



# How Google Does Big Data

## Solving Big Data Problems at Google Scale

James Chittenden  
Cloud Platform Engineer



# Agenda

1

Quick Google Cloud Platform Overview

2

Google & Big Data

3

Running Hadoop on GCE & Leveraging BigQuery

4

Q & A

# Agenda

- 1 → Quick Google Cloud Platform Overview
- 2 → Google & Big Data
- 3 → Running Hadoop on GCE & Leveraging BigQuery
- 4 → Q & A

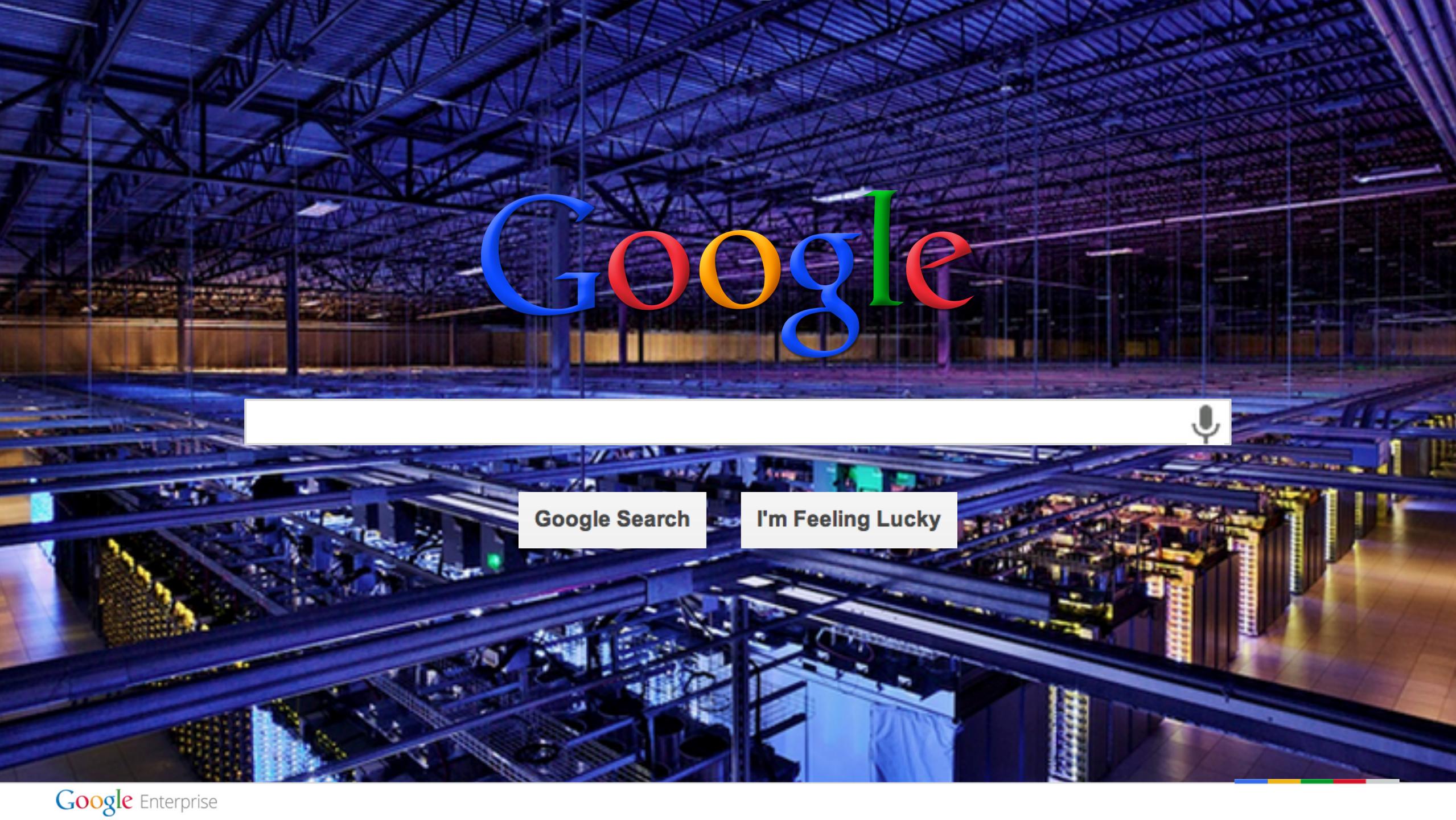


# Google

**Google Search**

**I'm Feeling Lucky**



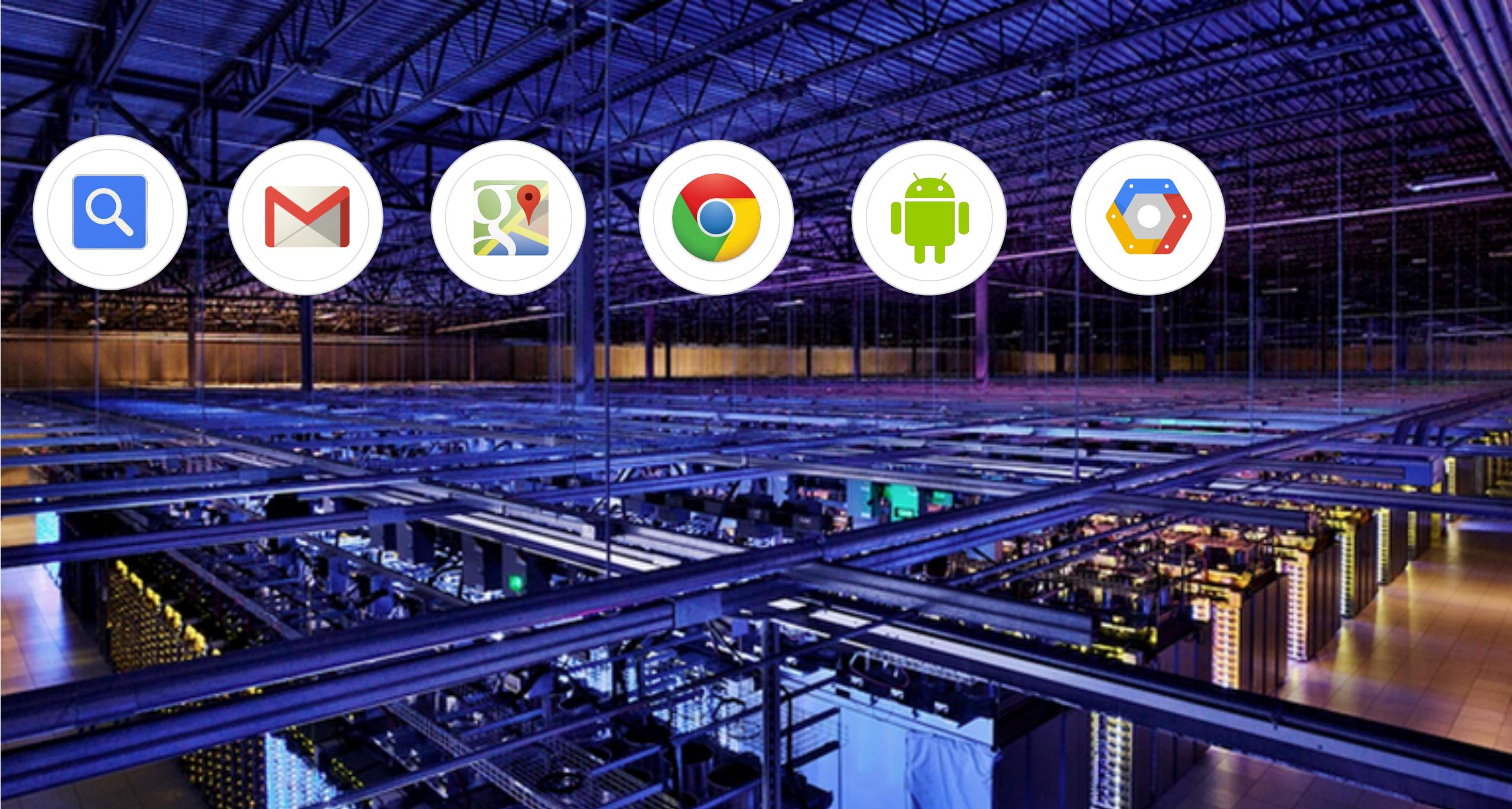
# Google



Google Search

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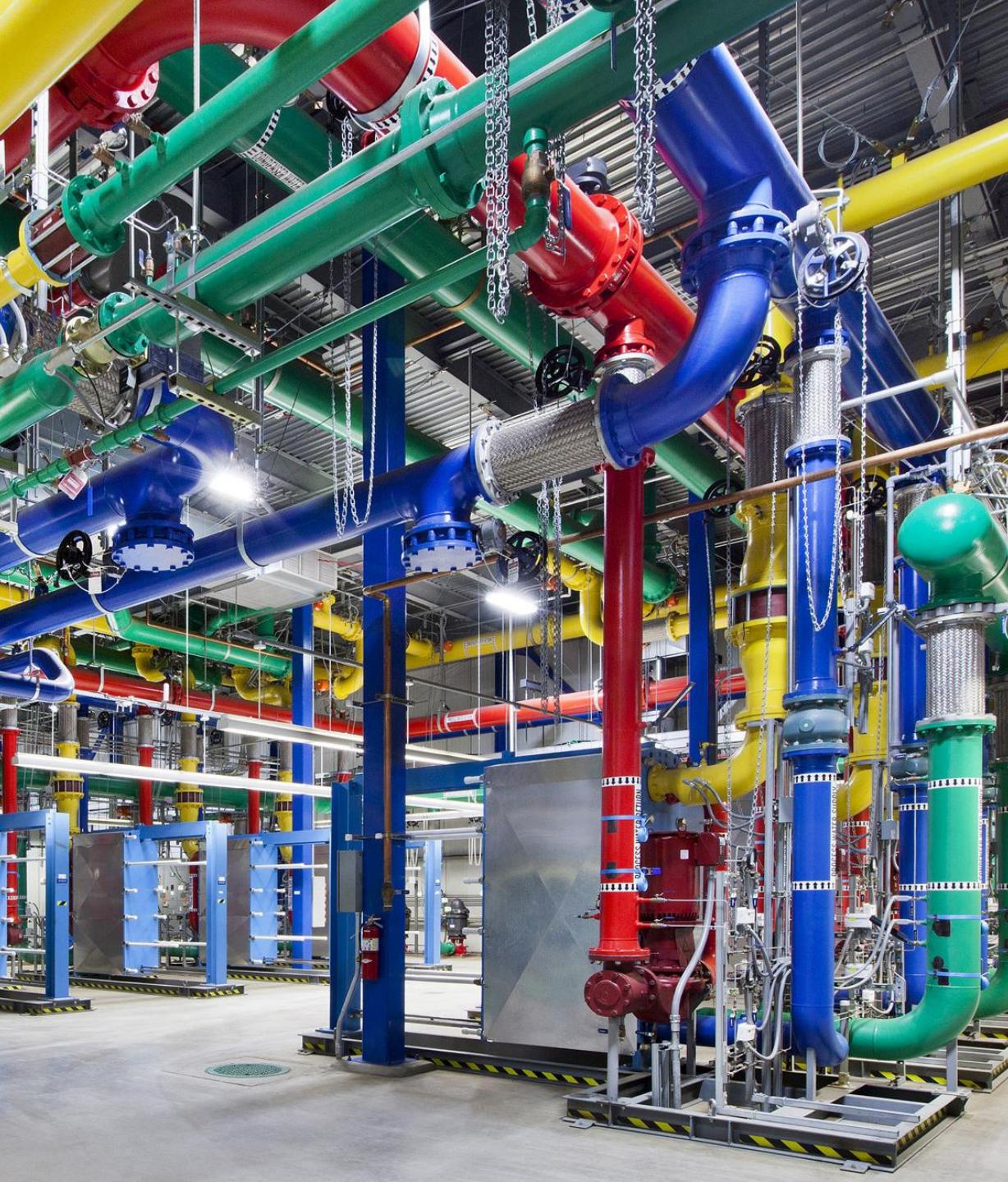
Google has been running some of the world's largest distributed systems with unique and stringent requirements.

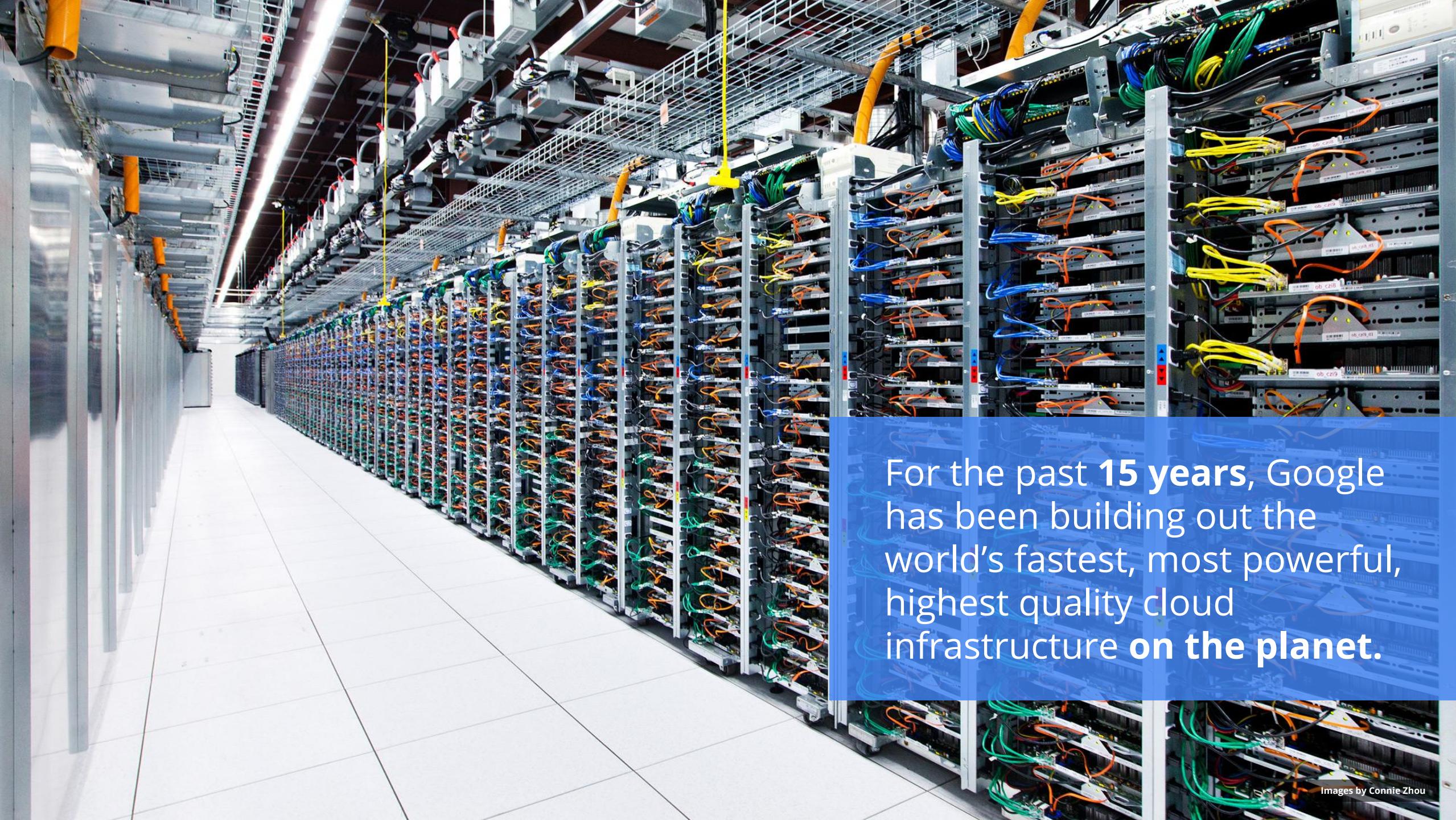


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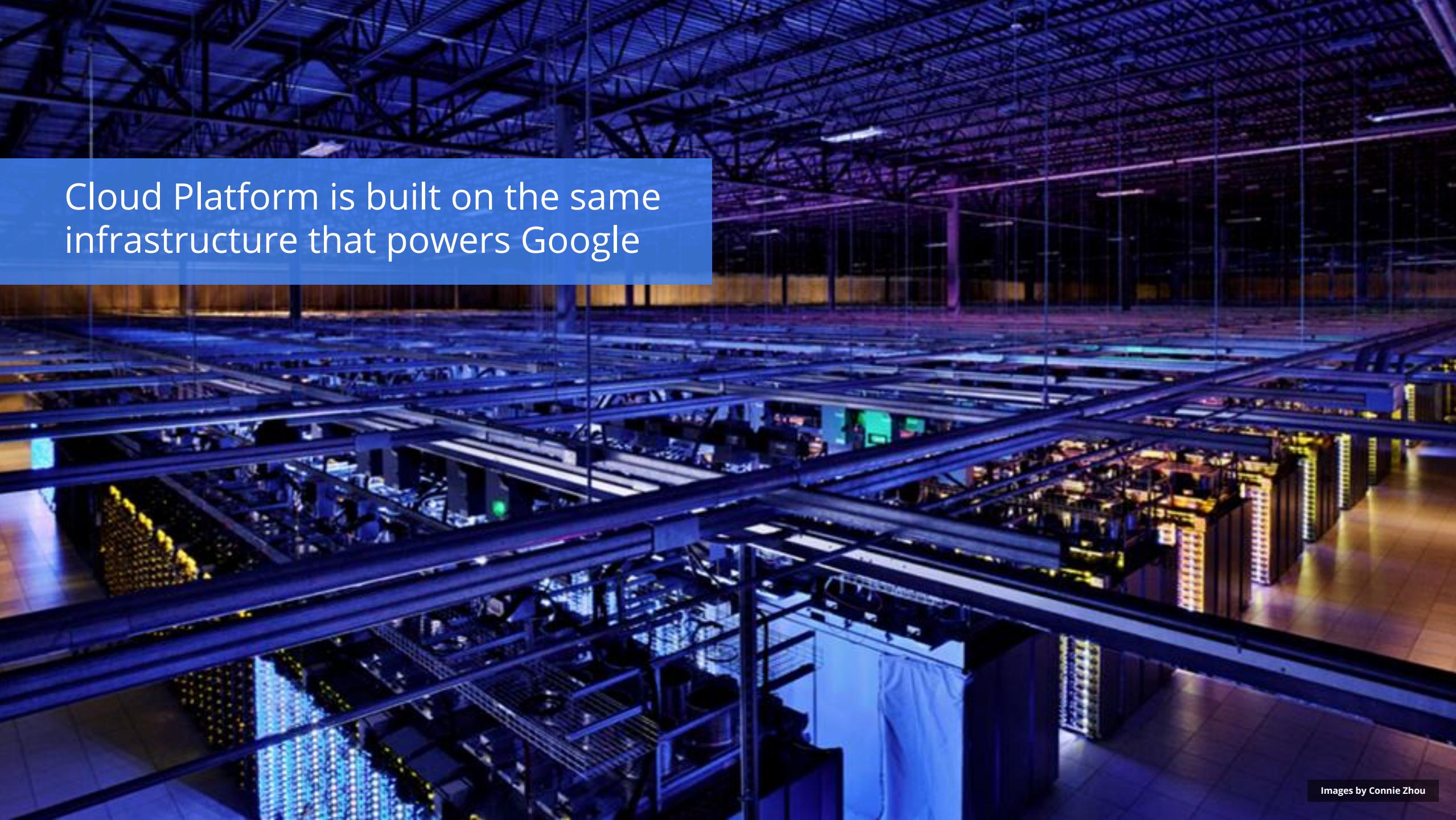
**"This is what makes Google Google:  
its physical network, its thousands of  
fiber miles, and those many thousands  
of servers that, in aggregate, add up to  
the mother of all clouds."**

