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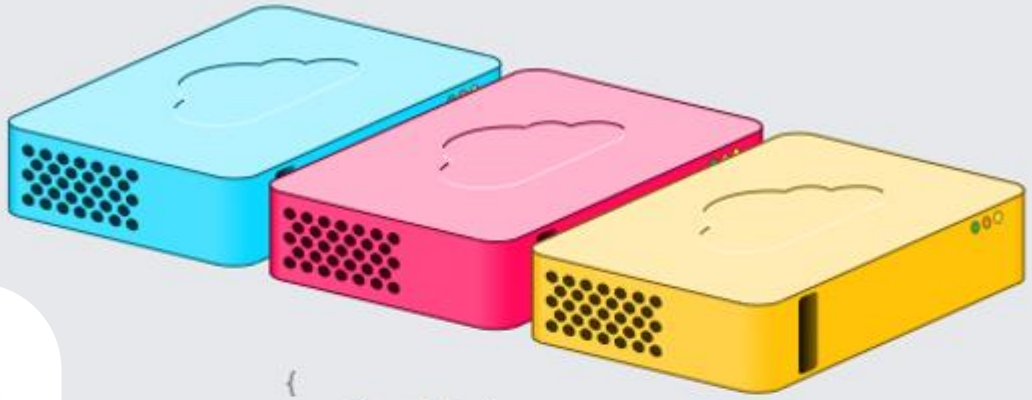

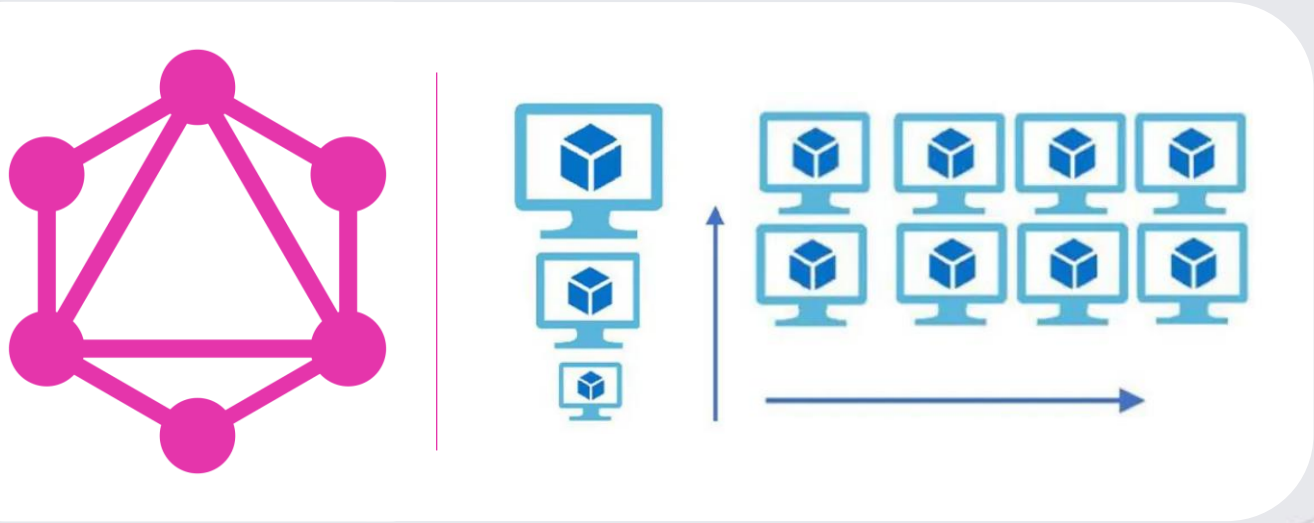

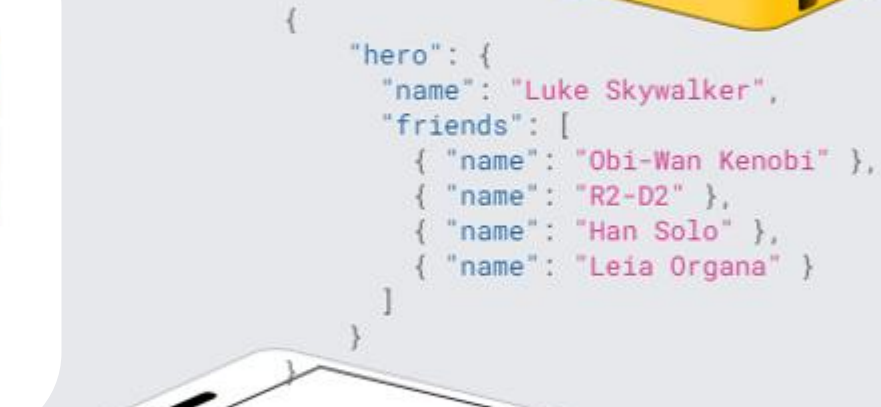

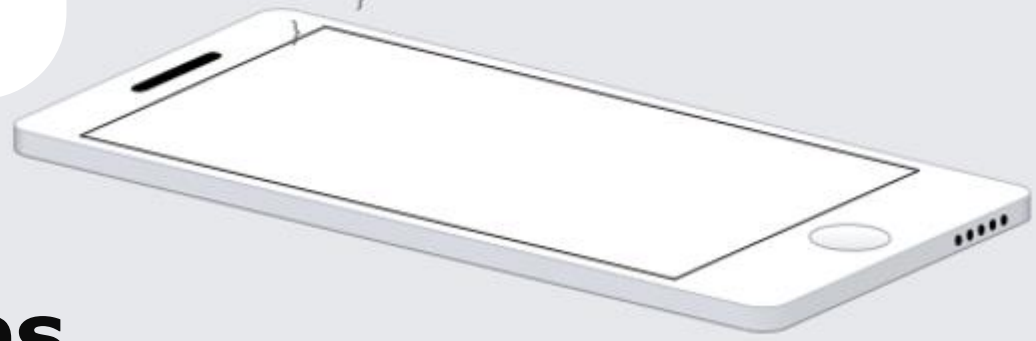

GraphQL At Scale

Presented by Miguel Rosales

About Me

Miguel Ángel Rosales Navarro

- Born and living on a little village at center-west of Granada, called **Purullena** **(Pure & Full** water**).**
- Telecommunications Engineer & Computer Science Engineer.
- Head of ELCA Spain Engineering Delivery Unit.
- Technical Expert & Senior Project Manager.
- Chispi’s father.

