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**AUTOMATED TESTING OF WEB APPLICATIONS USING**

**GRAPHQL QUERIES: APPROACHES AND TOOLS**

**Abstract.** An effective language for manipulating APIs in web services is

called Graph Query Language, or GraphQL. It has just lately been made public as a substitute method for resolving RESTful API constraints. This article presents an

automated approach to testing GraphQL APIs. We offer an overarching framework

for testing automated APIs, including test case development and other tools. In this

paper, we perform a comprehensive analysis of the GraphQL field by first outlining the GraphQL concept and its structure, followed by an organized mapping analysis of 84 main studies chosen from a total of 525. Through a generalization of the studies and a particular classification of this research, our work examines trends or knowledge gaps regarding GraphQL. The primary findings of the study indicate that the community is increasingly adopting GraphQL as a powerful substitute for implementing APIs. However, we found that applicable business and government research needed to increase the quantity and quality of empirical evidence collected. Furthermore, we identified the need for targeted research on the majority of GraphQL components, particularly the use of GraphQL API services. GraphQL provides a single endpoint and lets clients describe exactly what data they require, in contrast to REST, which depends on several APIs to obtain data. As a result, less data is sent over the network, performance is enhanced, and client-side development is given greater latitude. Testing with GraphQL is now primarily concerned with making sure the queries and schema are accurate, while the API reacts to client

requests as intended. This may be accomplished by using both human and automated

testing techniques to ensure the queries produce the desired results and validate the

schema. The choice between REST and GraphQL depends on the specific needs of

an application and the capabilities of the API. This necessitates test engineers to

possess the capability to adapt to any type of API. Fortunately, with the assistance

of appropriate tools and approaches, the complexity of underlying technicalities can

be alleviated, making GraphQL testing a more accessible and efficient process. This

№ 13(27) 2023 article delves into the evolving landscape of API development and highlights the importance of adept testing in the GraphQL era.

**Keywords:** GraphQL, API, automated test generation, API testing, schema.

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**АВТОМАТИЗОВАНЕ ТЕСТУВАННЯ ВЕБ-ДОДАТКІВ ІЗ**

**ВИКОРИСТАННЯМ ЗАПИТІВ GRAPHQL: ПІДХОДИ ТА**

**ІНСТРУМЕНТИ**

**Анотація.** Ефективна мова для роботи з API у вебсервісах називається

Graph Query Language, або GraphQL. Нещодавно він був оприлюднений як

альтернативний метод для вирішення обмежень RESTful API. У цій статті

представлено автоматизований підхід до тестування GraphQL API. Ми

пропонуємо загальну структуру для тестування автоматизованих API,

включно з розробленням тестів та інші інструменти. У цій статті ми виконуємо

комплексний аналіз поля GraphQL, спочатку окреслюючи концепцію GraphQL

та її структуру, а далі організовуючи картографічний аналіз 84 основних

досліджень, вибраних із загальної кількості, 525. Завдяки узагальненню

досліджень і конкретній класифікації цього дослідження наша робота вивчає

тенденції або прогалини в знаннях щодо GraphQL. Основні результати

дослідження свідчать про те, що спільнота все більше приймає GraphQL як

потужну заміну впровадження API. Однак, ми з’ясували, що для збільшення

кількості та якості зібраних емпіричних доказів необхідні відповідні

дослідження бізнесу та уряду. Крім того, ми визначили потребу в

цілеспрямованому дослідженні більшості компонентів GraphQL, зокрема

використання сервісів GraphQL API. GraphQL передбачає єдину кінцеву точку

та дає клієнтам змогу точно описувати, які дані їм потрібні, на відміну від

REST, що залежить від кількох API для отримання даних. Як результат, менше

даних надсилається через мережу, продуктивність підвищується, а

розроблення клієнтської частини отримує більше можливостей. Тестування за

допомогою GraphQL тепер здебільшого пов’язане з впевненістю в тому, що

запити та схема точні, тоді як API реагує на клієнтські запити за призначенням.