*- Wired 'Google Throws Open Doors To Its Top Secret Data Center', Wired, October 2012*



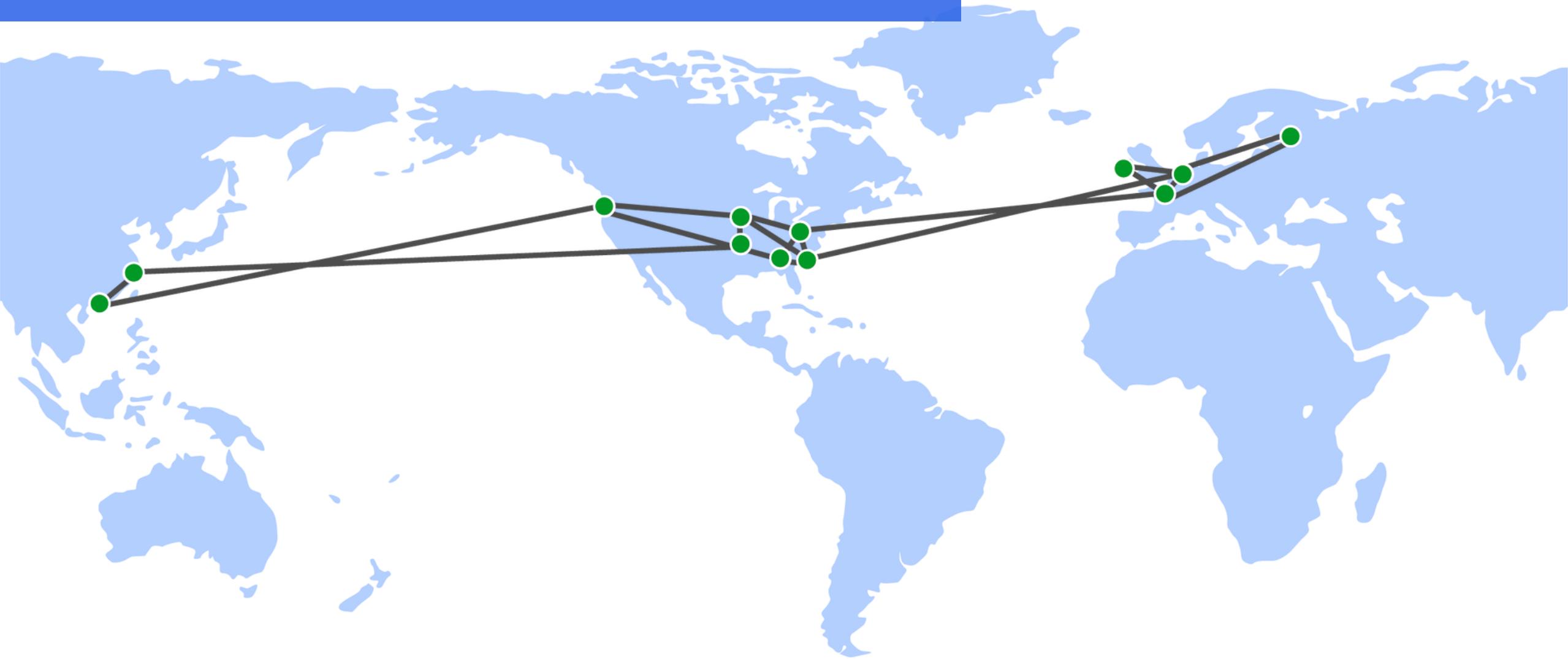


For the past **15 years**, Google has been building out the world's fastest, most powerful, highest quality cloud infrastructure **on the planet**.

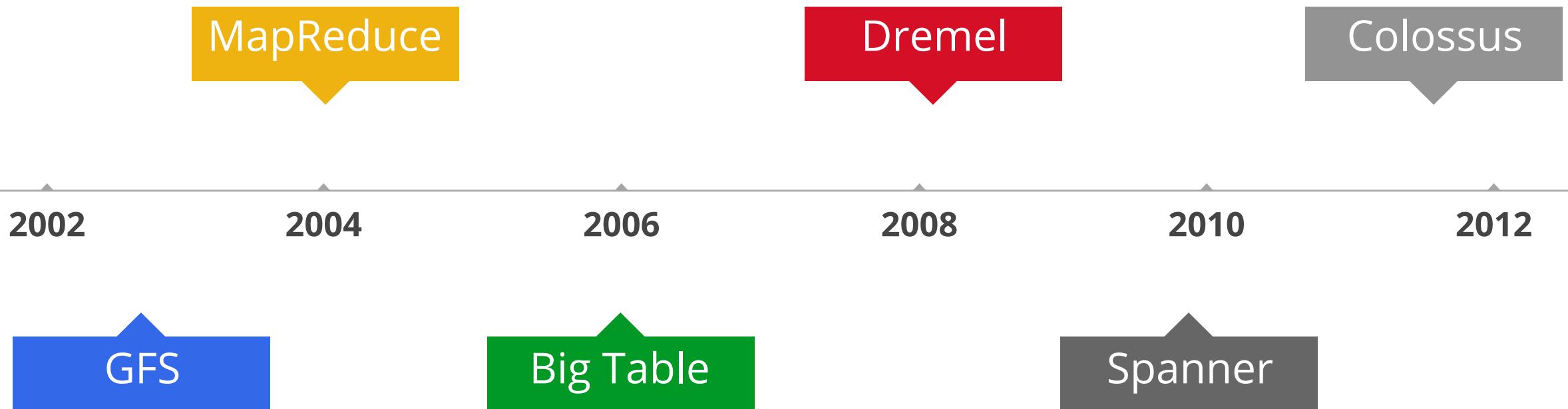


Cloud Platform is built on the same infrastructure that powers Google

# Google's Global OpenFlow Network



# Google Innovations in Software



# Investing In Our Cloud

\$2.9B in additional data center investments worldwide



**Googling good economic news for our community and state**



**Google to Build Taiwan Center as Demand for Gmail, YouTube Rises**



**Google to invest 150 mln euros in Finland data centre**



**Google to invest nearly \$400 million in Belgian data center to 'meet growing demand for its online services'**



**Google Expands into Latin America With New Data Center in Chile**



**Google to Invest \$120 Million in Singapore Data Center**



# Google Cloud Platform

## Compute



Compute Engine



App Engine

## Storage



Cloud Storage



Cloud SQL



Cloud Datastore

## App Services



BigQuery



Cloud Endpoints

# Agenda

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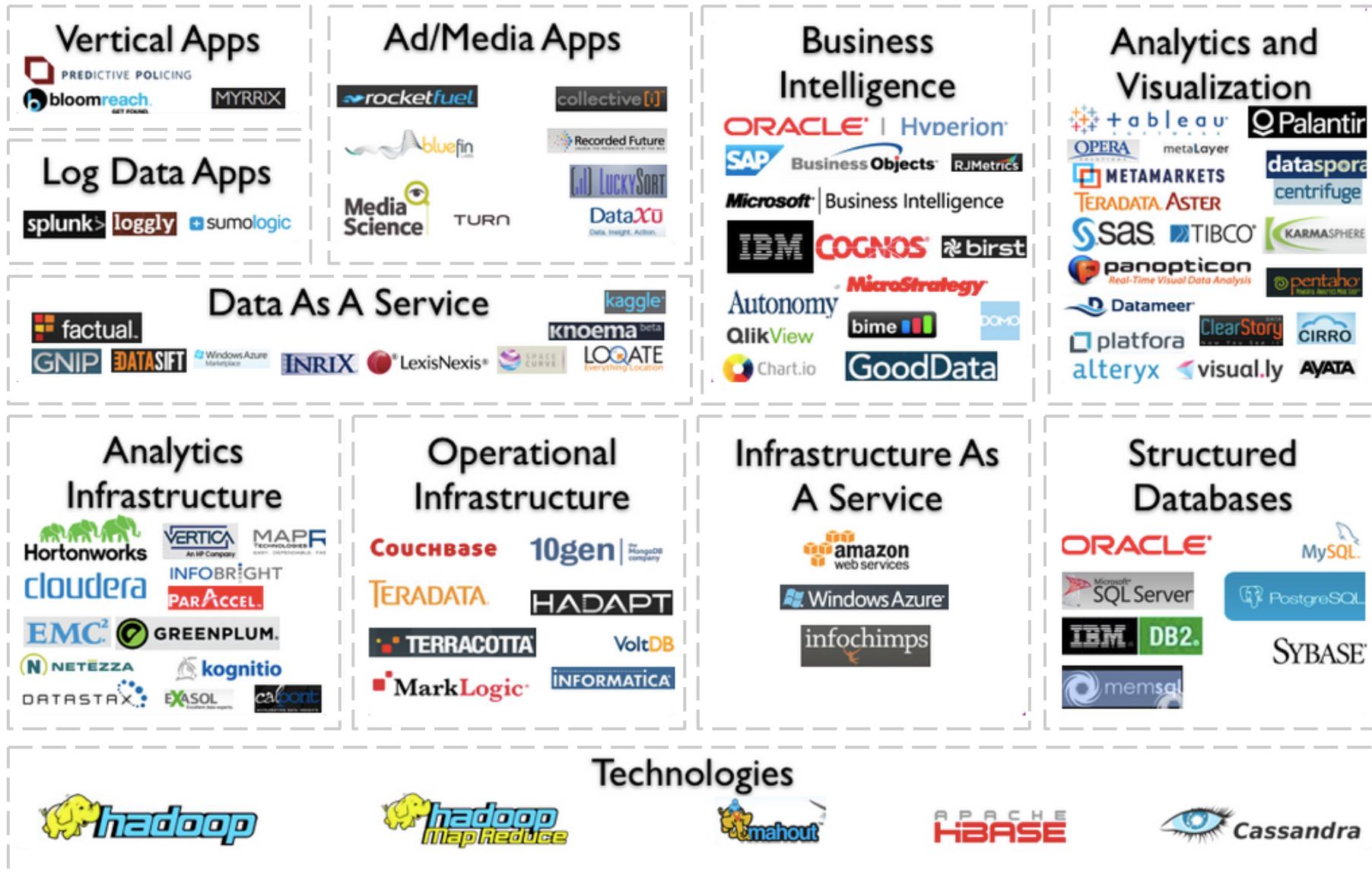
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Q & A



