How Google Does Big Data

Solving Big Data Problems at Google Scale

James Chittenden
Cloud Platform Engineer

Google Cloud Platform

Agenda

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

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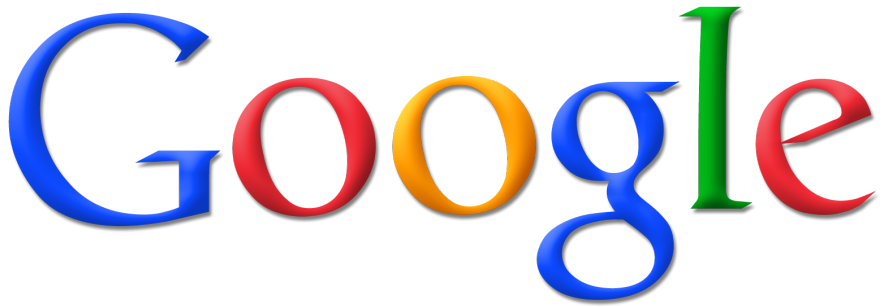
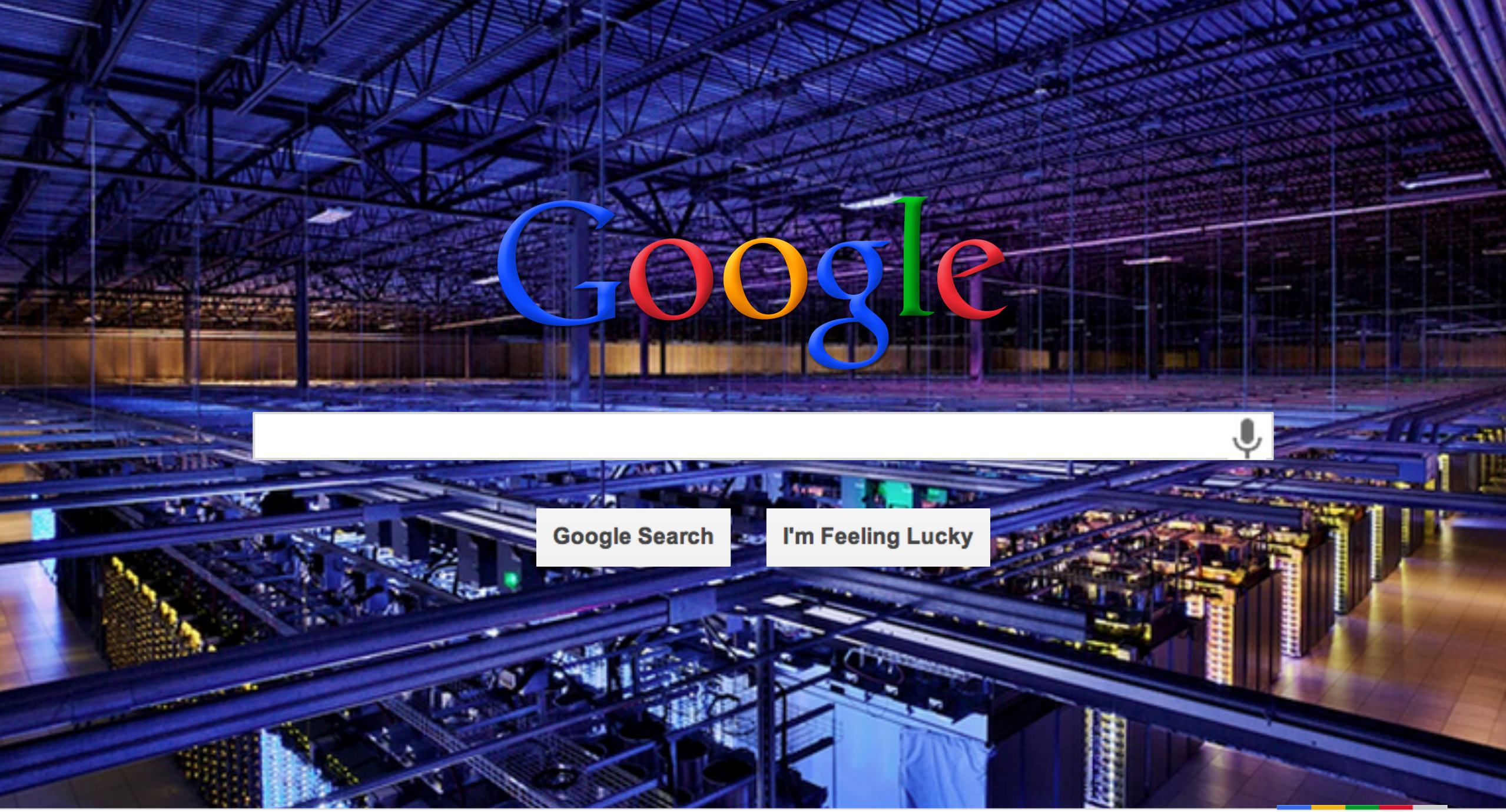


Google Search

I'm Feeling Lucky


Google
Google Search
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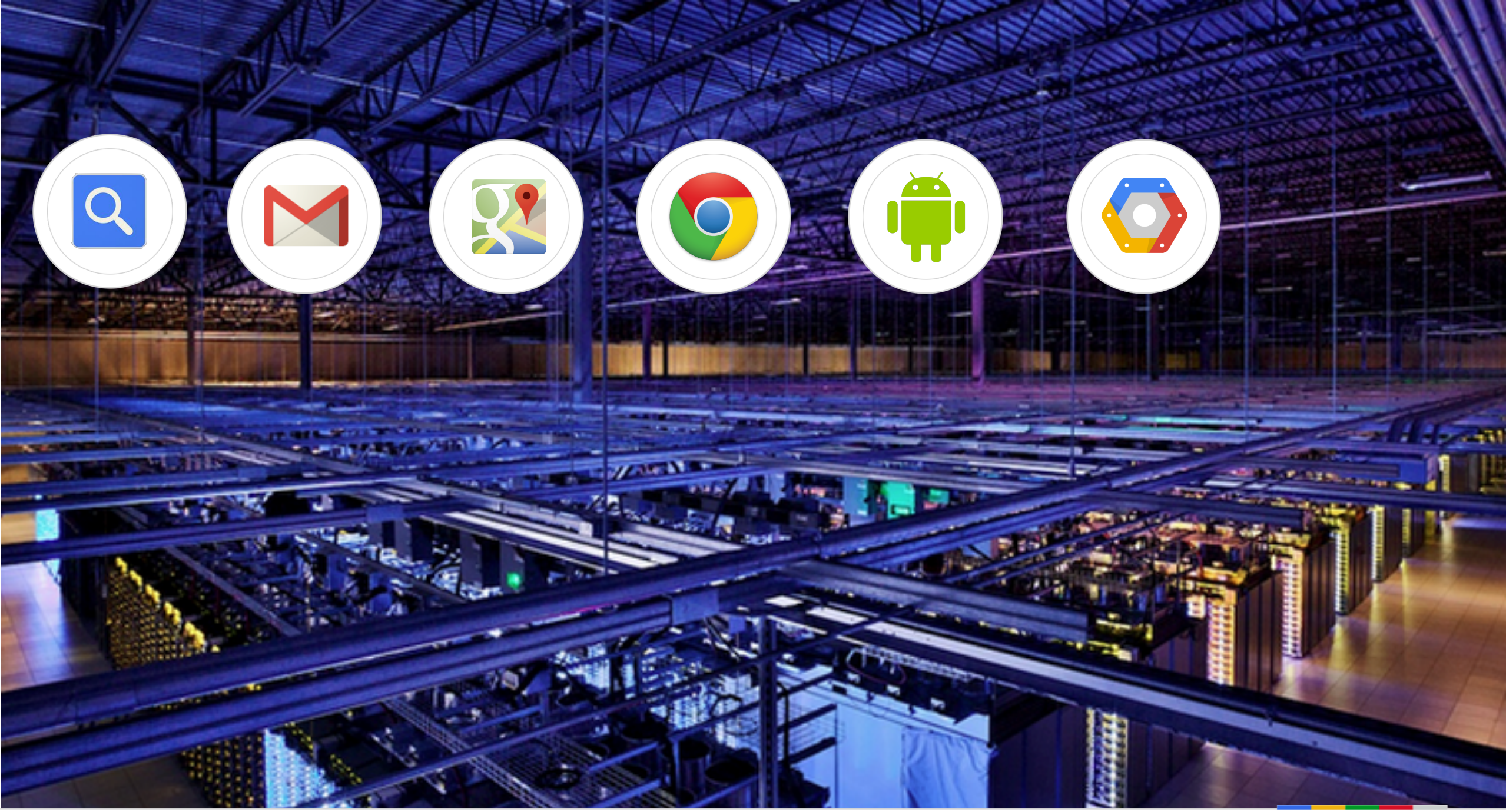
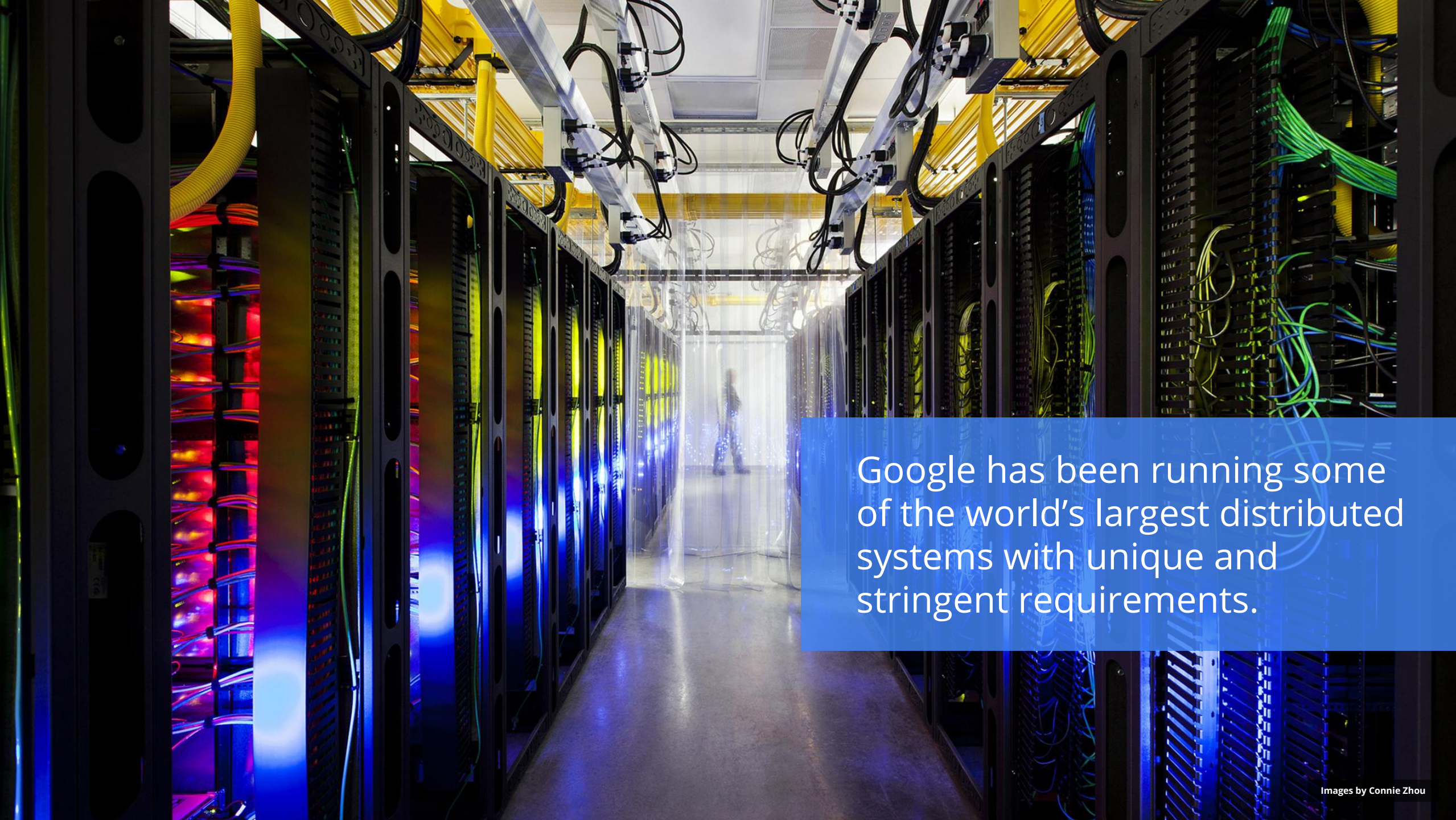


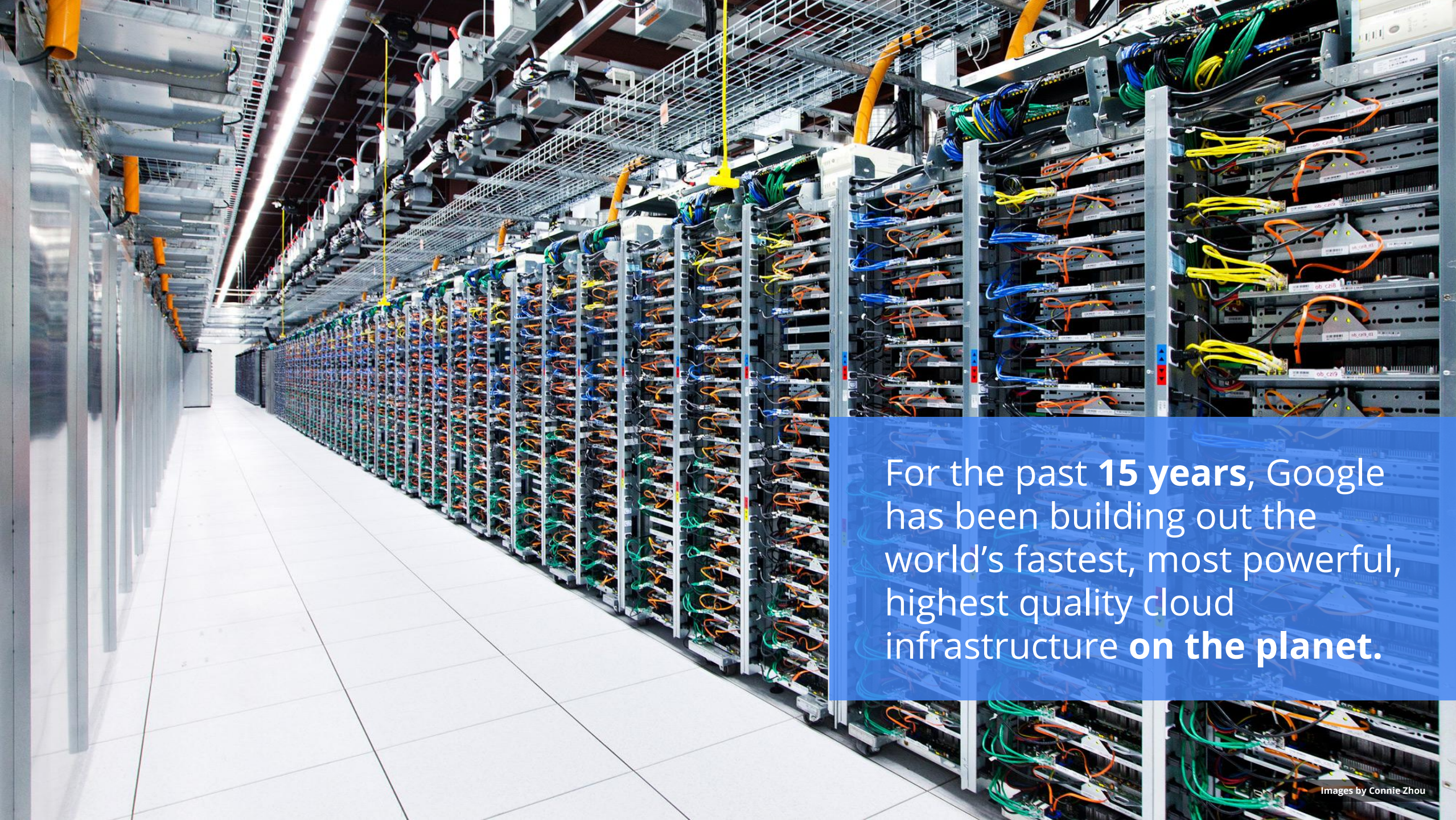


Google has been running some of the world's largest distributed systems with unique and stringent requirements.

