AWS AppSync

AWS AppSync Developer Guide

AWS AppSync: AWS AppSync Developer Guide
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Welcome

Welcome to the AWS AppSync Developer Guide. AWS AppSync is an enterprise-level, fully managed GraphQL service with real-time data synchronization and offline programming features.

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This guide focuses on using AWS AppSync to create and interact with data sources by using GraphQL from your application. Developers who want to build applications using GraphQL with robust database, search, and compute capabilities, can find the information they need to build an application or integrate existing data sources with AWS AppSync in the AWS AppSync Developer Guide.

Quick Start

This section describes how to use the AWS AppSync console to do the following:

- Launch a sample event app schema
- Automatically provision a DynamoDB data source and connect resolvers
- Write GraphQL queries and mutations
- Use the API in the sample app

AppSync provides a guided schema creation wizard (p. 41) that is recommended for first-time users who have never used GraphQL or AppSync before. Alternatively, you can import from an existing Amazon DynamoDB table to create a real-time and offline GraphQL API (p. 45) or build the entire backend with or without a pre-existing schema (p. 42).

You can also get started with AWS AppSync by writing a GraphQL schema from scratch, which can automatically provision and connect to a database for you. For more information, see Designing Your Schema (p. 11).

Topics

Launch a Sample Schema

This section describes how to use the AWS AppSync console to launch a sample schema and create and configure a GraphQL API.

Launch a Sample Schema

The Event App sample schema enables users to create an application where events (for example, “Going to the movies” or “Dinner at Mom & Dad’s”) can be entered. Application users can also comment on the events (for example, “See you at 7!”). This app demonstrates how to use GraphQL operations where state is persisted in Amazon DynamoDB.

To get started, you need to create a sample schema and provision it.

To create the API

1. Open the AWS AppSync console at https://console.aws.amazon.com/appsync/.
   - In the **Dashboard**, choose **Create API**.
2. In the bottom section list of samples, verify that **Event App** is selected. If it isn’t, select it. and choose **Start**.
3. Enter a friendly name for your API.
4. Choose **Create** and then wait for the provisioning process to finish.

Taking a Tour of the Console

After your schema is deployed and your resources are provisioned, you can use the GraphQL API in the AWS AppSync console. The first page you see is **Queries**, which contains basic queries and mutations.

The **Queries** page is a built-in designer included in the console for writing and running GraphQL queries and mutations, including introspection and documentation. That's covered in Run Queries and Mutations (p. 4).

Schema Designer

On the left side of the console, choose **Schema** to view the designer. The designer has your sample **Events** schema loaded. The code editor has linting and error checking capabilities that you can use when you write your own apps.

The right side of the console shows the GraphQL types that have been created and resolvers on different top-level types, such as queries. When adding new types to a schema (for example, `type TODO {...}`), you can have AWS AppSync provision DynamoDB resources for you. These include the proper primary key, sort key, and index design to best match your GraphQL data access pattern. If you choose **Create Resources** at the top and choose one of these user-defined types from the menu, you can choose different field options in the schema design. Don't select anything now, but try this in the future when you design a schema (p. 11).

Resolver Configuration

In the schema designer, choose one of the **resolvers** on the right, next to a field. A new page opens. This page shows the configured data source (the **Data Sources** tab of the console has a complete list) for a resolver, and the associated **Request** and **Response Mapping Template** designers. Sample mapping templates are provided for common use cases. This is also where you can configure custom logic for things such as parsing arguments from a GraphQL request, pagination token responses to clients, and custom query messages to Amazon Elasticsearch Service.

Functions and Data Sources

On the main navigation, choose **Functions**. A list of functions and the data sources that they're attached to are listed. Functions are single operations that you can run against a data source. Functions consist of a **Request Mapping Template** and a **Response Mapping Template**. The resolvers presented earlier in the sample schema are known as **Unit** resolvers. They're attached directly to a data source. You can also create a pipeline resolver, which contains one or more functions that are run in sequence on your GraphQL fields. Pipeline resolvers enable you to run operations against one or more data sources in a single network request. You can reuse logic across different resolvers, and mix or match data sources in a single resolver for different use cases (for example, authorization or data aggregation). For more information, see Pipeline Resolvers (p. 33).

Settings

On the **Settings** tab, you can configure the authorization method for your API. For more information about these options, see Security (p. 206).

Note: The default authorization mode, API_KEY, uses an API key to test the application. However, for production GraphQL APIs, you should use one of the stronger authorization modes, such as AWS Identity and Access Management with Amazon Cognito identity pools or user pools. For more information, see Security (p. 206).

Integration

The **Integration** page, summarizes the steps for setting up your API and outlines the next steps for building a client application. To locate this information, select the name of your AWS AppSync app in the navigation pane on the left side of the AWS AppSync console. In the **Getting Started** pane, find the section called **Integrate with your app**. This page provides details for using the AWS Amplify toolchain

to automate the process of connecting your API with iOS, Android, and JavaScript applications through config and code generation. The Amplify toolchain provides full support for building projects from your local workstation, including GraphQL provisioning and workflows for CI/CD.

This page also lists sample client applications (for example, JavaScript, iOS, etc.) for testing an end-to-end experience. You can clone and download these samples, and the configuration file that has the necessary information (such as your endpoint URL) you need to get started. Follow the instructions on AWS Amplify toolchain to run your app.

Run Queries and Mutations

Now that you have taken a tour of the console it's time to get more familiar with GraphQL. In the AWS AppSync console choose the **Queries** tab on the left hand side. The pane on the right side enables you to click through the operations, including queries, mutations, and subscriptions that your schema has exposed. Choose the **Mutation** node to see a mutation. You can add a new event to it as follows: `createEvent(....):Event`. Use this to add something to your database with GraphQL.

Add Data with a GraphQL Mutation

Your first step is to add more data with a GraphQL mutation. To do this, you use the `mutation` keyword and pass in the appropriate arguments (similar to how a function works). You can also select which data you want returned in the response by putting the fields inside curly braces. To get started, copy the following into the query editor and then choose **Run**:

```
mutation add {
    createEvent(
        name:"My first GraphQL event"
        where:"Day 1"
        when:"Friday night"
        description:"Catching up with friends"
    ){
        id
        name
        where
        when
        description
    }
}
```

The record is parsed by the GraphQL engine and inserted into your Amazon DynamoDB table by a resolver that is connected to a data source. (You can check this in the DynamoDB console.) Notice that you didn't need to pass in an `id`. An `id` is generated and returned in the results specified between the curly braces. As a best practice, this sample uses an `autoId()` function in a GraphQL resolver for the partition key set on your DynamoDB resources. For now, just make a note of the returned `id` value, which you'll use in the next section.

Retrieve Data with a GraphQL Query

Now that there is a record in your database, you'll get results when you run a query. One of the main advantages of GraphQL is the ability to specify the exact data requirements that your application has in a query. This time, only add a few of the fields inside the curly braces, pass the `id` argument to `getEvent()`, and then choose **Run** at the top:

```
query get {
    getEvent(id:"XXXXXX-XXXX-XXXXXXX-XXXX-XXXXXXXXX"){
```

```
        name
        where
        description
    }
}
```

This time, only the fields you specified are returned. You can also try listing all events as follows:

```
query getAllEvents {
    listEvents{
        items{
            id
            name
            when
        }
    }
}
```

This time the query shows nested types and gives the query a friendly name (`getAllEvents`), which is optional. Experiment by adding or removing, and then running the query again. When you're done, it's time to connect a client application (p. 49).

Running an Application

Now that your API is working, you can use a client application to interact with it. AWS AppSync provides samples in several programming languages to get you started. Go to the **Integration** page at the root of the console navigation on the left by selecting the **name of your API**, and you'll see a list of platforms. At the bottom clone the appropriate sample for the **Event app** to your local workstation, download the configuration file and, if necessary, use the Amplify CLI in the instructions to perform code generation with your API ID. The configuration file contains details, such as the endpoint URL of your GraphQL API and the API key, to include when getting started. You can change this information later when leveraging IAM or Amazon Cognito user pools in production. For more information, see Security (p. 206).

Next Steps

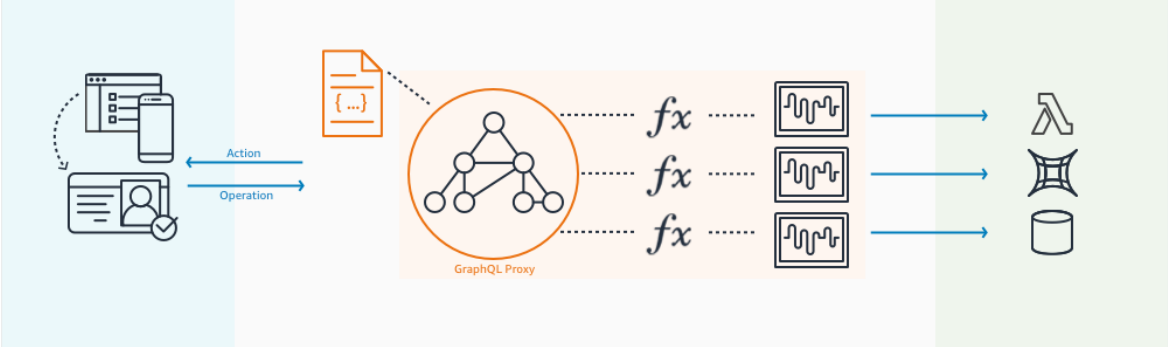
Now that you've run through the preconfigured schema, you can choose to build an API from scratch, incorporate an existing data source, or build a client application. For more information, see the following sections:

- Designing a GraphQL API (p. 10)
- Connecting Data Sources and Resolvers (p. 54)
- Building Client Applications (p. 49)

System Overview and Architecture

AWS AppSync enables developers to interact with their data by using a managed GraphQL service. GraphQL offers many benefits over traditional gateways, encourages declarative coding style, and works seamlessly with modern tools and frameworks, including React, React Native, iOS, and Android.

Architecture



Concepts

GraphQL Proxy

A component that runs the GraphQL engine for processing requests and mapping them to logical functions for data operations or triggers. The data resolution process performs a batching process (called the Data Loader) to your data sources. This component also manages conflict detection and resolution strategies.

Operation

AWS AppSync supports the three GraphQL operations: query (read-only fetch), mutation (write followed by a fetch), and subscription (long-lived requests that receive data in response to events).

Action

There is one action that AWS AppSync defines. This action is a notification to connected subscribers, which is the result of a mutation. Clients become subscribers through a handshake process following a GraphQL subscription.

Data Source

A persistent storage system or a trigger, along with credentials for accessing that system or trigger. Your application state is managed by the system or trigger defined in a data source. Examples of data sources include NoSQL databases, relational databases, AWS Lambda functions, and HTTP APIs.

Resolver

A function that converts the GraphQL payload to the underlying storage system protocol and executes if the caller is authorized to invoke it. Resolvers are comprised of request and response mapping templates, which contain transformation and execution logic.

Unit Resolver

A unit resolver is a resolver that performs a single operation against a predefined data source.

Pipeline Resolver

A pipeline resolver is a resolver that allows executing multiple operations against one or more data sources. A pipeline resolver is composed of a list of functions. Each function is executed in sequence and can execute a single operation against a predefined data source.

Function

A function defines a single operation that can be used across pipeline resolvers. Functions can be reused to perform redundant logic throughout the GraphQL Proxy. Functions are comprised of a request and a response mapping template, a data source name, and a version.

Identity

A representation of the caller based on a set of credentials, which must be sent along with every request to the GraphQL proxy. It includes permissions to invoke resolvers. Identity information is also passed as context to a resolver and the conflict handler to perform additional checks.

AWS AppSync Client

The location where GraphQL operations are defined. The client performs appropriate authorization wrapping of request statements before submitting to the GraphQL proxy. Responses are persisted in an offline store and mutations are made in a write-through pattern.

GraphQL Overview

GraphQL is a data language that was developed to enable apps to fetch data from servers. It has a declarative, self-documenting style. In a GraphQL operation, the client specifies how to structure the data when it is returned by the server. This makes it possible for the client to query only for the data it needs, in the format that it needs it in.

GraphQL has three top-level operations:

- **Query** - read-only fetch
- **Mutation** - write, followed by a fetch
- **Subscription** - long-lived connection for receiving data

GraphQL exposes these operations via a schema that defines the capabilities of an API. A schema is comprised of types, which can be root types (query, mutation, or subscription) or user-defined types. Developers start with a schema to define the capabilities of their GraphQL API, which a client application will communicate with. For more information about this process, see Designing Your Schema (p. 11).

After a schema is defined, the fields on a type need to return some data. The way this happens in a GraphQL API is through a GraphQL resolver. This is a function that either calls out to a data source or invokes a trigger to return some value (such as an individual record or a list of records). Resolvers can have many types of data sources, such as NoSQL databases, relational databases, or search engines. You can aggregate data from multiple data sources and return identical types, mixing and matching to meet your needs.

After a schema is connected to a resolver function, a client app can issue a GraphQL query or, optionally, a mutation or subscription. A query will have the `query` keyword followed by curly braces, and then the field name, such as `allPosts`. After the field name is a second set of curly braces with the data that you want to return. For example:

```
query {
 allPosts {
   id
   author
   title
   content
  }
}
```

This query invokes a resolver function against the `allPosts` field and returns just the `id`, `author`, `title`, and `content` values. If there were many posts in the system (assuming that `allPosts` return blog posts, for example), this would happen in a single network call. Though designs can vary, in traditional systems, this is usually modeled in separate network calls for each post. This reduction in network calls reduces bandwidth requirements and therefore saves battery life and CPU cycles consumed by client applications.

These capabilities make prototyping new applications, and modifying existing applications, very fast. A benefit of this is that the application's data requirements are colocated in the application with the UI code for your programming language of choice. This enables client and backend teams to work independently, instead of encoding data modeling on backend implementations.

Finally, the type system provides powerful mechanisms for pagination, relations, inheritance, and interfaces. You can relate different types between separate NoSQL tables when using the GraphQL type system.

For further reading, see the following resources:

- GraphQL
- Designing a GraphQL API (p. 10)
- Data Sources and Resolvers Tutorial (p. 54)

Designing a GraphQL API

If you are building a GraphQL API, there are some concepts you need to know, such as schema design and how to connect to data sources.

In this section, we show you how to build a schema from scratch, provision resources automatically, manually define a data source, and connect to it with a GraphQL resolver. AWS AppSync can also build out a schema and resolvers from scratch, if you have an existing Amazon DynamoDB table (p. 45) or build the entire backend with or without a pre-existing schema (p. 42). Additionally, AWS AppSync provides a guided schema creation wizard (p. 41) that is recommended for first-time GraphQL or AWS AppSync users.

GraphQL Schema

Each GraphQL API is defined by a single GraphQL schema. The GraphQL Type system describes the capabilities of a GraphQL server and is used to determine if a query is valid. A server's type system is referred to as that server's schema. It is made up of a set of object types, scalars, input types, interfaces, enums, and unions. It defines the shape of the data that flows through your API and also the operations that can be performed. GraphQL is a strongly typed protocol and all data operations are validated against this schema.

Data Source

Data sources are resources in your AWS account that GraphQL APIs can interact with. AWS AppSync supports AWS Lambda, Amazon DynamoDB, relational databases (Amazon Aurora Serverless), Amazon Elasticsearch Service, and HTTP endpoints as data sources.

An AWS AppSync API can be configured to interact with multiple data sources, enabling you to aggregate data in a single location. AWS AppSync can use AWS resources from your account that already exist or can provision DynamoDB tables on your behalf from a schema definition.

Resolvers

GraphQL resolvers connect the fields in a type's schema to a data source. Resolvers are the mechanism by which requests are fulfilled. AWS AppSync can automatically create and connect resolvers (p. 42) from a schema or create a schema and connect resolvers from an existing table (p. 45) without you needing to write any code.

Resolvers in AWS AppSync use mapping templates written in Apache Velocity Template Language (VTL) to convert a GraphQL expression into a format the data source can use.

An introductory tutorial-style programming guide for writing resolvers can be found in Resolver Mapping Template Programming Guide (p. 230) and helper utilities available to use when programming can be found in Resolver Mapping Template Context Reference (p. 241). AWS AppSync also has built-in test and debug flows that you can use when you're editing or authoring from scratch. For more information, see Test and Debug Resolvers (p. 31).

Topics

Designing Your Schema

Creating an Empty Schema

Schema files are text files, usually named `schema.graphql`. You can create this file and submit it to AWS AppSync by using the CLI or navigating to the console and adding the following under the **Schema** page:

```
schema {
}
```

Every schema has this root for processing. This fails to process until you add a root query type.

Adding a Root Query Type

For this example, we create a `Todo` application. A GraphQL schema must have a root query type, so we add a root type named `Query` with a single `getTodos` field that returns a list containing `Todo` objects. Add the following to your `schema.graphql` file:

```
schema {
    query:Query
}

type Query {
    getTodos: [Todo]
}
```

Notice that we haven't yet defined the `Todo` object type. Let's do that now.

Defining a Todo Type

Now, create a type that contains the data for a `Todo` object:

```
schema {
    query:Query
}

type Query {
    getTodos: [Todo]
}

type Todo {
    id: ID!
    name: String
    description: String
    priority: Int
}
```

Notice that the `Todo` object type has fields that are scalar types, such as strings and integers. AWS AppSync also has enhanced Scalar types in AWS AppSync (p. 15) in addition to the base GraphQL scalars that you can use in a schema. Any field that ends in an exclamation point is a required field. The `ID` scalar type is a unique identifier that can be either `String` or `Int`. You can control these in your resolver mapping templates for automatic assignment, which is covered later.

There are similarities between the `Query` and `Todo` types. In GraphQL, the root types (that is, `Query`, `Mutation`, and `Subscription`) are similar to the ones you define, but they're different in that you

expose them from your schema as the entry point for your API. For more information, see The Query and Mutation types.

Adding a Mutation Type

Now that you have an object type and can query the data, if you want to add, update, or delete data via the API you need to add a mutation type to your schema. For the `Todo` example, add this as a field named `addTodo` on a mutation type:

```
schema {
    query:Query
    mutation: Mutation
}

type Query {
    getTodos: [Todo]
}

type Mutation {
    addTodo(id: ID!, name: String, description: String, priority: Int): Todo
}

type Todo {
    id: ID!
    name: String
    description: String
    priority: Int
}
```

Note that the mutation is also added to this schema type because it is a root type.

Modifying the Todo Example with a Status

At this point, your GraphQL API is functioning structurally for reading and writing Todo objects–it just doesn't have a data source, which is described in the next section. You can modify this API with more advanced functionality, such as adding a status to your Todo, which comes from a set of values defined as an `ENUM`:

```
schema {
    query:Query
    mutation: Mutation
}

type Query {
    getTodos: [Todo]
}

type Mutation {
    addTodo(id: ID!, name: String, description: String, priority: Int, status: TodoStatus):
 Todo
}

type Todo {
    id: ID!
    name: String
    description: String
    priority: Int
    status: TodoStatus
}
```

```
enum TodoStatus {
    done
    pending
}
```

Choose **Save Schema**.

An `ENUM` is like a string, but it can take one of a set of values. In the previous example, you added this type, modified the Todo type, and added the Todo field to contain this functionality.

Note: You can skip directly to Attaching a Data Source (p. 26) and begin connecting your schema to a data source now, or keep reading to modify your schema with paginations and relational structure.

Subscriptions

Subscriptions in AWS AppSync are invoked as a response to a mutation. You configure this with a `Subscription` type and `@aws_subscribe()` directive in the schema to denote which mutations invoke one or more subscriptions. For more information about configuring subscriptions, see Real-Time Data (p. 165).

Further Reading

For more information, see the GraphQL type system.

Advanced - Relations and Pagination

Suppose you had a million `todos`. You wouldn't want to fetch all of these every time, instead you would want to paginate through them. Make the following changes to your schema:

- To the `getTodos` field, add two input arguments: `limit` and `nextToken`.
- Add a new `TodoConnection` type that has `todos` and `nextToken` fields.
- Change `getTodos` so that it returns `TodoConnection` (not a list of Todos).

```
schema {
    query:Query
    mutation: Mutation
}

type Query {
    getTodos(limit: Int, nextToken: String): TodoConnection
}

type Mutation {
    addTodo(id: ID!, name: String, description: String, priority: Int, status: TodoStatus):
 Todo
}

type Todo {
    id: ID!
    name: String
    description: String
    priority: Int
    status: TodoStatus
}

type TodoConnection {
    todos: [Todo]
```

```
    nextToken: String
}

enum TodoStatus {
    done
    pending
}
```

The `TodoConnection` type allows you to return a list of `todos` and a `nextToken` for getting the next batch of `todos`. Note that it is a single `TodoConnection` and not a list of connections. Inside the connection is a list of todo items (`[Todo]`) which gets returned with a pagination token. In AWS AppSync, this is connected to Amazon DynamoDB with a mapping template and automatically generated as an encrypted token. This converts the value of the `limit` argument to the `maxResults` parameter and the `nextToken` argument to the `exclusiveStartKey` parameter. For examples and the built-in template samples in the AWS AppSync console, see Resolver Mapping Template Reference (p. 226).

Next, suppose your todos have comments, and you want to run a query that returns all the comments for a `todo`. This is handled through `GraphQL connections`, as you created in the previous schema. Modify your schema to have a `Comment` type, add a `comments` field to the `Todo` type, and add an `addComment` field on the `Mutation` type as follows:

```
schema {
  query: Query
  mutation: Mutation
}

 type Query {
     getTodos(limit: Int, nextToken: String): TodoConnection
 }

 type Mutation {
     addTodo(id: ID!, name: String, description: String, priority: Int, status:
 TodoStatus): Todo
     addComment(todoid: ID!, content: String): Comment
 }

 type Comment {
     todoid: ID!
     commentid: String!
     content: String
 }

 type Todo {
     id: ID!
     name: String
     description: String
     priority: Int
     status: TodoStatus
     comments: [Comment]
 }

 type TodoConnection {
     todos: [Todo]
     nextToken: String
 }

 enum TodoStatus {
     done
     pending
 }
```

Choose **Save Schema**.

Note that the `Comment` type has the `todoid` that it's associated with, `commentid`, and `content`. This corresponds to a primary key + sort key combination in the Amazon DynamoDB table you create later.

The application graph on top of your existing data sources in AWS AppSync enables you to return data from two separate data sources in a single GraphQL query. In the example, the assumption is that there is both a Todos table and a Comments table. We'll show how to do this in Attaching a Data Source (p. 26) and Configuring Resolvers (p. 27).

Scalar types in AWS AppSync

A GraphQL object type has a name and fields, which must resolve to some concrete data. That's where the scalar types come in: they represent the leaves of the query. AppSync comes with a set of scalar types that can be used right out of the box, including a set of reserved types starting with an *AWS* prefix. AWS AppSync does not support custom scalar types.

Note: You cannot use *AWS* as a prefix for custom object types.

GraphQL Scalars

ID

The `ID` scalar type represents a unique identifier, often used to refetch an object or as the key for a cache. The ID type is serialized in the same way as a String, however, defining a field as an ID signifies that it is not intended to be human-readable.

String

The `String` scalar type represents textual data, represented as UTF-8 character sequences. The String type is most often used by GraphQL to represent free-form human-readable text.

Int

The `Int` scalar type represents non-fractional signed whole numeric values. Int can represent values between -(2^31) and 2^31 - 1.

Float

The `Float` scalar type represents signed double-precision fractional values as specified by IEEE 754.

Boolean

The `Boolean` scalar type represents a boolean value of either `true` or `false`.

AppSync Defined Scalars

AWSDate

The `AWSDate` scalar type represents a valid **extended** ISO 8601 Date string. In other words, this scalar type accepts date strings of the form `YYYY-MM-DD`. This scalar type can also accept time zone offsets. For example, `1970-01-01Z`, `1970-01-01-07:00` and `1970-01-01+05:30` are all valid dates. The time zone offset must either be `Z` (representing the UTC time zone) or be in the format `±hh:mm:ss`. The seconds field in the timezone offset will be considered valid even though it is not part of the ISO 8601 standard.

AWSTime

The `AWSTime` scalar type represents a valid **extended** ISO 8601 Time string. In other words, this scalar type accepts time strings of the form `hh:mm:ss.sss`. The field after the seconds field is a nanoseconds

field. It can accept between 1 and 9 digits. The seconds and nanoseconds fields are optional (the seconds field must be specified if the nanoseconds field is to be used). This scalar type can also accept time zone offsets. For example, `12:30Z`, `12:30:24-07:00` and `12:30:24.500+05:30` are all valid time strings. The time zone offset must either be `Z` (representing the UTC time zone) or be in the format `±hh:mm:ss`. The seconds field in the timezone offset will be considered valid even though it is not part of the ISO 8601 standard.

AWSDateTime

The `AWSDateTime` scalar type represents a valid **extended** ISO 8601 DateTime string. In other words, this scalar type accepts datetime strings of the form `YYYY-MM-DDThh:mm:ss.sssZ`. The field after the seconds field is a nanoseconds field. It can accept between 1 and 9 digits. The seconds and nanoseconds fields are optional (the seconds field must be specified if the nanoseconds field is to be used). The time zone offset is compulsory for this scalar. The time zone offset must either be `Z` (representing the UTC time zone) or be in the format `±hh:mm:ss`. The seconds field in the timezone offset will be considered valid even though it is not part of the ISO 8601 standard.

AWSTimestamp

The `AWSTimestamp` scalar type represents the number of seconds that have elapsed since `1970-01-01T00:00Z`. Timestamps are serialized and deserialized as numbers. Negative values are also accepted and these represent the number of seconds until `1970-01-01T00:00Z`.

AWSEmail

The `AWSEmail` scalar type represents an Email address string that complies with RFC 822. For example, **username@example.com** is a valid Email address.

AWSJSON

The `AWSJSON` scalar type represents a JSON string that complies with RFC 8259.

Maps like **{"upvotes": 10}**, lists like **[1,2,3]**, and scalar values like **"AWSJSON example string"**, **1**, and **true** are accepted as valid JSON. They will automatically be parsed and loaded in the resolver mapping templates as Maps, Lists, or Scalar values rather than as the literal input strings. Invalid JSON strings like **{a: 1}**, **{'a': 1}** and **Unquoted string** will throw GraphQL validation errors.

AWSURL

The `AWSURL` scalar type represents a valid URL string. The URL may use any scheme and may also be a local URL (for example, `<https://localhost/>`). URLs without schemes are considered invalid. URLs which contain double slashes are also considered invalid.

AWSPhone

The `AWSPhone` scalar type represents a valid Phone Number. Phone numbers are serialized and deserialized as Strings. Phone numbers provided may be whitespace delimited or hyphenated. The number can specify a country code at the beginning but this is not required for US phone numbers.

AWSIPAddress

The `AWSIPAddress` scalar type represents a valid IPv4 or IPv6 address string.

Example Schema Usage

If you are unfamiliar with creating GraphQL APIs in AWS AppSync, or connecting resolvers with Mapping Templates, please first review Designing a GraphQL API (p. 10) and Connecting Data Sources and Resolvers (p. 54) before moving forward.

Below we show a sample GraphQL schema which uses all of the custom scalars as an "object" as well as the resolver request and response templates for simple put, get, and list operations. Finally we show how this can be used when executing queries and mutations.

```
type Mutation {
    putObject(
        email: AWSEmail,
        json: AWSJSON,
        date: AWSDate,
        time: AWSTime,
        datetime: AWSDateTime,
        timestamp: AWSTimestamp,
        url: AWSURL,
        phoneno: AWSPhone,
        ip: AWSIPAddress
    ): Object
}

type Object {
    id: ID!
    email: AWSEmail
    json: AWSJSON
    date: AWSDate
    time: AWSTime
    datetime: AWSDateTime
    timestamp: AWSTimestamp
    url: AWSURL
    phoneno: AWSPhone
    ip: AWSIPAddress
}

type Query {
    getObject(id: ID!): Object
    listObjects: [Object]
}

schema {
    query: Query
    mutation: Mutation
}
```

Use the following **request** template for `putObject`:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        "id": $util.dynamodb.toDynamoDBJson($util.autoId()),
    },
    "attributeValues" : $util.dynamodb.toMapValuesJson($ctx.args)
}
```

The **response** template for `putObject` will be:

```
$util.toJson($ctx.result)
```

Use the following **request** template for `getObject`:

```
{
    "version": "2017-02-28",
    "operation": "GetItem",
    "key": {
```

```
        "id": $util.dynamodb.toDynamoDBJson($ctx.args.id),
    }
}
```

The **response** template for `getObject` will be:

```
$util.toJson($ctx.result)
```

Use the following **request** template for `listObjects`:

```
{
    "version" : "2017-02-28",
    "operation" : "Scan",
}
```

The **response** template for `listObjects` will be:

```
$util.toJson($ctx.result.items)
```

Some examples of using this schema with GraphQL queries are below:

```
mutation CreateObject {
    putObject(email: "nadiabailey@amazon.com"
        json: "{\"a\":1, \"b\":3, \"string\": 234}"
        date: "1970-01-01Z"
        time: "12:00:34."
        datetime: "1930-01-01T16:00:00-07:00"
        timestamp: -123123
        url:"https://amazon.co.in"
        phoneno: "+91 704-011-2342"
        ip: "127.0.0.1/8"
    ) {
        id
        email
        json
        date
        time
        datetime
        url
        timestamp
        phoneno
        ip
    }
}

query getObject {
    getObject(id:"0d97daf0-48e6-4ffc-8d48-0537e8a843d2"){
        email
        url
        timestamp
        phoneno
        ip
    }
}

query listObjects {
    listObjects {
        json
        date
        time
        datetime
```

```
    }
}
```

Interfaces and unions in GraphQL

This topic provides an overview of interface and union types in GraphQL.

Interfaces

The GraphQL type system supports Interfaces. An interface exposes a certain set of fields that a type must include to implement the interface. If you are just getting started with GraphQL, you should return to this topic at a later time when you want to evolve your schema or add more features. To simplify getting started with GraphQL, learn how to automatically create and connect resolvers (p. 42) from a schema.

For example, we could represent an `Event` interface that represents any kind of activity or gathering of people. Possible kinds of events are `Concert`, `Conference`, and `Festival`. These types all share common characteristics, including a name, a venue where the event is taking place, and a start and end date. These types also have differences, a `Conference` offers a list of speakers and workshops, while a `Concert` features a performing band.

In Schema Definition Language (SDL), the `Event` interface is defined as follows:

```
interface Event {
        id: ID!
        name : String!
        startsAt: String
        endsAt: String
        venue: Venue
        minAgeRestriction: Int
}
```

And each of the types implements the `Event` interface as follows:

```
type Concert implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
    performingBand: String
}

type Festival implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
    performers: [String]
}

type Conference implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
```

```
    minAgeRestriction: Int
    speakers: [String]
    workshops: [String]
}
```

Interfaces are useful to represent elements that might be of several types. For example, we could search for all events happening at a specific venue. Let's add a `findEventsByVenue` field to the schema as follows:

```
schema {
    query: Query
}

type Query {
    # Retrieve Events at a specific Venue
    findEventsAtVenue(venueId: ID!): [Event]
}

type Venue {
    id: ID!
    name: String
    address: String
    maxOccupancy: Int
}

type Concert implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
    performingBand: String
}

interface Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
}

type Festival implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
    performers: [String]
}

type Conference implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
    speakers: [String]
    workshops: [String]
}
```

`findEventsByVenue` returns a list of `Event`. Because GraphQL interface fields are common to all the implementing types, it's possible to select any fields on the `Event` interface (`id`, `name`, `startsAt`, `endsAt`, `venue`, and `minAgeRestriction`). Additionally, you can access the fields on any implementing type using GraphQL fragments, as long as you specify the type.

Let's examine an example of a GraphQL query that uses the interface.

```
query {
  findEventsAtVenue(venueId: "Madison Square Garden") {
    id
    name
    minAgeRestriction
    startsAt

    ... on Festival {
      performers
    }

    ... on Concert {
      performingBand
    }

    ... on Conference {
      speakers
      workshops
    }
  }
}
```

The previous query yields a single list of results, and the server could sort the events by start date by default.

```
{
  "data": {
    "findEventsAtVenue": [
      {
        "id": "Festival-2",
        "name": "Festival 2",
        "minAgeRestriction": 21,
        "startsAt": "2018-10-05T14:48:00.000Z",
        "performers": [
          "The Singers",
          "The Screamers"
        ]
      },
      {
        "id": "Concert-3",
        "name": "Concert 3",
        "minAgeRestriction": 18,
        "startsAt": "2018-10-07T14:48:00.000Z",
        "performingBand": "The Jumpers"
      },
      {
        "id": "Conference-4",
        "name": "Conference 4",
        "minAgeRestriction": null,
        "startsAt": "2018-10-09T14:48:00.000Z",
        "speakers": [
          "The Storytellers"
        ],
        "workshops": [
          "Writing",
          "Reading"
```

```
        ]
      }
    ]
  }
}
```

Since results are returned as a single collection of events, using interfaces to represent common characteristics is very helpful for sorting results.

Unions

The GraphQL type system also supports Unions. Unions are identical to interfaces, except that they don't define a common set of fields. Unions are generally preferred over interfaces when the possible types do not share a logical hierarchy.

For example, a search result might represent many different types. Using the `Event` schema, you can define a `SearchResult` union as follows:

```
type Query {
    # Retrieve Events at a specific Venue
    findEventsAtVenue(venueId: ID!): [Event]
    # Search across all content
    search(query: String!): [SearchResult]
}

union SearchResult = Conference | Festival | Concert | Venue
```

In this case, to query any field on our `SearchResult` union, you must use fragments. Let's examine the following example:

```
query {
  search(query: "Madison") {
    ... on Venue {
      id
      name
      address
    }

    ... on Festival {
      id
      name
      performers
    }

    ... on Concert {
      id
      name
      performingBand
    }

    ... on Conference {
      speakers
      workshops
    }
  }
}
```

Type resolution in AWS AppSync

Type resolution is the mechanism by which the GraphQL engine identifies a resolved value as a specific object type.

Coming back to the union search example, provided our query yielded results, each item in the results list must present itself as one of the possible types that the `SearchResult` union defined (that is, `Conference`, `Festival`, `Concert`, or `Venue`).

Because the logic to identify a `Festival` from a `Venue` or a `Conference` is dependent on the application requirements, the GraphQL engine must be given a hint to identify our possible types from the raw results.

With AWS AppSync, this hint is represented by a meta field named `__typename`, whose value corresponds to the identified object type name. `__typename` is required for return types that are interfaces or unions.

Type resolution example

Let's reuse the previous schema. You can follow along by navigating to the console and adding the following under the **Schema** page:

```
schema {
    query: Query
}

type Query {
    # Retrieve Events at a specific Venue
    findEventsAtVenue(venueId: ID!): [Event]
    # Search across all content
    search(query: String!): [SearchResult]
}

union SearchResult = Conference | Festival | Concert | Venue

type Venue {
    id: ID!
    name: String!
    address: String
    maxOccupancy: Int
}

interface Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
}

type Festival implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
    performers: [String]
}

type Conference implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
```

```
    speakers: [String]
    workshops: [String]
}

type Concert implements Event {
    id: ID!
    name: String!
    startsAt: String
    endsAt: String
    venue: Venue
    minAgeRestriction: Int
    performingBand: String
}
```

Let's attach a resolver to the `Query.search` field. In the console, choose **Attach Resolver**, create a new **Data Source** of type *NONE*, and then name it *StubDataSource*. For the sake of this example, we'll pretend we fetched results from an external source, and hard code the fetched results in the request mapping template.

In the request mapping template pane, enter the following:

```
{
    "version" : "2018-05-29",
    "payload":
    ## We are effectively mocking our search results for this example
    [
        {
            "id": "Venue-1",
            "name": "Venue 1",
            "address": "2121 7th Ave, Seattle, WA 98121",
            "maxOccupancy": 1000
        },
        {
            "id": "Festival-2",
            "name": "Festival 2",
            "performers": ["The Singers", "The Screamers"]
        },
        {
            "id": "Concert-3",
            "name": "Concert 3",
            "performingBand": "The Jumpers"
        },
        {
            "id": "Conference-4",
            "name": "Conference 4",
            "speakers": ["The Storytellers"],
            "workshops": ["Writing", "Reading"]
        }
    ]
}
```

If the application returns the type name as part of the `id` field, the type resolution logic must parse the `id` field to extract the type name and then add the `__typename` field to each of the results. You can perform that logic in the response mapping template as follows:

Note: You can also perform this task as part of your Lambda function, if you are using the Lambda data source.

