# High Level Design

## CAP and Data Stores

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# Contents

- Questions across HLD paradigms ( ~ 1 hour 15 minutes )
- 1 detailed design of a real-life system ( ~ 1 hour 15 minutes)
- Duration - ~ 2 hours 30 minutes

# CAP Theorem

## Primer

### Consistency

A query **Q** will produce the same answer **A** regardless the node that handles the request.

In order to guarantee full consistency we need to ensure that all nodes agree on the same value at all times.

Related topic -

- Eventual consistency

# CAP Theorem

## Primer

### Availability

If the distributed system receives query **Q** it will always produce an answer for that query.

Related topic -

- High availability (**HA**)

# CAP Theorem

## Primer

### Partition Tolerance

- The system continues to function despite the existence of a partition.
- This is not about having mechanisms to "fix" the partition.
- It is about tolerating the partition, i.e. continuing despite the partition.

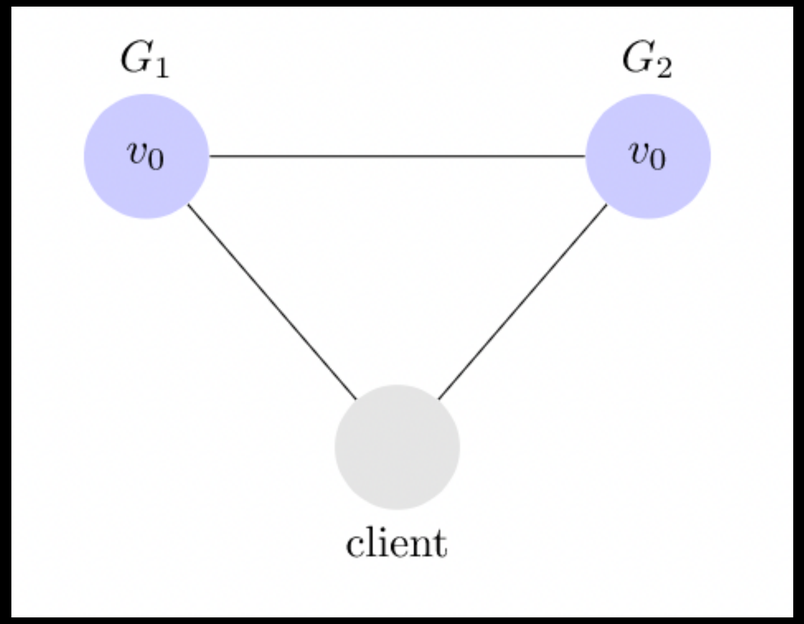
# CAP Theorem

## Primer

The **CAP Theorem** states than any distributed system can have at most two of above properties.

