CS145

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“Shiva” Shivakumar

Interests

Petabyte scale data systems (from cs145 -> Infolab -> now)

Building new data systems, products (and teams)

- Scaled to billions of consumers, billions of ad $s, millions of web publishers, trillions of data rows, million QPS systems
- E.g., AdSense, Search, Dremel/BigQuery, Gmail/Google Apps, Sitemaps, Warp, Google Maps, Healthcare data, etc.

Hello TAs

Staff

Instructor

Shiva Shivakumar

Teaching Assistants

Ailyn Tong (Head)

Ada Zhou

Aman Bansal

Amber Yang

Cara Van Uden

Qirui Zhou

Sanjari Srivastava

Silvia Gong

Sharmila Nangi

Class Logistics
http://cs145.stanford.edu

CS145

Goals

Course Summary

We'll learn How To…

- **Query** over small-med-large data sets with **SQL**? [Weeks 1 and 2]
  - On relational engines, and "big data" engines (e.g, MySQL, BigQuery, SPARK-like)
- **Scale** for big data sets? On Cloud Clusters? [Weeks 3, 4, 5]
  - Analytics ("Online Analytic Processing -- OLAP", 1st principles of scale)
- **Update** data sets? [Weeks 6, 7]
  - Writes, Transactions ("Online Transaction Processing - OLTP"), Logging, ACID properties
- **Design** "good" databases? [Weeks 8, 9]
  - Schema design, functional dependencies, query optimizers

Project: Query-Visualize-Learn on GB/TB scale data sets on a Cloud [sql + python]

Grading and Sections

Grading breakdown for CS 145?

- Projects: **50%** (10 + 15 + 25)
- Test: **15%** [Oct 28], Finals: **25%** [Dec 9, 7-10pm]
- Problem set (4): **10%** (ungraded, turn in on time)

[Bonus credit to students with insightful piazza/in-class participation]

Difference between problem set and projects?

Projects (3)

- apply class material in a real world manner on large data
- 2 late days
- Students -- "Very practical", "creative outlet", ...

Problem Set (4)

- accompany the material taught in class; self-grading
- Students **-- "Best practice material** for Tests"

Discussion sections?

TAs will do 4 biweekly sections to accompany the release of each problem set. They are optional. See online schedule for dates/times.

Do This Today

Join our Piazza: here

Add CS 145 in Gradescope with code: **P5BVKB**

Check that you are added to Canvas.

Get your GCP credits for projects -- instructions

If you require special accommodations (OAE) for exams, please email vatong AT stanford.edu.

Review Stanford Honor Code and Stanford CS Dept Honor Code Rules.

Review Stanford Honor Code

We follow the Stanford Honor Code and Stanford CS Dept Honor Code Rules. Any work submitted for grading should not be derived from or influenced by the work of others. All submissions are subject to plagiarism detection tools. Per university policy, suspected violations are referred to the Office of Community Standards. For more information regarding the honor code policy, please refer to the course website.

Examples of honor code violations include (but are not limited to):

- reusing your own or another student's assignment work from previous quarter
- sharing codes for assignments and projects
- sharing your responses/answers/code/design with other students nor publicly
- joint development/debugging
- use of web or public resources for public solutions
- copying code or answers
- posting up/dispersing your solutions or code on public repos

If you have any questions about the honor code and expectations, please reach out to the teaching staff via piazza and we will be happy to clarify for you"