# Complex Big Data Landscape



# The Flood of BIG DATA

**5.3**  
TRILLION ONLINE AD  
IMPRESSIONS IN 2012<sup>1</sup>

ONLINE AD  
IMPRESSIONS

**191**  
BILLION EMAILS  
SENT EVERY DAY<sup>2</sup>

EMAIL

**US \$109.7**  
BILLION ESTIMATED  
FOR 2014<sup>3</sup>

ONLINE  
AD SPEND

**US \$14.3**  
BILLION SPENT IN  
U.S. ON MOBILE ADS IN 2013<sup>4</sup>

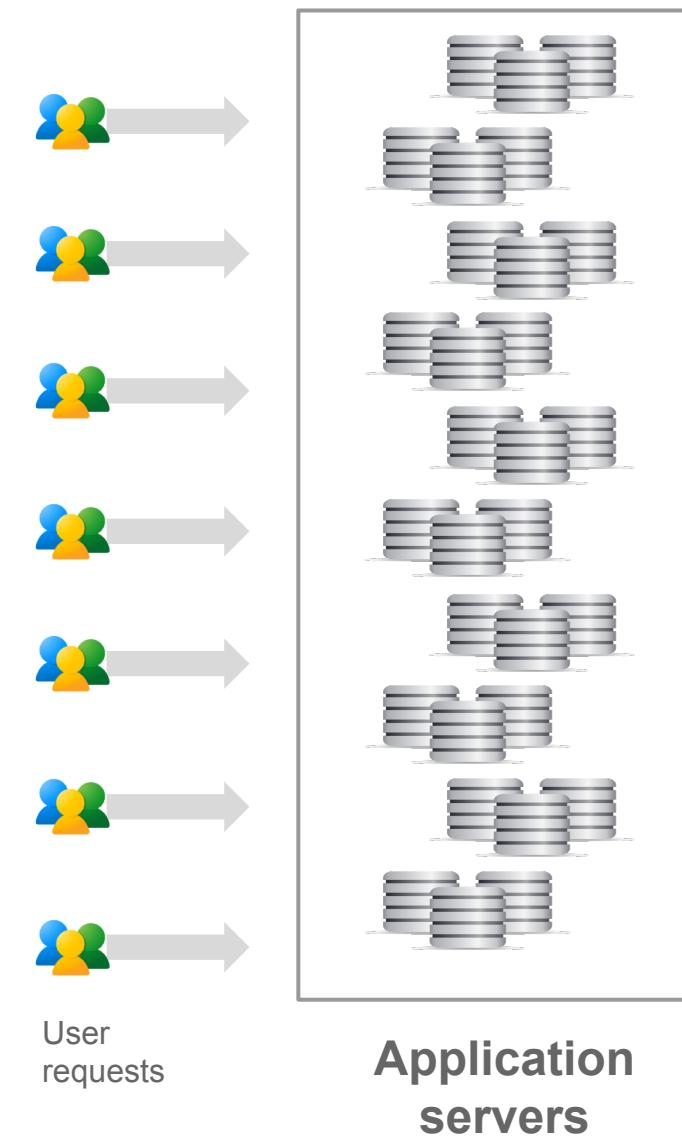
MOBILE  
AD

**500+**  
TERABYTES OF DATA  
UPLOADED DAILY<sup>5</sup>

FACEBOOK

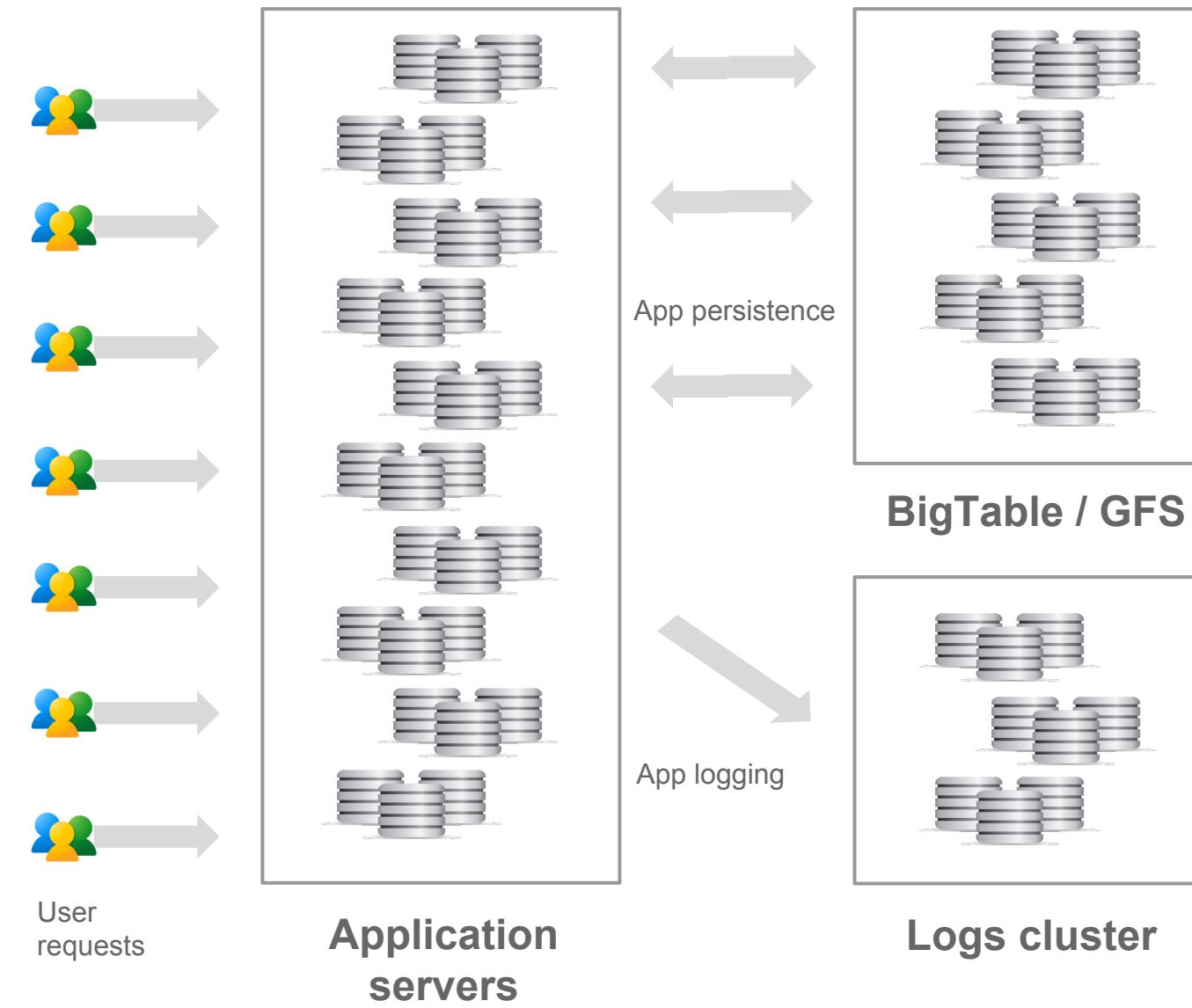
# How does Google process **Big Data?**

# Big Data processing example - application logs



Note: diagram is dramatically simplified

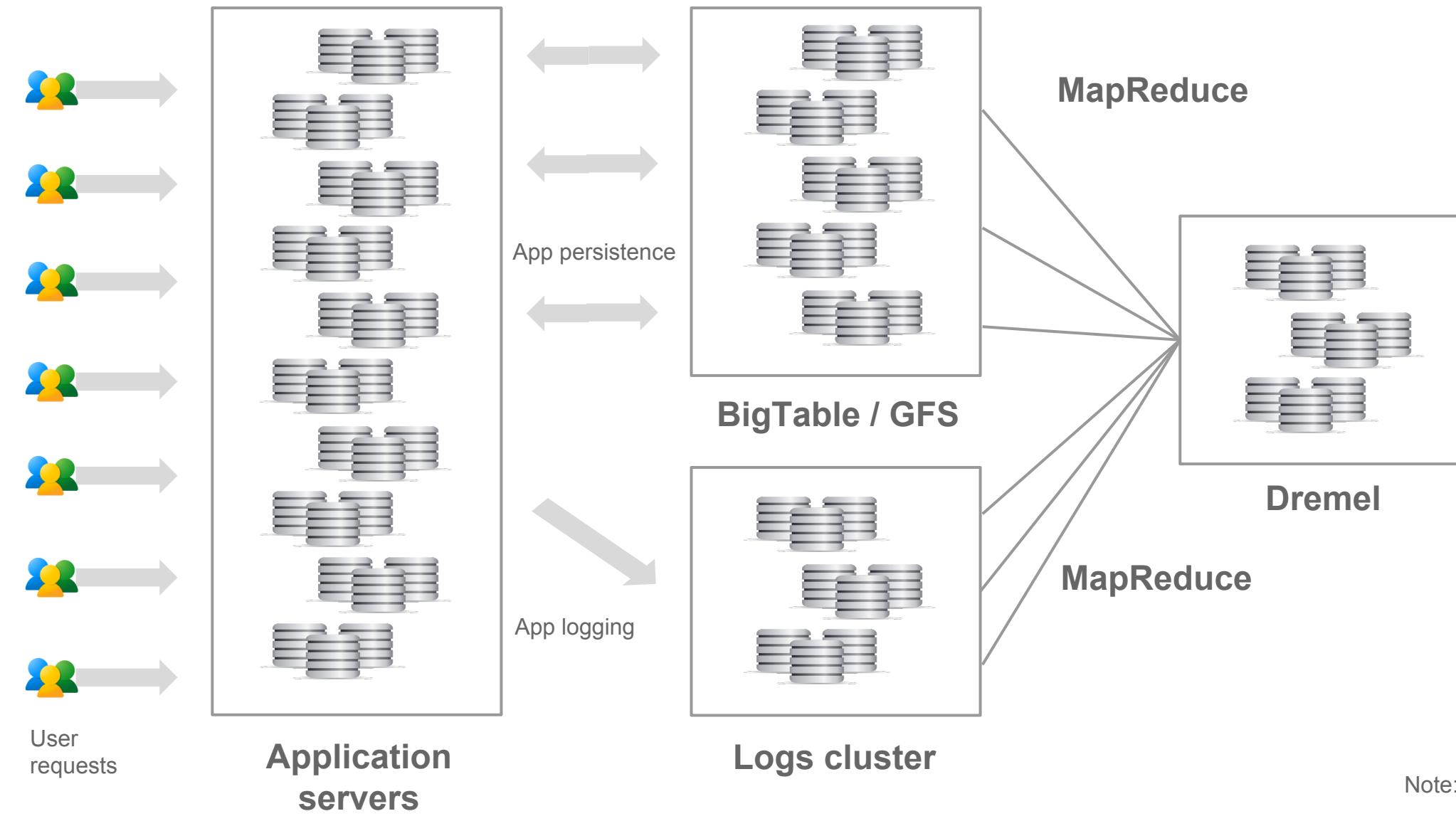
# Big Data processing example - application logs



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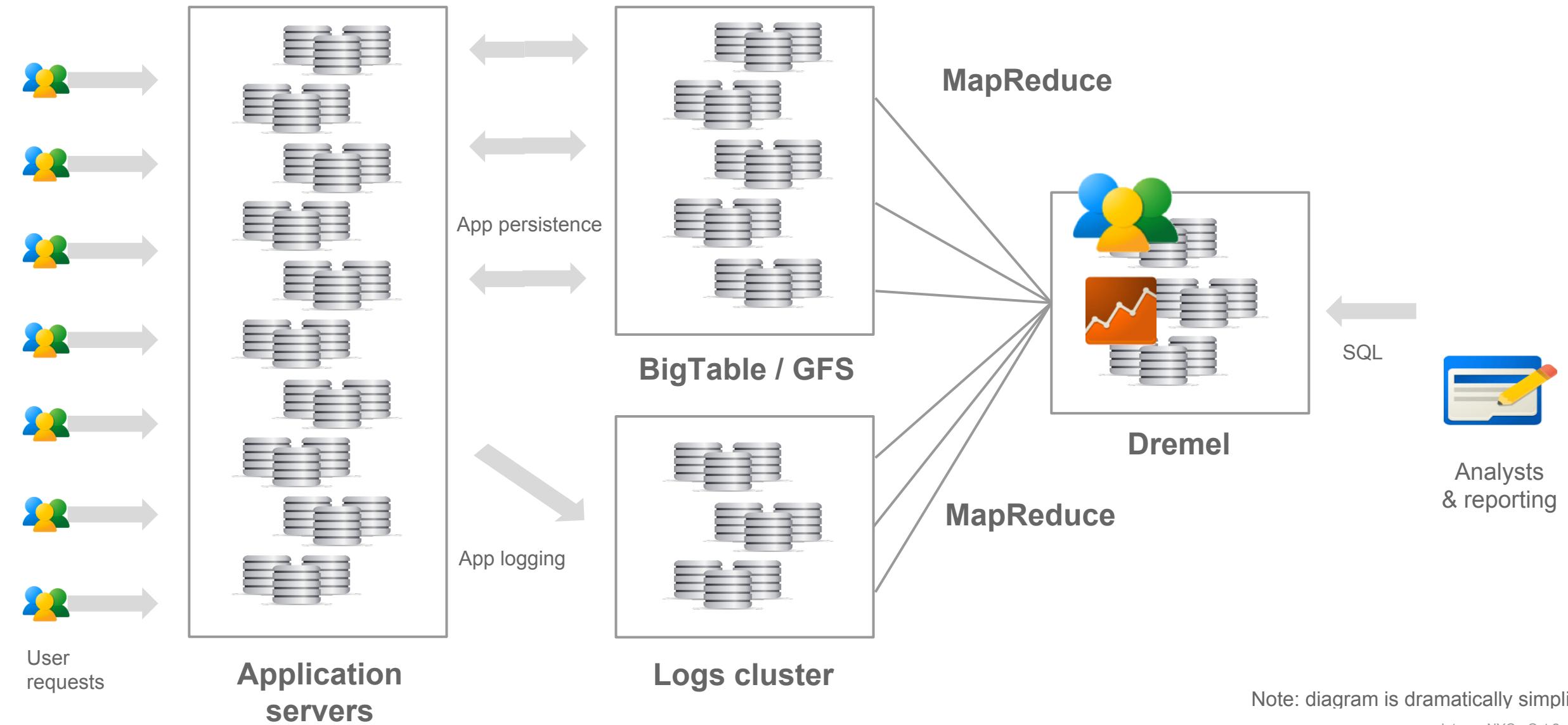
Interop NYC - Oct 2, 2012

# Big Data processing example - application logs

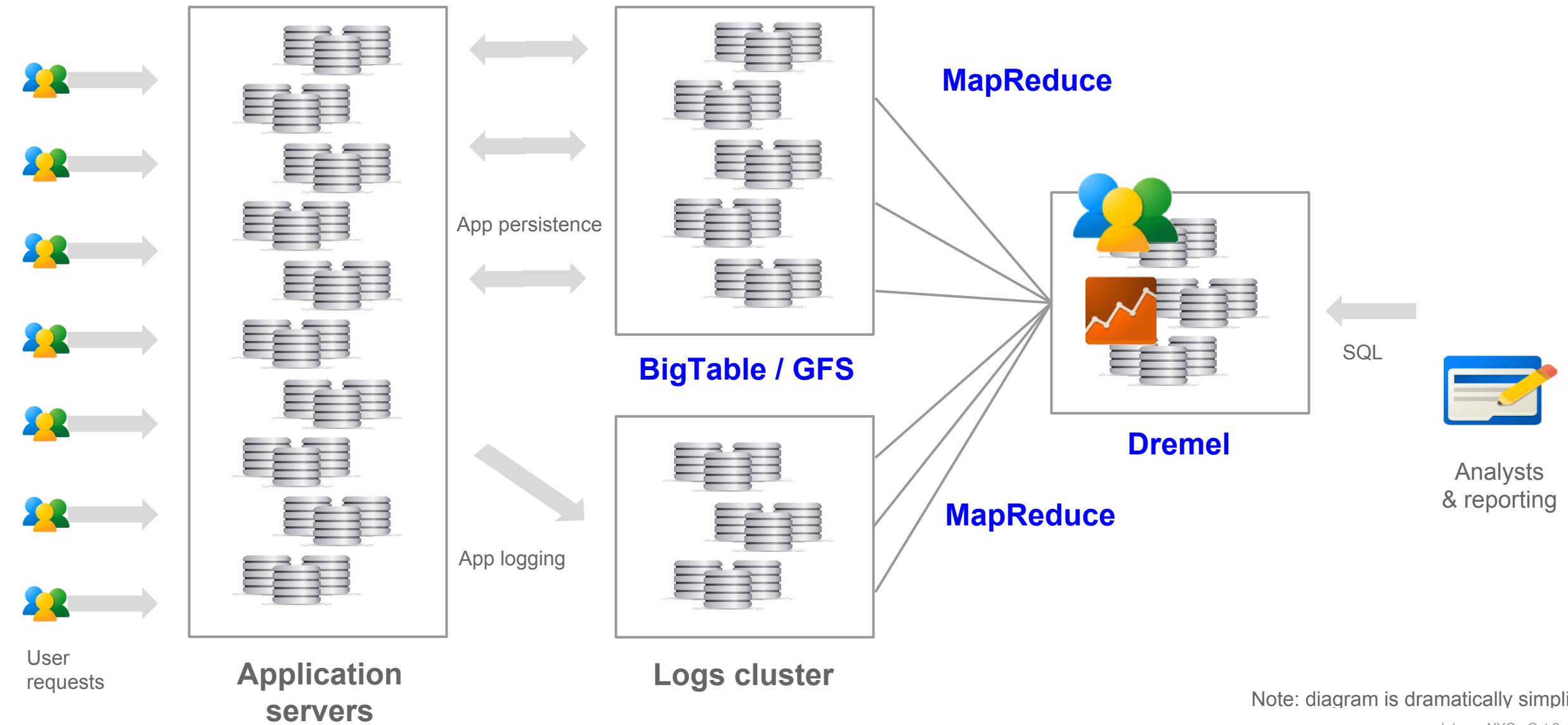


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# Big Data processing example - application logs



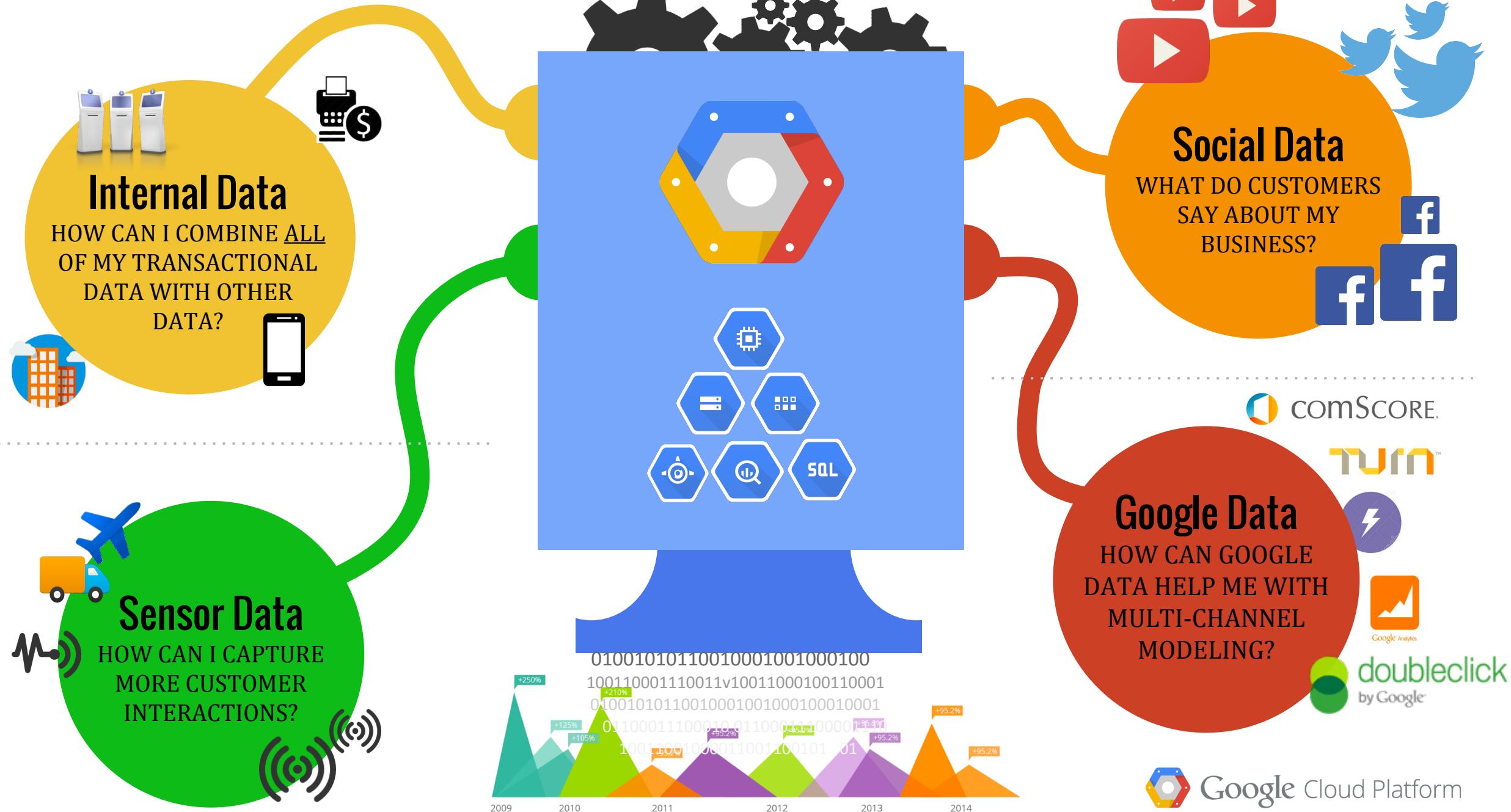
# Big Data processing example - application logs



Interop NYC - Oct 2, 2012

How does this apply  
to my **business**?





# Sample use cases - BigQuery usage today

## Display ads analytics (global top-5 media agency)

Analyze global campaign performance for F500 clients  
1 client = 20GB/day of DoubleClick impressions logs

## Ads network reporting (3rd party mobile ads)

Deliver x-platform performance analytics dashboards  
1B events/day x 100s of ads customers

## Fleet reservations (online travel operations)

Monitor customer demand vs supply shortfalls  
10,000 routes x 1000s customers = millions of daily events

## Mobile app statistics (online reading vendor)

Usage analysis on 60M installs; 10M active users  
2B API requests/day, 20GB log data/day

## Revenue optimization (holiday/travel properties)

Correlate marketing effectiveness vs global reservations  
10MBs / day from multiple data warehouses

# Today we see the same trends happening in industry

## Opportunities

...

Single place to capture data

Combine data from different sources

Detect patterns and correlations

Easily share data insights with org

Distributed decision making

## Challenges

...