Agenda

1. **What Is GraphQL**
2. When to use GraphQL vs REST
3. Why Scale GraphQL
4. Why Scale GraphQL Horizontally?
   - 4.1. Horizontal GraphQL Techniques
   - 4.2. Horizontal GraphQL Best Practices
5. Why Scale GraphQL Veritcally?
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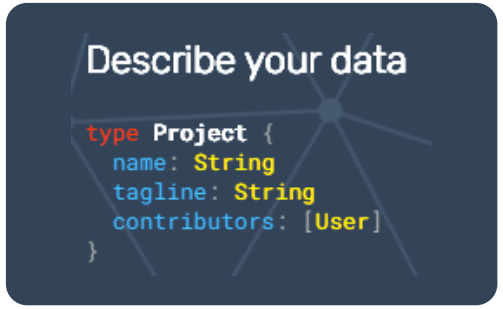
1. What Is GraphQL

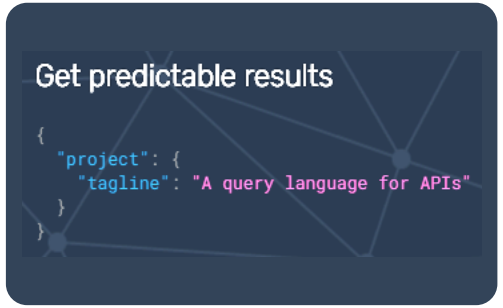
GraphQL is a query language for APIs that was developed by Facebook in 2012 to address some of the limitations of traditional APIs. Some of its key features are:

- Allows developers to request all the data they need in a single query.
- Enables developers to **define a schema that describes the data** available in their API. This makes it easier to understand and work with the data, especially when **dealing with complex relationships** between different entities.
- Allows developers to be able to build APIs that are better suited to **modern** web applications and **can be scaled more easily**.



— You can describe the data you want to create, use, modify, etc … in your application.

— You will be able to ask what you want to recover from the data you have already described.



— It ensures that the data received in the query will always have the same structure.

1. What Is GraphQL

— **The GraphQL operations** are simple string that a server can parse and respond to with data in a specific format.

— **A GraphQL query:** is used to read or **fetch values:**

```
query HeroNameAndFriends {
  hero {
    name
    friends {
      name
    }
  }
}
```

```
{
  "data": {
    "hero": {
      "name": "R2-D2",
      "friends": [
        {
          "name": "Luke Skywalker"
        },
        {
          "name": "Han Solo"
```

— **ELCA** projects examples:

COMPASSANA

SwissLife

OXYNADE
SELF-SERVICE
SAAS TICKETING

17 96
LOMBARD ODIER
LOMBARD ODIER DARIER HENTSCH

— **A GraphQL mutation:** is used to **write** or post values:

```
mutation CreateReviewForEpisode($ep: Episode
  createReview(episode: $ep, review: $review
    stars
    commentary
  }
}
```

VARIABLES

```
{
  "ep": "JEDI",
  "review": {
    "stars": 5,
    "commentary": "This is a great movie!"
  }
}
```

```
{
  "data": {
    "createReview": {
      "stars": 5,
      "commentary": "This is a great movie!"
    }
  }
}
```

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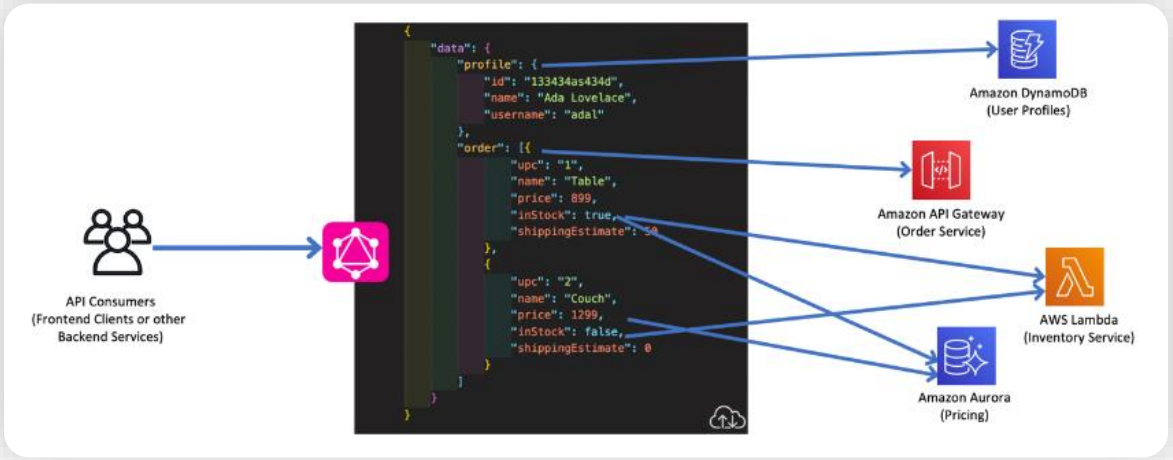
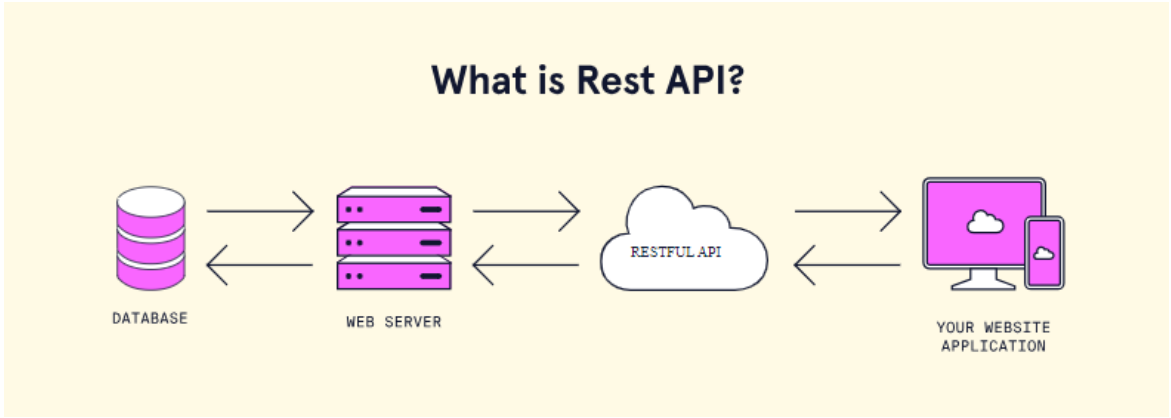
2. When to use GraphQL vs. REST

- **GraphQL** is a better choice on these considerations:
  - **Limited bandwidth**, so need to minimize the number of requests and responses.
  - **Multiple data sources**, to combine them at one endpoint.
  - Client **requests that vary significantly**, and expectation of very different responses.



- **REST** is a better choice on these considerations:
  - For **smaller applications** with less complex data.
  - Data and operations that all clients **use similarly**.
  - **No** requirements for **complex data** querying.



3. Why Scale GraphQL?

- **Scaling GraphQL** can bring a multitude of benefits to your system. By reducing the number of requests needed to fetch data or increasing the server/s capacity, you can **improve the performance** and user experience of your application.
- Additionally, scaling GraphQL can help with versioning. With other APIs, versioning can become difficult as changes to the API can break client applications. However, with GraphQL, **clients can specify exactly what data** they need, **eliminating the need for versioning** altogether.

Some real-world examples:

Facebook (2012) reported that after implementing GraphQL, they saw a **50% reduction in the number of API requests** made by their mobile apps.

Netflix (2015) were able to reduce the number of API requests by up to **60%**, resulting in faster load times and improved user experience.

Airbnb (2017) were able to **reduce the size of their API responses by up to 90%,** resulting in faster load times and reduced data usage for their users. They also saw a significant **decrease in server costs** due to the optimized queries provided by GraphQL.