# CAP Theorem

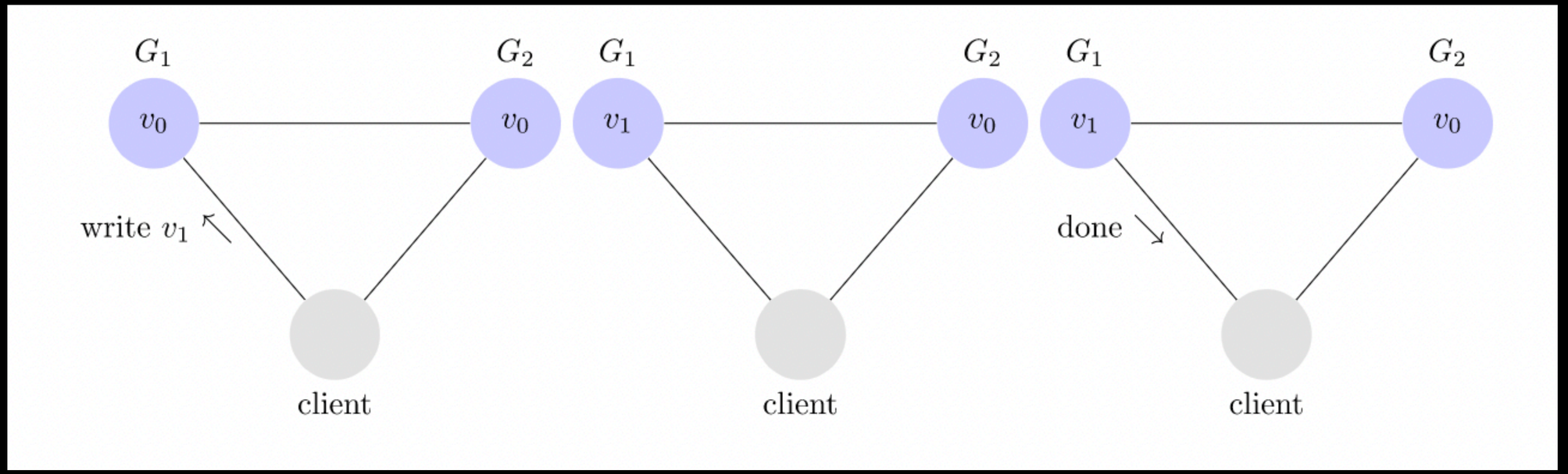
## Question 0 - Setup




- Servers - $G_1$, $G_2$
- Client
- Initial variable - $v_0$

# CAP Theorem

## Question 0 - Setup

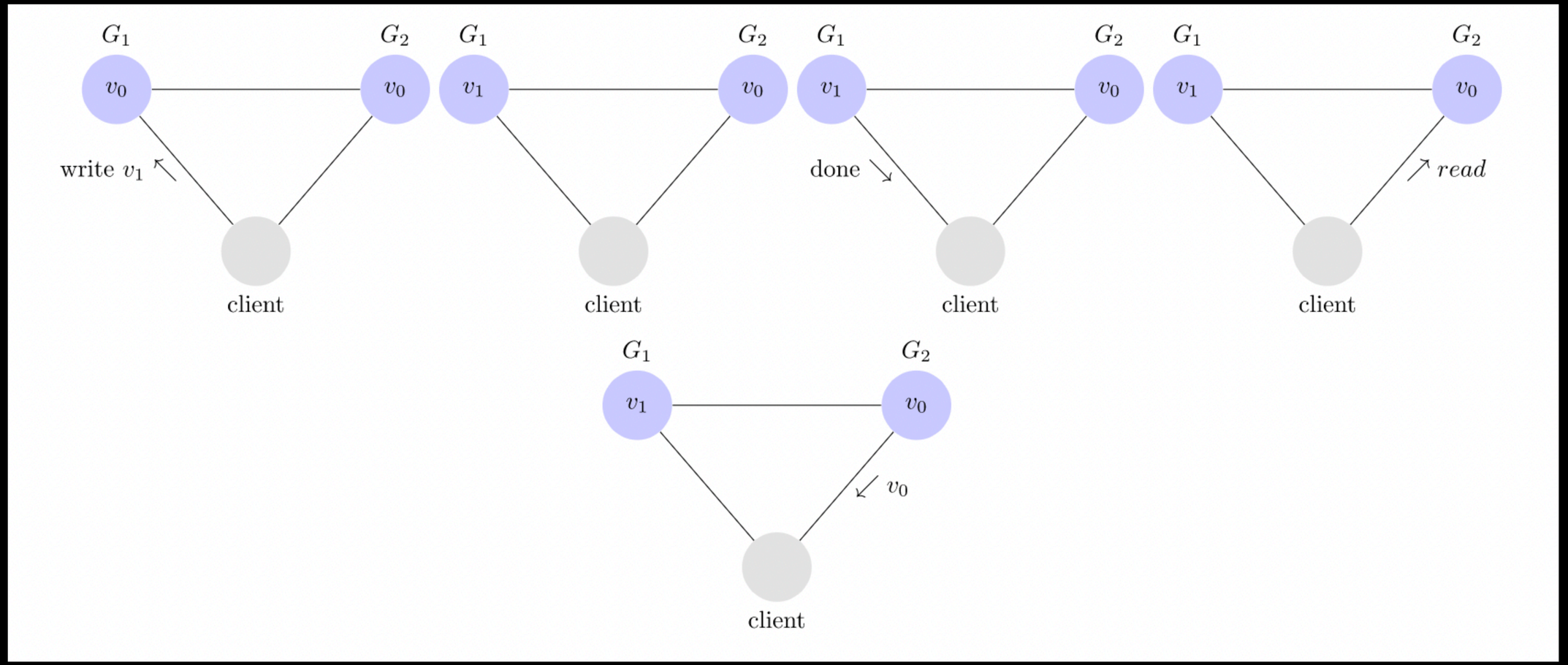



Example write

C -> $G_1$ -> $v_0$ -> $v_1$ -> C

# CAP Theorem

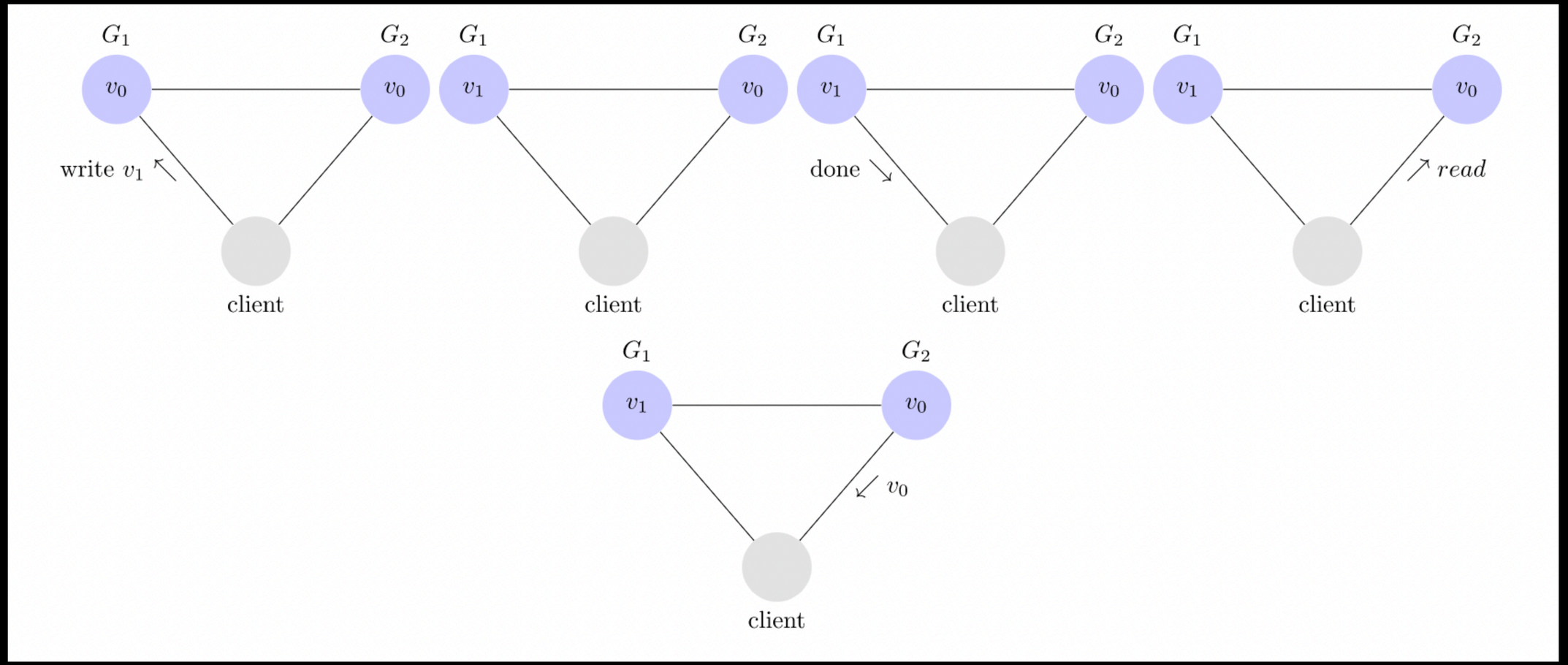
## Question 0




Identify which property out of CAP is being violated

# CAP Theorem

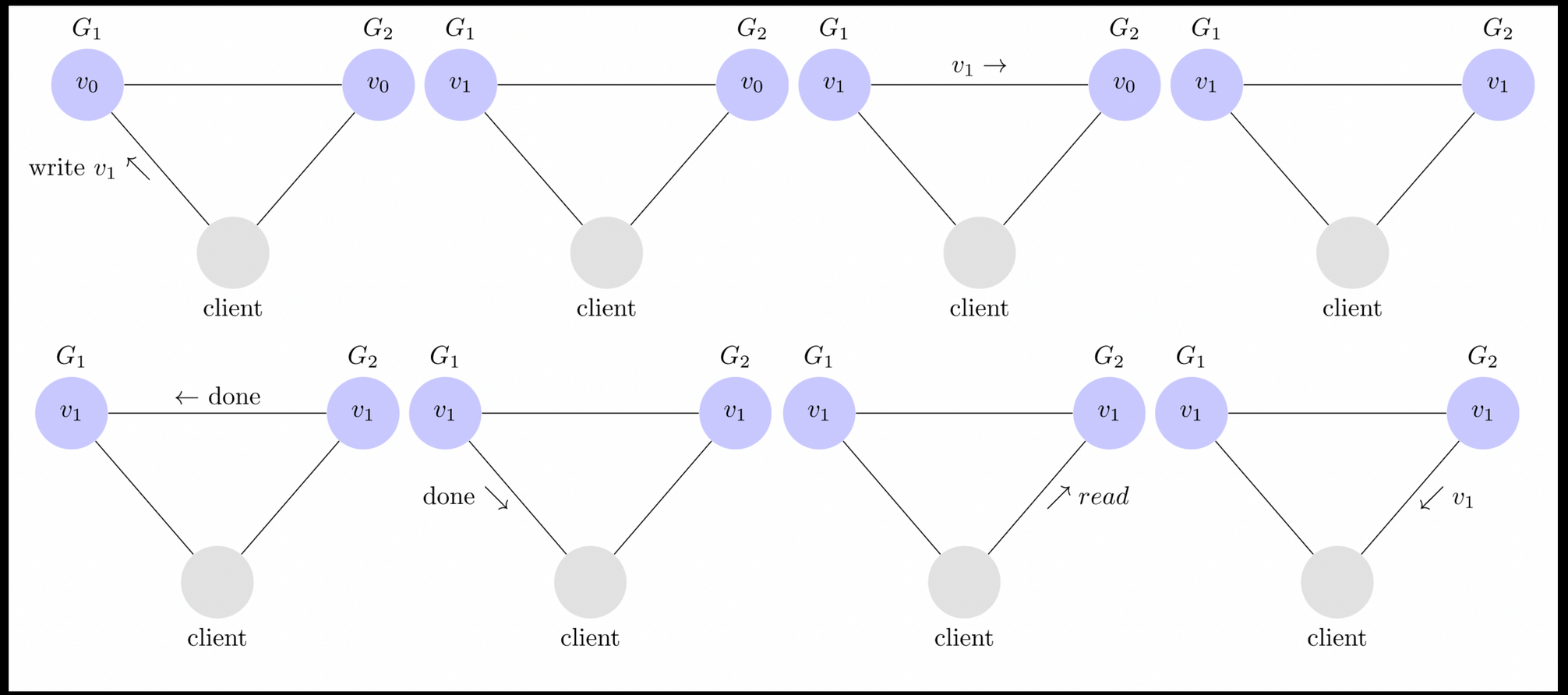
## Question 0 - Answer




The system is **inconsistent** since $v_0$ was returned

# CAP Theorem

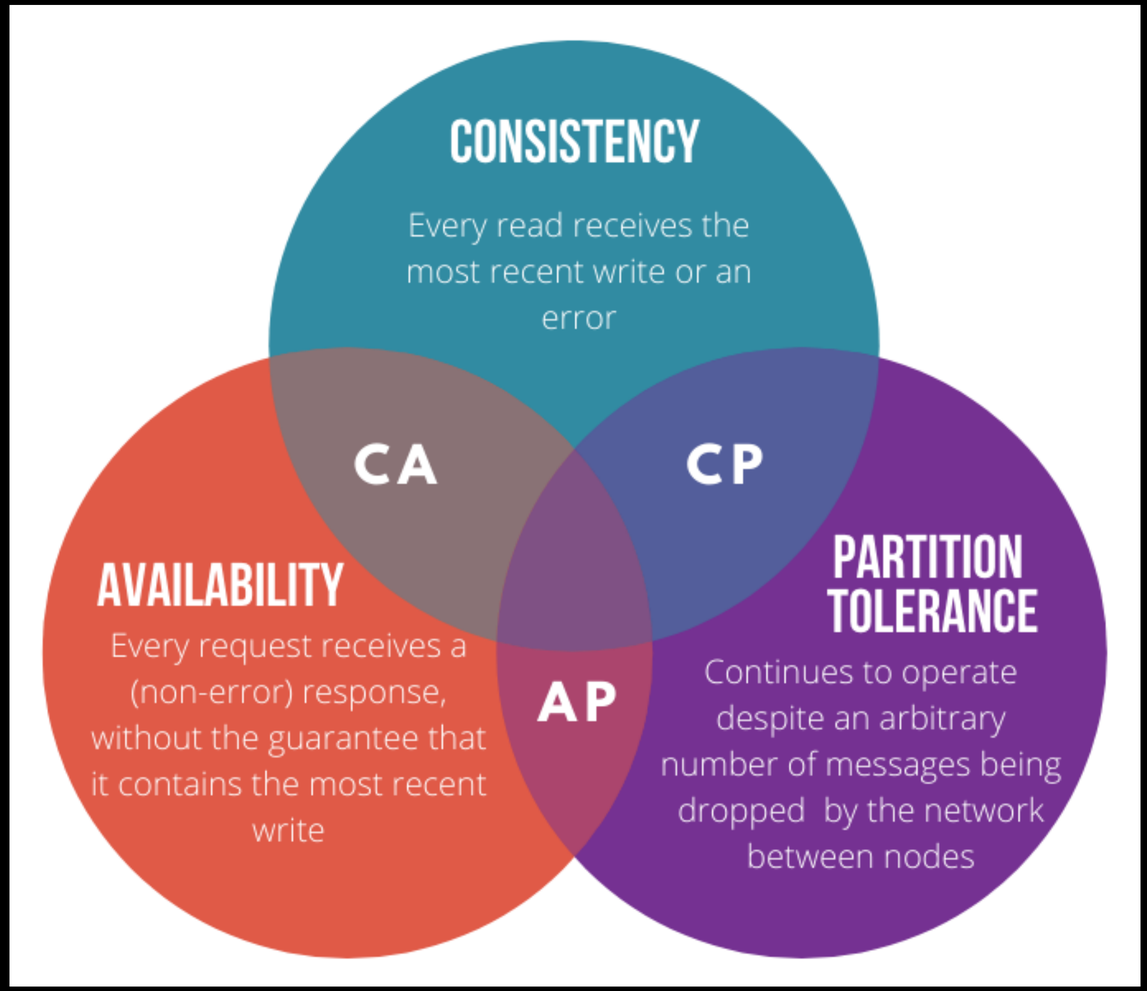
## Question 0 - Solution




… -> $v_0$ -> $v_1$ -> $G_2$ -> …

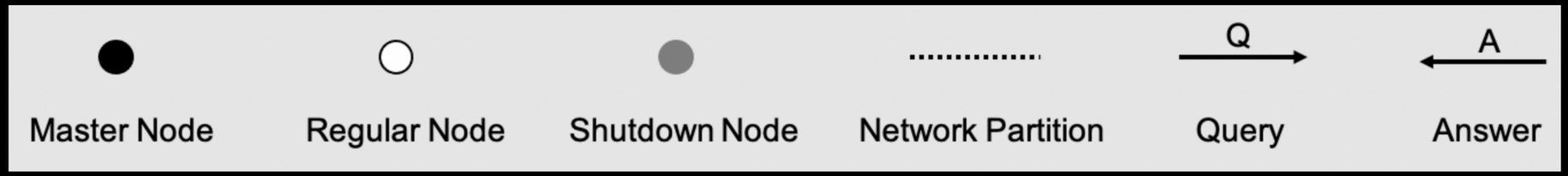