**The data is large**  
Up to 100-200 TB

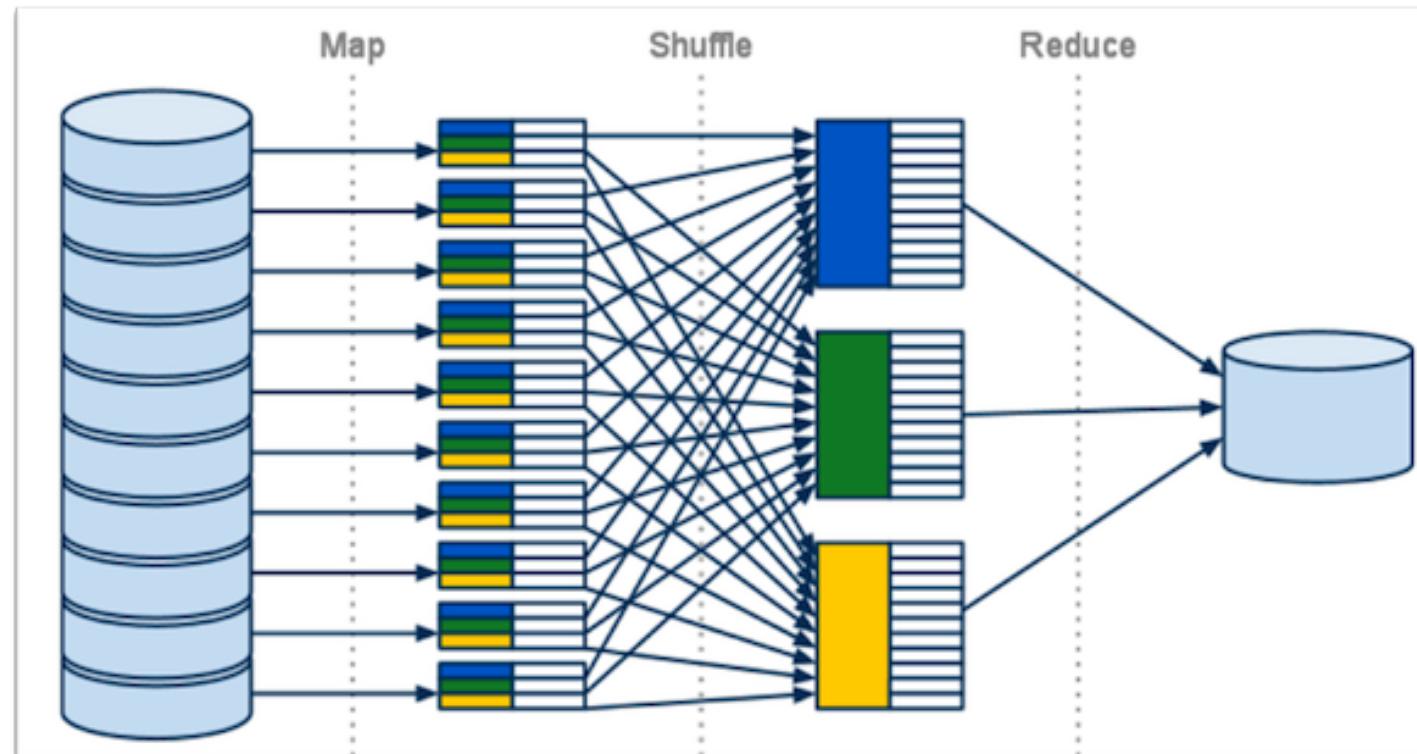
**High rate of growth**  
Up to 100-200 GB / day

**Non-relational**  
Unstructured or semi-structured

**Multiple sources**  
SaaS, Mobile devices, legacy

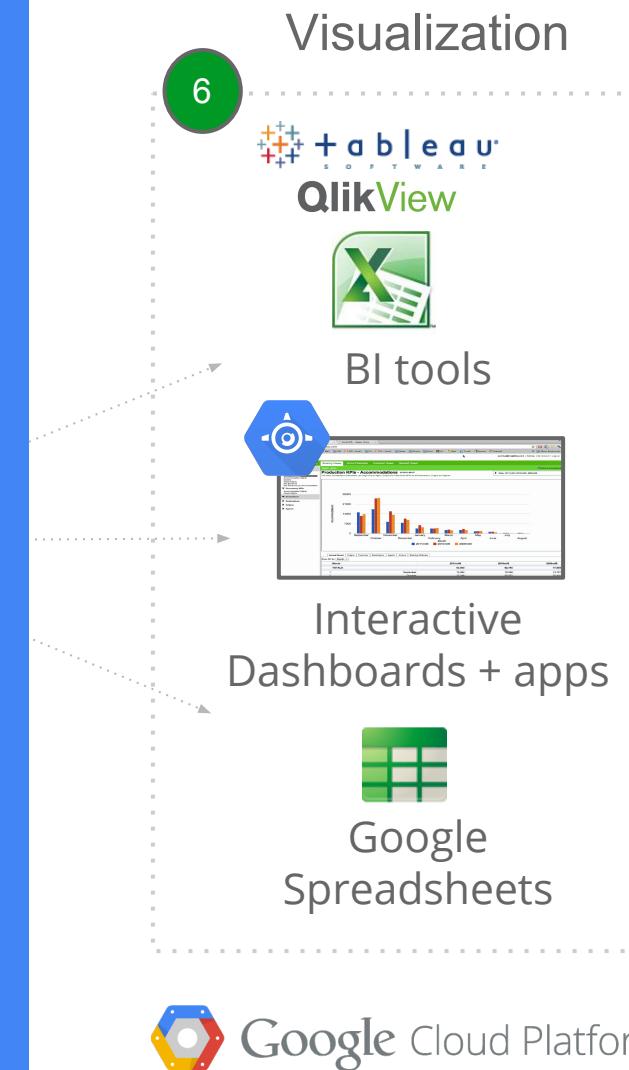
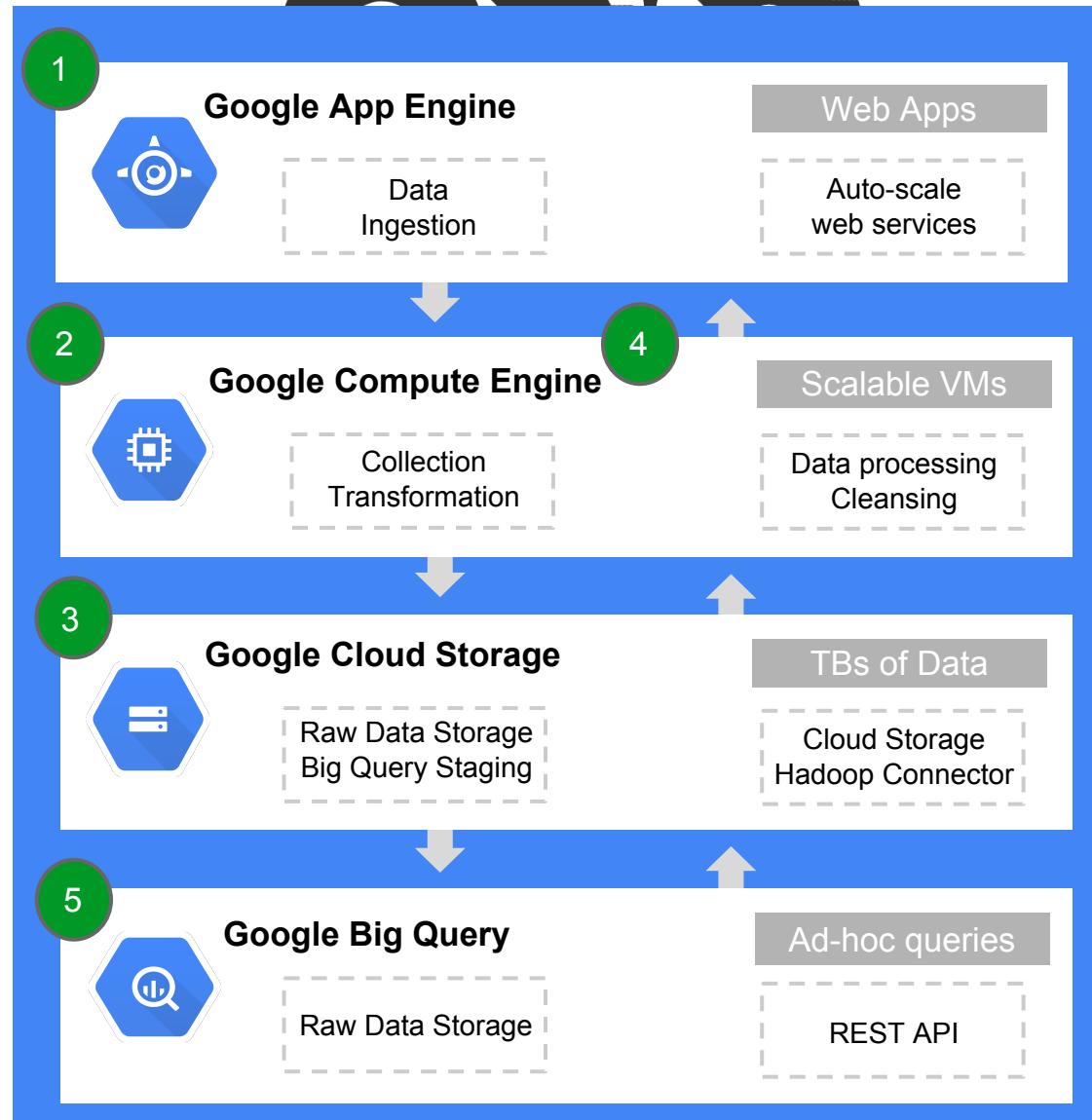
# Processing Data: MapReduce

- 2004: Google releases the MapReduce\* framework paper
- 2011: Big Data "analysis" using Hadoop and other Google inspired technology



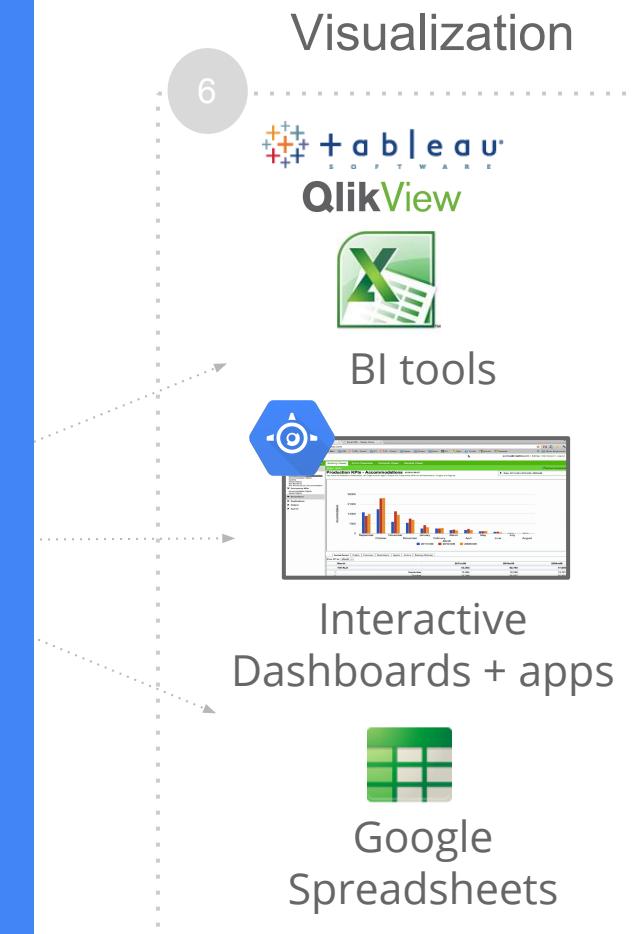
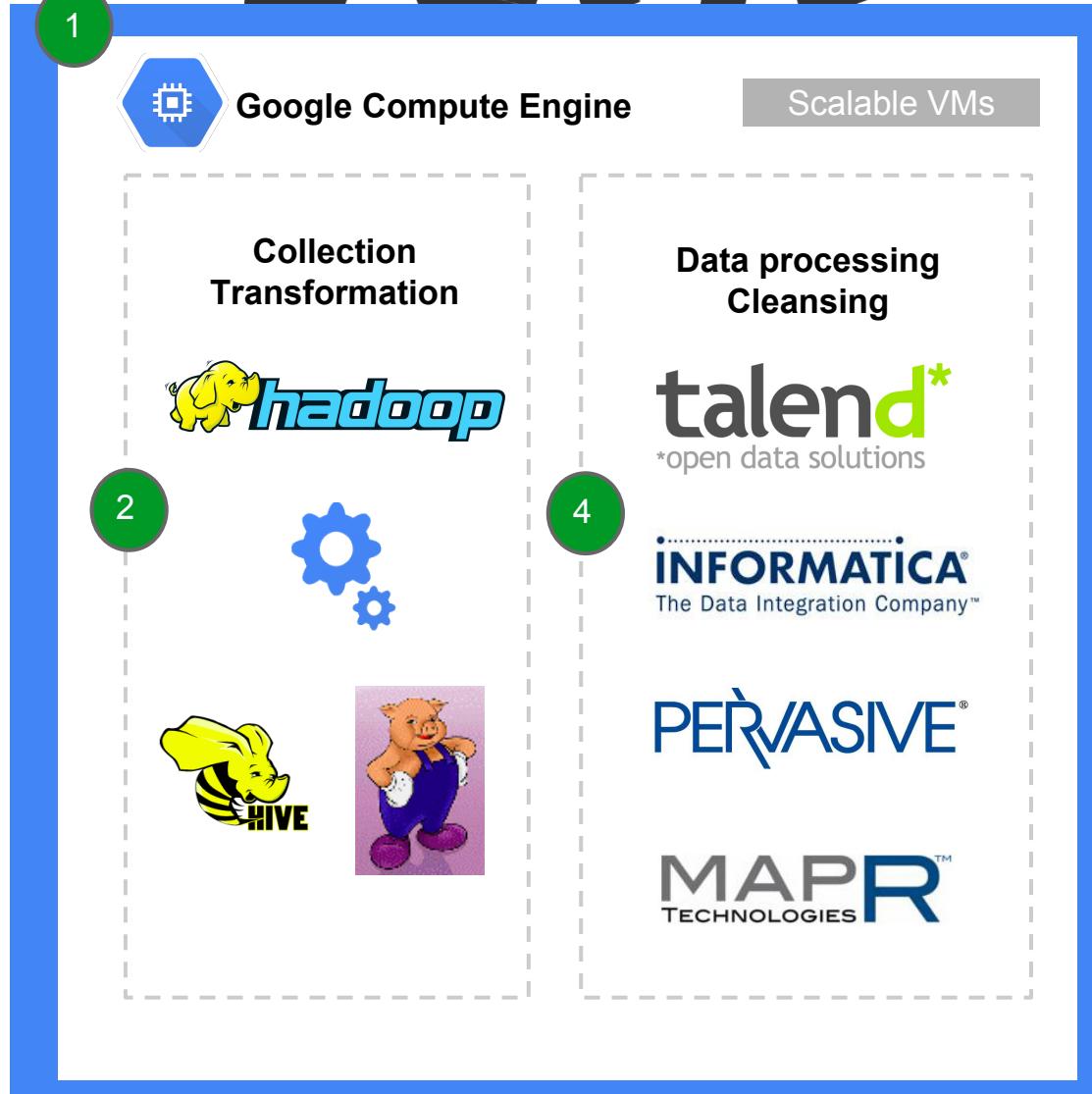


- 1 Data Collection
- 2 ETL
- 3 Raw Data Storage
- 4 Aggregation
- 5 Analytics Storage
- 6 Visualization