In this Section

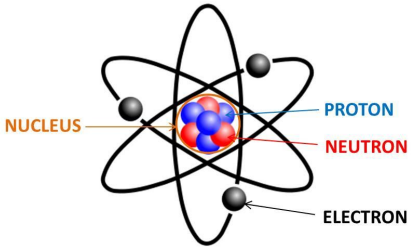
Applications of DBs and Data systems

Properties of general DBs, special-purpose DBs, data lakes

Unpack a DB: Example of a mobile game using a DB

- For Whom and Why?
- Sample data architectures

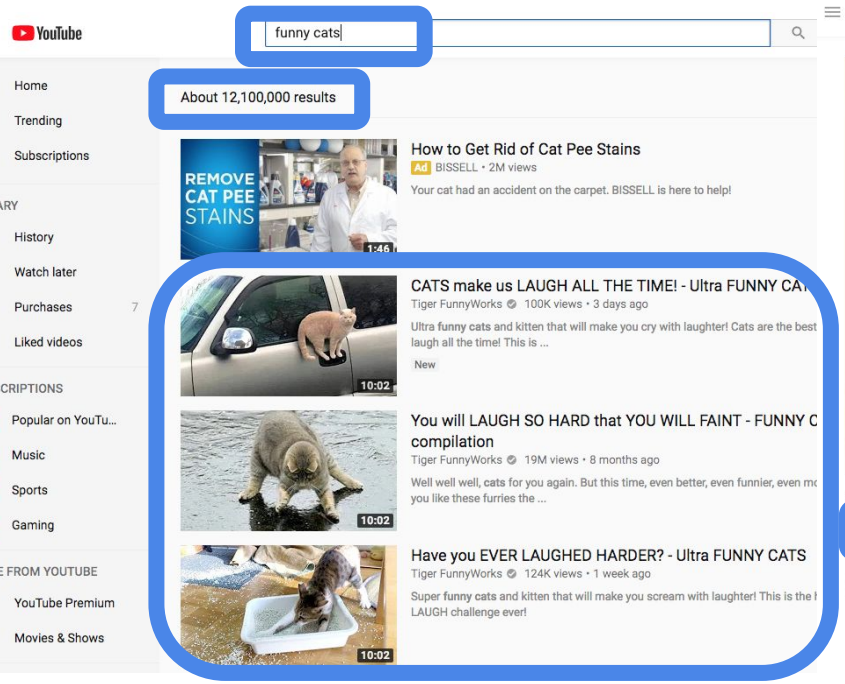
Details + Big picture

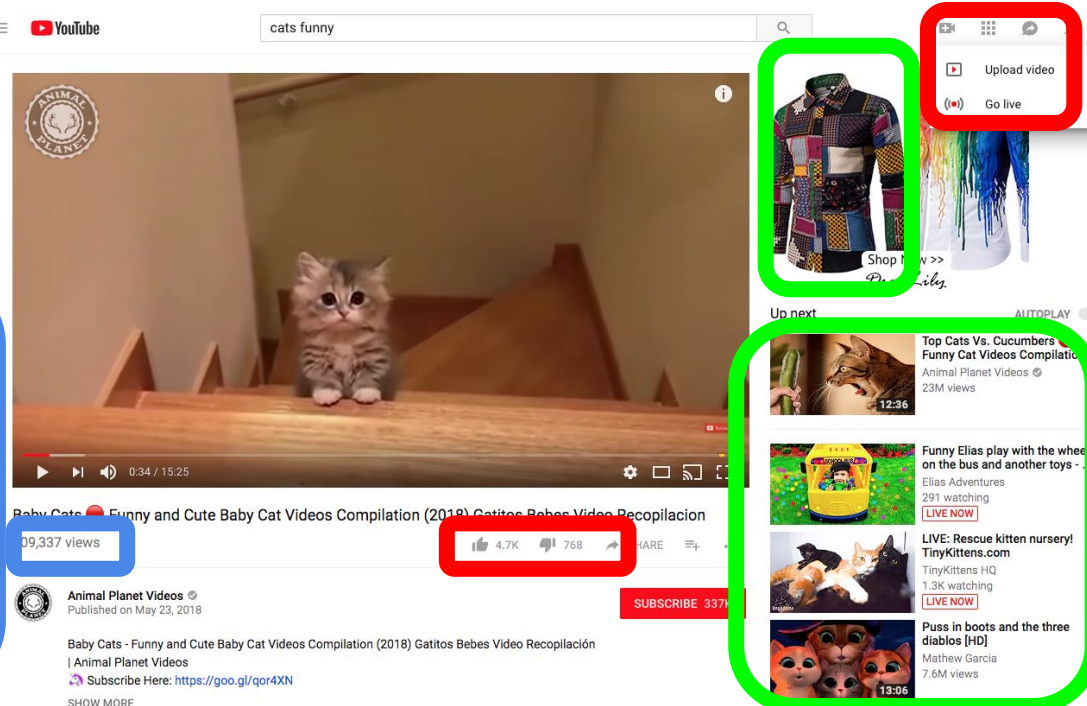


Focus on ‘atomic’ examples

Take in big picture, flavor of issues, how pieces fit

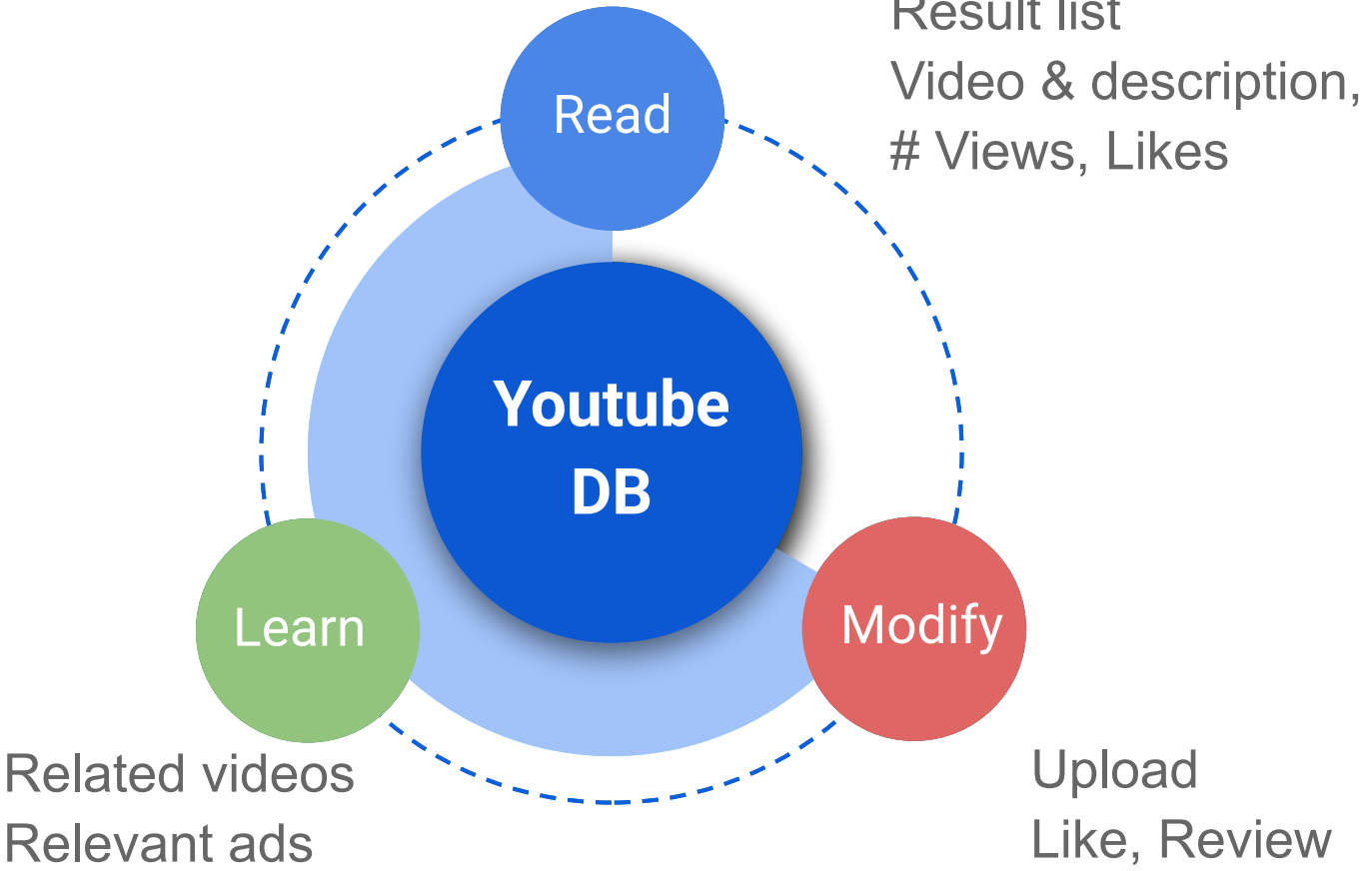