# CAP Theorem

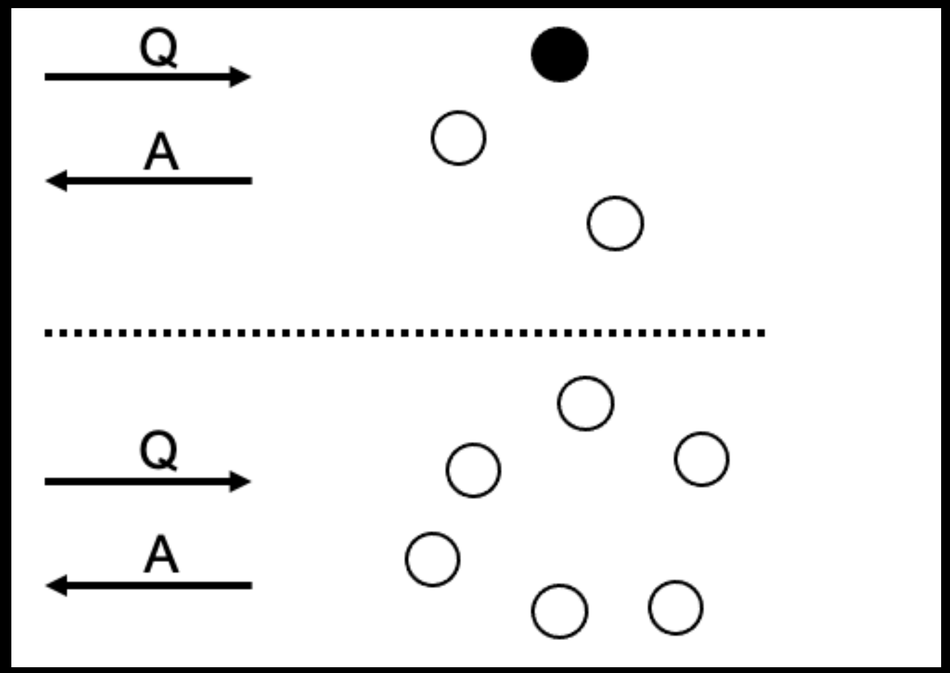
## System classifications



# CAP Theorem

## Question 1 - Setup



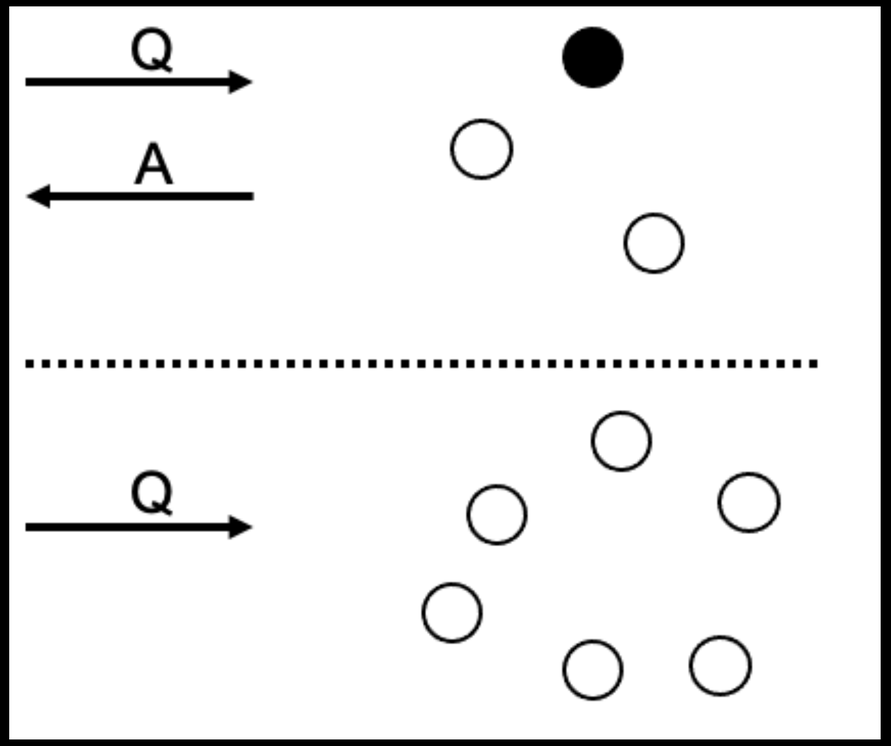



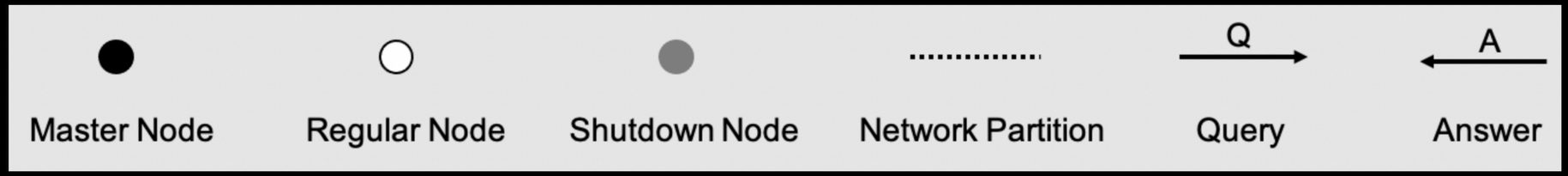

- Survived partition tolerance **(P)**
- Both partitions are responsive **(A)**
- **AP System**
- Why not consistent?

**Consistency is lost since both partitions individually update the state i.e. mutation**

# CAP Theorem

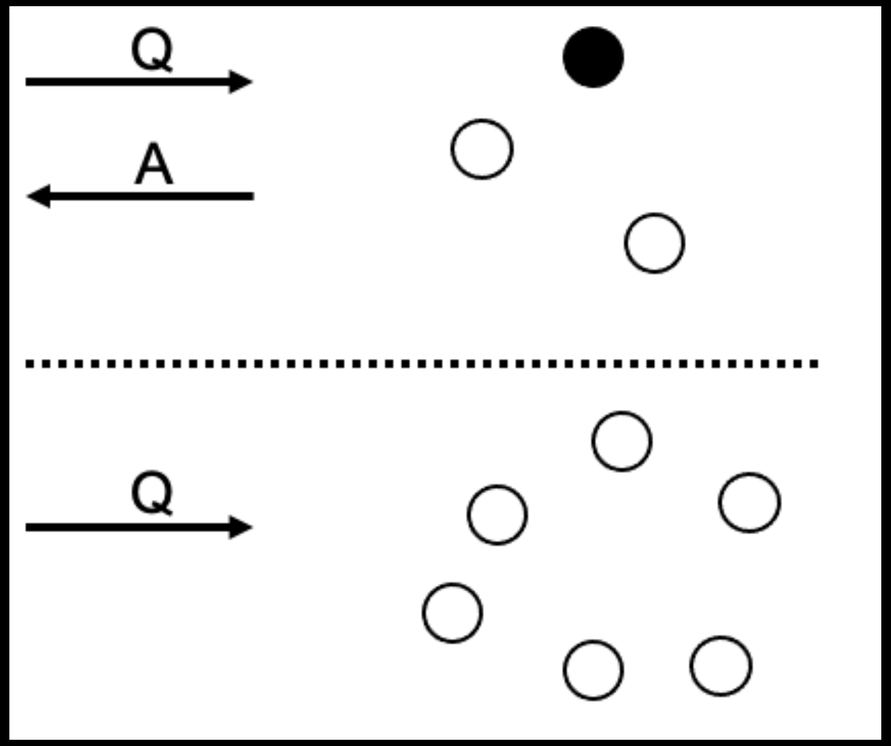
## Question 1



# CAP Theorem

## Question 1 - Answer

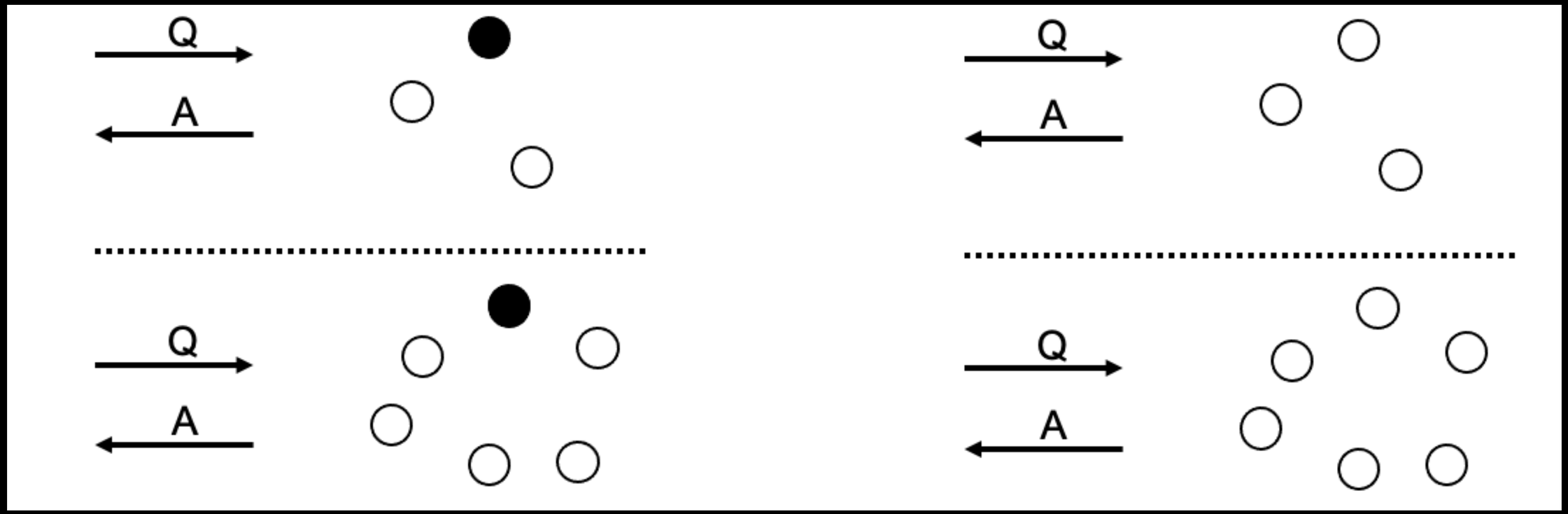


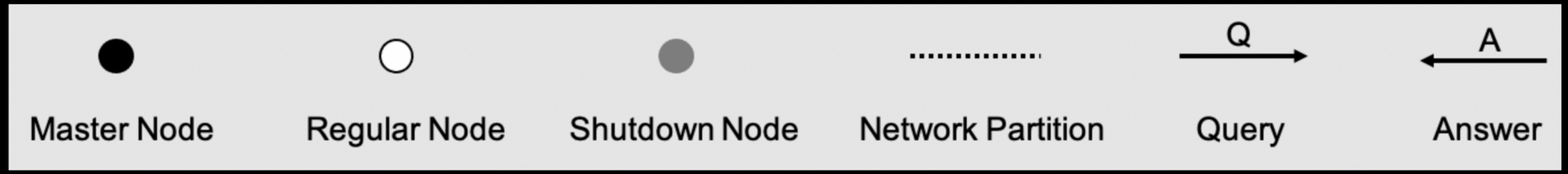

- Survived partition tolerance **(P)**
- Only one partition is responsive **(C)**
- **CP System**
- Why not available?

