

Software Engineering

Part (VIII)- System Design Netflix

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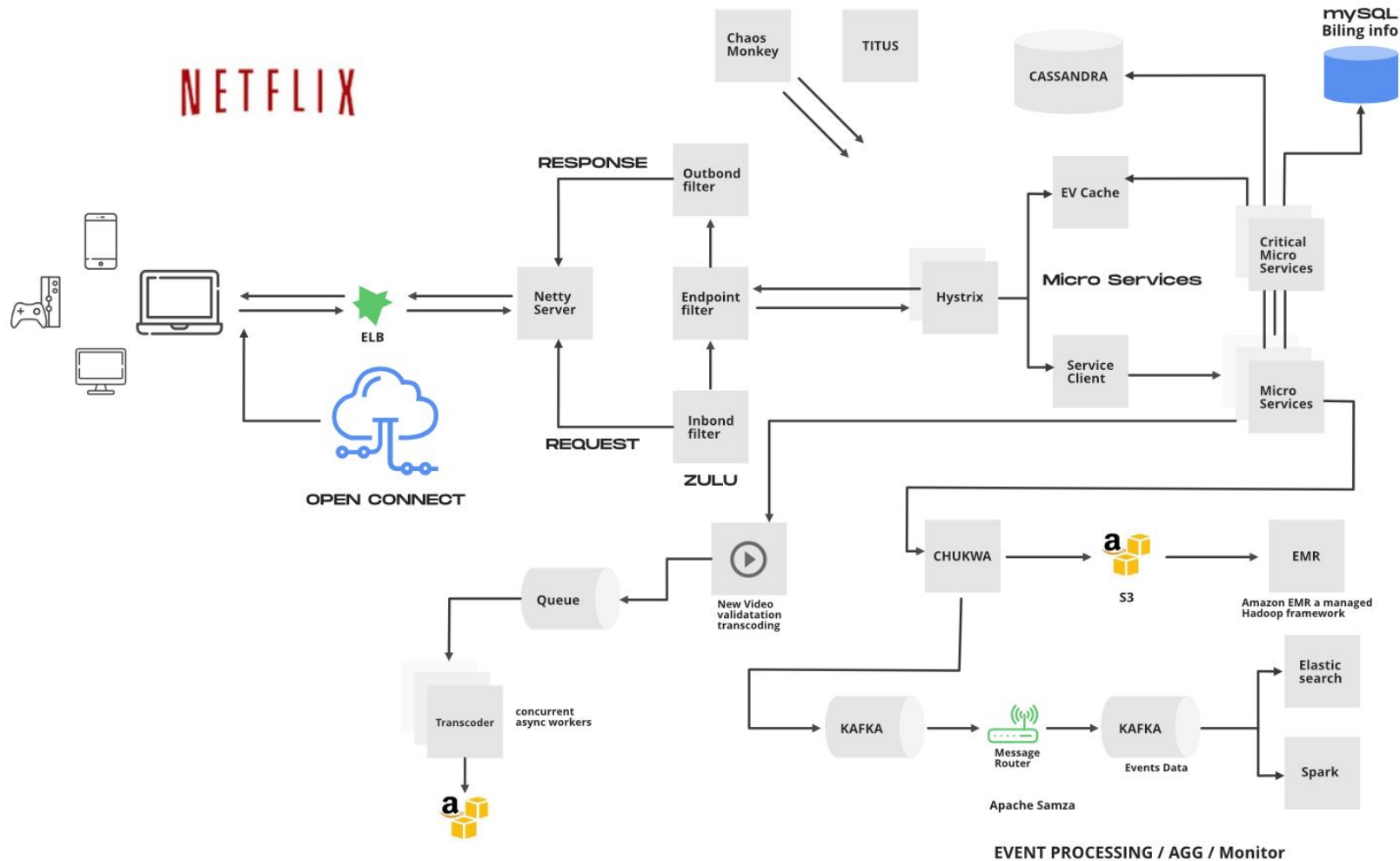
Netflix

- Netflix is an American subscription video on-demand over-the-top streaming service.
- It handles large categories of movies and television content and users pay the monthly rent to access these contents.