Example: Youtube DB



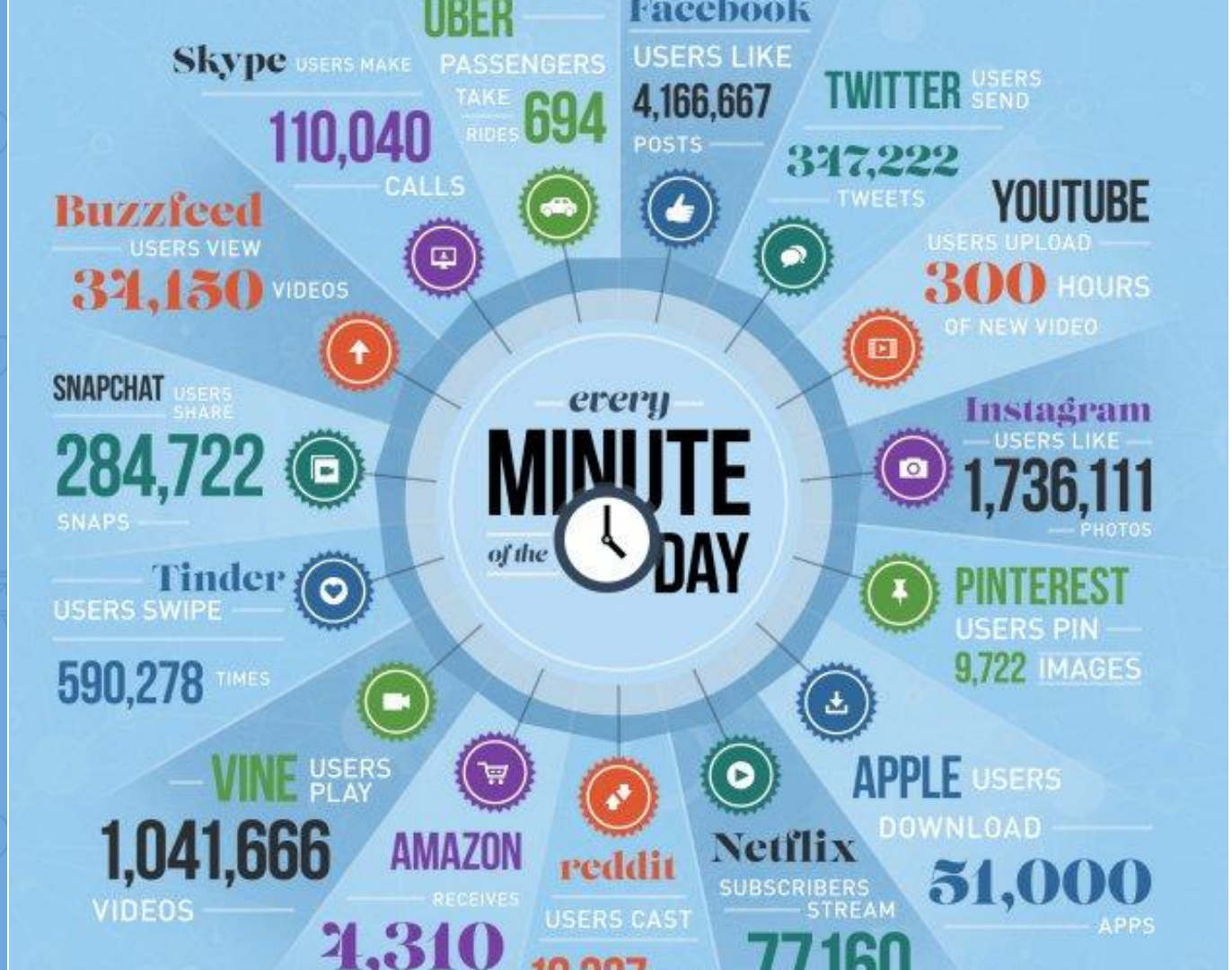


Example

Unpack
Youtube DB



Every minute on the Internet



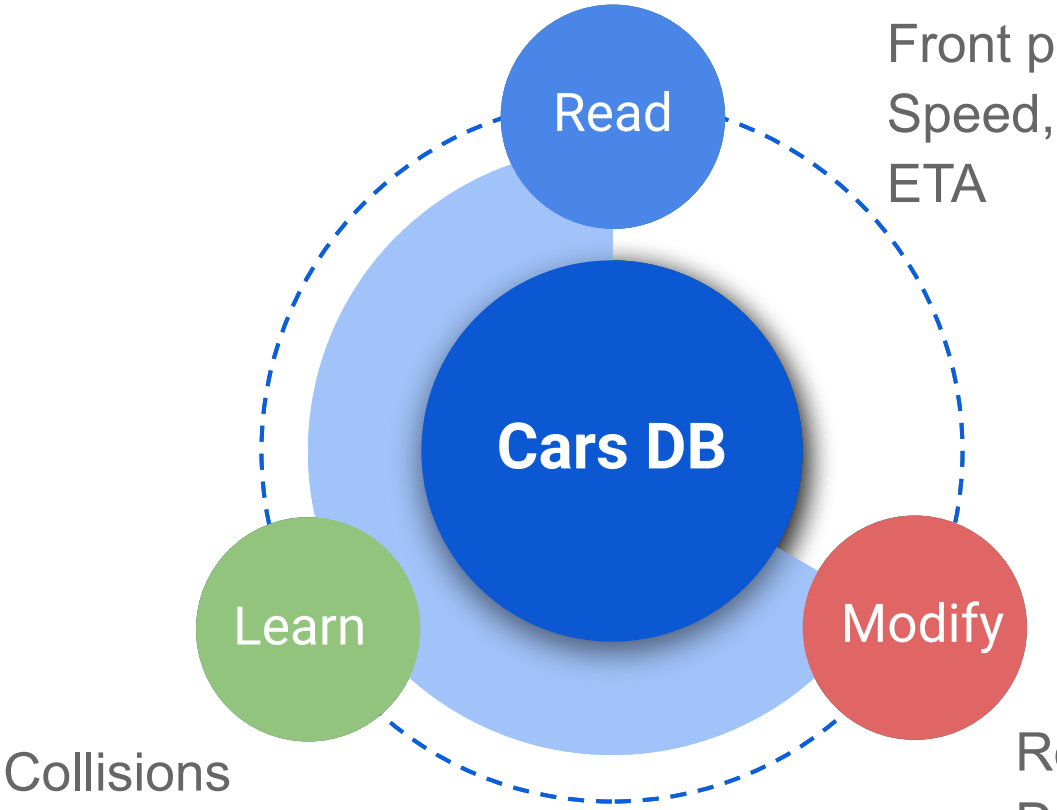
Example

Self Driving Cars

THE COMING FLOOD OF DATA IN AUTONOMOUS VEHICLES

Example