Це може здійснюватися за допомогою як людських, так і автоматизованих

методів тестування, щоби переконатися, що запити надають бажані результати

та підтверджують схему. Вибір між REST і GraphQL залежить від конкретних

потреб програми та можливостей API. Це вимагає від інженерів-тестувальників здатності адаптуватися до будь-якого типу API. На щастя, за допомогою відповідних інструментів і підходів можна зменшити складність основних технічних деталей, зробивши тестування GraphQL більш доступним і ефективним процесом. Ця стаття заглиблюється в зміни характеру

розроблення API та підкреслює важливість вмілого тестування в епоху

GraphQL.

**Ключові слова**: GraphQL, API, автоматизована генерація тестів,

тестування API, схема.

Problem statement. This article focuses on the operation of GraphQL, its

significance, and recommended techniques for GraphQL testing. The lack of

research on GraphQL query techniques is a problem for developers and businesses

looking to fully utilize this technology. A concentrated effort to record and distribute

best practices, optimization techniques, and practical use cases is needed to close

this gap. In addition, encouraging cooperation only within the GraphQL community

can help to create thorough resources that are up to date with the constantly changing

GraphQL ecosystem It guarantees that developers have the direction and expertise

required to build effective and high-performing GraphQL APIs. Reducing this

disparity will support GraphQL's continuous development and prosperity as a potent

and adaptable API technology. When it comes to addressing best practices and

tactics for efficiently formulating inquiries, this gap in the literature is very

noticeable. Although GraphQL's core concepts, schema design, and usage are widely

available, few comprehensive resources offer deep insights into query speed

optimization, data fetching efficiency enhancement, and frequent query issues in

GraphQL.

There is a literature gap that emphasizes the approaches of queries. It reduces

information over- and under-fetching by enabling customers to request just the

required data. However, even with its broad use and copious documentation, there

remains a significant literature vacuum about the query strategies used in the

GraphQL ecosystem. When it comes to sharing the best practices, tactics, and

resources for efficiently designing queries, this disparity is very noticeable.

There aren't many real-world instances of best practices and query

optimization in action. GraphQL query optimization tools that can evaluate, display,

and provide recommendations for developers and organizations would be very

useful, helping close the knowledge gap by illustrating the practical applications of

query optimization techniques.

Because of the size and diversity of the GraphQL community, it may be

possible to build query optimization and efficiency analysis tools through

cooperation. Community-driven tools can encourage the dissemination of best

practices and offer approachable solutions to common problems. Developers can

contribute to accessible projects aimed at improving GraphQL query performance.

GraphQL Ecosystem Evolution and Tool Adaptation: GraphQL is constantly

changing, with new extensions, libraries, and tools appearing regularly. These

advancements affect the way queries are designed and optimized. Tools need to

change and grow with the GraphQL ecosystem to give developers current and useful

solutions.

Literature Gap in Methods for GraphQL Testing: There is a noticeable

vacuum in the literature about the approaches and techniques for automated tools of

GraphQL-based web apps, even despite the growing popularity of GraphQL in the

development of web applications. Current materials mostly concentrate on

fundamental ideas and GraphQL schema creation, and there is no extensive advice

on testing methodologies.

Need for Specialized Testing Tools: The requirement for specialist testing

tools and frameworks is necessary to handle the complexities of GraphQL-based

web apps. There may be a gap in the test automation ecosystem as GraphQL queries,

mutation, and subscriptions may not be completely supported by the testing tools

available today, which are mostly made for RESTful APIs.

Test Automation for Reliability and Efficiency: Continuous integration and

delivery (CI/CD) is made possible by automated testing, a fundamental component

of contemporary software development. Unfortunately, the effectiveness and

dependability of development pipelines are hampered by the absence of strong

automated testing methodologies and tools for GraphQL-based web applications,

which may result in quality regressions and deployment delays.

Analysis of recent research and publications. A few research provide

methods for automatically generating tests for GraphQL.

