CARLSON SCHOOL
OF MANAGEMENT
UNIVERSITY OF MINNESOTA

Introduction to Cloud Computing and Amazon Web Services (AWS)

MSBA 6330 Prof Liu

Outline

- Concepts of cloud computing and virtualization/containerization
- Introduction to (AWS) and key components
- AWS big data line up and use cases
- Comparison between cloud computing platforms

Introduction to Cloud Computing and AWS

CONCEPTS OF CLOUD COMPUTING, VIRTUALIZATION, AND CONTAINERIZATION

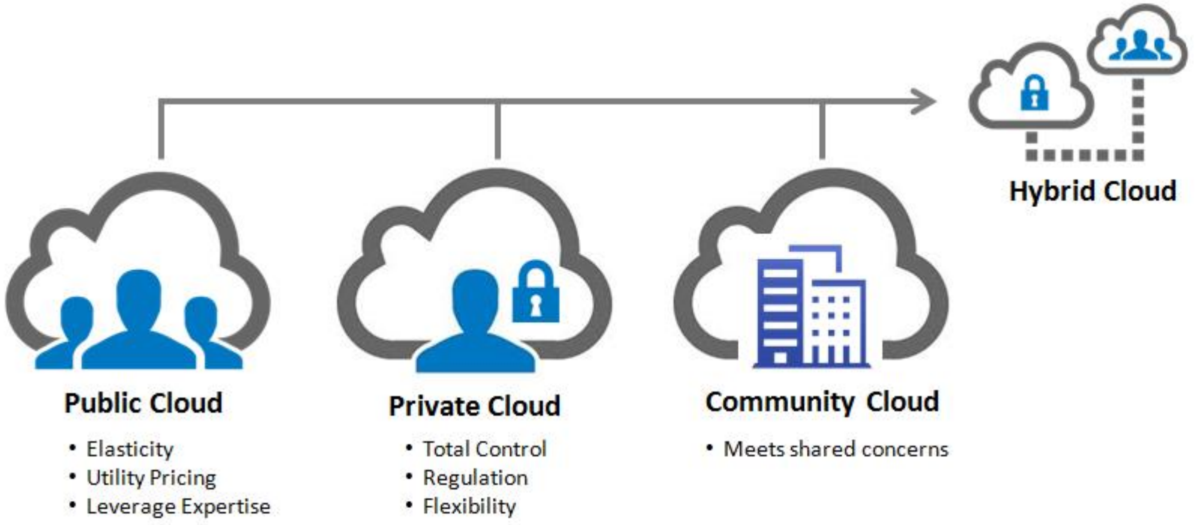
Cloud Computing

- **Cloud computing** is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
- Things you can do using cloud computing, e.g.
  – Create new apps and services
  – Store, back up, and recover data
  – Host websites and blogs
  – Stream audio and video
  – Deliver software on demand
  – Analyze data for patterns and make predictions

Source: NIST (http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf)

Types of Cloud Deployment

- **Public**: Provisioned for general public use based on shared physitical hardware, owned and operated by a third party provider (Eg. AWS, Azure, Google Cloud).
- **Private**: Provisioned for the use of a single entity, hosted on-site or in a service provider's data center.
- **Hybrid**: A combination of public and private cloud. Use the public cloud for non-sensitive operations, and the private cloud for business-critical oeprations.



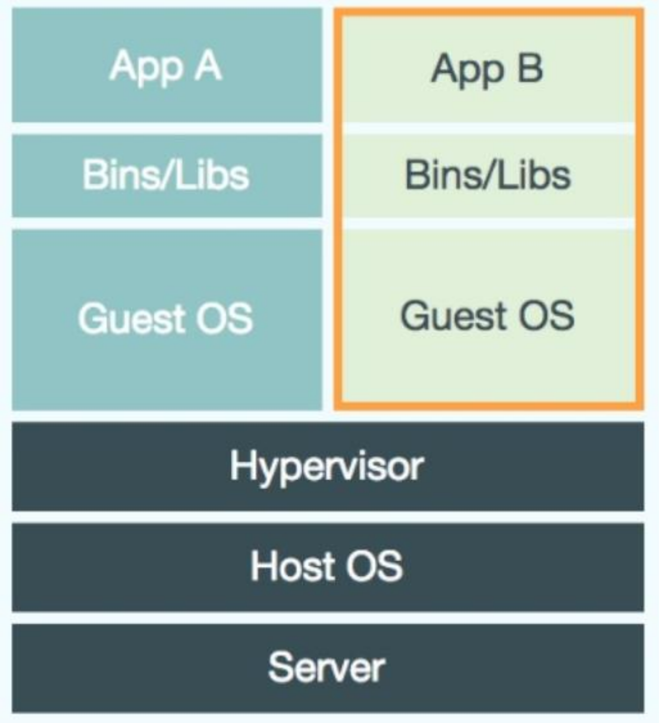
https://www.rackspace.com/en-us/cloud/cloud-computing/difference

Types of Cloud Computing Services

- Cloud computing is commonly characterized as providing three types of functionalities, referred to *IaaS, PaaS, SaaS*
  - **Infrastructure as a Service (IaaS)**: Offer basic building blocks of computing: processing, network connectivity, and storage. Virtual machines, storages, servers, network services.
    - Examples: Amazon’s EC2, Microsoft Azure, Rackspace, Google Compute Engine
  - **Platform as a Service (PaaS)**: provide a platform for developers to quickly build customized applications. Speed up development.
    - Examples: Google App Engine, Microsoft Azure Web Sites, Force.com
  - **Software as a Service (SaaS)**: uses the web to deliver applications that are managed by a third-party vendor (e.g. bug fixes, upgrades, back-end data management) and used by clients.
    - Google Apps, Concur, WebEx, Microsoft Office 365

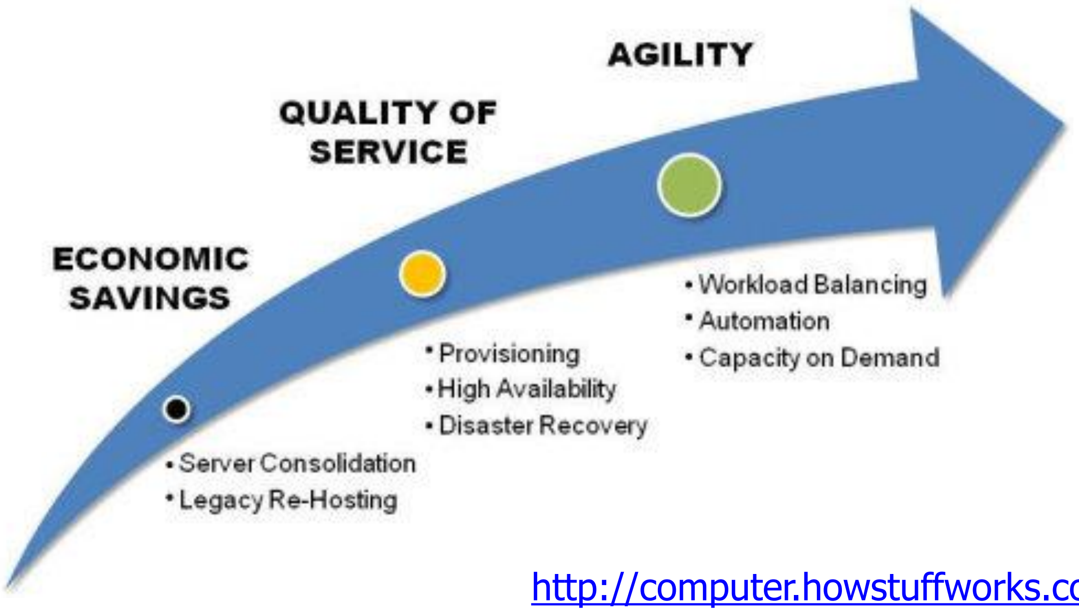
Technology behind Cloud computing: Virtualization

- **Virtualization** to make something that doesn't actually (physically) exist appear to exist.
  - Microprocess virtualization
  - Virtual Memory
  - Network virtualization
  - **Server Virtualization** (Virtual Machine)



Server virtualization

https://www.youtube.com/watch?v=hPkEqOoQSu4



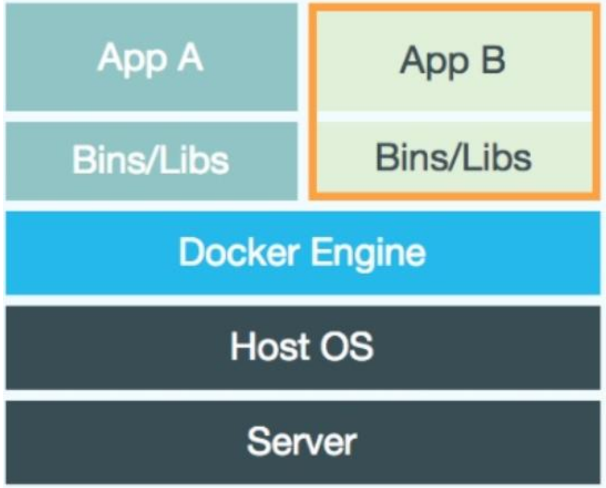
http://computer.howstuffworks.com/server-virtualization.htm/printable

Containerization - A Step Beyond

- **Container**: A software process whose access has been reduced to the point that it thinks it is the only thing running.
- **Containerization** (or operating-system level virtualization) allows the existence of multiple isolated user-space instances.
  - Docker: a platform for managing containers, started in March 2013.