Scaling Challenges with GraphQL

— As GraphQL applications scale, they can face several challenges, especially as the complexity of your application grows:

- Deal with **large number of concurrent queries** and mutations that can put a strain on the server's resources.
- Ensure that the **schema design can handle the increased traffic** without compromising performance.
- **Careful planning and implementation** to ensure that the application **can continue to function effectively** at scale.

— Fortunately, there are several techniques that can be used to address these challenges in both horizontal and vertical scaling.

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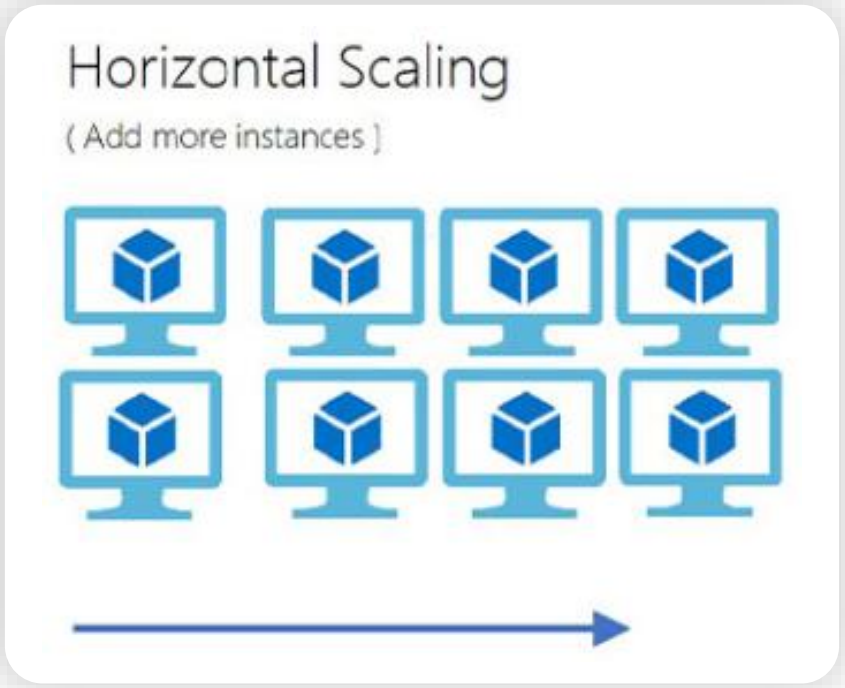
4. Why Scale GraphQL Horizontally?

- **Horizontal scaling** refers to increasing the capacity of processing requests **by adding multiple servers**.



- Scaling GraphQL horizontally can bring many benefits to your projects:
  - **Increase the performance** of your GraphQL API.
  - **Handle high traffic** easily.
  - **High availability**, isolation against single failures.

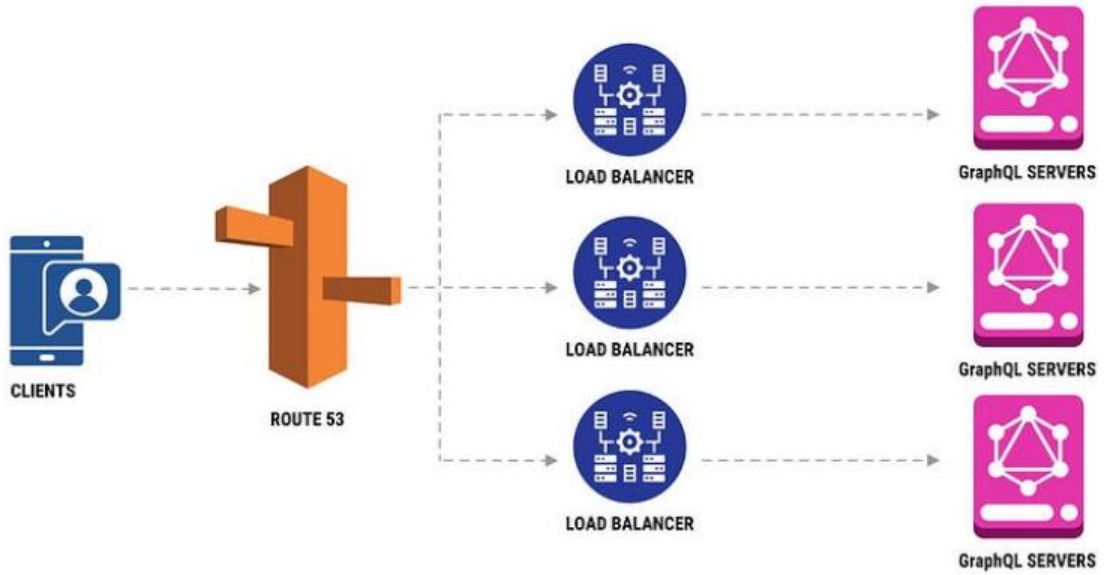
Uber

For example, **Uber** uses GraphQL to handle millions of requests per second by using horizontal scaling techniques like load balancing, sharding or clustering.

Horizontal GraphQL Scale Techniques: **LOAD BALANCING**

Load balancing is a technique used to distribute incoming network traffic across multiple servers.

- Scaling GraphQL horizontally, load balancing helps with:
  - Ensure that **no single server becomes overloaded** with requests, which can lead to slower response times and even downtime.
  - Instead, requests are spread out across multiple servers, **allowing for faster response times and better overall performance**.