Deviation testing is a test-generating method for GraphQL developed by

Vargas et al. mentioned in [1]. Deviation testing, a type of test amplification [2],

starts with a single test and generates what are known as deviations—variations of

the test. Fields Deviation, Not Null Deviation, Type Deviation, and Empty Fields

Deviation are the four methods used to produce these deviations. Using the GraphQL

schema as a guide, the Fields Deviation technique adds or eliminates features from

the original query. The Not Null Deviation method allows an error to be raised and

changes a not null variable with null. By substituting an input that is different from

the intended type, the Type Deviation technique anticipates an error. With the Empty

Fields Deviation technique, a query's subfields and fields are all deleted, and a syntax

mistake is anticipated. Three research individuals were used to test their method, and

the findings indicated that two of them had trouble with the Empty Fields Deviation.

This method's ease of use and low effort requirements for developers make it ideal

for expanding the current test suite with the addition of new test cases. FrontApp is

unable to employ this method, though, as it lacks test cases for its GraphQL API and

still needs pre-existing manually created test cases.

Based on GraphQL schemas, Karlsson et al. developed a test-generating tool

for GraphQL [3]. Based on the fields and objects in the schema, the produced tests'

queries are generated at random. Additionally, the tool features an argument

generator, producing arguments either entirely at random or based on predetermined

categories. For instance, the tool will generate a random integer rather than a random

text if a parameter is declared to be an integer. The HTTP status message and the

kinds of returned fields are the two main properties that are tested by the suggested

method. They run the query and first assess the status code that is returned. The kinds

of the provided fields are then confirmed by comparing the answers obtained from

the query's execution with the schema. The publication, however, is not clear about

how specific their tests are about the attributes that comprise the returning objects

that are confirmed by assertions. By creating scenarios for tests based on real queries

and the responses recorded from production, our study seeks to solve the

shortcomings of the previous research by eliminating the necessity for test creation

to be done randomly.

Eventually, utilizing preexisting unit test cases, Abdi et al. [4] create new

integration test cases. They employ the knowledge from unit test cases, such as how

to create classes, build parameters for method calls, and what the anticipated

outcome is to create more complicated test cases. Rather than concentrating on

calling individual methods, these test cases highlight class relationships. This

investigation shows promising results in identifying software bugs. The earlier

studies offer new methods or standards for creating test cases that increase coverage

or identify errors.

Web applications may have complicated query patterns, including dynamic

data fetching and highly nested inquiries, thanks to GraphQL's flexibility. The

specific issues these complexities present for automated testing include verifying

query correctness, data integrity, and overall system stability.

The purpose of the article: The goal of this work is twofold: first, it

presents the unique GraphQL paradigm by conceptualizing, illustrating, and

exemplifying its constituent parts. Next, to organize the field of interest of the

scientific community and provide an overview of the topic using a publication

categorization scheme, a systematic mapping study (SMS) of GraphQL should be

carried out. Researchers and practitioners are becoming more interested in

GraphQL, a revolutionary way to develop APIs. To provide a broad overview of this

field, we begin this work by introducing a conceptual framework that describes the

referred to GraphQL framework from its formal specification. We then go on to

illustrate and exemplify its various components, which will serve as the foundation

for developing an in-depth knowledge of the GraphQL paradigm and connecting the

different elements that have been studied. As the primary focus of our study, we then

carried out a systematic literature review (SMS) to present an overview of the field's

research and identify gaps and trends in GraphQL. Our study was specifically

concerned with identifying the who, where, when, what, and why of GraphQL

research, in addition to placing the various research topics in the context of the

GraphQL paradigm that we presented. Our study's findings support the notion that,

despite GraphQL's increasing popularity as a substitute for API development, there

is not a strong scientific community supporting it. While publishing in high-profile

publications is becoming more common, there are still gaps in the literature from

recent studies, particularly when it comes to the development of empirical evidence,

validation in practical use cases, and assessment of GraphQL's underutilized features

and extra-quality attributes.

Presenting main material. In the context of API-first development,

GraphQL adoption and GraphQL testing implementation have become essential.

The necessity of functional, scalable, and maintainable code has increased

dramatically due to the increasing need for contemporary software. For SOAP and

REST architectural styles, human and automated API testing is required to facilitate

autonomous growth and isolate the front end from the backend [5].