Virtualization	Containerization
Virtual Machines (VMs)	Containers
Hardware level virtualization	Operating system virtualization
Heavyweight	Lightweight
Slow provisioning	Real-time Provisioning and scalability
Limited performance	Native performance
Fully isolated and hence more secure	Process-level isolation and hence less secure

https://jaxenter.com/containerization-vs-virtualization-docker-introduction-120562.html



Kubernetes – Containers meet clusters

- Kubernetes is a platform hosting Docker containers in a clustered environment with multiple Docker hosts.
  - – A container platform
  - – A microservices platform
    - A software component of a system that is independently releasable and independent scalable from other parts of the system
  - – A portable cloud platform, and a lot more
- Open-sourced by Google in 2014

https://www.youtube.com/watch?v=R-3dfURb2hA

https://www.slideshare.net/imesh/an-introduction-to-kubernetes

https://kubernetes.io/docs/concepts/overview/what-is-kubernetes/

Introduction to Cloud Computing and AWS

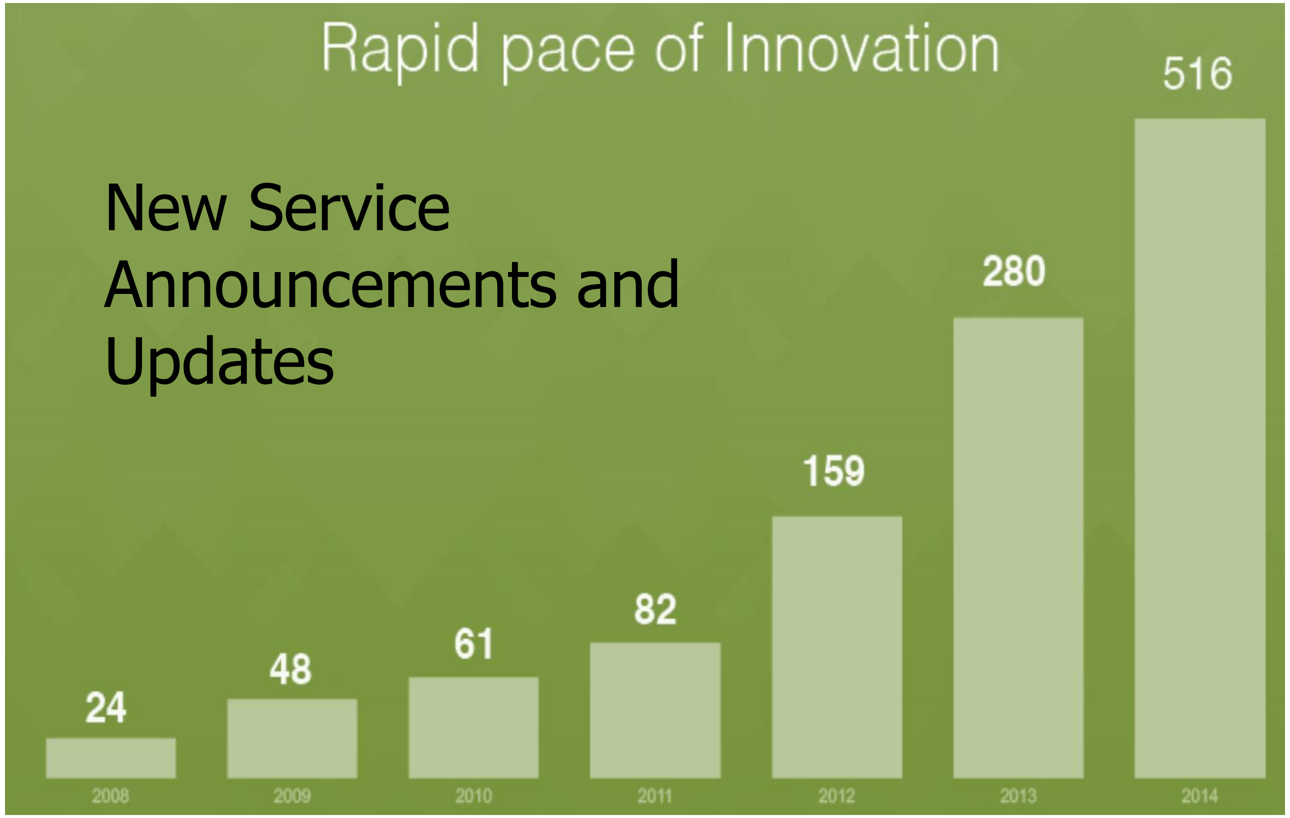
INTRODUCTION TO AWS AND KEY COMPONENTS

Amazon Web Services (AWS)

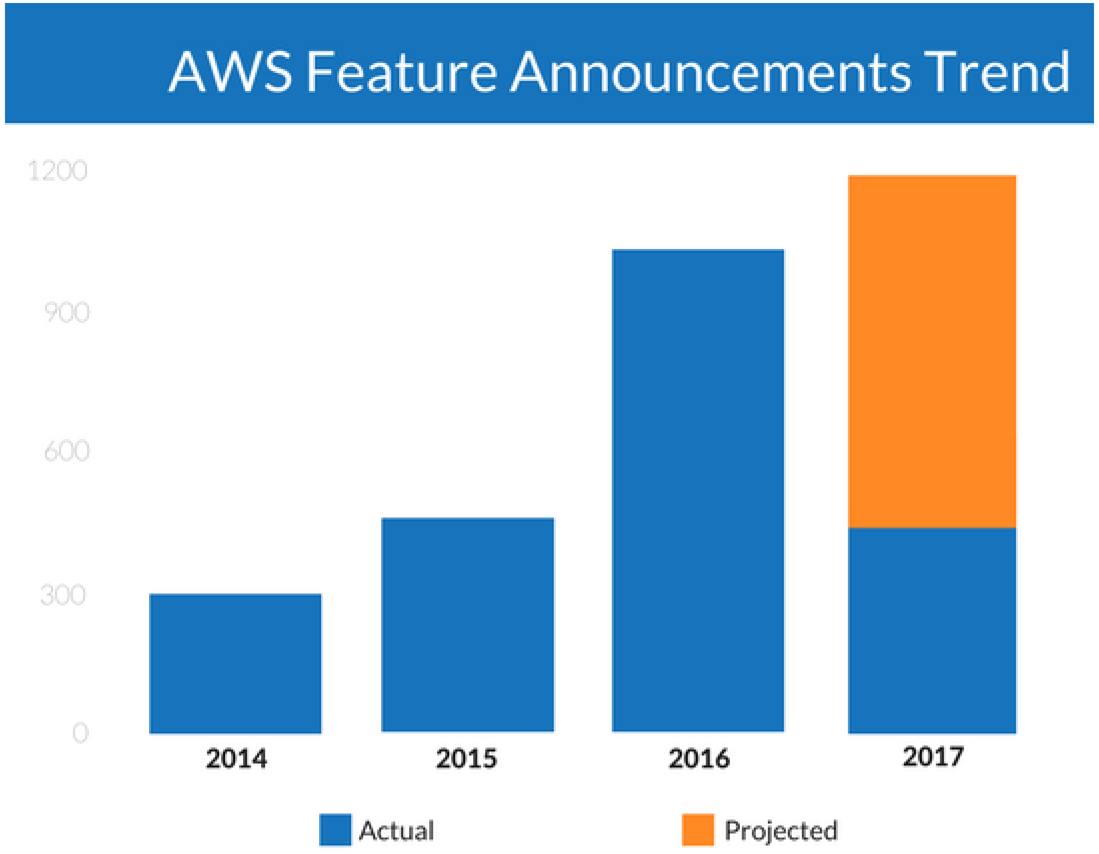
- Grew out of Amazon’s need to rapidly provision and configure machines for its own business.
- Early 2000s – Both private and shared data centers began using virtualization to perform “server consolidation”
- 2003 – Internal memo by Chris Pinkham describing an “infrastructure service for the world.”
- 2006 – S3 first deployed in the spring, EC2 in the fall
- 2008 – Competition heds up as Google and Microsoft launch cloud services
- 2009 – Virtual Private Cloud, Relational Database Service,
- 2012 – First customer event Re:invent (30000 registrations). RedShift, DynamoDB
- 2013 – CIA picks AWS over IBM for private cloud
- 2015-16 – Snowball (50 Terabyte appliance) Snowmobile (18-wheel truck with hard drives, 100TB).
- 2016 – AWS surpasses $10 billion revenue target
- 2017 – AWS nears 100 services (serverless computing, ML etc)