```
#foreach ($result in $context.result)
    ## Extract type name from the id field.
    #set( $typeName = $result.id.split("-")[0] )
    #set( $ignore = $result.put("__typename", $typeName))
```

```
#end
$util.toJson($context.result)
```

Run the following query:

```
query {
  search(query: "Madison") {
    ... on Venue {
      id
      name
      address
    }

    ... on Festival {
        id
      name
      performers
    }

    ... on Concert {
      id
      name
      performingBand
    }

    ... on Conference {
      speakers
      workshops
    }
  }
}
```

The query yields the following results:

```
{
  "data": {
    "search": [
      {
        "id": "Venue-1",
        "name": "Venue 1",
        "address": "2121 7th Ave, Seattle, WA 98121"
      },
      {
        "id": "Festival-2",
        "name": "Festival 2",
        "performers": [
          "The Singers",
          "The Screamers"
        ]
      },
      {
        "id": "Concert-3",
        "name": "Concert 3",
        "performingBand": "The Jumpers"
      },
      {
        "speakers": [
          "The Storytellers"
        ],
        "workshops": [
          "Writing",
          "Reading"
        ]
```

```
      }
    ]
  }
}
```

The type resolution logic varies depending on the application. For example, you could have a different identifying logic that checks for the existence of certain fields or even a combination of fields. That is, you could detect the presence of the `performers` field to identify a `Festival` or the combination of the `speakers` and the `workshops` fields to identify a `Conference`. Ultimately, it is up to you to define the logic you want to use.

Attaching a Data Source

(Recommended) Automatic Provision

Continuing on from Designing Your Schema (p. 11), you can have AWS AppSync automatically create tables based on your schema definition. This is an optional step, but recommended step if you are just getting started. AWS AppSync also creates all resolvers for you during this process and you can immediately write GraphQL queries, mutations, and subscriptions. You can follow this process in (Optional) Provision from Schema (p. 42). The rest of this tutorial assumes you are skipping the automatic provisioning process and building from scratch.

Adding a Data Source

Now that you created a schema in the AWS AppSync console and saved it, you can add a data source. The schema in the previous section assumes that you have a Amazon DynamoDB table called `Todos` with a primary key called **id** of type **String**. You can create this manually in the Amazon DynamoDB console or using the following AWS CloudFormation stack:

To add your data source

1. Choose the **Data Sources** tab in the console, and then choose **New**.
   - Give your data source a friendly name, such as `TodosTable`.
2. Choose **Amazon DynamoDB Table** as the type.
   - Choose the appropriate region.
3. Choose your **Todos** table. Then either create a new role (recommended) or choose an existing role that has IAM permissions for `PutItem` and scan for your table. Existing roles need a trust policy, as explained later.
4. If you have existing tables, you could also generate CRUD, List, and Query operations automatically by selecting **Automatically generate GraphQL** as outlined in (Optional) Import from Amazon DynamoDB (p. 45) but for this tutorial leave it unselected.

If you aren't following the advanced part of the tutorial where your schema uses pagination and relations (with GraphQL connections), you can go directly to Configuring Resolvers (p. 27).

If you're doing the advanced section with pagination and relations, you need to repeat the above with a table named `Comments` with a primary key of **todoid** and a sort key of **commentid**, where both are of type **String**. Additionally, you must create a global secondary index on the table called **todoid-index**

with a partition key **todoid** of type **String**. You can create this manually in the Amazon DynamoDB console or using the following AWS CloudFormation stack:

You need IAM permissions of code:*PutItem* and code:*Query* on the Comments table. We recommend you use **create new role** as shown previously.

Now that you've connected a data source, you can connect it to your schema with a resolver. Move onto Configuring Resolvers (p. 27).

IAM Trust Policy

If you're using an existing IAM role for your data source, you need to grant that role the appropriate permissions to perform operations on your AWS resource, such as `PutItem` on an Amazon DynamoDB table. You also need to modify the trust policy on that role to allow AWS AppSync to use it for resource access as shown in the following example policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
        "Effect": "Allow",
        "Principal": {
            "Service": "appsync.amazonaws.com"
        },
        "Action": "sts:AssumeRole"
        }
    ]
}
```

Configuring Resolvers

In this section, you walk through how to create a resolver, add a resolver for mutations, and use advanced configurations.

Create Your First Resolver

In the AWS AppSync console, go to the **Schema** page. In the **Query** type on the right side, choose **Attach resolver** next to the `getTodos` field. On the **Create Resolver** page, choose the data source you just created, and then choose a default template or paste in your own. For common use cases, the AWS AppSync console has built-in templates that you can use for getting items from data sources (for example, all item queries, individual lookups, etc.). For example, on the simple version of the schema from Designing Your Schema (p. 11) where `getTodos` didn't have pagination, the mapping template is as follows:

```
{
    "version" : "2017-02-28",
    "operation" : "Scan"
}
```

You always need a response mapping template. The console provides a default with the following passthrough value for lists:

```
$util.toJson($context.result.items)
```

In this example, the `context` object (aliased as `$ctx`) for lists of items has the form `$context.result.items`. If your GraphQL operation returns a single item, it would be `$context.result`. AWS AppSync provides helper functions for common operations, such as the `$util.toJson` function listed previously, to format responses properly. For a full list of functions, see Resolver Mapping Template Utility Reference (p. 248).

Note: The default resolver you have just created is a **Unit** resolver, but AppSync also supports creating **Pipeline** resolvers to run operations against multiple data sources in a sequence. See Pipeline Resolvers (p. 33) for more information.

Adding a Resolver for Mutations

Repeat the preceding process, starting at the **Schema** page and choosing **Attach resolver** for the `addTodo` mutation. Because this is a mutation where you're adding a new item to DynamoDB, use the following request mapping template:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    },
    "attributeValues" : $util.dynamodb.toMapValuesJson($ctx.args)
}
```

AWS AppSync automatically converts arguments defined in the `addTodo` field from your GraphQL schema into DynamoDB operations. The previous example stores records in DynamoDB using a key of `id`, which is passed through from the mutation argument as `$ctx.args.id`. All of the other fields you pass through are automatically mapped to DynamoDB attributes with `$util.dynamodb.toMapValuesJson($ctx.args)`.

For this resolver, use the following response mapping template:

```
$utils.toJson($context.result)
```

AWS AppSync also supports test and debug workflows for editing resolvers. You can use a mock `context` object to see the transformed value of the template before invoking. Optionally, you can view the full request execution to a data source interactively when you run a query. For more information, see Test and Debug Resolvers (p. 31) and Monitoring and Logging (p. 190).

At this point, if you're not using the advanced resolvers you can begin using your GraphQL API as outlined in Using Your API (p. 39).

Advanced Resolvers

If you are following the Advanced section and you're building a sample schema in Designing Your Schema (p. 11) to do a paginated scan, use the following request template for the `getTodos` field:

```
{
    "version" : "2017-02-28",
    "operation" : "Scan",
    "limit": $util.defaultIfNull(${ctx.args.limit}, 20),
    "nextToken": $util.toJson($util.defaultIfNullOrBlank($ctx.args.nextToken, null))
```

```
}
```

For this pagination use case, the response mapping is more than just a passthrough because it must contain both the *cursor* (so that the client knows what page to start at next) and the result set. The mapping template is as follows:

```
{
    "todos": $util.toJson($context.result.items),
    "nextToken": $util.toJson($context.result.nextToken)
}
```

The fields in the preceding response mapping template should match the fields defined in your `TodoConnection` type.

For the case of relations where you have a Comments table and you're resolving the comments field on the Todo type (which returns a type of `[Comment]`), you can use a mapping template that runs a query against the second table. To do this, you must have already created a data source for the Comments table as outlined in Attaching a Data Source (p. 26).

Note: We're using a query operation against a second table for illustrative purposes only. You could use another operation against DynamoDB instead. Further, you could pull the data from another data source, such as AWS Lambda or Amazon Elasticsearch Service, because the relation is controlled by your GraphQL schema.

On the **Schema** page in the console, choose the `comments` field in **Todo type**, and then choose **Attach**. Choose **Comments table data source** and use the following request mapping template:

```
{
    "version": "2017-02-28",
    "operation": "Query",
    "index": "todoid-index",
    "query": {
        "expression": "todoid = :todoid",
        "expressionValues": {
            ":todoid": {
                "S": $util.toJson($context.source.id)
            }
        }
    }
}
```

The `context.source` references the parent object of the current field that's being resolved. In this example, `source.id` refers to the individual `Todo` object, which is then used for the query expression.

You can use the passthrough response mapping template as follows:

```
$util.toJson($ctx.result.items)
```

Finally, on the **Schema** page in the console, attach a resolver to the `addComment` field, and specify the data source for the Comments table. The request mapping template in this case is a simple `PutItem` with the specific `todoid` that is commented on as an argument, but you use the `$utils.autoId()` utility to create a unique sort key for the comment as follows:

```
{
    "version": "2017-02-28",
    "operation": "PutItem",
    "key": {
```

```
        "todoid": { "S": $util.toJson($context.arguments.todoid) },
        "commentid": { "S": "$util.autoId()" }
    },
    "attributeValues" : $util.dynamodb.toMapValuesJson($ctx.args)
}
```

Use a passthrough response template as follows:

```
$util.toJson($ctx.result)
```

Direct Lambda Resolvers

Direct Lambda Resolvers

With Direct Lambda Resolvers, you can circumvent the use of VTL mapping templates when using AWS Lambda data sources. AppSync can provide a default payload to your Lamdba function as well as a default translation from a Lambda function's response to a GraphQL type. You can choose to provide a request template, a response template, or neither and AWS AppSync will handle it accordingly.

To learn more about the default request payload and response translation that AWS AppSync provides, see the Direct Lambda resolver reference (p. 323). For more information on setting up an AWS Lambda data source and setting up an IAM Trust Policy, see attaching a data source (p. 26).

Add a Lambda data source

Before you can activate Direct Lambda resolvers, you first have to add a Lambda data source.

To add a Lambda data source

1. Sign in to the AWS Management Console and open the AWS AppSync Console.
2. In the navigation pane, choose **Data Sources**, and then choose **Create data source**.
   a. For **Data source name**, enter a name for your data source, such as **`myFunction`**.
   b. For **Data source type**, choose **AWS Lambda function**.
   c. For **Region**, choose the appropriate region.
   d. For **Function ARN**, choose the Lamdba function from the dropdown list. You can search for the function name or manually enter the ARN of the function you want to use.
   e. Choose the **Create** button.
3. Create a new IAM role (recommended) or choose an existing role that has the `lambda:invokeFunction` IAM permission. Existing roles need a trust policy, as explained in attaching a data source (p. 26).

   The following is an example IAM policy that has the required permissions to perform operations on the resource:

```
{
     "Version": "2012-10-17",
     "Statement": [
         {
             "Effect": "Allow",
             "Action": [ "lambda:invokeFunction" ],
             "Resource": [
                 "arn:aws:lambda:us-west-2:123456789012:function:myFunction",
                 "arn:aws:lambda:us-west-2:123456789012:function:myFunction:*"
             ]
```

```
        }
    ]
}
```

Activate direct Lambda resolvers

After creating a Lambda data source and setting up the appropriate IAM role to allow AWS AppSync to invoke the function, you can link it to a resolver or pipeline function.

To link a Lambda data source to a resolver or pipeline function

1. Sign in to the AWS Management Console and open the AWS AppSync Console.
2. In the navigation pane, choose **Schema**.
3. In the **Resolvers** section, choose a field or operation and then select the **Attach** button.
4. In **Create new resolver**, choose the Lambda function from the dropdown list.
5. In order to leverage Direct Lambda resolvers, confirm that request and response mapping templates are disabled in the **Configure mapping templates** section.

By disabling a mapping template, you are signalling to AWS AppSync that you accept the default data translations specified in the Direct Lambda resolver reference (p. 323).

By disabling the request mapping template, your Lambda data source will receive a payload consisting of the entire Context (p. 241) object.

By disabling the response mapping template, the result of your Lambda invocation will be translated depending on the version of the request mapping template or if the request mapping template is also disabled.

Test and Debug Resolvers

AWS AppSync executes resolvers on a GraphQL field against a data source. As described in Resolver Mapping Template Overview (p. 226), resolvers communicate with data sources by using a templating language. This enables you to customize the behavior, and apply logic and conditions before and after communicating with the data source. For an introductory tutorial-style programming guide for writing resolvers, see the Resolver Mapping Template Programming Guide (p. 230).

To help developers write, test, and debug these resolvers, the AWS AppSync console also provides tools to create a GraphQL request and response with mock data, down to the individual field resolver. Additionally, you can perform queries, mutations, and subscriptions in the AWS AppSync console, and see a detailed log stream from Amazon CloudWatch of the entire request. This includes results from a data source.

Testing with Mock Data

When a GraphQL resolver is invoked, it contains a `context` object that has relevant information about the request for you to program against. This includes arguments from a client, identity information, and data from the parent GraphQL field. It also has results from the data source, which can be used in the response template. For more information about this structure and the available helper utilities to use when programming, see the Resolver Mapping Template Context Reference (p. 241).

When writing or editing a resolver function, you can pass a *mock* or *test* `context` object into the console editor. This enables you to see how both the request and the response templates evaluate without actually running against a data source. For example, you can pass a test `firstname: Shaggy` argument

and see how it evaluates when using `$ctx.args.firstname` in your template code. You could also test the evaluation of any utility helpers such as `$util.autoId()` or `util.time.nowISO8601()`.

Test a Resolver

In the AWS AppSync console, go to the **Schema** page, and choose an existing resolver on the right to edit it. Or, choose **Attach** to add a new resolver. At the top of the page, choose **Select test context**, choose **Create new context**, and then enter a name. Next, either select from an existing sample context object or populate the JSON manually, and then choose **Save**. To evaluate your resolver using this mocked context object, choose **Run Test**.

For example, suppose you have an app storing a GraphQL type of `Dog` that uses automatic ID generation for objects and stores them in Amazon DynamoDB. You also want to write some values from the arguments of a GraphQL mutation, and allow only specific users to see a response. The following shows what the schema might look like:

```
type Dog {
  breed: String
  color: String
}

type Mutation {
  addDog(firstname: String, age: Int): Dog
}
```

When you add a resolver for the `addDog` mutation, you can populate a context object like the one following. The following has arguments from the client of `name` and `age`, and a `username` populated in the `identity` object:

```
{
    "arguments" : {
        "firstname": "Shaggy",
        "age": 4
    },
    "source" : {},
    "result" : {
        "breed" : "Miniature Schnauzer",
        "color" : "black_grey"
    },
    "identity": {
        "sub" : "uuid",
        "issuer" : "https://cognito-idp.region.amazonaws.com/userPoolId",
        "username" : "Nadia",
        "claims" : { },
        "sourceIP" : "x.x.x.x",
        "defaultAuthStrategy" : "ALLOW"
    }
}
```

You can test this using the following request and response mapping templates:

Request Template

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        "id" : { "S" : "$util.autoId()" }
    },
    "attributeValues" : $util.dynamodb.toMapValuesJson($ctx.args)
```

```
}
```

Response Template

```
#if ($context.identity.username == "Nadia")
  $util.toJson($ctx.result)
#else
  $util.unauthorized()
#end
```

The evaluated template has the data from your test context object and the generated value from `$util.autoId()`. Additionally, if you were to change the `username` to a value other than `Nadia`, the results won't be returned because the authorization check would fail. For more information about fine grained access control, see Authorization Use Cases (p. 214).

Debugging a Live Query

There's no substitute for an end-to-end test and logging to debug a production application. AWS AppSync lets you log errors and full request details using Amazon CloudWatch. Additionally, you can use the AWS AppSync console to test GraphQL queries, mutations, and subscriptions and live stream log data for each request back into the query editor to debug in real time. For subscriptions, the logs display connection-time information.

To perform this, you need to have Amazon CloudWatch logs enabled in advance, as described in Monitoring and Logging (p. 190). Next, in the AWS AppSync console, choose the **Queries** tab and then enter a valid GraphQL query. In the lower-right section, select the **Logs** check box to open the logs view. At the top of the page, choose the play arrow icon to run your GraphQL query. In a few moments, your full request and response logs for the operation are streamed to this section and you can view then in the console.

Pipeline Resolvers

AWS AppSync executes resolvers on a GraphQL field. In some cases, applications require executing multiple operations to resolve a single GraphQL field. With pipeline resolvers, developers can now compose operations (called Functions) and execute them in sequence. Pipeline resolvers are useful for applications that, for instance, require performing an authorization check before fetching data for a field.

Anatomy of a pipeline resolver

A pipeline resolver is composed of a **Before** mapping template, an **After** mapping template, and a list of Functions. Each Function has a **request** and **response** mapping template that it executes against a Data Source. As a pipeline resolver delegates execution to a list of functions, it is therefore not linked to any data source. Unit resolvers and functions are primitives that execute operation against data sources. See the Resolver Mapping Template Overview (p. 226) for more information.

Before Mapping template

The request mapping template of a pipeline resolver or also called the **Before** step, allows to perform some preparation logic before executing the defined functions.

Functions list

The list of functions a pipeline resolver will run in sequence. The pipeline resolver request mapping template evaluated result is made available to the first function as `$ctx.prev.result`. Each function output is available to the next function as `$ctx.prev.result`.

After mapping template

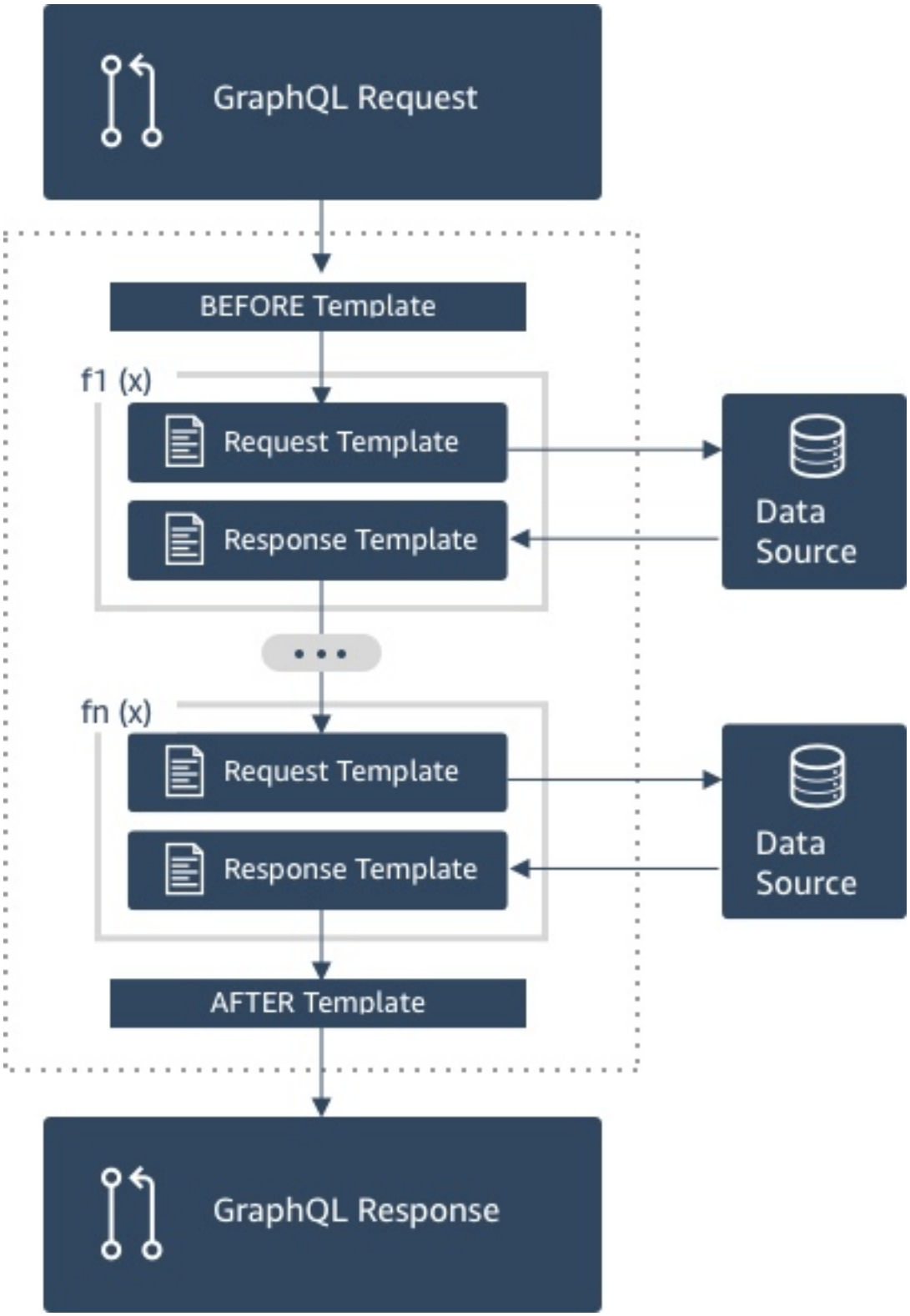
The response mapping template of a pipeline resolver or also called the **After** step, allows to perform some final mapping logic from the output of the last function to the expected GraphQL field type. The output of the last function in the functions list is available in the pipeline resolver mapping template as `$ctx.prev.result` or `$ctx.result`.

Execution Flow

Given a pipeline resolver comprised of 2 functions, the list below represents the execution flow when the resolver is invoked:

1. Pipeline resolver BEFORE mapping template
2. Function 1: Function request mapping template
3. Function 1: Data source invocation
4. Function 1: Function response mapping template
5. Function 2: Function request mapping template
6. Function 2: Data source invocation
7. Function 2: Function response mapping template
8. Pipeline resolver AFTER mapping template

Pipeline resolver execution flow is unidirectional and defined statically on the resolver.


GraphQL Request
BEFORE Template
f1 (x)
Request Template
Response Template
Data Source
fn (x)
Request Template
Response Template
Data Source
AFTER Template
GraphQL Response

Useful Apache Velocity Template Language (VTL) Utilities

As the complexity of an application increases, VTL utilities and directives are here to facilitate development productivity. The following utilities can help you when you're working with pipeline resolvers.

$ctx.stash

The stash is a Map that is made available inside each resolver and function mapping template. The same stash instance lives through a single resolver execution. What this means is you can use the stash to pass arbitrary data across request and response mapping templates, and across functions in a pipeline resolver. The stash exposes the same methods as the Java Map data structure.

$ctx.prev.result

The `$ctx.prev.result` represents the result of the previous operation that was executed in the pipeline. If the previous operation was the pipeline resolver request mapping template, then `$ctx.prev.result` represents the output of the evaluation of the template and is made available to the first function in the chain. If the previous operation was the first function, then `$ctx.prev.result` represents the output of the first function and is made available to the second function in the pipeline. If the previous operation was the last function, then `$ctx.prev.result` represents the output of the last function and is made available to the pipeline resolver response mapping template.

#return(data: Object)

The `#return(data: Object)` directive comes handy if you need to return prematurely from any mapping template. `#return(data: Object)` is analogous to the *return* keyword in programming languages because it returns from the closest scoped block of logic. What this means is that using `#return` inside a resolver mapping template returns from the resolver. Using `#return(data: Object)` in a resolver mapping template sets `data` on the GraphQL field. Additionally, using `#return(data: Object)` from a function mapping template returns from the function and continues the execution to either the next function in the pipeline or the resolver response mapping template.

#return

Same as `#return(data: Object)` but `null` will be returned instead.

$util.error

The `$util.error` utility is useful to throw a field error. Using `$util.error` inside a function mapping template throws a field error immediately, which prevents subsequent functions from being executed. For more details and other `$util.error` signatures, visit the Resolver Mapping Template Utility Reference (p. 248).

$util.appendError

The `$util.appendError` is similar to the `$util.error()`, with the major distinction that it doesn't interrupt the evaluation of the mapping template. Instead, it signals there was an error with the field, but allows the template to be evaluated and consequently return data. Using `$util.appendError` inside a function will not disrupt the execution flow of the pipeline. For more details and other `$util.error` signatures, visit the Resolver Mapping Template Utility Reference (p. 248).

Create A Pipeline Resolver

In the AWS AppSync console, go to the **Schema** page.

Save the following schema:

```
schema {
    query: Query
```

```
    mutation: Mutation
}

type Mutation {
    signUp(input: Signup): User
}

type Query {
    getUser(id: ID!): User
}

input Signup {
    username: String!
    email: String!
}

type User {
    id: ID!
    username: String
    email: AWSEmail
}
```

We are going to wire a pipeline resolver to the **signUp** field on the **Mutation** type. In the **Mutation** type on the right side, choose **Attach resolver** next to the `signUp` field. On the **Create Resolver** page, click on the **Switch to Pipeline** button. The page should now show 3 sections, a **Before Mapping Template** text area, a **Functions** section, and a **After Mapping template** text area.

Our pipeline resolver signs up a user by first validating the email address input and then saving the user in the system. We are going to encapsulate the email validation inside a **validateEmail** function, and the saving of the user inside a **saveUser** function. The **validateEmail** function executes first, and if the email is valid, then the **saveUser** function executes.

The execution flow will be as follow:

1. Mutation.signUp resolver request mapping template
2. validateEmail function
3. saveUser function
4. Mutation.signUp resolver response mapping template

Because we will probably reuse the **validateEmail** function in other resolvers on our API, we want to avoid accessing `$ctx.args` since these will change from one GraphQL field to another. Instead, we can use the `$ctx.stash` to store the email attribute from the `signUp(input: Signup)` input field argument.

BEFORE mapping template:

```
## store email input field into a generic email key
$util.qr($ctx.stash.put("email", $ctx.args.input.email))
{}
```

The console provides a default passthrough AFTER mapping template that will we use:

```
$util.toJson($ctx.result)
```

Create A Function

From the pipeline resolver page, on the **Functions** section, click on **Create Function**. It is also possible to create functions without going through the resolver page, to do this, in the AWS AppSync console, go to

the **Functions** page. Choose the **Create Function** button. Let's create a function that checks if an email is valid and comes from a specific domain. If the email is not valid, the function raises an error. Otherwise, it forwards whatever input it was given.

Select **NONE** data source on the function page, and fill in the **validateEmail** request mapping template:

```
#set($valid = $util.matches("^[a-zA-Z0-9_.+-]+@(?:(?:[a-zA-Z0-9-]+\.)?[a-zA-Z]+\.)?
(myvaliddomain)\.com", $ctx.stash.email))
#if (!$valid)
    $util.error("$ctx.stash.email is not a valid email.")
#end
{
    "payload": { "email": $util.toJson(${ctx.stash.email}) }
}
```

and response mapping template:

```
$util.toJson($ctx.result)
```

We just created our **validateEmail** function. Repeat these steps to create the **saveUser** function with the following request and response mapping templates. For the sake of simplicity we use a **NONE** data source and pretend the user has been saved in the system after the function executes.

Request mapping template:

```
## $ctx.prev.result contains the signup input values. We could have also
## used $ctx.args.input.
{
    "payload": $util.toJson($ctx.prev.result)
}
```

and response mapping template:

```
## an id is required so let's add a unique random identifier to the output
$util.qr($ctx.result.put("id", $util.autoId()))
$util.toJson($ctx.result)
```

We just created out **saveUser** function.

Adding a Function to a Pipeline Resolver

Our functions should have been automatically added to the pipeline resolver we just created. If you happened to have created the functions through the console **Functions** page, you can click on **Add Function** on the resolver page to attach them. Add both **validateEmail** and **saveUser** functions to the resolver. The **validateEmail** function should be placed before the **saveUser** function. As you add more functions you can use the up and down arrows to reorganize the order of execution of your functions.

Executing a Query

In the AWS AppSync console, go to the **Queries** page. Enter the following query:

```
mutation {
  signUp(input: {
    email: "nadia@myvaliddomain.com"
    username: "nadia"
  }) {
    id
    username
  }
```

```
}
```

should return something like:

```
{
  "data": {
    "signUp": {
      "id": "256b6cc2-4694-46f4-a55e-8cb14cc5d7fc",
      "username": "nadia"
    }
  }
}
```

We have successfully signed up our user and validated the input email using a pipeline resolver. To follow a more complete tutorial focusing on pipeline resolvers, you can go to Tutorial: Pipeline Resolvers (p. 147)

Using Your API

Now that you have a GraphQL API with a schema uploaded, data sources configured, and resolvers connected to your types, you can test your API. The following two examples assume you've used the basic schema from Designing Your Schema (p. 11).

In the AWS AppSync, choose the **Queries** tab and then enter the following text in the editor:

```
mutation add {
    addTodo(id:"123" name:"My TODO" description:"Testing AWS AppSync" priority:2){
        id
        name
        description
        priority
    }
}
```

Choose the button at the top to run your mutation. After the run is complete, the result from your selection set (that is, `id`, `name`, `description`, and `priority`) appear on the right. The data is also in the Amazon DynamoDB table for your data source, which you can verify using the console.

Now, run a query as follows:

```
query list {
    getTodos {
        id
        name
    }
}
```

This returns your data, but it only returns the two fields (`id` and `name`) from your selection set. **Note:** If you are getting an error such as **Validation error of type FieldUndefined**, you might have followed the instructions for setting up relations and pagination. If so, use the queries in the next section.

Relations and Pagination

If you have set up the advanced schema with relations and pagination, your `getTodos` query will look a bit different. First, add a comment to your `todo` as follows:

```
mutation addComment {
```

```
    addComment(todoid:"123" content:"GraphQL is fun"){
        todoid
        commentid
        content
    }
}
```

In this case, the `commentid` is automatically created. Add a few more `todos` and `comments`, set the `limit` to **2** records, and then run `getTodos` as follows:

```
query list {
    getTodos(limit:2){
        todos {
            id
            name
            status
            comments{
                commentid
                content
            }
        }
        nextToken
    }
}
```

Only two todos come back (with the comments) because you specified `limit:2` in the arguments. A long string should be returned for the `nextToken` field. If you copy this string, you can pass it as a second argument in `getTodos` by replacing `XXXXXXXXXXXX` in `getTodos(limit:2 nextToken:"XXXXXXXXXXXX")`. For example:

```
query list {
    getTodos(limit:2
 nextToken:"eyJ2ZXJzaW9uejE1a2RPanZPQzFCMlFTdGNxdUFBQUJxekNDQWFjR0NTcUdTSWIzRFFFSEJxQ0NBWmd3Z2dHVUFnRUF
{
        todos {
            id
            name
            status
            comments{
                commentid
                content
            }
        }
        nextToken
    }
}
```

In a client application you would pass this token through as an argument based on your pagination flow and logic.

Next Steps

Now that you've created a schema, you can walk through how to use it with different data sources, learn more about the advanced resolver capabilities, or build a client application. For more information, see the following sections:

- Data Sources tutorials (p. 54)
- Resolvers and Mapping Templates (p. 226)
- Building Client Applications (p. 49)

(Optional) Guided Schema Wizard

AWS AppSync can guide you through the process of creating your GraphQL API, including deploying data sources and connecting with resolvers. This guided creation or wizard gives you a form builder interface where you can add or remove attributes while creating a data model for your application to store in the cloud with GraphQL.

Create API

From the AWS AppSync home page, choose **Create API** and then choose **Create with wizard**. You are prompted to define your model and its related fields and functionality. A *model* is an object type that is added to your API and is backed by Amazon DynamoDB that comes preconfigured with GraphQL queries, mutations, and subscriptions. Models are how you define the data types of your application and how they are stored in the cloud. A model contains one or more *fields* that hold the specific attributes of your data type. For example, a *blog* model might have the following fields: id, title, and isPublished. These fields could have primitive types of id, string, or Boolean in addition to the custom scalars that AWS AppSync supports.

Populate Model

After you enter the model form, you can change the name of your model, which in turn defines the names of your GraphQL operations (that is, queries, mutations, and subscriptions). This also defines the name of your Amazon DynamoDB tables, but you can override that in the **Configure model table** section at the bottom of the screen.

Next, add one or more fields using logical names and types that suit your model. To view all available primitive types in AWS AppSync, choose the drop down under **Types**. Additionally, you can select one or both of the check boxes next to each field to mark it as a **List** or **Required**.

Types that are marked as **List** can hold multiple values. For example, if you had a blog Post model and a field called **Categories" you could mark this as a **List** to return multiple categories when running a query. **Required** fields must be entered as input when executing a GraphQL mutation.

Finally, you can use the **Configure model table** section at the bottom to optionally add an index. This is useful when you know that certain fields in your model will be queried frequently. For example, if the isPublished field of your blog model is going to be frequently queried to give all blogs that are published, you could create an index on that field. This automatically creates proper Amazon DynamoDB indexes and GraphQL queries for you.

After you are satisfied with your model and optional table configuration, choose **Next** and then the resource is created.

Execute GraphQL

After the process is complete, pre-populated GraphQL mutations and queries open in the editor for you to run on the **Queries** page of the AWS AppSync console. Choose the play button at the top and choose the option that starts with **Create <model name>** (this option name changes depending on your model name). A GraphQL mutation runs and places data in your Amazon DynamoDB table. You can then choose the play button again and select the option starting with **List** to view all of the records by running a GraphQL query.

Integrate with the App

After you complete a tour of the console, choose the root of the AWS AppSync navigation bar on the left to follow instructions for integrating a GraphQL API with your mobile or web app (p. 49).

(Optional) Provision from Schema

AWS AppSync can automatically provision Amazon DynamoDB tables from a schema definition, create data sources, and connect the resolvers on your behalf. This can be useful if you want to let AWS AppSync define the appropriate table layout and indexing strategy based on your schema definition and data access patterns.

You can also start with no schema and build it up from a type, letting AWS AppSync create the schema definition and different filtering options. You can use the two flows outlined in this topic independently or together throughout the lifecycle of your API.

No Schema

After you create an AWS AppSync API, go to the **Schema** page and choose **Create Resources**. The editor at the top contains a pre-defined template for a type. You can change the name, field types, and add or remove entries. For example, use the following sample type:

```
type Blog {
    id: ID!
    title: String!
    content: String
    rating: Int
    approved: Boolean
}
```

Lower on the page, you can change the table name, change the layout, or add indexes. Indexes are recommended as a best practice for performance if you plan to query often using a specific field. When creating an index, AWS AppSync builds the GraphQL schema and connects resolvers for you. For example, choose **Add Index** and name the index **rating**. In **Primary Key**, choose **rating**. In **Sort Key**, leave the default **none**. You should see a query like the following in the GraphQL that's generated:

```
queryBlogsByRating(rating:Int!, first:Int, nextToken: String): BlogConnection
```

After you've finished editing your type and creating any needed indices, choose **Create**, and then wait for the process to complete creating resources and connecting data sources to resolvers. You can go to the **Queries** page immediately and start running mutations, queries, and subscriptions. For example, create a blog post with the following mutation:

```
mutation add {
    createBlog(input:{
        title:"My first post"
        content:"AWS AppSync with GraphQL"
        rating:5
        approved:true
    }){
        id
    }
}
```

Notice that the `id` field is automatically generated. AWS AppSync does this if your type has a **Primary Key** field on a table of `id: ID!`. Otherwise, AWS AppSync require the **Primary Key** field to be passed as part of the argument. After creating a few blog posts with different content, run the following query:

```
query list {
    listBlogs(filter:{ content:{
        contains:"AppSync"
```

```
    }){
        items{
            id
            title
            content
            rating
        }
    }
}
```

It should only return the blogs with the string "**AppSync**" in the content field. You can explore the different filters on fields via GraphQL introspection on the **Queries** page of the console. AWS AppSync generates several queries and filters for common use cases on different scalar types to help you get up and running fast. It's important to note that as your application usage grows larger and you have more complex data requirements around scale or larger tables, all of these filters might no longer be appropriate and you should leverage different DynamoDB best practices or combine data sources in your GraphQL API, such as Amazon Elasticsearch Service for complex searches.

AWS AppSync creates filters on GraphQL scalar types (that is, ID, String, Int, Float, Boolean) for list operations. This is done by creating a base input type that contains the different fields for your defined type. Each one of these fields has an input filter type as appropriate for things like string searches, Boolean comparisons, etc. For example, only **String** supports **BEGINS_WITH** while **Boolean** supports **EQ**, **NE**, etc. You can view the supported operations in the generated GraphQL input types on the **Schema** page and a list of DynamoDB operations at DynamoDB operations.