GraphQL is being used by several digital businesses, including Facebook,

Amazon, AirBnB, GitHub, and others, in place of more conventional REST and

SOAP APIs.

GraphQL APIs are being used by major players in the industry, such as

Amazon (AWS), Twitter, Facebook, GitHub, and others, for both internal and

external operations.

GraphQL, also referred to as "SQL for APIs," is a runtime that effectively

pulls data from databases rather than just a query language. Whereas RESTful APIs

sometimes need to combine information from several server answers, GraphQL

enables apps to retrieve all relevant data with only one request.

Despite a noticeable lack of resources for GraphQL testing, this transition is

impressive. Although testing RESTful API endpoints is generally simple, there are

special issues with GraphQL because many tools now in use do not completely

support it [6].

Ensuring that GraphQL architectures are comprehensively, thoroughly, and

autonomously tested is essential to maintaining business processes and performant

APIs as the technology continues to gain adoption.

What is GraphQL? GraphQL functions as an API query language, enabling

the retrieval of data from databases to streamline the query execution process.

GraphQL uses types and fields rather than separate endpoints with predetermined

replies to get all necessary data in a single request, in contrast to REST APIs, that

rely on numerous resource URLs.

Resolvers, or GraphQL services, can be built in any programming language,

and language independence is guaranteed by the GraphQL schema language. Object

types are defined by schemas, and each one represents a fetch-able object with

related data. This provides developers with a recognizable framework [7].

Benefits of using GraphQL

Instead of creating many REST calls, the user may utilize GraphQL to make a

single call to retrieve the desired data. Here are a few benefits of utilizing GraphQL [8].

• Describe a data type: It is simple to predict the format of the data

returned from an inquiry since GraphQL queries replicate their answers. Writing a question following your application's needs is aided.

• Hierarchical by design: GraphQL naturally follows the exchange

between objects, while a RESTful service could need a SQL fancy join statement or

several round trips. Ultimately, this hierarchy works well with hierarchical user

interfaces and graph-structured information repositories.

• Firmly Typed: Each GraphQL query level correlates to a certain type,

which defines a collection of fields that may be obtained. This allows GraphQL to

provide informative error warnings before running code, much like SQL does.

• Considerate: An IDE such as GraphiQL or Relay, or statically typed

languages, can generate code on a secure platform made available by a GraphQL

server. Developers may quickly learn and inspect an API using GraphiQL without

having to dig through the codebase.

• No iterations: Because the client's query determines the form of the

return data only, servers become clear-cut and easy to understand. Typically, more

fields are introduced to the server while adding new features to the product. The

related server fields are obsolete while unsetting earlier functionality. With this slow,

backward-compatible method, an increasing version number is no longer required.

REST vs. GraphQL

Two well-liked methods for creating APIs are GraphQL and REST

(Representational State Transfer), each having advantages of its own.

An established standard called REST exposes data via a set of specified

endpoints. It works well for a wide range of applications because of its reputation

for ease of use and simplicity of caching.

However, GraphQL provides greater freedom. Clients may use GraphQL to

precisely request the data they want, which minimizes data over- and under-fetching.

It's perfect in scenarios where maximizing productivity and reducing network

queries are essential [9].

Which REST or GraphQL is better for your project will depend on its

particular needs. For more straightforward apps, REST is a good option, but

GraphQL excels when you want exact control for your API interactions.

Comprehending the distinct advantages of each might assist you in selecting the best

option for your API design [8].

Schema and Queries

The first step in implementing a GraphQL API is to define a schema using the

GraphQL schema language. This schema is a multi-graph, with objects serving as

nodes that specify types and hold lists of fields. As soon as a type specifies one of

its variables as another object, the multigraph edges become visible [10].

Querying GraphQL API

The following are the steps used how to interact with a GraphQL API via

HTTP before we can begin testing the various GraphQL components. There are

several methods available for initiating an API. I've included a few simple, oftenused methods below [5]:

• cURL: For processing data across the HTTP (and many more)

protocols, Curl is a well-liked command-line utility and library. Sending a curl

command with three arguments is required.

1) To start, since the question is a JSON string, the content-type is

application/json.