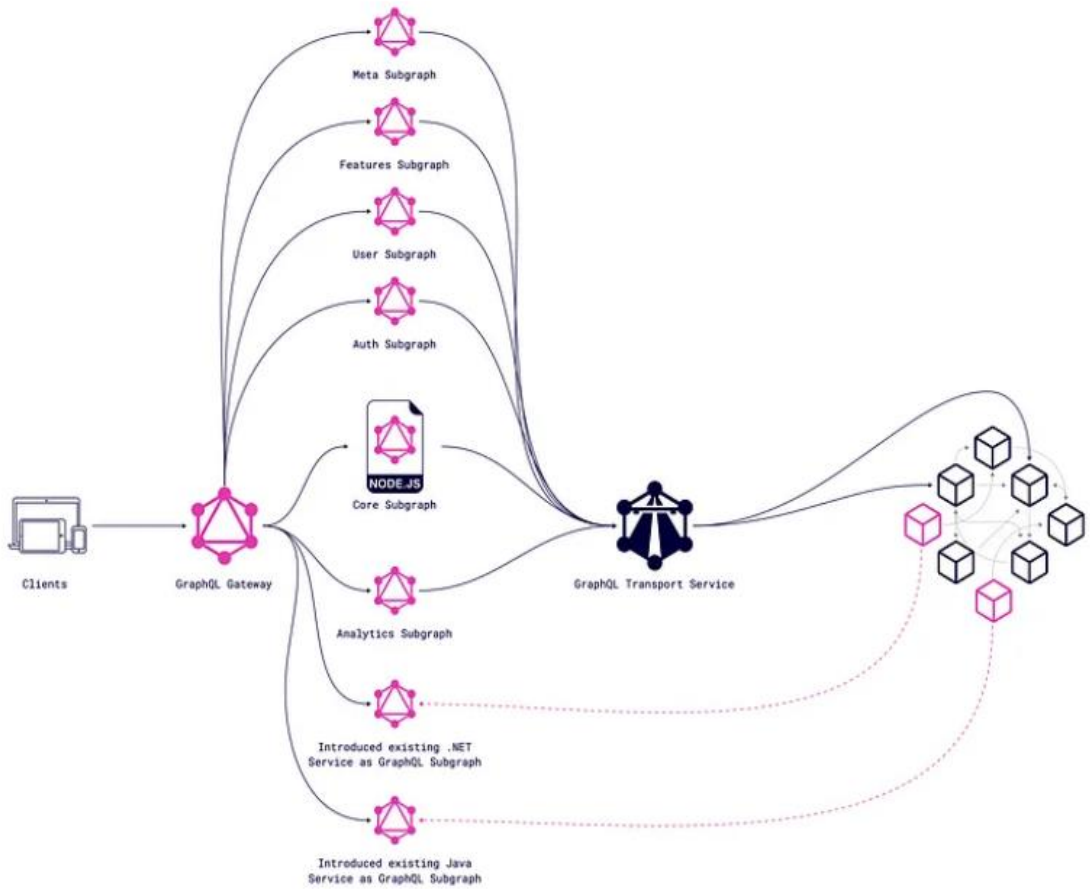
- Load balancing techniques:
  - **Round-robin** distributes requests evenly across all servers (different strategies: equal distribution, weighted servers, etc...)
  - **IP Hash** uses the client's IP address to determine which server to send the request to.
  - **Least connections** sends requests to the server with the fewest active connections.

Horizontal GraphQL Scale Techniques: **SHARDING**

- **Sharding** consists in splitting data into smaller, more manageable chunks called **shards**. Each shard contains a subset of the overall data and is stored on a separate server, allowing for faster response times.

- For example, the servers can be sharded based on user location or some other criteria, so that requests are routed to the appropriate shard. This can help **reduce latency** and improve response times.

- However, there are also drawbacks to consider such **as increased complexity** in managing multiple servers and potential data inconsistency.

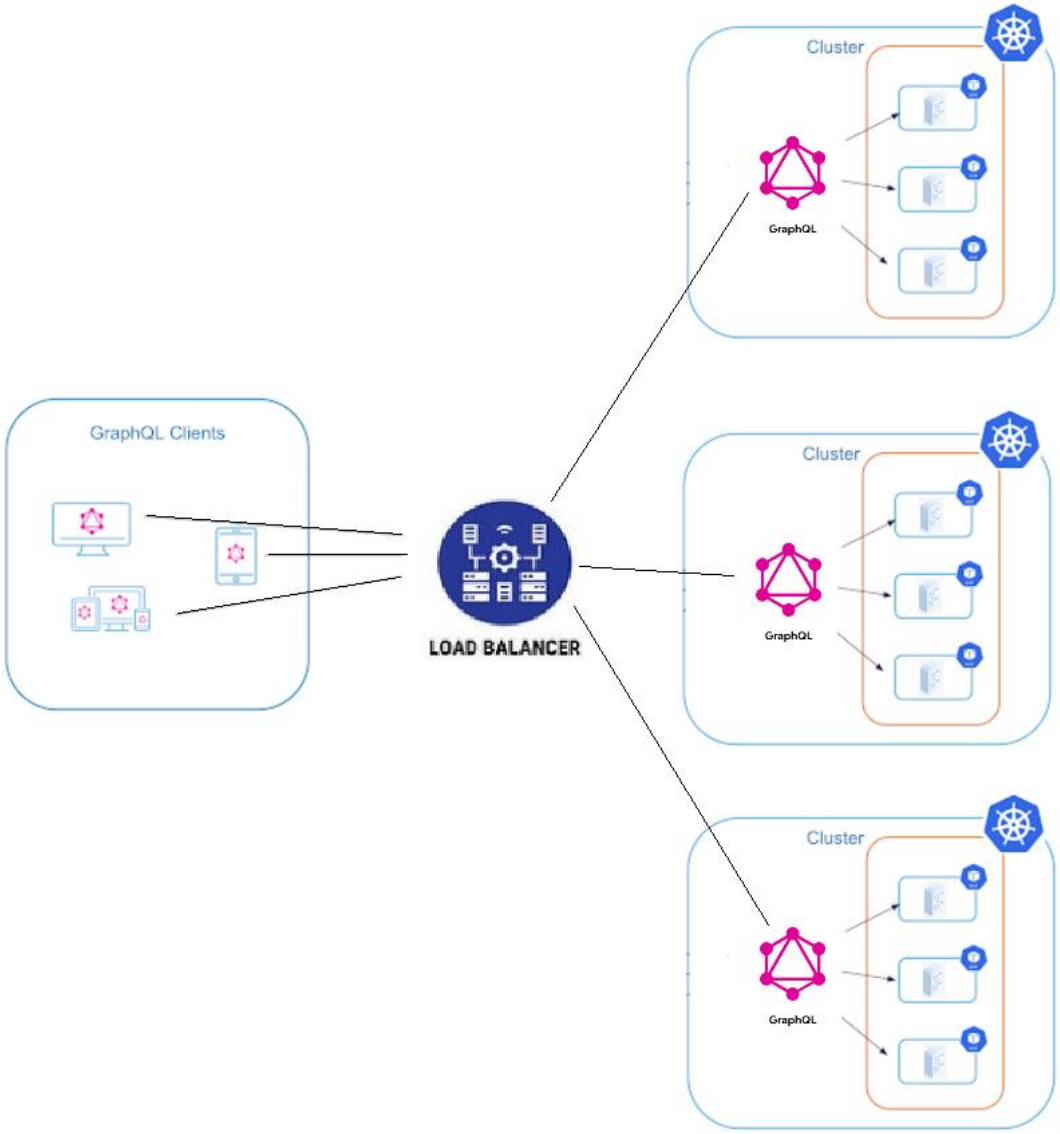


Horizontal GraphQL Scale Techniques: **CLUSTERING**

- **Clustering** consists in **grouping multiple servers together** into a cluster. These servers work together to handle incoming requests, with each server taking on a portion of the workload.

- One of the main benefits of clustering is its ability to provide **high availability and fault tolerance**. If one server in the cluster fails, the other servers can continue to handle requests without interruption.

- However, setting up and **maintaining a cluster can be complex** and time-consuming.