**Netflix has 180M+ subscribers
in 200+ countries.**

Netflix High-Level Software Architecture



Netflix External Clouds

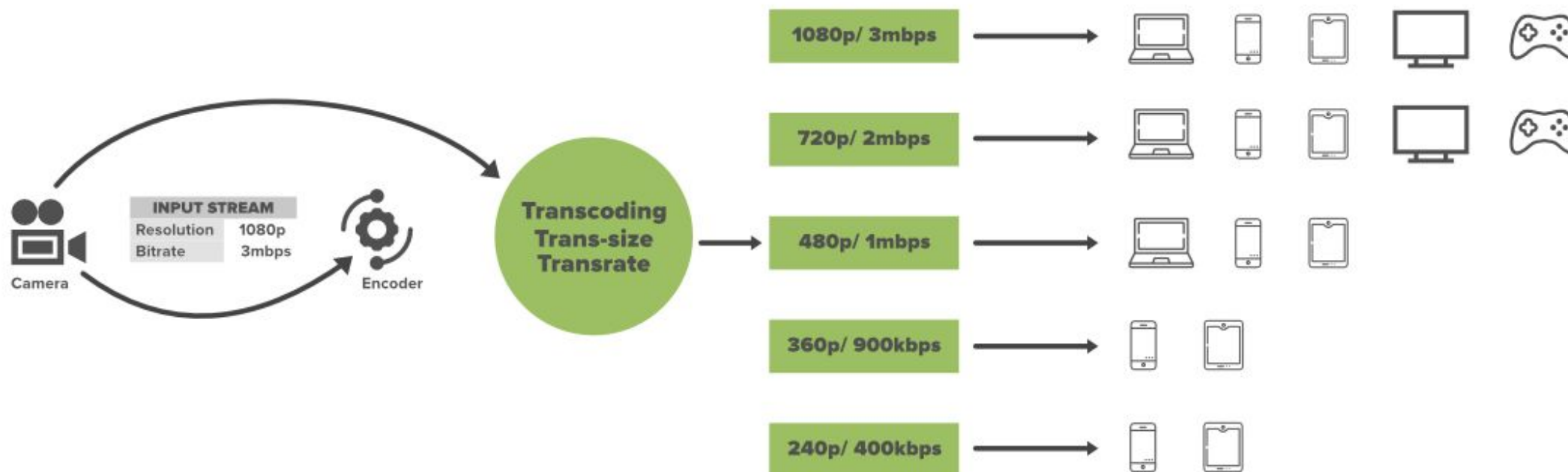
- Amazon Web Services (AWS)
- Open Connect CDN (OC)

Client Support

- Device (User Interface) which is used to browse and play Netflix videos.
- TV, XBOX, laptop or mobile phone, etc.
- Netflix supports more than 2200 devices and each one of them requires different resolutions and formats.
- Netflix performs **transcoding** or **encoding**, which involves finding errors and converting the original video into different formats and resolutions.

How Netflix Onboard a Movie/Video?

| INPUT PROTOCOLS | INPUT CODECS | OUTPUT CODECS | OUTPUT PROTOCOLS |
|--|---|---|---|
| Adobe RTMP, RTSP/RTP, MPEG-TS, ICY (SHOUTcast/Icecast) | <div>Video:</div> <div>H.265/HEVC, H.264/AVC, VP9, VP8 MPEG4 Part 2, MPEG2</div> <div>Audio:</div> <div>MP3, AAC, AAC-LC, HE-AAC+ v1 & v2, MPEG1 Part 1/2, Speex, G.711, Opus, Vorbis</div> | <div>Video:</div> <div>H.265/HEVC H.264/AVC, H.263 (v2), VP9</div> <div>Audio:</div> <div>AAC, AAC-LC, HE-AAC+ v1 & v2, Opus, G.711</div> | Apple HLS, Adobe HDS, MPEG-DASH, Microsoft Smooth Streaming, Adobe RTMP, RTSP/RTP, MPEG-TS |