**Second partition does not provide an answer to queries coming to it i.e. unavailable**

# CAP Theorem

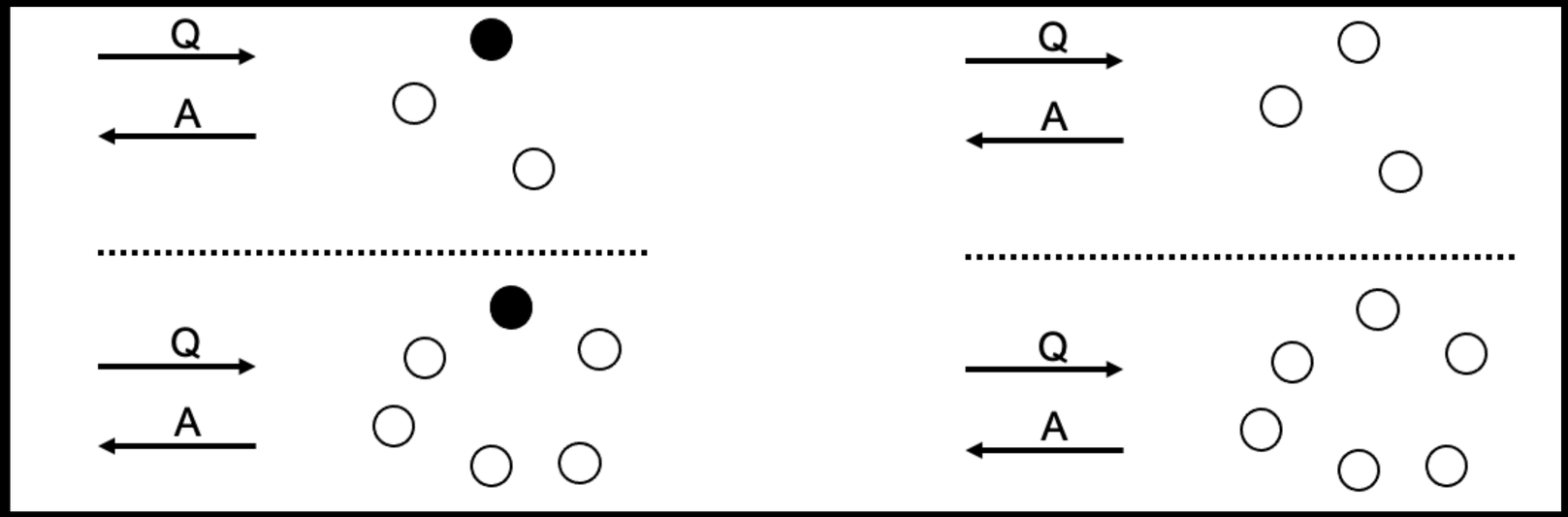
## Question 1



# CAP Theorem

## Question 1 - Answer




- Survived partition tolerance **(P)**
- Both partitions are responsive **(A)**
- **AP System**
- Why not consistent?

**Consistency is lost since both partitions individually update the state i.e. mutation**

**New master vs masterless cluster**

# CAP Theorem

## Question 1


- All requests have responses **(A)**
- Only one partition updates the state **(C)**
- **CA System**
- Network could not tolerate a partition

# CAP Theorem

## Question 1 - Bonus

| Data stores | CAP classification |
| --- | --- |
| RDBMS e.g MySQL | |
| MongoDB, Redis | |
| Cassandra, Dynamo | |

# CAP Theorem

## Question 1 - Bonus

| Data stores | CAP classification |
| --- | --- |
| RDBMS e.g MySQL | CA |
| MongoDB, Redis | CP |
| Cassandra, Dynamo | AP |

# Further reading

## CAP Theorem

- A plain english introduction to CAP Theorem
- Please stop calling databases CP or AP
- Notes on Distributed Systems for Young Bloods
- You Can’t Sacrifice Partition Tolerance
- PACELC theorem

# References


- CAP Theorem - 1
- CAP Theorem - 2
- CAP Theorem - 3
- CAP Theorem - 4

# Data stores

## Primer - Types of NoSQL databases

- Key-value
- Document store
- Graph
- Wide-column

# Data stores

## Primer - Types of NoSQL databases

### Key-value

- Simplest
- Every single item in the database is stored as an attribute name or key
- A hash table where there is a unique key and a pointer to a particular item of data

# Data stores

## Primer - Types of NoSQL databases

### Key-value

| Key | Value |
| --- | --- |
| Name | Joe Bloggs |
| Age | 42 |
| Occupation | Stunt Double |
| Height | 175cm |
| Weight | 77kg |

# Data stores

## Primer - Types of NoSQL databases

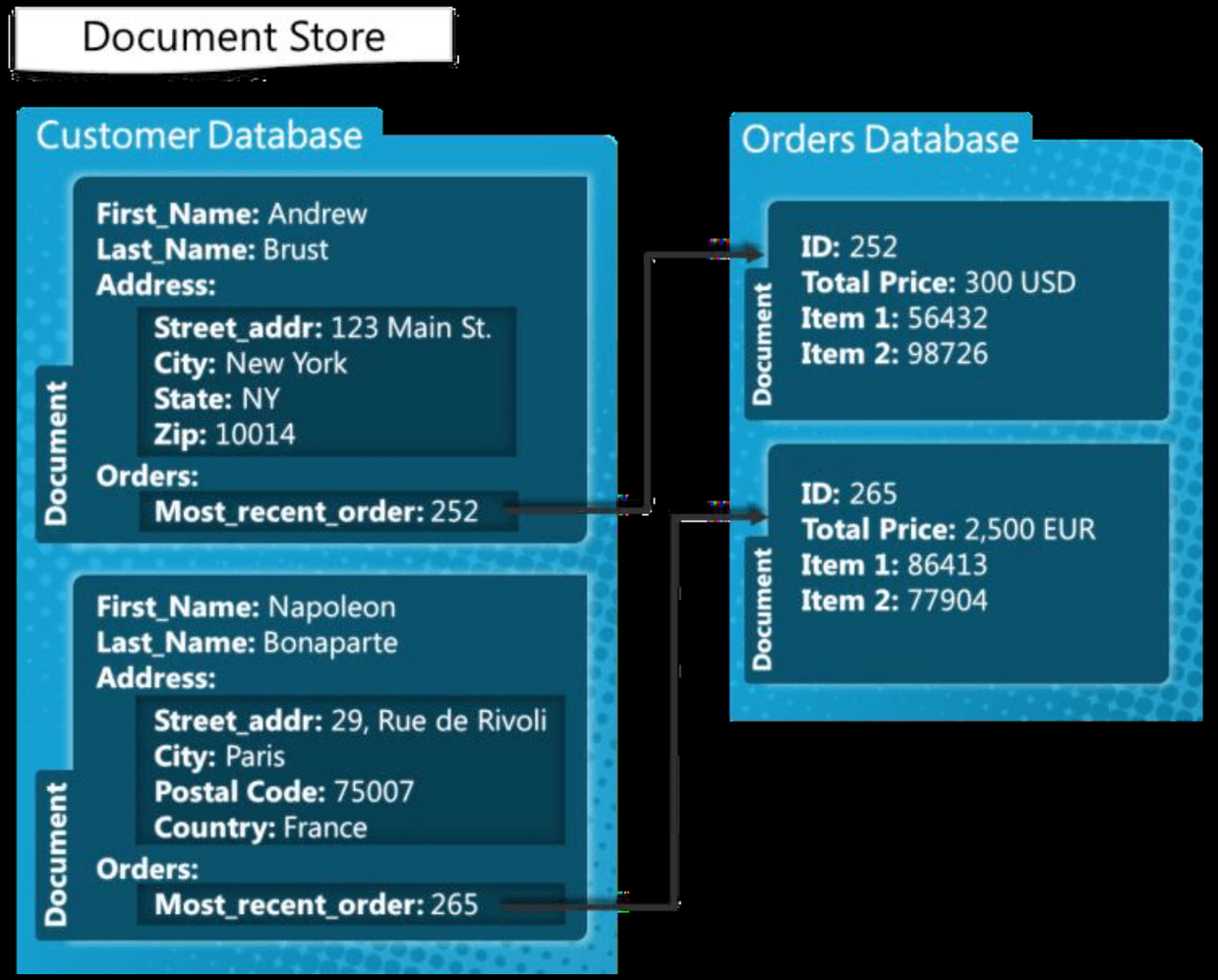
### Document store

- Stores data in documents similar to JSON objects
- Pairs each key with a complex data structure known as a document
- Documents can contain many different key-value pairs, or key-array pairs, or even nested documents