Continuing with the blog example type, the following generates a base input type in your schema:

```
input BlogInput {
    id: TableIDFilterInput
    title: TableStringFilterInput
    content: TableStringFilterInput
    rating: TableIntFilterInput
    approved: TableBooleanFilterInput
}
```

The AWS AppSync console automatically connects this to a query operation. If you want to do this yourself, it might look like the following:

```
listBlog(filter: BlogInput): [Blog]
```

When you attach a resolver to the `listBlog` query, the request mapping template uses the input on the `filter` key along with `$util.transform.toDynamoDBFilterExpression` as follows:

```
{
    "version": "2017-02-28",
    "operation": "Scan",
    "filter": #if($context.args.filter)
 $util.transform.toDynamoDBFilterExpression($ctx.args.filter) #else null #end
}
```

Existing Schema

These instructions start with the schema outlined in Designing Your Schema (p. 11). From the AWS AppSync console, go to the **Schema** page, enter the following schema into the editor, and then choose **Save Schema**:

```
schema {
```

```
    query:Query
    mutation: Mutation
}

type Query {
    allTodo: [Todo]
}

type Mutation {
    addTodo(id: ID!, name: String, description: String, priority: Int, status: TodoStatus):
 Todo
}

type Todo {
    id: ID!
    name: String
    description: String
    priority: Int
    status: TodoStatus
}

enum TodoStatus {
    done
    pending
}
```

After you save a schema, choose **Create resources** at the top of the page. Choose **Use existing type**, and then choose your `Todo` type. In the form that appears, you can configure the table details. You can change your DynamoDB primary or sort keys here, and add additional indexes. At the bottom of the page is a corresponding section for the GraphQL queries and mutations that are available to you, based on different key selections. AWS AppSync will provision DynamoDB tables that best match your data access pattern for efficient use of your database throughput. You can also select indices for different query options, which set up a DynamoDB local secondary index or global secondary indexes, as appropriate.

For the example schema, you can simply have `id` selected as the primary key and choose **Create**. If your type doesn't have `id` set as the primary key, all of the fields for that type are required for create operations. Otherwise, AWS AppSync automatically generates unique IDs for you in the resolvers. After a moment, your DynamoDB tables are created, data sources are created, and resolvers are connected. You can run mutations and queries as described in Using Your API (p. 39).

Note: There's a GraphQL `input` type for the arguments of the created schema. For example, if you provision from a schema with a GraphQL `type Books {...}`, there might be an input type like the following:

```
input CreateBooksInput {
    ISBN: String!
    Author: String
    Title: String
    Price: Int
}
```

To use this in a GraphQL query or mutation, you would use the following:

```
mutation add {
    createBooks(input:{
        ISBN:"2349238"
        Author:"Nadia Bailey"
        Title:"Running in the park"
        Price:10
    }){
```

```
        ISBN
        Author
    }
}
```

Also, as explained earlier in **No Schema** section of this document, default filters will be created for list operations. For example, if you want to return all items where the price is greater than `5`, you could run the following:

```
query list {
    listBooks(filter:{ Price:{
        gt:5
    }}){
        items{
            ISBN
            Author
            Title
            Price
        }
    }
}
```

(Optional) Import from Amazon DynamoDB

AWS AppSync can automatically create a GraphQL schema and connect resolvers to existing Amazon DynamoDB tables. This can be useful if you have DynamoDB tables that you want to expose data through a GraphQL endpoint, or if you're more comfortable starting first with your database design instead of a GraphQL schema.

Import a DynamoDB Table

From the AWS AppSync console, go to the **Data Sources** page, choose **New**, enter a friendly name for your data source, and then choose Amazon DynamoDB as the data source type. Choose the appropriate table, and then choose **Automatically generate GraphQL**.

The following two code editors with the GraphQL schema appear:

- **Top editor** - You can use this editor to give your type a custom name (such as `type MYNAME {...}`), which will contain the data from your DynamoDB table when you run queries or mutations. You can also add fields to the type, such as DynamoDB non-key attributes (which cannot be detected on import).
- **Bottom editor** - Use this read-only editor to review generated GraphQL schema snippets. It shows what types, queries, and mutations will be merged into your schema. If you edit the type in the top editor, the bottom editor changes as appropriate.

Choose **Create**. Your schema is merged and resolvers are created. After this is complete, you can run mutations and queries as described in Using Your API (p. 39).

Note: A GraphQL `input` type is created for the arguments of the created schema. For example, if you import a table called Books, there might be an input type like the following:

```
input CreateBooksInput {
    ISBN: String!
    Author: String
    Title: String
```

```
    Price: String
}
```

To use this in a GraphQL query or mutation, do the following:

```
mutation add {
    createBooks(input:{
        ISBN:2349238
        Author:"Nadia Bailey"
        Title:"Running in the park"
        Price:"10"
    }){
        ISBN
        Author
    }
}
```

Example Schema from Import

Suppose that you have a DynamoDB table with the following format:

```
{
    Table: {
        AttributeDefinitions: [
            {
                AttributeName: 'authorId',
                AttributeType: 'S'
            },
            {
                AttributeName: 'bookId',
                AttributeType: 'S'
            },
            {
                AttributeName: 'title',
                AttributeType: 'S'
            }
        ],
        TableName: 'BookTable',
        KeySchema: [
            {
                AttributeName: 'authorId',
                KeyType: 'HASH'
            },
            {
                AttributeName: 'title',
                KeyType: 'RANGE'
            }
        ],
        TableArn: 'arn:aws:dynamodb:us-west-2:012345678910:table/BookTable',
        LocalSecondaryIndexes: [
            {
                IndexName: 'authorId-bookId-index',
                KeySchema: [
                    {
                        AttributeName: 'authorId',
                        KeyType: 'HASH'
                    },
                    {
                        AttributeName: 'bookId',
                        KeyType: 'RANGE'
                    }
                ],
```

```
                Projection: {
                    ProjectionType: 'ALL'
                },
                IndexSizeBytes: 0,
                ItemCount: 0,
                IndexArn: 'arn:aws:dynamodb:us-west-2:012345678910:table/BookTable/index/
authorId-bookId-index'
            }
        ],
        GlobalSecondaryIndexes: [
            {
                IndexName: 'title-authorId-index',
                KeySchema: [
                    {
                        AttributeName: 'title',
                        KeyType: 'HASH'
                    },
                    {
                        AttributeName: 'authorId',
                        KeyType: 'RANGE'
                    }
                ],
                Projection: {
                    ProjectionType: 'ALL'
                },
                IndexArn: 'arn:aws:dynamodb:us-west-2:012345678910:table/BookTable/index/
title-authorId-index'
            }
        ]
    }
}
```

The type editor at the top shows the following:

```
type Book {
    # Key attributes. Changing these may result in unexpected behavior.
    authorId: String!
    title: String!

    # Index attributes. Changing these may result in unexpected behavior.
    bookId: String

    # Add additional non-key attributes below.
    isPublished: Boolean
}
```

This top editor is writable, and you need to add the non-key attributes shown in the bottom editor (for example, like `isPublished`) manually because they can't be inferred from DynamoDB automatically. For example, if you had another attribute on an item in your DynamoDB table called `rating`, you need to add it under `isPublished` to have it populated in the GraphQL schema. In this example, the bottom editor would have the following proposed schema merges:

```
type Query {
    getBook(authorId: ID!, title: String!): Book
    listBooks(first: Int, after: String): BookConnection
    getBookByAuthorIdBookIdIndex(authorId: ID!, bookId: ID!): Book
    queryBooksByAuthorIdBookIdIndex(authorId: ID!, first: Int, after: String):
 BookConnection
    getBookByTitleAuthorIdIndex(title: String!, authorId: ID!): Book
    queryBooksByTitleAuthorIdIndex(title: String!, first: Int, after: String):
 BookConnection
}
type Mutation {
```

```
    createBook(input: CreateBookInput!): Book
    updateBook(input: UpdateBookInput!): Book
    deleteBook(input: DeleteBookInput!): Book
}
type Subscription {
    onCreateBook(authorId: ID, title: String, bookId: ID, isPublished: Boolean): Book
 @aws_subscribe(mutations: ["createBook"])
    onUpdateBook(authorId: ID, title: String, bookId: ID, isPublished: Boolean): Book
 @aws_subscribe(mutations: ["updateBook"])
    onDeleteBook(authorId: ID, title: String, bookId: ID, isPublished: Boolean): Book
 @aws_subscribe(mutations: ["deleteBook"])
}
input CreateBookInput {
    authorId: ID!
    title: String!
    bookId: ID!
    isPublished: Boolean
}
input UpdateBookInput {
    authorId: ID!
    title: String!
    bookId: ID
    isPublished: Boolean
}
input DeleteBookInput {
    authorId: ID!
    title: String!
}
type BookConnection {
    items: [Book]
    nextToken: String
}
```

Building a Client App

If you are building complete client application workflows, including integration with other AWS services such as Amazon Cognito, Amazon S3, or Amazon Pinpoint to provide full capabilities around User Sign-Up/Sign-In, rich media, and analytics we suggest using the Amplify Framework. Amplify is an opinionated client framework for building web and mobile applications with full support for building apps from your local workstation, including GraphQL provisioning and workflows for CI/CD. This includes JavaScript-based application support (such as React, React Native, Angular, and Vue) as well as native iOS and Android.

- JavaScript documentation
- iOS documentation
- Android documentation

Additionally, you can use the AppSync SDK for Apollo to perform GraphQL queries or mutations from a NodeJS application, such as a Lambda function with the following tutorial (p. 50).

Topics

Building a NodeJS Client App

AWS AppSync integrates with the Apollo GraphQL client for building client applications. AWS provides Apollo plugins for offline support, authorization, and subscription handshaking. This tutorial shows how you can use the AWS AppSync SDK with the Apollo client directly in a Node.js application.

Note: For AWS Lambda functions, ensure you set `fetchPolicy: 'network-only'` as well as `disableOffline: true` in your AppSync client constructor.

Before You Begin

This tutorial expects a GraphQL schema with the following structure:

```
schema {
    query: Query
    mutation: Mutation
    subscription: Subscription
}

type Mutation {
    addPost(id: ID! author: String! title: String content: String url: String): Post!
    updatePost(id: ID! author: String! title: String content: String url: String ups: Int!
 downs: Int! expectedVersion: Int!): Post!
    deletePost(id: ID!): Post!
}

type Post {
    id: ID!
    author: String!
    title: String
    content: String
    url: String
    ups: Int
    downs: Int
    version: Int!
}

type Query {
    allPost: [Post]
    getPost(id: ID!): Post
}

type Subscription {
    newPost: Post
    @aws_subscribe(mutations:["addPost"])
}
```

This schema is from the DynamoDB resolvers tutorial (p. 54), with a subscription added. To follow the complete flow, you can optionally walk through that tutorial first. If you would like to do more customization of GraphQL resolvers, such as those that use DynamoDB, see the Resolver Mapping Template Reference (p. 226).

Get the GraphQL API Endpoint

After you create your GraphQL API, you'll need to get the API endpoint (URL) so you can use it in your client application. You can get the API endpoint in either of the following ways:

- In the AWS AppSync console, choose **Settings**. The API URL is displayed in the **API Details** section.

- Alternately, run the following CLI command. Replace the `$GRAPHQL_API_ID` parameter with a string specifying your API id:

```
aws appsync get-graphql-api --api-id $GRAPHQL_API_ID
```

The following instructions show how you can use `AWS_IAM` for client authorization. In the console, select **Settings** on the left, and then click **AWS_IAM**.

Create a Client Application

Create a new project and initialize it with npm, accepting the defaults, as follows:

```
mkdir appsync && cd appsync
touch index.js aws-exports.js
npm init
```

AWS AppSync supports several authorization types, which you can learn more about in Security (p. 206). We recommend using short-term credentials from Amazon Cognito Federated Identities or Amazon Cognito user pools. For example purposes, we show how you can use IAM keys. Your `aws-exports` file should look like the following:

```
"use strict";
Object.defineProperty(exports, "__esModule", { value: true });
var config = {
    AWS_ACCESS_KEY_ID: '',
    AWS_SECRET_ACCESS_KEY: '',
    HOST: 'URL.YOURREGION.amazonaws.com',
    REGION: 'YOURREGION',
    PATH: '/graphql',
    ENDPOINT: '',
};
config.ENDPOINT = "https://" + config.HOST + config.PATH;
exports.default = config;
```

Edit your `package.json` dependencies file and be sure it includes the following:

```
"dependencies": {
  "apollo-cache-inmemory": "^1.1.0",
  "apollo-client": "^2.0.3",
  "apollo-link": "^1.0.3",
  "apollo-link-http": "^1.2.0",
  "aws-sdk": "^2.141.0",
  "aws-appsync": "^1.0.0",
  "es6-promise": "^4.1.1",
  "graphql": "^0.11.7",
  "graphql-tag": "^2.5.0",
  "isomorphic-fetch": "^2.2.1",
  "ws": "^3.3.1"
}
```

Note: You _*MUST*_ use `"ws": "^3.3.1"` otherwise you will get WebSocket errors. Also note that you cannot use the WebSocket features in an AWS Lambda function, only GraphQL queries and mutations.

From a command line, run the following:

```
npm install
```

Now add the following code to your `index.js` file:

Note: If you're using this sample in an AWS Lambda function you must uncomment and use the `client.query({ query: query, fetchPolicy: 'network-only' })` statement. You must also uncomment `disableOffline: true` in the AppSync client constructor.

```
"use strict";
/**
* This shows how to use standard Apollo client on Node.js
*/

global.WebSocket = require('ws');
require('es6-promise').polyfill();
require('isomorphic-fetch');

// Require exports file with endpoint and auth info
const aws_exports = require('./aws-exports').default;

// Require AppSync module
const AUTH_TYPE = require('aws-appsync/lib/link/auth-link').AUTH_TYPE;
const AWSAppSyncClient = require('aws-appsync').default;

const url = aws_exports.ENDPOINT;
const region = aws_exports.REGION;
const type = AUTH_TYPE.AWS_IAM;

// If you want to use API key-based auth
const apiKey = 'xxxxxxxxx';
// If you want to use a jwtToken from Amazon Cognito identity:
const jwtToken = 'xxxxxxxx';

// If you want to use AWS...
const AWS = require('aws-sdk');
AWS.config.update({
    region: aws_exports.REGION,
    credentials: new AWS.Credentials({
        accessKeyId: aws_exports.AWS_ACCESS_KEY_ID,
        secretAccessKey: aws_exports.AWS_SECRET_ACCESS_KEY
    })
});
const credentials = AWS.config.credentials;

// Import gql helper and craft a GraphQL query
const gql = require('graphql-tag');
const query = gql(`
query AllPosts {
allPost {
    __typename
    id
    title
    content
    author
    version
}
}`);

// Set up a subscription query
const subquery = gql(`
subscription NewPostSub {
newPost {
    __typename
    id
    title
    author
    version
```

```
}
}`);

// Set up Apollo client
const client = new AWSAppSyncClient({
    url: url,
    region: region,
    auth: {
        type: type,
        credentials: credentials,
    }
    //disableOffline: true      //Uncomment for AWS Lambda
});

client.hydrated().then(function (client) {
    //Now run a query
    client.query({ query: query })
    //client.query({ query: query, fetchPolicy: 'network-only' })   //Uncomment for AWS
 Lambda
        .then(function logData(data) {
            console.log('results of query: ', data);
        })
        .catch(console.error);

    //Now subscribe to results
    const observable = client.subscribe({ query: subquery });

    const realtimeResults = function realtimeResults(data) {
        console.log('realtime data: ', data);
    };

    observable.subscribe({
        next: realtimeResults,
        complete: console.log,
        error: console.log,
    });
});
```

If you want to use an API key or Amazon Cognito user pools in the previous example, you could update the `AUTH_TYPE` as follows:

```
const type = AUTH_TYPE.API_KEY
const type = AUTH_TYPE.AMAZON_COGNITO_USER_POOLS
```

You need to provide the key or JWT token, as appropriate.

Resolver tutorials

Data sources and resolvers are how AWS AppSync translates GraphQL requests and fetches information from your AWS resources. AWS AppSync has support for automatic provisioning and connections with certain data source types. AWS AppSync supports AWS Lambda, Amazon DynamoDB, relational databases (Amazon Aurora Serverless), Amazon Elasticsearch Service, and HTTP endpoints as data sources. You can use a GraphQL API with your existing AWS resources or build data sources and resolvers. This section takes you through this process in a series of tutorials for better understanding how the details work and tuning options.

AWS AppSync uses *mapping templates* written in Apache Velocity Template Language (VTL) for resolvers. For more information about using mapping templates, see the Resolver mapping template reference (p. 226). More information about working with VTL is available in the Resolver mapping template programming guide (p. 230).

AWS AppSync supports the automatic provisioning of DynamoDB tables from a GraphQL schema as described in (Optional) Provision from Schema (p. 42) and Launch a Sample Schema (p. 2). You can also import from an existing DynamoDB table which will create schema and connect resolvers. This is outlined in (Optional) Import from Amazon DynamoDB (p. 45).

Topics

Tutorial: DynamoDB Resolvers

This tutorial shows how you can bring your own Amazon DynamoDB tables to AWS AppSync and connect them to a GraphQL API.

You can let AWS AppSync provision DynamoDB resources on your behalf. Or, if you prefer, you can connect your existing tables to a GraphQL schema by creating a data source and a resolver. In either case, you'll be able to read and write to your DynamoDB database through GraphQL statements and subscribe to real-time data.

There are specific configuration steps that need to be completed in order for GraphQL statements to be translated to DynamoDB operations, and for responses to be translated back into GraphQL. This tutorial outlines the configuration process through several real-world scenarios and data access patterns.

Setting Up Your DynamoDB Tables

To begin this tutorial, first you need to provision AWS resources using the following AWS CloudFormation template:

```
aws cloudformation create-stack \
    --stack-name AWSAppSyncTutorialForAmazonDynamoDB \
    --template-url https://s3.us-west-2.amazonaws.com/awsappsync/resources/dynamodb/
AmazonDynamoDBCFTemplate.yaml \
    --capabilities CAPABILITY_NAMED_IAM
```

You can launch the following AWS CloudFormation stack in the US West 2 (Oregon) region in your AWS account.

This creates the following:

- A DynamoDB table called `AppSyncTutorial-Post` that will hold `Post` data.
- An IAM role and associated IAM managed policy to allow AWS AppSync to interact with the `Post` table.

To see more details about the stack and the created resources, run the following CLI command:

```
aws cloudformation describe-stacks \
    --stack-name AWSAppSyncTutorialForAmazonDynamoDB
```

To delete the resources later, you can run the following:

```
aws cloudformation delete-stack \
    --stack-name AWSAppSyncTutorialForAmazonDynamoDB
```

Creating Your GraphQL API

To create the GraphQL API in AWS AppSync:

- Open the AWS AppSync console and choose **Create API**.
- Set the name of the API to `AWSAppSyncTutorial`.
- Choose **Custom schema**.
- Choose **Create**.

The AWS AppSync console creates a new GraphQL API for you using the API key authentication mode. You can use the console to set up the rest of the GraphQL API and run queries against it for the rest of this tutorial.

Defining a Basic Post API

Now that you set up an AWS AppSync GraphQL API, you can set up a basic schema that allows the basic creation, retrieval, and deletion of post data.

In the AWS AppSync console, choose the **Schema** tab. In the **Schema** pane, replace the contents with the following code, and then choose the **Save**:

```
schema {
    query: Query
    mutation: Mutation
}

type Query {
    getPost(id: ID): Post
}

type Mutation {
    addPost(
        id: ID!
        author: String!
        title: String!
        content: String!
        url: String!
    ): Post!
}

type Post {
    id: ID!
    author: String
    title: String
    content: String
    url: String
    ups: Int!
    downs: Int!
    version: Int!
}
```

This schema defines a `Post` type and operations to add and get `Post` objects.

Configuring the Data Source for the DynamoDB Tables

Next, link the queries and mutations defined in the schema to the `AppSyncTutorial-Post`DynamoDB table.

First, AWS AppSync needs to be aware of your tables. You do this by setting up a data source in AWS AppSync:

- Choose the **Data source** tab.
- Choose **New** to create a new data source.
- For the data source name, enter `PostDynamoDBTable`.
- For data source type, choose **Amazon DynamoDB table**.
- For region, choose **US-WEST-2**.
- From the list of tables, choose the **AppSyncTutorial-Post**DynamoDB table.
- In the **Create or use an existing role** section, choose **Existing role**.
- Choose **Create**.

Setting Up the addPost resolver (DynamoDB PutItem)

After AWS AppSync is aware of the DynamoDB table, you can link it to individual queries and mutations by defining **Resolvers**. The first resolver you create is the `addPost` resolver, which enables you to create a post in the `AppSyncTutorial-Post`DynamoDB table.

A resolver has the following components:

- The location in the GraphQL schema to attach the resolver. In this case, you are setting up a resolver on the `addPost` field on the `Mutation` type. This resolver will be invoked when the caller calls `mutation { addPost(...){...} }`.
- The data source to use for this resolver. In this case, you want to use the `PostDynamoDBTable` data source you defined earlier, so you can add entries into the `AppSyncTutorial-Post` DynamoDB table.
- The request mapping template. The purpose of the request mapping template is to take the incoming request from the caller and translate it into instructions for AWS AppSync to perform against DynamoDB.
- The response mapping template. The job of the response mapping template is to take the response from DynamoDB and translate it back into something that GraphQL expects. This is useful if the shape of the data in DynamoDB is different to the `Post` type in GraphQL, but in this case they have the same shape, so you just pass the data through.

To set up the resolver:

- Choose the **Schema** tab.
- In the **Data types** pane on the right, find the **addPost** field on the **Mutation** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
    },
    "attributeValues" : {
        "author" : $util.dynamodb.toDynamoDBJson($context.arguments.author),
        "title" : $util.dynamodb.toDynamoDBJson($context.arguments.title),
        "content" : $util.dynamodb.toDynamoDBJson($context.arguments.content),
        "url" : $util.dynamodb.toDynamoDBJson($context.arguments.url),
        "ups" : { "N" : 1 },
        "downs" : { "N" : 0 },
        "version" : { "N" : 1 }
    }
}
```

Note: A *type* is specified on all the keys and attribute values. For example, you set the `author` field to `{ "S" : "${context.arguments.author}" }`. The `S` part indicates to AWS AppSync and DynamoDB that the value will be a string value. The actual value gets populated from the `author` argument. Similarly, the `version` field is a number field because it uses `N` for the type. Finally, you're also initializing the `ups`, `downs` and `version` field.

For this tutorial you've specified that the GraphQL `ID!` type, which indexes the new item that is inserted to DynamoDB, comes as part of the client arguments. AWS AppSync comes with a utility for automatic ID generation called `$utils.autoId()` which you could have also used in the form of `"id" : { "S" : "${$utils.autoId()}" }`. Then you could simply leave the `id: ID!` out of the schema definition of `addPost()` and it would be inserted automatically. You won't use this technique for this tutorial, but you should consider it as a good practice when writing to DynamoDB tables.

For more information about mapping templates, see the Resolver Mapping Template Overview (p. 226) reference documentation. For more information about GetItem request mapping, see the GetItem (p. 266) reference documentation. For more information about types, see the Type System (Request Mapping) (p. 297) reference documentation.

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

Note: Because the shape of the data in the `AppSyncTutorial-Post` table exactly matches the shape of the `Post` type in GraphQL, the response mapping template just passes the results straight through. Also note that all of the examples in this tutorial use the same response mapping template, so you only create one file.

- Choose **Save**.

Call the API to Add a Post

Now that the resolver is set up, AWS AppSync can translate an incoming `addPost` mutation to a DynamoDB PutItem operation. You can now run a mutation to put something in the table.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following mutation:

```
mutation addPost {
  addPost(
    id: 123
    author: "AUTHORNAME"
    title: "Our first post!"
    content: "This is our first post."
    url: "https://aws.amazon.com/appsync/"
  ) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).
- The results of the newly created post should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "addPost": {
      "id": "123",
      "author": "AUTHORNAME",
      "title": "Our first post!",
      "content": "This is our first post.",
      "url": "https://aws.amazon.com/appsync/",
      "ups": 1,
      "downs": 0,
      "version": 1
    }
  }
}
```

Here's what happened:

- AWS AppSync received an `addPost` mutation request.
- AWS AppSync took the request, and the request mapping template, and generated a request mapping document. This would have looked like:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        "id" : { "S" : "123" }
    },
    "attributeValues" : {
        "author": { "S" : "AUTHORNAME" },
        "title": { "S" : "Our first post!" },
        "content": { "S" : "This is our first post." },
        "url": { "S" : "https://aws.amazon.com/appsync/" },
        "ups" : { "N" : 1 },
        "downs" : { "N" : 0 },
        "version" : { "N" : 1 }
    }
}
```

- AWS AppSync used the request mapping document to generate and execute a DynamoDB`PutItem` request.
- AWS AppSync took the results of the `PutItem` request and converted them back to GraphQL types.

```
{
    "id" : "123",
    "author": "AUTHORNAME",
    "title": "Our first post!",
    "content": "This is our first post.",
    "url": "https://aws.amazon.com/appsync/",
    "ups" : 1,
    "downs" : 0,
    "version" : 1
}
```

- Passed it through the response mapping document, which just passed it through unchanged.
- Returned the newly created object in the GraphQL response.

Setting Up the getPost Resolver (DynamoDB GetItem)

Now that you're able to add data to the `AppSyncTutorial-Post`DynamoDB table, you need to set up the `getPost` query so it can retrieve that data from the `AppSyncTutorial-Post` table. To do this, you set up another resolver.

- Choose the **Schema** tab.
- In the **Data types** pane on the right, find the **getPost** field on the **Query** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "GetItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    }
```

```
}
```

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

- Choose **Save**.

Call the API to Get a Post

Now the resolver has been set up, AWS AppSync knows how to translate an incoming `getPost` query to a DynamoDB`GetItem` operation. You can now run a query to retrieve the post you created earlier.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following:

```
query getPost {
  getPost(id:123) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).
- The post retrieved from DynamoDB should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "getPost": {
      "id": "123",
      "author": "AUTHORNAME",
      "title": "Our first post!",
      "content": "This is our first post.",
      "url": "https://aws.amazon.com/appsync/",
      "ups": 1,
      "downs": 0,
      "version": 1
    }
  }
}
```

Here's what happened:

- AWS AppSync received a `getPost` query request.
- AWS AppSync took the request, and the request mapping template, and generated a request mapping document. This would have looked like:

```
{
    "version" : "2017-02-28",
    "operation" : "GetItem",
    "key" : {
```

```
        "id" : { "S" : "123" }
    }
}
```

- AWS AppSync used the request mapping document to generate and execute a DynamoDB GetItem request.
- AWS AppSync took the results of the `GetItem` request and converted it back to GraphQL types.

```
{
    "id" : "123",
    "author": "AUTHORNAME",
    "title": "Our first post!",
    "content": "This is our first post.",
    "url": "https://aws.amazon.com/appsync/",
    "ups" : 1,
    "downs" : 0,
    "version" : 1
}
```

- Passed it through the response mapping document, which just passed it through unchanged.
- Returned the retrieved object in the response.

Create an updatePost Mutation (DynamoDB UpdateItem)

So far you can create and retrieve `Post` objects in DynamoDB. Next, you'll set up a new mutation to allow us to update object. You'll do this using the UpdateItem DynamoDB operation.

- Choose the **Schema** tab.
- In the **Schema** pane, modify the `Mutation` type to add a new `updatePost` mutation as follows:

```
type Mutation {
    updatePost(
        id: ID!,
        author: String!,
        title: String!,
        content: String!,
        url: String!
    ): Post
    addPost(
        author: String!
        title: String!
        content: String!
        url: String!
    ): Post!
}
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **updatePost** field on the **Mutation** type and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
```

```
        "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
    },
    "update" : {
        "expression" : "SET author = :author, title = :title, content = :content, #url
 = :url ADD version :one",
        "expressionNames": {
            "#url" : "url"
        },
        "expressionValues": {
            ":author" : $util.dynamodb.toDynamoDBJson($context.arguments.author),
            ":title" : $util.dynamodb.toDynamoDBJson($context.arguments.title),
            ":content" : $util.dynamodb.toDynamoDBJson($context.arguments.content),
            ":url" : $util.dynamodb.toDynamoDBJson($context.arguments.url),
            ":one" : { "N": 1 }
        }
    }
}
```

Note: This resolver is using the DynamoDB UpdateItem, which is significantly different from the PutItem operation. Instead of writing the entire item, you're just asking DynamoDB to update certain attributes. This is done using DynamoDB Update Expressions. The expression itself is specified in the `expression` field in the `update` section. It says to set the `author`, `title`, `content` and url attributes, and then increment the `version` field. The values to use do not appear in the expression itself; the expression has placeholders that have names starting with a colon, which are then defined in the `expressionValues` field. Finally, DynamoDB has reserved words that cannot appear in the `expression`. For example, `url` is a reserved word, so to update the `url` field you can use name placeholders and define them in the `expressionNames` field.

For more info about `UpdateItem` request mapping, see the UpdateItem (p. 270) reference documentation. For more information about how to write update expressions, see the DynamoDB UpdateExpressions documentation.

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

Call the API to Update a Post

Now the resolver has been set up, AWS AppSync knows how to translate an incoming `update` mutation to a DynamoDB`Update` operation. You can now run a mutation to update the item you wrote earlier.

- Choose the **Queries** tab.
- In **Queries** pane, paste the following mutation. You'll also need to update the `id` argument to the value you noted down earlier.

```
mutation updatePost {
  updatePost(
    id:"123"
    author: "A new author"
    title: "An updated author!"
    content: "Now with updated content!"
    url: "https://aws.amazon.com/appsync/"
  ) {
    id
    author
    title
    content
    url
    ups
```

```
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).
- The updated post in DynamoDB should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "updatePost": {
      "id": "123",
      "author": "A new author",
      "title": "An updated author!",
      "content": "Now with updated content!",
      "url": "https://aws.amazon.com/appsync/",
      "ups": 1,
      "downs": 0,
      "version": 2
    }
  }
}
```

In this example, the `ups` and `downs` fields were not modified because the request mapping template did not ask AWS AppSync and DynamoDB to do anything with those fields. Also, the `version` field was incremented by 1 because you asked AWS AppSync and DynamoDB to add 1 to the `version` field.

Modifying the updatePost Resolver (DynamoDB UpdateItem)

This is a good start to the `updatePost` mutation, but it has two main problems:

- If you want to update just a single field, you have to update all of the fields.
- If two people are modifying the object, you could potentially lose information.

To address these issues, you're going to modify the `updatePost` mutation to only modify arguments that were specified in the request, and then add a condition to the `UpdateItem` operation.

- Choose the **Schema** tab.
- In the **Schema** pane, modify the `updatePost` field in the `Mutation` type to remove the exclamation marks from the `author`, `title`, `content`, and `url` arguments, making sure to leave the `id` field as is. This will make them optional argument. Also, add a new, required `expectedVersion` argument.

```
type Mutation {
    updatePost(
        id: ID!,
        author: String,
        title: String,
        content: String,
        url: String,
        expectedVersion: Int!
    ): Post
    addPost(
        author: String!
        title: String!
```

```
        content: String!
        url: String!
    ): Post!
}
```

- Choose **Save**.
- In the **Data types** pane on the right, find the **updatePost** field on the **Mutation** type.
- Choose **PostDynamoDBTable** to open the existing resolver.
- In **Configure the request mapping template**, modify the request mapping template as follows:

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
    },

    ## Set up some space to keep track of things you're updating **
    #set( $expNames  = {} )
    #set( $expValues = {} )
    #set( $expSet = {} )
    #set( $expAdd = {} )
    #set( $expRemove = [] )

    ## Increment "version" by 1 **
    $!{expAdd.put("version", ":one")}
    $!{expValues.put(":one", { "N" : 1 })}

    ## Iterate through each argument, skipping "id" and "expectedVersion" **
    #foreach( $entry in $context.arguments.entrySet() )
        #if( $entry.key != "id" && $entry.key != "expectedVersion" )
            #if( (!$entry.value) && ("$!{entry.value}" == "") )
                ## If the argument is set to "null", then remove that attribute from the
 item in DynamoDB **

                #set( $discard = ${expRemove.add("#${entry.key}")} )
                $!{expNames.put("#${entry.key}", "$entry.key")}
            #else
                ## Otherwise set (or update) the attribute on the item in DynamoDB **

                $!{expSet.put("#${entry.key}", ":${entry.key}")}
                $!{expNames.put("#${entry.key}", "$entry.key")}
                $!{expValues.put(":${entry.key}", { "S" : "${entry.value}" })}
            #end
        #end
    #end

    ## Start building the update expression, starting with attributes you're going to SET
 **
    #set( $expression = "" )
    #if( !${expSet.isEmpty()} )
        #set( $expression = "SET" )
        #foreach( $entry in $expSet.entrySet() )
            #set( $expression = "${expression} ${entry.key} = ${entry.value}" )
            #if ( $foreach.hasNext )
                #set( $expression = "${expression}," )
            #end
        #end
    #end

    ## Continue building the update expression, adding attributes you're going to ADD **
    #if( !${expAdd.isEmpty()} )
        #set( $expression = "${expression} ADD" )
        #foreach( $entry in $expAdd.entrySet() )
```

```
            #set( $expression = "${expression} ${entry.key} ${entry.value}" )
            #if ( $foreach.hasNext )
                #set( $expression = "${expression}," )
            #end
        #end
    #end

    ## Continue building the update expression, adding attributes you're going to REMOVE
**
    #if( !${expRemove.isEmpty()} )
        #set( $expression = "${expression} REMOVE" )

        #foreach( $entry in $expRemove )
            #set( $expression = "${expression} ${entry}" )
            #if ( $foreach.hasNext )
                #set( $expression = "${expression}," )
            #end
        #end
    #end

    ## Finally, write the update expression into the document, along with any
expressionNames and expressionValues **
    "update" : {
        "expression" : "${expression}"
        #if( !${expNames.isEmpty()} )
            ,"expressionNames" : $utils.toJson($expNames)
        #end
        #if( !${expValues.isEmpty()} )
            ,"expressionValues" : $utils.toJson($expValues)
        #end
    },

    "condition" : {
        "expression"       : "version = :expectedVersion",
        "expressionValues" : {
            ":expectedVersion" :
$util.dynamodb.toDynamoDBJson($context.arguments.expectedVersion)
        }
    }
}
```

- Choose **Save**.

This template is one of the more complex examples. It demonstrates the power and flexibility of mapping templates. It loops through all of the arguments, skipping over `id` and `expectedVersion`. If the argument is set to something, it asks AWS AppSync and DynamoDB to update that attribute on the object in DynamoDB. If the attribute is set to null, it asks AWS AppSync and DynamoDB to remove that attribute from the post object. If an argument wasn't specified, it leaves the attribute alone. It also increments the `version` field.

Also, there is a new `condition` section. A condition expression enables you tell AWS AppSync and DynamoDB whether or not the request should succeed based on the state of the object already in DynamoDB before the operation is performed. In this case, you only want the `UpdateItem` request to succeed if the `version` field of the item currently in DynamoDB exactly matches the `expectedVersion` argument.

For more information about condition expressions, see the Condition Expressions (p. 304) reference documentation.

Call the API to Update a Post

Let's try updating the `Post` object with the new resolver:

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following mutation. You'll also need to update the `id` argument to the value you noted down earlier.

```
mutation updatePost {
  updatePost(
    id:123
    title: "An empty story"
    content: null
    expectedVersion: 2
  ) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).
- The updated post in DynamoDB should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "updatePost": {
      "id": "123",
      "author": "A new author",
      "title": "An empty story",
      "content": null,
      "url": "https://aws.amazon.com/appsync/",
      "ups": 1,
      "downs": 0,
      "version": 3
    }
  }
}
```

In this request, you asked AWS AppSync and DynamoDB to update the `title` and `content` field only. It left all the other fields alone (other than incrementing the `version` field). You set the `title` attribute to a new value, and removed the `content` attribute from the post. The `author`, `url`, `ups`, and `downs` fields were left untouched.

Try executing the mutation request again, leaving the request exactly as is. You should see a response similar to the following:

```
{
  "data": {
    "updatePost": null
  },
  "errors": [
    {
      "path": [
        "updatePost"
      ],
      "data": {
        "id": "123",
```

```
        "author": "A new author",
        "title": "An empty story",
        "content": null,
        "url": "https://aws.amazon.com/appsync/",
        "ups": 1,
        "downs": 0,
        "version": 3
      },
      "errorType": "DynamoDB:ConditionalCheckFailedException",
      "locations": [
        {
          "line": 2,
          "column": 3
        }
      ],
      "message": "The conditional request failed (Service: AmazonDynamoDBv2;
 Status Code: 400; Error Code: ConditionalCheckFailedException; Request ID:
 ABCDEFGHIJKLMNOPQRSTUVWXYZABCDEFGHIJKLMNOPQRSTUVWXYZ)"
    }
  ]
}
```

The request fails because the condition expression evaluates to false:

- The first time you ran the request, the value of the `version` field of the post in DynamoDB was `2`, which matched the `expectedVersion` argument. The request succeeded, which meant the `version` field was incremented in DynamoDB to `3`.
- The second time you ran the request, the value of the `version` field of the post in DynamoDB was `3`, which did not match the `expectedVersion` argument.