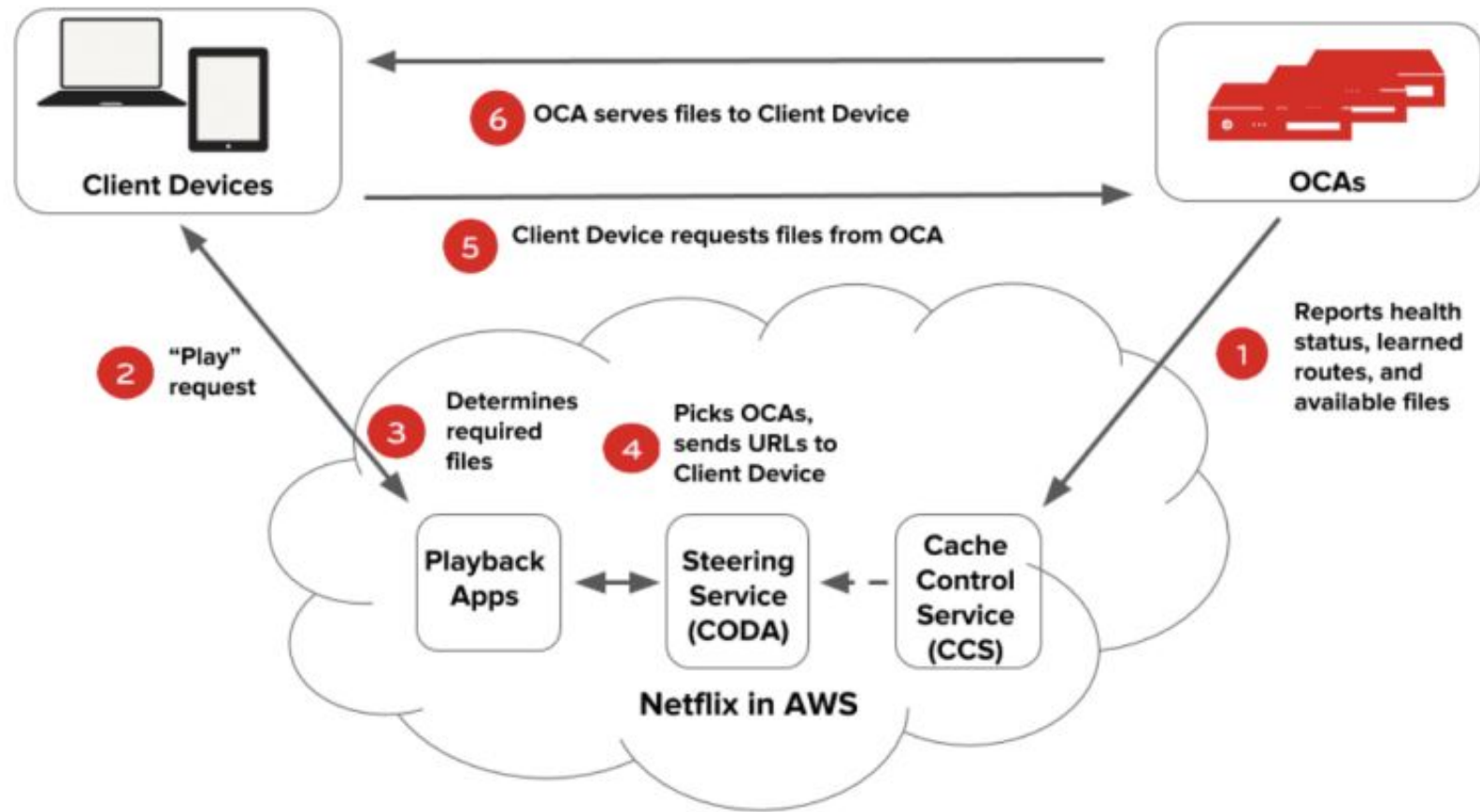
Video On-Demand

- Netflix creates **multiple replicas** (approx 1100-1200) for the **same movie with different resolutions**.
- They require a lot of **transcoding and preprocessing**.
- Netflix **breaks the original video** into different **smaller chunks** and using parallel workers in AWS it **converts these chunks** into different formats/resolutions.

OC (Open Connect) or Netflix CDN

- Open Connect is Netflix's own custom **global CDN** (Content delivery network).
- It handles everything which **involves video** streaming.
- It is distributed in different **locations** and once you hit the play button, the video stream from this component is displayed on your device.
- If you play the video in **North America**, it will be served from the **nearest open connect** instead of the original server.