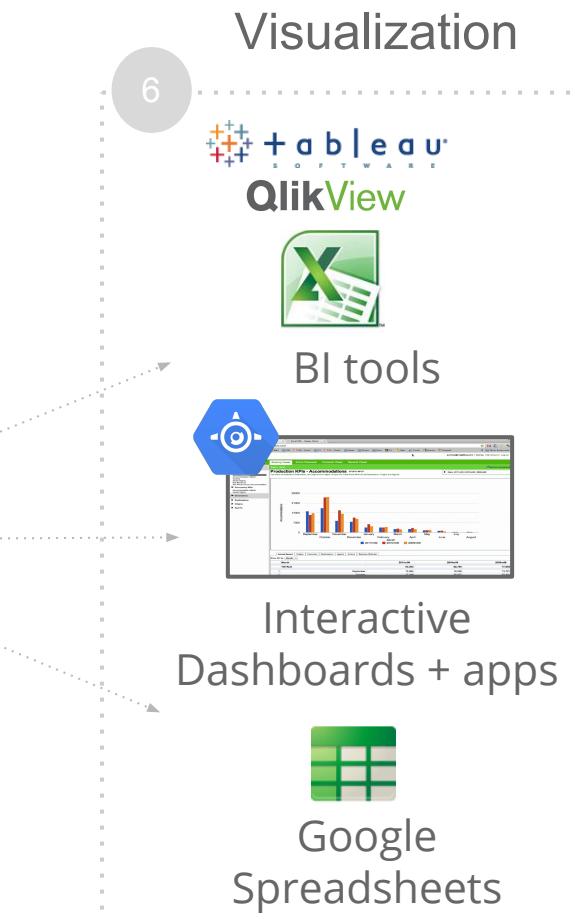
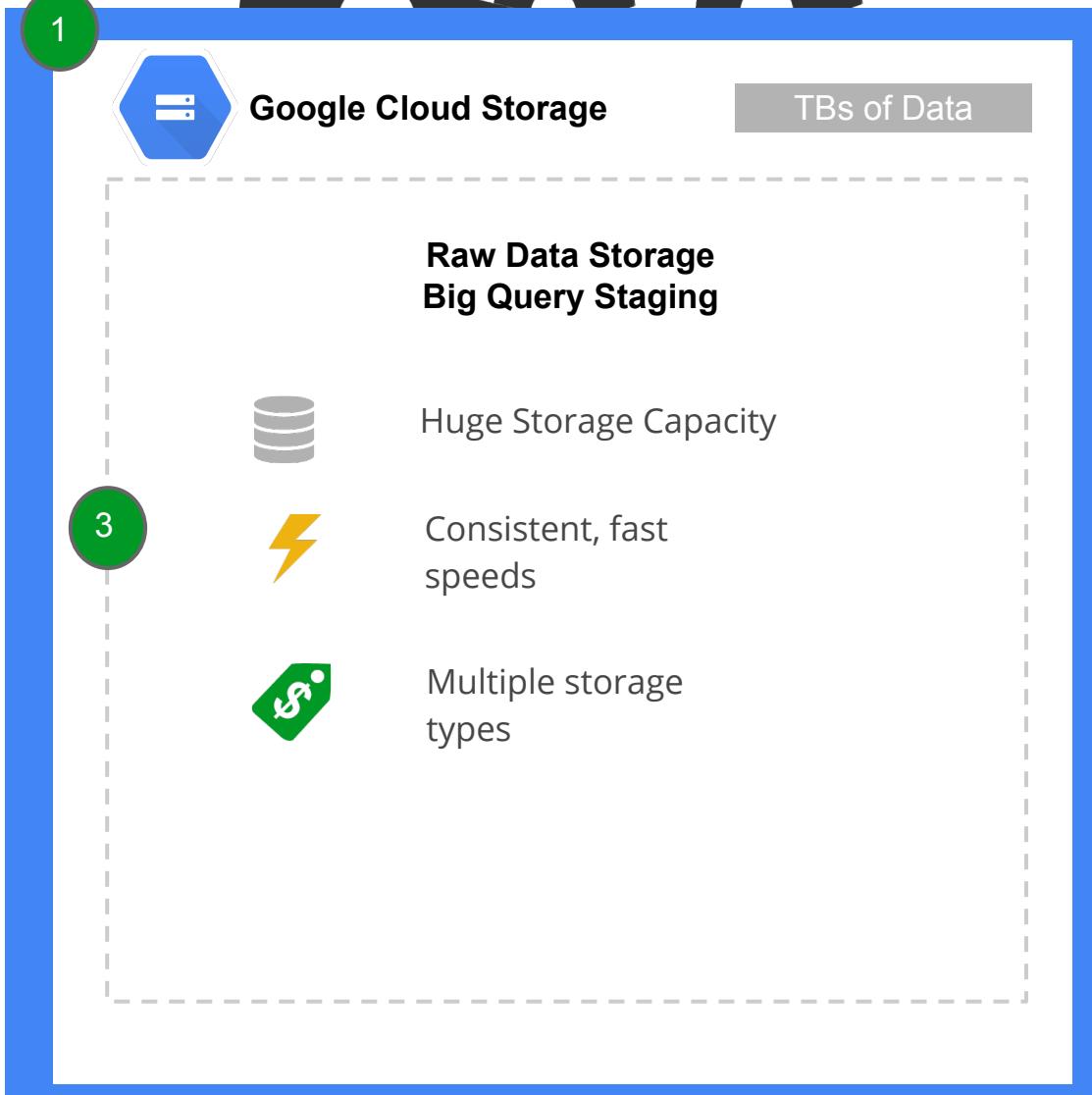
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Google Cloud Platform



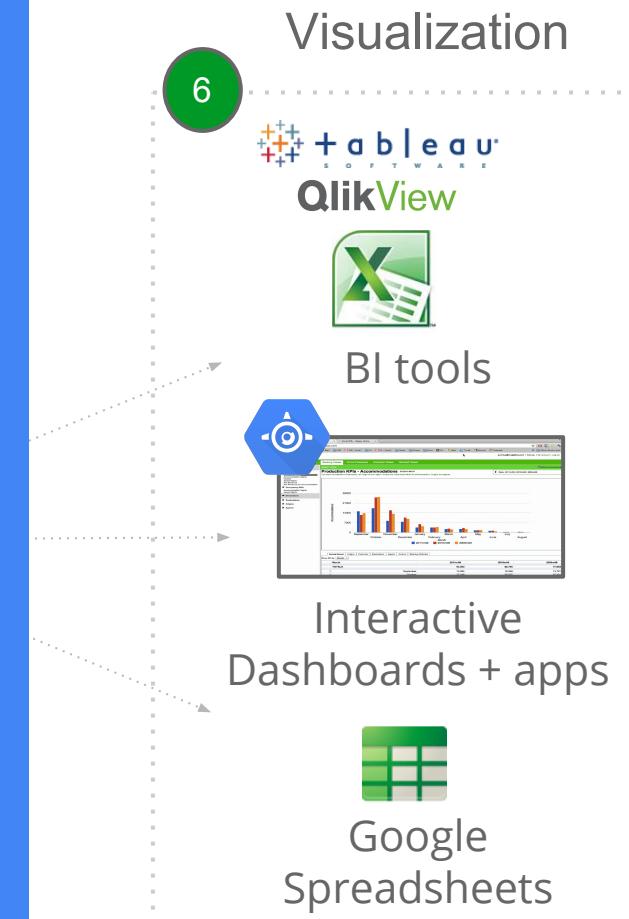
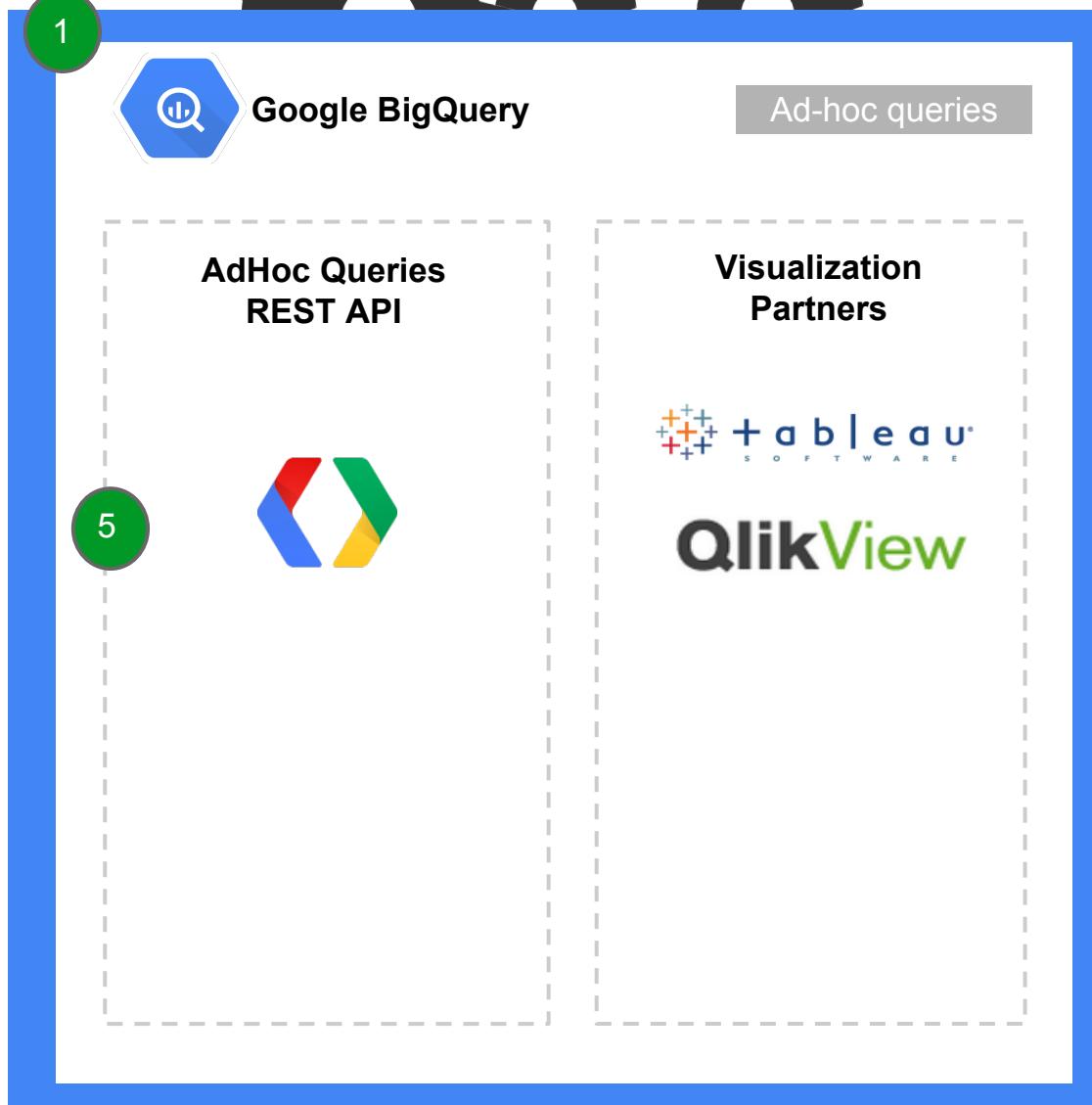
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Google Cloud Platform



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Google Cloud Platform

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# Google Compute Engine



+



# Demo

Hadoop on Google Compute Engine

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# BigData at Google

Running Hadoop on Google Compute Engine

## 1. Set up Hadoop

```
./compute_cluster_for_hadoop.py setup google-platform-demo  
hadoop-demo-jameschi
```



# BigData at Google

Running Hadoop on Google Compute Engine

## 2. Start Cluster

```
./compute_cluster_for_hadoop.py start google-platform-demo  
hadoop-demo-jameschi 500
```



# BigData at Google

Running Hadoop on Google Compute Engine

## 3. Start MapReduce

```
./compute_cluster_for_hadoop.py mapreduce google-platform-
demo hadoop-demo-jameschi \
--input gs://hadoop-demo-jameschi-input \
--output gs://hadoop-demo-jameschi-output \
--mapper sample/shortest-to-longest-mapper.pl \
--reducer sample/shortest-to-longest-reducer.pl \
--mapper-count 5 \
--reducer-count 1
```



# BigData at Google

Running Hadoop on Google Compute Engine

## 4. Shutdown Cluster

```
./compute_cluster_for_hadoop.py shutdown google-platform-demo
```



# Google Compute Engine Costs

## Total Costs for Running Hadoop:

Instance type	Virtual Cores	Memory	Price (US\$)/Hour (US hosted)
n1-standard-1	1	3.75GB	\$0.104

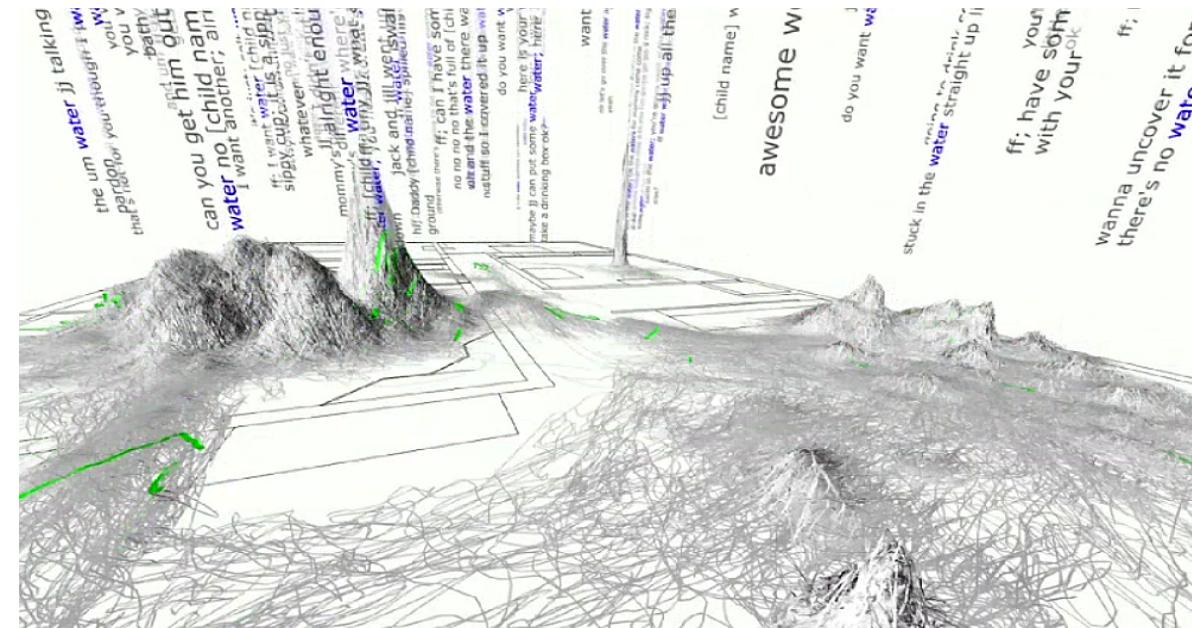
5 node Hadoop cluster x 20 minutes = **\$0.21**

5,000 node Hadoop cluster x 20 min = **\$8.67**



# How Google Approaches Analytics

- MapReduce based analysis can be slow for ad-hoc queries
- Managing data centers and tuning software takes time & money
- Analytics tools should be services

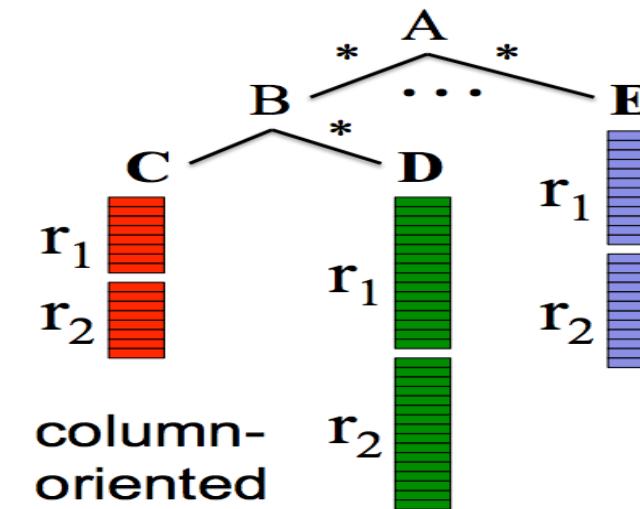
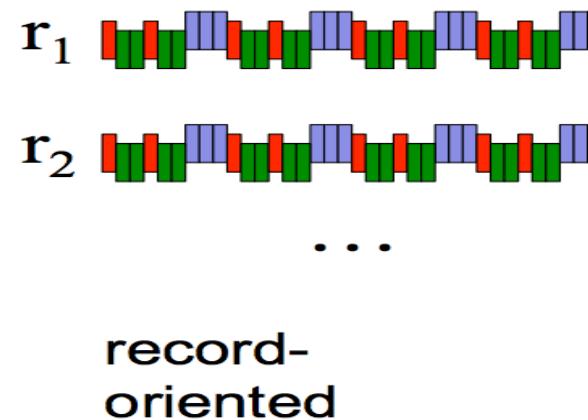