Horizontal GraphQL Scaling Best Practices

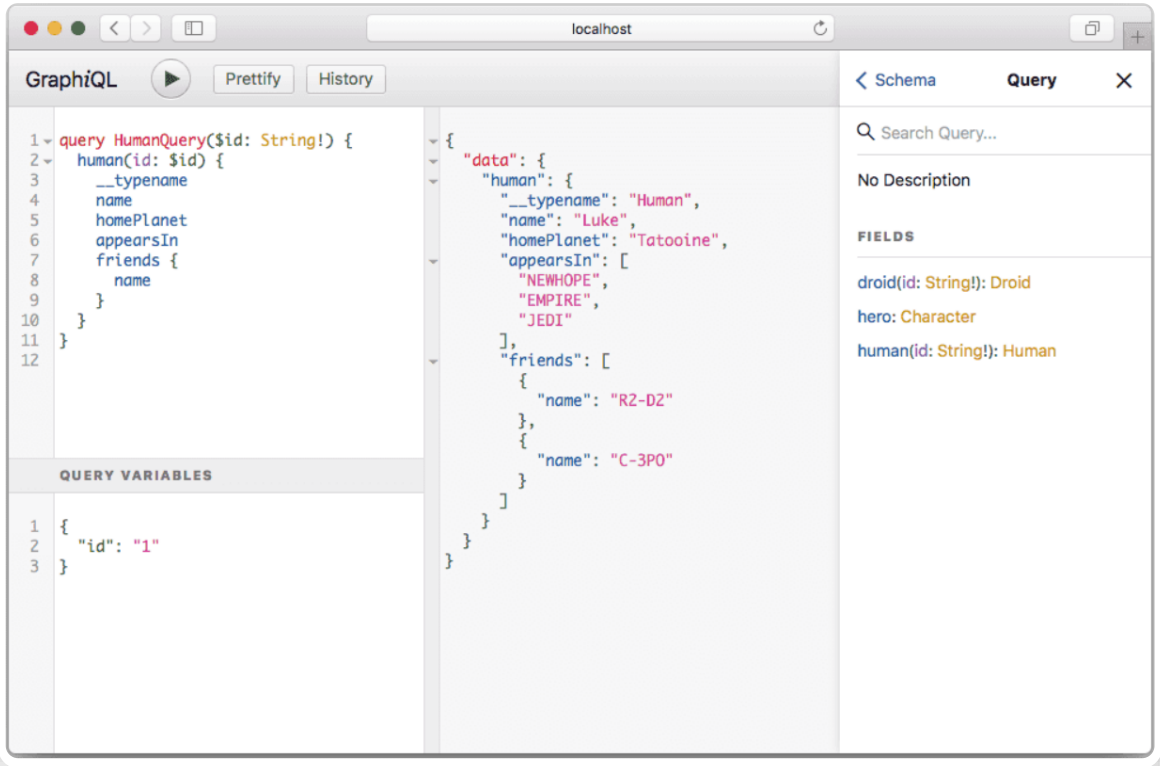
- Choosing the **right infrastructure** is crucial
  - Consider using **cloud-based services** like AWS or Google Cloud Platform, which offer **auto-scaling** and load balancing features.
  - Use a **CDN like Cloudflare** to distribute traffic and reduce latency.

- **Monitoring and optimizing** performance is key
  - Use a **distributed tracing system** that can help you identify performance bottlenecks and troubleshoot issues in real-time.
  - Implement **logging and error tracking** to capture detailed information about application errors and exceptions.

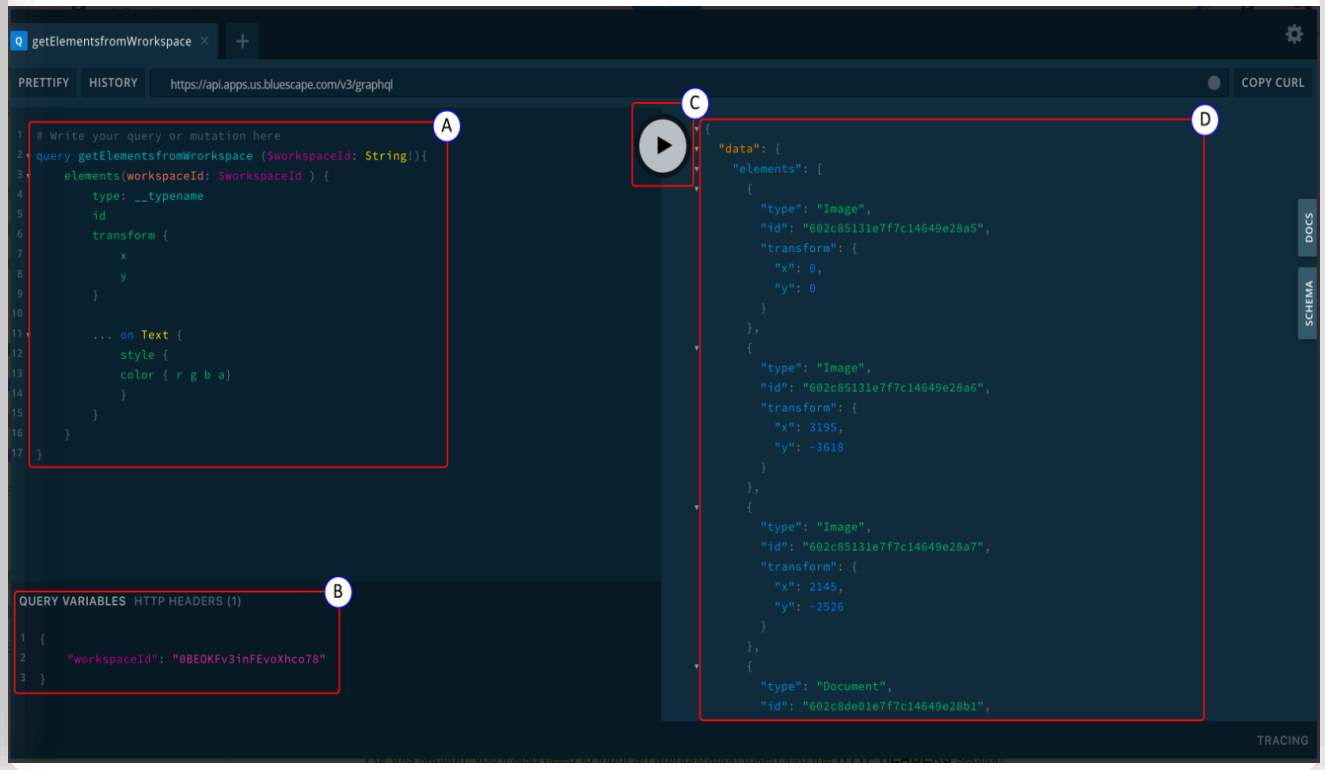
- Use **GraphQL introspection** to gain insights into the structure and behavior of your API
  - Use tools like **GraphiQL** or **GraphQL Playground**, you can explore your schema and query data in a more **interactive** and **visual** way, which can be especially helpful when **debugging complex issues**.