This pattern is typically called *optimistic locking*.

A feature of an AWS AppSync DynamoDB resolver is that it returns the current value of the post object in DynamoDB. You can find this in the `data` field in the `errors` section of the GraphQL response. Your application can use this information to decide how it should proceed. In this case, you can see the `version` field of the object in DynamoDB is set to `3`, so you could just update the `expectedVersion` argument to `3` and the request would succeed again.

For more information about handling condition check failures, see the Condition Expressions (p. 304) mapping template reference documentation.

Create upvotePost and downvotePost Mutations (DynamoDB UpdateItem)

The `Post` type has `ups` and `downs` fields to enable record upvotes and downvotes, but so far the API doesn't let us do anything with them. Let's add some mutations to let us upvote and downvote the posts.

- Choose the **Schema** tab.
- In the **Schema** pane, modify the `Mutation` type to add new `upvotePost` and `downvotePost` mutations as follows:

```
type Mutation {
    upvotePost(id: ID!): Post
    downvotePost(id: ID!): Post
    updatePost(
        id: ID!,
        author: String,
        title: String,
```

```
        content: String,
        url: String,
        expectedVersion: Int!
    ): Post
    addPost(
        author: String!,
        title: String!,
        content: String!,
        url: String!
    ): Post!
}
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **upvotePost** field on the **Mutation** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
    },
    "update" : {
        "expression" : "ADD ups :plusOne, version :plusOne",
        "expressionValues" : {
            ":plusOne" : { "N" : 1 }
        }
    }
}
```

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created `downvotePost` field on the **Mutation** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
    },
    "update" : {
        "expression" : "ADD downs :plusOne, version :plusOne",
        "expressionValues" : {
            ":plusOne" : { "N" : 1 }
        }
    }
}
```

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

- Choose **Save**.

Call the API to upvote and downvote a Post

Now the new resolvers have been set up, AWS AppSync knows how to translate an incoming `upvotePost` or `downvote` mutation to DynamoDB UpdateItem operation. You can now run mutations to upvote or downvote the post you created earlier.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following mutation. You'll also need to update the `id` argument to the value you noted down earlier.

```
mutation votePost {
  upvotePost(id:123) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).
- The post is updated in DynamoDB and should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "upvotePost": {
      "id": "123",
      "author": "A new author",
      "title": "An empty story",
      "content": null,
      "url": "https://aws.amazon.com/appsync/",
      "ups": 6,
      "downs": 0,
      "version": 4
    }
  }
}
```

- Choose **Execute query** a few more times. You should see the `ups` and `version` field incrementing by 1 each time you execute the query.
- Change the query to call the `downvotePost` mutation as follows:

```
mutation votePost {
  downvotePost(id:123) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
```

```
}
```

- Choose **Execute query** (the orange play button). This time, you should see the `downs` and `version` field incrementing by 1 each time you execute the query.

```
{
  "data": {
    "downvotePost": {
      "id": "123",
      "author": "A new author",
      "title": "An empty story",
      "content": null,
      "url": "https://aws.amazon.com/appsync/",
      "ups": 6,
      "downs": 4,
      "version": 12
    }
  }
}
```

Setting Up the deletePost Resolver (DynamoDB DeleteItem)

The next mutation you want to set up is to delete a post. You'll do this using the `DeleteItem` DynamoDB operation.

- Choose the **Schema** tab.
- In the **Schema** pane, modify the `Mutation` type to add a new `deletePost` mutation as follows:

```
type Mutation {
    deletePost(id: ID!, expectedVersion: Int): Post
    upvotePost(id: ID!): Post
    downvotePost(id: ID!): Post
    updatePost(
        id: ID!,
        author: String,
        title: String,
        content: String,
        url: String,
        expectedVersion: Int!
    ): Post
    addPost(
        author: String!,
        title: String!,
        content: String!,
        url: String!
    ): Post!
}
```

  This time you made the `expectedVersion` field optional, which is explained later when you add the request mapping template.

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **delete** field on the **Mutation** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "DeleteItem",
    "key": {
        "id": $util.dynamodb.toDynamoDBJson($context.arguments.id)
    }
    #if( $context.arguments.containsKey("expectedVersion") )
        ,"condition" : {
            "expression"       : "attribute_not_exists(id) OR version
 = :expectedVersion",
            "expressionValues" : {
                ":expectedVersion" :
 $util.dynamodb.toDynamoDBJson($context.arguments.expectedVersion)
            }
        }
    #end
}
```

Note: The `expectedVersion` argument is an optional argument. If the caller set an `expectedVersion` argument in the request, the template adds a condition that only allows the `DeleteItem` request to succeed if the item is already deleted or if the `version` attribute of the post in DynamoDB exactly matches the `expectedVersion`. If left out, no condition expression is specified on the `DeleteItem` request. It succeeds regardless of the value of `version`, or whether or not the item exists in DynamoDB.

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

Note: Even though you're deleting an item, you can return the item that was deleted, if it was not already deleted.

- Choose **Save**.

For more info about `DeleteItem` request mapping, see the DeleteItem (p. 273) reference documentation.

Call the API to Delete a Post

Now the resolver has been set up, AWS AppSync knows how to translate an incoming `delete` mutation to a DynamoDB`DeleteItem` operation. You can now run a mutation to delete something in the table.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following mutation. You'll also need to update the `id` argument to the value you noted down earlier.

```
mutation deletePost {
  deletePost(id:123) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).
- The post is deleted from DynamoDB. Note that AWS AppSync returns the value of the item that was deleted from DynamoDB, which should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "deletePost": {
      "id": "123",
      "author": "A new author",
      "title": "An empty story",
      "content": null,
      "url": "https://aws.amazon.com/appsync/",
      "ups": 6,
      "downs": 4,
      "version": 12
    }
  }
}
```

The value is only returned if this call to `deletePost` was the one that actually deleted it from DynamoDB.

- Choose **Execute query** again.
- The call still succeeds, but no value is returned.

```
{
  "data": {
    "deletePost": null
  }
}
```

Now let's try deleting a post, but this time specifying an `expectedValue`. First though, you'll need to create a new post because you've just deleted the one you've been working with so far.

- In the **Queries** pane, paste the following mutation:

```
mutation addPost {
  addPost(
    id:123
    author: "AUTHORNAME"
    title: "Our second post!"
    content: "A new post."
    url: "https://aws.amazon.com/appsync/"
  ) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).

- The results of the newly created post should appear in the results pane to the right of the query pane. Note down the `id` of the newly created object because you need it in just a moment. It should look similar to the following:

```
{
  "data": {
    "addPost": {
      "id": "123",
      "author": "AUTHORNAME",
      "title": "Our second post!",
      "content": "A new post.",
      "url": "https://aws.amazon.com/appsync/",
      "ups": 1,
      "downs": 0,
      "version": 1
    }
  }
}
```

Now let's try to delete that post, but put in the wrong value for `expectedVersion`:

- In the **Queries** pane, paste the following mutation. You'll also need to update the `id` argument to the value you noted down earlier.

```
mutation deletePost {
  deletePost(
    id:123
    expectedVersion: 9999
  ) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).

```
{
  "data": {
    "deletePost": null
  },
  "errors": [
    {
      "path": [
        "deletePost"
      ],
      "data": {
        "id": "123",
        "author": "AUTHORNAME",
        "title": "Our second post!",
        "content": "A new post.",
        "url": "https://aws.amazon.com/appsync/",
        "ups": 1,
        "downs": 0,
        "version": 1
      },
```

```
      "errorType": "DynamoDB:ConditionalCheckFailedException",
      "locations": [
        {
          "line": 2,
          "column": 3
        }
      ],
      "message": "The conditional request failed (Service: AmazonDynamoDBv2;
 Status Code: 400; Error Code: ConditionalCheckFailedException; Request ID:
 ABCDEFGHIJKLMNOPQRSTUVWXYZABCDEFGHIJKLMNOPQRSTUVWXYZ)"
    }
  ]
}
```

The request failed because the condition expression evaluates to false: the value for `version` of the post in DynamoDB does not match the `expectedValue` specified in the arguments. The current value of the object is returned in the `data` field in the `errors` section of the GraphQL response.

- Retry the request, but correct the `expectedVersion`:

```
mutation deletePost {
  deletePost(
    id:123
    expectedVersion: 1
  ) {
    id
    author
    title
    content
    url
    ups
    downs
    version
  }
}
```

- Choose **Execute query** (the orange play button).
- This time the request succeeds, and the value that was deleted from DynamoDB is returned:

```
{
  "data": {
    "deletePost": {
      "id": "123",
      "author": "AUTHORNAME",
      "title": "Our second post!",
      "content": "A new post.",
      "url": "https://aws.amazon.com/appsync/",
      "ups": 1,
      "downs": 0,
      "version": 1
    }
  }
}
```

- Choose **Execute query** again.
- The call still succeeds, but this time no value is returned because the post was already deleted in DynamoDB.

```
{
  "data": {
    "deletePost": null
```

```
  }
}
```

Setting Up the allPost Resolver (DynamoDB Scan)

So far the API is only useful if you know the `id` of each post you want to look at. Let's add a new resolver that returns all the posts in the table.

- Choose the **Schema** tab.
- In the **Schema** pane, modify the `Query` type to add a new `allPost` query as follows:

```
type Query {
    allPost(count: Int, nextToken: String): PaginatedPosts!
    getPost(id: ID): Post
}
```

- Add a new `PaginationPosts` type:

```
type PaginatedPosts {
    posts: [Post!]!
    nextToken: String
}
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **allPost** field on the **Query** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "Scan"
    #if( ${context.arguments.count} )
        ,"limit": $util.toJson($context.arguments.count)
    #end
    #if( ${context.arguments.nextToken} )
        ,"nextToken": $util.toJson($context.arguments.nextToken)
    #end
}
```

  This resolver has two optional arguments: `count`, which specifies the maximum number of items to return in a single call, and `nextToken`, which can be used to retrieve the next set of results (you'll show where the value for `nextToken` comes from later).

- In **Configure the response mapping template**, paste the following:

```
{
    "posts": $utils.toJson($context.result.items)
    #if( ${context.result.nextToken} )
        ,"nextToken": $util.toJson($context.result.nextToken)
    #end
}
```

  Note: This response mapping template is different from all the others so far. The result of the `allPost` query is a `PaginatedPosts`, which contains a list of posts and a pagination token. The shape of this object is different to what is returned from the AWS AppSync DynamoDB Resolver: the list of posts is called `items` in the AWS AppSync DynamoDB Resolver results, but is called `posts` in `PaginatedPosts`.

- Choose **Save**.

For more information about `Scan` request mapping, see the Scan (p. 278) reference documentation.

Call the API to Scan All Posts

Now the resolver has been set up, AWS AppSync knows how to translate an incoming `allPost` query to a DynamoDB`Scan` operation. You can now scan the table to retrieve all the posts.

Before you can try it out though, you need to populate the table with some data because you've deleted everything you've worked with so far.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following mutation:

```
mutation addPost {
  post1: addPost(id:1 author: "AUTHORNAME" title: "A series of posts, Volume 1" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post2: addPost(id:2 author: "AUTHORNAME" title: "A series of posts, Volume 2" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post3: addPost(id:3 author: "AUTHORNAME" title: "A series of posts, Volume 3" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post4: addPost(id:4 author: "AUTHORNAME" title: "A series of posts, Volume 4" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post5: addPost(id:5 author: "AUTHORNAME" title: "A series of posts, Volume 5" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post6: addPost(id:6 author: "AUTHORNAME" title: "A series of posts, Volume 6" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post7: addPost(id:7 author: "AUTHORNAME" title: "A series of posts, Volume 7" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post8: addPost(id:8 author: "AUTHORNAME" title: "A series of posts, Volume 8" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
  post9: addPost(id:9 author: "AUTHORNAME" title: "A series of posts, Volume 9" content:
 "Some content" url: "https://aws.amazon.com/appsync/" ) { title }
}
```

- Choose **Execute query** (the orange play button).

Now, let's scan the table, returning five results at a time.

- In the **Queries** pane, paste the following query:

```
query allPost {
  allPost(count: 5) {
    posts {
      id
      title
    }
    nextToken
  }
}
```

- Choose **Execute query** (the orange play button).
- The first five posts should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "allPost": {
```

```
      "posts": [
        {
          "id": "5",
          "title": "A series of posts, Volume 5"
        },
        {
          "id": "1",
          "title": "A series of posts, Volume 1"
        },
        {
          "id": "6",
          "title": "A series of posts, Volume 6"
        },
        {
          "id": "9",
          "title": "A series of posts, Volume 9"
        },
        {
          "id": "7",
          "title": "A series of posts, Volume 7"
        }
      ],
      "nextToken":
 "eyJ2ZXJzaW9uIjoxLCJ0b2tlbiI6IkFRSUNBSGo4eHR0RG0xWXhUa1F0cEhXMEp1R3B0M1B3eThOSmRvcG9ad2RHYjI3Z0lnRkJ
    }
  }
}
```

You got five results and a `nextToken` that you can use to get the next set of results.

- Update the `allPost` query to include the `nextToken` from the previous set of results:

```
query allPost {
  allPost(
    count: 5
    nextToken:
 "eyJ2ZXJzaW9uIjoxLCJ0b2tlbiI6IkFRSUNBSGo4eHR0RG0xWXhUa1F0cEhXMEp1R3B0M1B3eThOSmRvcG9ad2RHYjI3Z0lnRll
  ) {
    posts {
      id
      author
    }
    nextToken
  }
}
```

- Choose **Execute query** (the orange play button).
- The remaining four posts should appear in the results pane to the right of the query pane. There is no `nextToken` in this set of results because you've paged through all nine posts, with none remaining. It should look similar to the following:

```
{
  "data": {
    "allPost": {
      "posts": [
        {
          "id": "2",
          "title": "A series of posts, Volume 2"
        },
        {
          "id": "3",
          "title": "A series of posts, Volume 3"
```

```
        },
        {
          "id": "4",
          "title": "A series of posts, Volume 4"
        },
        {
          "id": "8",
          "title": "A series of posts, Volume 8"
        }
      ],
      "nextToken": null
    }
  }
}
```

Setting Up the allPostsByAuthor Resolver (DynamoDB Query)

In addition to scanning DynamoDB for all posts, you can also query DynamoDB to retrieve posts created by a specific author. The DynamoDB table you created earlier already has a `GlobalSecondaryIndex` called `author-index` you can use with a DynamoDB`Query` operation to retrieve all posts created by a specific author.

- Choose the **Schema** tab.
- In the **Schema** pane, modify the `Query` type to add a new `allPostsByAuthor` query as follows:

```
type Query {
    allPostsByAuthor(author: String!, count: Int, nextToken: String): PaginatedPosts!
    allPost(count: Int, nextToken: String): PaginatedPosts!
    getPost(id: ID): Post
}
```

  Note: This uses the same `PaginatedPosts` type that you used with the `allPost` query.
- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **allPostsByAuthor** field on the **Query** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "Query",
    "index" : "author-index",
    "query" : {
      "expression": "author = :author",
        "expressionValues" : {
          ":author" : $util.dynamodb.toDynamoDBJson($context.arguments.author)
        }
    }
    #if( ${context.arguments.count} )
        ,"limit": $util.toJson($context.arguments.count)
    #end
    #if( ${context.arguments.nextToken} )
        ,"nextToken": "${context.arguments.nextToken}"
    #end
}
```

Like the `allPost` resolver, this resolver has two optional arguments: `count`, which specifies the maximum number of items to return in a single call, and `nextToken`, which can be used to retrieve the next set of results (the value for `nextToken` can be obtained from a previous call).

- In **Configure the response mapping template**, paste the following:

```
{
    "posts": $utils.toJson($context.result.items)
    #if( ${context.result.nextToken} )
        ,"nextToken": $util.toJson($context.result.nextToken)
    #end
}
```

Note: This is the same response mapping template that you used in the `allPost` resolver.

- Choose **Save**.

For more information about `Query` request mapping, see the Query (p. 275) reference documentation.

Call the API to Query All Posts by an Author

Now the resolver has been set up, AWS AppSync knows how to translate an incoming `allPostsByAuthor` mutation to a DynamoDB`Query` operation against the `author-index` index. You can now query the table to retrieve all the posts by a specific author.

Before you do that, however, let's populate the table with some more posts, because every post so far has the same author.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following mutation:

```
mutation addPost {
  post1: addPost(id:10 author: "Nadia" title: "The cutest dog in the world" content: "So
 cute. So very, very cute." url: "https://aws.amazon.com/appsync/" ) { author, title }
  post2: addPost(id:11 author: "Nadia" title: "Did you know...?" content: "AppSync works
 offline?" url: "https://aws.amazon.com/appsync/" ) { author, title }
  post3: addPost(id:12 author: "Steve" title: "I like GraphQL" content: "It's great" url:
 "https://aws.amazon.com/appsync/" ) { author, title }
}
```

- Choose **Execute query** (the orange play button).

Now, let's query the table, returning all posts authored by `Nadia`.

- In the **Queries** pane, paste the following query:

```
query allPostsByAuthor {
  allPostsByAuthor(author: "Nadia") {
    posts {
      id
      title
    }
    nextToken
  }
}
```

- Choose **Execute query** (the orange play button).

- All the posts authored by `Nadia` should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "allPostsByAuthor": {
      "posts": [
        {
          "id": "10",
          "title": "The cutest dog in the world"
        },
        {
          "id": "11",
          "title": "Did you know...?"
        }
      ],
      "nextToken": null
    }
  }
}
```

Pagination works for `Query` just the same as it does for `Scan`. For example, let's look for all posts by `AUTHORNAME`, getting five at a time.

- In the **Queries** pane, paste the following query:

```
query allPostsByAuthor {
  allPostsByAuthor(
    author: "AUTHORNAME"
    count: 5
  ) {
    posts {
      id
      title
    }
    nextToken
  }
}
```

- Choose **Execute query** (the orange play button).
- All the posts authored by `AUTHORNAME` should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "allPostsByAuthor": {
      "posts": [
        {
          "id": "6",
          "title": "A series of posts, Volume 6"
        },
        {
          "id": "4",
          "title": "A series of posts, Volume 4"
        },
        {
          "id": "2",
          "title": "A series of posts, Volume 2"
        },
        {
          "id": "7",
```

```
          "title": "A series of posts, Volume 7"
        },
        {
          "id": "1",
          "title": "A series of posts, Volume 1"
        }
      ],
      "nextToken":
 "eyJ2ZXJzaW9uIjoxLCJ0b2tlbiI6IkFRSUNBSGo4eHR0RG0xWXhUa1F0cEhXMEp1R3B0M1B3eThOSmRvcG9ad2RHYjI3Z0lnSEx
    }
  }
}
```

- Update the `nextToken` argument with the value returned from the previous query as follows:

```
query allPostsByAuthor {
  allPostsByAuthor(
    author: "AUTHORNAME"
    count: 5
    nextToken:
 "eyJ2ZXJzaW9uIjoxLCJ0b2tlbiI6IkFRSUNBSGo4eHR0RG0xWXhUa1F0cEhXMEp1R3B0M1B3eThOSmRvcG9ad2RHYjI3Z0lnSEx
  ) {
    posts {
      id
      title
    }
    nextToken
  }
}
```

- Choose **Execute query** (the orange play button).
- The remaining posts authored by `AUTHORNAME` should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "allPostsByAuthor": {
      "posts": [
        {
          "id": "8",
          "title": "A series of posts, Volume 8"
        },
        {
          "id": "5",
          "title": "A series of posts, Volume 5"
        },
        {
          "id": "3",
          "title": "A series of posts, Volume 3"
        },
        {
          "id": "9",
          "title": "A series of posts, Volume 9"
        }
      ],
      "nextToken": null
    }
  }
}
```

Using Sets

Up to this point the `Post` type has been a flat key/value object. You can also model complex objects with the AWS AppSyncDynamoDB resolver, such as sets, lists, and maps.

Let's update the `Post` type to include tags. A post can have 0 or more tags, which are stored in DynamoDB as a String Set. You'll also set up some mutations to add and remove tags, and a new query to scan for posts with a specific tag.

- Choose the **Schema** tab.
- In the **Schema** pane, modify the `Post` type to add a new `tags` field as follows:

```
type Post {
  id: ID!
  author: String
  title: String
  content: String
  url: String
  ups: Int!
  downs: Int!
  version: Int!
  tags: [String!]
}
```

- In the **Schema** pane, modify the `Query` type to add a new `allPostsByTag` query as follows:

```
type Query {
  allPostsByTag(tag: String!, count: Int, nextToken: String): PaginatedPosts!
  allPostsByAuthor(author: String!, count: Int, nextToken: String): PaginatedPosts!
  allPost(count: Int, nextToken: String): PaginatedPosts!
  getPost(id: ID): Post
}
```

- In the **Schema** pane, modify the `Mutation` type to add new `addTag` and `removeTag` mutations as follows:

```
type Mutation {
  addTag(id: ID!, tag: String!): Post
  removeTag(id: ID!, tag: String!): Post
  deletePost(id: ID!, expectedVersion: Int): Post
  upvotePost(id: ID!): Post
  downvotePost(id: ID!): Post
  updatePost(
    id: ID!,
    author: String,
    title: String,
    content: String,
    url: String,
    expectedVersion: Int!
  ): Post
  addPost(
    author: String!,
    title: String!,
    content: String!,
    url: String!
  ): Post!
}
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **allPostsByTag** field on the **Query** type, and then choose **Attach**.

- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "Scan",
    "filter": {
      "expression": "contains (tags, :tag)",
        "expressionValues": {
          ":tag": $util.dynamodb.toDynamoDBJson($context.arguments.tag)
        }
    }
    #if( ${context.arguments.count} )
        ,"limit": $util.toJson($context.arguments.count)
    #end
    #if( ${context.arguments.nextToken} )
        ,"nextToken": $util.toJson($context.arguments.nextToken)
    #end
}
```

- In **Configure the response mapping template**, paste the following:

```
{
    "posts": $utils.toJson($context.result.items)
    #if( ${context.result.nextToken} )
        ,"nextToken": $util.toJson($context.result.nextToken)
    #end
}
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **addTag** field on the **Mutation** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
    },
    "update" : {
        "expression" : "ADD tags :tags, version :plusOne",
        "expressionValues" : {
            ":tags" : { "SS": [ $util.toJson($context.arguments.tag) ] },
            ":plusOne" : { "N" : 1 }
        }
    }
}
```

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **removeTag** field on the **Mutation** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
    },
    "update" : {
        "expression" : "DELETE tags :tags ADD version :plusOne",
        "expressionValues" : {
            ":tags" : { "SS": [ $util.toJson($context.arguments.tag) ] },
            ":plusOne" : { "N" : 1 }
        }
    }
}
```

- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

- Choose **Save**.

Call the API to Work with Tags

Now that you've set up the resolvers, AWS AppSync knows how to translate incoming `addTag`, `removeTag`, and `allPostsByTag` requests into DynamoDB`UpdateItem` and `Scan` operations.

To try it out, let's select one of the posts you created earlier. For example, let's use a post authored by `Nadia`.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following query:

```
query allPostsByAuthor {
  allPostsByAuthor(
    author: "Nadia"
  ) {
    posts {
      id
      title
    }
    nextToken
  }
}
```

- Choose **Execute query** (the orange play button).
- All of Nadia's posts should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "allPostsByAuthor": {
      "posts": [
        {
          "id": "10",
          "title": "The cutest dog in the world"
        },
        {
          "id": "11",
```

```
          "title": "Did you known...?"
        }
      ],
      "nextToken": null
    }
  }
}
```

- Let's use the one with the title `"The cutest dog in the world"`. Note down its `id` because you'll use it later.

Now let's try adding a `dog` tag.

- In the **Queries** pane, paste the following mutation. You'll also need to update the `id` argument to the value you noted down earlier.

```
mutation addTag {
  addTag(id:10 tag: "dog") {
    id
    title
    tags
  }
}
```

- Choose **Execute query** (the orange play button).
- The post is updated with the new tag.

```
{
  "data": {
    "addTag": {
      "id": "10",
      "title": "The cutest dog in the world",
      "tags": [
        "dog"
      ]
    }
  }
}
```

You can add more tags as follows:

- Update the mutation to change the `tag` argument to `puppy`.

```
mutation addTag {
  addTag(id:10 tag: "puppy") {
    id
    title
    tags
  }
}
```

- Choose **Execute query** (the orange play button).
- The post is updated with the new tag.

```
{
  "data": {
    "addTag": {
      "id": "10",
      "title": "The cutest dog in the world",
```

```
      "tags": [
        "dog",
        "puppy"
      ]
    }
  }
}
```

You can also delete tags:

- In the **Queries** pane, paste the following mutation. You'll also need to update the `id` argument to the value you noted down earlier.

```
mutation removeTag {
  removeTag(id:10 tag: "puppy") {
    id
    title
    tags
  }
}
```

- Choose **Execute query** (the orange play button).
- The post is updated and the `puppy` tag is deleted.

```
{
  "data": {
    "addTag": {
      "id": "10",
      "title": "The cutest dog in the world",
      "tags": [
        "dog"
      ]
    }
  }
}
```

You can also search for all posts that have a tag:

- In the **Queries** pane, paste the following query:

```
query allPostsByTag {
  allPostsByTag(tag: "dog") {
    posts {
      id
      title
      tags
    }
    nextToken
  }
}
```

- Choose **Execute query** (the orange play button).
- All posts that have the `dog` tag are returned as follows:

```
{
  "data": {
    "allPostsByTag": {
      "posts": [
        {
```

```
          "id": "10",
          "title": "The cutest dog in the world",
          "tags": [
            "dog",
            "puppy"
          ]
        }
      ],
      "nextToken": null
    }
  }
}
```

Using Lists and Maps

In addition to using DynamoDB sets, you can also use DynamoDB lists and maps to model complex data in a single object.

Let's add the ability to add comments to posts. This will be modeled as a list of map objects on the `Post` object in DynamoDB.

Note: in a real application, you would model comments in their own table. For this tutorial, you'll just add them in the `Post` table.

- Choose the **Schema** tab.
- In the **Schema** pane, add a new `Comment` type as follows:

```
type Comment {
    author: String!
    comment: String!
}
```

- In the **Schema** pane, modify the `Post` type to add a new `comments` field as follows:

```
type Post {
  id: ID!
  author: String
  title: String
  content: String
  url: String
  ups: Int!
  downs: Int!
  version: Int!
  tags: [String!]
  comments: [Comment!]
}
```

- In the **Schema** pane, modify the `Mutation` type to add a new `addComment` mutation as follows:

```
type Mutation {
  addComment(id: ID!, author: String!, comment: String!): Post
  addTag(id: ID!, tag: String!): Post
  removeTag(id: ID!, tag: String!): Post
  deletePost(id: ID!, expectedVersion: Int): Post
  upvotePost(id: ID!): Post
  downvotePost(id: ID!): Post
  updatePost(
    id: ID!,
    author: String,
    title: String,
```

```
    content: String,
    url: String,
    expectedVersion: Int!
  ): Post
  addPost(
    author: String!,
    title: String!,
    content: String!,
    url: String!
  ): Post!
}
```

- Choose **Save**.
- In the **Data types** pane on the right, find the newly created **addComment** field on the **Mutation** type, and then choose **Attach**.
- In **Data source name**, choose **PostDynamoDBTable**.
- In **Configure the request mapping template**, paste the following:

```
{
  "version" : "2017-02-28",
  "operation" : "UpdateItem",
  "key" : {
    "id" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
  },
  "update" : {
    "expression" : "SET comments =
 list_append(if_not_exists(comments, :emptyList), :newComment) ADD version :plusOne",
    "expressionValues" : {
      ":emptyList": { "L" : [] },
      ":newComment" : { "L" : [
        { "M": {
          "author": $util.dynamodb.toDynamoDBJson($context.arguments.author),
          "comment": $util.dynamodb.toDynamoDBJson($context.arguments.comment)
          }
        }
      ] },
      ":plusOne" : $util.dynamodb.toDynamoDBJson(1)
    }
  }
}
```

  This update expression will append a list containing our new comment to the existing `comments` list. If the list doesn't already exist, it will be created.
- In **Configure the response mapping template**, paste the following:

```
$utils.toJson($context.result)
```

- Choose **Save**.

Call the API to Add a Comment

Now that you've set up the resolvers, AWS AppSync knows how to translate incoming `addComment` requests into DynamoDB`UpdateItem` operations.

Let's try it out by adding a comment to the same post you added the tags to.

- Choose the **Queries** tab.
- In the **Queries** pane, paste the following query:

```
mutation addComment {
  addComment(
    id:10
    author: "Steve"
    comment: "Such a cute dog."
  ) {
    id
    comments {
      author
      comment
    }
  }
}
```

- Choose **Execute query** (the orange play button).
- All of Nadia's posts should appear in the results pane to the right of the query pane. It should look similar to the following:

```
{
  "data": {
    "addComment": {
      "id": "10",
      "comments": [
        {
          "author": "Steve",
          "comment": "Such a cute dog."
        }
      ]
    }
  }
}
```

If you execute the request multiple times, multiple comments will be appended to the list.

Conclusion

In this tutorial, you've built an API that lets us manipulate Post objects in DynamoDB using AWS AppSync and GraphQL. For more information, see the Resolver Mapping Template Reference (p. 226).

To clean up, you can delete the AppSync GraphQL API from the console.

To delete the DynamoDB table and the IAM role you created for this tutorial, you can run the following to delete the `AWSAppSyncTutorialForAmazonDynamoDB` stack, or visit the AWS CloudFormation console and delete the stack:

```
aws cloudformation delete-stack \
    --stack-name AWSAppSyncTutorialForAmazonDynamoDB
```

Tutorial: AWS Lambda Resolvers

AWS AppSync enables you to use AWS Lambda to resolve any GraphQL field. For example, a GraphQL query might send a call to an Amazon RDS instance, and a GraphQL mutation might write to a Amazon Kinesis stream. In this section, we'll show you how to write a Lambda function that performs business logic based on the invocation of a GraphQL field operation.

Create a Lambda Function

The following example shows a Lambda function written in `Node.js` that performs different operations on blog posts as part of a blog post application example.

```
exports.handler = (event, context, callback) => {
    console.log("Received event {}", JSON.stringify(event, 3));
    var posts = {
          "1": {"id": "1", "title": "First book", "author": "Author1", "url": "https://
amazon.com/", "content": "SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1
 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1", "ups": "100", "downs":
 "10"},
          "2": {"id": "2", "title": "Second book", "author": "Author2", "url": "https://
amazon.com", "content": "SAMPLE TEXT AUTHOR 2 SAMPLE TEXT AUTHOR 2 SAMPLE TEXT", "ups":
 "100", "downs": "10"},
          "3": {"id": "3", "title": "Third book", "author": "Author3", "url": null,
 "content": null, "ups": null, "downs": null },
          "4": {"id": "4", "title": "Fourth book", "author": "Author4", "url": "https://
www.amazon.com/", "content": "SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR
 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4
 SAMPLE TEXT AUTHOR 4", "ups": "1000", "downs": "0"},
          "5": {"id": "5", "title": "Fifth book", "author": "Author5", "url": "https://
www.amazon.com/", "content": "SAMPLE TEXT AUTHOR 5 SAMPLE TEXT AUTHOR 5 SAMPLE TEXT AUTHOR
 5 SAMPLE TEXT AUTHOR 5 SAMPLE TEXT", "ups": "50", "downs": "0"} };

    var relatedPosts = {
        "1": [posts['4']],
        "2": [posts['3'], posts['5']],
        "3": [posts['2'], posts['1']],
        "4": [posts['2'], posts['1']],
        "5": []
    };

    console.log("Got an Invoke Request.");
    switch(event.field) {
        case "getPost":
            var id = event.arguments.id;
            callback(null, posts[id]);
            break;
        case "allPosts":
            var values = [];
            for(var d in posts){
                values.push(posts[d]);
            }
            callback(null, values);
            break;
        case "addPost":
            // return the arguments back
            callback(null, event.arguments);
            break;
        case "addPostErrorWithData":
            var id = event.arguments.id;
            var result = posts[id];
            // attached additional error information to the post
            result.errorMessage = 'Error with the mutation, data has changed';
            result.errorType = 'MUTATION_ERROR';
            callback(null, result);
            break;
        case "relatedPosts":
            var id = event.source.id;
            callback(null, relatedPosts[id]);
            break;
        default:
            callback("Unknown field, unable to resolve" + event.field, null);
```

```
            break;
    }
};
```

This Lambda function handles retrieving a post by ID, adding a post, retrieving a list of posts, and fetching related posts for a given post.

Note: The `switch` statement on `event.field` enables the Lambda function to determine which field is being currently resolved.

Now let's create this Lambda function using the AWS Management Console or with AWS CloudFormation by choosing the following:

```
aws cloudformation create-stack --stack-name AppSyncLambdaExample \
--template-url https://s3.us-west-2.amazonaws.com/awsappsync/resources/lambda/
LambdaCFTemplate.yaml \
--capabilities CAPABILITY_NAMED_IAM
```

You can launch the following AWS CloudFormation stack in the US West 2 (Oregon) Region in your AWS account:

Configure Data Source for AWS Lambda

After the AWS Lambda function has been created, navigate to your AWS AppSync GraphQL API in the console and choose the **Data Sources** tab.

Choose **New**, enter a friendly name for the data source (for example, `"Lambda"`), and then choose AWS Lambda in **Data source type**. Choose the appropriate AWS Region, and then you should see your Lambda functions listed.

After selecting your Lambda function, you can either create a new role (for which AWS AppSync assigns the appropriate permissions) or choose an existing role that has the following inline policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "lambda:InvokeFunction"
            ],
            "Resource": "arn:aws:lambda:REGION:ACCOUNTNUMBER:function/LAMBDA_FUNCTION"
        }
    ]
}
```

You also need to set up a trust relationship with AWS AppSync for that role as follows:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "appsync.amazonaws.com"
            },
```

```
            "Action": "sts:AssumeRole"
        }
    ]
}
```

Creating a GraphQL Schema

Now that the data source is connected to your Lambda function, let's create a GraphQL schema.

From the schema editor in the AWS AppSync console, make sure your schema matches the following schema:

```
schema {
    query: Query
    mutation: Mutation
}

type Query {
    getPost(id:ID!): Post
    allPosts: [Post]
}

type Mutation {
    addPost(id: ID!, author: String!, title: String, content: String, url: String): Post!
}

type Post {
    id: ID!
    author: String!
    title: String
    content: String
    url: String
    ups: Int
    downs: Int
    relatedPosts: [Post]
}
```

Configuring Resolvers

Now that we've registered an AWS Lambda data source and a valid GraphQL schema, we can connect our GraphQL fields to our Lambda data source using resolvers.

To create a resolver, we'll need mapping templates. To learn more about mapping templates, read AWS AppSync mapping templates overview Resolver Mapping Template Overview (p. 226).

For more information about Lambda mapping templates, see Resolver Mapping Template Reference for Lambda (p. 320).

In this step, you attach a resolver to the Lambda function for the following fields: `getPost(id:ID!): Post`, `allPosts: [Post]`, `addPost(id: ID!, author: String!, title: String, content: String, url: String): Post!`, and `Post.relatedPosts: [Post]`.

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `getPost(id:ID!): Post`.

Choose your AWS Lambda data source. In the **request mapping template** section, choose **Invoke And Forward Arguments**.

Modify the `payload` object to add the field name. Your template should look like the following:

```
{
```

```
    "version": "2017-02-28",
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "arguments":  $utils.toJson($context.arguments)
    }
}
```

In the **response mapping template** section, choose **Return Lambda Result**.

In this case, use the base template as-is. It should look like the following:

```
$utils.toJson($context.result)
```

Choose **Save**. You have successfully attached your first resolver. Repeat this operation for the remaining fields as follows:

For `addPost(id: ID!, author: String!, title: String, content: String, url: String): Post!` request mapping template:

```
{
    "version": "2017-02-28",
    "operation": "Invoke",
    "payload": {
        "field": "addPost",
        "arguments":  $utils.toJson($context.arguments)
    }
}
```

For `addPost(id: ID!, author: String!, title: String, content: String, url: String): Post!` response mapping template:

```
$utils.toJson($context.result)
```

For `allPosts: [Post]` request mapping template:

```
{
    "version": "2017-02-28",
    "operation": "Invoke",
    "payload": {
        "field": "allPosts"
    }
}
```

For `allPosts: [Post]` response mapping template:

```
$utils.toJson($context.result)
```

For `Post.relatedPosts: [Post]` request mapping template:

```
{
    "version": "2017-02-28",
    "operation": "Invoke",
    "payload": {
        "field": "relatedPosts",
        "source":  $utils.toJson($context.source)
    }
}
```

For `Post.relatedPosts: [Post]` response mapping template:

```
$utils.toJson($context.result)
```

Testing Your GraphQL API

Now that your Lambda function is connected to GraphQL resolvers, you can run some mutations and queries using the console or a client application.

On the left side of the AWS AppSync console, choose the **Queries** tab, and then paste in the following code:

addPost Mutation

```
mutation addPost {
    addPost(
        id: 6
        author: "Author6"
        title: "Sixth book"
        url: "https://www.amazon.com/"
        content: "This is the book is a tutorial for using GraphQL with AWS AppSync."
    ) {
        id
        author
        title
        content
        url
        ups
        downs
    }
}
```

getPost Query

```
query {
    getPost(id: "2") {
        id
        author
        title
        content
        url
        ups
        downs
    }
}
```

allPosts Query

```
query {
    allPosts {
        id
        author
        title
        content
        url
        ups
        downs
        relatedPosts {
```

```
            id
            title
        }
    }
}
```

Returning Errors

Any given field resolution can result in an error. AWS AppSync enables you raise errors from the following sources:

- Request or response mapping template
- Lambda function

From the Mapping Template

You can use the `$utils.error` helper method from the VTL template to raise intentional errors. It takes as argument an `errorMessage`, an `errorType`, and an optional `data` value. The `data` is useful for returning extra data back to the client when an error occurs. The `data` object is added to the `errors` in the GraphQL final response.

The following example shows how to use it in the `Post.relatedPosts: [Post]` response mapping template:

```
$utils.error("Failed to fetch relatedPosts", "LambdaFailure", $context.result)
```

This yields a GraphQL response similar to the following:

```
{
    "data": {
        "allPosts": [
            {
                "id": "2",
                "title": "Second book",
                "relatedPosts": null
            },
            ...
        ]
    },
    "errors": [
        {
            "path": [
                "allPosts",
                0,
                "relatedPosts"
            ],
            "errorType": "LambdaFailure",
            "locations": [
                {
                    "line": 5,
                    "column": 5
                }
            ],
            "message": "Failed to fetch relatedPosts",
            "data": [
                {
                  "id": "2",
                  "title": "Second book"
                },
```

```
                {
                  "id": "1",
                  "title": "First book"
                }
            ]
        }
    ]
}
```

Where `allPosts[0].relatedPosts` is *null* because of the error and the `errorMessage`, `errorType`, and `data` are present in the `data.errors[0]` object.

From the Lambda Function

AWS AppSync also understands errors thrown from the Lambda function. The Lambda programming model lets you raise *handled* errors. If an error is thrown from the Lambda function, AWS AppSync fails to resolve the current field. Only the error message returned from Lambda will be set in the response. Currently, you can't pass any extraneous data back to the client by raising an error from the Lambda function.

Note: If your Lambda function raises an *unhandled* error, AWS AppSync uses the error message set by AWS Lambda.

The following Lambda function raises an error:

```
exports.handler = (event, context, callback) => {
    console.log("Received event {}", JSON.stringify(event, 3));
    callback("I fail. Always.");
};
```

This returns a GraphQL response similar to the following:

```
{
    "data": {
        "allPosts": [
            {
                "id": "2",
                "title": "Second book",
                "relatedPosts": null
            },
            ...
        ]
    },
    "errors": [
        {
            "path": [
                "allPosts",
                0,
                "relatedPosts"
            ],
            "errorType": "Lambda:Handled",
            "locations": [
                {
                    "line": 5,
                    "column": 5
                }
            ],
            "message": "I fail. Always."
        }
    ]
}
```

Advanced Use Case: Batching

The Lambda function in this example has a `relatedPosts` field that returns a list of related posts for a given post. In the example queries, the `allPosts` field invocation from the Lambda function returns five posts. Because we have specified that we also want to resolve `relatedPosts` for each returned post, the `relatedPosts` field operation will, in turn, be invoked five times.