# How Google Approaches Analytics

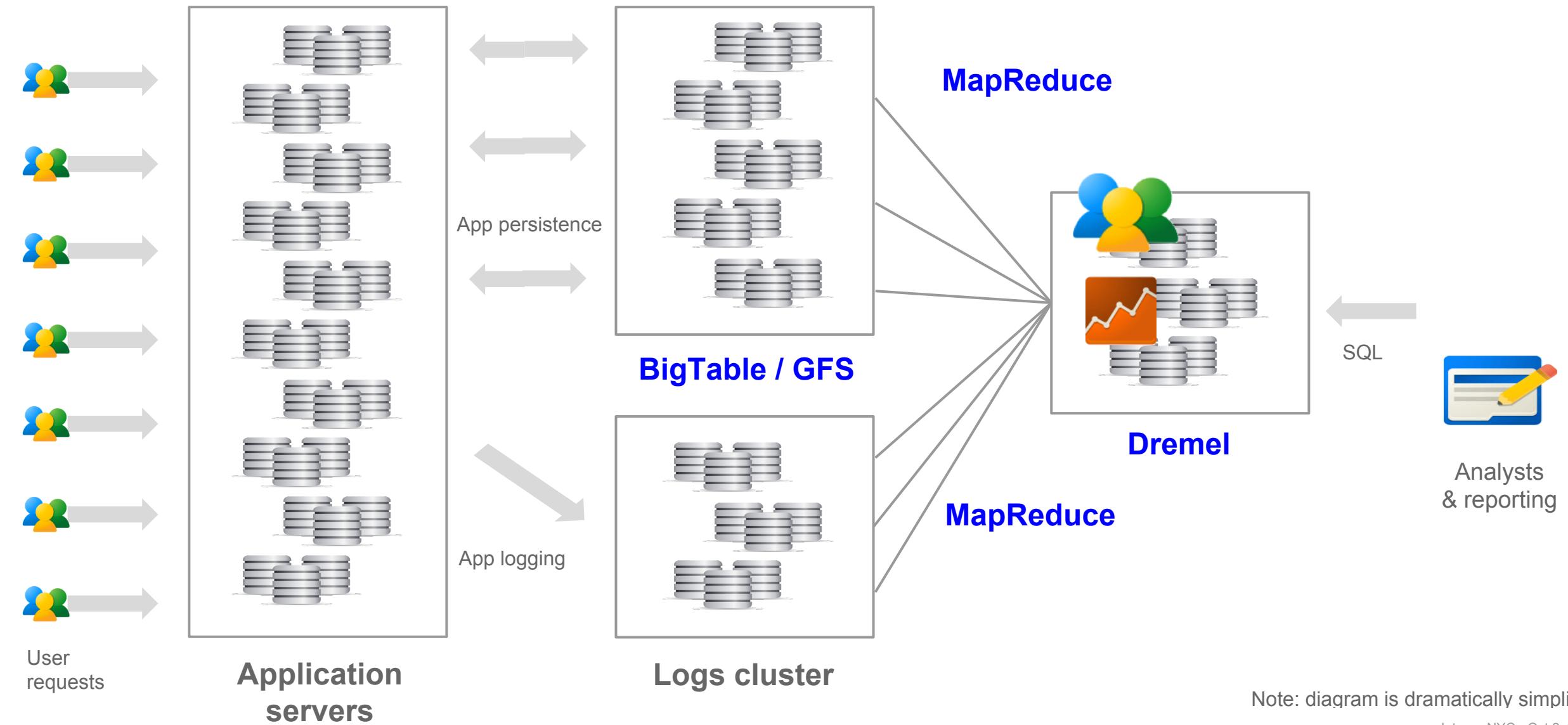
## Dremel

Ad-hoc query system for terabyte datasets

- Query execution tree
- Column Oriented records
- ...and a lot of nodes



# Big Data processing example - application logs



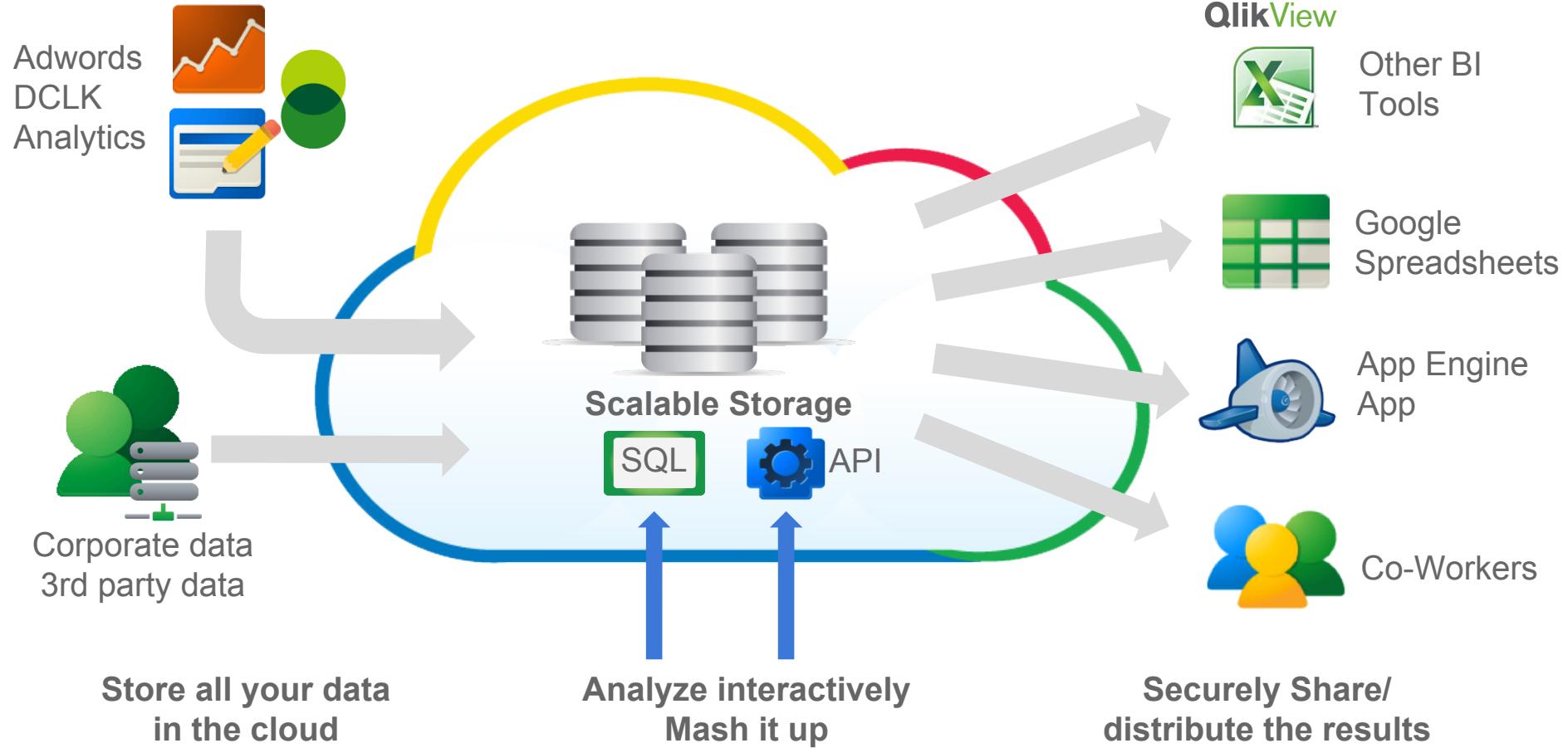
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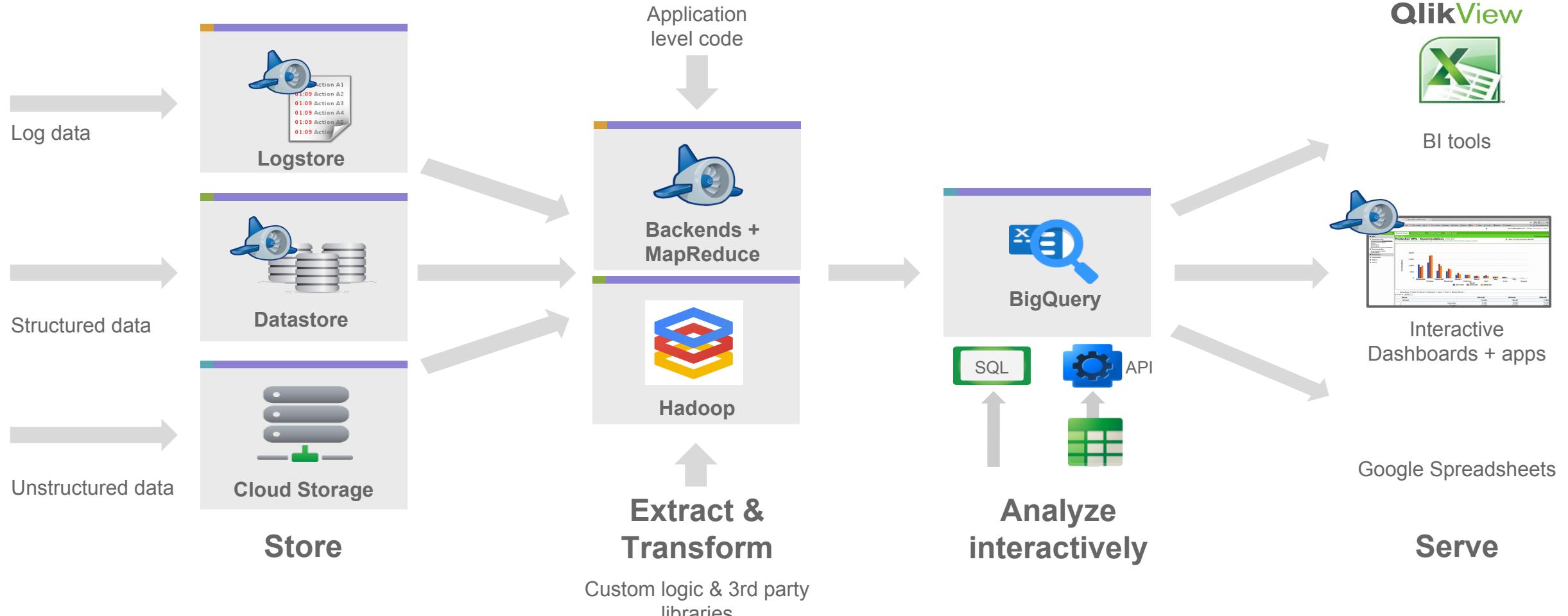
# What is BigQuery?

Google BigQuery: An Overview

**BigQuery: a fully-managed data analytics service in the cloud.**  
Unlimited storage. Interactive analysis on multi-terabyte datasets.



# Cloud-based data analytics pipeline

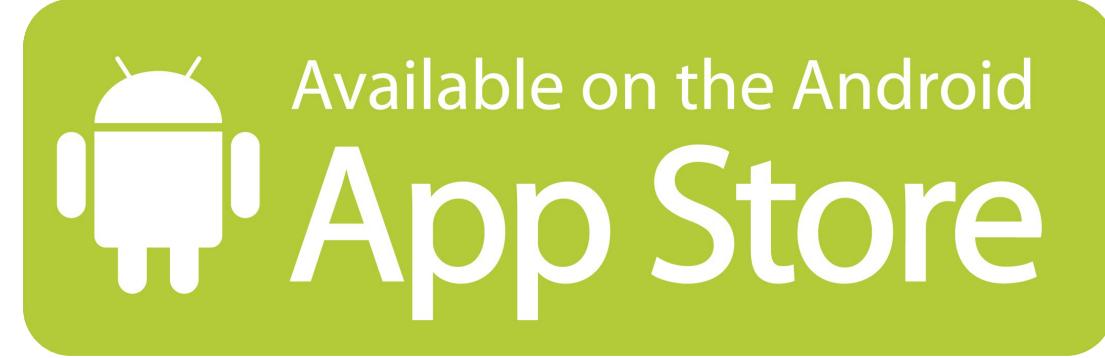


# Origins of BigQuery



# Origins of BigQuery

Google BigQuery: An Overview



How can a business analyst find Top 20 Apps in matter of seconds?

# Origins of BigQuery

Google BigQuery: An Overview



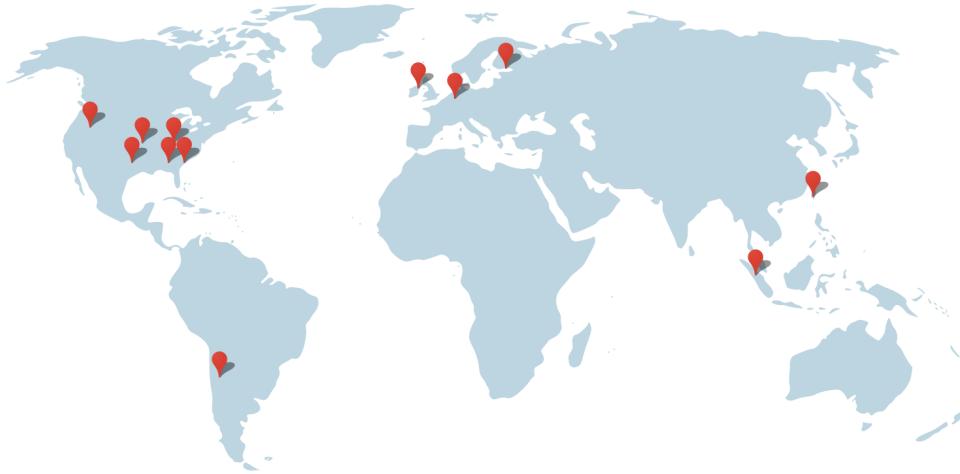
How can a business analyst find Top 20 Apps in matter of seconds?

```
SELECT  
    top(appId, 20) AS app,  
    count(*) AS count  
FROM installlog.2012;  
ORDER BY  
    count DESC
```

Result in ~20 seconds!

# Origins of BigQuery

Google BigQuery: An Overview



Google | Data Centers

How do you find slow running servers from billions of log entries - in seconds?

# Origins of BigQuery

Google BigQuery: An Overview



Google | Data Centers

How do you find slow running servers from billions of log entries - in seconds?

```
SELECT
    count(*) AS count, source_machine AS
    machine
FROM product.product_log.live
WHERE
    elapsed_time > 4000
GROUP BY
    source_machine
ORDER BY
    count DESC
```

Result in ~20 seconds!



# Origins of BigQuery

Google BigQuery: An Overview



## Venue

Proc. of the 36th Int'l Conf on Very Large Data Bases (2010), pp. 330-339

## Publication Year

2010

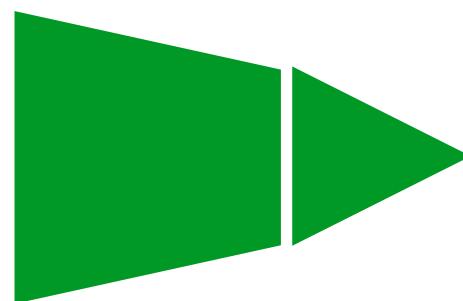
## Authors

Sergey Melnik, Andrey Gubarev, Jing Jing Long, Geoffrey Romer, Shiva Shivakumar, Matt Tolton, [Theo Vassilakis](#)

## Dremel: Interactive Analysis of Web-Scale Datasets



**Abstract:** Dremel is a scalable, interactive ad-hoc query system for analysis of read-only nested data. By combining multi-level execution trees and columnar data layout, it is capable of running aggregation queries over trillion-row tables in seconds. The system scales to thousands of CPUs and petabytes of data, and has thousands of users at Google. In this paper, we describe the architecture and implementation of Dremel, and explain how it complements MapReduce-based computing. We present a novel columnar storage representation for nested records and discuss experiments on few-thousand node instances of the system.



# Google BigQuery

# BigQuery -- Sweetspots

Google BigQuery: An Overview

Use cases/applications where

**Interactive analysis** on large data sets is a requirement

**Data mashups** at scale and ease is important

**Elasticity** of environment is important

**Minimal administration** is required

**Empowering** Analysts or Data scientist with self service capabilities



# Demo

Ad-hoc Analysis with BigQuery

---



# Why is BigQuery so Special?



# Why BigQuery is Special?

Google BigQuery: An Overview



# 0

## ZERO Administration for Performance and Scale



No complex data architecture required.

- Simple denormalized data structure
- Data can be loaded in csv or JSON format

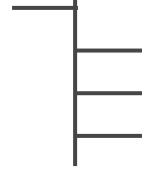


Supports Open Standards

- SQL like language
- Standard BI/ETL tools supported
- REST API Support for integrating analytics programmatically

# Why BigQuery is Special?

Google BigQuery: An Overview



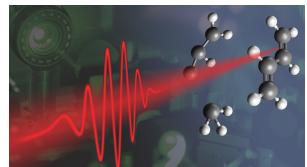
## Nested Field Support

- Analyze details for headers (items of the order, clicks of the session in single SQL statement)
- Ingest Web data (Typically in JSON format) directly into BigQuery



## Query Result Caching at Scale

- Caching of query results at Scale (24 hours best effort)
- Option to re-generate results / update cache



## Real-time Data Ingest and Reporting

- Data ingest at 100 rows/second (with peak 1000 rows/second) into BigQuery
- Support for real-time to near real-time query/reporting

# Why BigQuery is Special?

Google BigQuery: An Overview



## And many more...

SQL like Query Language and REST based APIS

High performance queries on strings (use of REGEXP and pattern matching)

Data window functions and many aggregation capabilities

Table Wildcards

Table decorators for time based queries..

## Integration with Google Stack

Google Analytics Premium (hit level data) - BigQuery

Google App Engine Datastore to BigQuery - Trusted Tester

# What BigQuery is Not?



# Why BigQuery is Not?

Google BigQuery: An Overview



## Relational Database Management System (RDBMS)

- Data is stored in BigQuery in Columnar fashion
- BigQuery tables are immutable (no updates or deletes)\*

## Not a replacement for existing Data warehouse en-mass

- Specifically designed for large data sets
- Queries requiring massive processing

## On-premise solution or Appliance

- It is available only in Google Cloud in a fully hosted fashion
- Data needs to be in Google Cloud (BigQuery) for analysis

\* alternate ways to support these capabilities

# Columnar Storage and Tree Architecture of Dremel

## Why Dremel can be so drastically fast as the examples show?

The answer can be found in two core technologies which gives Dremel this unprecedented performance:

- **Columnar Storage.** Data is stored in a columnar storage fashion which makes possible to achieve very high compression ratio and scan throughput.
- **Tree Architecture** is used for dispatching queries and aggregating results across thousands of machines in a few seconds.

# Dremel: Key to Run Business at “Google Speed”

Google has been using Dremel in production since 2006 and has been continuously evolving it for the last 6 years.