OC (Open Connect) or Netflix CDN



Open Connect Advantages

- Less Expensive
- Better Quality
- More Scalable

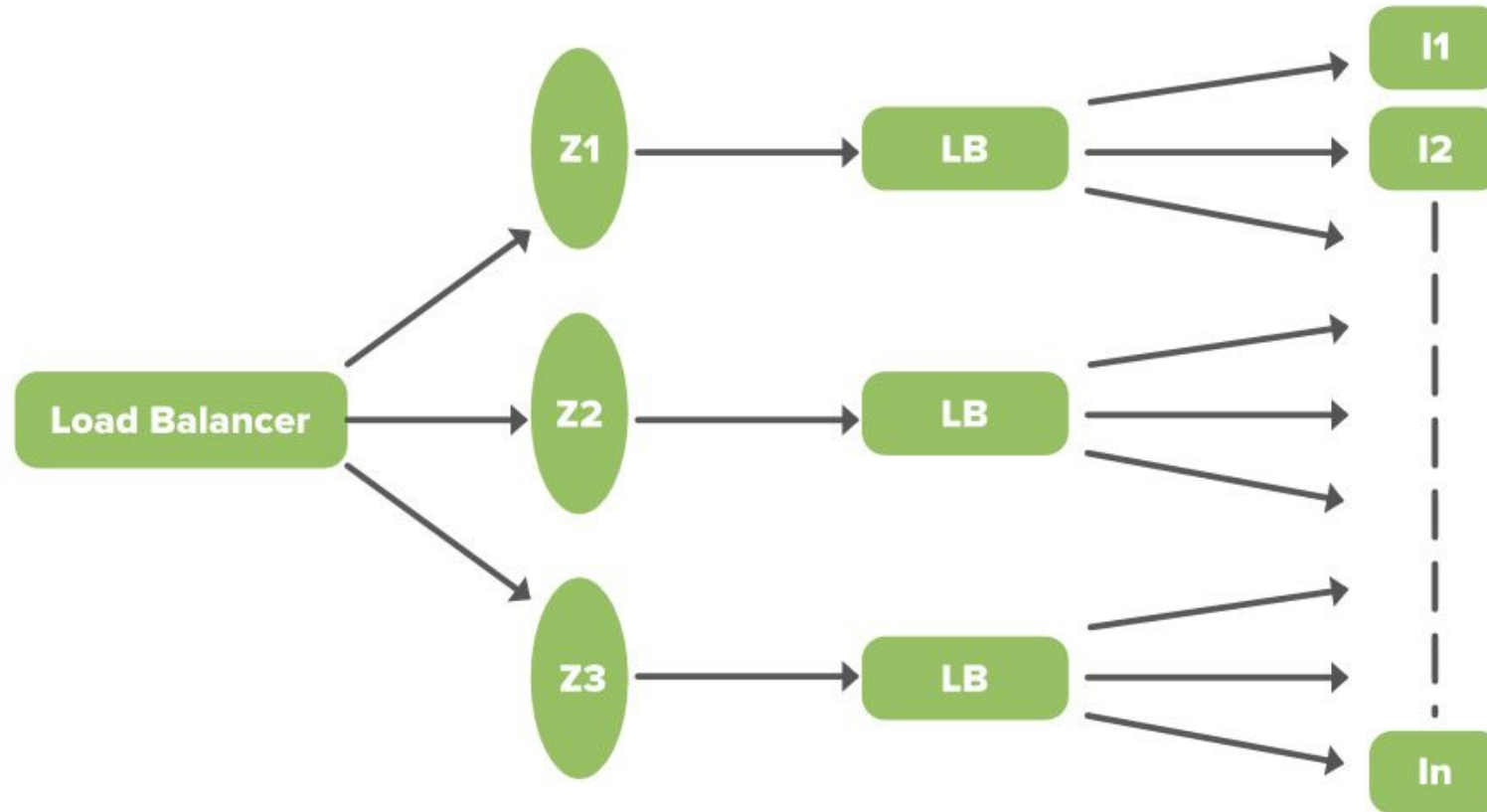
Amazon AWS

- [Amazon S3](#) or Amazon Simple Storage Service is a service provides [object storage](#) through a web service interface.
- Amazon EC2 or Amazon Elastic Compute Cloud is a web service that provides [secure, resizable compute capacity](#) in the cloud. It is designed to make web-scale cloud computing easier for developers.

Netflix frontend is written in ReactJS:

- **Startup speed**
- **Runtime performance**
- **Modularity**

Elastic Load Balancer (ELB)



ELB in Netflix

- ELB in Netflix is responsible for **routing the traffic** to front-end services.
- ELB performs a **two-tier load-balancing** scheme where the load is balanced over zones first and then instances (servers).

ZUUL

- ZUUL is a **gateway service** that provides dynamic routing, monitoring, resiliency, and security.
- It provides **easy routing** based on query parameters, URL, and path.



ZUUL

- The **Netty server** handles the network protocol, web server, connection management, and proxying work. When the request will hit the Netty server, it will **proxy the request** to the inbound filter.
- The **inbound filter** is responsible for **authentication**, **routing**, or **decorating** the request. Then it forwards the request to the **endpoint filter**.

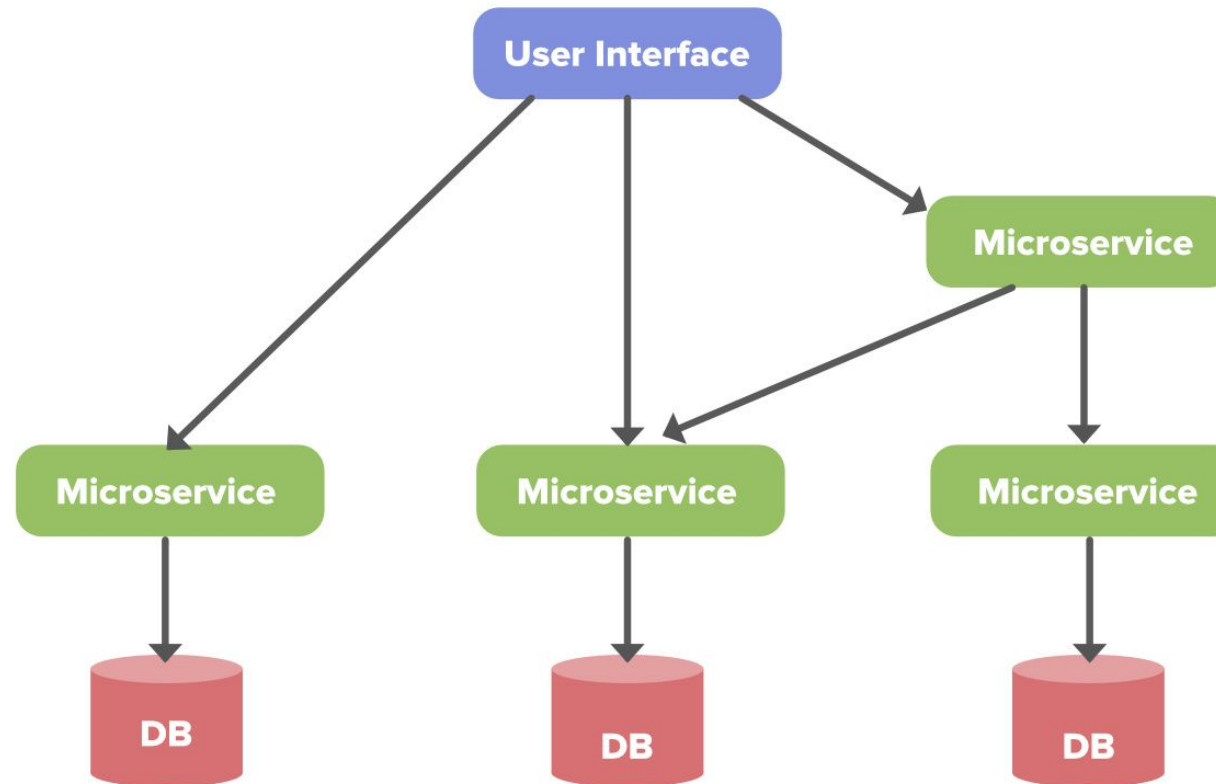
ZUUL

- The **endpoint filter** returns a [static response](#) or to forward the request to the [backend service](#). Once it receives the response from the backend service, it sends it to the [outbound filter](#).
- An **outbound filter** is used for [zipping the content](#), calculating the metrics, or adding/removing [custom headers](#). The response is sent back to the [Netty server](#) and then it is received by the [client](#).