```
query {
    allPosts {   // 1 Lambda invocation - yields 5 Posts
        id
        author
        title
        content
        url
        ups
        downs
        relatedPosts {   // 5 Lambda invocations - each yields 5 posts
            id
            title
        }
    }
}
```

While this doesn't sound substantial in this specific example, the application can be undermined quickly by this compounded over-fetching.

If you were to fetch `relatedPosts` again on the returned related `Posts` in the same query, the number of invocations would increase dramatically.

```
query {
    allPosts {   // 1 Lambda invocation - yields 5 Posts
        id
        author
        title
        content
        url
        ups
        downs
        relatedPosts {   // 5 Lambda invocations - each yield 5 posts = 5 x 5 Posts
            id
            title
            relatedPosts {  // 5 x 5 Lambda invocations - each yield 5 posts = 25 x 5 Posts
                id
                title
                author
            }
        }
    }
}
```

In this relatively simple query, AWS AppSync would invoke the Lambda function 1 + 5 + 25 = 31 times.

This is a fairly common challenge and is often called the N+1 problem (in this case, N = 5), and it can incur increased latency and cost to the application.

One approach to solving this issue is to batch similar field resolver requests together. In this example, instead of having the Lambda function resolve a list of related posts for a single given post, instead it could resolve a list of related posts for a given batch of posts.

To demonstrate this, let's switch the `Post.relatedPosts: [Post]` resolver to a batch-enabled resolver.

On the right side of the AWS AppSync console, choose the existing `Post.relatedPosts: [Post]` resolver. Change the request mapping template to the following:

```
{
    "version": "2017-02-28",
    "operation": "BatchInvoke",
    "payload": {
        "field": "relatedPosts",
        "source":  $utils.toJson($context.source)
    }
}
```

Only the `operation` field has changed from `Invoke` to `BatchInvoke`. The payload field now becomes an array of whatever has been specified in the template. In this example, the Lambda function receives the following as input:

```
[
    {
        "field": "relatedPosts",
        "source": {
            "id": 1
        }
    },
    {
        "field": "relatedPosts",
        "source": {
            "id": 2
        }
    },
    ...
]
```

When `BatchInvoke` is specified in the request mapping template, the Lambda function receives a list of requests and returns a list of results.

Specifically, the list of results *must* match the size and order of the request payload entries so that AWS AppSync can match the results accordingly.

In this batching example, the Lambda function returns a batch of results as follows:

```
[
    [{"id":"2","title":"Second book"}, {"id":"3","title":"Third book"}],   // relatedPosts
 for id=1
    [{"id":"3","title":"Third book"}]
       // relatedPosts for id=2
]
```

The following AWS Lambda function in Node.js demonstrates this batching functionality for the `Post.relatedPosts` field as follows:

```
exports.handler = (event, context, callback) => {
    console.log("Received event {}", JSON.stringify(event, 3));
    var posts = {
         "1": {"id": "1", "title": "First book", "author": "Author1", "url": "https://
amazon.com/", "content": "SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1
 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1", "ups": "100", "downs":
 "10"},
         "2": {"id": "2", "title": "Second book", "author": "Author2", "url": "https://
amazon.com", "content": "SAMPLE TEXT AUTHOR 2 SAMPLE TEXT AUTHOR 2 SAMPLE TEXT", "ups":
 "100", "downs": "10"},
```

```
        "3": {"id": "3", "title": "Third book", "author": "Author3", "url": null,
 "content": null, "ups": null, "downs": null },
        "4": {"id": "4", "title": "Fourth book", "author": "Author4", "url": "https://
www.amazon.com/", "content": "SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR
 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4
 SAMPLE TEXT AUTHOR 4", "ups": "1000", "downs": "0"},
        "5": {"id": "5", "title": "Fifth book", "author": "Author5", "url": "https://
www.amazon.com/", "content": "SAMPLE TEXT AUTHOR 5 SAMPLE TEXT AUTHOR 5 SAMPLE TEXT AUTHOR
 5 SAMPLE TEXT AUTHOR 5 SAMPLE TEXT", "ups": "50", "downs": "0"} };

    var relatedPosts = {
        "1": [posts['4']],
        "2": [posts['3'], posts['5']],
        "3": [posts['2'], posts['1']],
        "4": [posts['2'], posts['1']],
        "5": []
    };

    console.log("Got a BatchInvoke Request. The payload has %d items to resolve.",
 event.length);
    // event is now an array
    var field = event[0].field;
    switch(field) {
        case "relatedPosts":
            var results = [];
            // the response MUST contain the same number
            // of entries as the payload array
            for (var i=0; i< event.length; i++) {
                console.log("post {}", JSON.stringify(event[i].source));
                results.push(relatedPosts[event[i].source.id]);
            }
            console.log("results {}", JSON.stringify(results));
            callback(null, results);
            break;
        default:
            callback("Unknown field, unable to resolve" + field, null);
            break;
    }
};
```

Returning Individual Errors

The previous examples show that it's possible to return a single error from the Lambda function or raise an error from the mapping templates. For batched invocations, raising an error from the Lambda function flags an entire batch as failed. This might be acceptable for specific scenarios where an irrecoverable error occurs, such as, a failed connection to a data store. However, in cases where some items in the batch succeed and some others fail, it's possible to return both errors and valid data. Because AWS AppSync requires that the batch response list elements matching the original size of the batch, you need to define a data structure that can differentiate valid data from an error.

For example, if the Lambda function is expected to return a batch of related posts, you could choose to return a list of `Response` objects where each object has optional *data*, *errorMessage*, and *errorType* fields. If the *errorMessage* field is present, it means that an error occurred.

The following code shows how you could update Lambda function:

```
exports.handler = (event, context, callback) => {
    console.log("Received event {}", JSON.stringify(event, 3));
    var posts = {
         "1": {"id": "1", "title": "First book", "author": "Author1", "url": "https://
amazon.com/", "content": "SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1
 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1 SAMPLE TEXT AUTHOR 1", "ups": "100", "downs":
 "10"},
```

```
        "2": {"id": "2", "title": "Second book", "author": "Author2", "url": "https://
amazon.com", "content": "SAMPLE TEXT AUTHOR 2 SAMPLE TEXT AUTHOR 2 SAMPLE TEXT", "ups":
 "100", "downs": "10"},
        "3": {"id": "3", "title": "Third book", "author": "Author3", "url": null,
 "content": null, "ups": null, "downs": null },
        "4": {"id": "4", "title": "Fourth book", "author": "Author4", "url": "https://
www.amazon.com/", "content": "SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR
 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4 SAMPLE TEXT AUTHOR 4
 SAMPLE TEXT AUTHOR 4", "ups": "1000", "downs": "0"},
        "5": {"id": "5", "title": "Fifth book", "author": "Author5", "url": "https://
www.amazon.com/", "content": "SAMPLE TEXT AUTHOR 5 SAMPLE TEXT AUTHOR 5 SAMPLE TEXT AUTHOR
 5 SAMPLE TEXT AUTHOR 5 SAMPLE TEXT", "ups": "50", "downs": "0"} };

    var relatedPosts = {
        "1": [posts['4']],
        "2": [posts['3'], posts['5']],
        "3": [posts['2'], posts['1']],
        "4": [posts['2'], posts['1']],
        "5": []
    };

    console.log("Got a BatchInvoke Request. The payload has %d items to resolve.",
 event.length);
    // event is now an array
    var field = event[0].field;
    switch(field) {
        case "relatedPosts":
            var results = [];
            results.push({ 'data': relatedPosts['1'] });
            results.push({ 'data': relatedPosts['2'] });
            results.push({ 'data': null, 'errorMessage': 'Error Happened', 'errorType':
 'ERROR' });
            results.push(null);
            results.push({ 'data': relatedPosts['3'], 'errorMessage': 'Error Happened with
 last result', 'errorType': 'ERROR' });
            callback(null, results);
            break;
        default:
            callback("Unknown field, unable to resolve" + field, null);
            break;
    }
};
```

For this example, the following response mapping template parses each item of the Lambda function and raises any errors that occur:

```
#if( $context.result && $context.result.errorMessage )
    $utils.error($context.result.errorMessage, $context.result.errorType,
 $context.result.data)
#else
    $utils.toJson($context.result.data)
#end
```

This example returns a GraphQL response similar to the following:

```
{
  "data": {
    "allPosts": [
      {
        "id": "1",
        "relatedPostsPartialErrors": [
          {
            "id": "4",
```

```
            "title": "Fourth book"
          }
        ]
      },
      {
        "id": "2",
        "relatedPostsPartialErrors": [
          {
            "id": "3",
            "title": "Third book"
          },
          {
            "id": "5",
            "title": "Fifth book"
          }
        ]
      },
      {
        "id": "3",
        "relatedPostsPartialErrors": null
      },
      {
        "id": "4",
        "relatedPostsPartialErrors": null
      },
      {
        "id": "5",
        "relatedPostsPartialErrors": null
      }
    ]
  },
  "errors": [
    {
      "path": [
        "allPosts",
        2,
        "relatedPostsPartialErrors"
      ],
      "errorType": "ERROR",
      "locations": [
        {
          "line": 4,
          "column": 9
        }
      ],
      "message": "Error Happened"
    },
    {
      "path": [
        "allPosts",
        4,
        "relatedPostsPartialErrors"
      ],
      "data": [
        {
          "id": "2",
          "title": "Second book"
        },
        {
          "id": "1",
          "title": "First book"
        }
      ],
      "errorType": "ERROR",
      "locations": [
        {
```

```
          "line": 4,
          "column": 9
        }
      ],
      "message": "Error Happened with last result"
    }
  ]
}
```

Tutorial: Amazon Elasticsearch Service Resolvers

AWS AppSync supports using Amazon Elasticsearch Service from domains that you have provisioned in your own AWS account, provided they don't exist inside a VPC. After your domains are provisioned, you can connect to them using a data source, at which point you can configure a resolver in the schema to perform GraphQL operations such as queries, mutations, and subscriptions. This tutorial will take you through some common examples.

For more information, see the Resolver Mapping Template Reference for Elasticsearch (p. 317).

One-Click Setup

To automatically setup a GraphQL endpoint in AWS AppSync with Amazon Elasticsearch Service configured you can use this AWS CloudFormation template:

After the AWS CloudFormation deployment completes you can skip directly to running GraphQL queries and mutations (p. 107).

Create a New Amazon ES Domain

To get started with this tutorial, you need an existing Amazon ES domain. If you don't have one, you can use the following sample. Note that it can take up to 15 minutes for an Amazon ES domain to be created before you can move on to integrating it with an AWS AppSync data source.

```
aws cloudformation create-stack --stack-name AppSyncElasticsearch \
--template-url https://s3.us-west-2.amazonaws.com/awsappsync/resources/elasticsearch/
ESResolverCFTemplate.yaml \
--parameters ParameterKey=ESDomainName,ParameterValue=ddtestdomain
 ParameterKey=Tier,ParameterValue=development \
--capabilities CAPABILITY_NAMED_IAM
```

You can launch the following AWS CloudFormation stack in the US West 2 (Oregon) region in your AWS account:

Configure Data Source for Amazon ES

After the Amazon ES domain is created, navigate to your AWS AppSync GraphQL API and choose the **Data Sources** tab. Choose **New** and enter a friendly name for the data source, such as "Elasticsearch". Then choose **Amazon Elasticsearch domain** for **Data source type**, choose the appropriate region, and

you should see your Amazon ES domain listed. After selecting it you can either create a new role and AWS AppSync will assign the role-appropriate permissions, or you can choose an existing role, which has the following inline policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "Stmt1234234",
            "Effect": "Allow",
            "Action": [
                "es:ESHttpDelete",
                "es:ESHttpHead",
                "es:ESHttpGet",
                "es:ESHttpPost",
                "es:ESHttpPut"
            ],
            "Resource": [
                "arn:aws:es:REGION:ACCOUNTNUMBER:domain/democluster/*"
            ]
        }
    ]
}
```

You'll also need to set up a trust relationship with AWS AppSync for that role:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "appsync.amazonaws.com"
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

Additionally, the Amazon ES domain has it's own **Access Policy** which you can modify through the Amazon Elasticsearch Service console. You will need to add a policy similar to the below, with the appropriate actions and resource for the Amazon ES domain. Note that the **Principal** will be the AppSync data source role, which if you let the console create this would start with the name of **appsync-datasource-es-** and can be found in the AWS IAM console.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
        "Effect": "Allow",
        "Principal": {
            "AWS": "arn:aws:iam::ACCOUNTNUMBER:role/service-role/APPSYNC_DATASOURCE_ROLE"
        },
        "Action": [
            "es:ESHttpDelete",
            "es:ESHttpHead",
            "es:ESHttpGet",
            "es:ESHttpPost",
            "es:ESHttpPut"
        ],
        "Resource": "arn:aws:es:REGION:ACCOUNTNUMBER:domain/DOMAIN_NAME/*"
        }
```

```
    ]
}
```

Connecting a Resolver

Now that the data source is connected to your Amazon ES domain, you can connect it to your GraphQL schema with a resolver, as shown in the following example:

```
 schema {
   query: Query
   mutation: Mutation
 }

 type Query {
   getPost(id: ID!): Post
   allPosts: [Post]
 }

 type Mutation {
   addPost(id: ID!, author: String, title: String, url: String, ups: Int, downs: Int,
 content: String): Post
 }

type Post {
  id: ID!
  author: String
  title: String
  url: String
  ups: Int
  downs: Int
  content: String
}
...
```

Note that there is a user-defined `Post` type with a field of `id`. In the following examples, we assume there is a process (which can be automated) for putting this type into your Amazon ES domain, which would map to a path root of `/id/post`, where `id` is the index and `post` is the type. From this root path, you can perform individual document searches, wildcard searches with `/id/post*` or multi-document searches with a **path** of `/id/post/_search`. If you have another type `User`, for example, one that is indexed under the same index `id`, you can perform multi-document searches with a **path** of `/id/_search`. This searches for fields on both `Post` and `User`.

From the schema editor in the AWS AppSync console, modify the preceding `Posts` schema to include a `searchPosts` query:

```
type Query {
  getPost(id: ID!): Post
  allPosts: [Post]
  searchPosts: [Post]
}
```

Save the schema. On the right side, for `searchPosts`, choose **Attach resolver**. Choose your Amazon ES data source. Under the **request mapping template** section, select the drop-down for **Query posts** to get a base template. Modify the `path` to be `/id/post/_search`. It should look like the following:

```
{
    "version":"2017-02-28",
    "operation":"GET",
    "path":"/id/post/_search",
```

```
    "params":{
        "headers":{},
        "queryString":{},
        "body":{
            "from":0,
            "size":50
        }
    }
}
```

This assumes that the preceding schema has documents with an `id` field, and that the documents have been indexed in Amazon ES by this field. If you structure your data differently, then you'll need to update accordingly.

Under the **response mapping template** section, you need to specify the appropriate `_source` filter if you want to get back the data results from an Amazon ES query and translate to GraphQL. Use the following template:

```
[
    #foreach($entry in $context.result.hits.hits)
    #if( $velocityCount > 1 ) , #end
    $utils.toJson($entry.get("_source"))
    #end
]
```

Modifying Your Searches

The preceding request mapping template performs a simple query for all records. Suppose you want to search by a specific author. Further, suppose you want that author to be an argument defined in your GraphQL query. In the schema editor of the AWS AppSync console, add an `allPostsByAuthor` query:

```
type Query {
  getPost(id: ID!): Post
  allPosts: [Post]
  allPostsByAuthor(author: String!): [Post]
  searchPosts: [Post]
}
```

Now choose **Attach resolver** and select the Amazon ES data source, but use the following example in the **response mapping template**:

```
{
    "version":"2017-02-28",
    "operation":"GET",
    "path":"/id/post/_search",
    "params":{
        "headers":{},
        "queryString":{},
        "body":{
            "from":0,
            "size":50,
            "query":{
                "term" :{
                    "author": $util.toJson($context.arguments.author)
                }
            }
        }
    }
}
```

Note that the `body` is populated with a term query for the `author` field, which is passed through from the client as an argument. You could optionally have prepopulated information, such as standard text, or even use other utilities (p. 241).

If you're using this resolver, fill in the **response mapping template** with the same information as the previous example.

Adding Data to Amazon ES

You may want to add data to your Amazon ES domain as the result of a GraphQL mutation. This is a powerful mechanism for searching and other purposes. Because you can use GraphQL subscriptions to make your data real-time (p. 165), it serves as a mechanism for notifying clients of updates to data in your Amazon ES domain.

Return to the **Schema** page in the AWS AppSync console and select **Attach resolver** for the `addPost()` mutation. Select the Amazon ES data source again and use the following **response mapping template** for the `Posts` schema:

```
{
    "version":"2017-02-28",
    "operation":"PUT",
    "path": $util.toJson("/id/post/$context.arguments.id"),
    "params":{
        "headers":{},
        "queryString":{},
        "body":{
            "id": $util.toJson($context.arguments.id),
            "author": $util.toJson($context.arguments.author),
            "ups": $util.toJson($context.arguments.ups),
            "downs": $util.toJson($context.arguments.downs),
            "url": $util.toJson($context.arguments.url),
            "content": $util.toJson($context.arguments.content),
            "title": $util.toJson($context.arguments.title)
        }
    }
}
```

As before, this is an example of how your data might be structured. If you have different field names or indexes, you need to update the `path` and `body` as appropriate. This example also shows how to use `$context.arguments` to populate the template from your GraphQL mutation arguments.

Before moving on, use the following response mapping template, which will be explained more in the next section:

```
$utils.toJson($context.result.get("_source"))
```

Retrieving a Single Document

Finally, if you want to use the `getPost(id:ID)` query in your schema to return an individual document, find this query in the schema editor of the AWS AppSync console and choose **Attach resolver**. Select the Amazon ES data source again and use the following mapping template:

```
{
    "version":"2017-02-28",
    "operation":"GET",
    "path": $util.toJson("/id/post/$context.arguments.id"),
    "params":{
        "headers":{},
```

```
        "queryString":{},
        "body":{}
    }
}
```

Because the `path` above uses the `id` argument with an empty body, this returns the single document. However, you need to use the following response mapping template, because now you're returning a single item and not a list:

```
$utils.toJson($context.result.get("_source"))
```

Perform Queries and Mutations

You should now be able to perform GraphQL operations against your Amazon ES domain. Navigate to the **Queries** tab of the AWS AppSync console and add a new record:

```
mutation {
    addPost(
        id:"12345"
        author: "Fred"
        title: "My first book"
        content: "This will be fun to write!"
    ){
        id
        author
        title
    }
}
```

If the record is inserted successfully, you'll see the fields on the right. Similarly, you can now run a `searchPosts` query against your Amazon ES domain:

```
query {
    searchPosts {
        id
        title
        author
        content
    }
}
```

Best Practices

- Amazon ES should be for querying data, not as your primary database. You may want to use Amazon ES in conjunction with Amazon DynamoDB as outlined in Combining GraphQL Resolvers (p. 109).
- Only give access to your domain by allowing the AWS AppSync service role to access the cluster.
- You can start small in development, with the lowest-cost cluster, and then move to a larger cluster with high availability (HA) as you move into production.

Tutorial: Local Resolvers

AWS AppSync allows you to use supported data sources (AWS Lambda, Amazon DynamoDB, or Amazon Elasticsearch Service) to perform various operations. However, in certain scenarios, a call to a supported data source might not be necessary.

This is where the local resolver comes in handy. Instead of calling a remote data source, the local resolver will just **forward** the result of the request mapping template to the response mapping template. The field resolution will not leave AWS AppSync.

Local resolvers are useful for several use cases. The most popular use case is to publish notifications without triggering a data source call. To demonstrate this use case, let's build a paging application; where users can page each other. This example leverages *Subscriptions*, so if you aren't familiar with *Subscriptions*, you can follow the Real-Time Data (p. 165) tutorial.

Create the Paging Application

In our paging application, clients can subscribe to an inbox, and send pages to other clients. Each page includes a message. Here is the schema:

```
schema {
    query: Query
    mutation: Mutation
    subscription: Subscription
}

type Subscription {
    inbox(to: String!): Page
    @aws_subscribe(mutations: ["page"])
}

type Mutation {
    page(body: String!, to: String!): Page!
}

type Page {
    from: String!
    to: String!
    body: String!
    sentAt: String!
}

type Query {
    me: String
}
```

Let's attach a resolver on the `Mutation.page` field. In the **Schema** pane, click on *Attach Resolver* next to the field definition on the right panel. Create a new data source of type *None* and name it *PageDataSource*.

For the request mapping template, enter:

```
{
  "version": "2017-02-28",
  "payload": {
    "body": $util.toJson($context.arguments.body),
    "from": $util.toJson($context.identity.username),
    "to":  $util.toJson($context.arguments.to),
    "sentAt": "$util.time.nowISO8601()"
  }
}
```

And for the response mapping template, select the default *Forward the result*. Save your resolver. You application is now ready, let's page!

Send and subscribe to pages

For clients to receive pages, they must first be subscribed to an inbox.

In the **Queries** pane let's execute the `inbox` subscription:

```
subscription Inbox {
    inbox(to: "Nadia") {
        body
        to
        from
        sentAt
    }
}
```

Nadia will receive pages whenever the `Mutation.page` mutation is invoked. Let's invoke the mutation by executing the mutation:

```
mutation Page {
    page(to: "Nadia", body: "Hello, World!") {
        body
        to
        from
        sentAt
    }
}
```

We just demonstrated the use of local resolvers, by sending a Page and receiving it without leaving AWS AppSync.

Tutorial: Combining GraphQL Resolvers

Resolvers and fields in a GraphQL schema have 1:1 relationships with a large degree of flexibility. Because a data source is configured on a resolver independently of a schema, you have the ability for GraphQL types to be resolved or manipulated through different data sources, mixing and matching on a schema to best meet your needs.

The following example scenarios show how you might mix and match data sources in your schema, but before doing so you should have familiarity with setting up data sources and resolvers for AWS Lambda, Amazon DynamoDB, and Amazon Elasticsearch Service as outlined in the previous sections.

Example Schema

The below schema has a type of `Post` with 3 `Query` operations and 3 `Mutation` operations defined:

```
type Post {
    id: ID!
    author: String!
    title: String
    content: String
    url: String
    ups: Int
    downs: Int
    version: Int!
}
```

```
type Query {
    allPost: [Post]
    getPost(id: ID!): Post
    searchPosts: [Post]
}

type Mutation {
    addPost(
        id: ID!,
        author: String!,
        title: String,
        content: String,
        url: String
    ): Post
    updatePost(
        id: ID!,
        author: String!,
        title: String,
        content: String,
        url: String,
        ups: Int!,
        downs: Int!,
        expectedVersion: Int!
    ): Post
    deletePost(id: ID!): Post
}
```

In this example you would have a total of 6 resolvers to attach. One possible way would to have all of these come from an Amazon DynamoDB table, called `Posts`, where `AllPosts` runs a scan and `searchPosts` runs a query, as outlined in the DynamoDB Resolver Mapping Template Reference (p. 266). However, there are alternatives to meet your business needs, such as having these GraphQL queries resolve from Lambda or Amazon ES.

Alter Data Through Resolvers

You might have the need to return results from a database such as DynamoDB (or Amazon Aurora) to clients with some of the attributes changed. This might be due to formatting of the data types, such as timestamp differences on clients, or to handle backwards compatibility issues. For illustrative purposes in the below example, we show an AWS Lambda function that manipulates the up-votes and down-votes for blog posts by assigning them random numbers each time the GraphQL resolver is invoked:

```
'use strict';
const doc = require('dynamodb-doc');
const dynamo = new doc.DynamoDB();

exports.handler = (event, context, callback) => {
    const payload = {
        TableName: 'Posts',
        Limit: 50,
        Select: 'ALL_ATTRIBUTES',
    };

    dynamo.scan(payload, (err, data) => {
        const result = { data: data.Items.map(item =>{
            item.ups = parseInt(Math.random() * (50 - 10) + 10, 10);
            item.downs = parseInt(Math.random() * (20 - 0) + 0, 10);
            return item;
        }) };
        callback(err, result.data);
    });
};
```

This is a perfectly valid Lambda function and could be attached to the `AllPosts` field in the GraphQL schema so that any query returning all the results gets random numbers for the ups/downs.

DynamoDB and Amazon ES

For some applications, you might perform mutations or simple lookup queries against DynamoDB, and have a background process transfer documents to Amazon ES. You can then simply attach the `searchPosts` Resolver to the Amazon ES data source and return search results (from data that originated in DynamoDB) using a GraphQL query. This can be extremely powerful when adding advanced search operations to your applications such keyword, fuzzy word matches or even geospatial lookups. Transferring data from DynamoDB could be done through an ETL process or alternatively you can stream from DynamoDB using Lambda. You can launch a complete example of this using the following AWS CloudFormation stack in the US West 2 (Oregon) Region in your AWS account:

The schema in this example will let you add posts using a DynamoDB resolver as follows:

```
mutation add {
    putPost(author:"Nadia"
        title:"My first post"
        content:"This is some test content"
        url:"https://aws.amazon.com/appsync/"
    ){
        id
        title
    }
}
```

This writes data to DynamoDB which then streams data via Lambda to Amazon Elasticsearch Service which you could search for all posts by different fields. For example, since the data is in Amazon Elasticsearch Service you can search either the author or content fields with free-form text, even with spaces, as follows:

```
query searchName{
    searchAuthor(name:"   Nadia   "){
        id
        title
        content
    }
}

query searchContent{
    searchContent(text:"test"){
        id
        title
        content
    }
}
```

Because the data is written directly to DynamoDB, you can still perform efficient list or item lookup operations against the table with the `allPosts{...}` and `singlePost{...}` queries. This stack uses the following example code for DynamoDB streams:

Note: This code is for example only.

```
var AWS = require('aws-sdk');
```

```
var path = require('path');
var stream = require('stream');

var esDomain = {
    endpoint: 'https://elasticsearch-domain-name.REGION.es.amazonaws.com',
    region: 'REGION',
    index: 'id',
    doctype: 'post'
};

var endpoint = new AWS.Endpoint(esDomain.endpoint)
var creds = new AWS.EnvironmentCredentials('AWS');

function postDocumentToES(doc, context) {
    var req = new AWS.HttpRequest(endpoint);

    req.method = 'POST';
    req.path = '/_bulk';
    req.region = esDomain.region;
    req.body = doc;
    req.headers['presigned-expires'] = false;
    req.headers['Host'] = endpoint.host;

    // Sign the request (Sigv4)
    var signer = new AWS.Signers.V4(req, 'es');
    signer.addAuthorization(creds, new Date());

    // Post document to ES
    var send = new AWS.NodeHttpClient();
    send.handleRequest(req, null, function (httpResp) {
        var body = '';
        httpResp.on('data', function (chunk) {
            body += chunk;
        });
        httpResp.on('end', function (chunk) {
            console.log('Successful', body);
            context.succeed();
        });
    }, function (err) {
        console.log('Error: ' + err);
        context.fail();
    });
}

exports.handler = (event, context, callback) => {
    console.log("event => " + JSON.stringify(event));
    var posts = '';

    for (var i = 0; i < event.Records.length; i++) {
        var eventName = event.Records[i].eventName;
        var actionType = '';
        var image;
        var noDoc = false;
        switch (eventName) {
            case 'INSERT':
                actionType = 'create';
                image = event.Records[i].dynamodb.NewImage;
                break;
            case 'MODIFY':
                actionType = 'update';
                image = event.Records[i].dynamodb.NewImage;
                break;
            case 'REMOVE':
            actionType = 'delete';
                image = event.Records[i].dynamodb.OldImage;
                noDoc = true;
```

```
                break;
        }

        if (typeof image !== "undefined") {
            var postData = {};
            for (var key in image) {
                if (image.hasOwnProperty(key)) {
                    if (key === 'postId') {
                        postData['id'] = image[key].S;
                    } else {
                        var val = image[key];
                        if (val.hasOwnProperty('S')) {
                            postData[key] = val.S;
                        } else if (val.hasOwnProperty('N')) {
                            postData[key] = val.N;
                        }
                    }
                }
            }

            var action = {};
            action[actionType] = {};
            action[actionType]._index = 'id';
            action[actionType]._type = 'post';
            action[actionType]._id = postData['id'];
            posts += [
                JSON.stringify(action),
            ].concat(noDoc?[]:[JSON.stringify(postData)]).join('\n') + '\n';
        }
    }
    console.log('posts:',posts);
    postDocumentToES(posts, context);
};
```

You can then use DynamoDB streams to attach this to a DynamoDB table with a primary key of `id`, and any changes to the source of DynamoDB would stream into your Amazon ES domain. For more information about configuring this, see the DynamoDB Streams documentation.

Tutorial: DynamoDB Batch Resolvers

AWS AppSync supports using Amazon DynamoDB batch operations across one or more tables in a single region. Supported operations are `BatchGetItem`, `BatchPutItem`, and `BatchDeleteItem`. By using these features in AWS AppSync, you can perform tasks such as:

- Pass a list of keys in a single query and return the results from a table
- Read records from one or more tables in a single query
- Write records in bulk to one or more tables
- Conditionally write or delete records in multiple tables that might have a relation

Using batch operations with DynamoDB in AWS AppSync is an advanced technique that takes a little extra thought and knowledge of your backend operations and table structures. Additionally, batch operations in AWS AppSync have two key differences from non-batched operations:

- The data source role must have permissions to all tables which the resolver will access.
- The table specification for a resolver is part of the mapping template.

Permissions

Like other resolvers, you need to create a data source in AWS AppSync and either create a role or use an existing one. Because batch operations require different permissions on DynamoDB tables, you need to grant the configured role permissions for read or write actions:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "dynamodb:BatchGetItem",
                "dynamodb:BatchWriteItem"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:dynamodb:region:account:table/TABLENAME",
                "arn:aws:dynamodb:region:account:table/TABLENAME/*"
            ]
        }
    ]
}
```

Note: Roles are tied to data sources in AWS AppSync, and resolvers on fields are invoked against a data source. Data sources configured to fetch against DynamoDB only have one table specified, to keep configuration simple. Therefore, when performing a batch operation against multiple tables in a single resolver, which is a more advanced task, you must grant the role on that data source access to any tables the resolver will interact with. This would be done in the **Resource** field in the IAM policy above. Configuration of the tables to make batch calls against is done in the resolver template, which we describe below.

Data Source

For the sake of simplicity, we'll use the same data source for all the resolvers used in this tutorial. On the **Data sources** tab, create a new DynamoDB data source and name it **BatchTutorial**. The table name can be anything because table names are specified as part of the request mapping template for batch operations. We will give the table name `empty`.