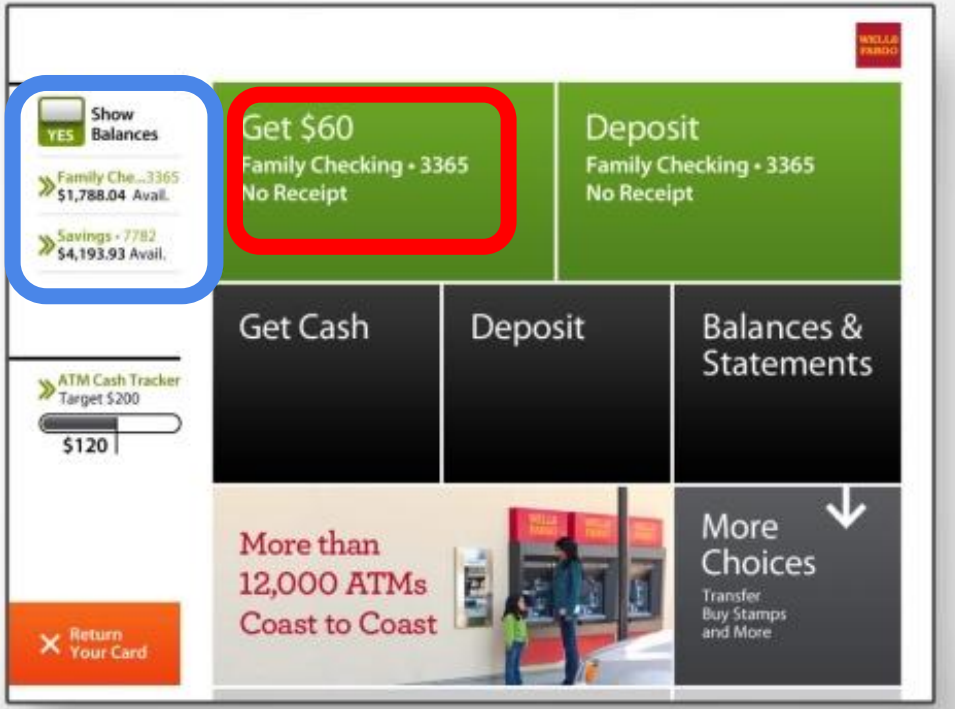
Unpack
Cars DB



Example

Unpack ATM DB:

Transaction



WELLS FARGO

Read Balance
Give money
Update Balance

vs

Read Balance
Update Balance
Give money

Transactions

Example

Transfer $3k from a10 to a20:

1 Debit $3k from a10
2 Credit $3k to a20

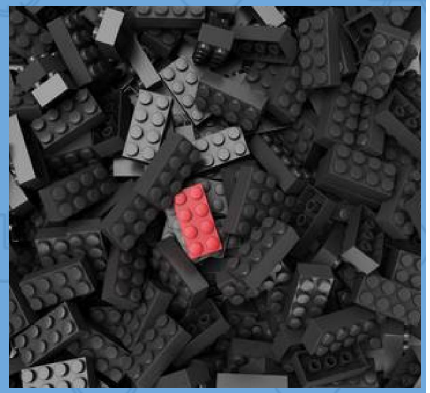
Acct	Balance
a10	20,000
a20	15,000

Acct	Balance
a10	17,000
a20	18,000

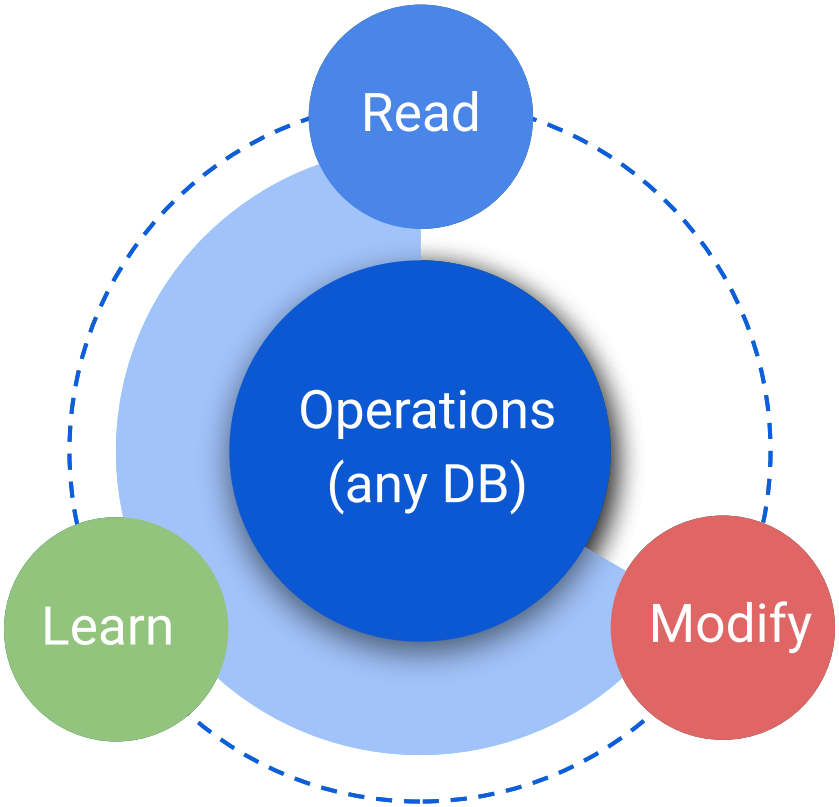
Scenarios

1. Crash before 1?
2. After 1 but before 2? [Bad!! a10: 17,000, a20: 15,000]
3. After 2?

Goals of Standard Databases



Platform to store, manage data

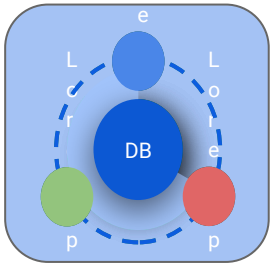


Supporting

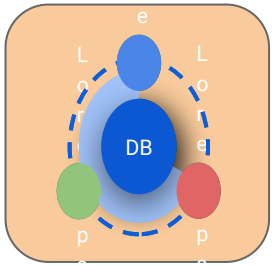
- Scale
- Speed
- Stability
- Evolution
- Reliability
- Cost efficiency

Goals of Special Databases

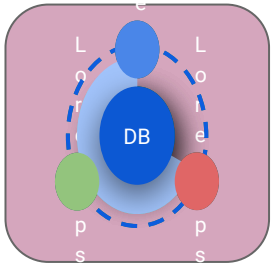
DBs are often optimized for key use cases



Store current data (e.g., lot of reads)



Optimize historical data (e.g., logs)



Run batch Workloads (e.g. training)

> 100 viable data engines on market

(MySql, Postgres, Oracle, IBM/SAP to
data clouds on AWS/Azure, GCP, to Spark, Cockroach/Spanner, Mongo, ….)

For Whom?

For What?

How?

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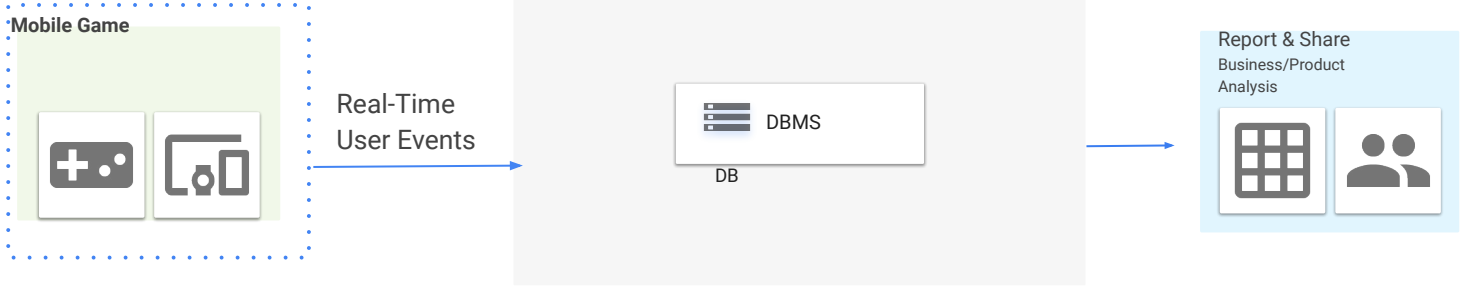
How?

Example Game App

DB v0



Q1: 1000 users/sec?
Q2: Offline?
Q3: Support v1, v1' versions?

App designer

Q7: How to model/evolve game data?
Q8: How to scale to millions of users?
Q9: When machines die, restore game state gracefully?