# Data stores

## Primer - Types of NoSQL databases

### Document store



# Data stores

## Primer - Types of NoSQL databases

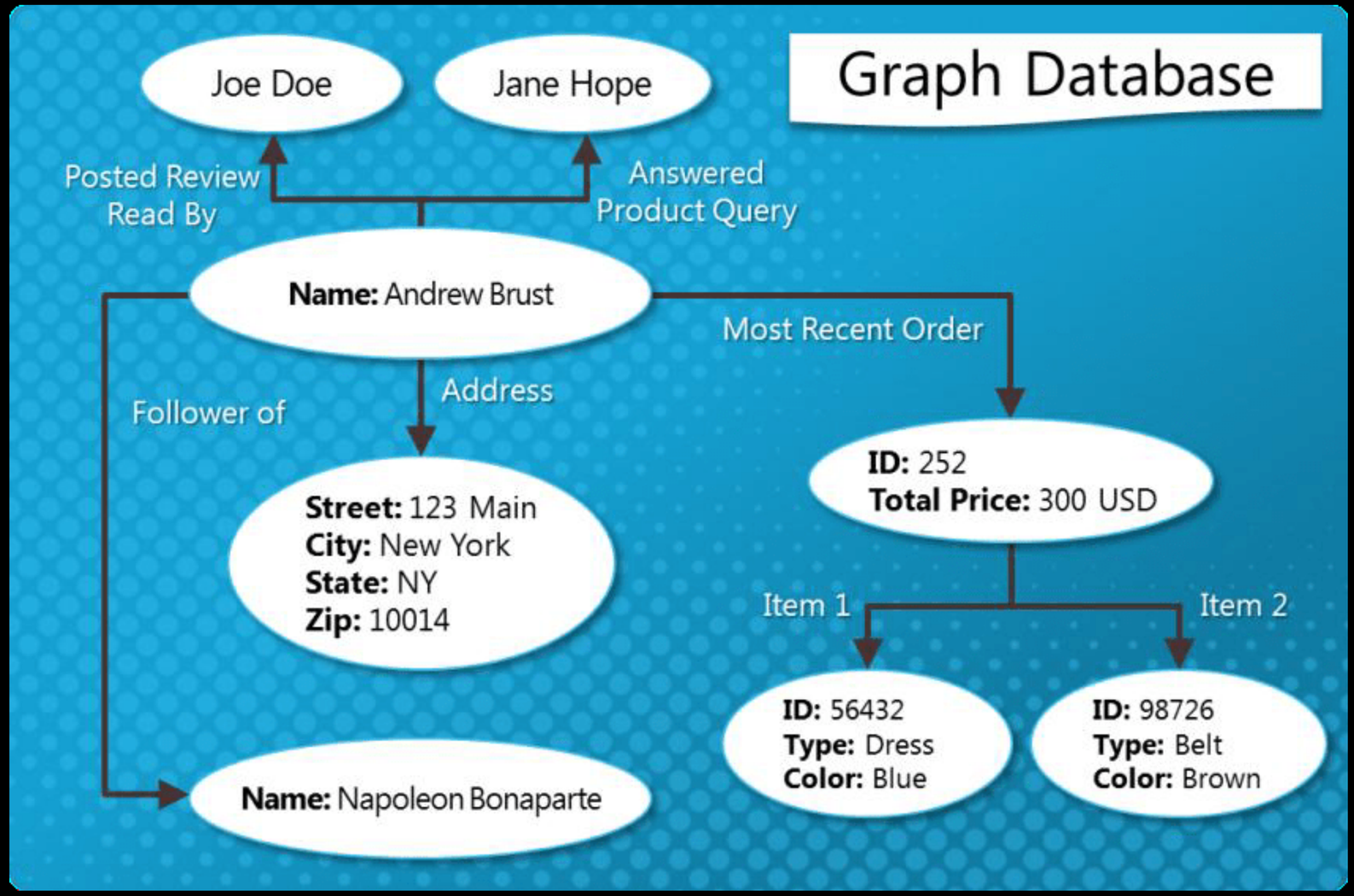
### Graph

- Stores data in nodes and edges
- Nodes typically store information about people, places, and things
- Edges store information about the relationships between the nodes.

# Data stores

## Primer - Types of NoSQL databases

### Graph



# Data stores

## Primer - Types of NoSQL databases

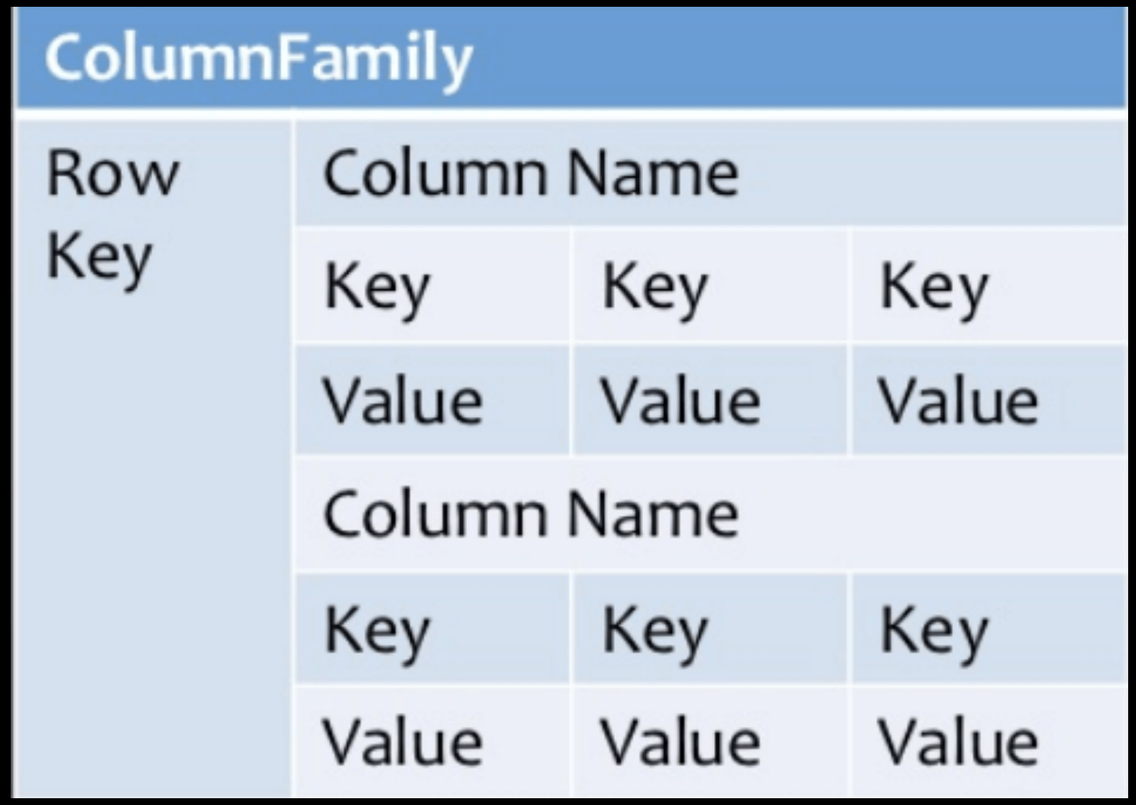
### Wide-column stores

- Similar to relational databases
- Stores data in tables, rows, and dynamic columns
- Names and format of the columns can vary across rows

# Data stores

## Primer - Types of NoSQL databases

### Wide-column stores



# Data stores

## Question 0 - Match each database to its type

- Key-value
- Document store
- Graph
- Wide-column

| Data store | Type |
| --- | --- |
| MongoDB | |
| Neo4J | |
| Redis | |
| Cassandra | |

# Data stores

## Answer - Match each database to its type

- Key-value
- Document store
- Graph
- Wide-column

| Data store | Type |
| --- | --- |
| **MongoDB** | Document store |
| **Neo4J** | Graph |
| **Redis** | Key-value |
| **Cassandra** | Wide-column |

# Data stores

## Question 1 - Choosing the right NoSQL database

- Simple schema
- No complex queries such as joins
- Fast reads and writes
- No frequent updates

# Data stores

## Answer - Choosing the right NoSQL database

- Simple schema
- No complex queries such as joins
- Fast reads and writes
- No frequent updates

# Choice - Key-value store

# Data stores

## Question 1 - Choosing the right NoSQL database

- Flexible schema
- Complex querying
- Complex indices
- Balanced read to write ratio

# Data stores

## Question 1 - Choosing the right NoSQL database

- Flexible schema
- Complex querying
- Complex indices
- Balanced read to write ratio

# Choice - Document store

# Data stores

## Question 1 - Choosing the right NoSQL database

- Need to detect patterns between data points
- Need to store properties related to relationships between data points
- Complex queries to determine relationships between data points

# Data stores

## Question 1 - Choosing the right NoSQL database

- Need to detect patterns between data points
- Need to store properties related to relationships between data points
- Complex queries to determine relationships between data points

# Choice - Graph Database

# Data stores

## Question 1 - Choosing the right NoSQL database

- Large amount of data
- Fetch specific attribute for number for rows
- Need to use for analytics
- No complex indices

# Data stores

## Question 1 - Choosing the right NoSQL database

- Large amount of data
- Fetch specific attribute for number for rows
- Need to use for analytics
- No complex indices

# Choice - Wide-column store

# Further reading

## NoSQL data stores

- Choosing the right NoSQL database
- What is NoSQL
- Scaling databases
- CQRS

# References

## Data Stores

- NoSQL database types
- Choose the right NoSQL Database

# System Design


- Spotify is a digital music, podcast, and video service.
- Spotify gives you access to millions of songs and other content from creators all over the world.