Images by Connie Zhou

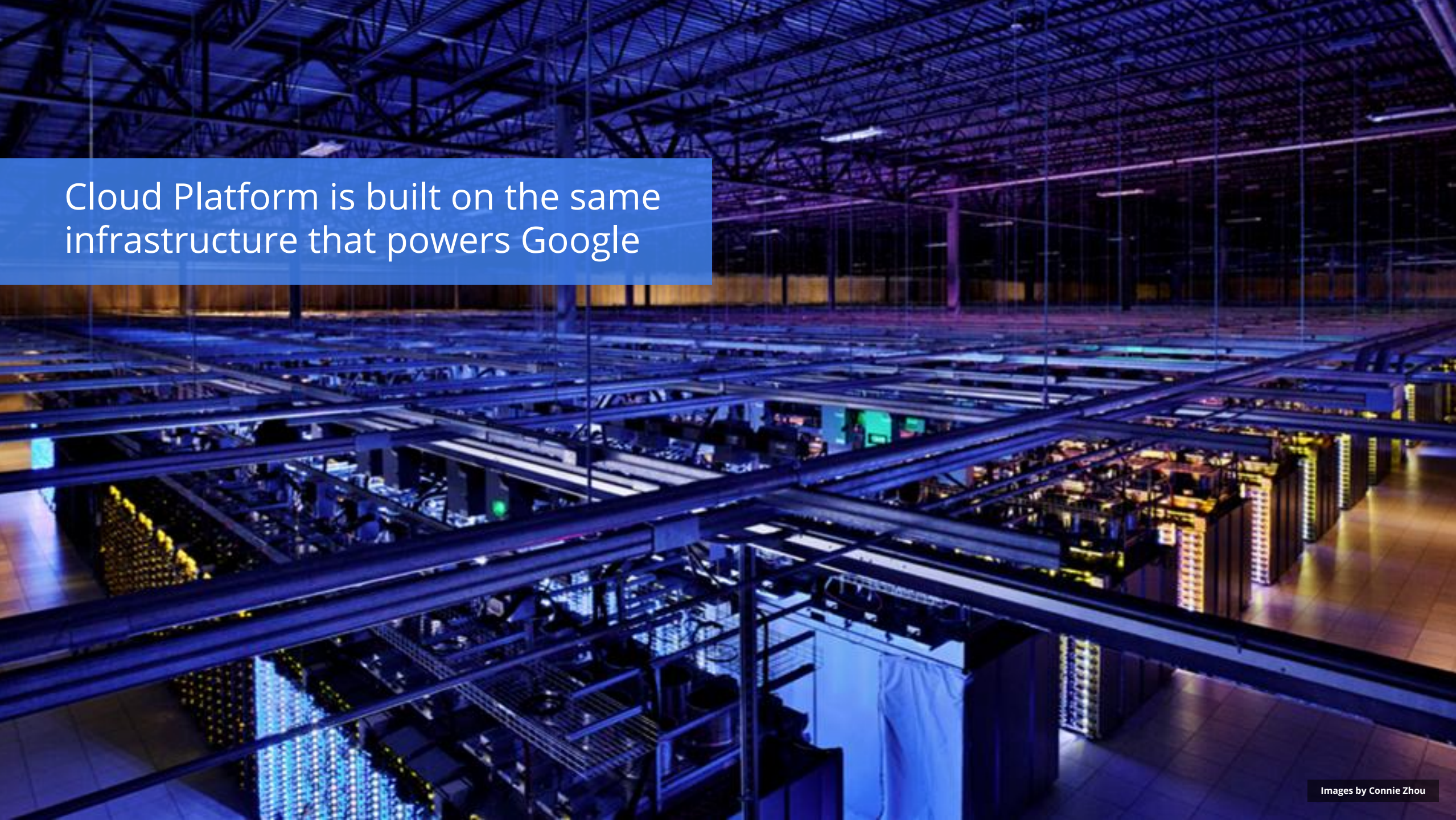
"**This is what makes Google Google:** its physical network, its thousands of fiber miles, and those many thousands of servers that, in aggregate, add up to the mother of all clouds."

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

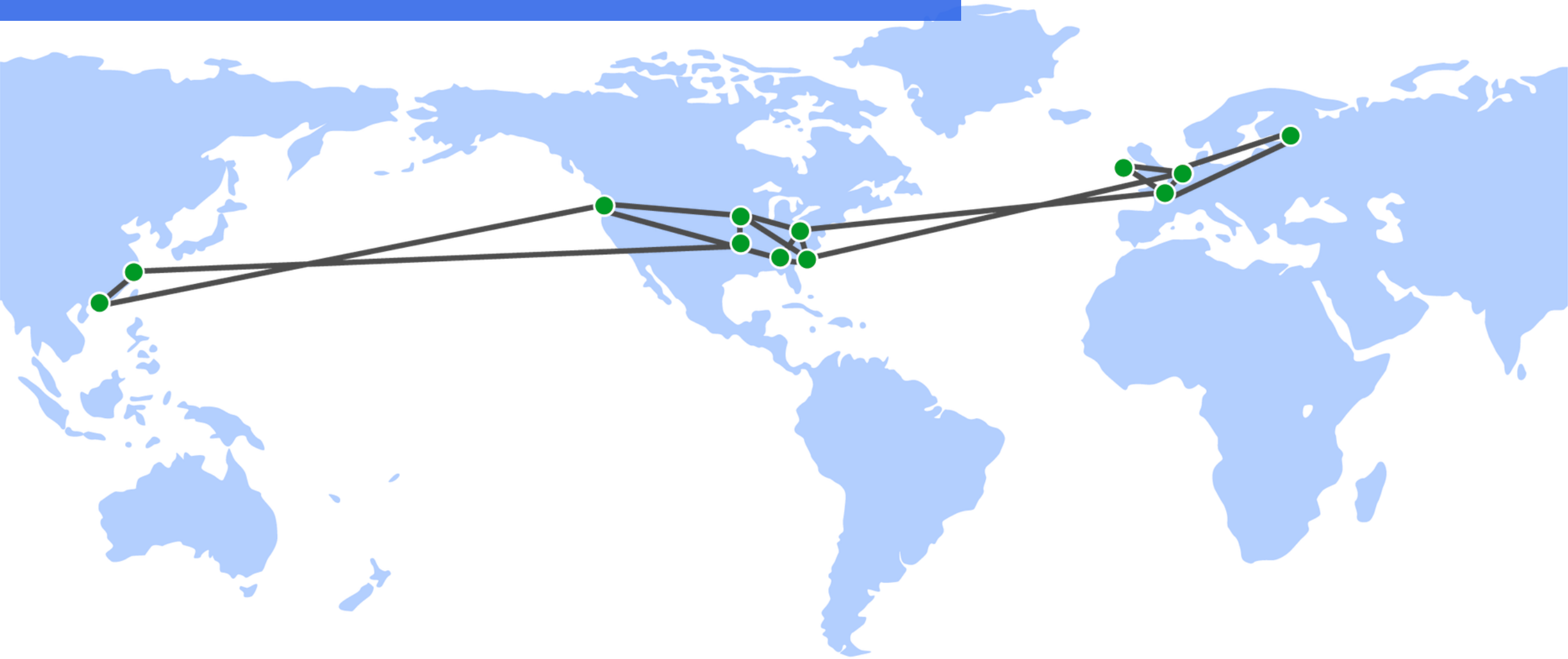


For the past **15 years**, Google has been building out the world's fastest, most powerful, highest quality cloud infrastructure **on the planet.**

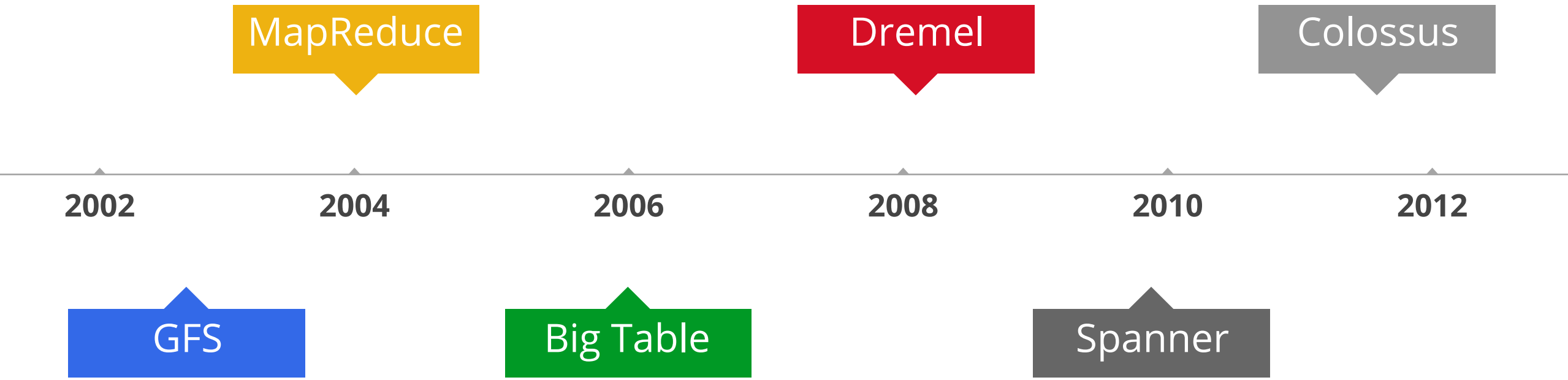
Images by Connie Zhou


Cloud Platform is built on the same infrastructure that powers Google
Images by Connie Zhou