For this tutorial, any role with the following inline policy will work:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "dynamodb:BatchGetItem",
                "dynamodb:BatchWriteItem"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:dynamodb:region:account:table/Posts",
                "arn:aws:dynamodb:region:account:table/Posts/*",
                "arn:aws:dynamodb:region:account:table/locationReadings",
                "arn:aws:dynamodb:region:account:table/locationReadings/*",
                "arn:aws:dynamodb:region:account:table/temperatureReadings",
                "arn:aws:dynamodb:region:account:table/temperatureReadings/*"
            ]
        }
    ]
```

```
}
```

Single Table Batch

For this example, suppose you have a single table named **Posts** to which you want to add and remove items with batch operations. Use the following schema, noting that for the query, we'll pass in a list of IDs:

```
type Post {
    id: ID!
    title: String
}

input PostInput {
    id: ID!
    title: String
}

type Query {
    batchGet(ids: [ID]): [Post]
}

type Mutation {
    batchAdd(posts: [PostInput]): [Post]
    batchDelete(ids: [ID]): [Post]
}

schema {
    query: Query
    mutation: Mutation
}
```

Attach a resolver to the `batchAdd()` field with the following **Request Mapping Template**. This automatically takes each item in the GraphQL `input PostInput` type and builds a map, which is needed for the `BatchPutItem` operation:

```
#set($postsdata = [])
#foreach($item in ${ctx.args.posts})
    $util.qr($postsdata.add($util.dynamodb.toMapValues($item)))
#end

{
    "version" : "2018-05-29",
    "operation" : "BatchPutItem",
    "tables" : {
        "Posts": $utils.toJson($postsdata)
    }
}
```

In this case, the **Response Mapping Template** is a simple passthrough, but the table name is appended as `..data.Posts` to the context object as follows:

```
$util.toJson($ctx.result.data.Posts)
```

Now navigate to the **Queries** page of the AWS AppSync console and run the following **batchAdd** mutation:

```
mutation add {
    batchAdd(posts:[{
```

```
            id: 1 title: "Running in the Park"},{
            id: 2 title: "Playing fetch"
        }]){
            id
            title
    }
}
```

You should see the results printed to the screen, and can independently validate through the DynamoDB console that both values wrote to the **Posts** table.

Next, attach a resolver to the `batchGet()` field with the following **Request Mapping Template**. This automatically takes each item in the GraphQL `ids:[]` type and builds a map that is needed for the `BatchGetItem` operation:

```
#set($ids = [])
#foreach($id in ${ctx.args.ids})
    #set($map = {})
    $util.qr($map.put("id", $util.dynamodb.toString($id)))
    $util.qr($ids.add($map))
#end

{
    "version" : "2018-05-29",
    "operation" : "BatchGetItem",
    "tables" : {
        "Posts": {
            "keys": $util.toJson($ids),
            "consistentRead": true
        }
    }
}
```

The **Response Mapping Template** is again a simple passthrough, with again the table name appended as `..data.Posts` to the context object:

```
$util.toJson($ctx.result.data.Posts)
```

Now go back to the **Queries** page of the AWS AppSync console, and run the following **batchGet Query**:

```
query get {
    batchGet(ids:[1,2,3]){
        id
        title
    }
}
```

This should return the results for the two `id` values that you added earlier. Note that a `null` value returned for the `id` with a value of `3`. This is because there was no record in your **Posts** table with that value yet. Also note that AWS AppSync returns the results in the same order as the keys passed in to the query, which is an additional feature that AWS AppSync does on your behalf. So if you switch to `batchGet(ids:[1,3,2)`, you'll see the order changed. You'll also know which `id` returned a `null` value.

Finally, attach a resolver to the `batchDelete()` field with the following **Request Mapping Template**. This automatically takes each item in the GraphQL `ids:[]` type and builds a map that is needed for the `BatchGetItem` operation:

```
#set($ids = [])
```

```
#foreach($id in ${ctx.args.ids})
    #set($map = {})
    $util.qr($map.put("id", $util.dynamodb.toString($id)))
    $util.qr($ids.add($map))
#end

{
    "version" : "2018-05-29",
    "operation" : "BatchDeleteItem",
    "tables" : {
        "Posts": $util.toJson($ids)
    }
}
```

The **Response Mapping Template** is again a simple passthrough, with again the table name appended as `..data.Posts` to the context object:

```
$util.toJson($ctx.result.data.Posts)
```

Now go back to the **Queries** page of the AWS AppSync console, and run the following **batchDelete** mutation:

```
mutation delete {
    batchDelete(ids:[1,2]){ id }
}
```

The records with `id` `1` and `2` should now be deleted. If you re-run the `batchGet()` query from earlier, these should return `null`.

Multi-Table Batch

AWS AppSync also enables you to perform batch operations across tables. Let's build a more complex application. Imagine we are building a Pet Health app, where sensors report the pet location and body temperature. The sensors are battery powered and attempt to connect to the network every few minutes. When a sensor establishes connection, it sends its readings to our AWS AppSync API. Triggers then analyze the data so a dashboard can be presented to the pet owner. Let's focus on representing the interactions between the sensor and the backend data store.

As a prerequisite, let's first create two DynamoDB tables; **locationReadings** will store sensor location readings and **temperatureReadings** will store sensor temperature readings. Both tables happen to share the same primary key structure: `sensorId (String)` being the partition key, and `timestamp (String)` the sort key.

Let's use the following GraphQL schema:

```
type Mutation {
    # Register a batch of readings
    recordReadings(tempReadings: [TemperatureReadingInput], locReadings:
 [LocationReadingInput]): RecordResult
    # Delete a batch of readings
    deleteReadings(tempReadings: [TemperatureReadingInput], locReadings:
 [LocationReadingInput]): RecordResult
}

type Query {
    # Retrieve all possible readings recorded by a sensor at a specific time
    getReadings(sensorId: ID!, timestamp: String!): [SensorReading]
}
```

```
type RecordResult {
    temperatureReadings: [TemperatureReading]
    locationReadings: [LocationReading]
}

interface SensorReading {
    sensorId: ID!
    timestamp: String!
}

# Sensor reading representing the sensor temperature (in Fahrenheit)
type TemperatureReading implements SensorReading {
    sensorId: ID!
    timestamp: String!
    value: Float
}

# Sensor reading representing the sensor location (lat,long)
type LocationReading implements SensorReading {
    sensorId: ID!
    timestamp: String!
    lat: Float
    long: Float
}

input TemperatureReadingInput {
    sensorId: ID!
    timestamp: String
    value: Float
}

input LocationReadingInput {
    sensorId: ID!
    timestamp: String
    lat: Float
    long: Float
}
```

BatchPutItem - Recording Sensor Readings

Our sensors need to be able to send their readings once they connect to the internet. The GraphQL field `Mutation.recordReadings` is the API they will use to do so. Let's attach a resolver to bring our API to life.

Select **Attach** next to the `Mutation.recordReadings` field. On the next screen, pick the same `BatchTutorial` data source created at the beginning of the tutorial.

Let's add the following request mapping template:

Request Mapping Template

```
## Convert tempReadings arguments to DynamoDB objects
#set($tempReadings = [])
#foreach($reading in ${ctx.args.tempReadings})
    $util.qr($tempReadings.add($util.dynamodb.toMapValues($reading)))
#end

## Convert locReadings arguments to DynamoDB objects
#set($locReadings = [])
#foreach($reading in ${ctx.args.locReadings})
    $util.qr($locReadings.add($util.dynamodb.toMapValues($reading)))
#end
```

```
{
    "version" : "2018-05-29",
    "operation" : "BatchPutItem",
    "tables" : {
        "locationReadings": $utils.toJson($locReadings),
        "temperatureReadings": $utils.toJson($tempReadings)
    }
}
```

As you can see, the `BatchPutItem` operation allows us to specify multiple tables.

Let's use the following response mapping template.

Response Mapping Template

```
## If there was an error with the invocation
## there might have been partial results
#if($ctx.error)
    ## Append a GraphQL error for that field in the GraphQL response
    $utils.appendError($ctx.error.message, $ctx.error.message)
#end
## Also returns data for the field in the GraphQL response
$utils.toJson($ctx.result.data)
```

With batch operations, there can be both errors and results returned from the invocation. In that case, we're free to do some extra error handling.

Note: The use of `$utils.appendError()` is similar to the `$util.error()`, with the major distinction that it doesn't interrupt the evaluation of the mapping template. Instead, it signals there was an error with the field, but allows the template to be evaluated and consequently return data back to the caller. We recommend you use `$utils.appendError()` when your application needs to return partial results.

Save the resolver and navigate to the **Queries** page of the AWS AppSync console. Let's send some sensor readings!

Execute the following mutation:

```
mutation sendReadings {
  recordReadings(
    tempReadings: [
      {sensorId: 1, value: 85.5, timestamp: "2018-02-01T17:21:05.000+08:00"},
      {sensorId: 1, value: 85.7, timestamp: "2018-02-01T17:21:06.000+08:00"},
      {sensorId: 1, value: 85.8, timestamp: "2018-02-01T17:21:07.000+08:00"},
      {sensorId: 1, value: 84.2, timestamp: "2018-02-01T17:21:08.000+08:00"},
      {sensorId: 1, value: 81.5, timestamp: "2018-02-01T17:21:09.000+08:00"}
    ]
    locReadings: [
      {sensorId: 1, lat: 47.615063, long: -122.333551, timestamp:
 "2018-02-01T17:21:05.000+08:00"},
      {sensorId: 1, lat: 47.615163, long: -122.333552, timestamp:
 "2018-02-01T17:21:06.000+08:00"}
      {sensorId: 1, lat: 47.615263, long: -122.333553, timestamp:
 "2018-02-01T17:21:07.000+08:00"}
      {sensorId: 1, lat: 47.615363, long: -122.333554, timestamp:
 "2018-02-01T17:21:08.000+08:00"}
      {sensorId: 1, lat: 47.615463, long: -122.333555, timestamp:
 "2018-02-01T17:21:09.000+08:00"}
    ]) {
    locationReadings {
      sensorId
      timestamp
      lat
```

```
      long
    }
    temperatureReadings {
      sensorId
      timestamp
      value
    }
  }
}
```

We sent 10 sensor readings in one mutation, with readings split up across two tables. Use the DynamoDB console to validate that data shows up in both the **locationReadings** and **temperatureReadings** tables.

BatchDeleteItem - Deleting Sensor Readings

Similarly, we would also need to delete batches of sensor readings. Let's use the `Mutation.deleteReadings` GraphQL field for this purpose. Select **Attach** next to the `Mutation.recordReadings` field. On the next screen, pick the same `BatchTutorial` data source created at the beginning of the tutorial.

Let's use the following request mapping template.

Request Mapping Template

```
## Convert tempReadings arguments to DynamoDB primary keys
#set($tempReadings = [])
#foreach($reading in ${ctx.args.tempReadings})
    #set($pkey = {})
    $util.qr($pkey.put("sensorId", $reading.sensorId))
    $util.qr($pkey.put("timestamp", $reading.timestamp))
    $util.qr($tempReadings.add($util.dynamodb.toMapValues($pkey)))
#end

## Convert locReadings arguments to DynamoDB primary keys
#set($locReadings = [])
#foreach($reading in ${ctx.args.locReadings})
    #set($pkey = {})
    $util.qr($pkey.put("sensorId", $reading.sensorId))
    $util.qr($pkey.put("timestamp", $reading.timestamp))
    $util.qr($locReadings.add($util.dynamodb.toMapValues($pkey)))
#end

{
    "version" : "2018-05-29",
    "operation" : "BatchDeleteItem",
    "tables" : {
        "locationReadings": $utils.toJson($locReadings),
        "temperatureReadings": $utils.toJson($tempReadings)
    }
}
```

The response mapping template is the same as the one we used for `Mutation.recordReadings`.

Response Mapping Template

```
## If there was an error with the invocation
## there might have been partial results
#if($ctx.error)
    ## Append a GraphQL error for that field in the GraphQL response
    $utils.appendError($ctx.error.message, $ctx.error.message)
#end
## Also return data for the field in the GraphQL response
```

```
$utils.toJson($ctx.result.data)
```

Save the resolver and navigate to the **Queries** page of the AWS AppSync console. Now, let's delete a couple of sensor readings!

Execute the following mutation:

```
mutation deleteReadings {
  # Let's delete the first two readings we recorded
  deleteReadings(
    tempReadings: [{sensorId: 1, timestamp: "2018-02-01T17:21:05.000+08:00"}]
    locReadings: [{sensorId: 1, timestamp: "2018-02-01T17:21:05.000+08:00"}]) {
    locationReadings {
      sensorId
      timestamp
      lat
      long
    }
    temperatureReadings {
      sensorId
      timestamp
      value
    }
  }
}
```

Validate through the DynamoDB console that these two readings have been deleted from the **locationReadings** and **temperatureReadings** tables.

BatchGetItem - Retrieve Readings

Another common operation for our Pet Health app would be to retrieve the readings for a sensor at a specific point in time. Let's attach a resolver to the `Query.getReadings` GraphQL field on our schema. Select **Attach**, and on the next screen pick the same `BatchTutorial` data source created at the beginning of the tutorial.

Let's add the following request mapping template.

Request Mapping Template

```
## Build a single DynamoDB primary key,
## as both locationReadings and tempReadings tables
## share the same primary key structure
#set($pkey = {})
$util.qr($pkey.put("sensorId", $ctx.args.sensorId))
$util.qr($pkey.put("timestamp", $ctx.args.timestamp))

{
    "version" : "2018-05-29",
    "operation" : "BatchGetItem",
    "tables" : {
        "locationReadings": {
            "keys": [$util.dynamodb.toMapValuesJson($pkey)],
            "consistentRead": true
        },
        "temperatureReadings": {
            "keys": [$util.dynamodb.toMapValuesJson($pkey)],
            "consistentRead": true
        }
    }
}
```

Note that we are now using the **BatchGetItem** operation.

Our response mapping template is going to be a little different because we chose to return a `SensorReading` list. Let's map the invocation result to the desired shape.

Response Mapping Template

```
## Merge locationReadings and temperatureReadings
## into a single list
## __typename needed as schema uses an interface
#set($sensorReadings = [])

#foreach($locReading in $ctx.result.data.locationReadings)
    $util.qr($locReading.put("__typename", "LocationReading"))
    $util.qr($sensorReadings.add($locReading))
#end

#foreach($tempReading in $ctx.result.data.temperatureReadings)
    $util.qr($tempReading.put("__typename", "TemperatureReading"))
    $util.qr($sensorReadings.add($tempReading))
#end

$util.toJson($sensorReadings)
```

Save the resolver and navigate to the **Queries** page of the AWS AppSync console. Now, let's retrieve sensor readings!

Execute the following query:

```
query getReadingsForSensorAndTime {
  # Let's retrieve the very first two readings
  getReadings(sensorId: 1, timestamp: "2018-02-01T17:21:06.000+08:00") {
    sensorId
    timestamp
    ...on TemperatureReading {
      value
    }
    ...on LocationReading {
      lat
      long
    }
  }
}
```

We have successfully demonstrated the use of DynamoDB batch operations using AWS AppSync.

Error Handling

In AWS AppSync, data source operations can sometimes return partial results. Partial results is the term we will use to denote when the output of an operation is comprised of some data and an error. Because error handling is inherently application specific, AWS AppSync gives you the opportunity to handle errors in the response mapping template. The resolver invocation error, if present, is available from the context as `$ctx.error`. Invocation errors always include a message and a type, accessible as properties `$ctx.error.message` and `$ctx.error.type`. During the response mapping template invocation, you can handle partial results in three ways:

1. swallow the invocation error by just returning data
2. raise an error (using `$util.error(...)`) by stopping the response mapping template evaluation, which won't return any data.

3. append an error (using `$util.appendError(...)`) and also return data

Let's demonstrate each of the three points above with DynamoDB batch operations!

DynamoDB Batch operations

With DynamoDB batch operations, it is possible that a batch partially completes. That is, it is possible that some of the requested items or keys are left unprocessed. If AWS AppSync is unable to complete a batch, unprocessed items and an invocation error will be set on the context.

We will implement error handling using the `Query.getReadings` field configuration from the `BatchGetItem` operation from the previous section of this tutorial. This time, let's pretend that while executing the `Query.getReadings` field, the `temperatureReadings` DynamoDB table ran out of provisioned throughput. DynamoDB raised a **ProvisionedThroughputExceededException** at the second attempt by AWS AppSync to process the remaining elements in the batch.

The following JSON represents the serialized context after the DynamoDB batch invocation but before the response mapping template was evaluated.

```
{
  "arguments": {
    "sensorId": "1",
    "timestamp": "2018-02-01T17:21:05.000+08:00"
  },
  "source": null,
  "result": {
    "data": {
      "temperatureReadings": [
        null
      ],
      "locationReadings": [
        {
          "lat": 47.615063,
          "long": -122.333551,
          "sensorId": "1",
          "timestamp": "2018-02-01T17:21:05.000+08:00"
        }
      ]
    },
    "unprocessedKeys": {
      "temperatureReadings": [
        {
          "sensorId": "1",
          "timestamp": "2018-02-01T17:21:05.000+08:00"
        }
      ],
      "locationReadings": []
    }
  },
  "error": {
    "type": "DynamoDB:ProvisionedThroughputExceededException",
    "message": "You exceeded your maximum allowed provisioned throughput for a table or for
 one or more global secondary indexes. (...)"
  },
  "outErrors": []
}
```

A few things to note on the context:

- the invocation error has been set on the context at `$ctx.error` by AWS AppSync, and the error type has been set to **DynamoDB:ProvisionedThroughputExceededException**.

- results are mapped per table under `$ctx.result.data`, even though an error is present
- keys that were left unprocessed are available at `$ctx.result.data.unprocessedKeys`. Here, AWS AppSync was unable to retrieve the item with key (sensorId:1, timestamp:2018-02-01T17:21:05.000+08:00) because of insufficient table throughput.

Note: For `BatchPutItem`, it is `$ctx.result.data.unprocessedItems`. For `BatchDeleteItem`, it is `$ctx.result.data.unprocessedKeys`.

Let's handle this error in three different ways.

1. Swallowing the invocation error

Returning data without handling the invocation error effectively swallows the error, making the result for the given GraphQL field always successful.

The response mapping template we write is familiar and only focuses on the result data.

Response mapping template:

```
$util.toJson($ctx.result.data)
```

GraphQL response:

```
{
  "data": {
    "getReadings": [
      {
        "sensorId": "1",
        "timestamp": "2018-02-01T17:21:05.000+08:00",
        "lat": 47.615063,
        "long": -122.333551
      },
      {
        "sensorId": "1",
        "timestamp": "2018-02-01T17:21:05.000+08:00",
        "value": 85.5
      }
    ]
  }
}
```

No errors will be added to the error response as only data was acted on.

2. Raising an error to abort the template execution

When partial failures should be treated as complete failures from the client's perspective, you can abort the template execution to prevent returning data. The `$util.error(...)` utility method achieves exactly this behavior.

Response mapping template:

```
## there was an error let's mark the entire field
## as failed and do not return any data back in the response
#if ($ctx.error)
    $util.error($ctx.error.message, $ctx.error.type, null,
 $ctx.result.data.unprocessedKeys)
#end

$util.toJson($ctx.result.data)
```

GraphQL response:

```
{
  "data": {
    "getReadings": null
  },
  "errors": [
    {
      "path": [
        "getReadings"
      ],
      "data": null,
      "errorType": "DynamoDB:ProvisionedThroughputExceededException",
      "errorInfo": {
        "temperatureReadings": [
          {
            "sensorId": "1",
            "timestamp": "2018-02-01T17:21:05.000+08:00"
          }
        ],
        "locationReadings": []
      },
      "locations": [
        {
          "line": 58,
          "column": 3
        }
      ],
      "message": "You exceeded your maximum allowed provisioned throughput for a table or
 for one or more global secondary indexes. (...)"
    }
  ]
}
```

Even though some results might have been returned from the DynamoDB batch operation, we chose to raise an error such that the `getReadings` GraphQL field is null and the error has been added to the GraphQL response *errors* block.

3. Appending an error to return both data and errors

In certain cases, to provide a better user experience, applications can return partial results and notify their clients of the unprocessed items. The clients can decide to either implement a retry or translate the error back to the end user. The `$util.appendError(...)` is the utility method that enables this behavior by letting the application designer append errors on the context without interfering with the evaluation of the template. After evaluating the template, AWS AppSync will process any context errors by appending them to the errors block of the GraphQL response.

Response mapping template:

```
#if ($ctx.error)
    ## pass the unprocessed keys back to the caller via the `errorInfo` field
    $util.appendError($ctx.error.message, $ctx.error.type, null,
 $ctx.result.data.unprocessedKeys)
#end

$util.toJson($ctx.result.data)
```

We forwarded both the invocation error and unprocessedKeys element inside the errors block of the GraphQL response. The `getReadings` field also return partial data from the **locationReadings** table as you can see in the response below.

GraphQL response:

```
{
  "data": {
    "getReadings": [
      null,
      {
        "sensorId": "1",
        "timestamp": "2018-02-01T17:21:05.000+08:00",
        "value": 85.5
      }
    ]
  },
  "errors": [
    {
      "path": [
        "getReadings"
      ],
      "data": null,
      "errorType": "DynamoDB:ProvisionedThroughputExceededException",
      "errorInfo": {
        "temperatureReadings": [
          {
            "sensorId": "1",
            "timestamp": "2018-02-01T17:21:05.000+08:00"
          }
        ],
        "locationReadings": []
      },
      "locations": [
        {
          "line": 58,
          "column": 3
        }
      ],
      "message": "You exceeded your maximum allowed provisioned throughput for a table or
 for one or more global secondary indexes. (...)"
    }
  ]
}
```

Tutorial: DynamoDB Transaction Resolvers

AWS AppSync supports using Amazon DynamoDB transaction operations across one or more tables in a single region. Supported operations are `TransactGetItems` and `TransactWriteItems`. By using these features in AWS AppSync, you can perform tasks such as:

- Pass a list of keys in a single query and return the results from a table
- Read records from one or more tables in a single query
- Write records in transaction to one or more tables in an all-or-nothing way
- Execute transactions when some conditions are satisfied

Permissions

Like other resolvers, you need to create a data source in AWS AppSync and either create a role or use an existing one. Because transaction operations require different permissions on DynamoDB tables, you need to grant the configured role permissions for read or write actions:

```
{
```

```
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "dynamodb:DeleteItem",
                "dynamodb:GetItem",
                "dynamodb:PutItem",
                "dynamodb:Query",
                "dynamodb:Scan",
                "dynamodb:UpdateItem"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:dynamodb:region:accountId:table/TABLENAME",
                "arn:aws:dynamodb:region:accountId:table/TABLENAME/*"
            ]
        }
    ]
}
```

Note: Roles are tied to data sources in AWS AppSync, and resolvers on fields are invoked against a data source. Data sources configured to fetch against DynamoDB only have one table specified, to keep configuration simple. Therefore, when performing a transaction operation against multiple tables in a single resolver, which is a more advanced task, you must grant the role on that data source access to any tables the resolver will interact with. This would be done in the **Resource** field in the IAM policy above. Configuration of the transaction calls against the tables is done in the resolver template, which we describe below.

Data Source

For the sake of simplicity, we'll use the same data source for all the resolvers used in this tutorial. On the **Data sources** tab, create a new DynamoDB data source and name it **TransactTutorial**. The table name can be anything because table names are specified as part of the request mapping template for transaction operations. We will give the table name `empty`.

We'll have two tables called **savingAccounts** and **checkingAccounts**, both with `accountNumber` as partition key, and a **transactionHistory** table with `transactionId` as partition key.

For this tutorial, any role with the following inline policy will work. Replace `region` and `accountId` with your region and account ID:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "dynamodb:DeleteItem",
                "dynamodb:GetItem",
                "dynamodb:PutItem",
                "dynamodb:Query",
                "dynamodb:Scan",
                "dynamodb:UpdateItem"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:dynamodb:region:accountId:table/savingAccounts",
                "arn:aws:dynamodb:region:accountId:table/savingAccounts/*",
                "arn:aws:dynamodb:region:accountId:table/checkingAccounts",
                "arn:aws:dynamodb:region:accountId:table/checkingAccounts/*",
                "arn:aws:dynamodb:region:accountId:table/transactionHistory",
                "arn:aws:dynamodb:region:accountId:table/transactionHistory/*"
```

```
            ]
        }
    ]
}
```

Transactions

For this example, the context is a classic banking transaction, where we'll use `TransactWriteItems` to:

- Transfer money from saving accounts to checking accounts
- Generate new transaction records for each transaction

And then we'll use `TransactGetItems` to retrieve details from saving accounts and checking accounts.

We define our GraphQL schema as follows:

```
type SavingAccount {
    accountNumber: String!
    username: String
    balance: Float
}

type CheckingAccount {
    accountNumber: String!
    username: String
    balance: Float
}

type TransactionHistory {
    transactionId: ID!
    from: String
    to: String
    amount: Float
}

type TransactionResult {
    savingAccounts: [SavingAccount]
    checkingAccounts: [CheckingAccount]
    transactionHistory: [TransactionHistory]
}

input SavingAccountInput {
    accountNumber: String!
    username: String
    balance: Float
}

input CheckingAccountInput {
    accountNumber: String!
    username: String
    balance: Float
}

input TransactionInput {
    savingAccountNumber: String!
    checkingAccountNumber: String!
    amount: Float!
}

type Query {
    getAccounts(savingAccountNumbers: [String], checkingAccountNumbers: [String]):
 TransactionResult
```

```
}

type Mutation {
    populateAccounts(savingAccounts: [SavingAccountInput], checkingAccounts:
 [CheckingAccountInput]): TransactionResult
    transferMoney(transactions: [TransactionInput]): TransactionResult
}

schema {
    query: Query
    mutation: Mutation
}
```

TransactWriteItems - Populate Accounts

In order to transfer money between accounts, we need to populate the table with the details. We'll use the GraphQL operation `Mutation.populateAccounts` to do so.

In the Schema section click on **Attach** next to the `Mutation.populateAccounts` operation. On the next screen, select the same `TransactTutorial` data source.

Now use the following request mapping template:

Request Mapping Template

```
#set($savingAccountTransactPutItems = [])
#set($index = 0)
#foreach($savingAccount in ${ctx.args.savingAccounts})
    #set($keyMap = {})
    $util.qr($keyMap.put("accountNumber",
 $util.dynamodb.toString($savingAccount.accountNumber)))
    #set($attributeValues = {})
    $util.qr($attributeValues.put("username",
 $util.dynamodb.toString($savingAccount.username)))
    $util.qr($attributeValues.put("balance",
 $util.dynamodb.toNumber($savingAccount.balance)))
    #set($index = $index + 1)
    #set($savingAccountTransactPutItem = {"table": "savingAccounts",
        "operation": "PutItem",
        "key": $keyMap,
        "attributeValues": $attributeValues})
    $util.qr($savingAccountTransactPutItems.add($savingAccountTransactPutItem))
#end

#set($checkingAccountTransactPutItems = [])
#set($index = 0)
#foreach($checkingAccount in ${ctx.args.checkingAccounts})
    #set($keyMap = {})
    $util.qr($keyMap.put("accountNumber",
 $util.dynamodb.toString($checkingAccount.accountNumber)))
    #set($attributeValues = {})
    $util.qr($attributeValues.put("username",
 $util.dynamodb.toString($checkingAccount.username)))
    $util.qr($attributeValues.put("balance",
 $util.dynamodb.toNumber($checkingAccount.balance)))
    #set($index = $index + 1)
    #set($checkingAccountTransactPutItem = {"table": "checkingAccounts",
        "operation": "PutItem",
        "key": $keyMap,
        "attributeValues": $attributeValues})
    $util.qr($checkingAccountTransactPutItems.add($checkingAccountTransactPutItem))
#end
```

```
#set($transactItems = [])
$util.qr($transactItems.addAll($savingAccountTransactPutItems))
$util.qr($transactItems.addAll($checkingAccountTransactPutItems))

{
    "version" : "2018-05-29",
    "operation" : "TransactWriteItems",
    "transactItems" : $util.toJson($transactItems)
}
```

And the following response mapping template:

Response Mapping Template

```
#if ($ctx.error)
    $util.appendError($ctx.error.message, $ctx.error.type, null,
 $ctx.result.cancellationReasons)
#end

#set($savingAccounts = [])
#foreach($index in [0..2])
    $util.qr($savingAccounts.add(${ctx.result.keys[$index]}))
#end

#set($checkingAccounts = [])
#foreach($index in [3..5])
    $util.qr($checkingAccounts.add(${ctx.result.keys[$index]}))
#end

#set($transactionResult = {})
$util.qr($transactionResult.put('savingAccounts', $savingAccounts))
$util.qr($transactionResult.put('checkingAccounts', $checkingAccounts))

$util.toJson($transactionResult)
```

Save the resolver and navigate to the **Queries** section of the AWS AppSync console to populate the accounts.

Execute the following mutation:

```
mutation populateAccounts {
  populateAccounts (
    savingAccounts: [
      {accountNumber: "1", username: "Tom", balance: 100},
      {accountNumber: "2", username: "Amy", balance: 90},
      {accountNumber: "3", username: "Lily", balance: 80},
    ]
    checkingAccounts: [
      {accountNumber: "1", username: "Tom", balance: 70},
      {accountNumber: "2", username: "Amy", balance: 60},
      {accountNumber: "3", username: "Lily", balance: 50},
    ]) {
    savingAccounts {
      accountNumber
    }
    checkingAccounts {
      accountNumber
    }
  }
}
```

We populated 3 saving accounts and 3 checking accounts in one mutation.

Use the DynamoDB console to validate that data shows up in both the **savingAccounts** and **checkingAccounts** tables.

TransactWriteItems - Transfer Money

Attach a resolver to the `transferMoney` mutation with the following **Request Mapping Template**. Note the values of `amounts`, `savingAccountNumbers`, and `checkingAccountNumbers` are the same.

```
#set($amounts = [])
#foreach($transaction in ${ctx.args.transactions})
    #set($attributeValueMap = {})
    $util.qr($attributeValueMap.put(":amount",
 $util.dynamodb.toNumber($transaction.amount)))
    $util.qr($amounts.add($attributeValueMap))
#end

#set($savingAccountTransactUpdateItems = [])
#set($index = 0)
#foreach($transaction in ${ctx.args.transactions})
    #set($keyMap = {})
    $util.qr($keyMap.put("accountNumber",
 $util.dynamodb.toString($transaction.savingAccountNumber)))
    #set($update = {})
    $util.qr($update.put("expression", "SET balance = balance - :amount"))
    $util.qr($update.put("expressionValues", $amounts[$index]))
    #set($index = $index + 1)
    #set($savingAccountTransactUpdateItem = {"table": "savingAccounts",
        "operation": "UpdateItem",
        "key": $keyMap,
        "update": $update})
    $util.qr($savingAccountTransactUpdateItems.add($savingAccountTransactUpdateItem))
#end

#set($checkingAccountTransactUpdateItems = [])
#set($index = 0)
#foreach($transaction in ${ctx.args.transactions})
    #set($keyMap = {})
    $util.qr($keyMap.put("accountNumber",
 $util.dynamodb.toString($transaction.checkingAccountNumber)))
    #set($update = {})
    $util.qr($update.put("expression", "SET balance = balance + :amount"))
    $util.qr($update.put("expressionValues", $amounts[$index]))
    #set($index = $index + 1)
    #set($checkingAccountTransactUpdateItem = {"table": "checkingAccounts",
        "operation": "UpdateItem",
        "key": $keyMap,
        "update": $update})
    $util.qr($checkingAccountTransactUpdateItems.add($checkingAccountTransactUpdateItem))
#end

#set($transactionHistoryTransactPutItems = [])
#foreach($transaction in ${ctx.args.transactions})
    #set($keyMap = {})
    $util.qr($keyMap.put("transactionId", $util.dynamodb.toString(${utils.autoId()})))
    #set($attributeValues = {})
    $util.qr($attributeValues.put("from",
 $util.dynamodb.toString($transaction.savingAccountNumber)))
    $util.qr($attributeValues.put("to",
 $util.dynamodb.toString($transaction.checkingAccountNumber)))
    $util.qr($attributeValues.put("amount", $util.dynamodb.toNumber($transaction.amount)))
    #set($transactionHistoryTransactPutItem = {"table": "transactionHistory",
        "operation": "PutItem",
        "key": $keyMap,
        "attributeValues": $attributeValues})
```

```
    $util.qr($transactionHistoryTransactPutItems.add($transactionHistoryTransactPutItem))
#end

#set($transactItems = [])
$util.qr($transactItems.addAll($savingAccountTransactUpdateItems))
$util.qr($transactItems.addAll($checkingAccountTransactUpdateItems))
$util.qr($transactItems.addAll($transactionHistoryTransactPutItems))

{
    "version" : "2018-05-29",
    "operation" : "TransactWriteItems",
    "transactItems" : $util.toJson($transactItems)
}
```

We will have 3 banking transactions in a single `TransactWriteItems` operation. Use the following **Response Mapping Template**:

```
#if ($ctx.error)
    $util.appendError($ctx.error.message, $ctx.error.type, null,
 $ctx.result.cancellationReasons)
#end

#set($savingAccounts = [])
#foreach($index in [0..2])
    $util.qr($savingAccounts.add(${ctx.result.keys[$index]}))
#end

#set($checkingAccounts = [])
#foreach($index in [3..5])
    $util.qr($checkingAccounts.add(${ctx.result.keys[$index]}))
#end

#set($transactionHistory = [])
#foreach($index in [6..8])
    $util.qr($transactionHistory.add(${ctx.result.keys[$index]}))
#end

#set($transactionResult = {})
$util.qr($transactionResult.put('savingAccounts', $savingAccounts))
$util.qr($transactionResult.put('checkingAccounts', $checkingAccounts))
$util.qr($transactionResult.put('transactionHistory', $transactionHistory))

$util.toJson($transactionResult)
```

Now navigate to the **Queries** section of the AWS AppSync console and execute the **transferMoney** mutation as follows:

```
mutation write {
  transferMoney(
    transactions: [
      {savingAccountNumber: "1", checkingAccountNumber: "1", amount: 7.5},
      {savingAccountNumber: "2", checkingAccountNumber: "2", amount: 6.0},
      {savingAccountNumber: "3", checkingAccountNumber: "3", amount: 3.3}
    ]) {
    savingAccounts {
      accountNumber
    }
    checkingAccounts {
      accountNumber
    }
    transactionHistory {
      transactionId
    }
```

```
  }
}
```

We sent 2 banking transactions in one mutation. Use the DynamoDB console to validate that data shows up in the **savingAccounts**, **checkingAccounts**, and **transactionHistory** tables.

TransactGetItems - Retrieve Accounts

In order to retrieve the details from saving accounts and checking accounts in a single transactional request we'll attach a resolver to the `Query.getAccounts` GraphQL operation on our schema. Select **Attach**, and on the next screen pick the same `TransactTutorial` data source created at the beginning of the tutorial. Configure the templates as follows:

Request Mapping Template

```
#set($savingAccountsTransactGets = [])
#foreach($savingAccountNumber in ${ctx.args.savingAccountNumbers})
    #set($savingAccountKey = {})
    $util.qr($savingAccountKey.put("accountNumber",
 $util.dynamodb.toString($savingAccountNumber)))
    #set($savingAccountTransactGet = {"table": "savingAccounts", "key": $savingAccountKey})
    $util.qr($savingAccountsTransactGets.add($savingAccountTransactGet))
#end

#set($checkingAccountsTransactGets = [])
#foreach($checkingAccountNumber in ${ctx.args.checkingAccountNumbers})
    #set($checkingAccountKey = {})
    $util.qr($checkingAccountKey.put("accountNumber",
 $util.dynamodb.toString($checkingAccountNumber)))
    #set($checkingAccountTransactGet = {"table": "checkingAccounts", "key":
 $checkingAccountKey})
    $util.qr($checkingAccountsTransactGets.add($checkingAccountTransactGet))
#end

#set($transactItems = [])
$util.qr($transactItems.addAll($savingAccountsTransactGets))
$util.qr($transactItems.addAll($checkingAccountsTransactGets))

{
    "version" : "2018-05-29",
    "operation" : "TransactGetItems",
    "transactItems" : $util.toJson($transactItems)
}
```

Response Mapping Template

```
#if ($ctx.error)
    $util.appendError($ctx.error.message, $ctx.error.type, null,
 $ctx.result.cancellationReasons)
#end

#set($savingAccounts = [])
#foreach($index in [0..2])
    $util.qr($savingAccounts.add(${ctx.result.items[$index]}))
#end

#set($checkingAccounts = [])
#foreach($index in [3..4])
    $util.qr($checkingAccounts.add($ctx.result.items[$index]))
#end

#set($transactionResult = {})
```

```
$util.qr($transactionResult.put('savingAccounts', $savingAccounts))
$util.qr($transactionResult.put('checkingAccounts', $checkingAccounts))

$util.toJson($transactionResult)
```

Save the resolver and navigate to the **Queries** sections of the AWS AppSync console. In order to retrieve the saving accounts and checing accounts, execute the following query:

```
query getAccounts {
  getAccounts(
    savingAccountNumbers: ["1", "2", "3"],
    checkingAccountNumbers: ["1", "2"]
  ) {
    savingAccounts {
      accountNumber
      username
      balance
    }
    checkingAccounts {
      accountNumber
      username
      balance
    }
  }
}
```

We have successfully demonstrated the use of DynamoDB transactions using AWS AppSync.

Tutorial: HTTP Resolvers

AWS AppSync enables you to use supported data sources (that is, AWS Lambda, Amazon DynamoDB, Amazon Elasticsearch Service, or Amazon Aurora) to perform various operations, in addition to any arbitrary HTTP endpoints to resolve GraphQL fields. After your HTTP endpoints are available, you can connect to them using a data source. Then, you can configure a resolver in the schema to perform GraphQL operations such as queries, mutations, and subscriptions. This tutorial walks you through some common examples.

In this tutorial you use a REST API (created using Amazon API Gateway and Lambda) with an AWS AppSync GraphQL endpoint.

One-Click Setup

If you want to automatically set up a GraphQL endpoint in AWS AppSync with an HTTP endpoint configured (using Amazon API Gateway and Lambda), you can use the following AWS CloudFormation template :

Creating a REST API

You can use the following AWS CloudFormation template to set up a REST endpoint that works for this tutorial:

The AWS CloudFormation stack performs the following steps:

1. Sets up a Lambda function that contains your business logic for your microservice.
2. Sets up an API Gateway REST API with the following endpoint/method/content type combination:

API Resource Path	HTTP Method	Supported Content Type
/v1/users	POST	application/xml
/v1/users/1	GET	application/json
/v1/users/1	PUT	application/json
/v1/users/1	DELETE	application/json

Creating Your GraphQL API

To create the GraphQL API in AWS AppSync:

- Open the AWS AppSync console and choose **Create API**.
- For the API name, type `UserData`.
- Choose **Custom schema**.
- Choose **Create**.

The AWS AppSync console creates a new GraphQL API for you using the API key authentication mode. You can use the console to set up the rest of the GraphQL API and run queries on it for the remainder of this tutorial.