ZUUL: Advantages

- You can **create rules** and **share** the traffic by distributing the different parts of the traffic to different servers.
- Developers can also do **load testing** on newly deployed clusters in some machines.
- You can also **test new services**. When you upgrade the service and you want to check how it behaves with the real-time API requests, you can deploy the particular service on one server and you can **redirect some part of the traffic**.

Microservice Architecture of Netflix



Microservice Architecture of Netflix

- Separate Critical Microservices
 - Netflix separates out some critical services (or endpoint or APIs) and make it **less dependent or independent** of other services.
 - Netflix also makes some critical services **dependent** only on other **reliable services**.

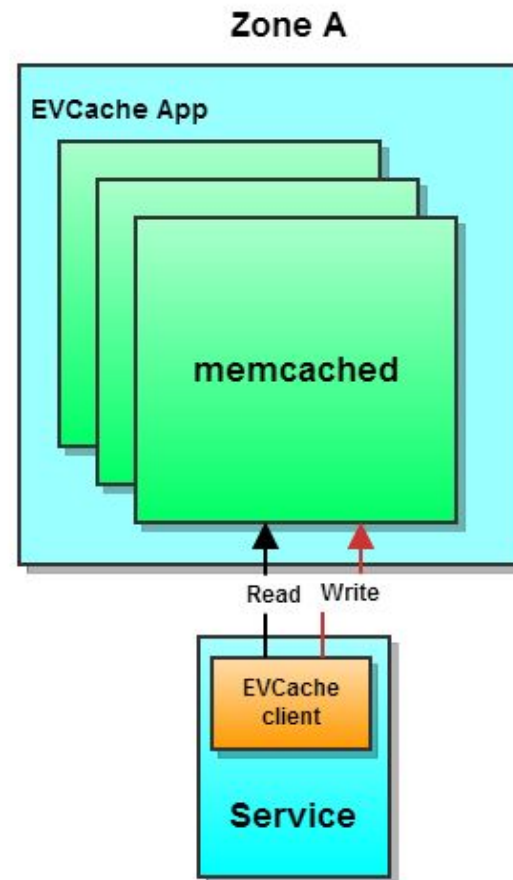
Microservice Architecture of Netflix

- Treat Servers as Stateless
 - It is an application program that **does not save client data** generated in one session for use in the next session with that client.
 - Each session is carried out as if **it was the first time** and **responses are not dependent** upon data from a previous session.