Google's Global OpenFlow Network

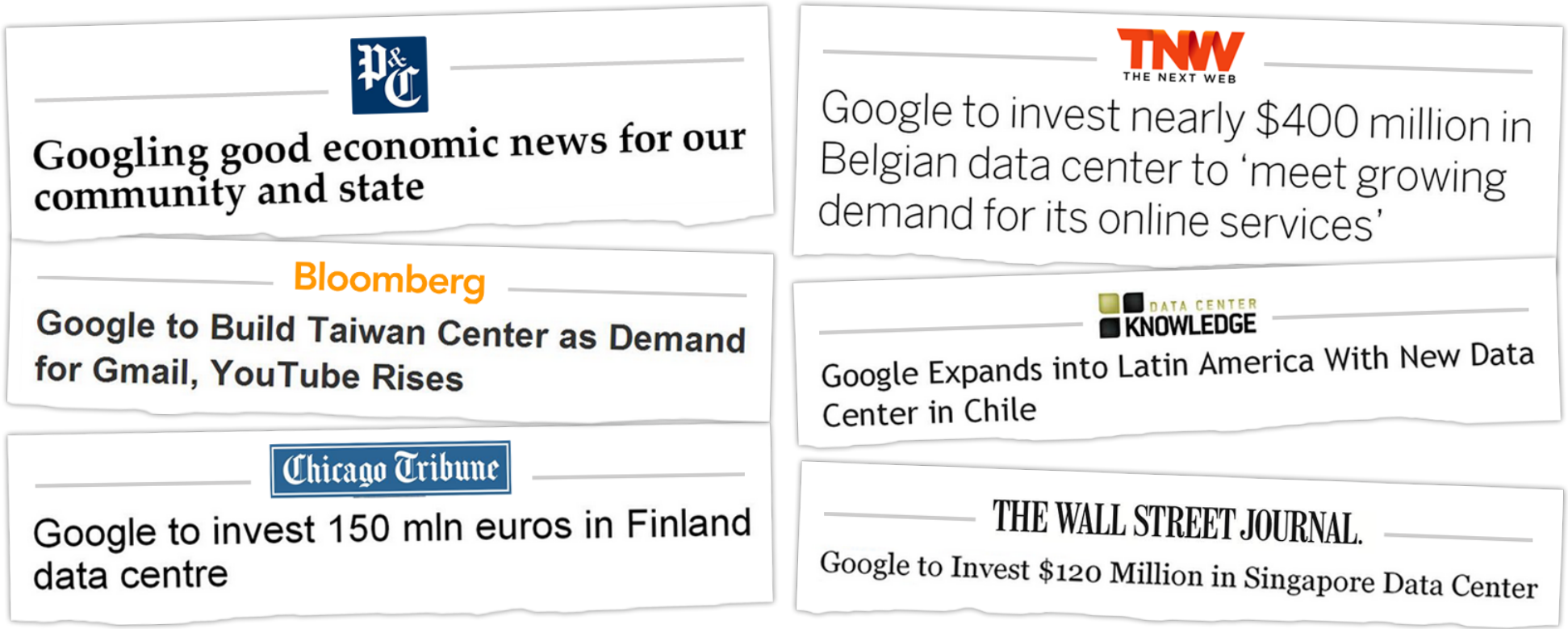


Google Innovations in Software



Investing In Our Cloud

$2.9B in additional data center investments worldwide



Google Cloud Platform

Compute

- Compute Engine
- App Engine

Storage

- Cloud Storage
- Cloud SQL
- Cloud Datastore

App Services

- BigQuery
- Cloud Endpoints

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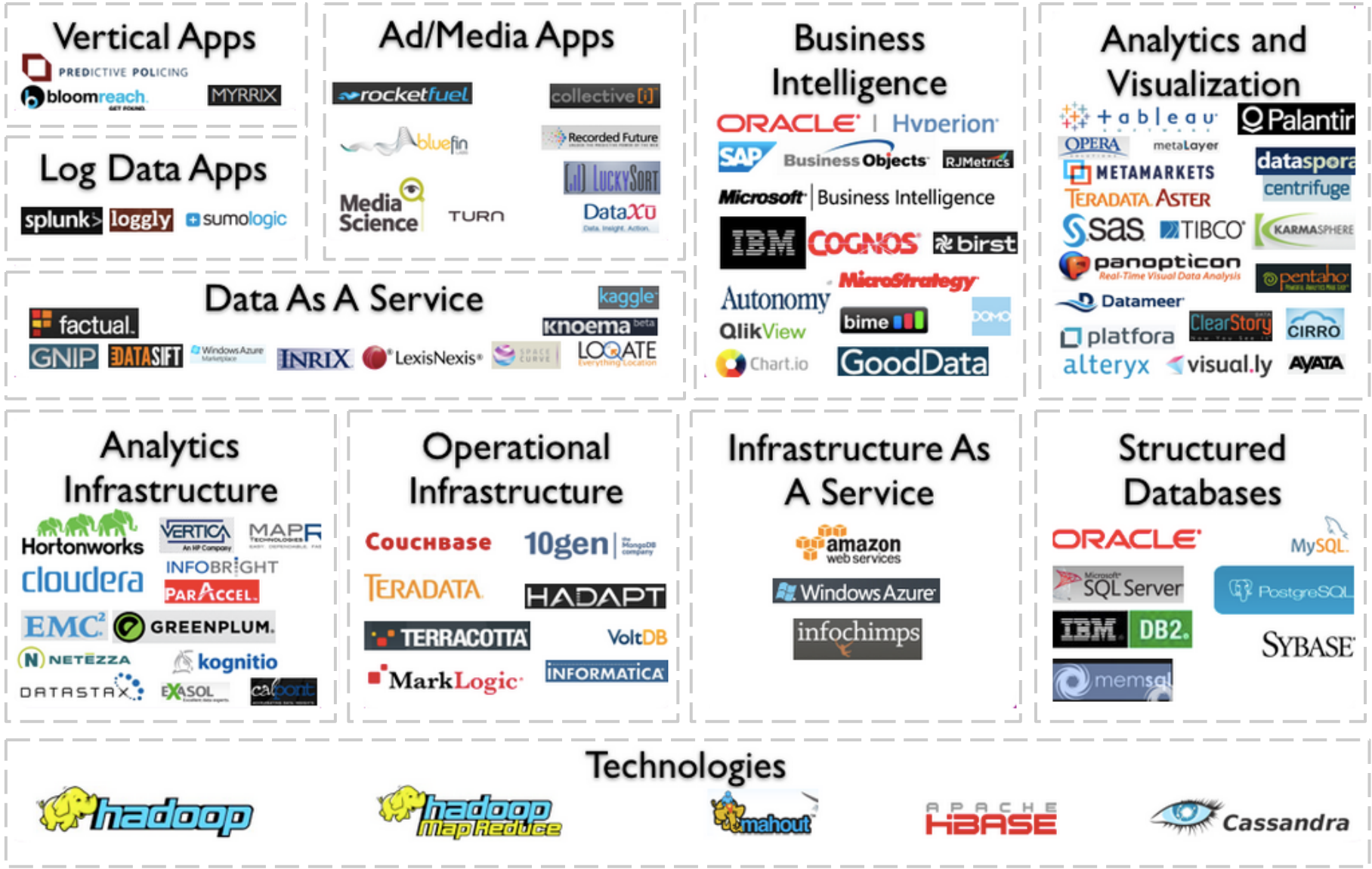
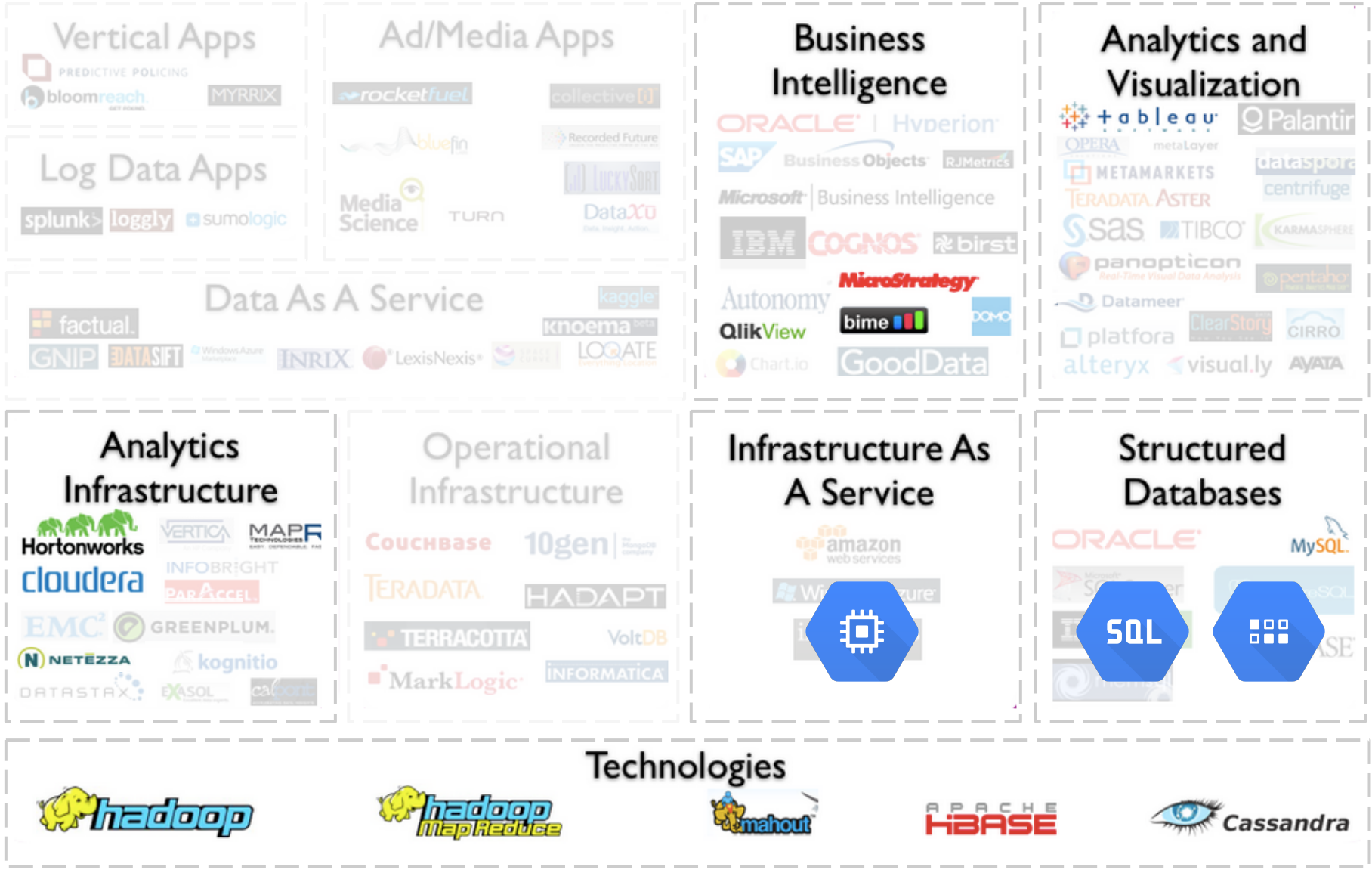
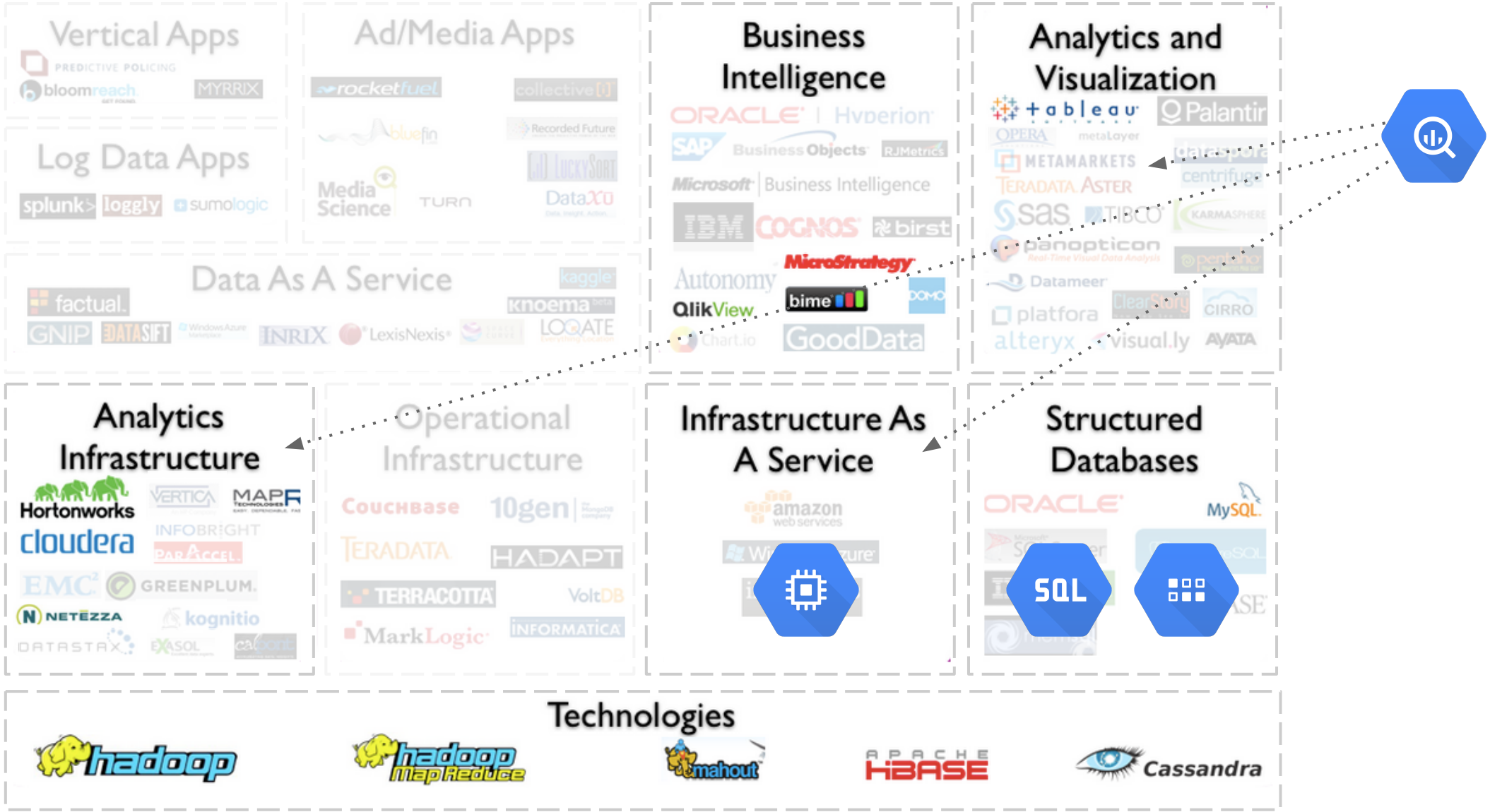
Complex Big Data Landscape



Complex Big Data Landscape



Complex Big Data Landscape



The Flood of BIG DATA

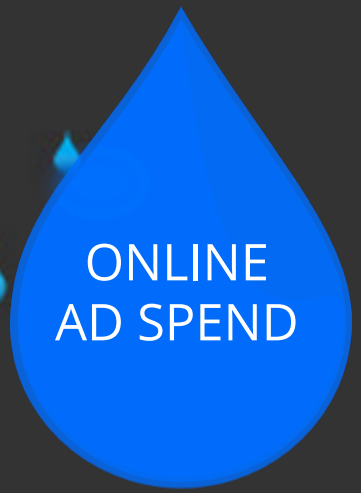
5.3
TRILLION ONLINE AD IMPRESSIONS IN 2012 [1]

191
BILLION EMAILS SENT EVERY DAY [2]

US $109.7
BILLION ESTIMATED FOR 2014 [3]

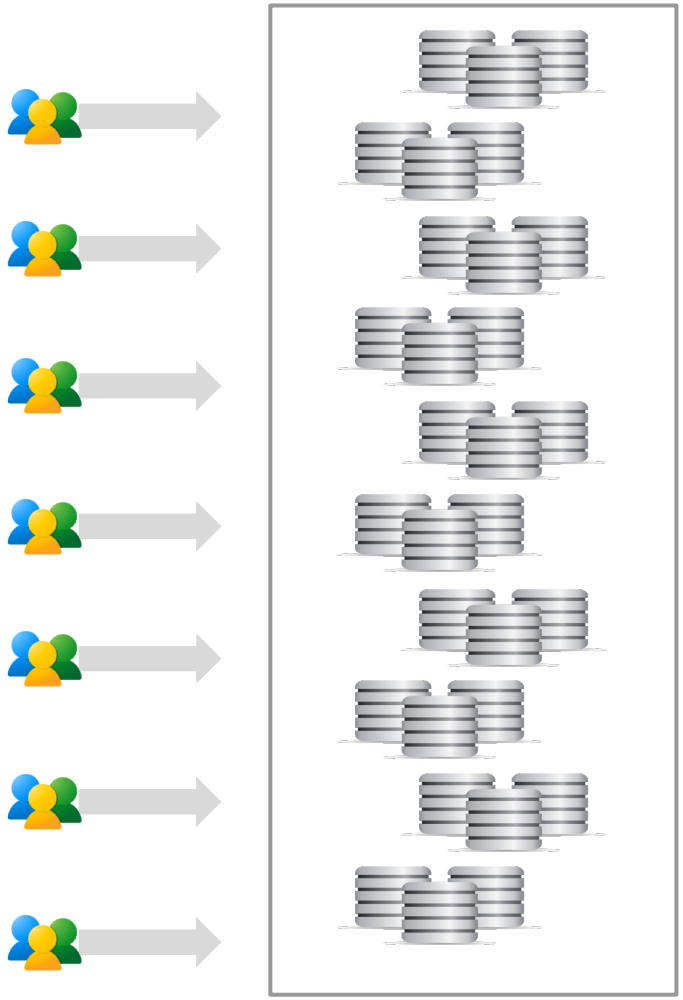
US $14.3
BILLION SPENT IN U.S. ON MOBILE ADS IN 2013 [4]

500+
TERABYTES OF DATA UPLOADED DAILY [5]



How does Google process **Big Data**?

Big Data processing example - application logs

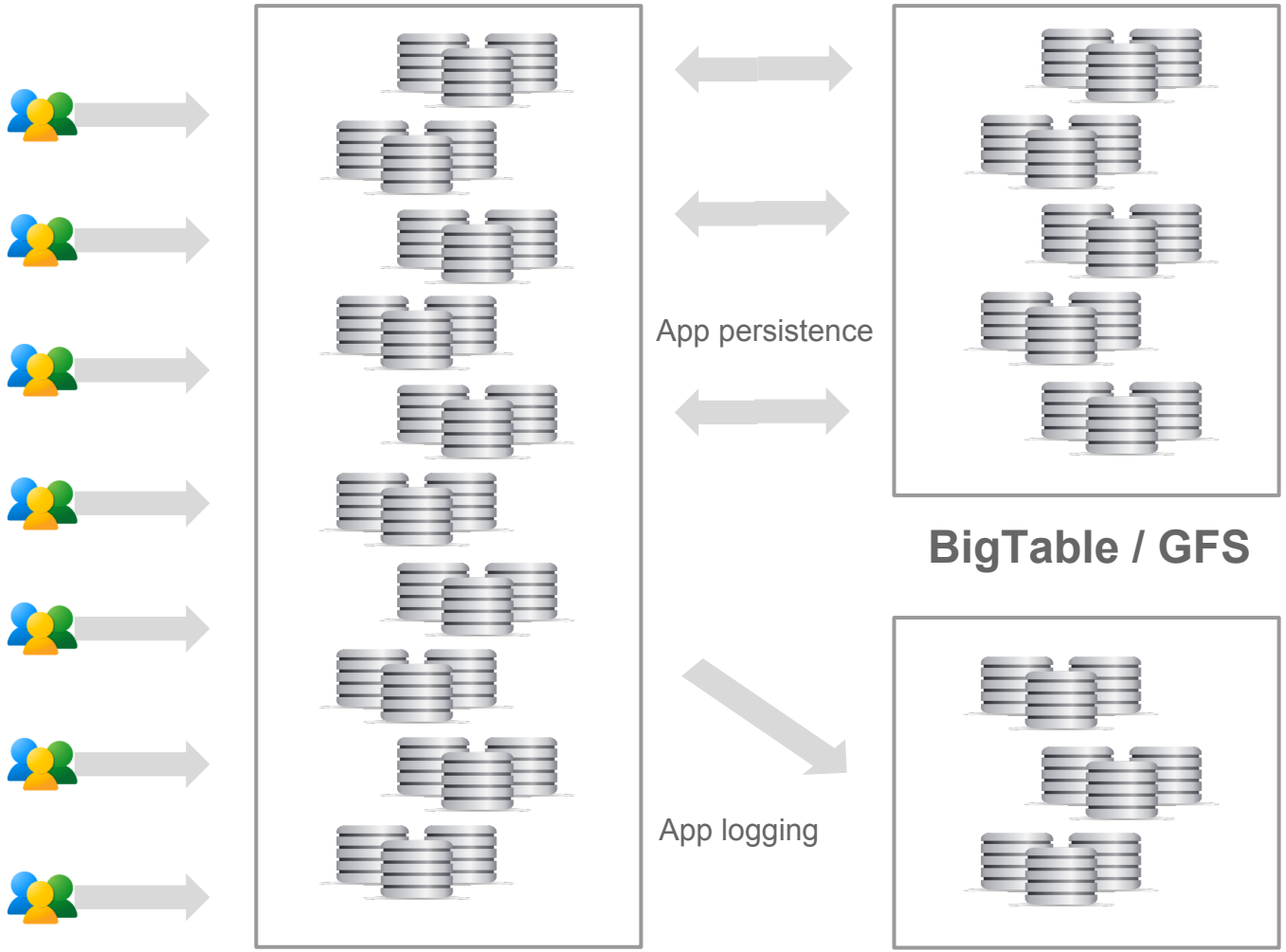


User requests

Application servers

Note: diagram is dramatically simplified

Big Data processing example - application logs



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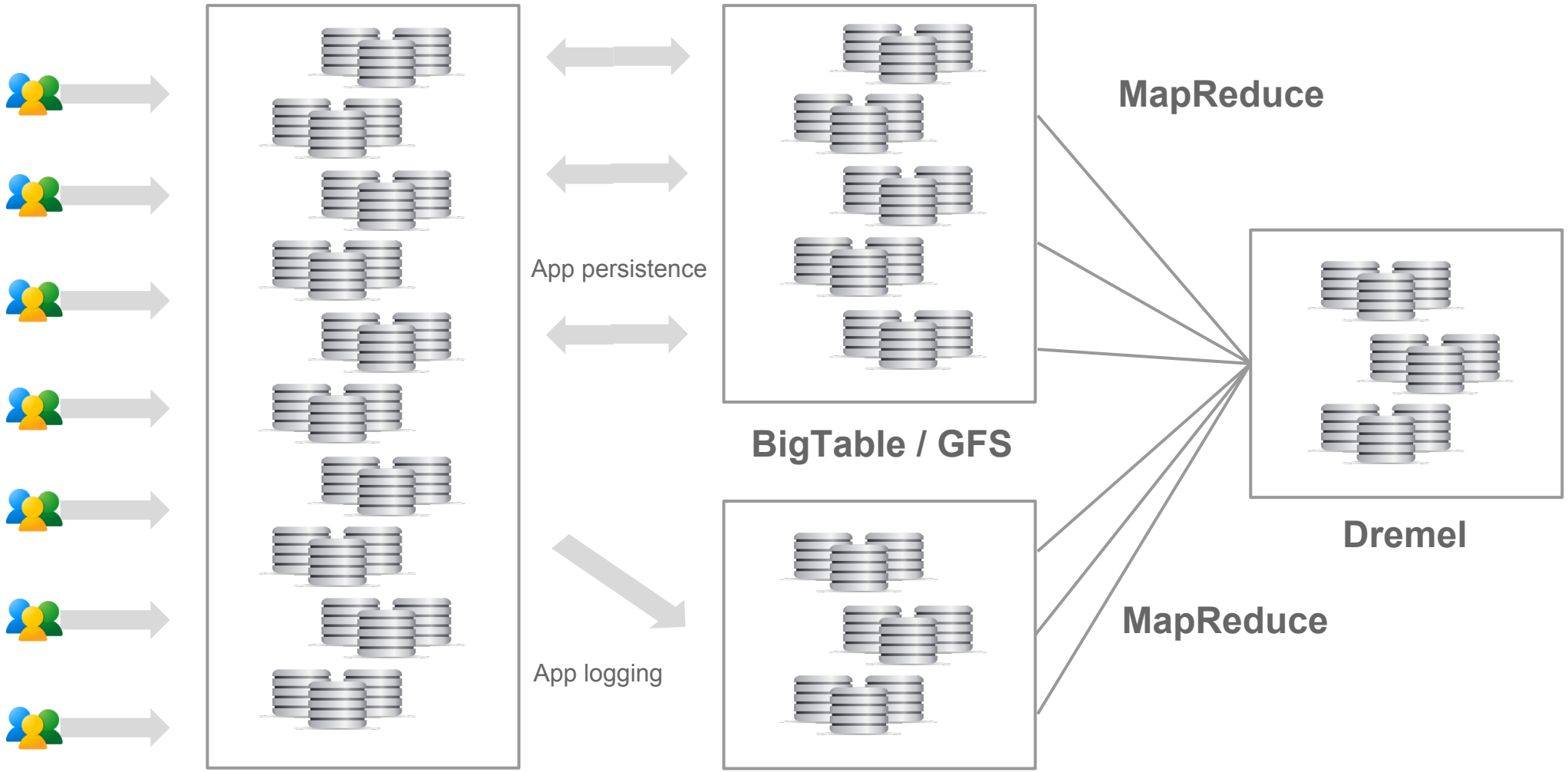
Big Data processing example - application logs



