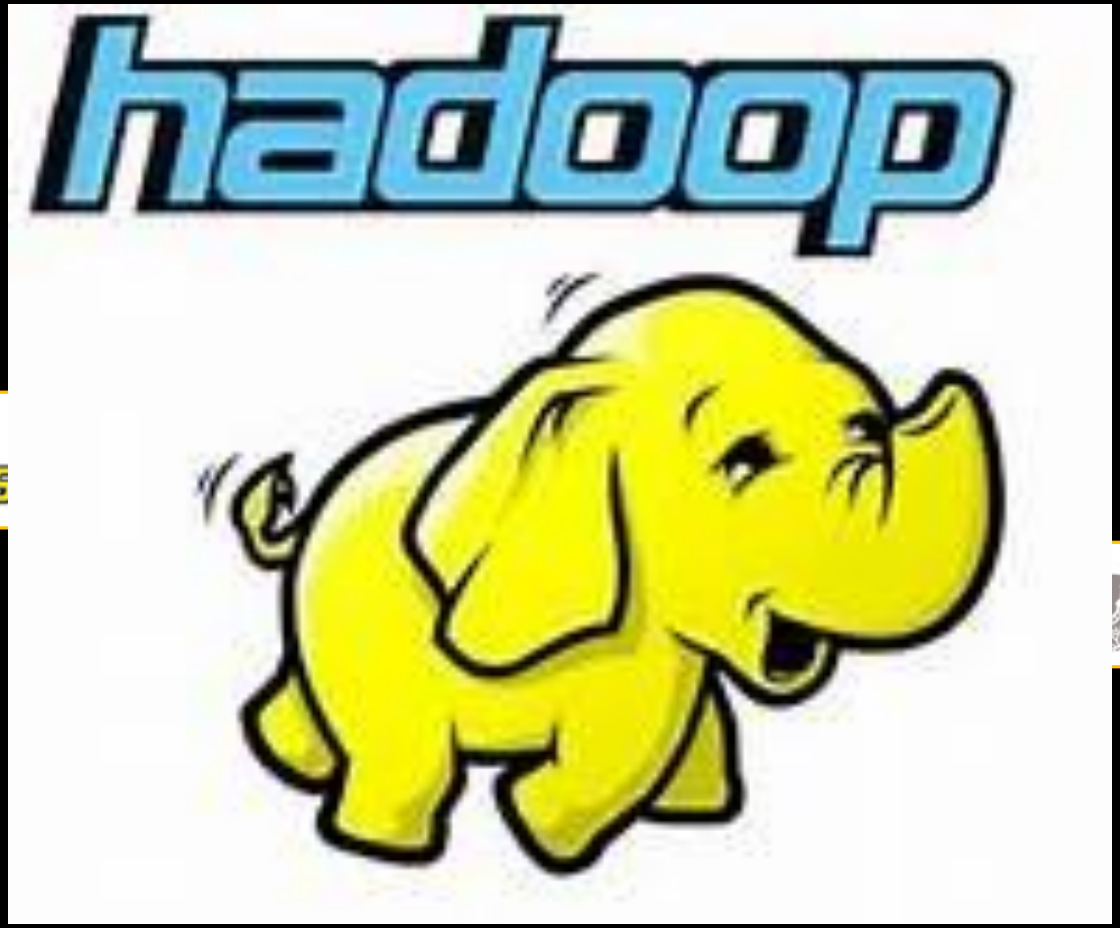
These are both frameworks for distributing and retrieving data. Hadoop is focused on disk based data and a basic map-reduce scheme, and Spark evolves that in several directions that we will get in to. Both can accommodate multiple types of databases and *achieve their performance gains by using parallel workers*.

The mother of Hadoop was necessity. It is trendy to ridicule its primitive design, but it was the first step.

We have repurposed many of these blocks to build a better framework.



Hadoop Impact



And lots more...