GraphQL Testing:

GraphiQL:



GraphQL Playground:



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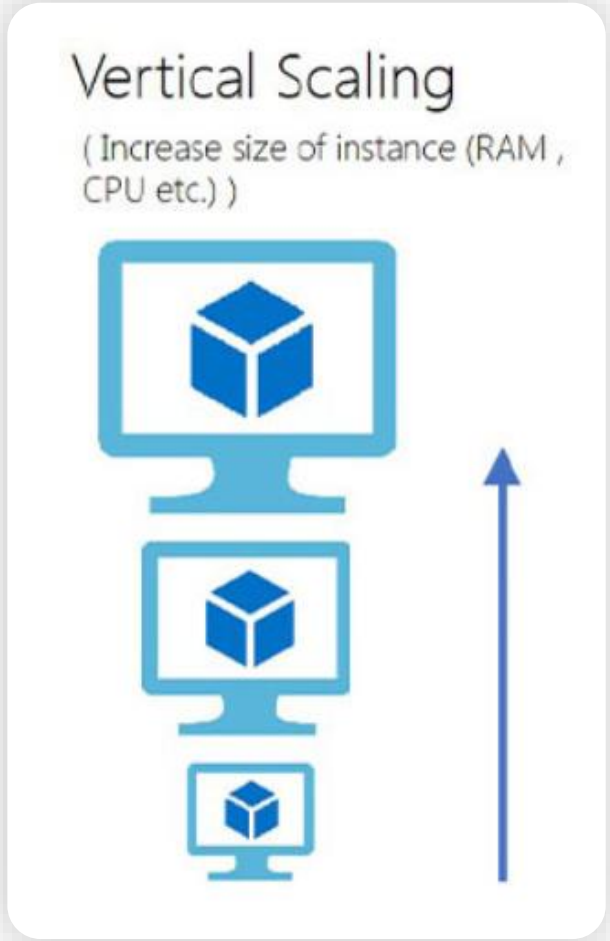
Why Scale GraphQL Vertically?

- **Vertical scaling** refers to **increasing the capacity of a single server** by adding more resources such as CPU, memory, or storage.
- Vertical scaling of GraphQL has several benefits:
  - **Increased performance** to handle more requests.
  - **Reduced costs** due to not adding additional servers.

— For example, **Netflix** uses vertical scaling to handle their massive amounts of traffic. They have a complex system of microservices that communicate with each other using GraphQL. By scaling vertically, **they can handle the high volume of requests while keeping costs down by using fewer servers**.



Vertical GraphQL Scale Techniques: **CACHING**

Caching is a powerful tool for scaling GraphQL vertically. It consists in **storing frequently accessed data in memory**.

At server-side, caching can significantly **reduce the number of database queries** required to fulfill requests. A cache such as **Redis or Memcached** can be used to overall performance. Warning: if there is horizontal scale, the cache should support distributed mode.

At client-side, caching allows the client to store query results in memory and **avoid redundant network requests**, reducing the number of requests sent to the server and resulting in faster and more responsive applications. Tools like **Apollo Client** can be used.

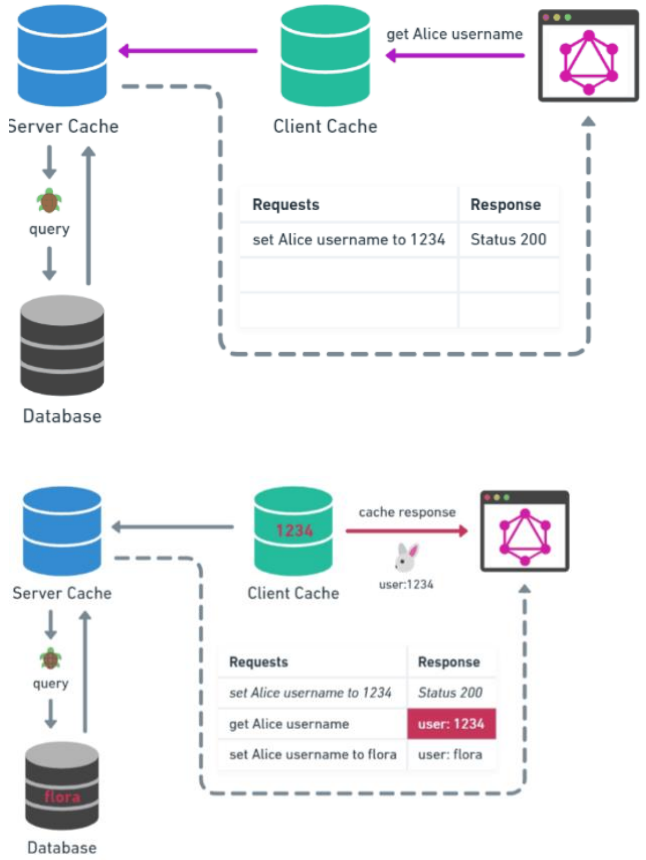
— There are several caching strategies that can be used with GraphQL, including:

- **Query-level** caching involves caching entire queries. **Parsing Level**.
- **Field-level** caching caches individual fields within a query. **Validation Level**.
- **Result-level** caching caches the results of a query, regardless of the specific fields requested. **Execution Level**.

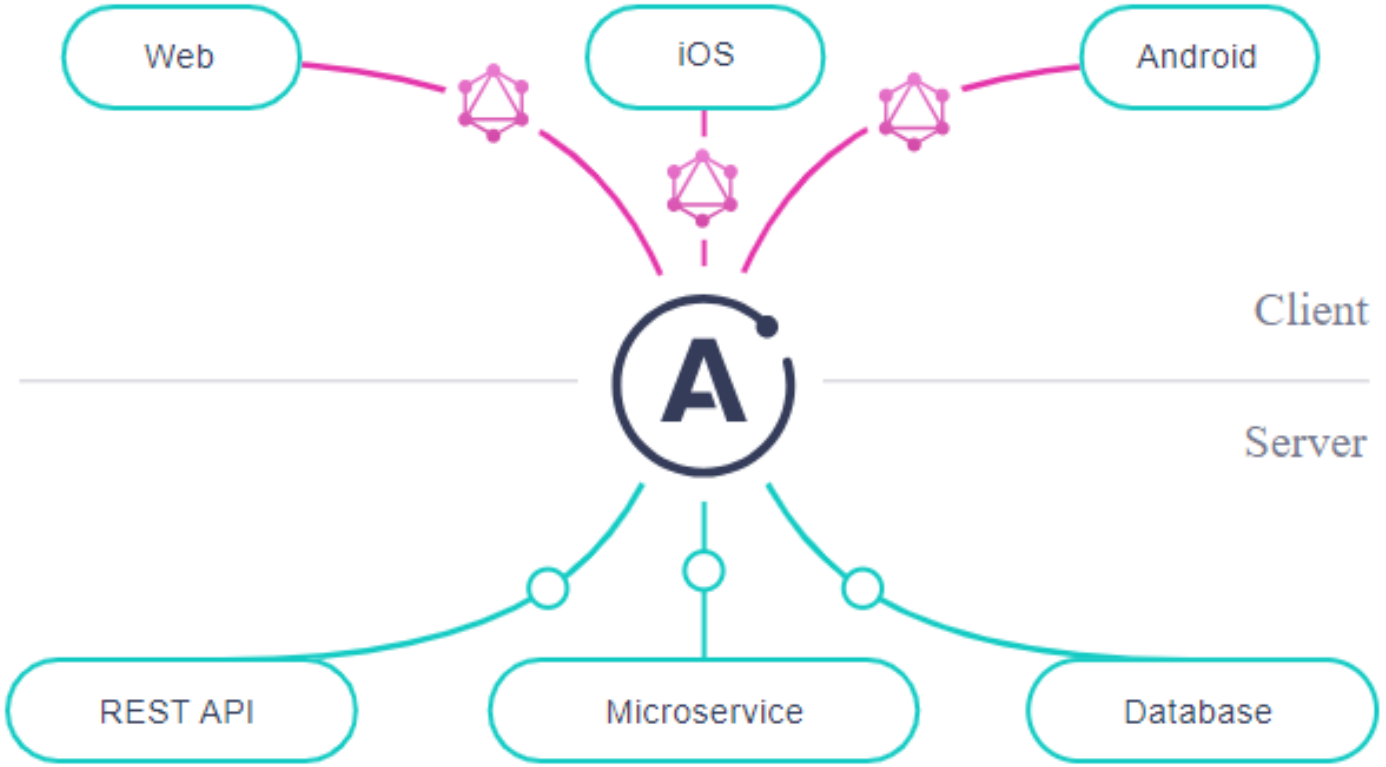
— Be sure to **set appropriate cache expiration times** to ensure data remains up-to-date.