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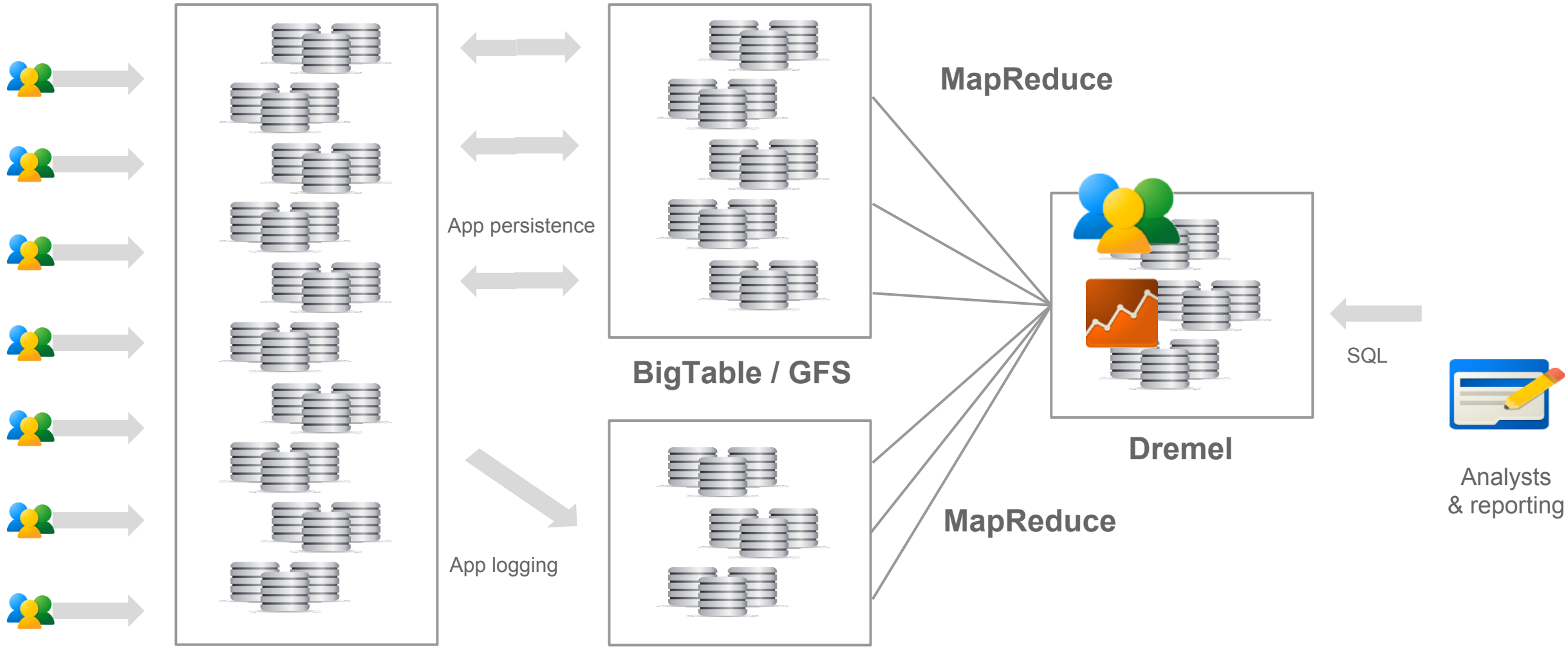
Big Data processing example - application logs



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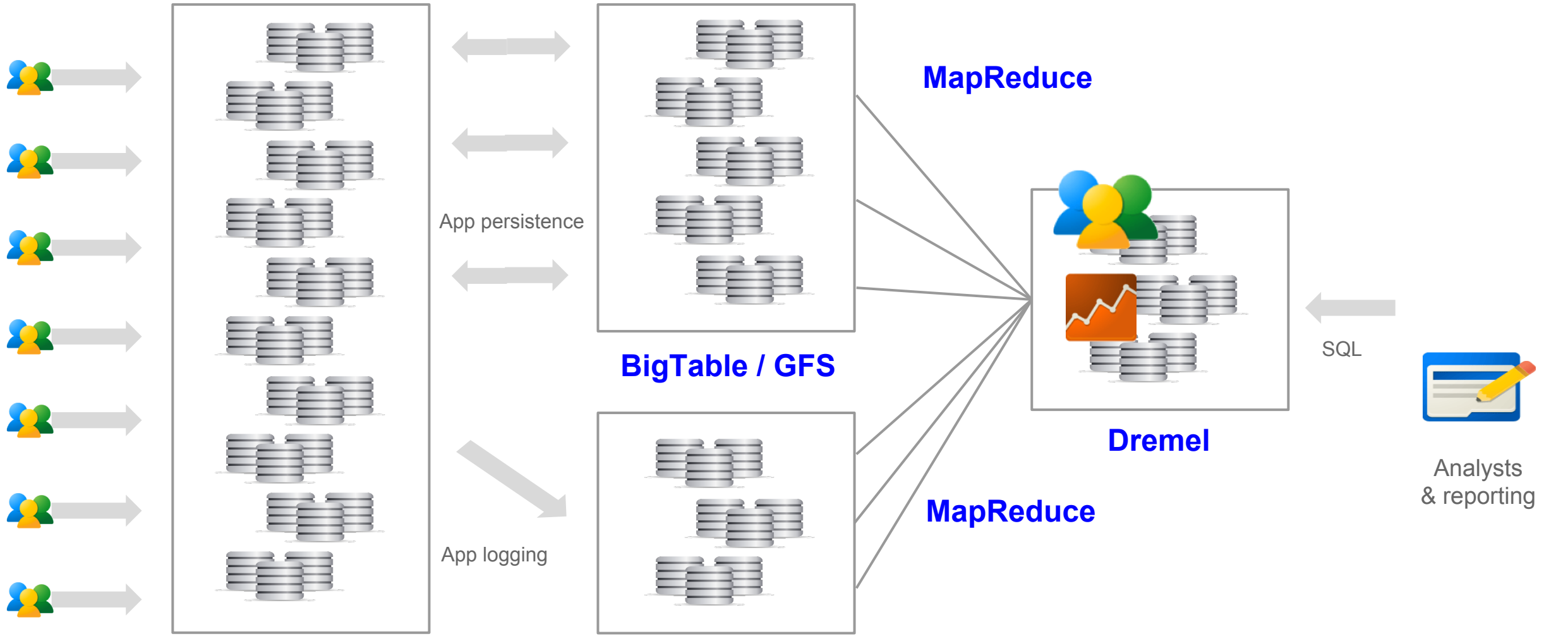
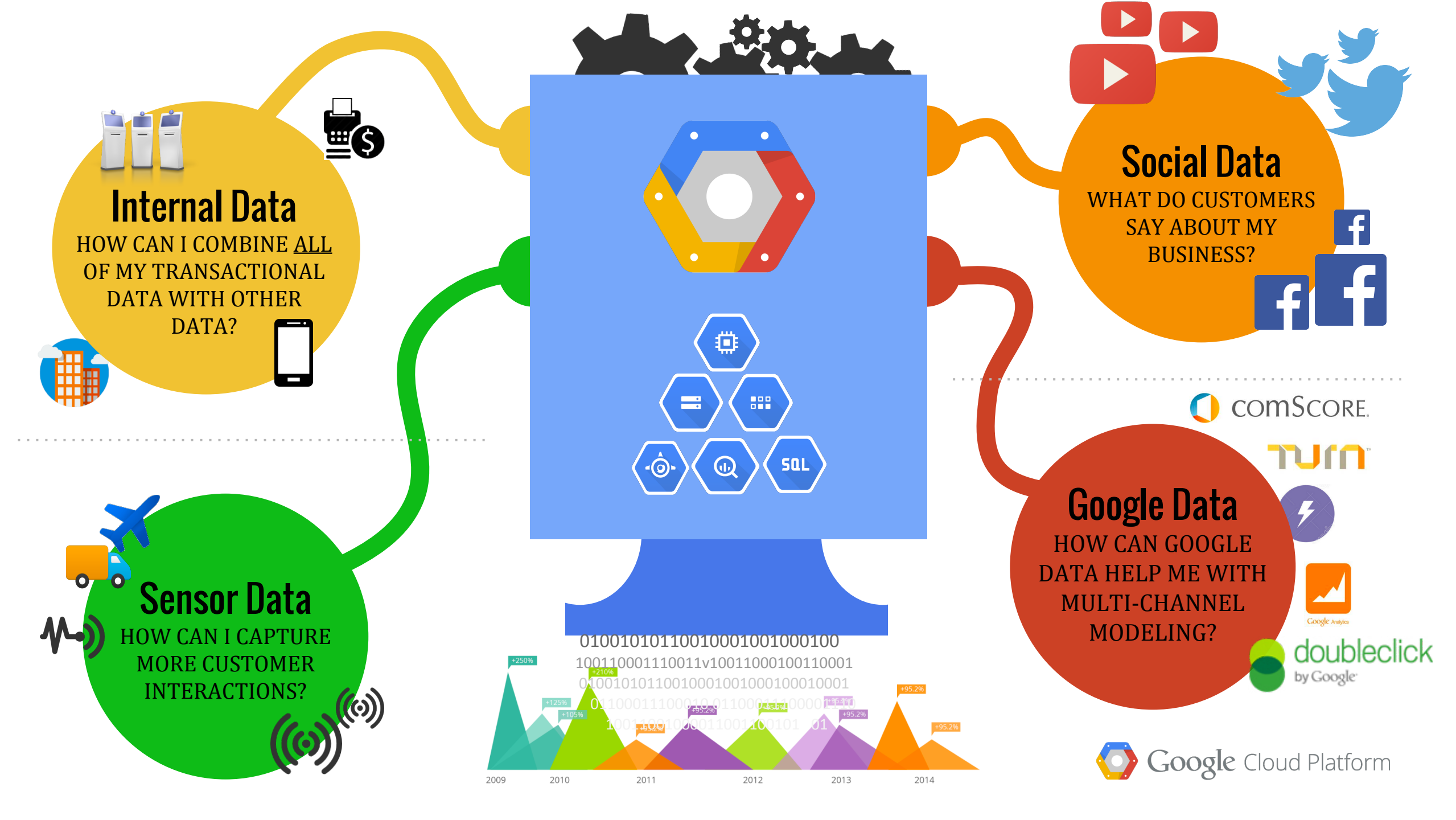
Big Data processing example - application logs



Note: diagram is dramatically simplified

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


Internal Data
HOW CAN I COMBINE ALL OF MY TRANSACTIONAL DATA WITH OTHER DATA?
Social Data
WHAT DO CUSTOMERS SAY ABOUT MY BUSINESS?
Sensor Data
HOW CAN I CAPTURE MORE CUSTOMER INTERACTIONS?
Google Data
HOW CAN GOOGLE DATA HELP ME WITH MULTI-CHANNEL MODELING?
SQL
comScore
TURN
Google Analytics
doubleclick by Google
Google Cloud Platform
2009
2010
2011
2012
2013
2014

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

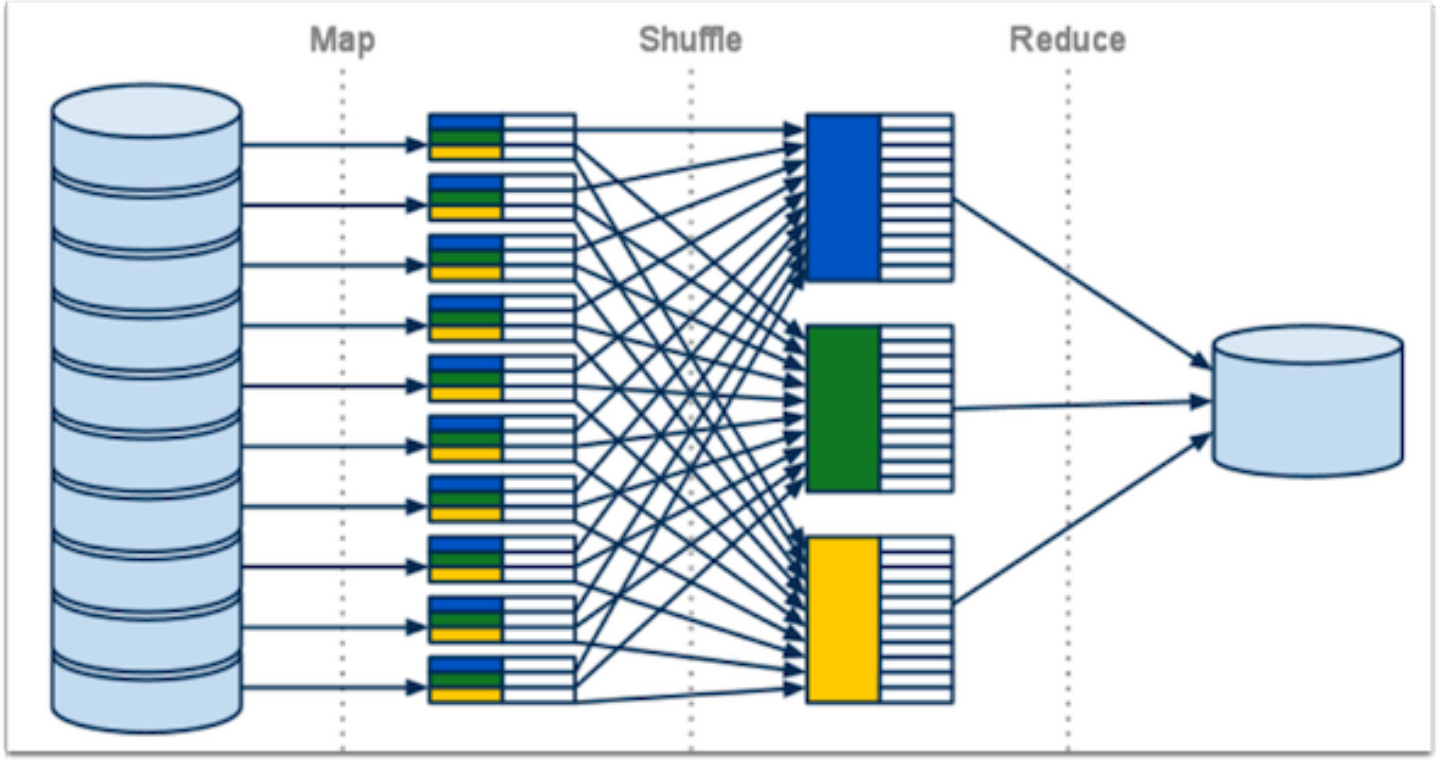
Non-relational
Unstructured or semi-structured

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

1 Google App Engine

Data Ingestion

Web Apps

Auto-scale web services

2 Google Compute Engine

Collection Transformation

4 Scalable VMs

Data processing Cleansing

3 Google Cloud Storage

Raw Data Storage Big Query Staging

TBs of Data

Cloud Storage Hadoop Connector

5 Google Big Query

Raw Data Storage

Ad-hoc queries

REST API

Visualization

6

tableau

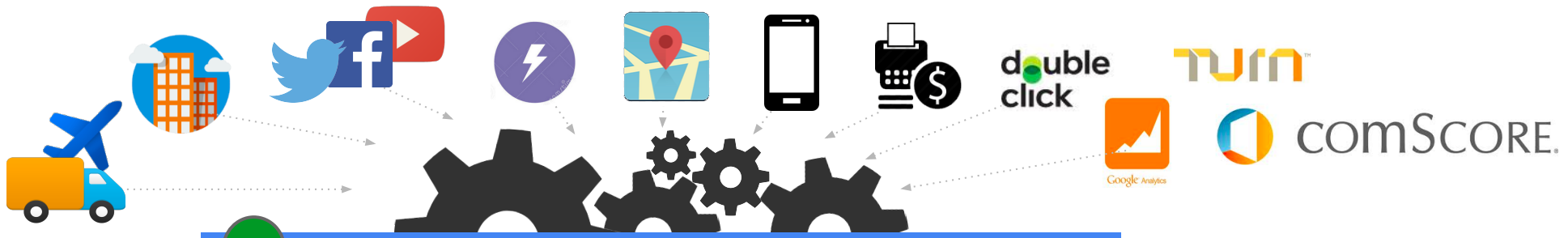
QlikView

BI tools

Interactive Dashboards + apps

Google Spreadsheets

Google Cloud Platform



1. Data Collection
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6. Visualization

1

Google Compute Engine

Scalable VMs

Collection Transformation

2

Data processing Cleansing

4

talend
*open data solutions

INFORMATICA
The Data Integration Company™

PERVASIVE

MAPR TECHNOLOGIES

Visualization

6

tableau SOFTWARE

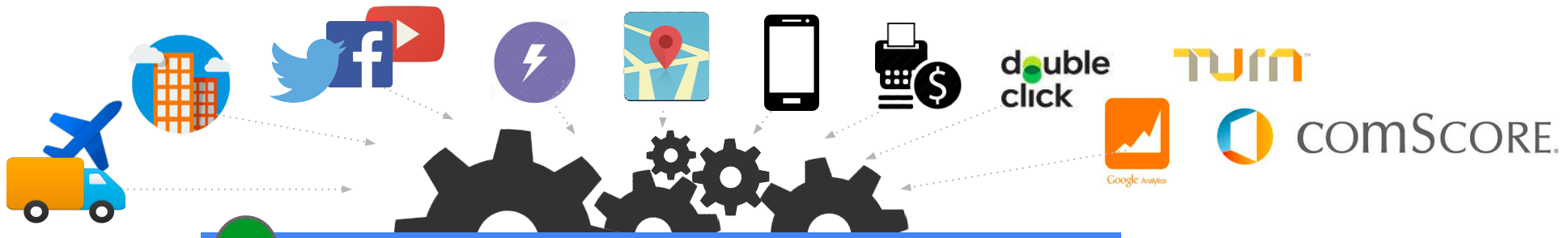
QlikView

BI tools

Interactive Dashboards + apps

Google Spreadsheets

Google Cloud Platform



1. Data Collection
2. ETL
3. Raw Data Storage
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5. Analytics Storage
6. Visualization