# Spotify®


Devices
App Finder
YOUR MUSIC
Songs
Albums
Artists
Local Files
Morning Commute
Make it to work the right
Your Favorite Coffee
Ready for the Day
This fun, upbeat playlist
ill help get you up and
dy to start your day
Feelin Good
Feel good with this positively timeless Soul playlist
On Wheels To Work
Take your bike to work, breathe in the fresh air, and listen to these tunes
Spotify
SPOTLIGHT
ARTIST · VIEW PROFILE
Foster The People
FOLLOWERS
1,079,828
FOLLOWING
PAUSE
FOLLOWING
OVERVIEW
RELATED ARTISTS
BIOGRAPHY
POPULAR
1 Pumped up Kicks 92,077,824
2 Helena Beat 34,493,970
3 Houdini 28,992,336
4 Don't Stop (Color on the Walls) 23,494,826
Best Friend 8,897,687
SHOW 5 MORE
ALBUMS
RELATED ARTISTS
Coldplay
The Killers
Mark Foster
Elite Gymnastics
RELATED MUSIC
Best Friend
Foster The People
Sex
The 1975
Sleepyhead
Passion Pit
The Mother We ...
CHVRCHES
Contact High
Architecture In Helsinki
The Struggle
Grizfolk
Miss You
Foster The People
Best Friend
Foster The People
1:57
4:27
Search
Browse
Radio
Your Music
Follow
Sara
FOSTER THE PEOPLE SUPERMODEL
FOSTERTHEPEOPLE
09:41
9:41 AM
100%
Foster The People
FOLLOWING
1 079 908 FOLLOWERS
SHUFFLE PLAY
POPULAR
1 Pumped up Kicks
92 077 824
2 Helena Beat
34 493 970
Best Friend
Foster The People
PLAYING FROM ARTIST
Calvin Harris
CALVIN
HARRIS
BLAME
FEAT. JOHN NEWMAN
Blame
Calvin Harris
0:54
3:34

# Spotify

## Numbers

Subscribers:

**96 million**

Monthly active users:

**207 million**

Tracks:

**40+ million**

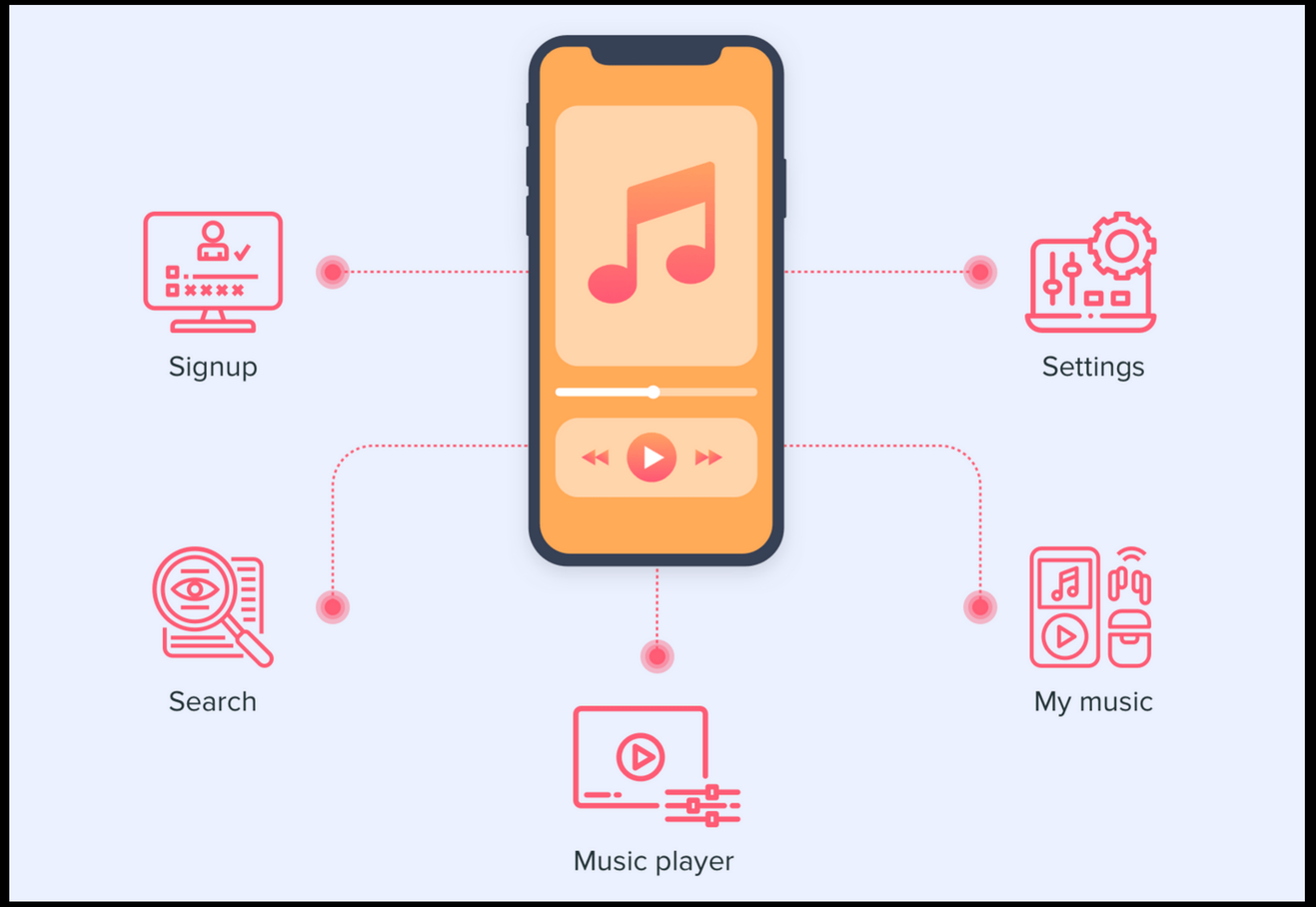
Available in:

**78 markets**

Source https://investors.spotify.com/home/default.aspx

# Spotify

## Requirements



# Spotify

## Scope

- Requirements
- Data flow
- Artist to Spotify architecture
- Spotify to user architecture
- Event delivery system

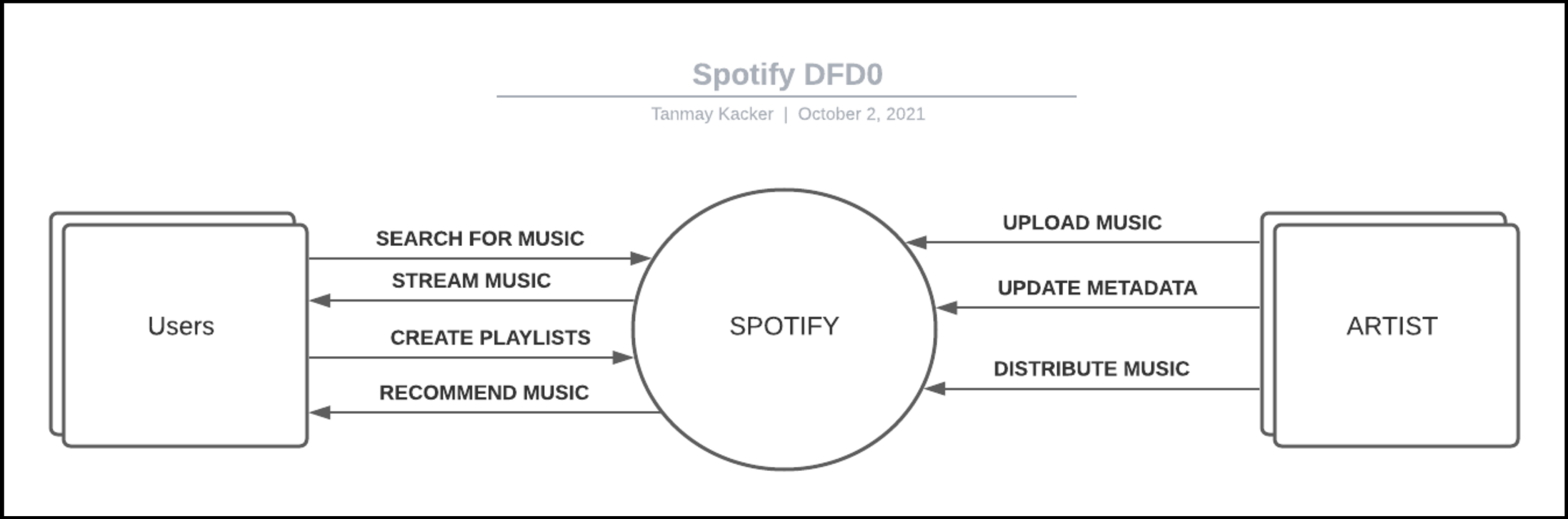
# Spotify

## Requirements

- Search for music
- Listen to music
- Add music to playlist
- Upload music
- Distribute music