For more details: https://goo.gl/u3YN5E

Rapid Pace of Innovation at AWS



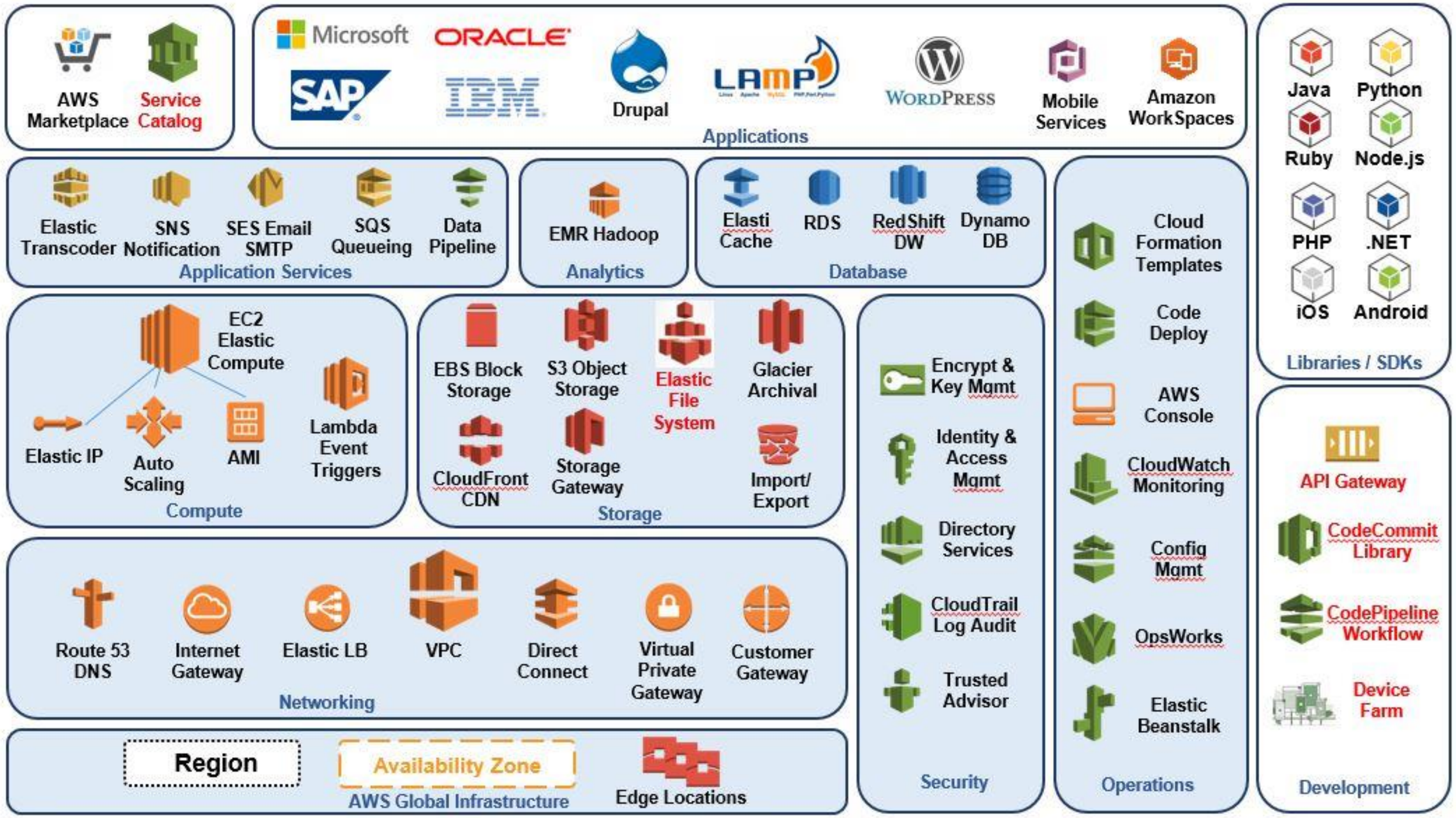
New Service Announcements and Updates



https://goo.gl/fKXK95

Today (2015) it looks like this….

aws

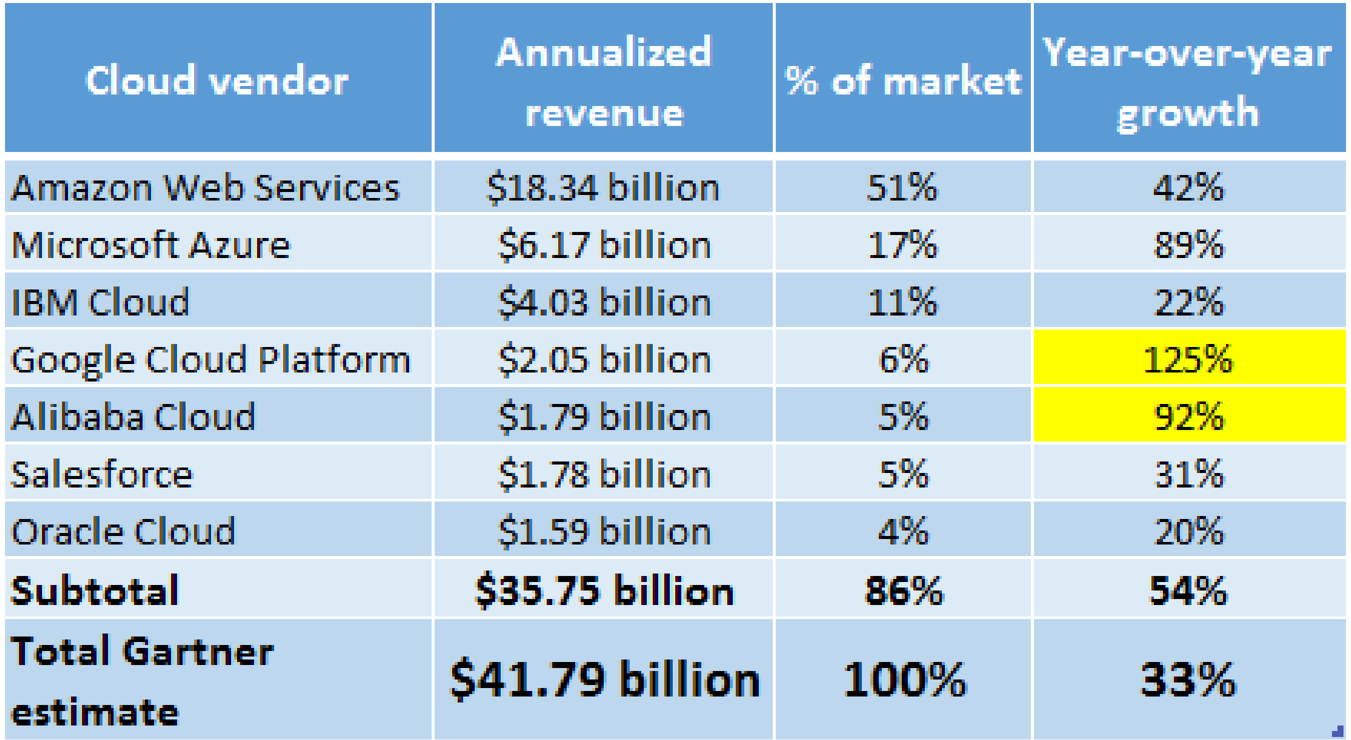


Source: https://cloudit4you.wordpress.com/

For more: https://goo.gl/1iX2F3

The tremendous growth of the public cloud industry

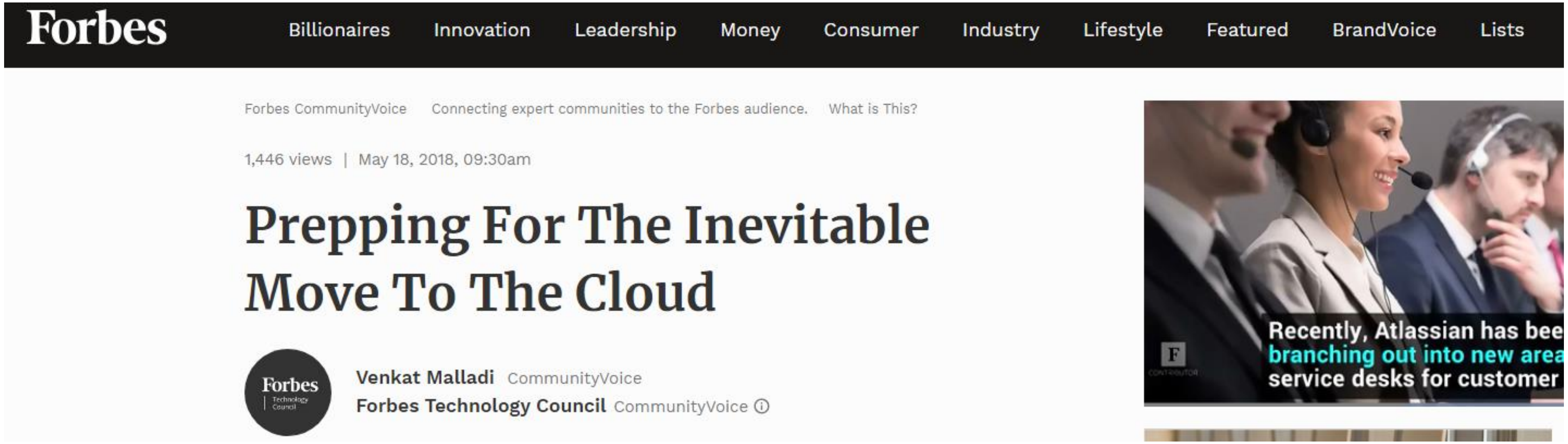
- AWS still dominates the cloud market, but Azure, Google and Alibaba are growing faster.