1

Google Cloud Storage

TBs of Data

Raw Data Storage
Big Query Staging

3

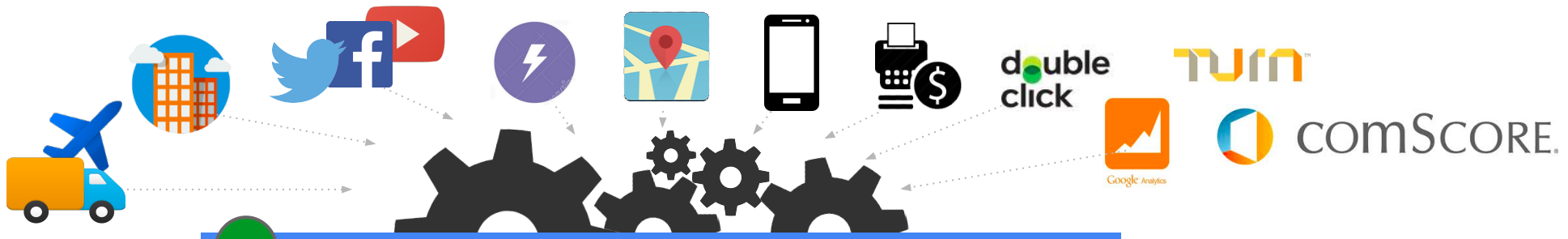
- Huge Storage Capacity
- Consistent, fast speeds
- Multiple storage types

Visualization

6

- tableau
- QlikView
- BI tools
- Interactive Dashboards + apps
- Google Spreadsheets

Google Cloud Platform



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

1

Google BigQuery

Ad-hoc queries

AdHoc Queries
REST API

5

Visualization
Partners

tableau SOFTWARE

QlikView

Visualization

6

tableau SOFTWARE

QlikView

BI tools

Interactive
Dashboards + apps

Google
Spreadsheets

Google Cloud Platform

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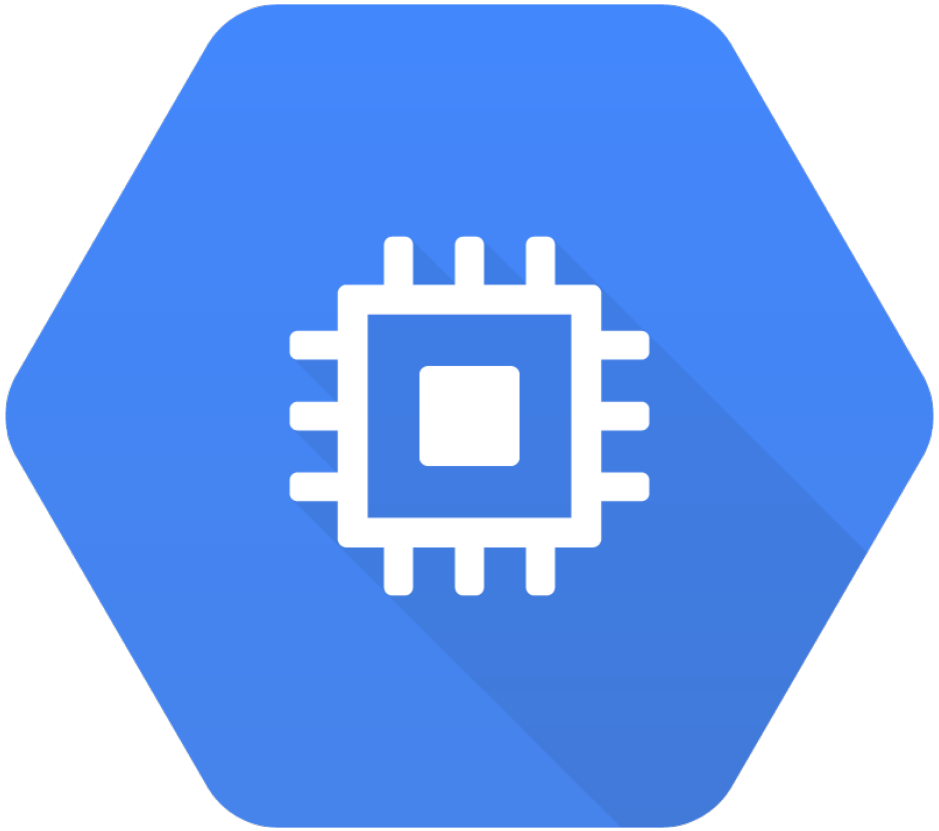
Google Compute Engine



+

Demo

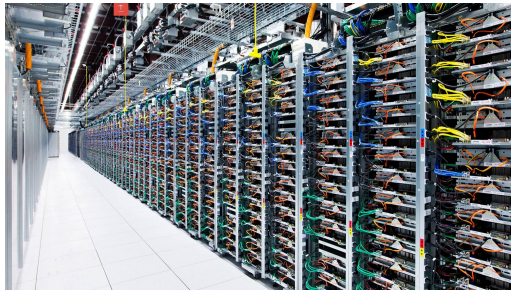
Hadoop on Google Compute Engine

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
```

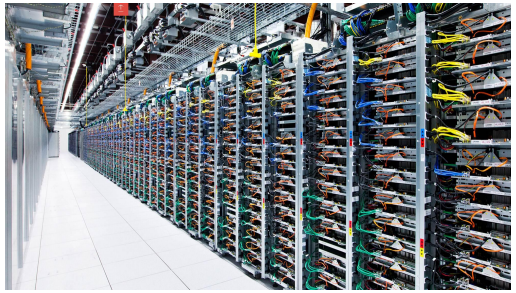


BigData at Google

Running Hadoop on Google Compute Engine

2. Start Cluster

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

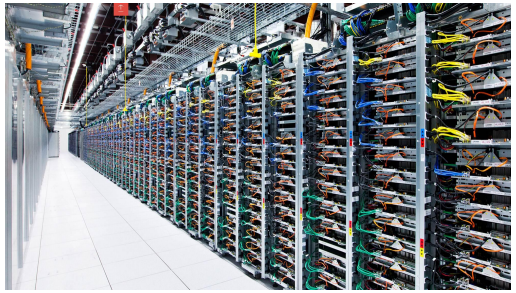


BigData at Google

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
```

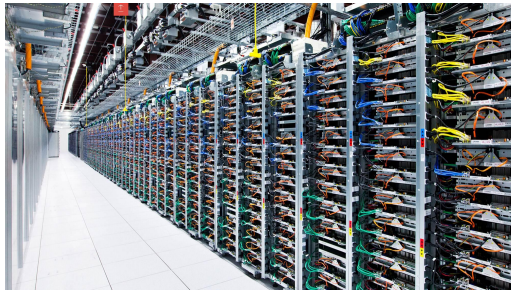


BigData at Google

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:

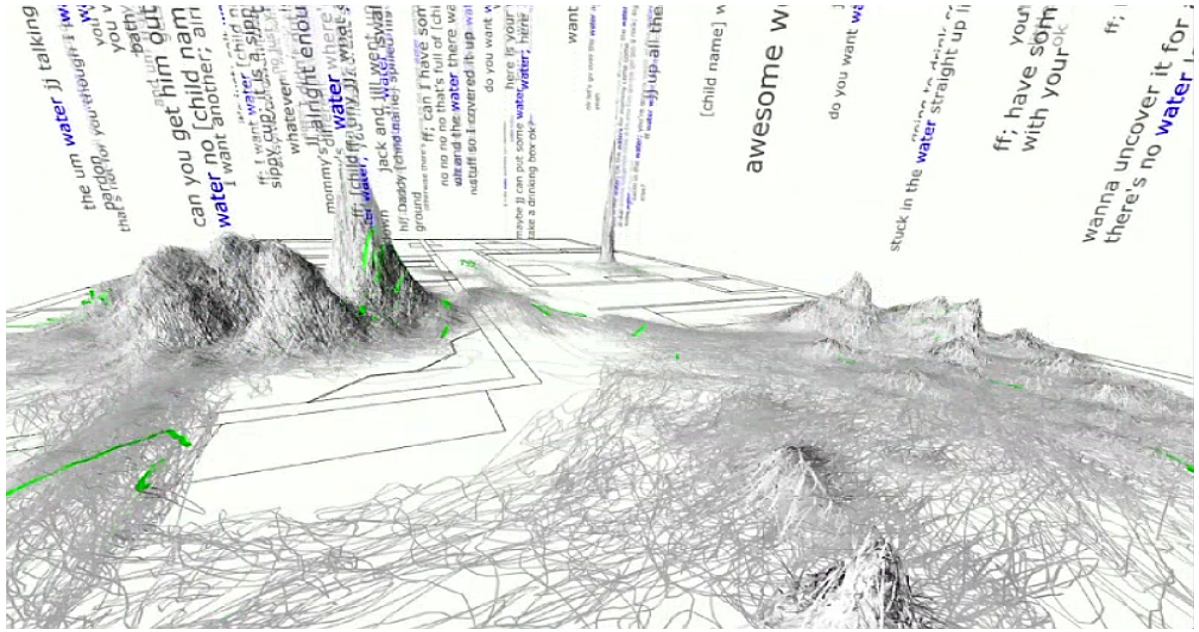
Instance type	Virtual Cores	Memory	Price (US$)/Hour (US hosted)
n1-standard-1	1	3.75GB	$0.104

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*

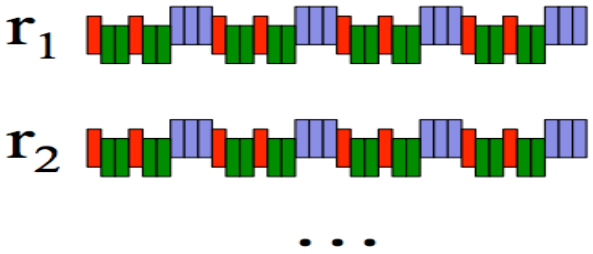


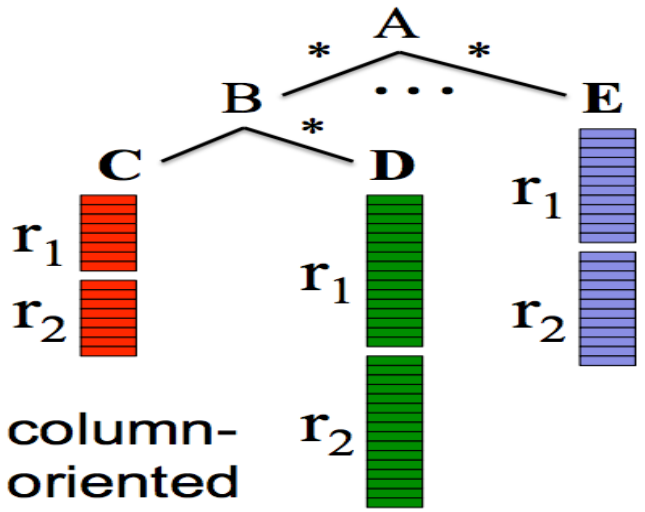
How Google Approaches Analytics

Dremel

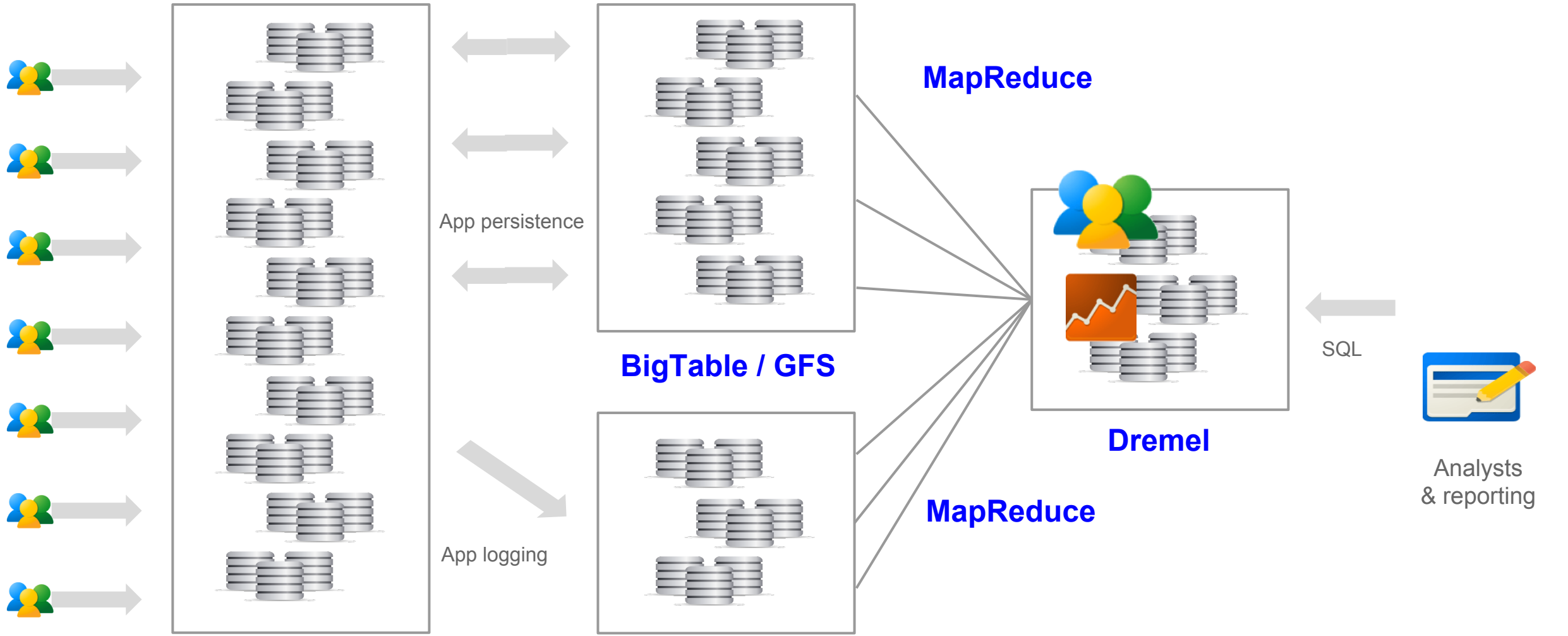
Ad-hoc query system for terabyte datasets

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





Big Data processing example - application logs



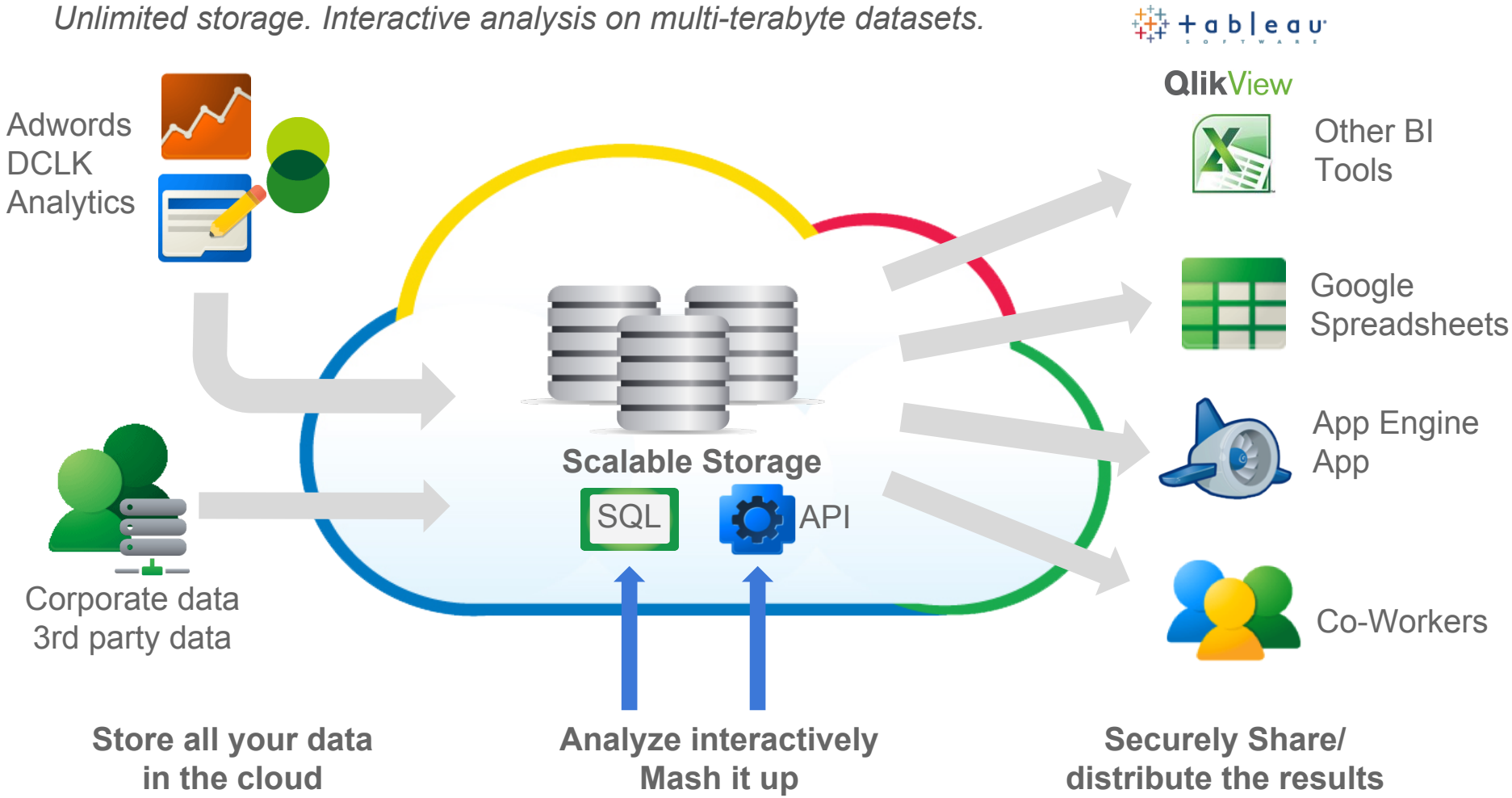
Note: diagram is dramatically simplified

What is BigQuery?