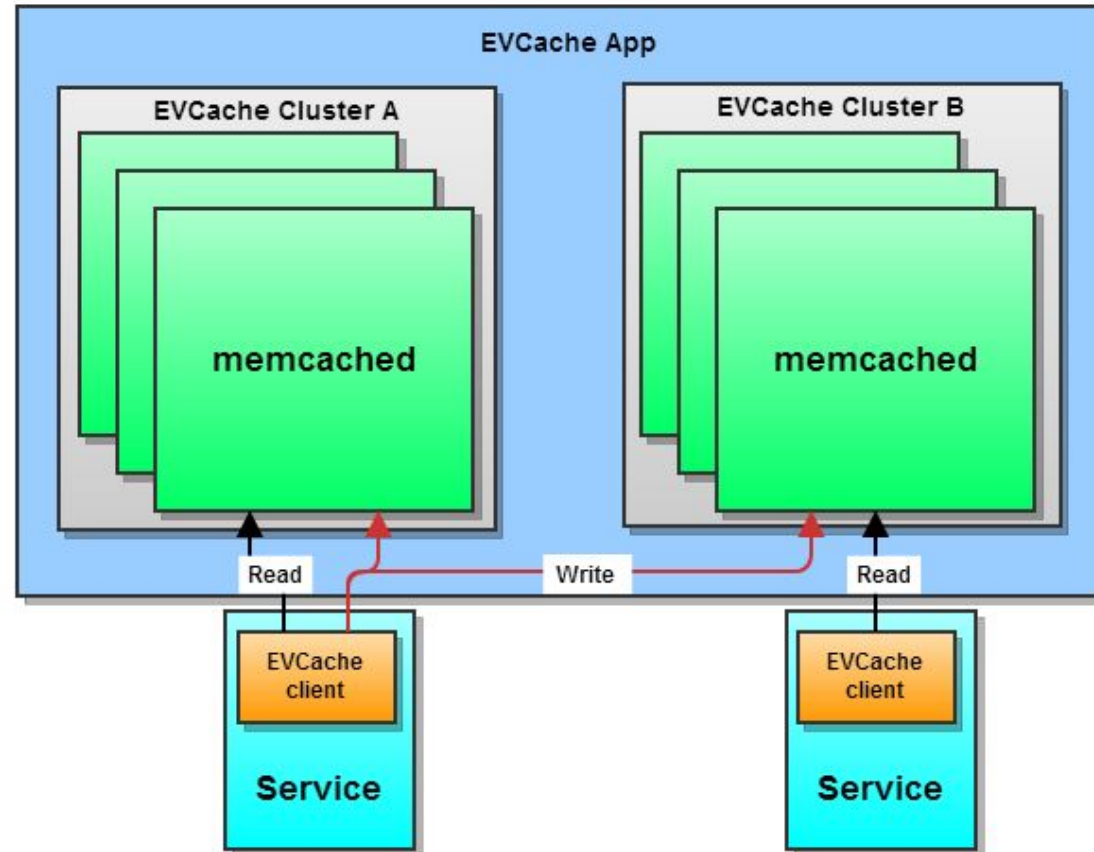
EVCache

- EV (Ephemeral Volatile) Cache
 - In most applications, some amount of data is frequently used.
 - For faster response, these data can be cached in so many endpoints and it can be fetched from the cache instead of the original server.
 - Netflix has built its own custom caching layer called EV cache.

Simple EVCache



Multi-Zone EVCache Deployment



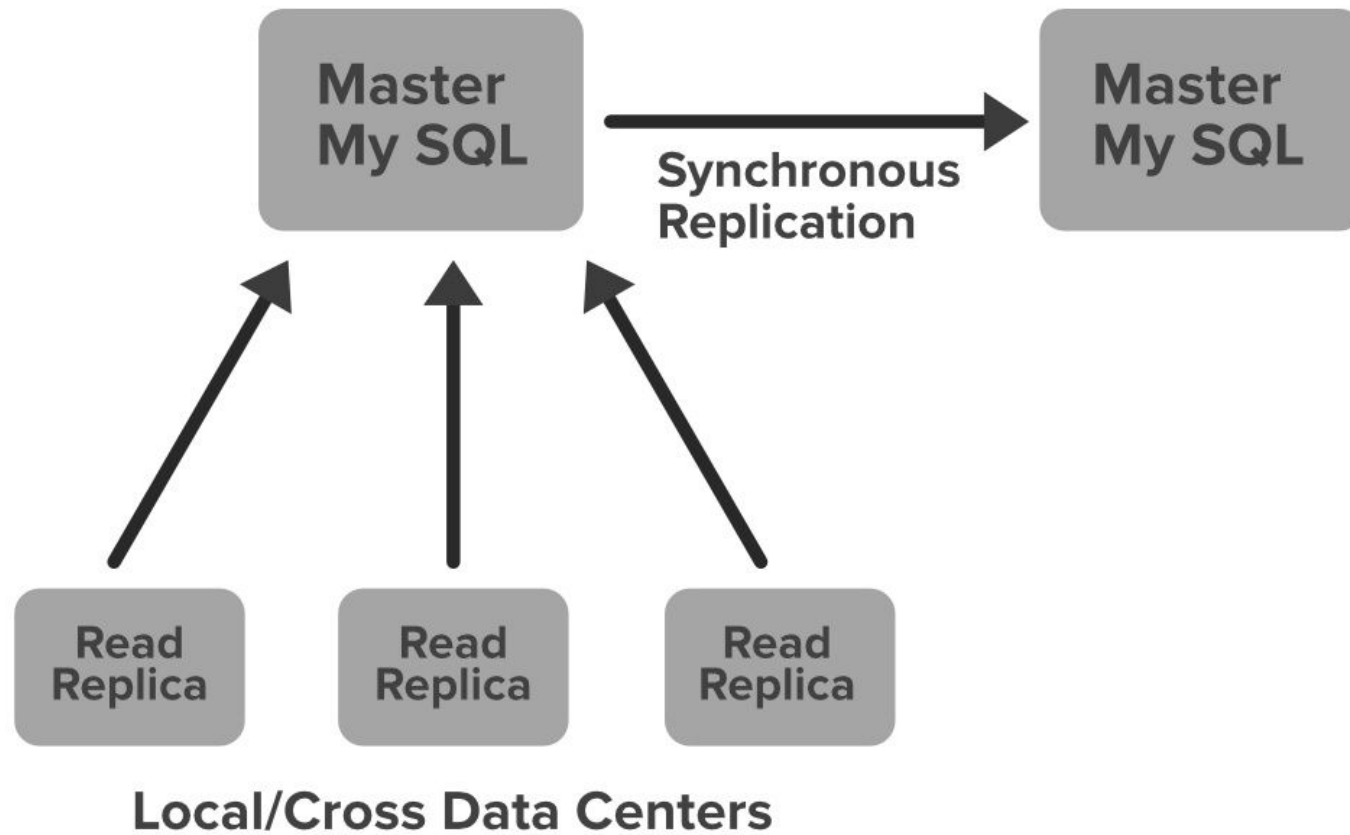
Databases

- Netflix uses two different databases
 - MySQL(RDBMS)
 - Cassandra(NoSQL)

MySQL in Netflix Architecture

- Netflix saves data like billing information, user information, and transaction information in MySQL because it needs **ACID** compliance.
- Netflix has a **master-master** setup for MySQL and it is deployed on Amazon's large **EC2 instances** using InnoDB.

Master-Master MySQL Setup



Cassandra in Netflix Architecture

- Cassandra is a NoSQL database that can handle large amounts of data and it can also handle heavy writing and reading.
- When Netflix started acquiring more users, the viewing history data for each member also started increasing.