Cloud vendor	Annualized revenue	% of market	Year-over-year growth
Amazon Web Services	$18.34 billion	51%	42%
Microsoft Azure	$6.17 billion	17%	89%
IBM Cloud	$4.03 billion	11%	22%
Google Cloud Platform	$2.05 billion	6%	125%
Alibaba Cloud	$1.79 billion	5%	92%
Salesforce	$1.78 billion	5%	31%
Oracle Cloud	$1.59 billion	4%	20%
Subtotal	**$35.75 billion**	**86%**	**54%**
Total Gartner estimate	**$41.79 billion**	**100%**	**33%**

Source (2018): http://aclouda.com/blog/ms/aws-still-dominating-cloud-market-but-azure-google-and-alibaba-are-growing-faster/

The Inevitable Move to the Cloud



Forbes CommunityVoice Connecting expert communities to the Forbes audience. What is This?

1,446 views | May 18, 2018, 09:30am

Prepping For The Inevitable Move To The Cloud

Venkat Malladi CommunityVoice
Forbes Technology Council CommunityVoice

- Over 50% of global enterprise in 2018 will rely on public cloud technologies in implementing digital transformation and drive customer experience.

Source: Forbes 2018 https://goo.gl/hMo1Su

AWS Infrastructure

- Characteristics of AWS
  - **Auto Scaling** and **Elastic load balancing**
    - Scale up or down based on demand
  - Deploy systems in multiple regions
    - Lower latency and better experiences
  - Tools to run a wide range of applications

- **Regions**: physical location in the world
  - Contains multiple availability zones
- **Availability Zones** (Azs)
  - One or more discrete data centers
  - Redundant power/networking/connectivity
  - Housed in separate facilities.

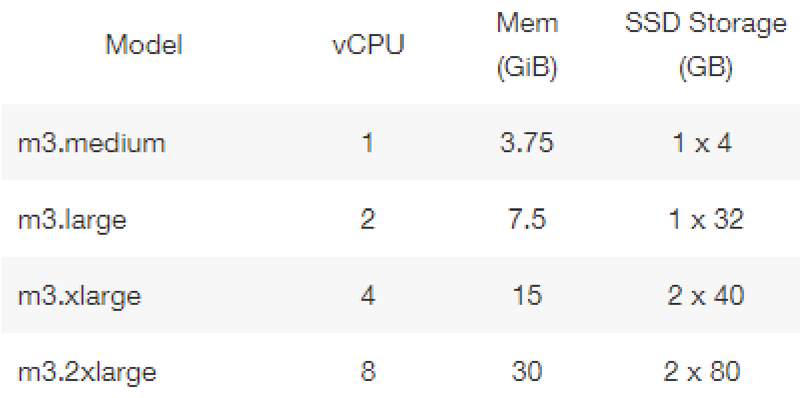
AWS Cloud Practitioner Essentials

Free training self-paced course

Compute

- **EC2 = Elastic Compute Cloud**
- Plain English: Amazon Virtual Servers
  - Allow you to obtain and boot new server instances in minutes
  - Allow you to quickly scale capacity, both up and down, as your computing requirements change.
  - Reserved and Spot instances

Amazon EC2



Model	vCPU	Mem (GiB)	SSD Storage (GB)
m3.medium	1	3.75	1 x 4
m3.large	2	7.5	1 x 32
m3.xlarge	4	15	2 x 40
m3.2xlarge	8	30	2 x 80

Storage

- **S3**: **Simple Storage Service**
  - In Plain English: Amazon's unlimited FTP server that allows you to store files, images, etc.
  - Scalable, secure, highly available, durable.
  - Used for static content, data for analytics, and back up.

Amazon S3

Amazon S3

Internet scale storage via API

Images

Videos

Files

Binaries

Snapshots

Simple Storage Service (S3)

- S3 stores objects in **buckets**.
  - A bucket can hold any number of **objects**, which are files of up to 5TB. A bucket has a name that must be **globally unique**.
  - A bucket has a **flat directory structure** (despite the appearance given by the interactive web interface.)

- S3 Addresses
  - Internal address (used within AWS): e.g.
    - s3://**mybucket1245/auction_data/auctiondata.csv**

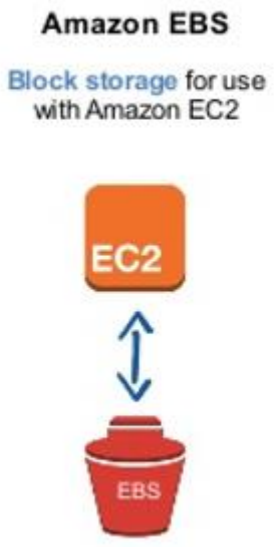
      Bucket name

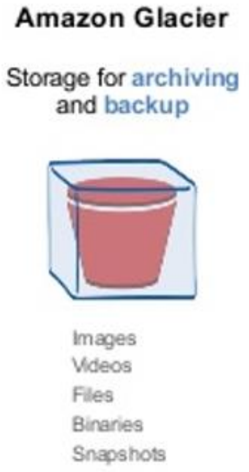
      Object name
  - External address (if made public) https://s3.amazonaws.com/mybucket1245/auction_data/auctiondata.csv

Storage

- **EBS** - **Elastic Block Store**
- In plain English – virtual hard disk to be used by EC2 instances.
  - Low-latency performance & scalability
  - More expensive than S3 storage

- Also: **Amazon Glacier** (for low-cost archive).
  - Optimized for infrequent access.
  - Extremely low cost ($0.01/GB/Month).





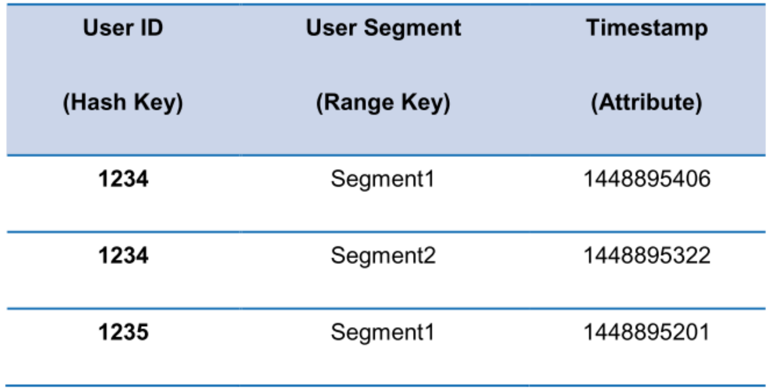
Database

- **RDS – Relational Database Service**
  - – Fully managed database services
  - – MySQL, Oracle, SQL Server, PostegreSQL, & Amazon Aurora (Amazon's MySQL Replacement).
  - – Autoscaling
  - – Support backup

Amazon RDS

Database

- **DynamoDB** – NoSQL keystore database
  - – Like Amazon's MongoDB
  - – Milliseconds latency



User ID (Hash Key)	User Segment (Range Key)	Timestamp (Attribute)
1234	Segment1	1448895406
1234	Segment2	1448895322
1235	Segment1	1448895201

Amazon DynamoDB

- **ElastiCache** - In-memory caches for fast performance
  - Support engines: Memcached & Redis

Amazon ElastiCache

Management Tools

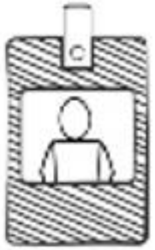
- **IAM** – Identity and Access Management – users, permission, SSH keys etc.

- **VPC: virtual private cloud**
- In Plain English: Make all of your AWS services are on the same little network (separated from other things on AWS). Amazon’s VLANs.

Amazon VPC

AWS IAM (Identity & Access Mgmt)

Manage users, groups & permissions



Amazon VPC:

Private, isolated section of the AWS Cloud

EC2
EC2
EC2
EC2

More Information on AWS Services and Categories

- Amazon Virtual Private Cloud (VPC)
- Security Groups
- EC2
- Lambda
- AWS Elastic Beanstalk
- Auto Scaling
- Amazon Elastic Block Store (EBS)
- Amazon Simple Storage Service (S3)
- Amazon Glacier
- Amazon RDS
- Amazon DynamoDB
- Amazon RedShift
- Amazon Aurora
- Etc.