Examples of applications include:

- Analysis of crawled web documents
- Tracking install data for applications in the Android Market
- Crash reporting for Google products
- OCR results from Google Books
- Spam analysis
- Debugging of map tiles on Google Maps
- Tablet migrations in managed Bigtable instances
- Results of tests run on Google’s distributed build system
- Disk I/O statistics for hundreds of thousands of disks
- Resource monitoring for jobs run in Google’s data centers
- Symbols and dependencies in Google’s codebase

# BigQuery Sample Use Cases

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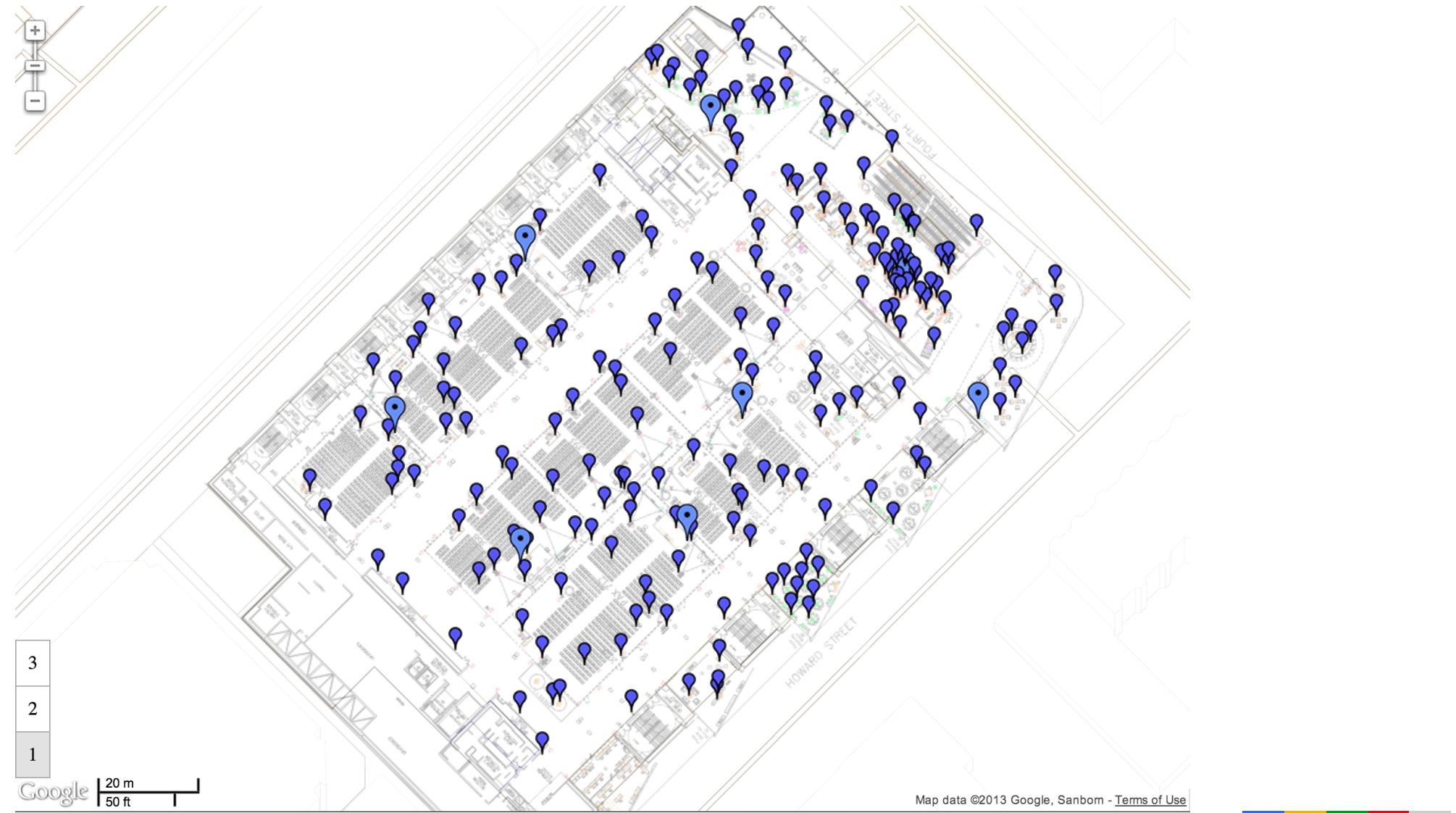




# Sensor Data Analytics



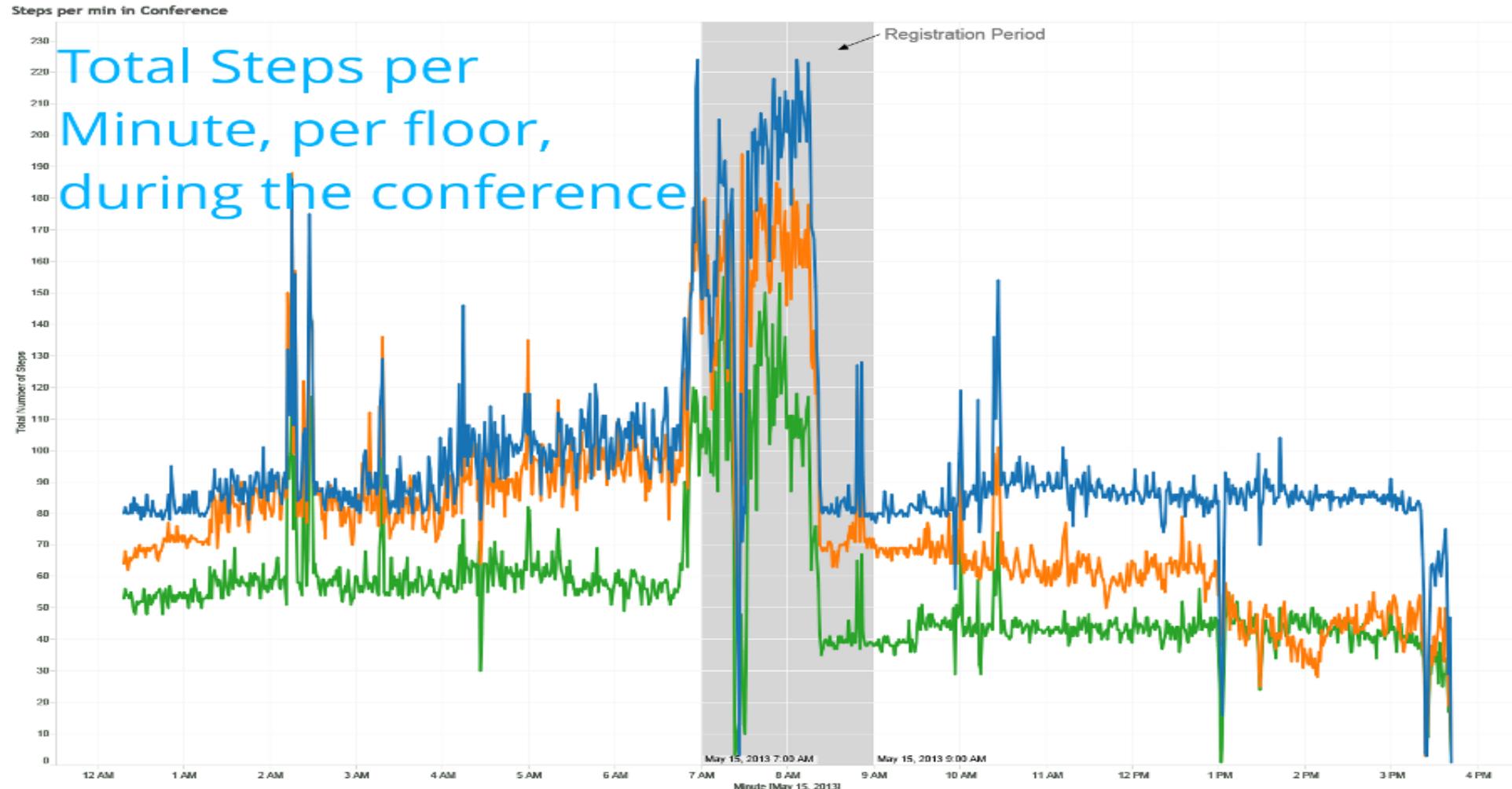
# Sensor Data Analytics



# Sensor Data Analytics



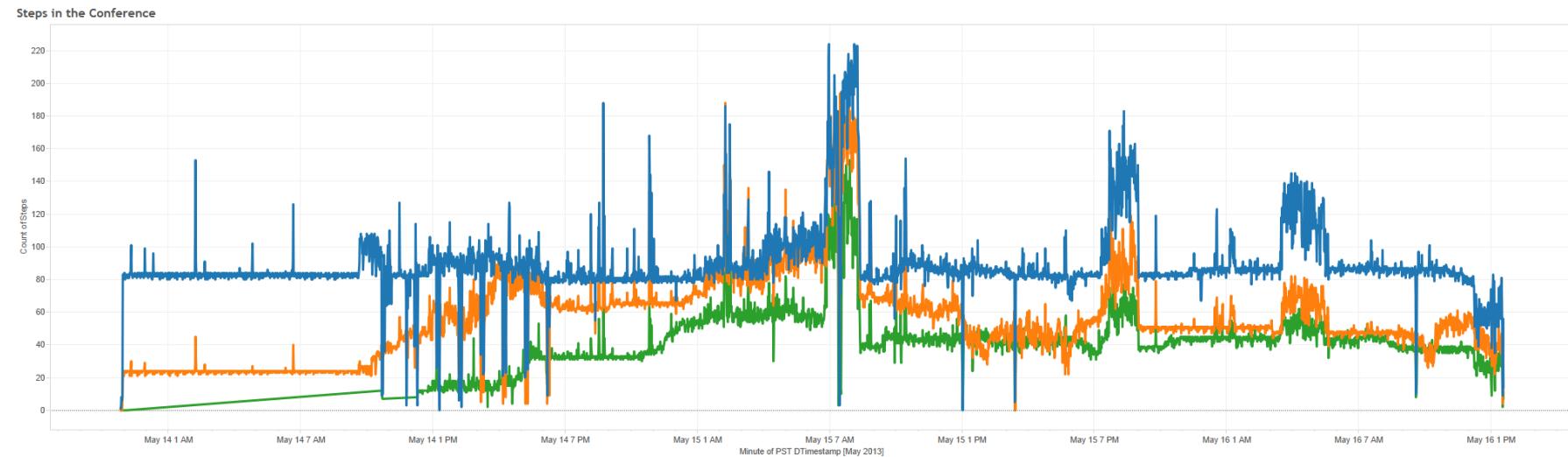
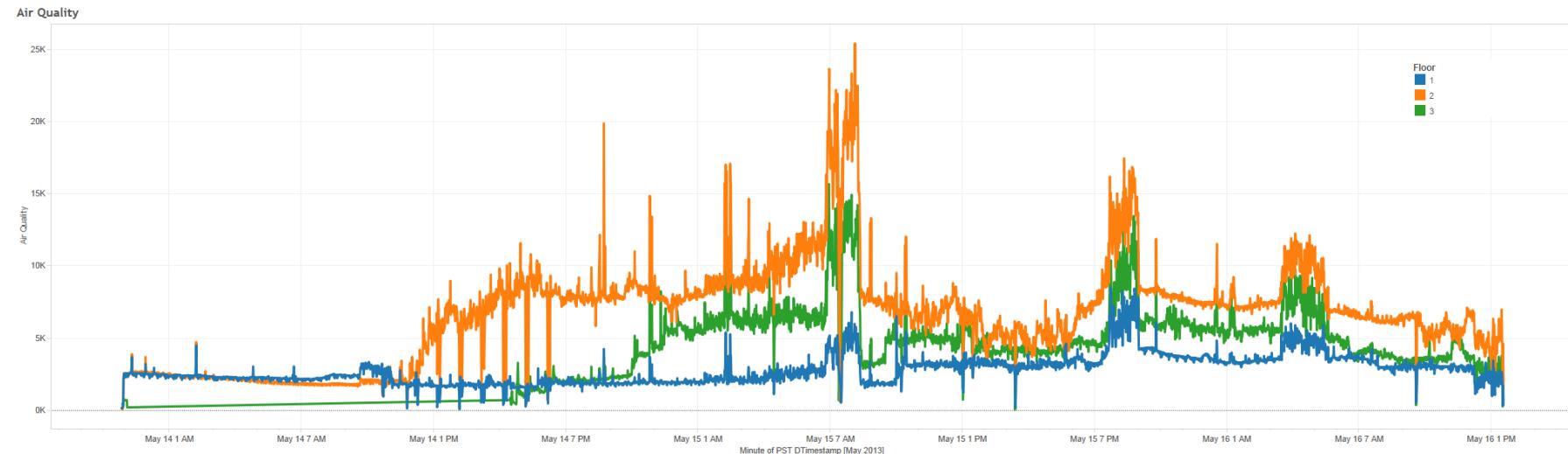
# Sensor Data Analytics



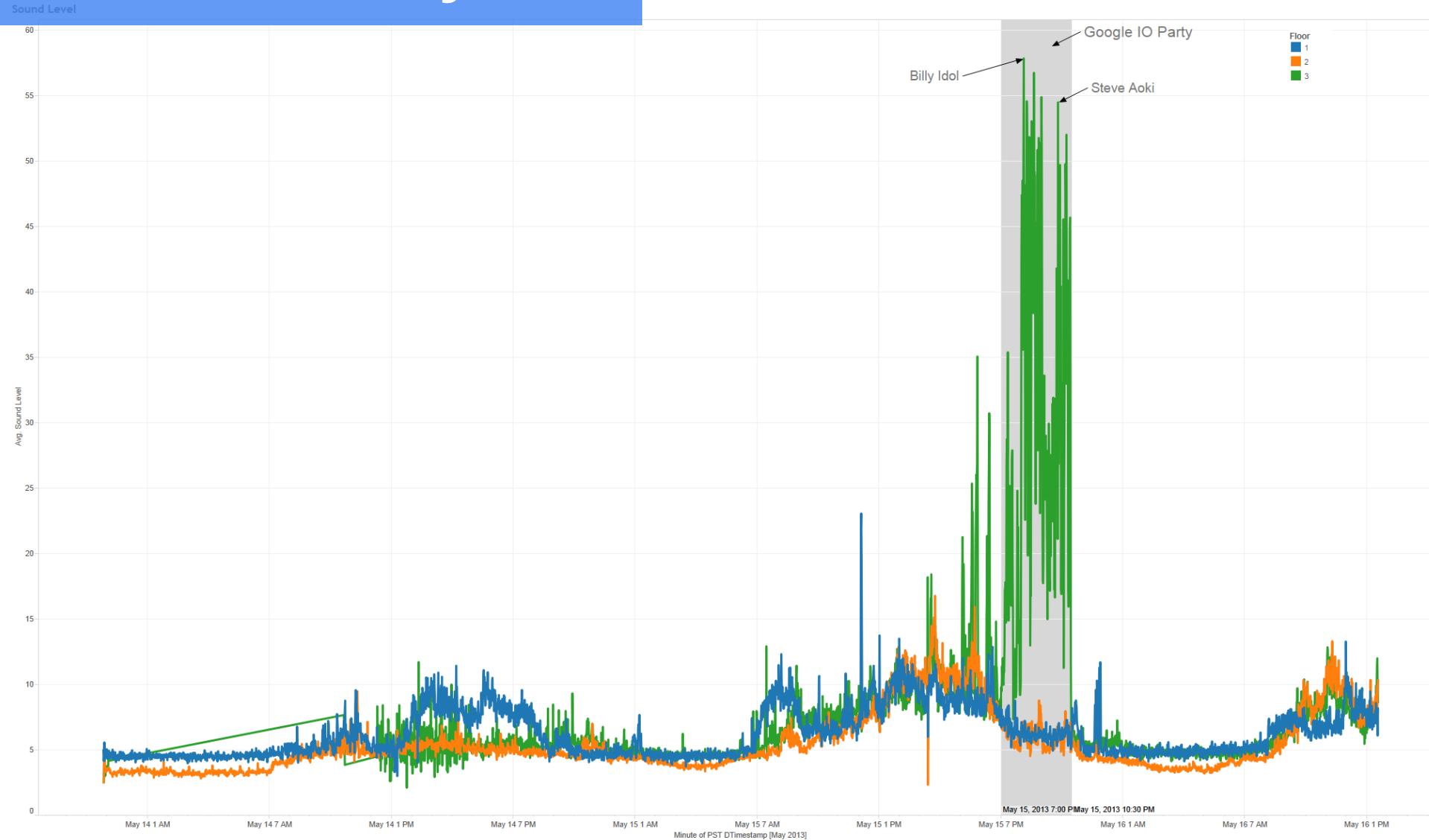
The trend of count of Data for PST DTimestamp Minute. Color shows details about Floor. The data is filtered on SensorType, which keeps motion. The view is filtered on Exclusions (Floor,MINUTE(PST DTimestamp)) and Floor. The Exclusions (Floor,MINUTE(PST DTimestamp)) filter keeps 3,142 members. The Floor filter keeps 1, 2 and 3.