Cassandra in Netflix Architecture

- Netflix scaled the storage of viewing history data-keeping
 - **Smaller Storage** Footprint.
 - Consistent **Read/Write Performance** as viewing per member grows (viewing history data write-to-read ratio is about 9:1 in Cassandra).

SQL vs NoSQL in System Design

| Consider SQL databases when... | Consider NoSQL databases when... |
|---|--|
| <ul style="list-style-type: none">• Your data is highly structured, and that structure doesn't change frequently• You support transaction-oriented systems such as accounting or financial applications• You require a high degree of data integrity and security• You routinely perform complex queries, including ad hoc requests• You don't require the scale-out capabilities that NoSQL offers | <ul style="list-style-type: none">• You're working with large amounts of unstructured or semi-structured data that doesn't fit the relational model• You require the flexibility of a dynamic schema or want more choice over the data model• You require a database system that can be scaled horizontally, perhaps across multiple geographic locations• You want to streamline development and avoid the overhead of a more structured approach• Your applications don't require the level of data integrity offered by SQL databases |

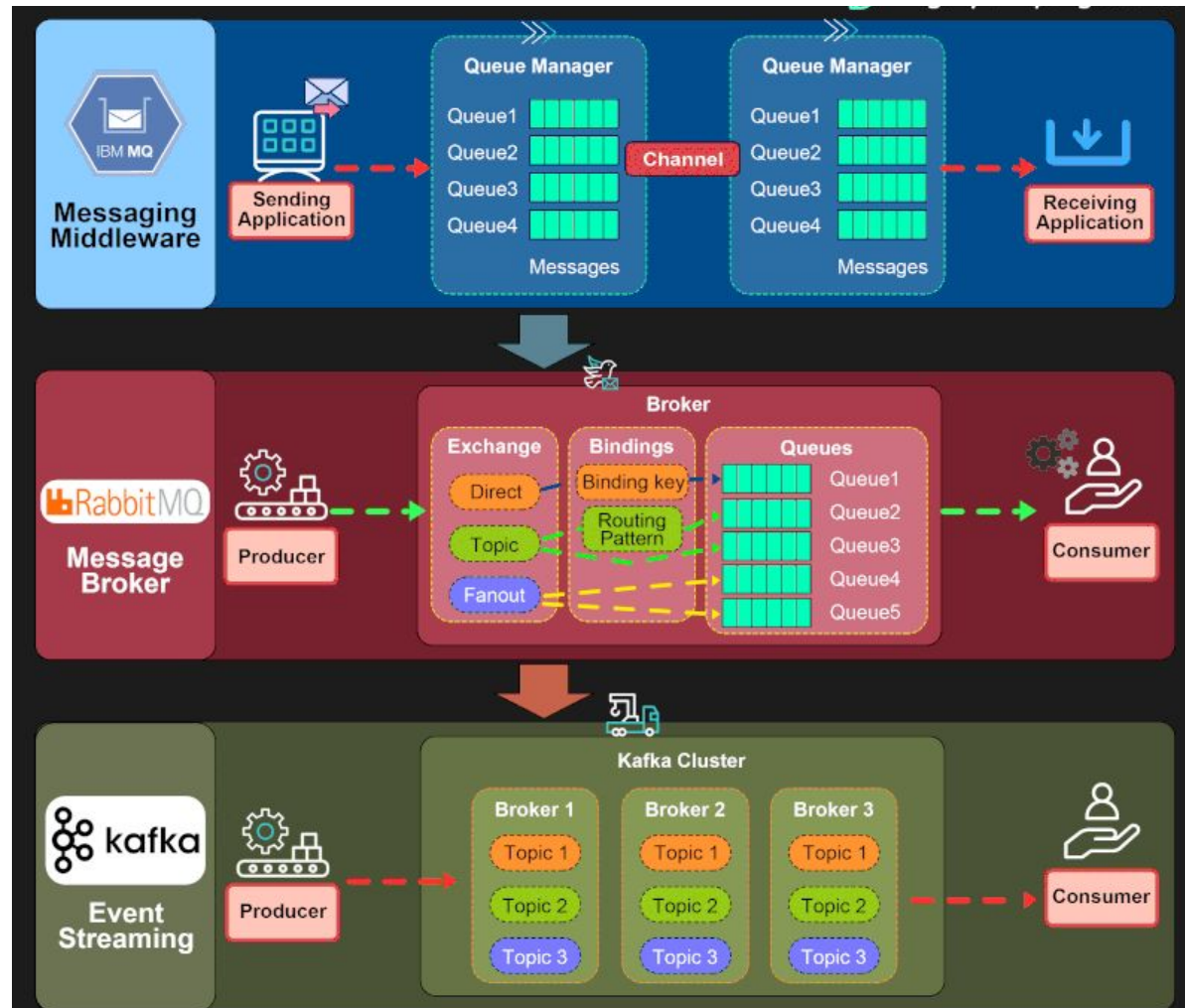
Data Processing in Netflix

- Netflix provides almost 500B data events that consume 1.3 PB/day and 8 million events that consume 24 GB/Second during peak time.
- Events in Netflix:
 - Error logs
 - UI activities
 - Performance events
 - Video viewing activities
 - Troubleshooting and diagnostic events

Data Processing in Netflix Using Kafka

- Apache Kafka has a distributed architecture capable of handling incoming messages with higher volume and velocity.
- Kafka is highly scalable without any downtime impact.
- Apache Kafka is able to handle thousands of messages per second.