AWS Cloud Practitioner Essentials (Intro and demos) https://www.aws.training/learningobject/curriculum?id=16357

Hands on labs: https://amazon.qwiklabs.com/catalog?locale=en

Introduction to Cloud Computing and AWS

AWS BIG DATA LINE UP AND USE CASES

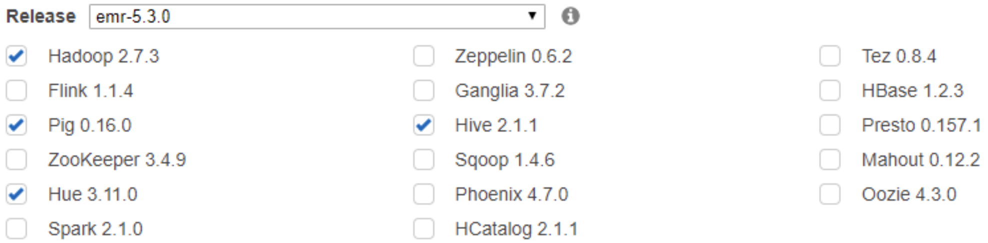
AWS's Big Data Line up

- **Kinesis Streams**: store and analyze real-time streaming data (by default, data is retained for 24 hours)
- **AWS Lambda**: serverless computing; let you run code without provisioning or managing servers. Useful real time, event driven processing.
- **EMR (elastic mapreduce)**: amazon's Hadoop stack, including Hive, Pig, spark, etc. Ideal for batch ETL, ad hoc analytics and data mining.
- **Amazon Machine Learning**: let you build ML models through wizards and run against data stored in S3, Redshift or RDS. (up to 100GB; bigger datasets should use EMR/Spark MLlib).
- **Amazon DynamoDB**: NoSQL database for low-latency frequent read/write. Commonly used for supporting live apps (mobile apps, voting, ad serving, e-commerce websites, streaming data storage, etc).
- **Amazon RedShift**: petabyte scale data warehouse; SQL-based; Useful for large scale OLAP and BI reporting.
- **Amazon Elasticsearch**: real time distributed full-text search, structured search and analytics.
- **Amazon QuickSight**: (2015) a business intelligence, visualization, ad hoc analysis tool.
- **Amazon EC2**: for building your self-managed big data analytics applications.

Ref: Big Data Analytics Options on AWS

Big Data

- **EMR** – Elastic Map Reduce
  - Amazon’s Hadoop Cluster, auto scaling, fully managed
  - Use EC2 as its computing instances.
  - Transient versus Persistent modes



Release emr-5.3.0

☑ Hadoop 2.7.3
☐ Flink 1.1.4
☑ Pig 0.16.0
☐ ZooKeeper 3.4.9
☑ Hue 3.11.0
☐ Spark 2.1.0
☐ Zeppelin 0.6.2
☐ Ganglia 3.7.2
☑ Hive 2.1.1
☐ Sqoop 1.4.6
☐ Phoenix 4.7.0
☐ HCatalog 2.1.1
☐ Tez 0.8.4
☐ HBase 1.2.3
☐ Presto 0.157.1
☐ Mahout 0.12.2
☐ Oozie 4.3.0

- **Redshift** - Amazon’s petabyte-scale data warehouse,
  - Support standard SQL and BI tools
  - Uses columnar storage format.
  - Massively parallel query execution
  - Include Redshift Spectrum for query unstructured data in S3 (including Avro, CSV, ORC, RegexSerDe, textfile etc)

Amazon EMR (Elastic Map Reduce)

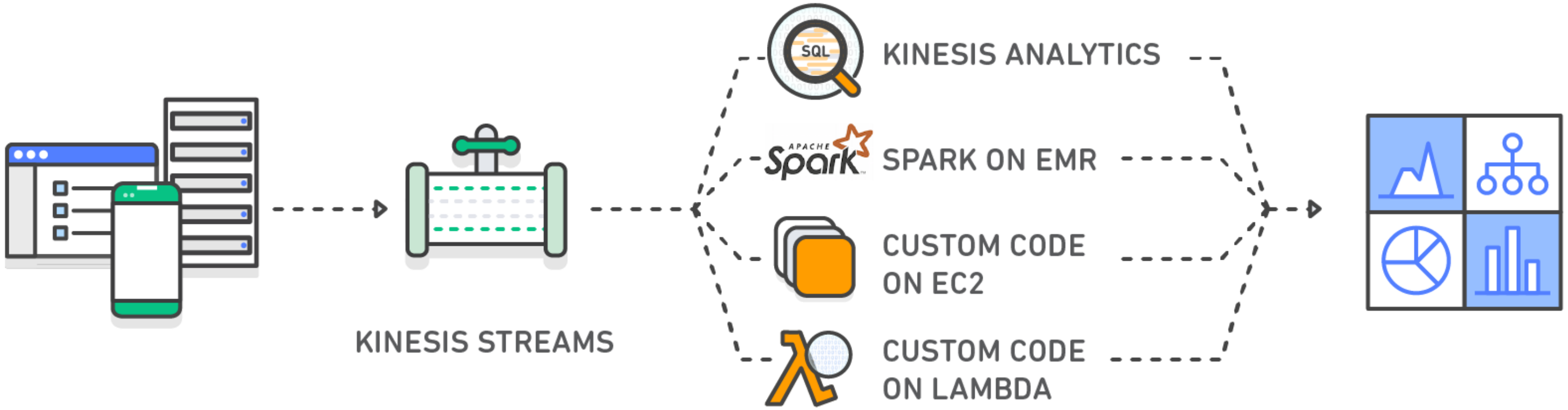
Hosted Hadoop framework

Amazon Redshift

Petabyte-scale data warehouse service

Streaming Processing

- **Kinesis** – for real-time ingestion & processing of streaming data
  - Amazon’s Kafka, fully managed, scalable
  - Ingest, process, and analyze real-time data such as application logs, website clickstreams, IoT telemetry data



Capture and send data to Kinesis Streams

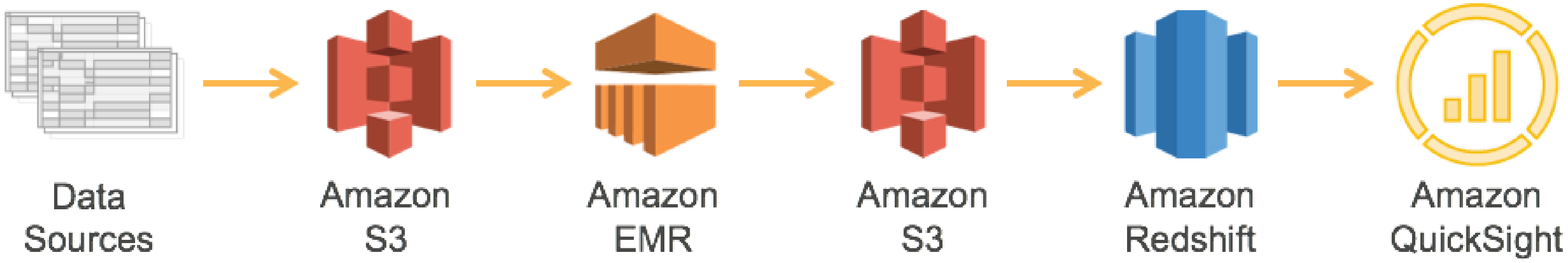
Build custom, real-time applications using Kinesis Analytics, stream processing frameworks like Apache Spark, or your code running on Amazon EC2 or AWS Lambda

Load processed data to any data store, send real-time alerts, feed live dashboards, and more

See more reference architectures @ https://aws.amazon.com/kinesis/?nc2=h_m1

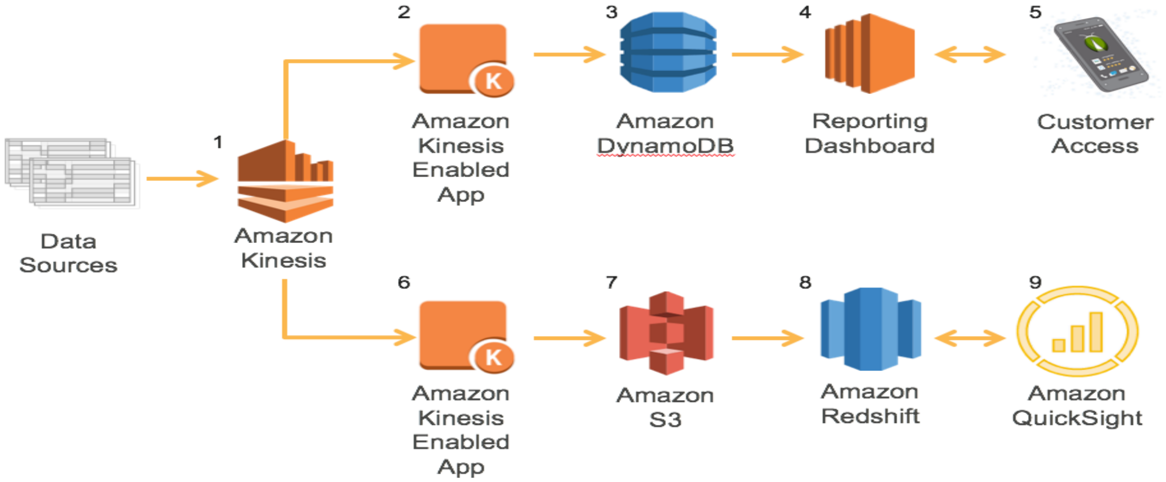
AWS big data use case 1- Enterprise data warehouse