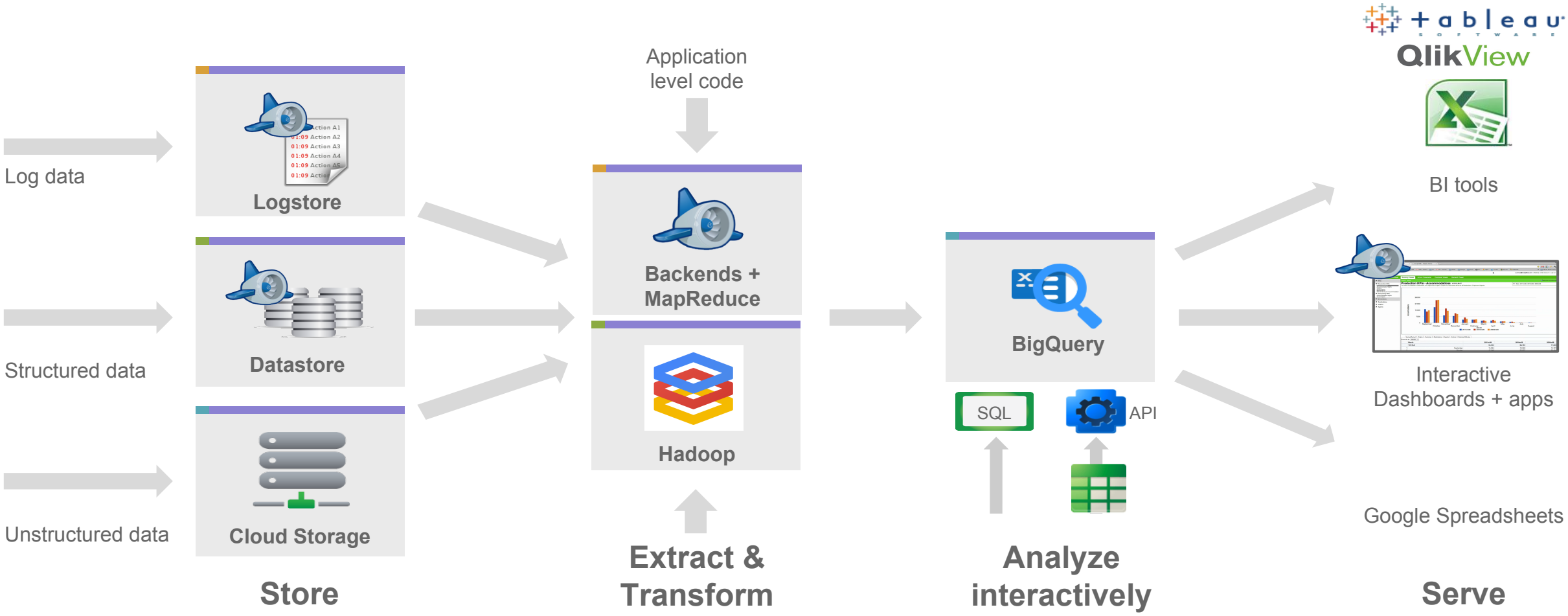
Google BigQuery: An Overview

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

Available on the Android App Store

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

Origins of BigQuery

Google BigQuery: An Overview

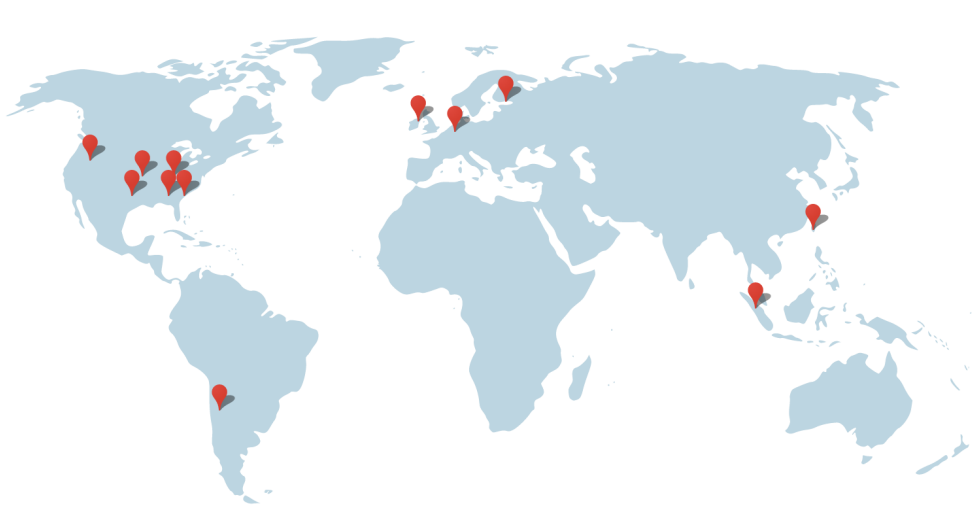
How can a business analyst find Top 20 Apps in matter of seconds?

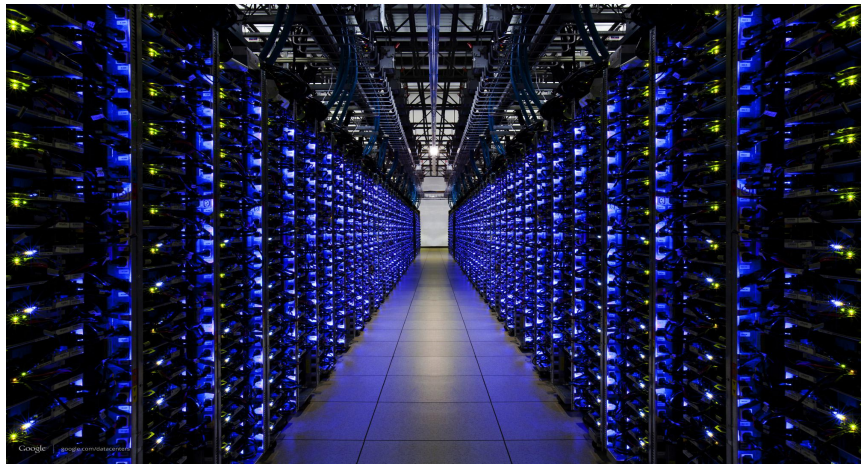
```
SELECT
  top(appId, 20) AS app,
  count(*) AS count
FROM installlog.2012;
ORDER BY
  count DESC
```

Result in ~20 seconds!

Origins of BigQuery

Google BigQuery: An Overview



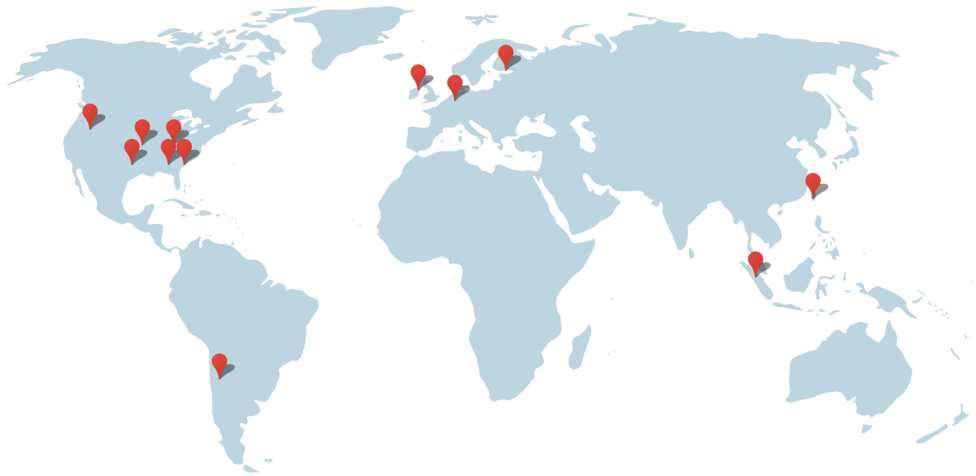


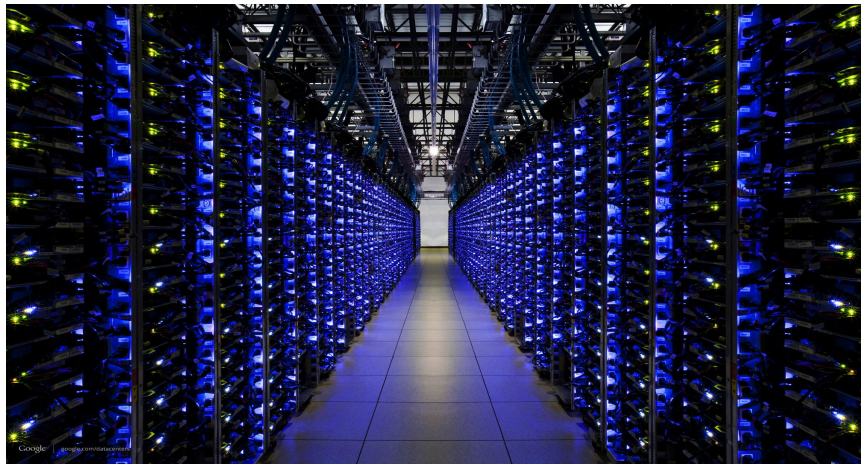
Google | Data Centers

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

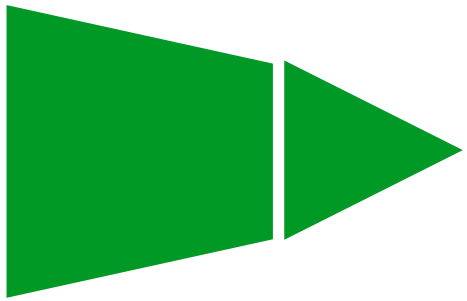
2010

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.

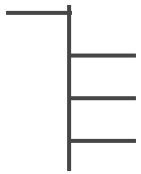
- Simple denormalized data structure
- Data can be loaded in csv or JSON format