Kafka vs. RabbitMQ



Elastic in Netflix

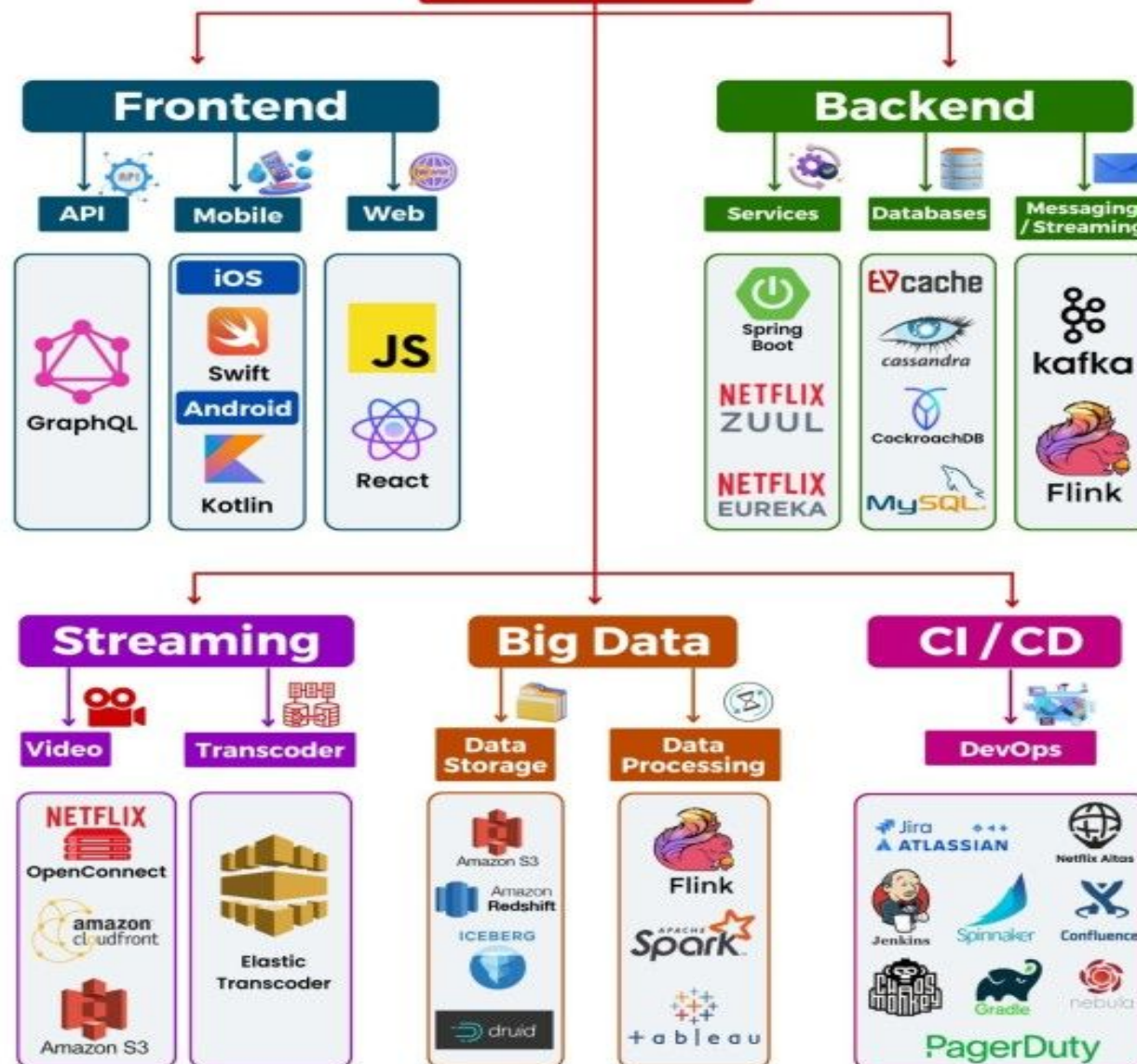
- Elasticsearch is a **distributed search and analytics engine** built on Apache Lucene.
- It is used for log analytics, full-text search, security intelligence, business analytics, and operational intelligence use cases.
- Netflix is running approximately **150 clusters** of elasticsearch and **3,500 hosts** with instances.

Apache Spark For Movie Recommendation

- Apache Spark is an open-source unified **analytics engine** for large-scale data processing.
- Netflix uses Apache Spark and Machine learning for Movie recommendations.
- In Netflix, Apache Spark is used for **content recommendations** and personalization.

ARCHITECTURE OF NETFLIX

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Readings

- <https://www.geeksforgeeks.org/system-design-netflix-a-complete-architecture/>
- <https://www.linkedin.com/pulse/netflix-whole-system-design-20-points-sandeep-kella/>
- <https://dev.to/gbengelebs/netflix-system-design-backend-architecture-10i3>
- <https://interviewnoodle.com/netflix-system-architecture-bedfc1d4bce5>