- Enterprise data warehouse
  - – Ingest data into S3
  - – Use EMR to transform and cleanse data, store results to S3
  - – Redshift loads, sorts, distributes, and compress data into tables for fast OLAP analytics queries.
  - – QuickSight can be used for analytics, or external visualization tools connected to RedShift



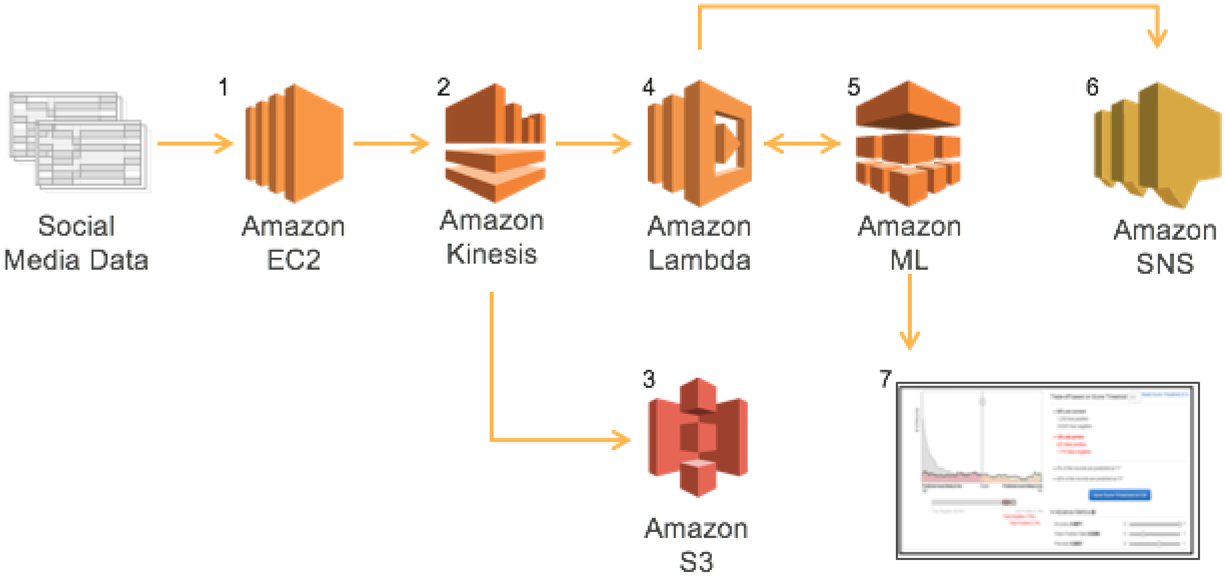
AWS big data use case 2- Capturing and Analyzing Sensor Data

- Sensor data uploaded into Kinesis streams.
- Custom Kinesis app on EC2 reads data, and send sensitive data to near real-time dashboard reporting (2-5), DynamoDB is used for fast storage. Reporting dashboard is a custom-build web-application using EC2 and data in DynamoDB
- Steps 6-9 process the same data at slower pace for non-real-time data warehouse style analytics and reporting.



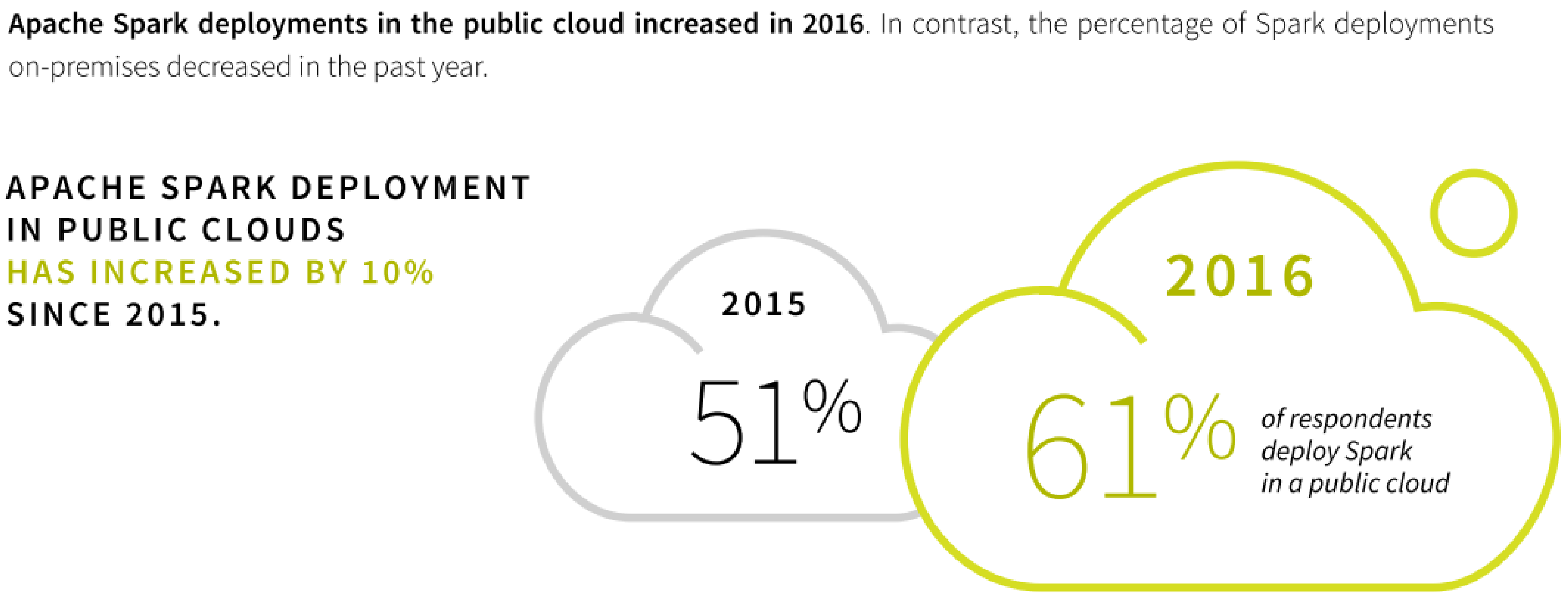
AWS big data use case 3- Sentiment Analysis of Social Media Data

- EC2 instances harvests social media data through APIs. Multiple social media streams are publishes to Kinesis.
- Raw data is stored in S3 for long term archival.
- Lambda is used for processing/normalizing data and request predictions from Amazon ML in near real time. ML also produces performance metrics via AWS console.
- Actionable data (alerts, predictions, via emails or text) is sent to Amazon SNS (simple notification service).



Popularity of Big Data in the Cloud

- More and more big data deployments are in the public cloud



Apache Spark deployments in the public cloud increased in 2016. In contrast, the percentage of Spark deployments on-premises decreased in the past year.

APACHE SPARK DEPLOYMENT IN PUBLIC CLOUDS HAS INCREASED BY 10% SINCE 2015.

https://databricks.com/blog/2016/09/27/spark-survey-2016-released.html

Use Case – NY Times

NYTimes "TimesMachine" (June 2008)

Welcome. TimesMachine can take you back to any issue from Volum
Daily Times, on September 18, 1851, through The New York Times of Dec
history and flip electronically through the pages, displayed with their origi

TUESDAY
APRIL 16, 1912
The Titanic Sinks

MONDAY
NOVEMBER 11, 1918
World War I Ends

The New York Times.
TITANIC SINKS FOUR HOURS AFTER HITTING ICEBERG;
The New York Times.
ARMISTICE SIGNED, END OF THE WAR!
BERLIN SEIZED BY REVOLUTIONISTS;
NEW CHANCELLOR BEGS FOR ORDER;
OUSTED KAISER FLEES TO HOLLAND

1851-1922 Articles

TIFF -> PDF

Input: 11 Million Articles (4TB of data)

What did he do ?