2) The second thing that will be supplied is an actual query, such as

{"query":" {movies {name}}"}.

3) Lastly, here is the GraphQL 4) endpoint: The URL is n7b67.sse.

codesandbox.io/graphql. Furthermore, the majority of GraphQL requests would be

made using the POST HTTP verb.

Components to Test in GraphQL

Here are several test kinds that might be utilized [10]:

• Query tests: Verify that a given query and its associated variables

provide the intended result.

• Ensure that a particular query and its associated variables correctly keep

information inside the database by running mutation tests.

• Load tests: Ensure the API continues functioning (per SLAs) even in

the face of a high volume of queries.

• Security tests: Verify that sensitive data is not returned via APIs without

taking the required security measures.

You should mimic replies when employing GraphQL for testing a third-party

web service (such as GitHub V4). It can shorten test run durations and help you

prevent unused consumption. To mimic these services, you may occasionally use

fixtures and mocks. But in other situations, virtualizing services could be necessary

to examine consumption and additional metrics.

GraphQL testing tools

A GraphQL server may be tested using a variety of instruments. For instance,

GraphQL servers may be tested using some of the same frameworks used for Node.js

servers. One well-liked JavaScript testing framework for testing GraphQL servers

in Node.js is called Mocha. With Mocha, you can create asynchronous tests,

sequentially execute tests, provide reports, and map the exceptions to the test cases

https://www.apollographql.com https://mochajs.org/#getting-started. There are

more frameworks available, such as Sails.js, Chai, and SuperTest. The schema itself

may be evaluated in addition to the query testing process. With Apollo's Mocking8,

it is possible to create tests using actual queries that concentrate on the schema's type

definition. By employing mocks, these tests help prevent any type of conflict.

Simulating inquiries and seeing the answer is a crucial activity. It is one benefit of

utilizing Graphene9's Test Client. It enables testing to ensure that a Django template

renders a query request with certain values. The tools listed above make it easier to

write tests for GraphQL servers [11].

Test generation techniques

Model-based testing (MBT) is one method of automated test creation where

a test oracle is created using a model of the system being tested to determine if the

test passes or fails. Various models can be employed to depict distinct components

of the system. In engineering and architecture, physical models, like models of

structures or bridges, have always been used for testing. Software system models

can characterize several facets of the system that is being tested [9]. A requirements

data model, for example, specifies the range of values that can be assigned to a

parameter. The set of acceptable and unacceptable variables that will be produced

for that variable in a test is defined by a test-generating method based on this model.

Another typical illustration of a model is the state machine, which describes a

system's behavior in terms of legitimate states that the system can reach depending

on actions taken on it. As a result, automated test creation using models like this is

feasible, where the test input is the entrance action to the state that represents the

anticipated behavior and the subsequent state is the behavior that is expected. The

GraphQL schema may be thought of as a system model for a GraphQL API [12].

New techniques or criteria for automated testing

Using a method that builds functional abstracts from test suites, authors [13]

accumulate cases till the operational abstract becomes static. They choose the test

cases using the operational difference approach after they have been prepared

to enhance fault detection.

Later, Greca et al [14] examined the variables influencing test suite

augmentation in his research and found that the approach was one of them. Xu

describes his approach for guided test suite augmentation and conducts concolic

testing as a tool for test case generation. Based on the code coverage, the findings

indicate that his approach performed more effectively and efficiently than the

concolic technique.

To separate the test code from the test input and to extend pre and postconditions, Lam et al. [15] propose test generation and mutation. It provides the

opportunity to use symbolic parameters to abstract a sizable portion of the code

input. Additionally, they use variety to determine the relevant behavior; the more

mistakes a post-condition stores, the more relevant it is.