Vertical GraphQL Scale Techniques: **CACHING**

Caching example:



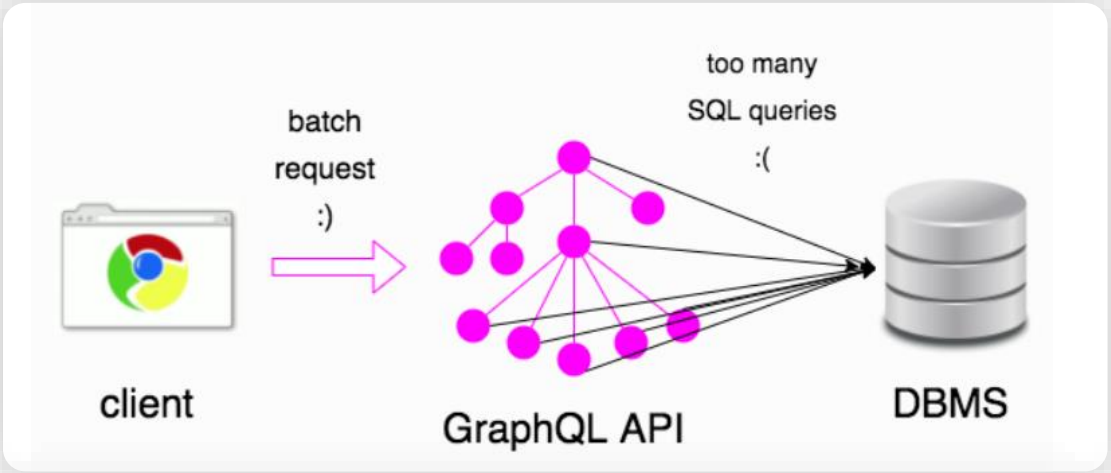
GraphQL Apollo (Client + Server):

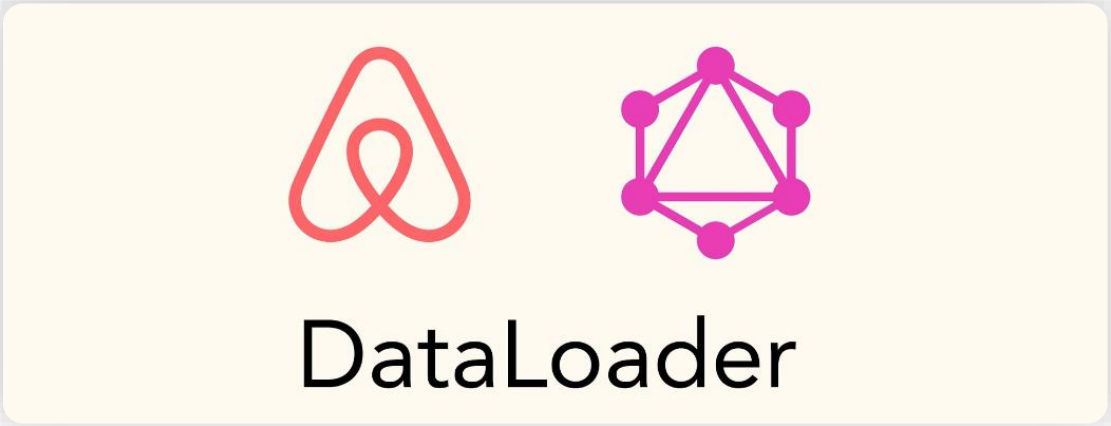


Vertical GraphQL Scale Techniques: **BATCHING QUERIES**

Batching queries consists in reduce the number of requests sent to the server. Instead of sending multiple queries one at a time, batching allows for **multiple queries to be grouped together and sent in a single request**.

- This approach can significantly **improve the performance** of GraphQL applications, particularly when dealing with large amounts of data or complex queries. **DataLoader** is a great library for batching queries.
- By reducing the number of requests, batching can also help to **minimize network overhead** and improve the overall user experience.
- It must be properly analyzed as **can introduce performance issues** at the server-side.





Vertical GraphQL Scaling Best Practices

- One of the main **challenges** of scaling GraphQL vertically is **increased complexity**. As more resources are added to a single server, it becomes **harder to manage and maintain.** This can lead to issues such as slower response times and increased downtime.
- Another challenge is the potential for **single points of failure**. If a single server goes down, it can bring down the entire system. This can be mitigated by using redundancy and failover mechanisms, but these can also **add to the complexity and cost of the system**.
- **Monitor your system** regularly to ensure that it is performing optimally. This includes monitoring CPU usage, memory usage, and network traffic. Use tools like **Prometheus or Grafana** to track metrics and identify potential issues before they become critical.
- **Test your system** to ensure that it can handle the expected traffic. Use tools like **Apache JMeter** or **Gatling** to simulate user traffic and identify potential bottlenecks. **Test both read and write operations** to ensure that your system can handle both types of traffic.