Systems designer

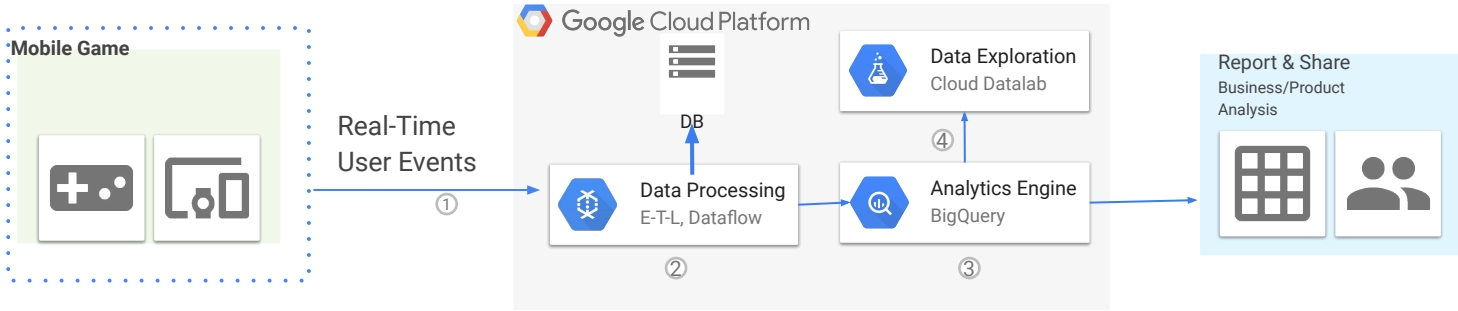
Q4: Which user cohorts?
Q5: Next features to build? Experiments to run?
Q6: Predict ads demand?

Product/Biz designer

How?

Example Game App

Data system “v1” on Cloud



1 Log user actions

2 Store in DB, after Extract-Transform-Load

3 Run queries in a peta scale analytics system

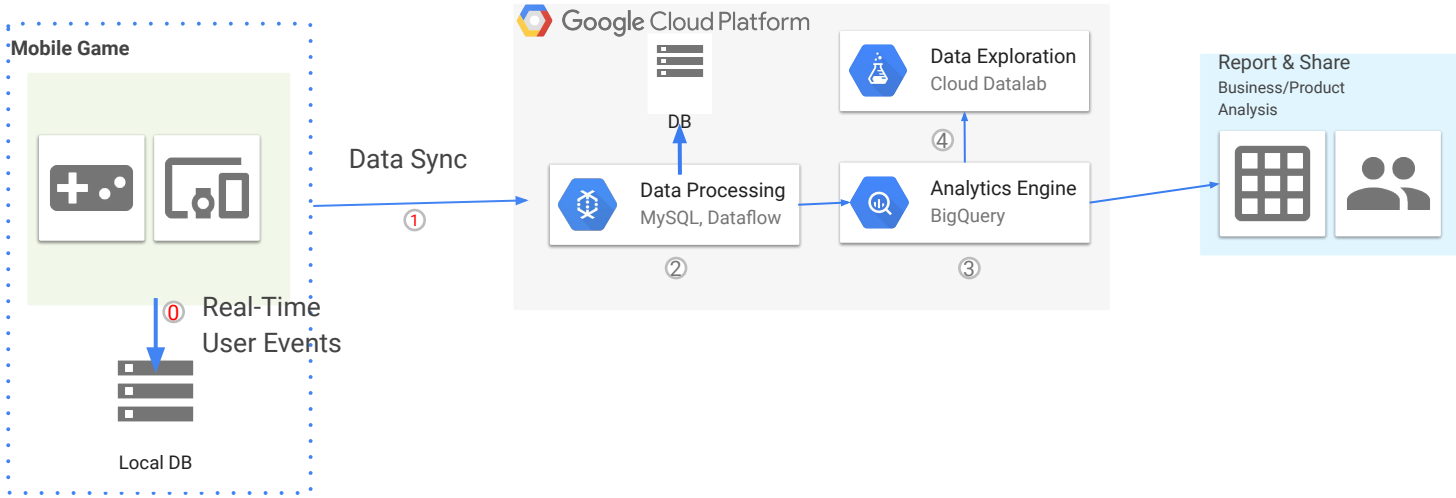
4 Visualize query results

How?