# Sensor Data Analytics



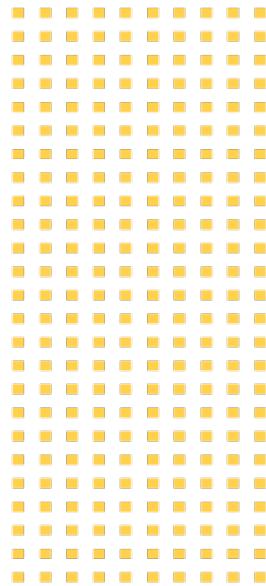
# Sensor Data Analytics



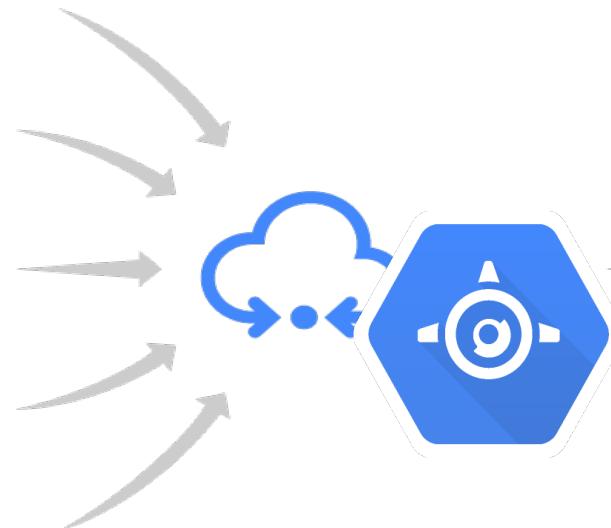
# Sensor Data Analytics

Data Sensing Lab

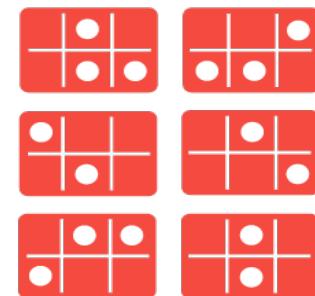
**Sensors**



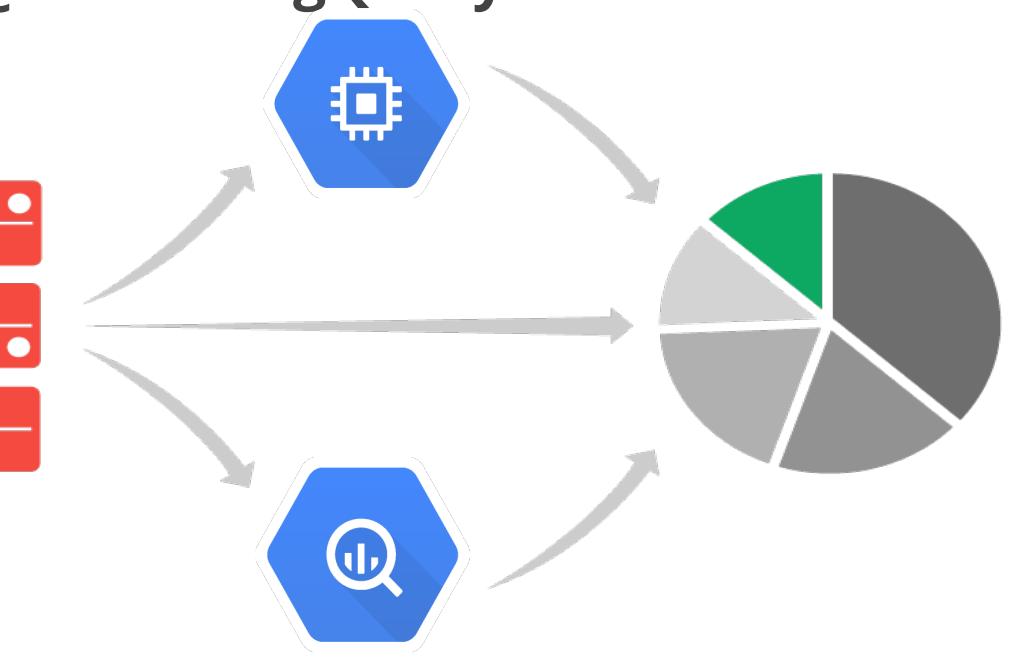
**Endpoints/App Engine**



**Datastore**



**Compute Engine/  
BigQuery**



Generate

Ingest/Process

Store

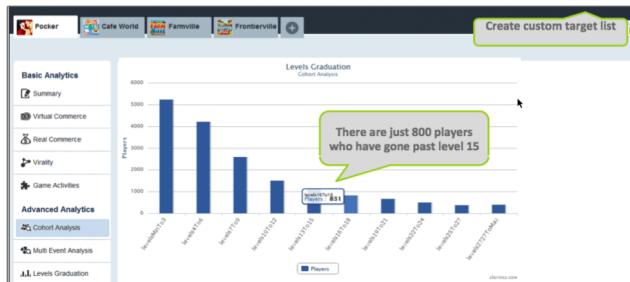
Compute

Visualize  
Analyze

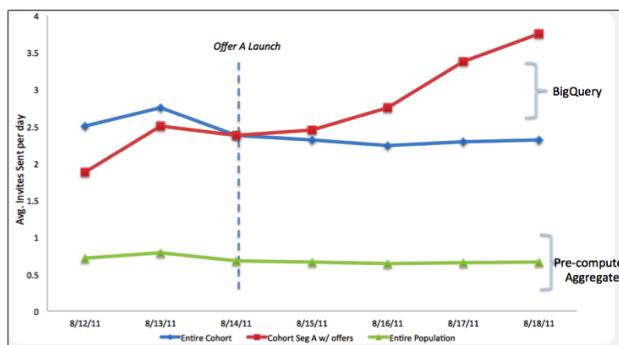
# Mobile and Social Gaming User Analysis



Notice trend change



Slice user data, identify segments

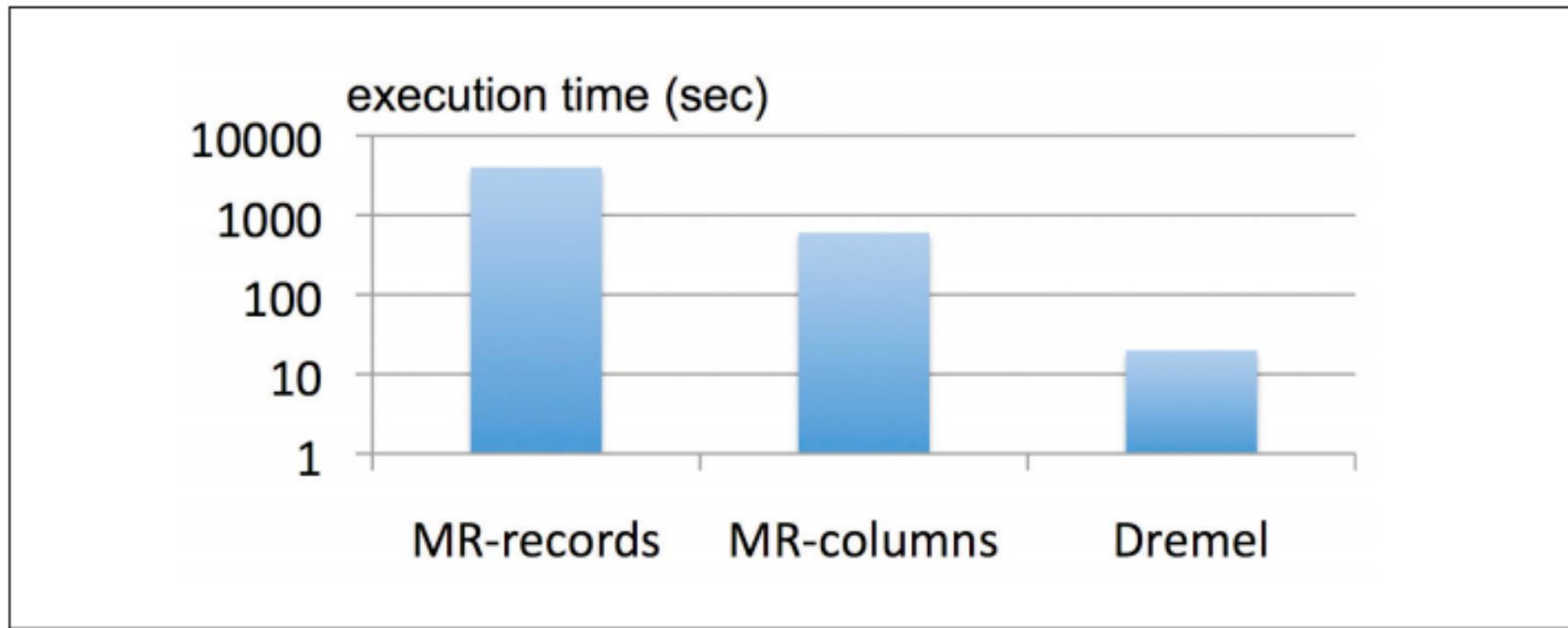


Compare segments  
vs general population

# BigQuery versus MapReduce

- BigQuery is designed as an **interactive** data analysis tool for large datasets
- MapReduce is designed as a programming framework to **batch process** large datasets

# BigQuery versus MapReduce



*Figure 3 MapReduce and Dremel Execution Time Comparison*

The comparison was done on 85 billion records and 3000 nodes. "MR-records" refers to MapReduce jobs accessing row-based storage whereas "MR-columns" refers to MR jobs with column-based storage. For more information, refer to section 7. EXPERIMENTS of the Dremel: Interactive Analysis of Web-Scale Datasets paper<sup>1</sup>.

# BigQuery versus MapReduce

Key Differences	BigQuery	MapReduce
<b>What is it?</b>	Query service for large datasets	Programming model for processing large datasets
<b>Common use cases</b>	Ad hoc and trial-and-error interactive query of large dataset for quick analysis and troubleshooting	Batch processing of large dataset for time-consuming data conversion or aggregation
<b>Sample use cases</b>		
OLAP/BI use case	Yes	No
Data Mining use case	Partially (e.g. preflight data analysis for data mining)	Yes
Very fast response	Yes	No (takes minutes - days)
Easy to use for non-programmers (analysts, tech support, etc)	Yes	No (requires Hive/Tenzing)
Programming complex data processing logic	No	Yes
Processing unstructured data	Partially (regular expression matching on text)	Yes

# BigQuery: Key Differentiators



## Agile : BigData Analytic Hosted Environment

- Fully managed cloud service
- Interactive querying on Terabytes of data
- Always on



## Cost Effective: Low TCO / TCD

- No CapEx as no hardware/software to own
- No administration or management overhead
- Pay for only what you use.



## Non disruptive, fits right into IT landscape

- Expanding ISV ecosystem (BI/ETL)
- Use of standards (SQL like, REST API etc...)
- Integrated with other Google Services (GCE, GAE, GCE etc...)

# BigQuery versus MapReduce



## Secure and Reliable

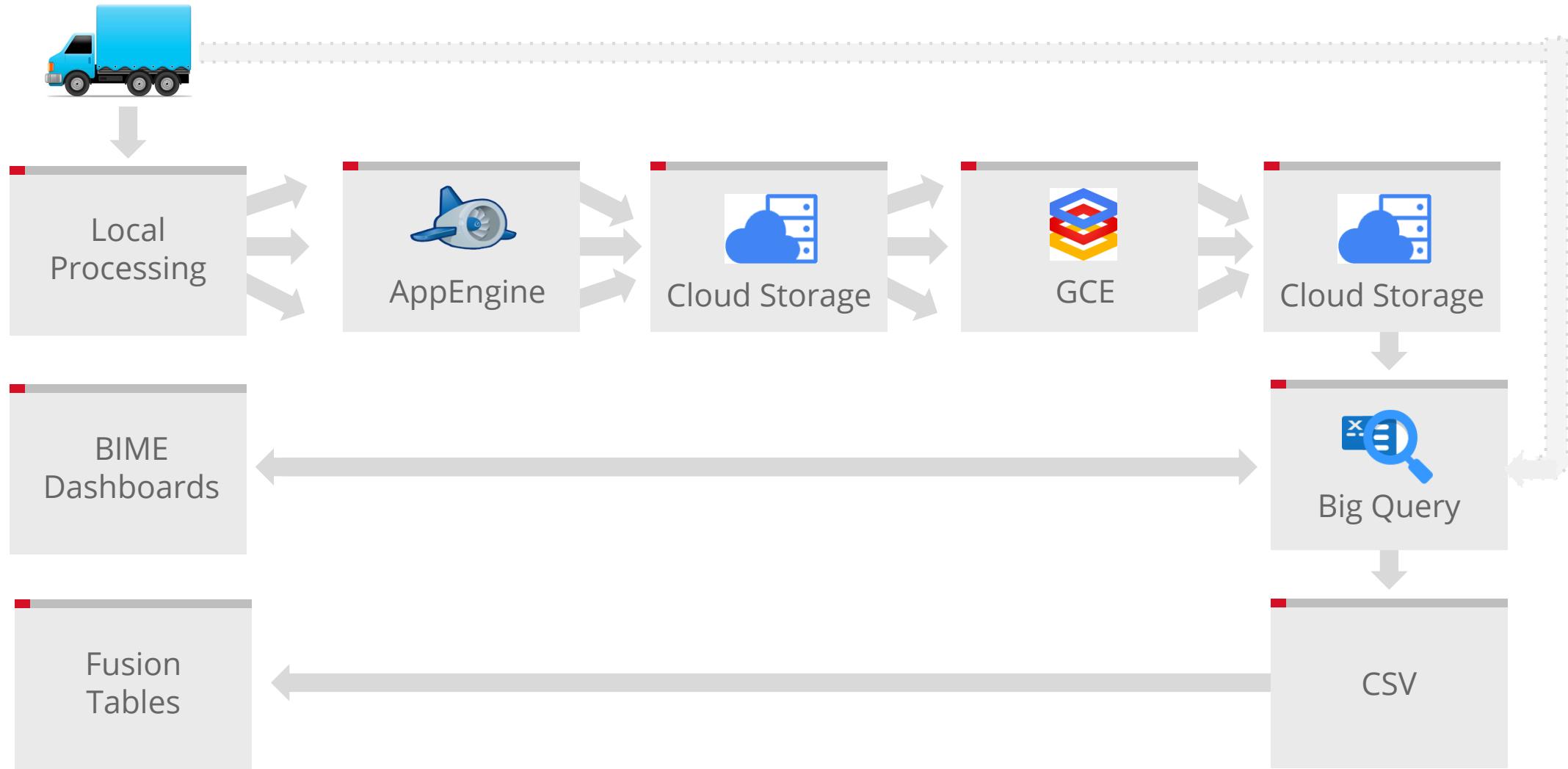
- Uptime SLA (99.9% uptime)
- OAUTH 2.0 Support, User/Group ACL
- Uses Google's core network/data center backbone



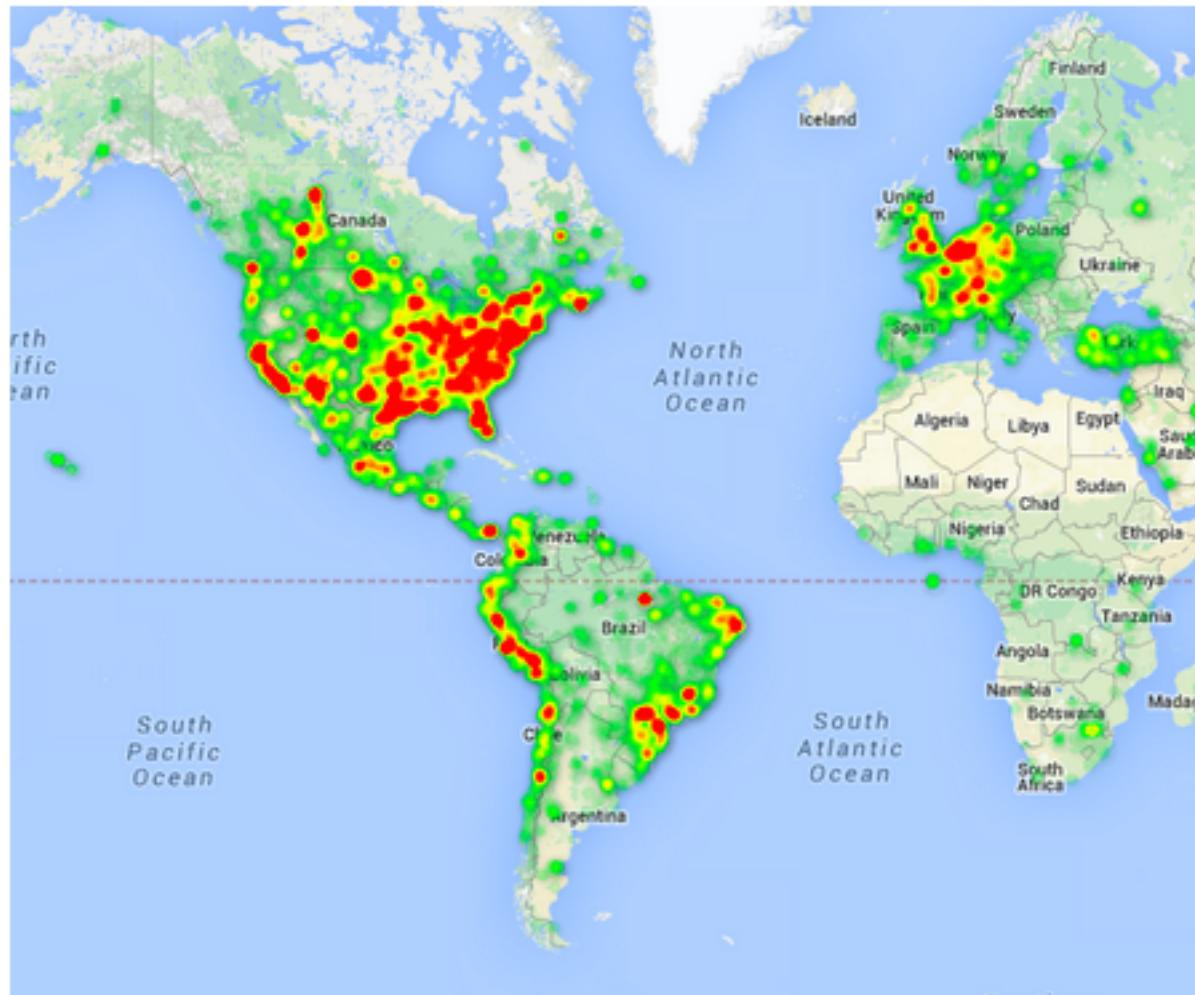
## Innovative

- Innovation momentum: 2 releases since launch
- New capabilities/concepts: e.g. Queryable Nested fields
- e.g. Use of RegExp without performance loss

# Recent Manufacturer POC



# Recent Manufacturer POC



- Achieved a **200,000 rows per second** ingestion rate, and it took about 10 minutes from when the file is first dropped into GCS to when you can query the data in BigQuery.
- Demonstrated **ingesting 120 million rows in 10 minutes** into BigQuery.

# Recent Manufacturer POC



- Leveraged **Google Fusion Tables** to easily collaborate on datasets with business and partners.
- Also discovered manufacturer had machines that consumed **250+ billion gallons of fuel** as of July 30th.

# Recent Manufacturer POC



- Spun up **BIME Dashboard** to interactively connect to BigQuery dataset.
- With dashboards connected to BQ (**BIME**, **Tableau**, **QlikView**, etc), we can drill into **billions** of rows near real-time data with ease.



# BigQuery: Ever Expanding Ecosystem of Partners



QlikView



**talend\***  
\*open integration solutions

**PERVASIVE®**



**crystalloids**  
crystallizing your predictive enterprise

**PA Consulting Group**

# Agenda

1

Quick Google Cloud Platform Overview

2

Google & Big Data

3

Running Hadoop on GCE & Leveraging BigQuery

4

Q & A

# Thank You





cloud.google.com

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Google Cloud Platform