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

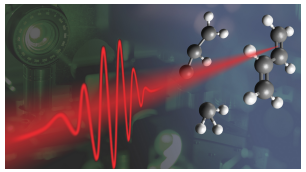


Nested Field Support

- 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

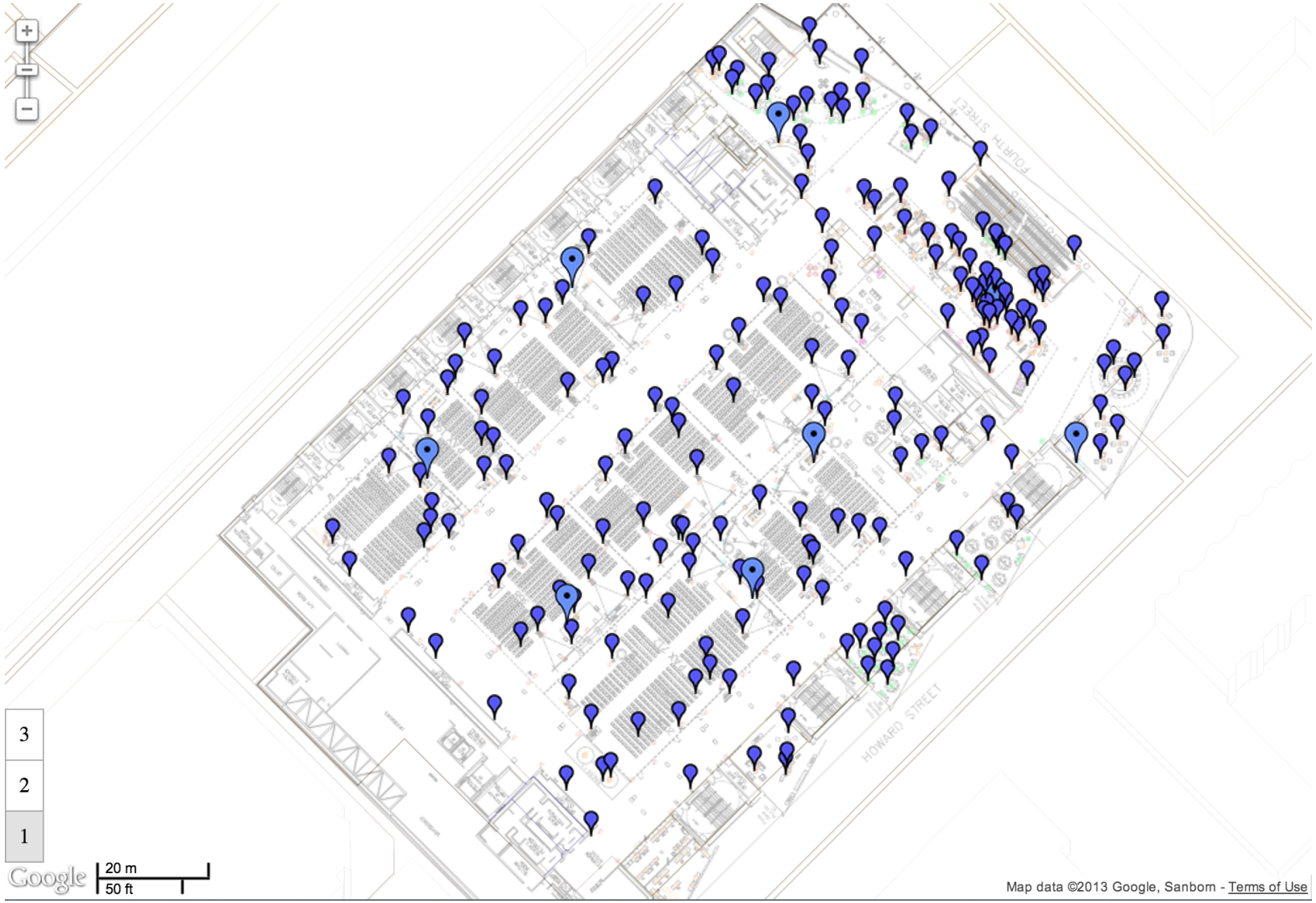
DATA SENSING LAB

Hardware hacking for data scientists

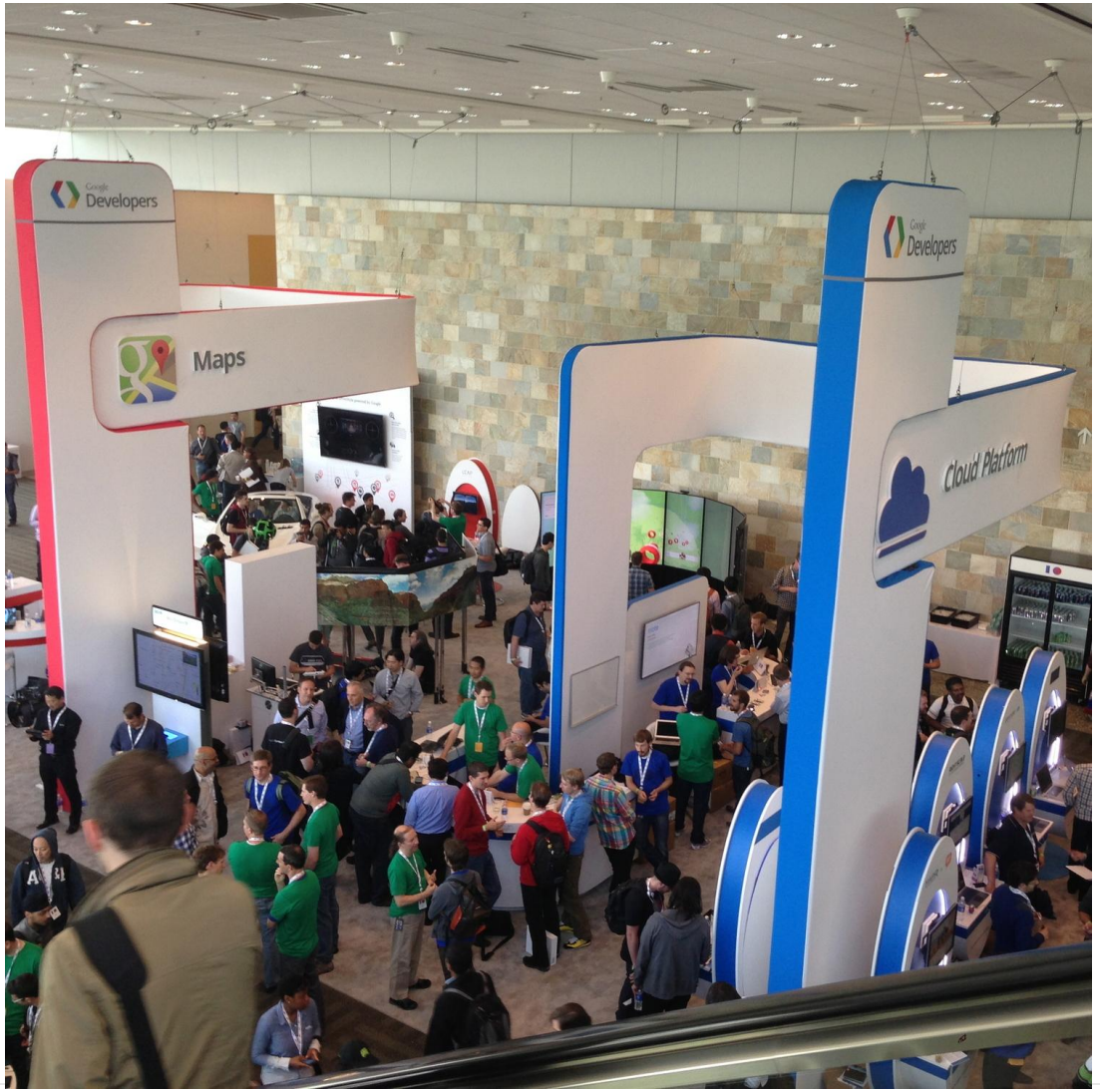
Google I/O 13

Sensor Data Analytics

Sensor Data Analytics



Sensor Data Analytics



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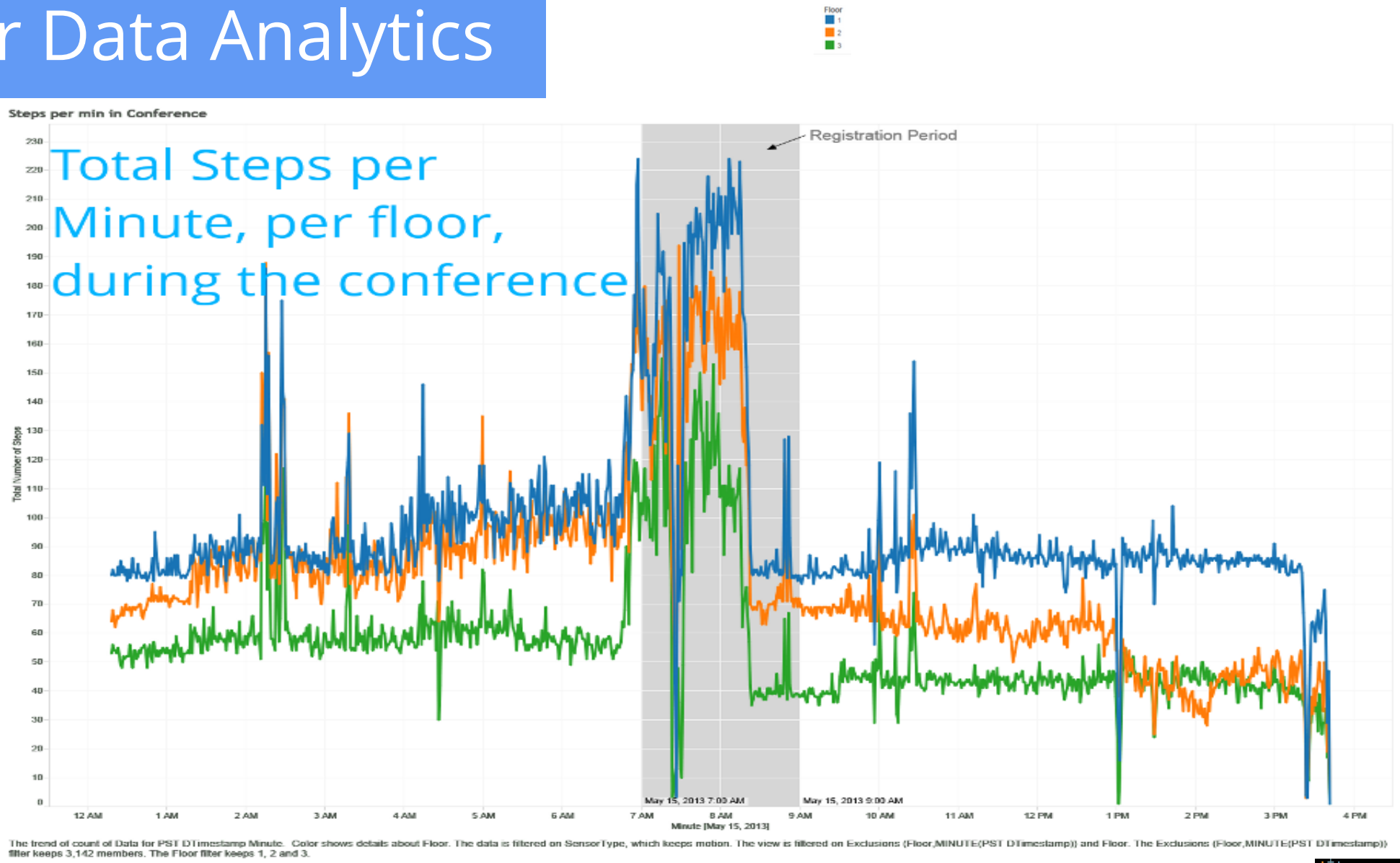

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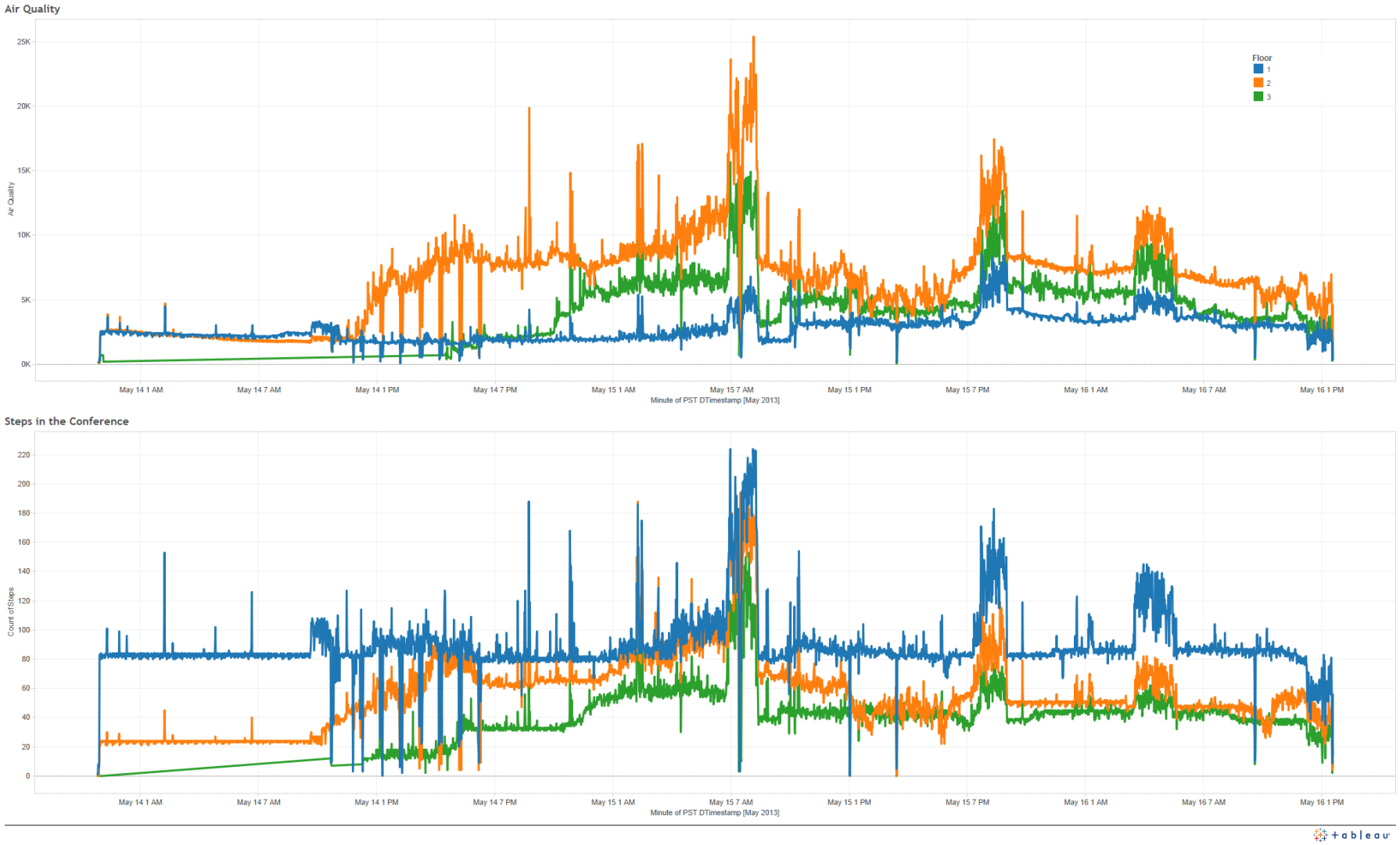

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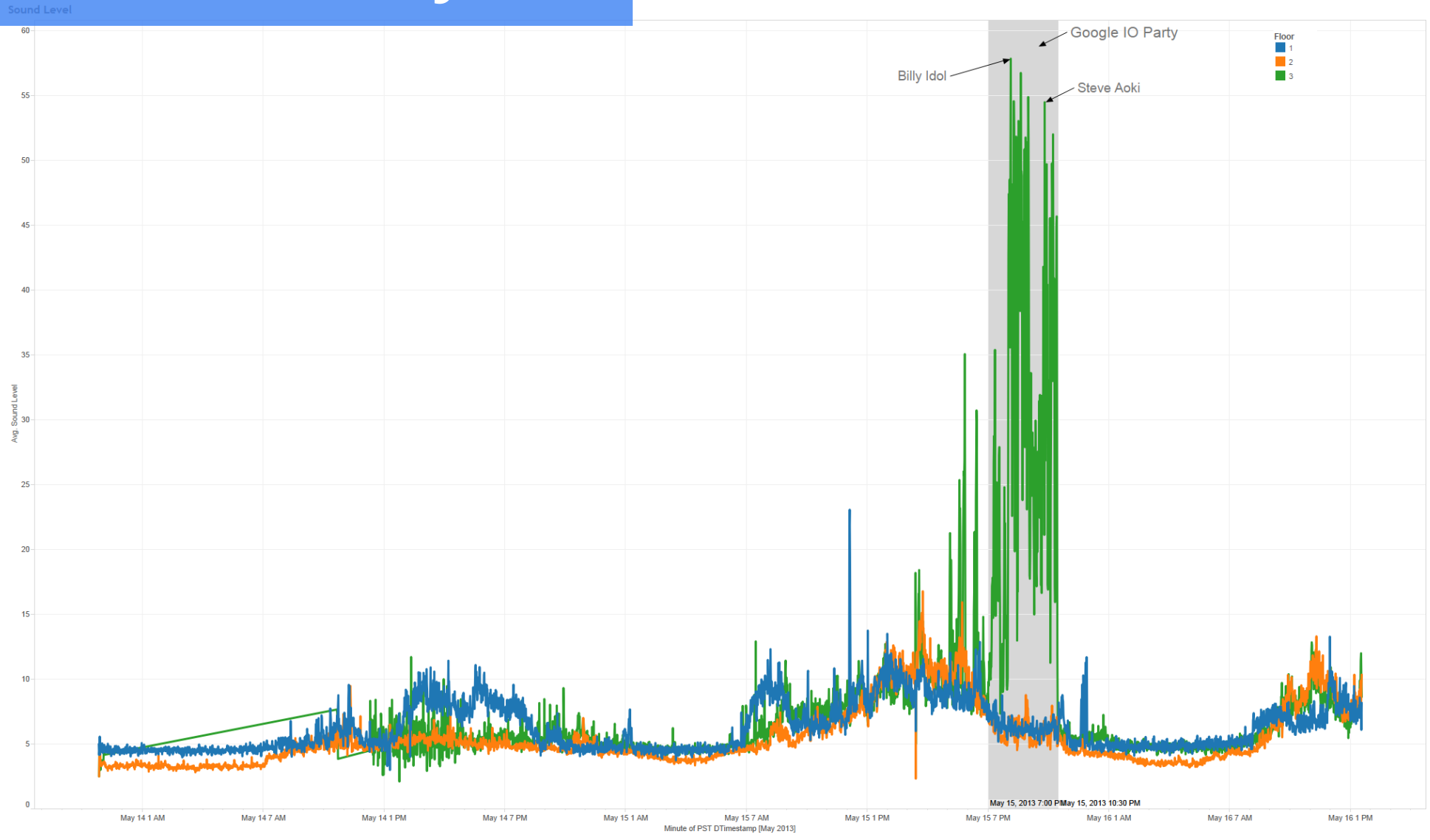
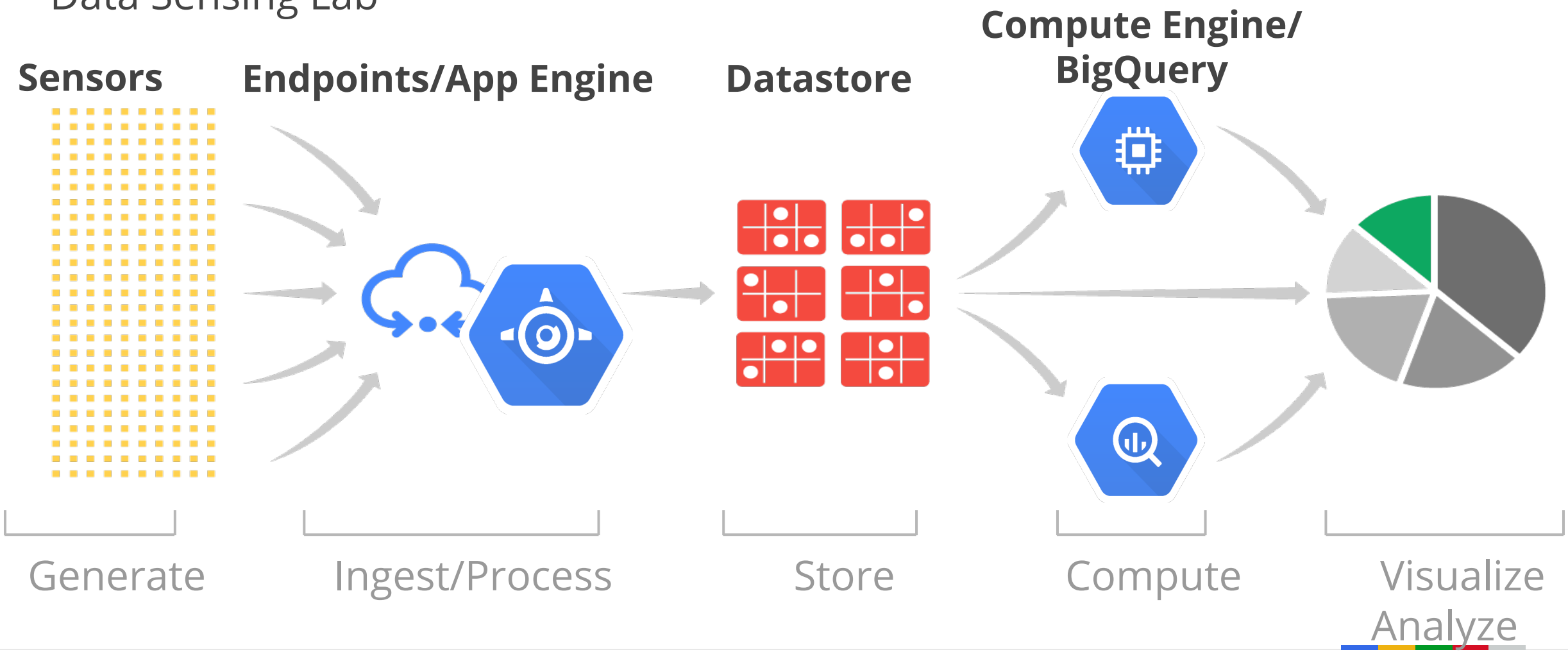
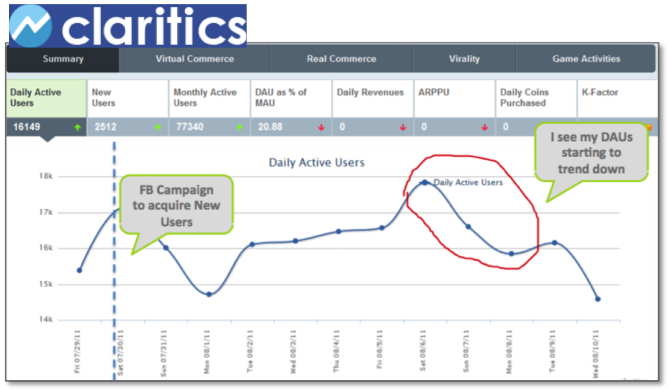