Creating a GraphQL Schema

Now that you have a GraphQL API, let's create a GraphQL schema. From the schema editor in the AWS AppSync console, make sure you schema matches the following schema:

```
schema {
    query: Query
    mutation: Mutation
}

type Mutation {
    addUser(userInput: UserInput!): User
    deleteUser(id: ID!): User
}

type Query {
    getUser(id: ID): User
}

type User {
    id: ID!
    username: String!
    firstname: String
    lastname: String
    phone: String
    email: String
}
```

```
input UserInput {
    id: ID!
    username: String!
    firstname: String
    lastname: String
    phone: String
    email: String
}
```

Configure Your HTTP Data Source

To configure your HTTP data source, do the following:

- On the **DataSources** tab, choose **New**, and then type a friendly name for the data source (for example, `HTTP`).
- In **Data source type**, choose **HTTP**.
- Set the endpoint to the API Gateway endpoint that is created. Make sure that you don't include the stage name as part of the endpoint.

Note: At this time only public endpoints are supported by AWS AppSync.

Note: For more information about the certifying authorities that are recognized by the AWS AppSync service, see Certificate Authorities (CA) Recognized by AWS AppSync for HTTPS Endpoints (p. 329).

Configuring Resolvers

In this step, you connect the http data source to the **getUser** query.

To set up the resolver:

- Choose the **Schema** tab.
- In the **Data types** pane on the right under the **Query** type, find the **getUser** field and choose **Attach**.
- In **Data source name**, choose **HTTP**.
- In **Configure the request mapping template**, paste the following code:

```
{
    "version": "2018-05-29",
    "method": "GET",
    "params": {
        "headers": {
            "Content-Type": "application/json"
        }
    },
    "resourcePath": $util.toJson("/v1/users/${ctx.args.id}")
}
```

- In **Configure the response mapping template**, paste the following code:

```
## return the body
#if($ctx.result.statusCode == 200)
    ##if response is 200
    $ctx.result.body
#else
    ##if response is not 200, append the response to error block.
```

```
    $utils.appendError($ctx.result.body, "$ctx.result.statusCode")
#end
```

- Choose the **Query** tab, and then run the following query:

```
query{
    getUser(id:1){
        firstname
        username
    }
}
```

This should return the following response:

```
{
    "data": {
        "getUser": {
            "id": "1",
            "username": "nadia"
        }
    }
}
```

- Choose the **Schema** tab.
- In the **Data types** pane on the right under **Mutation**, find the **addUser** field and choose **Attach**.
- In **Data source name**, choose **HTTP**.
- In **Configure the request mapping template**, paste the following code:

```
#set($xml = "<User>")
#foreach ($mapEntry in $ctx.args.userInput.entrySet())
    #set($xml = "$xml<$mapEntry.key>$mapEntry.value</$mapEntry.key>")
#end
#set($xml = "$xml</User>")
{
"version": "2018-05-29",
"method": "POST",
"params": {
    "headers":{
        "Content-Type":"application/xml"
    },
        "body":"$xml"
},
"resourcePath": "/v1/users"
}
```

- In **Configure the response mapping template**, paste the following code:

```
## return the body
#if($ctx.result.statusCode == 200)
    ##if response is 200
    ## Because the response is of type XML, we are going to convert
    ## the result body as a map and only get the User object.
    $utils.toJson($utils.xml.toMap($ctx.result.body).User)
#else
    ##if response is not 200, append the response to error block.
    $utils.appendError($ctx.result.body, "$ctx.result.statusCode")
```

```
#end
```

- Choose the **Query** tab, and then run the following query:

```
mutation{
    addUser(userInput:{
        id:"2",
        username:"shaggy"
    }){
        id
        username
    }
}
```

This should return the following response:

```
{
    "data": {
        "getUser": {
        "id": "2",
        "username": "shaggy"
        }
    }
}
```

Invoking AWS Services

You can use HTTP resolvers to set up a GraphQL API interface for AWS services. HTTP requests to AWS must be signed with the Signature Version 4 process so that AWS can identify who sent them. AWS AppSync calculates the signature on your behalf when you associate an IAM role with the HTTP data source.

You provide two additional components to invoke AWS services with HTTP resolvers:

- An AWS IAM role with permissions to call the AWS service APIs
- Signing configuration in the data source

For example, if you want to call the ListGraphqlApis operation with HTTP resolvers, you first create an IAM role (p. 26) that AWS AppSync assumes with the following policy attached:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "appsync:ListGraphqlApis"
            ],
            "Effect": "Allow",
            "Resource": "*"
        }
    ]
}
```

Next, create the HTTP data source for AWS AppSync. In this example, you call AWS AppSync in the US West (Oregon) Region. Set up the following HTTP configuration in a file named `http.json`, which includes the signing region and service name:

```
{
    "endpoint": "https://appsync.us-west-2.amazonaws.com/",
    "authorizationConfig": {
        "authorizationType": "AWS_IAM",
        "awsIamConfig": {
            "signingRegion": "us-west-2",
            "signingServiceName": "appsync"
        }
    }
}
```

Then, use the AWS CLI to create the data source with an associated role as follows:

```
aws appsync create-data-source --api-id <API-ID> \
                               --name AWSAppSync \
                               --type HTTP \
                               --http-config file:///http.json \
                               --service-role-arn <ROLE-ARN>
```

When you attach a resolver to the field in the schema, use the following request mapping template to call AWS AppSync:

```
{
    "version": "2018-05-29",
    "method": "GET",
    "resourcePath": "/v1/apis"
}
```

When you run a GraphQL query for this data source, AWS AppSync signs the request using the role you provided and includes the signature in the request. The query returns a list of AWS AppSync GraphQL APIs in your account in that AWS Region.

Tutorial: Aurora Serverless

AWS AppSync provides a data source for executing SQL commands against Amazon Aurora Serverless clusters which have been enabled with a Data API. You can use AppSync resolvers to execute SQL statements against the Data API with GraphQL queries, mutations, and subscriptions.

Create cluster

Before adding an RDS data source to AppSync you must first enable a Data API on an Aurora Serverless cluster and **configure a secret** using AWS Secrets Manager. You can create an Aurora Serverless cluster first with AWS CLI:

```
aws rds create-db-cluster --db-cluster-identifier http-endpoint-test  --master-username
 USERNAME \
--master-user-password COMPLEX_PASSWORD --engine aurora --engine-mode serverless \
--region us-east-1
```

This will return an ARN for the cluster.

Create a Secret via the AWS Secrets Manager Console or also via the CLI with an input file such as the following using the USERNAME and COMPLEX_PASSWORD from the previous step:

```
{
```

```
    "username": "USERNAME",
    "password": "COMPLEX_PASSWORD"
}
```

Pass this as a parameter to the AWS CLI:

```
aws secretsmanager create-secret --name HttpRDSSecret --secret-string file://creds.json --
region us-east-1
```

This will return an ARN for the secret.

Note the ARN of your Aurora Serverless cluster and Secret for later use in the AppSync console when creating a data source.

Enable Data API

You can enable the Data API on your cluster by following the instructions in the RDS documentation. The Data API must be enabled before adding as an AppSync data source.

Create database and table

Once you have enabled your Data API you can ensure it works with the `aws rds-data execute-statement` command in the AWS CLI. This will ensure that your Aurora Serverless cluster is configured correctly before adding it to your AppSync API. First create a database called *TESTDB* with the `--sql` parameter like so:

```
aws rds-data execute-statement --resource-arn "arn:aws:rds:us-
east-1:123456789000:cluster:http-endpoint-test" \
--schema "mysql"  --secret-arn "arn:aws:secretsmanager:us-
east-1:123456789000:secret:testHttp2-AmNvc1"  \
--region us-east-1 --sql "create DATABASE TESTDB"
```

If this runs without error, add a table with the *create table* command:

```
aws rds-data execute-statement --resource-arn "arn:aws:rds:us-
east-1:123456789000:cluster:http-endpoint-test" \
 --schema "mysql"  --secret-arn "arn:aws:secretsmanager:us-
east-1:123456789000:secret:testHttp2-AmNvc1" \
 --region us-east-1 \
 --sql "create table Pets(id varchar(200), type varchar(200), price float)" --database
 "TESTDB"
```

If everything has run without issue you can move forward to adding the cluster as a data source in your AppSync API.

GraphQl schema

Now that your Aurora Serverless Data API is up and running with a table, we will create a GraphQL schema and attach resolvers for performing mutations and subscriptions. Create a new API in the AWS AppSync console and navigate to the **Schema** page, and enter the following:

```
type Mutation {
    createPet(input: CreatePetInput!): Pet
    updatePet(input: UpdatePetInput!): Pet
    deletePet(input: DeletePetInput!): Pet
```

```
}

input CreatePetInput {
    type: PetType
    price: Float!
}

input UpdatePetInput {
id: ID!
    type: PetType
    price: Float!
}

input DeletePetInput {
    id: ID!
}

type Pet {
    id: ID!
    type: PetType
    price: Float
}

enum PetType {
    dog
    cat
    fish
    bird
    gecko
}

type Query {
    getPet(id: ID!): Pet
    listPets: [Pet]
    listPetsByPriceRange(min: Float, max: Float): [Pet]
}

schema {
    query: Query
    mutation: Mutation
}
```

Save your schema and navigate to the **Data Sources** page and create a new data source. Select **Relational database** for the Data source type, and provide a friendly name. Use the database name that you created in the last step, as well as the **Cluster ARN** that you created it in. For the **Role** you can either have AppSync create a new role or create one with a policy similar to the below:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "rds-data:DeleteItems",
                "rds-data:ExecuteSql",
                "rds-data:ExecuteStatement",
                "rds-data:GetItems",
                "rds-data:InsertItems",
                "rds-data:UpdateItems"
            ],
            "Resource": [
                "arn:aws:rds:us-east-1:123456789012:cluster:mydbcluster",
                "arn:aws:rds:us-east-1:123456789012:cluster:mydbcluster:*"
            ]
```

```
        },
        {
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetSecretValue"
            ],
            "Resource": [
                "arn:aws:secretsmanager:us-east-1:123456789012:secret:mysecret",
                "arn:aws:secretsmanager:us-east-1:123456789012:secret:mysecret:*"
            ]
        }
    ]
}
```

Note there are two **Statements** in this policy which you are granting role access. The first **Resource** is your Aurora Serverless cluster and the second is your AWS Secrets Manager ARN. You will need to provide **BOTH** ARNs in the AppSync data source configuration before clicking **Create**.

Configuring Resolvers

Now that we have a valid GraphQL schema and an RDS data source, we can attach resolvers to the GraphQL fields on our schema. Our API will offer the following capabilities:

1. create a pet via the *Mutation.createPet* field
2. update a pet via the *Mutation.updatePet* field
3. delete a pet via the *Mutation.deletePet* field
4. get a single pet via the *Query.getPet* field
5. list all pets via the *Query.listPets* field
6. list pets in a price range via the *Query.listPetsByPriceRange* field

Mutation.createPet

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `createPet(input: CreatePetInput!): Pet`. Choose your RDS data source. In the **request mapping template** section, add the following template:

```
#set($id=$utils.autoId())
{
    "version": "2018-05-29",
    "statements": [
        "insert into Pets VALUES ('$id', '$ctx.args.input.type', $ctx.args.input.price)",
        "select * from Pets WHERE id = '$id'"
    ]
}
```

The SQL statements will execute sequentially, based on the order in the **statements** array. The results will come back in the same order. Since this is a mutation, we run a *select* statement after the *insert* to retrieve the committed values in order to populate the GraphQL response mapping template.

In the **response mapping template** section, add the following template:

```
$utils.toJson($utils.rds.toJsonObject($ctx.result)[1][0])
```

Because the *statements* has two SQL queries, we need to specify the second result in the matrix that comes back from the database with: `$utils.rds.toJsonString($ctx.result))[1][0]`).

Mutation.updatePet

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `updatePet(input: UpdatePetInput!): Pet`. Choose your RDS data source. In the **request mapping template** section, add the following template:

```
{
    "version": "2018-05-29",
    "statements": [
        $util.toJson("update Pets set type='$ctx.args.input.type', price=
$ctx.args.input.price WHERE id='$ctx.args.input.id'"),
        $util.toJson("select * from Pets WHERE id = '$ctx.args.input.id'")
    ]
}
```

In the **response mapping template** section, add the following template:

```
$utils.toJson($utils.rds.toJsonObject($ctx.result)[1][0])
```

Mutation.deletePet

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `deletePet(input: DeletePetInput!): Pet`. Choose your RDS data source. In the **request mapping template** section, add the following template:

```
{
    "version": "2018-05-29",
    "statements": [
        $util.toJson("select * from Pets WHERE id='$ctx.args.input.id'"),
        $util.toJson("delete from Pets WHERE id='$ctx.args.input.id'")
    ]
}
```

In the **response mapping template** section, add the following template:

```
$utils.toJson($utils.rds.toJsonObject($ctx.result)[0][0])
```

Query.getPet

Now that the mutations are created for your schema, we will connect the three queries to showcase how to get individual items, lists, and apply SQL filtering. From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `getPet(id: ID!): Pet`. Choose your RDS data source. In the **request mapping template** section, add the following template:

```
{
    "version": "2018-05-29",
        "statements": [
            $util.toJson("select * from Pets WHERE id='$ctx.args.id'")
    ]
}
```

In the **response mapping template** section, add the following template:

```
$utils.toJson($utils.rds.toJsonObject($ctx.result)[0][0])
```

Query.listPets

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `getPet(id: ID!): Pet`. Choose your RDS data source. In the **request mapping template** section, add the following template:

```
{
    "version": "2018-05-29",
    "statements": [
        "select * from Pets"
    ]
}
```

In the **response mapping template** section, add the following template:

```
$utils.toJson($utils.rds.toJsonObject($ctx.result)[0])
```

Query.listPetsByPriceRange

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `getPet(id: ID!): Pet`. Choose your RDS data source. In the **request mapping template** section, add the following template:

```
{
    "version": "2018-05-29",
    "statements": [
            "select * from Pets where price > :MIN and price < :MAX"
    ],

    "variableMap": {
        ":MAX": $util.toJson($ctx.args.max),
        ":MIN": $util.toJson($ctx.args.min)
    }
}
```

In the **response mapping template** section, add the following template:

```
$utils.toJson($utils.rds.toJsonObject($ctx.result)[0])
```

Run mutations

Now that you have configured all of your resolvers with SQL statements and connected your GraphQL API to your Serverless Aurora Data API, you can begin performing mutations and queries. In AWS AppSync console, choose the **Queries** tab and enter the following to create a Pet:

```
mutation add {
    createPet(input : { type:fish, price:10.0 }){
        id
        type
        price
    }
}
```

The response should contain the *id*, *type*, and *price* like so:

```
{
```

```
  "data": {
    "createPet": {
      "id": "c6fedbbe-57ad-4da3-860a-ffe8d039882a",
      "type": "fish",
      "price": "10.0"
    }
  }
}
```

You can modify this item by running the *updatePet* mutation:

```
mutation update {
    updatePet(input : {
        id:"c6fedbbe-57ad-4da3-860a-ffe8d039882a",
        type:bird,
        price:50.0
    }){
        id
        type
        price
    }
}
```

Note that we used the *id* which was returned from the *createPet* operation earlier. This will be a unique value for your record as the resolver leveraged `$util.autoId()`. You could delete a record in a similar manner:

```
mutation {
    deletePet(input : {id:ID_PLACEHOLDER}){
        id
        type
        price
    }
}
```

Create a few records with the first mutation with different values for *price* and then run some queries.

Run Queries

Still in the **Queries** tab of the console, use the following statement to list all of the records you've created:

```
query allpets {
    listPets {
        id
        type
        price
    }
}
```

This is nice but let's leverage the SQL *WHERE* predicate that had `where price > :MIN and price < :MAX` in our mapping template for *Query.listPetsByPriceRange* with the following GraphQL query:

```
query {
    listPetsByPriceRange(minPrice:1, maxPrice:11) {
        id
        type
        price
    }
```

```
}
```

You should only see records with a *price* over $1 or less than $10. Finally, you can perform queries to retrieve individual records as follows:

```
query {
    getPet(id:ID_PLACEHOLDER){
        id
        type
        price
    }
}
```

Input Sanitization

We strongly encourage the developers to sanitize the arguments of GraphQL operations. One way to do this is to provide input specific validation steps in the request mapping template before execution of a SQL statement against your Data API. Let's see how we can modify the request mapping template of the `listPetsByPriceRange` example. Instead of relying solely on the user input you can do the following:

```
#set($validMaxPrice = $util.matches("\d{1,3}[,\\.]?(\\d{1,2})?",$ctx.args.maxPrice))

#set($validMinPrice = $util.matches("\d{1,3}[,\\.]?(\\d{1,2})?",$ctx.args.minPrice))


#if (!$validMaxPrice || !$validMinPrice)
    $util.error("Provided price input is not valid.")
#end
{
    "version": "2018-05-29",
    "statements": [
            "select * from Pets where price > :MIN and price < :MAX"
    ],

    "variableMap": {
        ":MAX": $util.toJson($ctx.args.maxPrice),
        ":MIN": $util.toJson($ctx.args.minPrice)
    }
}
```

Another way to protect against rogue input when executing resolvers against your Data API is to use prepared statements together with stored procedure and parameterized inputs. For example, in the resolver for `listPets` define the following procedure that executes the *select* as a prepared statement:

```
CREATE PROCEDURE listPets (IN type_param VARCHAR(200))
  BEGIN
     PREPARE stmt FROM 'SELECT * FROM Pets where type=?';
     SET @type = type_param;
     EXECUTE stmt USING @type;
     DEALLOCATE PREPARE stmt;
  END
```

This can be created in your Aurora Serverless Instance using the following execute sql command:

```
aws rds-data execute-statement --resource-arn "arn:aws:rds:us-
east-1:xxxxxxxxxxxx:cluster:http-endpoint-test" \
--schema "mysql"  --secret-arn "arn:aws:secretsmanager:us-
east-1:xxxxxxxxxxxx:secret:httpendpoint-xxxxxx"  \
```

```
--region us-east-1  --database "DB_NAME" \
--sql "CREATE PROCEDURE listPets (IN type_param VARCHAR(200)) BEGIN PREPARE stmt FROM
 'SELECT * FROM Pets where type=?'; SET @type = type_param; EXECUTE stmt USING @type;
 DEALLOCATE PREPARE stmt; END"
```

The resulting resolver code for listPets is simplified since we now simply call the stored procedure. At a minimum, any string input should have single quotes escaped (p. 147).

```
#set ($validType = $util.isString($ctx.args.type) && !$util.isNullOrBlank($ctx.args.type))
#if (!$validType)
    $util.error("Input for 'type' is not valid.", "ValidationError")
#end

{
    "version": "2018-05-29",
    "statements": [
        "CALL listPets(:type)"
    ]
    "variableMap": {
        ":type": $util.toJson($ctx.args.type.replace("'", "''"))
    }
}
```

Escaping strings

Single quotes represent the start and end of string literals in an SQL statement, eg. `'some string value'`. To allow string values with one or more single quote characters (`'`) to be used within a string, each must be replaced with two single quotes (`''`). For example, if the input string is `Nadia's dog`, you would escape it for the SQL statement like

```
update Pets set type='Nadia''s dog' WHERE id='1'
```

Tutorial: Pipeline Resolvers

AWS AppSync provides a simple way to wire a GraphQL field to a single data source through unit resolvers. However, executing a single operation might not be enough. Pipeline resolvers offer the ability to serially execute operations against data sources. Create functions in your API and attach them to a pipeline resolver. Each function execution result is piped to the next until no function is left to execute. With pipeline resolvers you can now build more complex workflows directly in AWS AppSync. In this tutorial, you build a simple pictures viewing app, where users can post and view pictures posted by their friends.

One-Click Setup

If you want to automatically set up the GraphQL endpoint in AWS AppSync with all the resolvers configured and the necessary AWS resources, you can use the following AWS CloudFormation template :

This stack creates the following resources in your account:

- IAM Role for AWS AppSync to access the resources in your account
- 2 DynamoDB tables

- 1 Amazon Cognito user pool
- 2 Amazon Cognito user pool groups
- 3 Amazon Cognito user pool users
- 1 AWS AppSync API

At the end of the AWS CloudFormation stack creation process you receive one email for each of the three Amazon Cognito users that were created. Each email contains a temporary password that you use to log in as an Amazon Cognito user to the AWS AppSync console. Save the passwords for the remainder of the tutorial.

Manual Setup

If you prefer to manually go through a step-by-step process through the AWS AppSync console, follow the setup process below.

Setting Up Your Non AWS AppSync Resources

The API communicates with two DynamoDB tables: a **pictures** table that stores pictures and a **friends** table that stores relationships between users. The API is configured to use Amazon Cognito user pool as authentication type. The following AWS CloudFormation stack sets up these resources in the account.

At the end of the AWS CloudFormation stack creation process you receive one email for each of the three Amazon Cognito users that were created. Each email contains a temporary password that you use to log in as an Amazon Cognito user to the AWS AppSync console. Save the passwords for the remainder of the tutorial.

Creating Your GraphQL API

To create the GraphQL API in AWS AppSync:

1. Open the AWS AppSync console and choose **Build From Scratch** and choose **Start**.
2. Set the name of the API to `AppSyncTutorial-PicturesViewer`.
3. Choose **Create**.

The AWS AppSync console creates a new GraphQL API for you using the API key authentication mode. You can use the console to set up the rest of the GraphQL API and run queries against it for the rest of this tutorial.

Configuring The GraphQL API

You need to configure the AWS AppSync API with the Amazon Cognito user pool that you just created.

1. Choose the **Settings** tab.
2. Under the **Authorization Type** section, choose *Amazon Cognito User Pool*.
3. Under **User Pool Configuration**, choose **US-WEST-2** for the *AWS Region*.
4. Choose the **AppSyncTutorial-UserPool** user pool.
5. Choose **DENY** as *Default Action*.
6. Leave the **AppId client regex** field blank.

7. Choose **Save**.

The API is now set up to use Amazon Cognito user pool as its authorization type.

Configuring Data Sources for the DynamoDB Tables

After the DynamoDB tables have been created, navigate to your AWS AppSync GraphQL API in the console and choose the **Data Sources** tab. Now, you're going to create a datasource in AWS AppSync for each of the DynamoDB tables that you just created.

1. Choose the **Data source** tab.
2. Choose **New** to create a new data source.
3. For the data source name, enter `PicturesDynamoDBTable`.
4. For data source type, choose **Amazon DynamoDB table**.
5. For region, choose **US-WEST-2**.
6. From the list of tables, choose the **AppSyncTutorial-Pictures**DynamoDB table.
7. In the **Create or use an existing role** section, choose **Existing role**.
8. Choose the role that was just created from the CloudFormation template. If you did not change the *ResourceNamePrefix*, the name of the role should be **AppSyncTutorial-DynamoDBRole**.
9. Choose **Create**.

Repeat the same process for the **friends** table, the name of the DynamoDB table should be **AppSyncTutorial-Friends** if you did not change the *ResourceNamePrefix* parameter at the time of creating the CloudFormation stack.

Creating the GraphQL Schema

Now that the data sources are connected to your DynamoDB tables, let's create a GraphQL schema. From the schema editor in the AWS AppSync console, make sure your schema matches the following schema:

```
schema {
    query: Query
    mutation: Mutation
}

type Mutation {
    createPicture(input: CreatePictureInput!): Picture!
    @aws_auth(cognito_groups: ["Admins"])
    createFriendship(id: ID!, target: ID!): Boolean
    @aws_auth(cognito_groups: ["Admins"])
}

type Query {
    getPicturesByOwner(id: ID!): [Picture]
    @aws_auth(cognito_groups: ["Admins", "Viewers"])
}

type Picture {
    id: ID!
    owner: ID!
    src: String
}

input CreatePictureInput {
    owner: ID!
    src: String!
```

```
}
```

Choose **Save Schema** to save your schema.

Some of the schema fields have been annotated with the *@aws_auth* directive. Since the API default action configuration is set to *DENY*, the API rejects all users that are not members of the groups mentioned inside the *@aws_auth* directive. For more information about how to secure your API, you can read the Security (p. 206) page. In this case, only admin users have access to the *Mutation.createPicture* and *Mutation.createFriendship* fields, while users that are members of either *Admins* or *Viewers* groups can access the *Query.getPicturesByOwner* field. All other users don't have access.

Configuring Resolvers

Now that you have a valid GraphQL schema and two data sources, you can attach resolvers to the GraphQL fields on the schema. The API offers the following capabilities:

- Create a picture via the *Mutation.createPicture* field
- Create friendship via the *Mutation.createFriendship* field
- Retrieve a picture via the *Query.getPicture* field

Mutation.createPicture

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `createPicture(input: CreatePictureInput!): Picture!`. Choose the DynamoDB*PicturesDynamoDBTable* data source. In the **request mapping template** section, add the following template:

```
#set($id = $util.autoId())

{
    "version" : "2018-05-29",

    "operation" : "PutItem",

    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($id),
        "owner": $util.dynamodb.toDynamoDBJson($ctx.args.input.owner)
    },

    "attributeValues" : $util.dynamodb.toMapValuesJson($ctx.args.input)
}
```

In the **response mapping template** section, add the following template:

```
#if($ctx.error)
    $util.error($ctx.error.message, $ctx.error.type)
#end
$util.toJson($ctx.result)
```

The create picture functionality is done. You are saving a picture in the **Pictures** table, using a randomly generated UUID as id of the picture, and using the Cognito username as owner of the picture.

Mutation.createFriendship

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `createFriendship(id: ID!, target: ID!): Boolean`. Choose the DynamoDB**FriendsDynamoDBTable** data source. In the **request mapping template** section, add the following template:

```
#set($userToFriendFriendship = { "userId" : "$ctx.args.id", "friendId":
 "$ctx.args.target" })
#set($friendToUserFriendship = { "userId" : "$ctx.args.target", "friendId":
 "$ctx.args.id" })
#set($friendsItems = [$util.dynamodb.toMapValues($userToFriendFriendship),
 $util.dynamodb.toMapValues($friendToUserFriendship)])

{
    "version" : "2018-05-29",
    "operation" : "BatchPutItem",
    "tables" : {
        ## Replace 'AppSyncTutorial-' default below with the ResourceNamePrefix you
 provided in the CloudFormation template
        "AppSyncTutorial-Friends": $util.toJson($friendsItems)
    }
}
```

Important: In the **BatchPutItem** request template, the exact name of the DynamoDB table should be present. The default table name is *AppSyncTutorial-Friends*. If you are using the wrong table name, you get an error when AppSync tries to assume the provided role.

For the sake of simplicity in this tutorial, proceed as if the friendship request has been approved and save the relationship entry directly into the **AppSyncTutorialFriends** table.

Effectively, you're storing two items for each friendship as the relationship is bi-directional. For more details about Amazon DynamoDB best practices to represent many-to-many relationships, see DynamoDB Best Practices .

In the **response mapping template** section, add the following template:

```
#if($ctx.error)
    $util.error($ctx.error.message, $ctx.error.type)
#end
true
```

Note: Make sure your request template contains the right table name. The default name is *AppSyncTutorial-Friends*, but your table name might differ if you changed the CloudFormation **ResourceNamePrefix** parameter.

Query.getPicturesByOwner

Now that you have friendships and pictures, you need to provide the ability for users to view their friends' pictures. To satisfy this requirement, you need to first check that the requester is friend with the owner, and finally query for the pictures.

Because this functionality requires two data source operations, you're going to create two functions. The first function, **isFriend**, checks whether the requester and the owner are friends. The second function, **getPicturesByOwner**, retrieves the requested pictures given an owner ID. Let's look at the execution flow below for the proposed resolver on the *Query.getPicturesByOwner* field:

1. Before mapping template: Prepare the context and field input arguments.
2. isFriend function: Checks whether the requester is the owner of the picture. If not, it checks whether the requester and owner users are friends by doing a DynamoDB GetItem operation on the friends table.
3. getPicturesByOwner function: Retrieves pictures from the Pictures table using a DynamoDB Query operation on the *owner-index* Global Secondary Index.
4. After mapping template: Maps picture result so DynamoDB attributes map correctly to the expected GraphQL type fields.

Let's first create the functions.

isFriend Function

1. Choose the **Functions** tab.
2. Choose **Create Function** to create a function.
3. For the data source name, enter `FriendsDynamoDBTable`.
4. For the function name, enter *isFriend*.
5. Inside the request mapping template text area, paste the following template:

```
#set($ownerId = $ctx.prev.result.owner)
#set($callerId = $ctx.prev.result.callerId)

## if the owner is the caller, no need to make the check
#if($ownerId == $callerId)
    #return($ctx.prev.result)
#end

{
    "version" : "2018-05-29",

    "operation" : "GetItem",

    "key" : {
        "userId" : $util.dynamodb.toDynamoDBJson($callerId),
        "friendId" : $util.dynamodb.toDynamoDBJson($ownerId)
    }
}
```

6. Inside the response mapping template text area, paste the following template:

```
#if($ctx.error)
    $util.error("Unable to retrieve friend mapping message: ${ctx.error.message}",
 $ctx.error.type)
#end

## if the users aren't friends
#if(!$ctx.result)
    $util.unauthorized()
#end

$util.toJson($ctx.prev.result)
```

7. Choose **Create Function**.

Result: You've created the **isFriend** function.

getPicturesByOwner function

1. Choose the **Functions** tab.
2. Choose **Create Function** to create a function.
3. For the data source name, enter `PicturesDynamoDBTable`.
4. For the function name, enter `getPicturesByOwner`.
5. Inside the request mapping template text area, paste the following template:

```
{
    "version" : "2018-05-29",
```

```
    "operation" : "Query",

    "query" : {
        "expression": "#owner = :owner",
        "expressionNames": {
            "#owner" : "owner"
        },
        "expressionValues" : {
            ":owner" : $util.dynamodb.toDynamoDBJson($ctx.prev.result.owner)
        }
    },

    "index": "owner-index"
}
```

6. Inside the response mapping template text area, paste the following template:

```
#if($ctx.error)
    $util.error($ctx.error.message, $ctx.error.type)
#end

$util.toJson($ctx.result)
```

7. Choose **Create Function**.

Result: You've created the **getPicturesByOwner** function. Now that the functions have been created, attach a pipeline resolver to the *Query.getPicturesByOwner* field.

From the schema editor in the AWS AppSync console, on the right side choose **Attach Resolver** for `Query.getPicturesByOwner(id: ID!): [Picture]`. On the following page, choose the **Convert to pipeline resolver** link that appears underneath the data source drop-down list. Use the following for the before mapping template:

```
#set($result = { "owner": $ctx.args.id, "callerId": $ctx.identity.username })
$util.toJson($result)
```

In the **after mapping template** section, use the following:

```
#foreach($picture in $ctx.result.items)
    ## prepend "src://" to picture.src property
    #set($picture['src'] = "src://${picture['src']}")
#end
$util.toJson($ctx.result.items)
```

Choose **Create Resolver**. You have successfully attached your first pipeline resolver. On the same page, add the two functions you created previously. In the functions section, choose **Add A Function** and then choose or type the name of the first function, **isFriend**. Add the second function by following the same process for the **getPicturesByOwner** function. Make sure the **isFriend** function appears first in the list followed by the **getPicturesByOwner** function. You can use the up and down arrows to rearrange to order of execution of the functions in the pipeline.

Now that the pipeline resolver is created and you've attached the functions, let's test the newly created GraphQL API.

Testing Your GraphQL API

First, you need to populate pictures and friendships by executing a few mutations using the admin user you created. On the left side of the AWS AppSync console, choose the **Queries** tab.

createPicture Mutation

1. In AWS AppSync console, choose the **Queries** tab.
2. Choose **Login With User Pools**.
3. On the modal, enter the Cognito Sample Client ID that was created by the CloudFormation stack for example, 37solo6mmhh7k4v63cqdfgdg5d).
4. Enter the user name you passed as parameter to the CloudFormation stack. Default is **nadia**.
5. Use the temporary password that was sent to the email you provided as parameter to the CloudFormation stack (for example, *UserPoolUserEmail*).
6. Choose Login. You should now see the button renamed to **Logout nadia**, or whatever user name you chose when creating the CloudFormation stack (that is, *UserPoolUsername*).

Let's send a few *createPicture* mutations to populate the pictures table. Execute the following GraphQL query inside the console:

```
mutation {
  createPicture(input:{
    owner: "nadia"
    src: "nadia.jpg"
  }) {
    id
    owner
    src
  }
}
```

The response should look like below:

```
{
  "data": {
    "createPicture": {
      "id": "c6fedbbe-57ad-4da3-860a-ffe8d039882a",
      "owner": "nadia",
      "src": "nadia.jpg"
    }
  }
}
```

Let's add a few more pictures:

```
mutation {
  createPicture(input:{
    owner: "shaggy"
    src: "shaggy.jpg"
  }) {
    id
    owner
    src
  }
}
```

```
mutation {
  createPicture(input:{
    owner: "rex"
    src: "rex.jpg"
  }) {
    id
```

```
    owner
    src
  }
}
```

You've added three pictures using **nadia** as the admin user.

createFriendship Mutation

Let's add a friendship entry. Execute the following mutations in the console.

Note: You must still be logged in as the admin user (the default admin user is **nadia**).

```
mutation {
  createFriendship(id: "nadia", target: "shaggy")
}
```

The response should look like:

```
{
  "data": {
    "createFriendship": true
  }
}
```

nadia and **shaggy** are friends. **rex** is not friends with anybody.

getPicturesByOwner Query

For this step, log in as the **nadia** user using Cognito User Pools, using the credentials set up in the beginning of this tutorial. As **nadia**, retrieve the pictures owned by **shaggy**.

```
query {
    getPicturesByOwner(id: "shaggy") {
        id
        owner
        src
    }
}
```

Since **nadia** and **shaggy** are friends, the query should return the corresponding picture.

```
{
  "data": {
    "getPicturesByOwner": [
      {
        "id": "05a16fba-cc29-41ee-a8d5-4e791f4f1079",
        "owner": "shaggy",
        "src": "src://shaggy.jpg"
      }
    ]
  }
}
```

Similarly, if **nadia** attempts to retrieve her own pictures, it also succeeds. The pipeline resolver has been optimized to avoid running the **isFriend** GetItem operation in that case. Try the following query:

```
query {
```

```
    getPicturesByOwner(id: "nadia") {
        id
        owner
        src
    }
}
```

If you enable logging on your API (in the **Settings** pane), set the debug level to **ALL**, and run the same query again, it returns logs for the field execution. By looking at the logs, you can determine whether the **isFriend** function returned early at the **Request Mapping Template** stage:

```
{
  "errors": [],
  "mappingTemplateType": "Request Mapping",
  "path": "[getPicturesByOwner]",
  "resolverArn": "arn:aws:appsync:us-west-2:XXXX:apis/XXXX/types/Query/fields/
getPicturesByOwner",
  "functionArn": "arn:aws:appsync:us-west-2:XXXX:apis/XXXX/functions/
o2f42p2jrfdl3dw7s6xub2csdfs",
  "functionName": "isFriend",
  "earlyReturnedValue": {
    "owner": "nadia",
    "callerId": "nadia"
  },
  "context": {
    "arguments": {
      "id": "nadia"
    },
    "prev": {
      "result": {
        "owner": "nadia",
        "callerId": "nadia"
      }
    },
    "stash": {},
    "outErrors": []
  },
  "fieldInError": false
}
```

The *earlyReturnedValue* key represents the data that was returned by the *#return* directive.

Finally, even though **rex** is a member of the **Viewers** Cognito UserPool Group, and because **rex** isn't friends with anybody, he won't be able to access any of the pictures owned by **shaggy** or **nadia**. If you log in as **rex** in the console and execute the following query:

```
query {
    getPicturesByOwner(id: "nadia") {
        id
        owner
        src
    }
}
```

You get the following unauthorized error:

```
{
  "data": {
    "getPicturesByOwner": null
  },
  "errors": [
    {
```

```
      "path": [
        "getPicturesByOwner"
      ],
      "data": null,
      "errorType": "Unauthorized",
      "errorInfo": null,
      "locations": [
        {
          "line": 2,
          "column": 9,
          "sourceName": null
        }
      ],
      "message": "Not Authorized to access getPicturesByOwner on type Query"
    }
  ]
}
```

You have successfully implemented complex authorization using pipeline resolvers.

Tutorial: Delta Sync

Client applications in AWS AppSync store data by caching GraphQL responses locally to disk in a mobile/web application. Versioned data sources and `Sync` operations give customers the ability to perform the sync process using a single resolver. This allows clients to hydrate their local cache with results from one base query that might have a lot of records, and then receive only the data altered since their last query (the *delta updates*). By allowing clients to perform the base hydration of the cache with an initial request and incremental updates in another, you can move the computation from your client application to the backend. This is substantially more efficient for client applications that frequently switch between online and offline states.