A testing strategy based on black-box properties was presented by Karlsson

et al. [11]. The following stages make up the procedure. Initially, every type

specification together with its relationship is taken out of the schema. Using userprovided "data generators" that are tailored to their needs, data is created at random

by the schema. Furthermore, the authors provide two approaches that may be used

as automated oracles: the initial one checks the HTTP status codes that are returned,

and the second one confirms that the returned data is consistent with the specified

schema. Test GraphQL API Implementations Front-end systems and back-end APIs are separated by an abstraction layer called GraphQL. Because of this, GraphQL is necessary for testing. Multiple

backend resources may be accessed and combined into a single, meaningful result

using GraphQL queries. Because they facilitate the creation of new building pieces that may be used

for various applications, backend APIs are frequently granular. This does not imply,

however, that the intended front-end operations are carried out. GraphQL makes

working with backend data easier. A connection with schemas that define system

behavior is used to do this. Then, you may use APIs to obtain effective data.

Every GraphQL schema translates to functions, which call your backend in

turn. Calls are conducted to databases, REST APIs, and other resources necessary

for gathering the needed data by business logic.

The functions then put all the pieces together to create a response that keeps

the structure of the request. This facilitates the process of determining which data is

related to each request element.

In addition, GraphQL may be configured to call different backend services as

it puts together a query answer. This can shorten the time a user needs to spend

reading and comprehending the information returned by a request by reducing the

amount of time they spend browsing through API documentation [16].

Using GraphQL Playground

A GraphQL client is called GraphQL Playground [17]. It may be used to test

various queries, create distinct playgrounds within GraphQL IDEs, and organize

them thematically or by giving them names. Similar to GraphiQL, Playground may

generate documentation automatically without requiring you to submit and handle

introspection queries and responses by hand. Another fantastic benefit is that it

doesn't require the availability of the GraphiQL interface. The tool may be used

locally using a data file, or it can be directed to the GraphQL nodes through a URL.

You may use GraphQL Playground to immediately test for vulnerabilities instead of

sending HTTP queries through a personal proxy. This implies that you may evaluate

and interact with GraphQL in a basic way using this tool. Use an individual proxy

for additional, more sophisticated payloads.

Keep in mind that you might occasionally require altering the headers of the

HTTP request at the bottom to include an authentication method, such as a session

ID. To confirm whether authorization problems actually exist, this nevertheless

permits the creation of numerous "IDEs" with various rights.

EasyGraphQL Most functional tests in GraphQL are optimized to make sure that the

requests, modifications, and schema perform as intended on the client side. For this

kind of testing, a plethora of security testing technologies are available. You may

select the ones that work best for your language, platform, test infrastructure, and

specific testing needs.

For example, the most popular tool for functional GraphQL testing for

creating JavaScript APIs is EasyGraphQL. As a component of your automation test

toolset, you may link it with a library like Mocha and then test assertions to assess

API answers [18].

Apollo GraphQL is a full-stack platform designed for GraphQL API

development [17]. It offers frameworks and tools that make creating, maintaining,

and using GraphQL APIs easier.

The Apollo Server, an efficient and adaptable server that makes it simple to

create scalable and effective GraphQL APIs, is the central component of the Apollo

GraphQL platform. The Apollo Server facilitates seamless integration with preexisting systems by supporting a broad spectrum of data sources, such as databases,

REST APIs, and other services.

Apollo also offers several client libraries that make using GraphQL APIs

easier, such as the Apollo Client for web and mobile. The Apollo Client offers

sophisticated functionalities including caching, an optimistic user interface, realtime updates, and an easy-to-use query and mutation tool for data.

Apollo offers several more tools and services besides the Apollo Server and

Apollo Client, such as a schema maintenance system, a GraphQL analytics service,

and a collection of developer tools for creating and debugging GraphQL APIs.

The Katalon Platform

QA teams may plan, develop, execute, and diagnose automation API and UI

integration test cases with the aid of Katalon [19], a test automation platform.

Furthermore, users may create queries and changes in Java/Groovy using Script

Mode. Strong API testing capabilities are offered by Katalon, which allows you to

test REST, SOAP, and GraphQL APIs. You can test your new API schema on the

same platform as traditional API assets and import current API specifications thanks

to its connections with GraphQL tools like Postman, Swagger, and SoapUI.

• Using RESTful methods, GET and POST to create test requests and

execute;

• Complete visualization of the headers, content, and status code;

• Parameterization of query variables; and execution against the JSON

schema.