Spun 100 EC2 Instances for 24 hours

Input: All data on S3

Output: 1.5 TB of Data

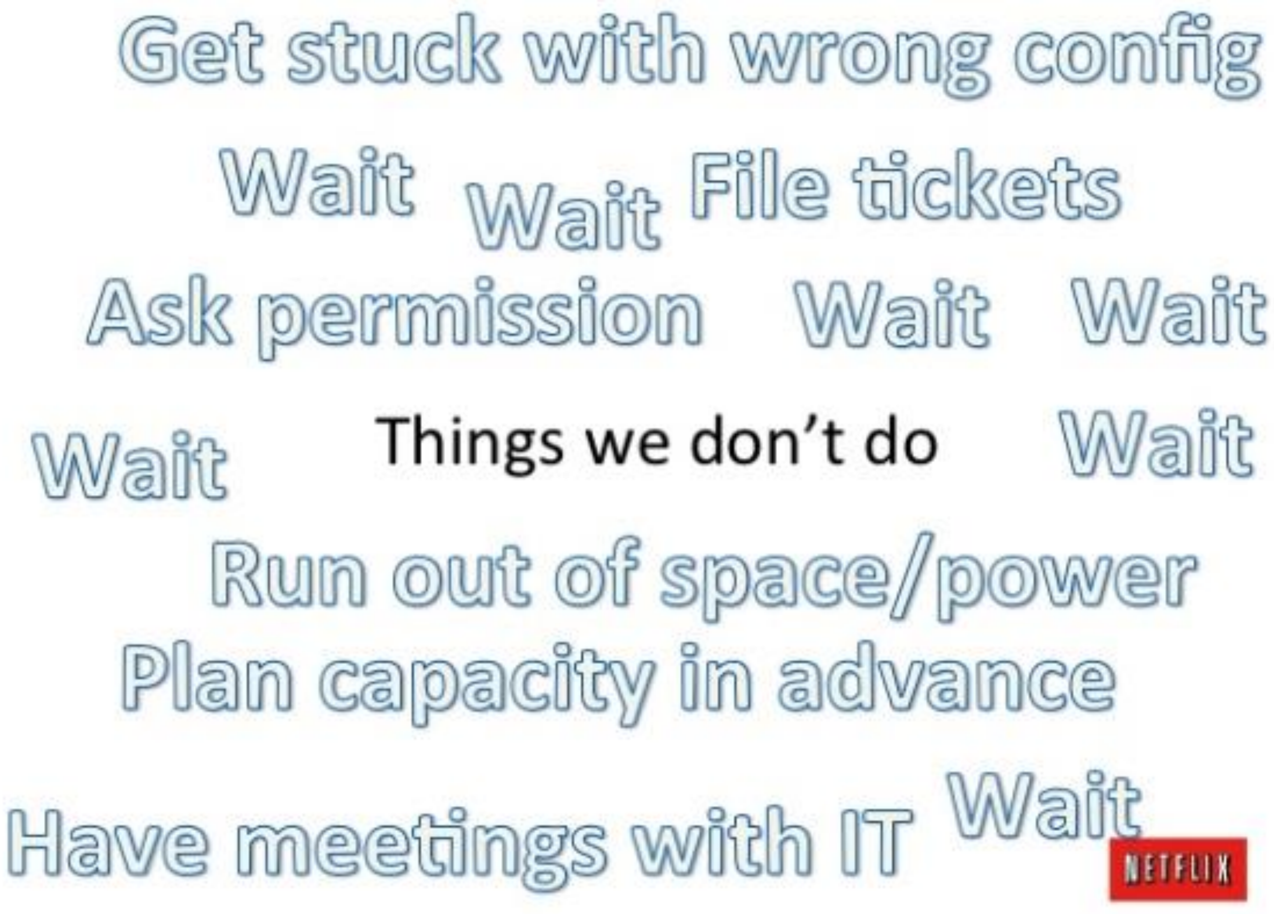
Used: Hadoop, iText, JetS3t

Use Case - Netflix

- Moved its entire technology infrastructure in Nov 2012
- Linux-based Web Servers
  - EC2 instances
  - Use Amazon S3, Cassandra Database services
- Transcoding
  - EMR for computing, S3 for storage
- Recommendation
  - Hive & Pig & Machine Learning for offline analytics and model building

https://aws.amazon.com/solutions/case-studies/netflix/

Why Netflix Uses Cloud Infrastructure



Get stuck with wrong config

Wait Wait File tickets

Ask permission Wait Wait

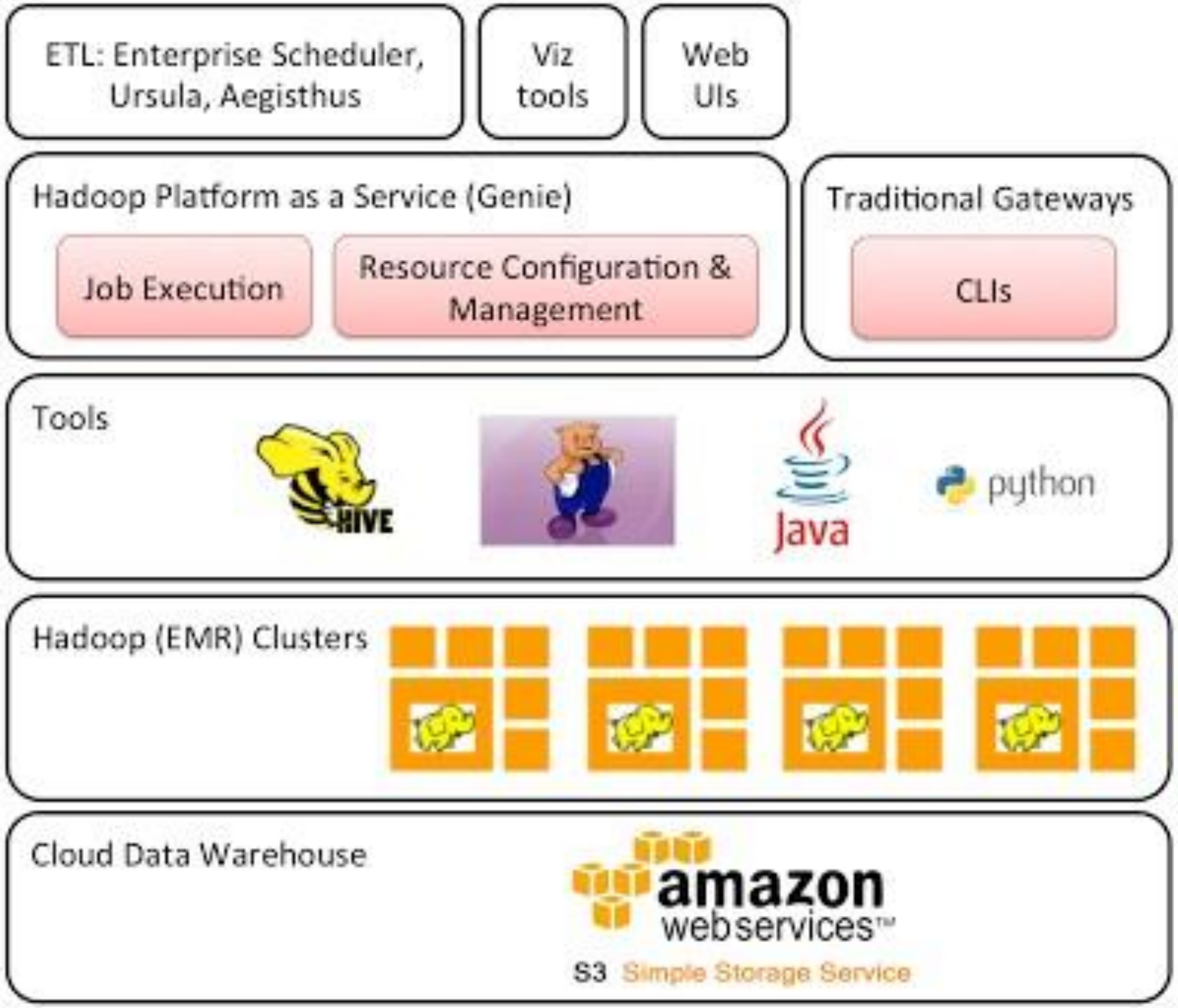
Wait Things we don’t do Wait

Run out of space/power

Plan capacity in advance

Have meetings with IT Wait

Use Case - Netflix



ETL: Enterprise Scheduler, Ursula, Aegisthus

Viz tools

Web UIs

Hadoop Platform as a Service (Genie)