# Spotify

## Data Flow (DFD0)



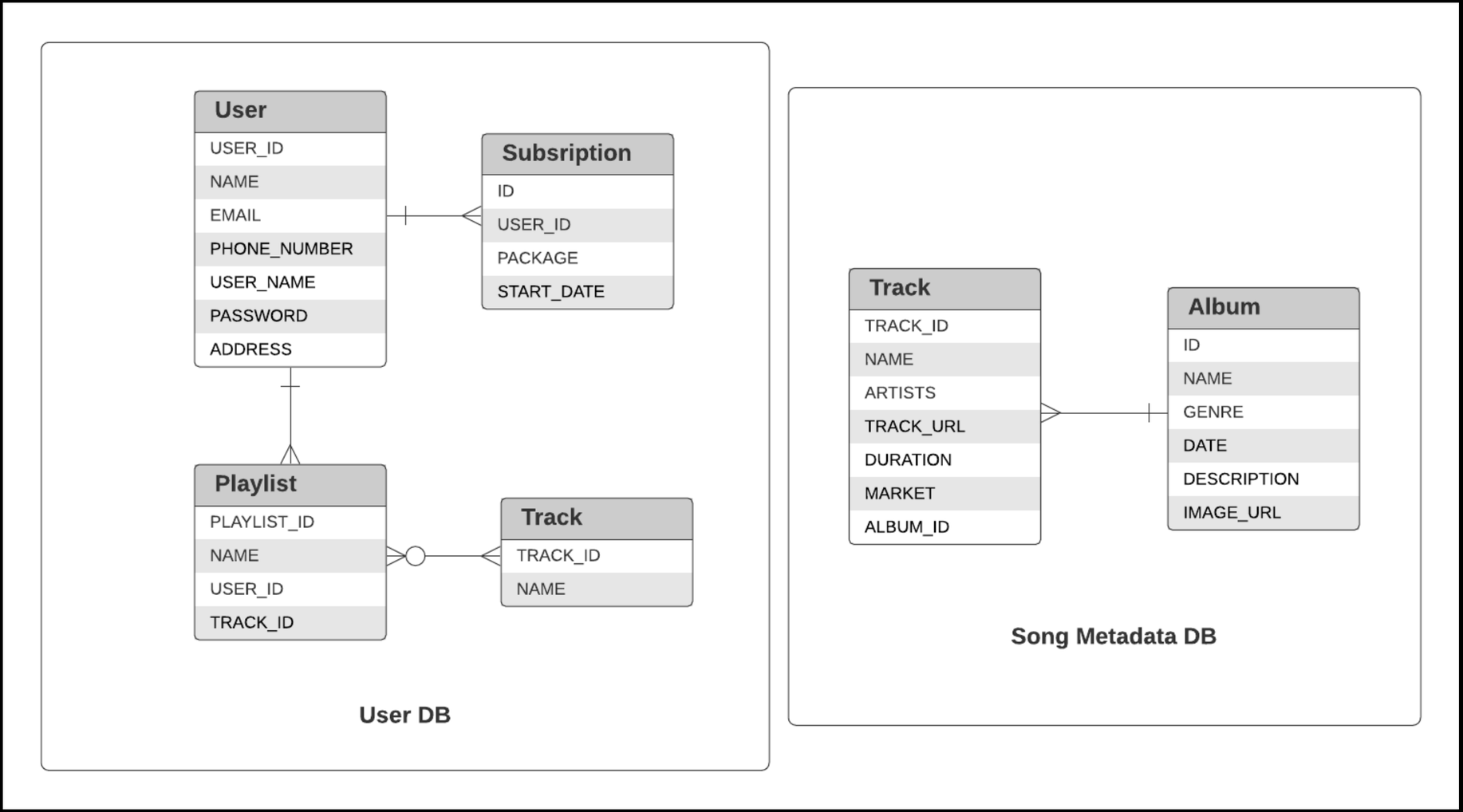
# Spotify

## Sample Microservices

- Account service (username, password)
- Search service (song name, album name, lyrics)
- Song service (song ID)
- Playlist service (song ID, playlist ID)
- Publisher service (genre, artists, market, labels, name, tracks, restrictions)