Sensor Data Analytics

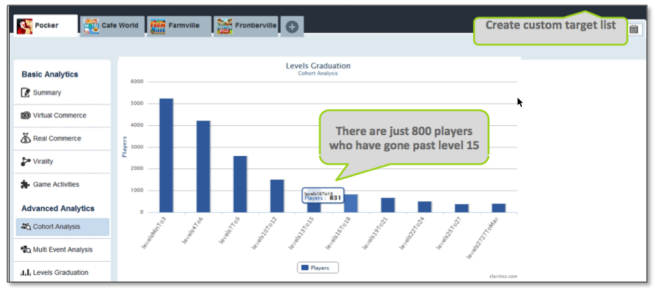
Data Sensing Lab



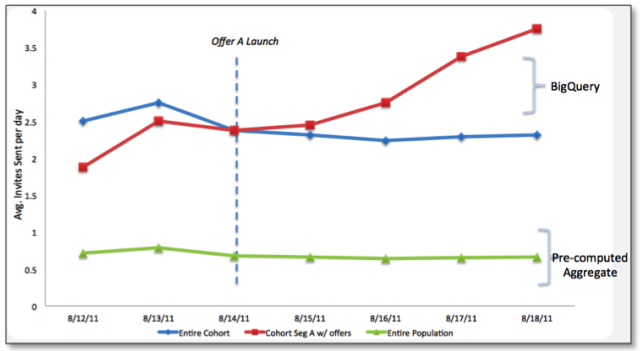
Mobile and Social Gaming User Analysis



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

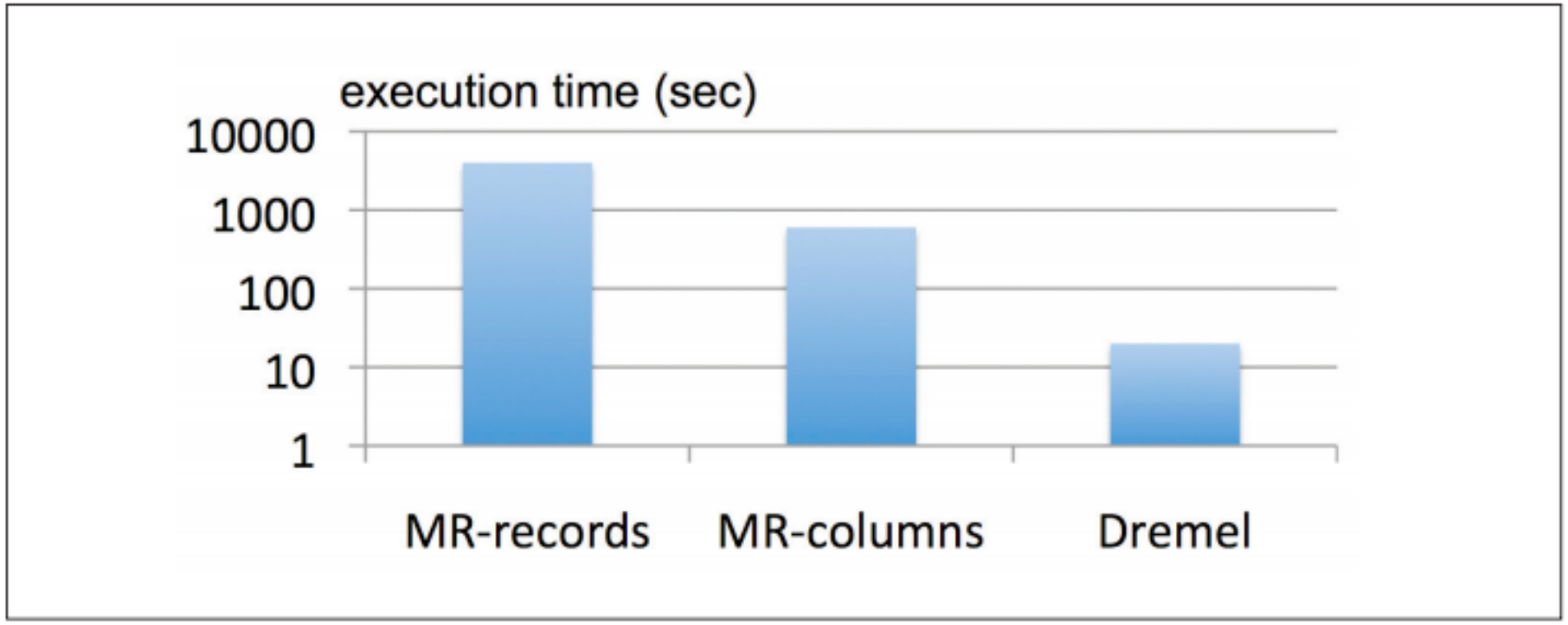


Figure 3 MapReduce and Dremel Execution Time Comparison

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[1].

BigQuery versus MapReduce

Key Differences	BigQuery	MapReduce
What is it?	Query service for large datasets	Programming model for processing large datasets
Common use cases	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
Sample use cases		
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

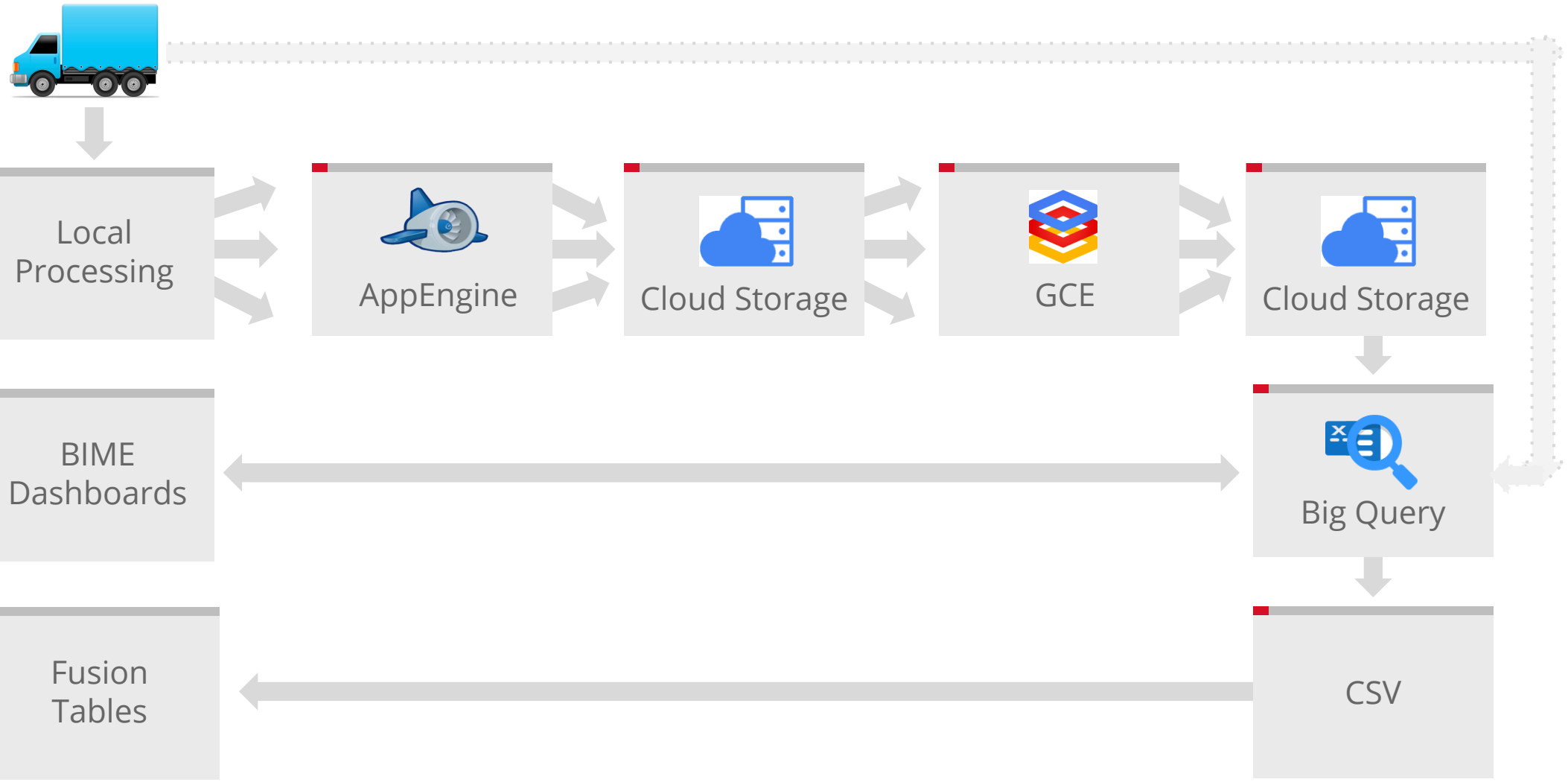
Secure and Reliable

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

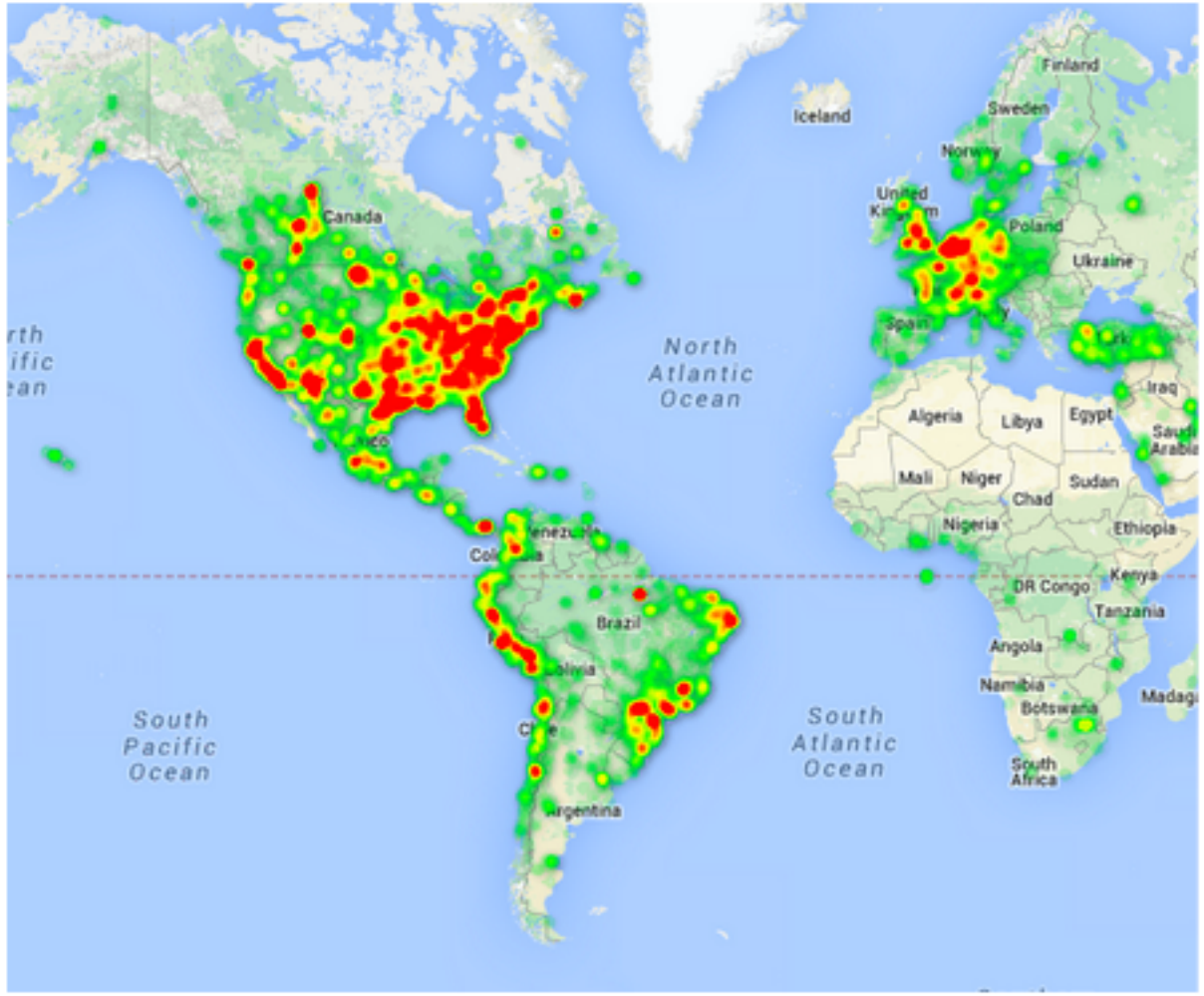
Innovative

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

Recent Manufacturer POC

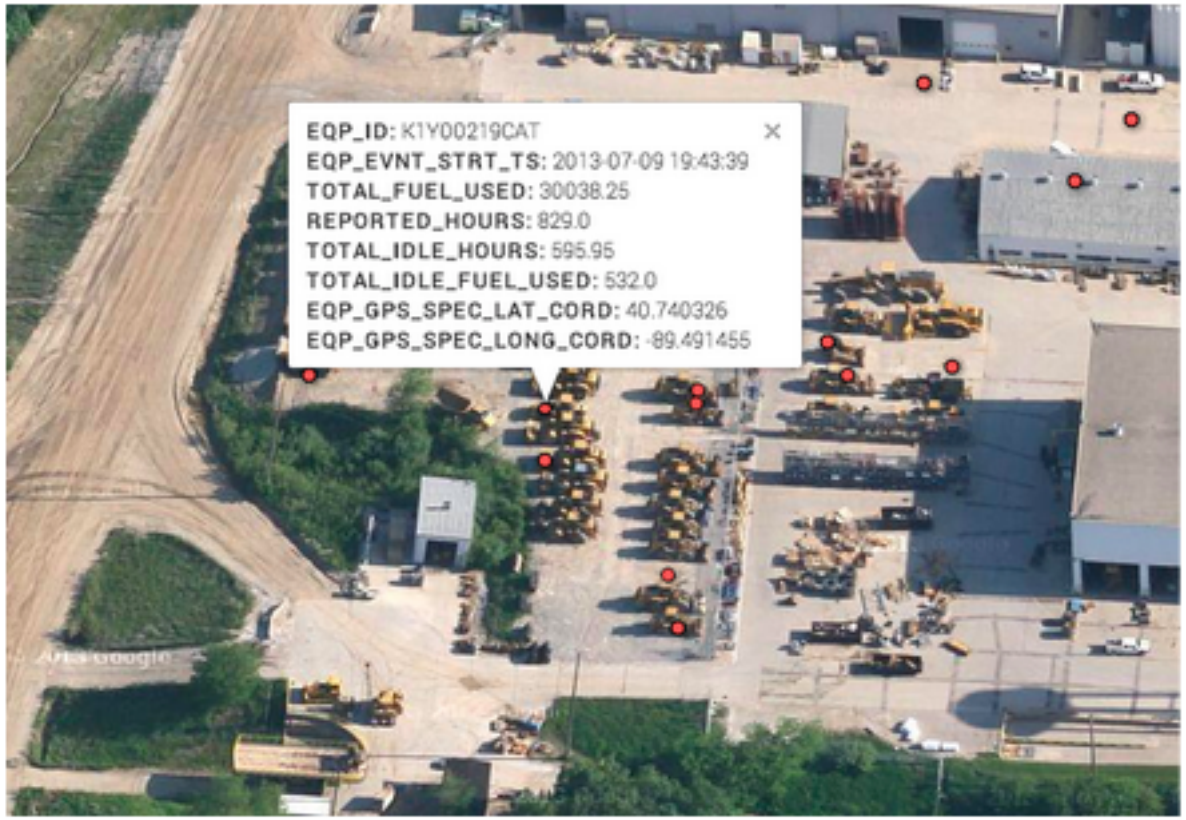


Recent Manufacturer POC



- 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

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
Images by Connie Zhou

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Google Cloud Platform