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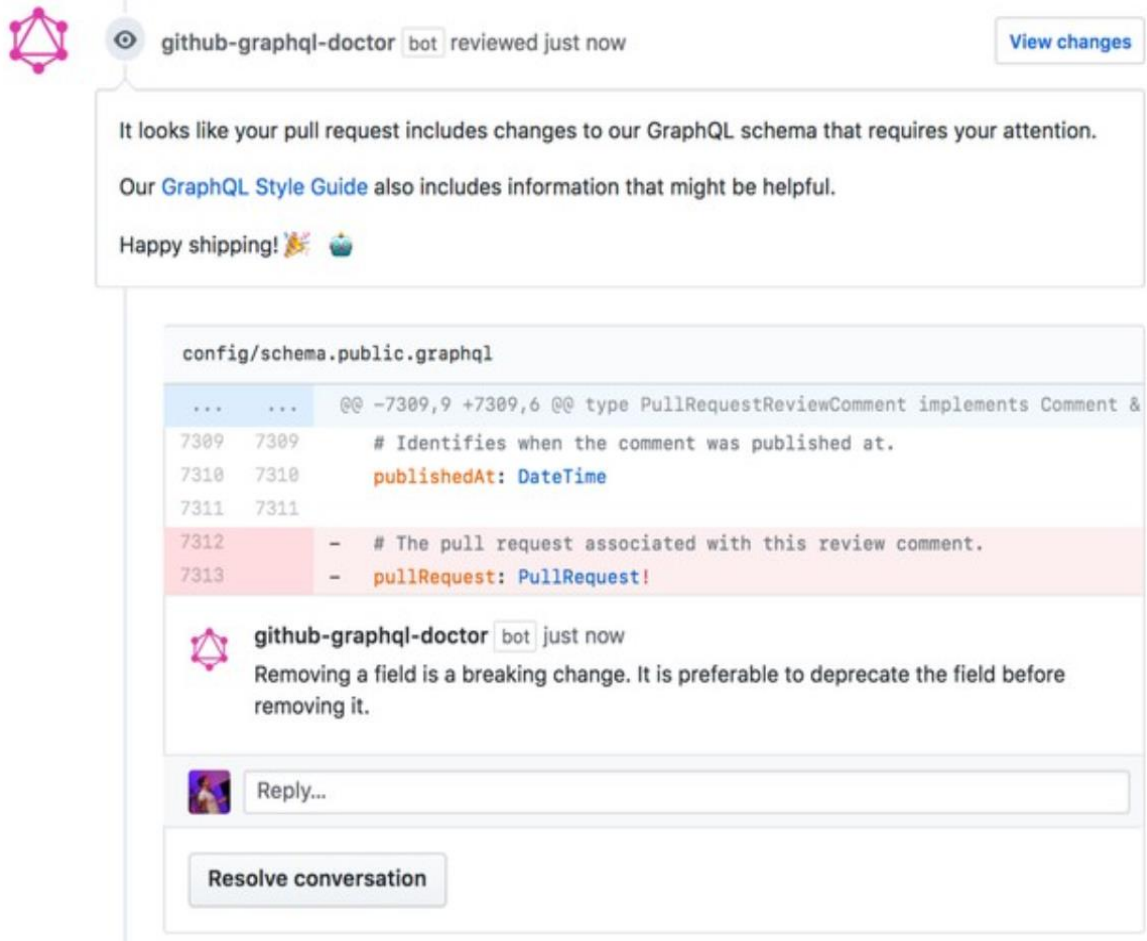
Other Best Practices for Scaling: **SCHEMA DESIGN**

- Design good GraphQL schemas helps to ensure scalability and maintainability.
- Keep the schema modular and well-organized, breaking down it into smaller, reusable components that can be easily combined to create more complex types and queries.
- Use a consistent naming convention for types and fields. This can make it easier to understand and navigate the schema, especially as it grows in size and complexity.

GraphQL-Doctor:



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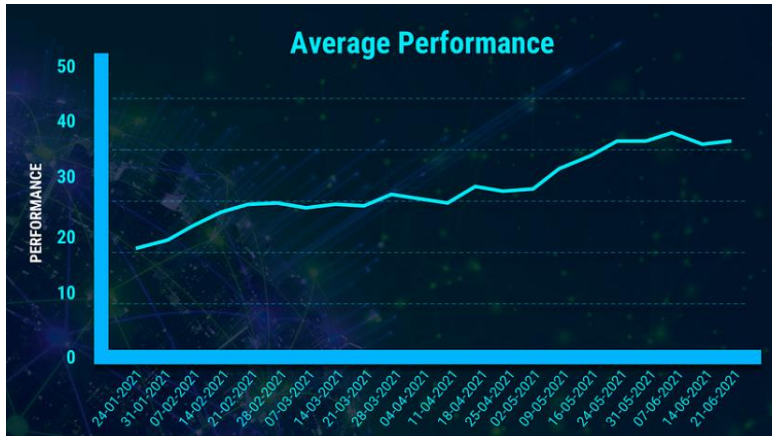
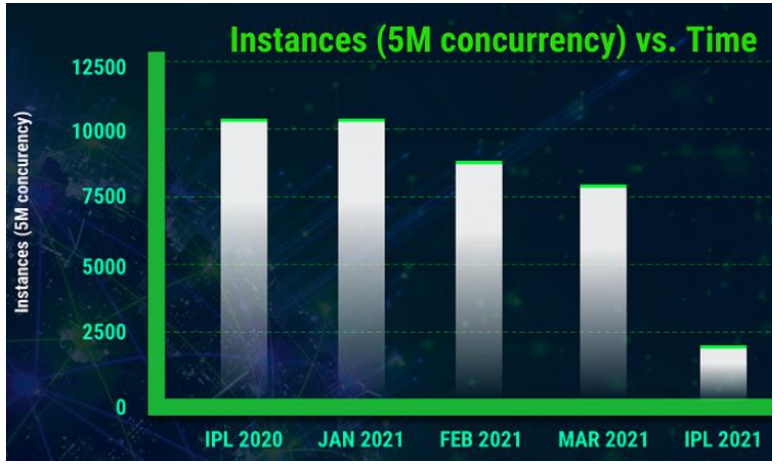
Real World Example: **Dream11 Engineering**

- Dream11 is a company that provides a “Fantasy Sports” app that has grown from just 300,000 users in 2015 to over 110 million in 2021.



- They implemented GraphQL and Scale it using a mix of different techniques:
  - Load Balancing.
  - Batching Queries.
  - Caching (Parsing and Validating Phase).
  - Monitoring and testing including benchmarking.
  - Code Changes (removing immutable code from hot points).
  - Lazy Evaluation.
  - Infrastructure tuning (weighted DNS).



- The results were increasing the performance and reducing the costs significatively.
  https://blog.dream11engineering.com/lessons-learned-from-running-graphql-at-scale-2ad60b3cefeb

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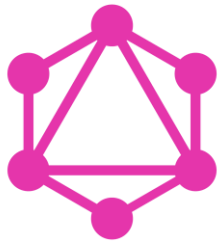
Conclusions



GraphQL is a powerful tool for **building scalable applications**. Scaling GraphQL is crucial for businesses that want to stay competitive in today's fast-paced digital landscape.

- Furthermore, the **benefits** of using GraphQL over traditional APIs for large projects are significant. With its ability to **reduce network overhead** and provide a **more flexible data mod**el, GraphQL is quickly becoming the preferred choice for developers across industries.
- By understanding the unique challenges that **arise when scaling GraphQL** applications, and **implementing best practices** such as caching strategies, batching queries, load balancing, sharding and good schema design, we can provide GraphQL APIs that are both fast and reliable and **create performant and maintainable applications**. Also monitoring and testing is highly recommended.

> However, it is important to keep in mind the **potential challenges that come with scaling**, such as increased **complexity** or single points of failure. **A mix** of horizontal and vertical scaling **would be the ideal solution**.


Questions?

Links

- https://speakerdeck.com/xuorig/continuous-evolution-of-graphql-schemas-at-github
- https://new.apollographql.com/Apollo-graphql-at-enterprise-scale-final.pdf
- https://frenzel-tim.medium.com/fast-cache-invalidation-for-graphql-with-quell-d6f61c0d69d2
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- Apollo GraphQL Server and Client:
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- Tool for caching and batching:
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- Tool for schema maintenance:
  https://github.com/cap-collectif/graphql-doctor

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