Example Game App

Data system

“v2” Cloud + Local



0 Log user actions In local DB

1 Data sync to cloud

2 Store in DB, after ETL

3 Run queries in a petabyte scale analytics system

4 Visualize query results

Summary

Data bases

Data systems

Data lakes

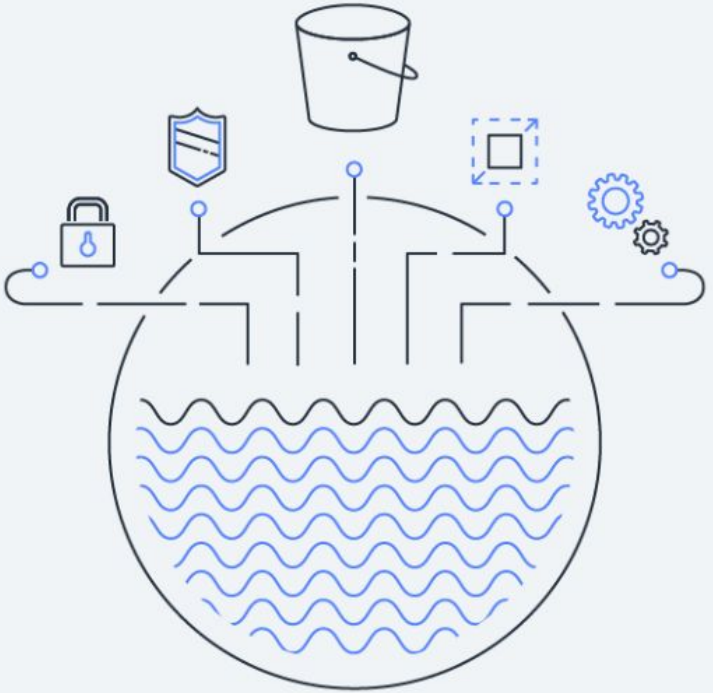
DBs - General + Optimized

Data System - Connect DBs to solve a problem

Data Lake - Set of Data Systems for different data (e.g., Netflix has HD movies (1GB?) and user logs)

Why build a data lake on Amazon S3?

Amazon S3 is designed for 99.999999999% (11 9s) of data durability. With that level of durability, you can expect that if you store 10,000,000 objects in Amazon S3, you should only expect to lose a single object every 10,000 years! The service automatically creates and stores copies of all uploaded S3 objects across multiple systems. This means your data is available when needed and protected against failures, errors, and threats.



Security by design
Protect data with an infrastructure designed for the most data-sensitive organizations

Scalability on demand
Instantly scale up storage capacity, without lengthy resource procurement cycles

Durable against the failure of an entire AWS Availability Zone
Automatically store copies of data across a minimum of three Availability Zones (AZs). To provide fault tolerance, Availability Zones are separated by several miles —but no more than a hundred to ensure low latencies.

AWS services for analytics, HPC, AI, ML, and media data processing
Use AWS native services to run applications on your data lake

Integrations with third-party service providers
Bring preferred analytics platforms to your S3 data lake from the APN.

Wide range of data management features
Comprehensive flexibility to operate at an object level while managing at scale, configure access, enable cost efficiencies, and audit data across an S3 data lake.

Amazon S3 data lake lifecycle

A data lake built on Amazon S3 lets you store everything in one place, dive into your data with flexible access, future-proof your storage, and connect to powerful insights.

Ingest and store data

- Migrate data from a variety of data sources
- Real-time data movement
- Remove siloes with one data lake for structured and unstructured data
- Unmatched scale, durability, security, and performance

Catalog and transform data

- Know your data with better management and higher quality data
- AWS Glue crawls, catalogs, and indexes data for searchability
- AWS Glue automates the effort in building, maintaining and running ETL jobs

Analyze

Run AWS analytics and machine learning services to gain insights

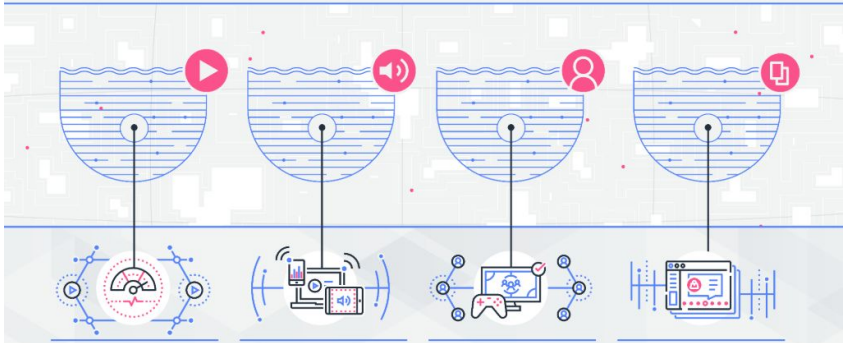
- Amazon Athena	- Amazon SageMaker	- Amazon FSx for Lustre
- Amazon Redshift	- Amazon Rekognition	- Amazon EMR

Extract value from data

- Improve customer interactions
- Guide R&D innovation choices
- Maximize operational efficiencies

Amazon S3 is the largest and most performant storage service for structured and unstructured data, allowing you to cost-effectively build and scale a data lake of any size in a secure environment.

10,000+ data lakes on Amazon S3



NETFLIX

delivers billions of hours of content and runs analytics on an S3 data lake

SONOS

1 billion events per week from connected devices

EPIC GAMES

analyzes satisfaction of 125 million players to drive engagement

Georgia-Pacific

analyzes equipment to predict failures to save millions

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- **Scale** for big data sets? On Clusters? [Weeks 3, 4, 5]
  - OLAP/Analytics, 1st principles of scale
- **Update** data sets? [Weeks 6, 7]
  - Writes, Transactions, Logging, ACID properties
- **Design** "good" databases? [Weeks 8, 9]
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Project: Query-Visualize-Learn on GB/TB scale data sets on a Cloud [sql + python]