Job Execution

Resource Configuration & Management

Traditional Gateways

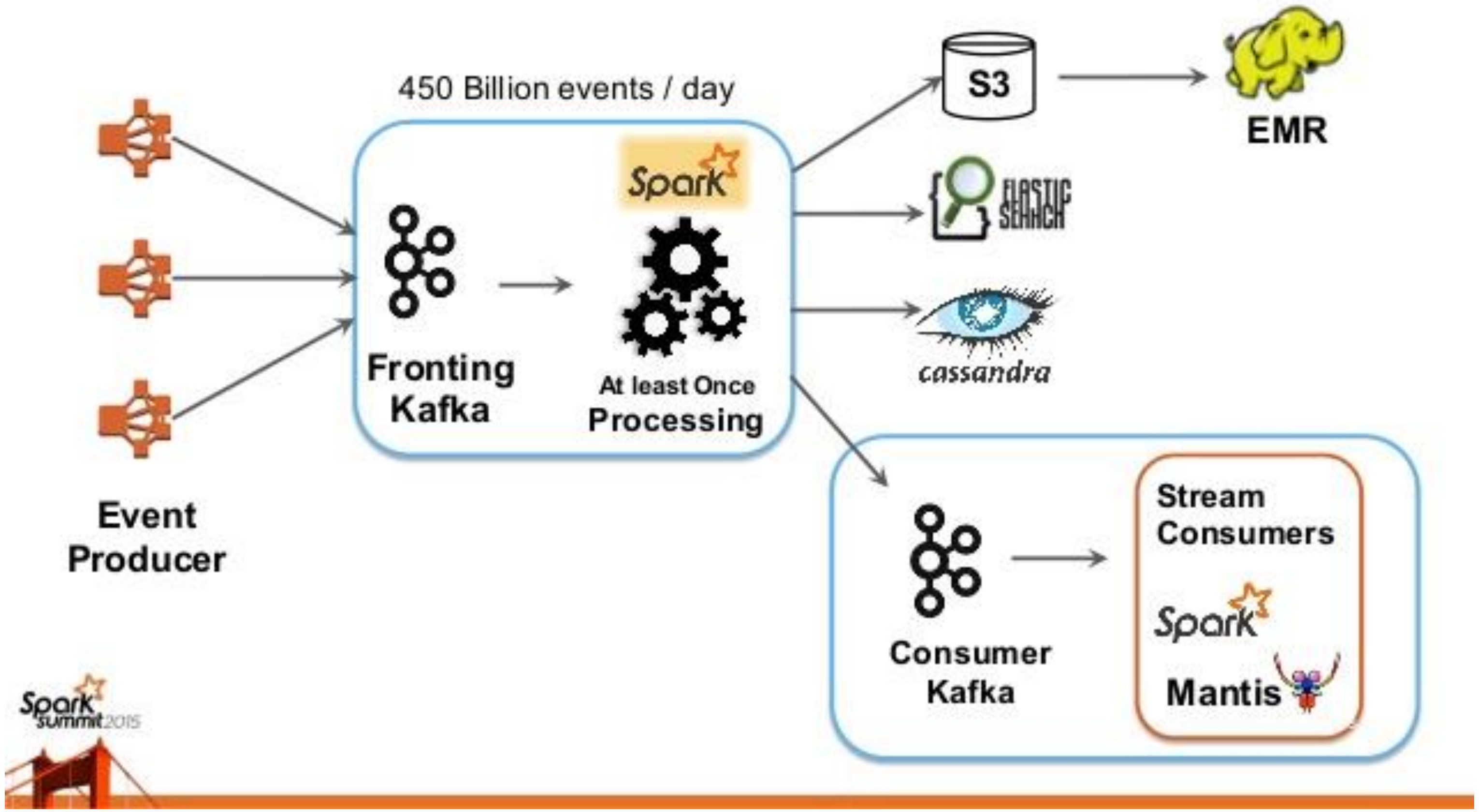
CLIs

Tools

Hadoop (EMR) Clusters

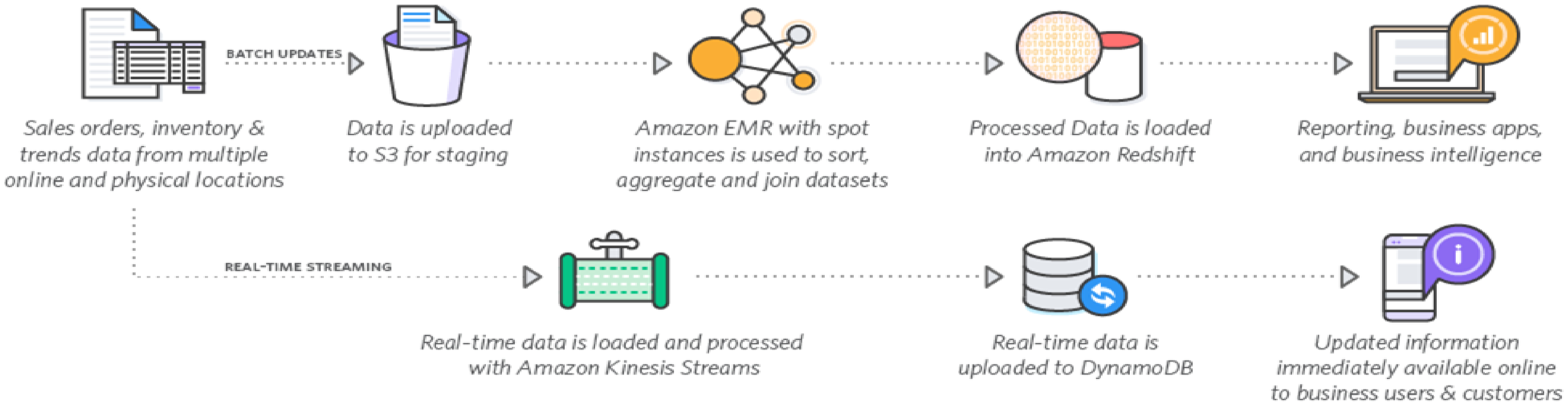
Cloud Data Warehouse

Use Case – Netflix' Event Data Pipeline



http://www.slideshare.net/SparkSummit/spark-and-spark-streaming-at-netfix-sedakar-daxini

Big Data Cloud Computing Use Case: Lyft



Sales orders, inventory & trends data from multiple online and physical locations

Data is uploaded to S3 for staging

Amazon EMR with spot instances is used to sort, aggregate and join datasets

Processed Data is loaded into Amazon Redshift

Reporting, business apps, and business intelligence

Real-time data is loaded and processed with Amazon Kinesis Streams

Real-time data is uploaded to DynamoDB

Updated information immediately available online to business users & customers

- Ride location tracking
  - DynamoDB (NoSQL)
- Lyft App events
  - open an app, driver action car movement, user action
  - Amazon Kinesis

1 Million service requests/sec

10,000 people in Lyfts at any moment in US

Introduction to Cloud Computing and AWS

COMPARISON BETWEEN CLOUD COMPUTING PLATFORMS

Comparisons between Major Cloud Providers: Compute

Function	AWS	Azure	Google
Virtual Machines, Containers	EC2 + EC2 Container Service	Virtual Machines, Azure Kubernetes Service	Compute Engine Kubernetes Engine
Event driven compute	Amazon Lambda	Functions	Cloud Functions
Realtime data processing	Amazon Kinesis, Amazon data pipline	Event hubs Apache Storm for HDInsight	Cloud Dataflow
Hadoop	Elastic MapReduce	HDInsight	Cloud Dataproc
Machine Learning	Amazon Machine Learning, MXNet, Deeep Learning, TensorFlow etc	Azure Machine Learning etc.	Cloud Machine Learning Engine, Cloud Deep Learning Image,

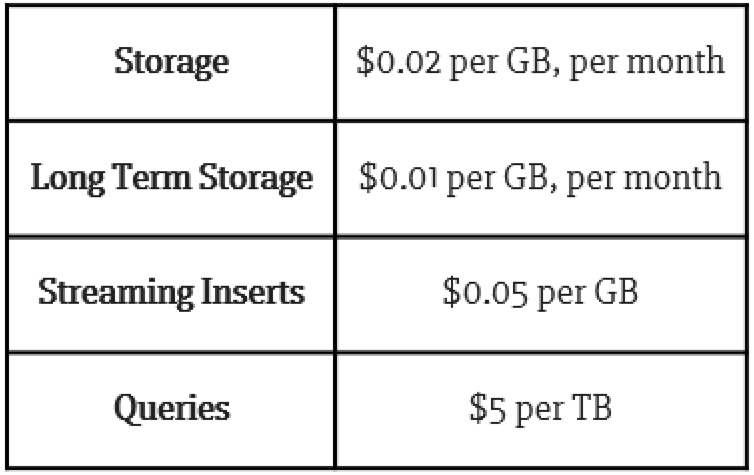
https://www.whizlabs.com/blog/aws-vs-azure-vs-google/

Comparisons Between Major Cloud Providers: Compute

Function	**AWS**	**Azure**	**Google**
Data storage web services	Amazon S3	Storage	Cloud Storage
Archiving	AWS Glacier	Azure Backup	Cloud Storage Nearline
Database as Service	Amazon RDS , Aurora	Azure SQL Database, Cosmos DB	Cloud SQL
NoSQL	DynamoDB	Table Storage	Cloud Datastore, BigTable
Data Warehousing	AWS Redshift	SQL Data Warehouse	BigTable / BigQuery

Demo: Google BigQuery

- Google BigQuery
  - SQL based large-scale cloud data warehouse
  - Google's Answer to Amazon's Redshift
  - Pay per query and for table storage



Storage	$0.02 per GB, per month
Long Term Storage	$0.01 per GB, per month
Streaming Inserts	$0.05 per GB
Queries	$5 per TB

Reference: https://cloud.google.com/files/BigQueryTechnicalWP.pdf

Resources

- Video tutorials (great resource to get introduced to AWS)
  - http://aws.amazon.com/getting-started/
  - AWS Educate program. Free videos and AWS tutorials
- AWS documentation
  - most comprehensive source of information
- AWS EMR developer guide:
  - handbook of EMR services and how to use them.
- AWS EMR management guide:
  - How to setup, manage, and debug EMR clusters.
- Big Data Analytics Options on AWS:
  - Ideal usage of big data tools on AWS, including redshift, Kinesis, EMR, DynamoDB, ML, Lambda, ElasticSearch and three stylized use cases.
- AWS Tutorials & Training for Big Data
  - https://aws.amazon.com/big-data/getting-started/tutorials/
- Data Lakes and Analytics on AWS
  - https://aws.amazon.com/big-data/datalakes-and-analytics/

Resources

- Videos
  - Google Cloud Platform & Big Data
  - Google Cloud Platform 2016 Keynote
  - AWS 2016 Keynote
  - GOTO Conferences: The latest in software development
- AWS, Google Cloud and Azure links
  - http://blogs.aws.amazon.com/bigdata/
  - https://cloudplatform.googleblog.com/
  - https://azure.microsoft.com/en-us/
  - https://cloud.google.com/free-trial/