UI integration testing

Web components like buttons, dropdown menus, and input fields are arranged

inside an object repository. This is essential for updating properties and locators

globally throughout test cases.

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Additionally, there is a test recorder and keyword library for simple drag and

drop. Imagine having the ability to quickly create an automation script from your

manual testing.

Data-driven testing

Because Katalon supports several databases (MySQL, Oracle, and SQL

Server) and data formats (CSV, Excel), it makes it possible to automate API testing

with a variety of data situations. In order to link variables to the appropriate data

elements from external data sources, testers might create parameters in test scripts,

objects, or request attributes.

Create, write, execute, and evaluate

All the capabilities required for end-to-end continuous automated testing are

integrated into Katalon: Writing tests in either full-code or low-code formats,

running them in CLI mode between environments, and getting visibility through

thorough reporting are all examples of this. There's no requirement for installs or

workarounds for integration.

Auto-triggered on CI

Katalon's tool connections with Circle CI, Jenkins, and GitLab facilitate the

automation and execution of test cases within the CI/CD pipeline. Setting up UI and

API tests to run automatically guarantees that integration problems are found and

fixed quickly.

Karate

Karate is a framework for GraphQL testing that simplifies the process of

testing GraphQL APIs. It makes it simple to add variables to your searches and

supports JSON. You may use Karate's match assertions to check the answer and pass

the GraphQL query exactly as is. Among this tool's primary characteristics are [20]:

• Simple Execution: Java Runner files and maven commands may be

used to run test suites.

• Adaptability: 1. Reusable feature files and scripts that can be called by

other feature files and scripts. 2. An integrated JavaScript engine that enables the

creation of reusable JavaScript functions. Payload information and user-defined

routines can be reused throughout many tests.

• Built-In Assertions: Return response code, reaction response time,

headers, and other properties may all be validated using built-in assertions.

• Parallel Execution: Using Karate DSL, built-in multi-threaded

execution in parallel is supported.

• Integration: JUnit, TestNG, and other unit testing frameworks are

simple to integrate with.

• Performance Testing: Capability to use Gatling to test an application's

performance.

• Custom Code: Java/JS user-defined functions may be written in Karate.

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• Markers: Use markers such as #ignore, #null, #notnull, and

#boolean to demonstrate assertion capabilities.

Testing schema For schema testing, we may make use of test queries, fake schemas, and static type checks. Schema testing may be done with the libraries graphql-schema-linter and eslint-plugin-graphql6.

A tool to check the schema specification is graphql-schema-linter, and a linter

to expand ESLint rules is Est-lint-plugin-graphql. Schema testing will benefit from

mocking the schema using a mock-server using graphql-tools (a collection of npm

packages), in addition to static type checks, and paying attention to potential

combinations [21]. Testing mutations and queries Easygraphql-tester allows us to mimic queries and modifications, even though we may utilize an automated technique for query testing by utilizing the libraries "request" and "supertest.". Alternatively, we may use easygraphql-tester to explicitly construct test assertions rather than using mocking [14].

Testing Resolvers Since resolvers are pure functions, testing them is simpler. Resolvers are merely javascript functions or functions written in any programming language the GraphQL server depends on, therefore we don't require packages to test them.

Schemas provide the information that resolvers gather, thus it's important to test

them early to prevent expensive mistakes [21].

Conclusions. In 2023, GraphQL is becoming more and more popular as wellknown digital companies—not only Facebook—use it for internal as well as external

APIs. GraphQL testing doesn't have to be difficult; all it takes is the appropriate

equipment and procedures. Developers have been utilizing the classic REST

architectural API for many years, but GraphQL is rapidly taking the lead as an

alternative. It allows front-end developers to use a single API to query only the

required data. Back-end developers are using industry-standard techniques to ensure

they create scalable and fluid APIs in GraphQL due to its many advantages.

The needs of the app and the capabilities of the API are two factors that will

determine which protocol is best suited for a particular application. The ability to

deal with any kind of API is a prerequisite for a test engineer. By using an aid, the

overall burden of underlying technicalities can be reduced.

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