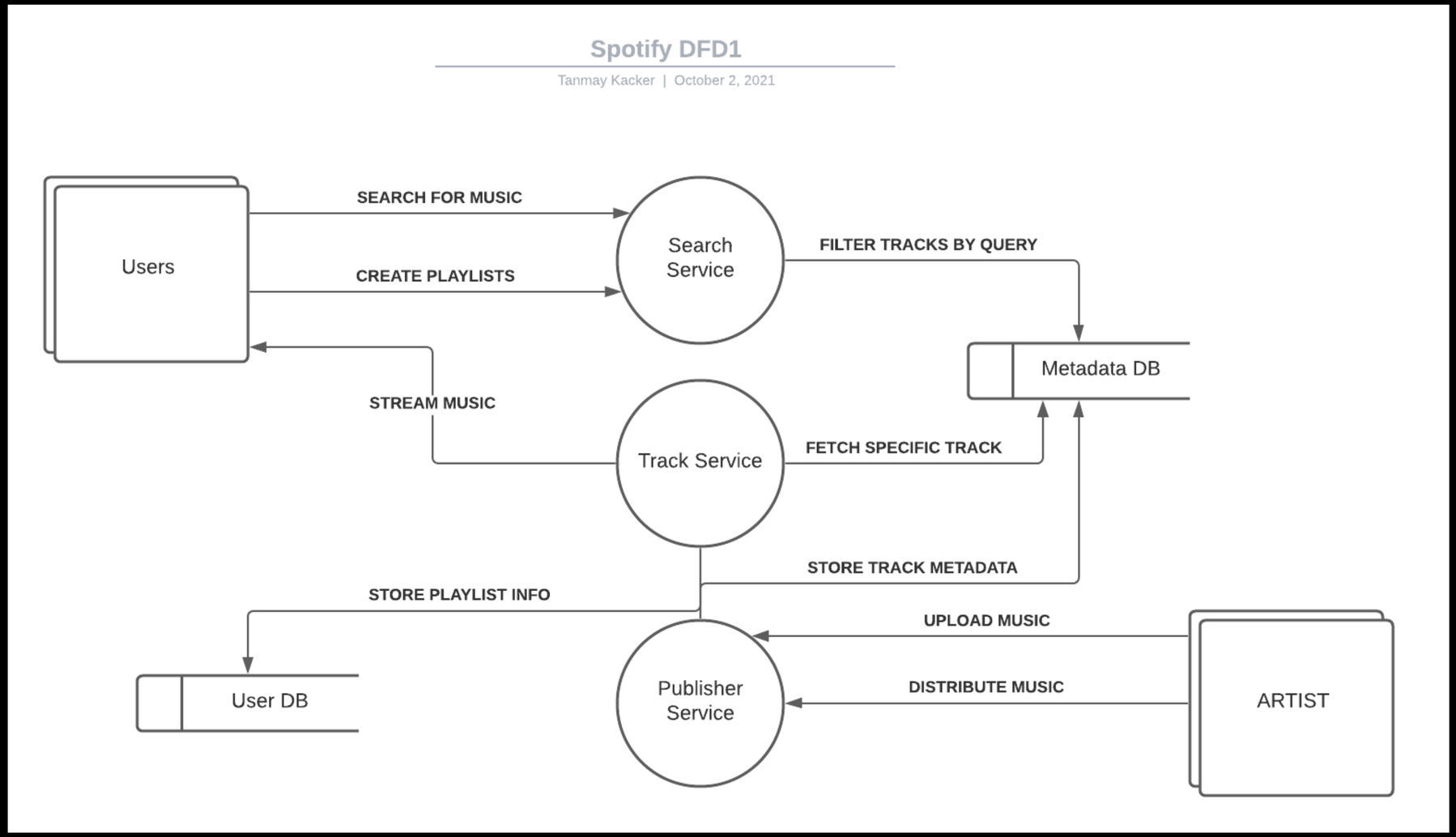
# Spotify

## Data Models



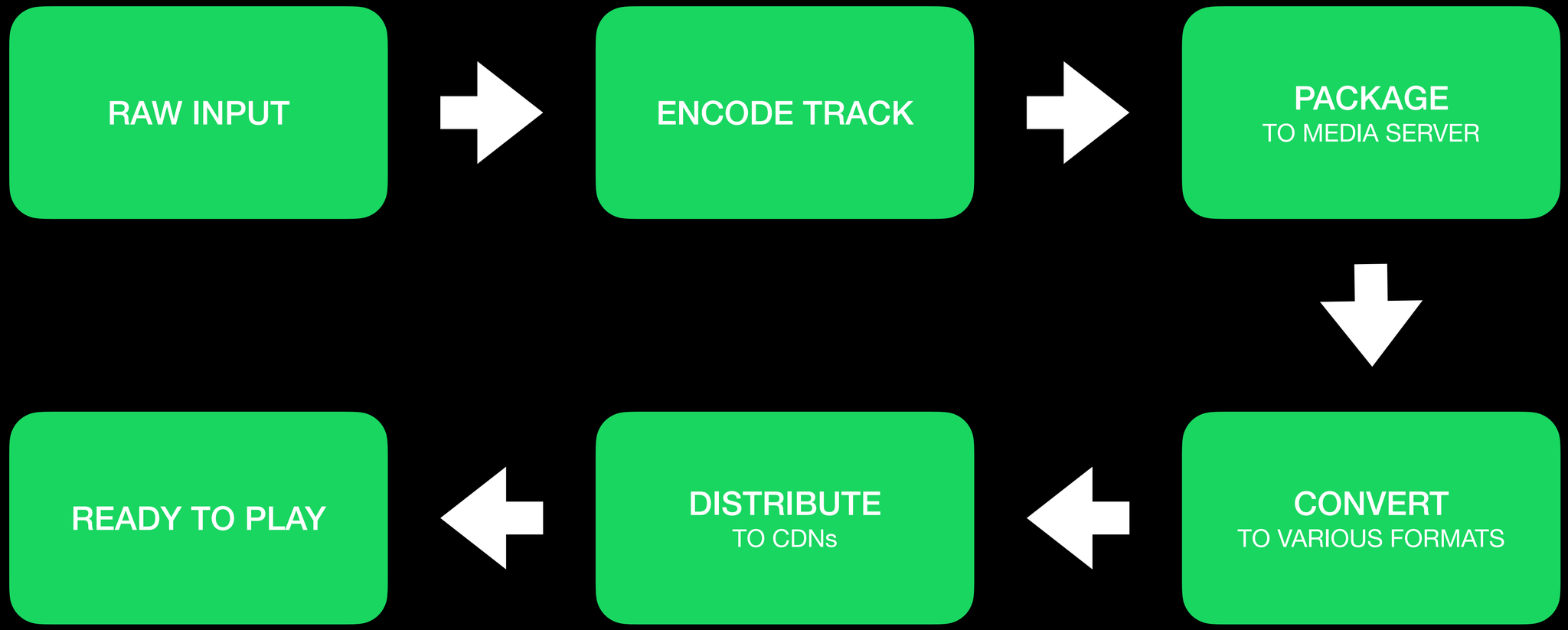
# Spotify

## Data Flow (DFD1)



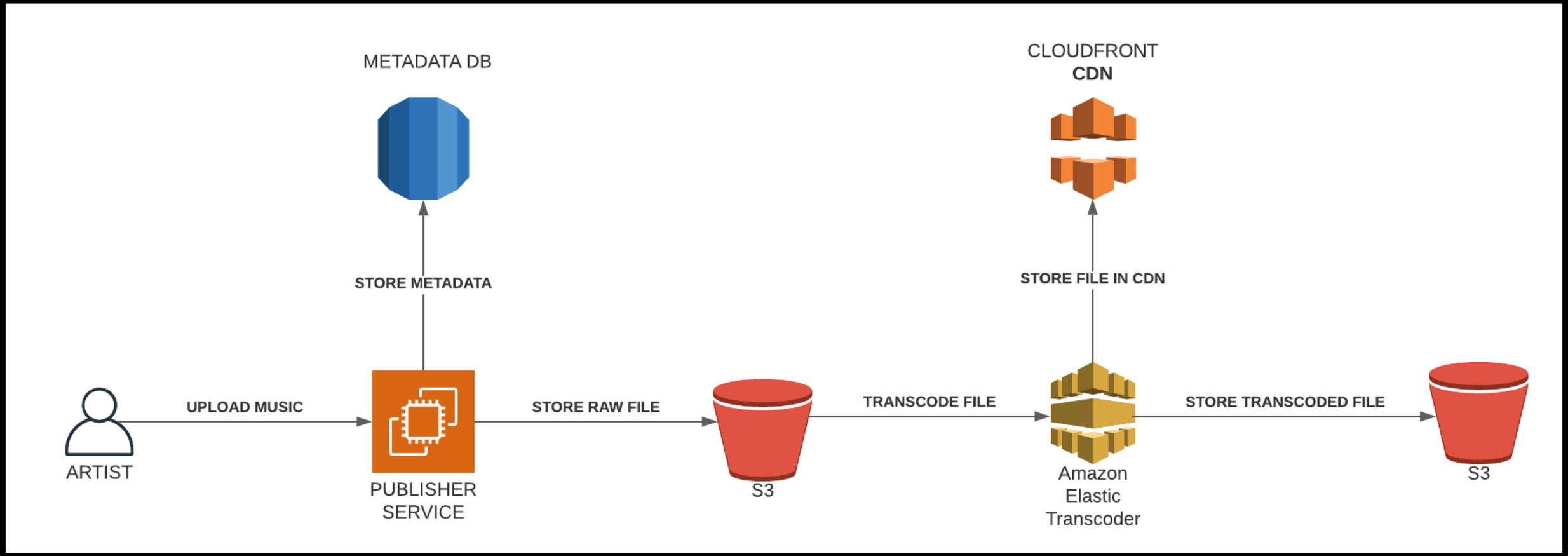
# Spotify

## Artist to Listener



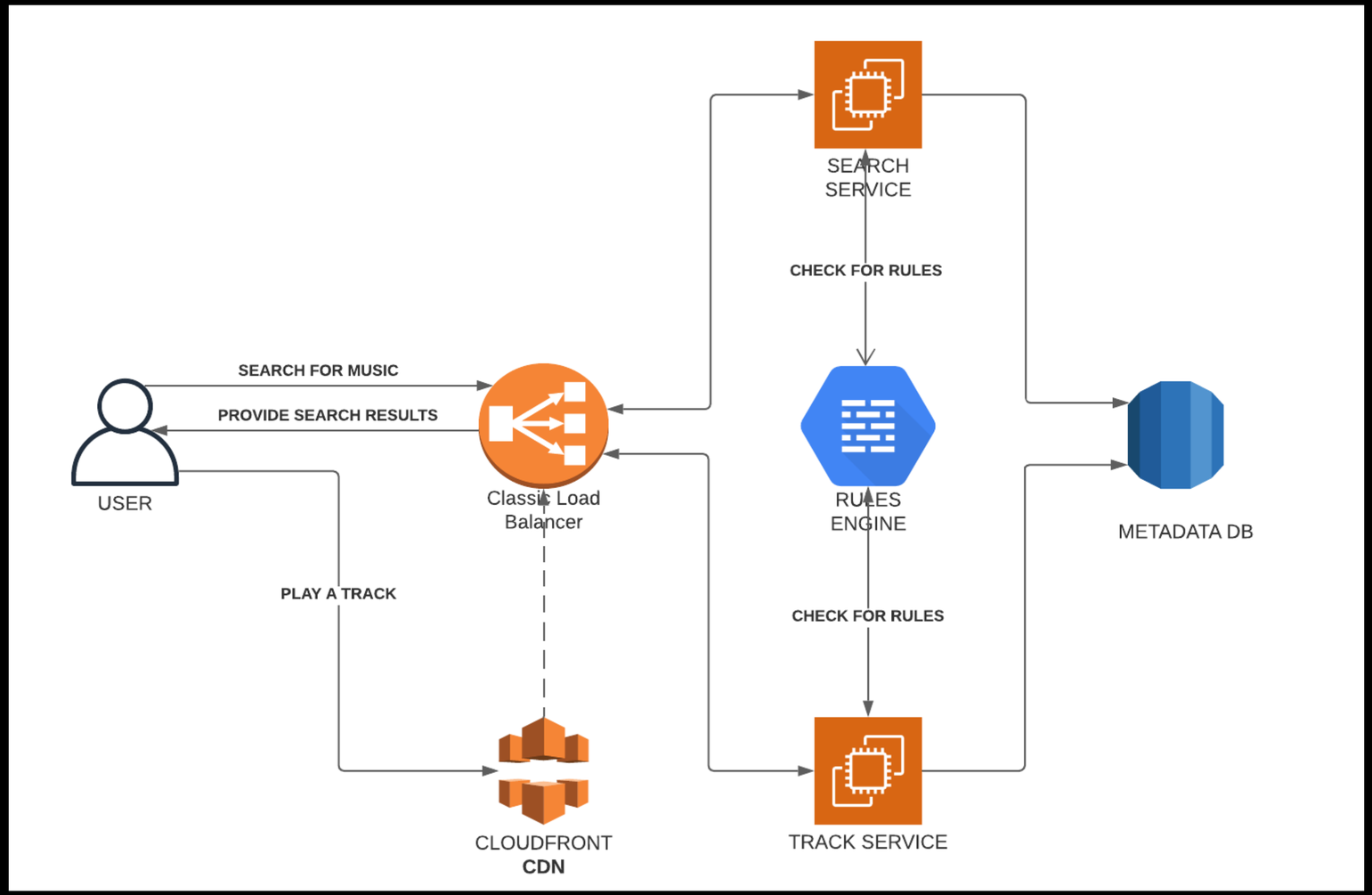
# Spotify

## Artist to Spotify



# Spotify

## Server to Listener



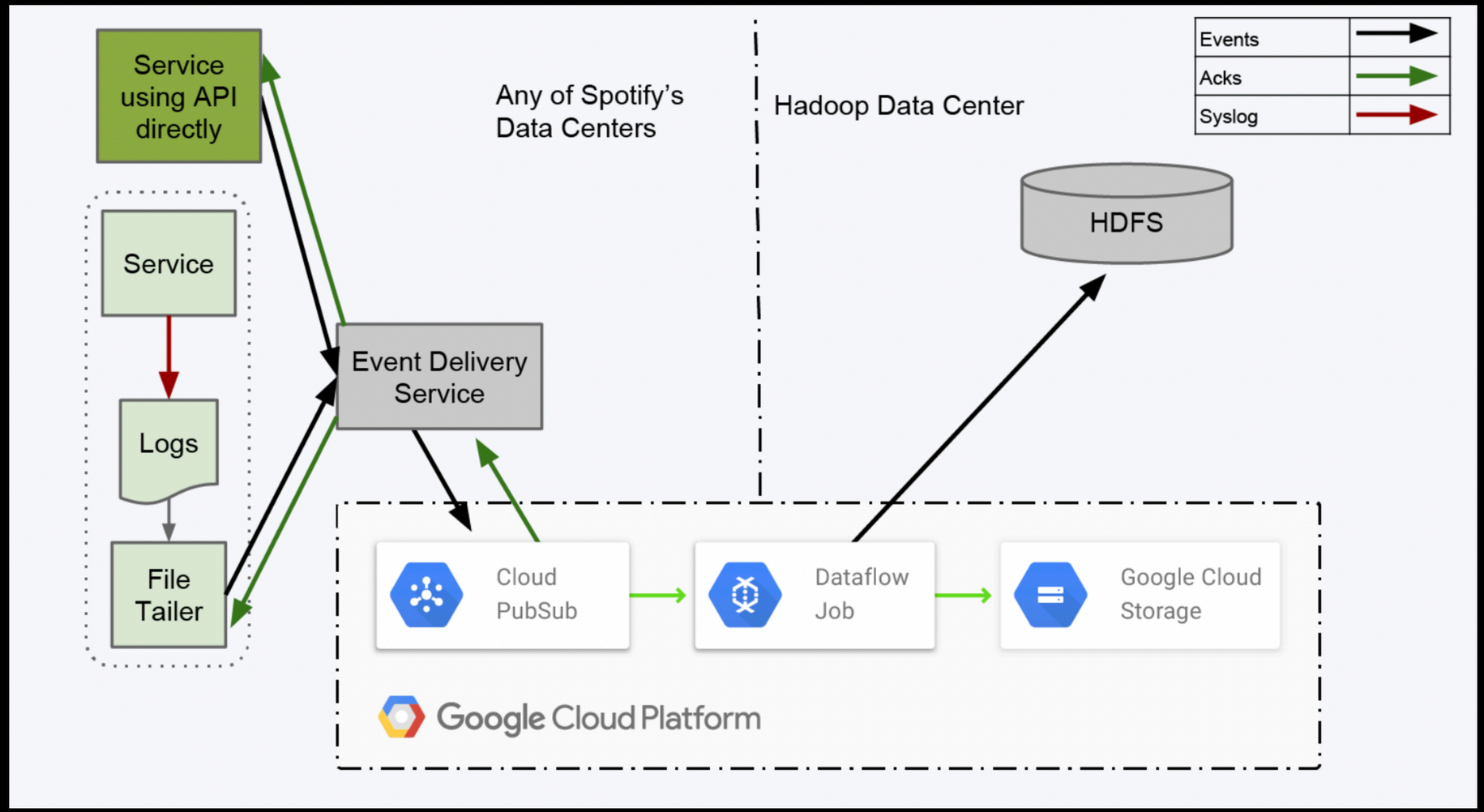
# Spotify

## X-factor

- Spotify stores music on various servers
- To stream a random track on your mobile, Spotify finds it on one of the millions of servers and sends it to your device
- Servers, in this case, are computers and all other gadgets of Spotify's subscribers. P2P
- Reduces playback latency

# Spotify

## Bonus - Event delivery system



# Further reading

## Spotify

- What is a data flow diagram
- Rules engine
- Spotify’s peer to peer
- Streaming protocols

# References

## Spotify

- System Design: Spotify
- Spotify's Event Delivery - I
- Spotify's Event Delivery - II