To implement Delta Sync, the `Sync` query uses the `Sync` operation on a versioned data source. When an AWS AppSync mutation changes an item in a versioned data source, a record of that change will be stored in the *Delta* table as well. You can choose to use different *Delta* tables (e.g. one per type, one per domain area) for other versioned data sources or a single *Delta* table for your API. AWS AppSync recommends against using a single *Delta* table for multiple APIs to avoid the collision of primary keys.

In addition, Delta Sync clients can also receive a subscription as an argument, and then the client coordinates subscription reconnects and writes between offline to online transitions. Delta Sync performs this by automatically resuming subscriptions (including exponential backoff and retry with jitter through different network error scenarios), and storing events in a queue. The appropriate delta or base query is then run before merging any events from the queue, and finally processing subscriptions as normal.

Documentation for client configuration options, including the Amplify DataStore, is available on the Amplify Framework website. This documentation outlines how to set up versioned DynamoDB data sources and `Sync` operations to work with the Delta Sync client for optimal data access.

One-Click Setup

To automatically set up the GraphQL endpoint in AWS AppSync with all the resolvers configured and the necessary AWS resources, use this AWS CloudFormation template:

This stack creates the following resources in your account:

- 2 DynamoDB tables (Base and Delta)
- 1 AWS AppSync API with API key
- 1 IAM Role with policy for DynamoDB tables

Two tables are used to partition your sync queries into a second table that acts as a journal of missed events when the clients were offline. To keep the queries efficient on the delta table, Amazon DynamoDB TTLs are used to automatically groom the events as necessary. The TTL time is configurable for your needs on the data source (you might want this as 1hour, 1day, etc.).

Schema

To demonstrate Delta Sync, the sample application creates a *Posts* schema backed by a *Base* and *Delta* table in DynamoDB. AWS AppSync automatically writes the mutations to both tables. The sync query pulls records from the *Base* or *Delta* table as appropriate, and a single subscription is defined to show how clients can leverage this in their reconnection logic.

```
input CreatePostInput {
    author: String!
    title: String!
    content: String!
    url: String
    ups: Int
    downs: Int
    _version: Int
}

interface Connection {
  nextToken: String
  startedAt: AWSTimestamp!
}

type Mutation {
    createPost(input: CreatePostInput!): Post
    updatePost(input: UpdatePostInput!): Post
    deletePost(input: DeletePostInput!): Post
}

type Post {
    id: ID!
    author: String!
    title: String!
    content: String!
    url: AWSURL
    ups: Int
    downs: Int
    _version: Int
    _deleted: Boolean
    _lastChangedAt: AWSTimestamp!
}

type PostConnection implements Connection {
    items: [Post!]!
    nextToken: String
    startedAt: AWSTimestamp!
}

type Query {
    getPost(id: ID!): Post
    syncPosts(limit: Int, nextToken: String, lastSync: AWSTimestamp): PostConnection!
}
```

```
type Subscription {
    onCreatePost: Post
        @aws_subscribe(mutations: ["createPost"])
    onUpdatePost: Post
        @aws_subscribe(mutations: ["updatePost"])
    onDeletePost: Post
        @aws_subscribe(mutations: ["deletePost"])
}

input DeletePostInput {
    id: ID!
    _version: Int!
}

input UpdatePostInput {
    id: ID!
    author: String
    title: String
    content: String
    url: String
    ups: Int
    downs: Int
    _version: Int!
}

schema {
    query: Query
    mutation: Mutation
    subscription: Subscription
}
```

The GraphQL schema is standard, but a couple things are worth calling out before moving forward. First, all of the mutations automatically first write to the *Base* table and then to the *Delta* table. The *Base* table is the central source of truth for state while the *Delta* table is your journal. If you don't pass in the `lastSync: AWSTimestamp`, the `syncPosts` query runs against the *Base* table and hydrates the cache as well as running at periodic times as a *global catchup process* for edge cases when clients are offline longer than your configured TTL time in the *Delta* table. If you do pass in the `lastSync: AWSTimestamp`, the `syncPosts` query runs against your *Delta* table and is used by clients to retrieve changed events since they were last offline. Amplify clients automatically pass the `lastSync: AWSTimestamp` value, and persist to disk appropriately.

The *_deleted* field on *Post* is used for **DELETE** operations. When clients are offline and records are removed from the *Base* table, this attribute notifies clients performing synchronization to evict items from their local cache. In cases where clients are offline for longer periods of time and the item has been removed before the client can retrieve this value with a Delta Sync query, the global catch-up event in the base query (configurable in the client) runs and removes the item from the cache. This field is marked optional because it only returns a value when running a sync query that has deleted items present.

Mutations

For all of the mutations, AWS AppSync does a standard Create/Update/Delete operation in the *Base* table and also records the change in the *Delta* table automatically. You can reduce or extend the time to keep records by modifying the `DeltaSyncTableTTL` value on the data source. For organizations with a high velocity of data, it may make sense to keep this short. Alternatively, if your clients are offline for longer periods of time, it might be prudent to keep this longer.

Sync Queries

The *base query* is a DynamoDB Sync operation without a `lastSync` value specified. For many organizations, this works because the base query only runs on startup and at a periodic basis thereafter.

The *delta query* is a DynamoDB Sync operation with a `lastSync` value specified. The *delta query* executes whenever the client comes back online from an offline state (as long as the base query periodic time hasn't triggered to run). Clients automatically track the last time they successfully ran a query to sync data.

When a delta query is run, the query's resolver uses the `ds_pk` and `ds_sk` to query only for the records that have changed since the last time the client performed a sync. The client stores the appropriate GraphQL response.

For more information on executing Sync Queries, see the Sync Operation documentation (p. 190).

Example

Let's start first by calling a `createPost` mutation to create an item:

```
mutation create {
  createPost(input: {author: "Nadia", title: "My First Post", content: "Hello World"}) {
    id
    author
    title
    content
    _version
    _lastChangedAt
    _deleted
  }
}
```

The return value of this mutation will look as follows:

```
{
  "data": {
    "createPost": {
      "id": "81d36bbb-1579-4efe-92b8-2e3f679f628b",
      "author": "Nadia",
      "title": "My First Post",
      "content": "Hello World",
      "_version": 1,
      "_lastChangedAt": 1574469356331,
      "_deleted": null
    }
  }
}
```

If you examine the contents of the *Base* table, you will see a record that looks like:

```
{
  "_lastChangedAt": {
    "N": "1574469356331"
  },
  "_version": {
    "N": "1"
  },
  "author": {
    "S": "Nadia"
  },
  "content": {
    "S": "Hello World"
  },
  "id": {
    "S": "81d36bbb-1579-4efe-92b8-2e3f679f628b"
```

```
  },
  "title": {
    "S": "My First Post"
  }
}
```

If you examine the contents of the *Delta* table, you will see a record that looks like:

```
{
  "_lastChangedAt": {
    "N": "1574469356331"
  },
  "_ttl": {
    "N": "1574472956"
  },
  "_version": {
    "N": "1"
  },
  "author": {
    "S": "Nadia"
  },
  "content": {
    "S": "Hello World"
  },
  "ds_pk": {
    "S": "AppSync-delta-sync-post:2019-11-23"
  },
  "ds_sk": {
    "S": "00:35:56.331:81d36bbb-1579-4efe-92b8-2e3f679f628b:1"
  },
  "id": {
    "S": "81d36bbb-1579-4efe-92b8-2e3f679f628b"
  },
  "title": {
    "S": "My First Post"
  }
}
```

Now we can simulate a *Base* query that a client will run to hydrate its local data store using a `syncPosts` query like:

```
query baseQuery {
  syncPosts(limit: 100, lastSync: null, nextToken: null) {
    items {
      id
      author
      title
      content
      _version
      _lastChangedAt
    }
    startedAt
    nextToken
  }
}
```

The return value of this *Base* query will look as follows:

```
{
  "data": {
    "syncPosts": {
      "items": [
```

```
        {
          "id": "81d36bbb-1579-4efe-92b8-2e3f679f628b",
          "author": "Nadia",
          "title": "My First Post",
          "content": "Hello World",
          "_version": 1,
          "_lastChangedAt": 1574469356331
        }
      ],
      "startedAt": 1574469602238,
      "nextToken": null
    }
  }
}
```

We'll save the `startedAt` value later to simulate a *Delta* query, but first we need to make a change to our table. Let's use the `updatePost` mutation to modify our existing Post:

```
mutation updatePost {
  updatePost(input: {id: "81d36bbb-1579-4efe-92b8-2e3f679f628b", _version: 1, title:
 "Actually this is my Second Post"}) {
    id
    author
    title
    content
    _version
    _lastChangedAt
    _deleted
  }
}
```

The return value of this mutation will look as follows:

```
{
  "data": {
    "updatePost": {
      "id": "81d36bbb-1579-4efe-92b8-2e3f679f628b",
      "author": "Nadia",
      "title": "Actually this is my Second Post",
      "content": "Hello World",
      "_version": 2,
      "_lastChangedAt": 1574469851417,
      "_deleted": null
    }
  }
}
```

If you examine the contents of the *Base* table now, you should see the updated item:

```
{
  "_lastChangedAt": {
    "N": "1574469851417"
  },
  "_version": {
    "N": "2"
  },
  "author": {
    "S": "Nadia"
  },
  "content": {
    "S": "Hello World"
  },
```

```
  "id": {
    "S": "81d36bbb-1579-4efe-92b8-2e3f679f628b"
  },
  "title": {
    "S": "Actually this is my Second Post"
  }
}
```

If you examine the contents of the *Delta* table now, you should see two records:

1. A record when the item was created
2. A record for when the item was updated.

The new item will look like:

```
{
  "_lastChangedAt": {
    "N": "1574469851417"
  },
  "_ttl": {
    "N": "1574473451"
  },
  "_version": {
    "N": "2"
  },
  "author": {
    "S": "Nadia"
  },
  "content": {
    "S": "Hello World"
  },
  "ds_pk": {
    "S": "AppSync-delta-sync-post:2019-11-23"
  },
  "ds_sk": {
    "S": "00:44:11.417:81d36bbb-1579-4efe-92b8-2e3f679f628b:2"
  },
  "id": {
    "S": "81d36bbb-1579-4efe-92b8-2e3f679f628b"
  },
  "title": {
    "S": "Actually this is my Second Post"
  }
}
```

Now we can simulate a *Delta* query to retrieve modifications that occurred when a client was offline. We will use the `startedAt` value returned from our *Base* query to make the request:

```
query delta {
  syncPosts(limit: 100, lastSync: 1574469602238, nextToken: null) {
    items {
      id
      author
      title
      content
      _version
    }
    startedAt
    nextToken
  }
}
```

The return value of this *Delta* query will look as follows:

```
{
  "data": {
    "syncPosts": {
      "items": [
        {
          "id": "81d36bbb-1579-4efe-92b8-2e3f679f628b",
          "author": "Nadia",
          "title": "Actually this is my Second Post",
          "content": "Hello World",
          "_version": 2
        }
      ],
      "startedAt": 1574470400808,
      "nextToken": null
    }
  }
}
```

Real-Time Data

GraphQL Schema Subscription Directives

Subscriptions in AWS AppSync are invoked as a response to a mutation. This means that you can make any data source in AWS AppSync real time by specifying a GraphQL schema directive on a mutation. The AWS AppSync client SDK automatically handles subscription connection management. The SDK uses either pure WebSockets or MQTT over WebSockets as the network protocol between the client and service. The protocol depends on the version of the client you're using.

Important
As of July 2020, new regions will *only* support pure WebSockets. MQTT over WebSockets is available in the following regions:

- US East (`us-east-1`/North Virginia and `us-east-2`/Ohio)
- US West (`us-west-2`/Oregon)
- EU (`eu-central-1`/Frankfurt, `eu-west-1`/Ireland, `eu-west-2`/London)
- Asia Pacific (`ap-northeast-1`/Tokyo, `ap-northeast-2`/Seoul, `ap-south-1`/Mumbai, `ap-southeast-1`/Singapore, `ap-southeast-2`/Sydney)

Pure WebSockets come with a larger payload size (240kb), a wider variety of client options, and improved CloudWatch metrics. For more information on using pure WebSocket clients, see *Building a Real-time WebSocket Client* (p. 170).

Note: To control authorization at connection time to a subscription, you can leverage controls such as IAM, Amazon Cognito identity pools, or Amazon Cognito user pools for field-level authorization. For fine-grained access controls on subscriptions, you can attach resolvers to your subscription fields and perform logic using the identity of the caller and AWS AppSync data sources. For more information, see Security (p. 206).

Subscriptions are triggered from mutations and the mutation selection set is sent to subscribers.

The following example shows how to work with GraphQL subscriptions. It doesn't specify a data source because the data source could be AWS Lambda, Amazon DynamoDB, or Amazon Elasticsearch Service.

To get started with subscriptions, you must add a subscription entry point to your schema as follows:

```
schema {
    query: Query
    mutation: Mutation
    subscription: Subscription
}
```

Suppose you have a blog post site, and you want to subscribe to new blogs and changes to existing blogs. To do this, add the following `Subscription` definition to your schema:

```
type Subscription {
    addedPost: Post
    updatedPost: Post
    deletedPost: Post
}
```

Suppose further that you have the following mutations:

```
type Mutation {
    addPost(id: ID! author: String! title: String content: String url: String): Post!
    updatePost(id: ID! author: String! title: String content: String url: String ups: Int!
 downs: Int! expectedVersion: Int!): Post!
    deletePost(id: ID!): Post!
}
```

You can make these fields real time by adding an `@aws_subscribe(mutations: ["mutation_field_1", "mutation_field_2"])` directive for each of the subscriptions you want to receive notifications for, as follows:

```
type Subscription {
    addedPost: Post
    @aws_subscribe(mutations: ["addPost"])
    updatedPost: Post
    @aws_subscribe(mutations: ["updatePost"])
    deletedPost: Post
    @aws_subscribe(mutations: ["deletePost"])
}
```

Because the `@aws_subscribe(mutations: ["",..,""])` takes an array of mutation inputs, you can specify multiple mutations, which trigger a subscription. If you're subscribing from a client, your GraphQL query might look like the following:

```
subscription NewPostSub {
    addedPost {
        __typename
        version
        title
        content
        author
        url
    }
}
```

The subscription query above is needed for client connections and tooling. However, if you're using MQTT over WebSockets, the client triggering the mutation specifies the selection set that subscribers receive. To demonstrate this, suppose that a mutation was made from another mobile client or a server (for example, `mutation addPost(...){id author title }`). In this case, the content, version, and URL are not published to subscribers. Instead, the ID, author, and title are published.

If you use the pure WebSockets client, selection set filtering is done per client, as each client can define its own selection set. In this case, the subscription selection set must be a subset of the mutation selection set. For example, a subscription `addedPost{author title}` linked to the mutation `addPost(...){id author title url version}` receives only the author and title of the post. It does not receive the other fields. However, if the mutation lacked the author in its selection set, the subscriber would get a `null` value for the author field (or an error in case the author field is defined as required/not-null in the schema).

Furthermore, if you are using MQTT over WebSockets in your application, there are some changes you need to be aware of. If you didn't configure the associated subscription selection set with the required fields and relied on the mutation fields to push data to subscribed client, the behavior will change when you move to pure WebSockets. In the example above, a subscription without the "author" field defined in its selection set would still return the author name with MQTT over WebSockets as the field is defined in the mutation, the same behavior won't apply for pure WebSockets. The subscription selection set is essential when using pure WebSockets: if a field is not explicitly defined in the subscription it won't be returned by AWS AppSync.

In the previous example, the subscriptions didn't have arguments. Suppose your schema looks like the following:

```
type Subscription {
    updatedPost(id:ID! author:String): Post
    @aws_subscribe(mutations: ["updatePost"])
}
```

In this case, your client defines a subscription as follows:

```
subscription UpdatedPostSub {
    updatedPost(id:"XYZ", author:"ABC") {
        title
        content
    }
}
```

The return type of a `subscription` field in your schema must match the return type of the corresponding mutation field. In the previous example, this was shown as both `addPost` and `addedPost` returned as a type of `Post`.

To set up subscriptions on the client, see Building a Client App (p. 49).

Using Subscription Arguments

An important part of using GraphQL subscriptions is understanding when and how to use arguments because subtle changes enable you to modify how and when clients are notified about mutations that have occurred. To do this, see the sample schema from the Quickstart section Launch a Sample Schema (p. 2), which creates "Events" and "Comments". For this sample schema, the following mutation occurs:

```
type Mutation {
    createEvent(
        name: String!,
        when: String!,
        where: String!,
        description: String!
    ): Event
    deleteEvent(id: ID!): Event
    commentOnEvent(eventId: ID!, content: String!, createdAt: String!): Comment
}
```

In the default sample, clients can subscribe to comments when a specific eventId argument is passed through:

```
type Subscription {
    subscribeToEventComments(eventId: String!): Comment
        @aws_subscribe(mutations: ["commentOnEvent"])
}
```

However, if you want to enable clients to subscribe to a single event OR all events, you can make this argument optional by removing the exclamation point (!) from the subscription prototype:

```
subscribeToEventComments(eventId: String): Comment
```

With this change, clients that omitted this argument get comments for all events. Additionally, if you want clients to explicitly subscribe to all comments for all events, you should remove the argument as follows:

```
subscribeToEventComments: Comment
```

Use these for comments on one or more events. If you want to know about all events that are created, you could do the following:

```
type Subscription {
    subscribeToNewEvents: Event
        @aws_subscribe(mutations: ["createEvent"])
}
```

Multiple arguments can also be passed. For example, if you want to get notified of new events at a specific place and time, you could do the following:

```
type Subscription {
    subscribePlaceDate(where: String! when: String!): Event
            @aws_subscribe(mutations: ["createEvent"])
}
```

As a result, the client application can now do the following:

```
subscription myplaces {
    subscribePlaceDate(where: "Seattle" when: "Saturday"){
        id
        name
        description
    }
}
```

Argument null value has meaning

When making a subscription query in AWS AppSync, a `null` argument value will filter the results differently than omitting the argument entirely.

Let's explain with an example. Let's go back to the events app sample where we could create events and post comments on events. See the sample schema from the Quickstart section Launch a Sample Schema (p. 2).

Let's modify our schema to include a new `location` field on the `Comment` field, that describes where the comment was sent from. The value could be a set of coordinates or a place. See below the schema, note that we stripped it down for the sake of brevity:

```
type Comment {
    # The id of the comment's parent event.
    eventId: ID!
    # A unique identifier for the comment.
    commentId: String!
    # The comment's content.
    content: String
    # Location where the comment was made
    location: String
}

type Event {
```

```
    id: ID!
    name: String
    where: String
    when: String
    description: String
}

type Mutation {
    commentOnEvent(eventId: ID!, location: String, content: String): Comment
}

type Subscription {
    subscribeToEventComments(eventId: String!, location: String, content: String): Comment
        @aws_subscribe(mutations: ["commentOnEvent"])
}
```

Note the new optional field `Comment.location`.

Now say that we want to get notified of all the comments as they are posted for a particular event, we would write the following subscription:

```
subscribeToEventComments(eventId: "1") {
    eventId
    commentId
    location
    content
}
```

Now if we were to instead add the field argument `location: null` to the subscription above,

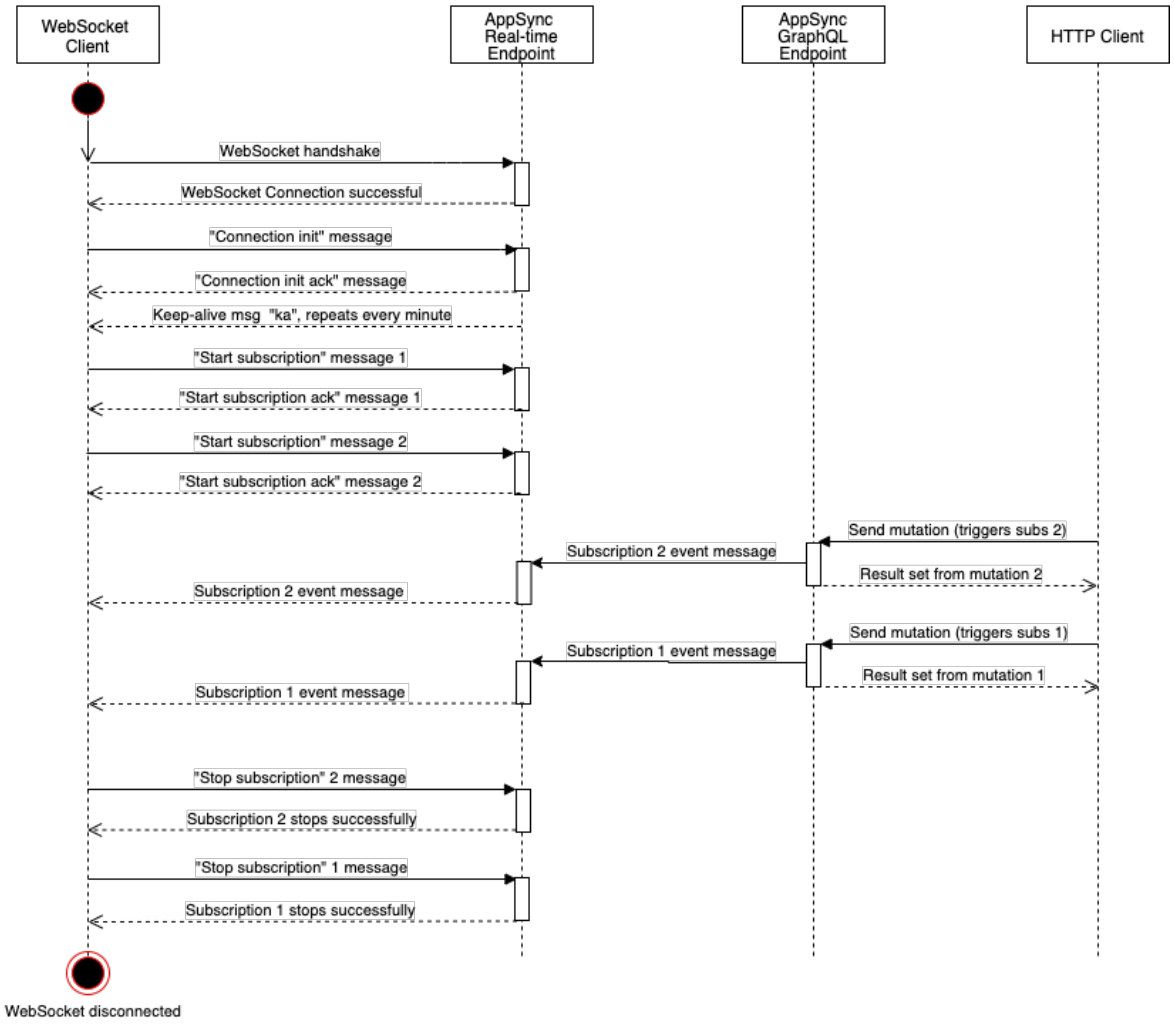
```
subscribeToEventComments(eventId: "1" location: null) {
    eventId
    commentId
    location
    content
}
```

we would now be asking a different question. This subscription now registers the client to get notified of all the comments that have **not** provided a location for a particular event.

Building a Real-time WebSocket Client

AWS AppSync Real-time WebSocket client implementation guide for GraphQL Subscriptions

The following sequence diagram and steps show the real-time subscriptions workflow between the WebSocket client, HTTP client, and the AWS AppSync service.



1. The client establishes a WebSocket connection with the AWS AppSync real-time endpoint. If there is a network error, the client should do a jittered exponential backoff. For more information, see Exponential Backoff And Jitter in the AWS Architecture Blog.
2. After the WebSocket connection is successfully established, the client sends a `connection_init` message.

3. The client waits for `connection_ack` message from AWS AppSync. This message includes a `connectionTimeoutMs` parameter, which is the maximum wait time in milliseconds for a `"ka"`, keep-alive, message.
4. AWS AppSync sends **keep-alive** messages, `"ka"`, periodically. The client keeps track of the time it received each `"ka"` message. If no `"ka"` message is received within `connectionTimeoutMs` milliseconds, the client should terminate the connection.
5. The client registers the subscription by sending a `start` subscription message. A single WebSocket connection supports multiple subscriptions even if they are in different authorization modes.
6. The client waits for AWS AppSync to send `start_ack` messages to confirm successful subscriptions. If there is an error, AWS AppSync returns a `"type": "error"` message.
7. The client listens for subscription events. Those are sent after a corresponding mutation was called. Queries and mutations are usually sent through `https://` to the AWS AppSync GraphQL endpoint. Subscriptions flow through the AWS AppSync real-time endpoint using the secure WebSocket (`wss://`).
8. The client unregisters the subscription by sending a `stop` subscription message.
9. After unregistering all subscriptions and checking that there are no messages transferring through the WebSocket, the client can disconnect from the WebSocket connection.

Handshake details to establish the WebSocket connection

To connect and initiate a successful handshake with AWS AppSync, a WebSocket client needs the following:

- The AppSync real-time endpoint
- A query string that contains the following parameters: `header` and `payload`:
  - `header`: Contains information relevant to the AWS AppSync endpoint and authorization. This is a base64 string encoded from a stringified JSON object. The JSON object content varies depending on the authorization mode.
  - `payload`: Base64 encoded string of `payload`.

With these required details, a WebSocket client can connect to the URL, which is contains the API real-time endpoint with the query string, using `graphql-ws` as the WebSocket protocol.

Discovering the AWS AppSync real-time endpoint from the AWS AppSync GraphQL endpoint

The AWS AppSync GraphQL endpoint and the AWS AppSync real-time endpoint are slightly different in protocol and domain. You can retrieve the AWS AppSync GraphQL endpoint using the AWS CLI command `aws appsync get-graphql-api`.

AWS AppSync GraphQL endpoint:

```
https://example1234567890000.appsync-api.us-east-1.amazonaws.com/graphql
```

AWS AppSync real-time endpoint:

```
wss://example1234567890000.appsync-realtime-api.us-east-1.amazonaws.com/
graphql
```

Applications can connect to the AWS AppSync GraphQL endpoint (`https://`) using any HTTP client for queries and mutations. Applications can connect to the AWS AppSync real-time endpoint (`wss://`) using any WebSocket client for subscriptions.

Header parameter format based on AWS AppSync API authorization mode

The format of the `header` object used in the connection query string varies depending to the AWS AppSync API authorization mode. The `host` field in the object refers to the AWS AppSync GraphQL endpoint, which is used to validate the connection even if the `wss://` call is made against the real-time endpoint. To initiate the handshake and establish the authorized connection, the `payload` should be an empty JSON object.

API Key

Header contents:

- `"host": <string>`: This is the host for the AWS AppSync GraphQL endpoint.
- `"x-api-key": <string>`: API key configured for AWS AppSync API.

Example:

```
{
    "host":"example1234567890000.appsync-api.us-east-1.amazonaws.com",
    "x-api-key":"da2-12345678901234567890123456"
}
```

Payload content:

```
{}
```

Request URL:

```
wss://example1234567890000.appsync-realtime-api.us-east-1.amazonaws.com/graphql?
header=eyJob3N0IjoiZXhhbXBsZTEyMzQ1Njc4OTAwMDAuYXBwc3luYy1hcGkudXMtZWFzdC0xLmFtYXpvbmF3cy5jb20iLCJ4LWFt
```

Amazon Cognito user pools and OpenID Connect (OIDC)

Header contents:

- `"Authorization": <string>`: JWT Access Token.
- `"host": <string>`: This is the host for the AWS AppSync GraphQL endpoint.

Example:

```
{

 "Authorization":"eyEXAMPLEiJjbG5xb3A5eW5MK09QYXIrMTJHWEFLSXBieU5WNHhsQjEXAMPLEnM2WldvPSIsImFsZyI6IlEXA
zEE2DJH7sHOl2zxYi7f-SmEGoh2AD8emxQRYajByz-rE4Jh0QOymN2Ys-ZIkMpVBTPgu-
TMWDyOHhDUmUj2OP82yeZ3wlZAtr_gM4LzjXUXmI_K2yGjuXfXTaa1mvQEBG0mQfVd7SfwXB-
```

```
jcv4RYVi6j25qgow9Ew52ufurPqaK-3WAKG32KpV8J4-Wejq8t0c-
yA7sb8EnB551b7TU93uKRiVVK3E55Nk5ADPoam_WYE45i3s5qVAP_-InW75NUoOCGTsS8YWMfb6ecHYJ-1j-
bzA27zaT9VjctXn9byNFZmEXAMPLExw",
    "host":"example1234567890000.appsync-api.us-east-1.amazonaws.com"
}
```

Payload content:

```
{}
```

Request URL:

```
wss://example1234567890000.appsync-realtime-api.us-east-1.amazonaws.com/graphql?
header=eyJBdXRob3JpemF0aW9uIjoiZXlKcmFXUWlPaUpqYkc1eGIzQTVlVzVNSzA5UVlYSXJNVEpIV0VGTFNYQmllVTVXTkhoc1Fq
```

IAM

Header contents include the following:

- `"accept": "application/json, text/javascript"`: A constant `<string>` parameter.
- `"content-encoding": "amz-1.0"`: A constant `<string>` parameter.
- `"content-type": "application/json; charset=UTF-8"`: A constant `<string>` parameter.
- `"host": <string>`: This is the host for the AWS AppSync GraphQL endpoint. - `"x-amz-date": <string>`: The timestamp must be in UTC and in the following ISO 8601 format: YYYYMMDD'T'HHMMSS'Z'. For example, 20150830T123600Z is a valid timestamp. Do not include milliseconds in the timestamp. For more information, see Handling dates in Signature Version 4 in the *AWS General Reference*.
  - `"X-Amz-Security-Token"`: <string>: The AWS session token, which is required when using temporary security credentials. For more information, see Using Temporary Credentials With AWS Resources in the *IAM User Guide*.
  - `"Authorization": <string>`: SigV4 signing information for the AWS AppSync endpoint. For more information on the signing process, see Task 4: Add the signature to the HTTP request in the *AWS General Reference*.

The SigV4 signing HTTP request includes a canonical URL, which is the AWS AppSync GraphQL endpoint with `/connect` appended. The service endpoint AWS Region is same region where you're using the AWS AppSync API, and service name is 'appsync'. The HTTP request to sign is the following:

```
{
  url: "https://example1234567890000.appsync-api.us-east-1.amazonaws.com/graphql/connect",
  data: "{}",
  method: "POST",
  headers: {
    "accept": "application/json, text/javascript",
    "content-encoding": "amz-1.0",
    "content-type": "application/json; charset=UTF-8",
  }
}
```

Example:

```
{
  "accept": "application/json, text/javascript",
  "content-encoding": "amz-1.0",
  "content-type": "application/json; charset=UTF-8",
  "host": "example1234567890000.appsync-api.us-east-1.amazonaws.com",
```

```
  "x-amz-date": "20200401T001010Z",
  "X-Amz-Security-Token":
 "AgEXAMPLEZ2luX2VjEAoaDmFwLXNvdXRoZWFEXAMPLEcwRQIgAh97Cljq7wOPL8KsxP3YtDuyc/9hAj8PhJ7Fvf38SgoCIQDhJEXA
+
+pEagWCveZUjKEn0zyUhBEXAMPLEjj//////////8BEXAMPLExODk2NDgyNzg1NSIMo1mWnpESWUoYw4BkKqEFSrm3DXuL8w
+ZbVc4JKjDP4vUCKNR6Le9C9pZp9PsW0NoFy3vLBUdAXEXAMPLEOVG8feXfiEEA+1khgFK/
wEtwR+9zF7NaMMMse07wN2gG2tH0eKMEXAMPLEQX+sMbytQo8iepP9PZOzlZsSFb/
dP5Q8hk6YEXAMPLEYcKZsTkDAq2uKFQ8mYUVA9EtQnNRiFLEY83aKvG/tqLWNnGlSNVx7SMcfovkFDqQamm
+88y1OwwAEYK7qcoceX6Z7GGcaYuIfGpaX2MCCELeQvZ+8WxEgOnIfz7GYvsYNjLZSaRnV4G
+ILY1F0QNW64S9Nvj+BwDg3ht2CrNvpwjVYlj9U3nmxE0UG5ne83LL5hhqMpm25kmL7enVgw2kQzmU2id4IKu0C/
WaoDRuO2F5zE63vJbxN8AYs7338+4B4HBb6BZ6OUgg96Q15RA41/
gIqxaVPxyTpDfTU5GfSLxocdYeniqqpFMtZG2n9d0u7GsQNcFkNcG3qDZm4tDo8tZbuym0a2VcF2E5hFEgXBa
+XLJCfXi/77OqAEjP0x7Qdk3B43p8KG/BaioP5RsV8zBGvH1zAgyPha2rN70/
tT13yrmPd5QYEfwzexjKrV4mWIuRg8NTHYSZJUaeyCwTom80VFUJXG
+GYTUyv5W22aBcnoRGiCiKEYTLOkgXecdKFTHmcIAejQ9Welr0a196Kq87w5KNMCkcCGFnwBNFLmfnbpNqT6rUBxxs3X5ntX9d8HVtS
aox0FtHX21eF6qIGT8j1z+l2opU+ggwUgkhUUgCH2TfqBj+MLMVVvpgqJsPKt582caFKArIFIvO
+9QupxLnEH2hz04TMTfnU6bQC6z1buVe7h
+tOLnh1YPFsLQ88anib/7TTC8k9DsBTq0ASe8R2GbSEsmO9qbbMwgEaYUhOKtGeyQsSJdhSk6XxXThrWL9EnwBCXDkICMqdntAxyyM9
+WgtPtKOOweDlCaRs3R2qXcbNgVhleMk4IWnF8D1695AenU1LwHjOJLkCjxgNFiWAFEPH9aEXAMPLExA==",
  "Authorization": "AWS4-HMAC-SHA256 Credential=XXXXXXXXXXXXXXXXXXX/20200401/
us-east-1/appsync/aws4_request, SignedHeaders=accept;content-
encoding;content-type;host;x-amz-date;x-amz-security-token,
 Signature=83EXAMPLEbcc1fe3ee69f75cd5ebbf4cb4f150e4f99cec869f149c5EXAMPLEdc"
}
```

Payload content:

```
{}
```

Request URL:

```
wss://example1234567890000.appsync-realtime-api.us-east-1.amazonaws.com/graphql?
header=eyEXAMPLEHQiOiJhcHBsaWNhdGlvbi9qc29uLCB0ZXh0L2phdmFEXAMPLEQiLCJjb250ZW50LWVuY29kaW5nIjoEXAMPLEEu
```

Note: One WebSocket connection can have multiple subscriptions (even with different authentication modes). One way to implement this is to create a WebSocket connection for the first subscription and close it when the last subscription is unregistered. This could be optimized by waiting a few seconds before closing the WebSocket connection, in case the App is subscribed immediately after the last subscription is unregistered. For a mobile app example, when changing from one screen to another, on *unmounting* event, it stops a subscription and on *mounting* event, it starts a different subscription.

Real-time WebSocket Operation

After initiating a successful WebSocket handshake with AWS AppSync, the client needs to send a subsequent message to complete the connection step to AWS AppSync for different operations. These messages require the following data:

- `type`: The type of the operation.
- `id`: An unique identifier for the subscription. We recommend using a UUID for this purpose.
- `payload`: Associated payload depending of the operation type.

The `type` field is the only required field, with `id` and `payload` optional.

Sequence of events

To successfully initiate, establish, register and process the subscription request, the client must step through the following sequence:

1. Initialize connection (`connection_init`)
2. Connection acknowledgment (`connection_ack`)
3. Subscription registration (`start`)
4. Subscription acknowledgment (`start_ack`)
5. Processing subscription (`data`)
6. Subscription unregistration (`stop`)

Connection init message

After a successful handshake, the client must send the `connection_init` message to start the communication with the AWS AppSync real-time endpoint. Without this step, all other messages will be ignored. The message is a string obtained by stringifying the following JSON object as follows:

```
{ "type": "connection_init" }
```

Connection acknowledge message

After sending the `connection_init` message, the client must wait for the `connection_ack` message. All messages sent before receiving `connection_ack` will be ignored. The message should read as follows:

```
{
  "type": "connection_ack",
  "payload": {
    // Time in milliseconds waiting for ka message before the client should terminate the
 WebSocket connection
    "connectionTimeout": 300000
  }
}
```

Keep-alive message

In addition to the connection acknowledge message, the client periodically receives keep-alive messages. If no keep-alive message is received within the connection timeout period, the client should terminate the connection. AWS AppSync will keep sending these messages and servicing the registered subscriptions until it shuts down the connection automatically (after 24 hours). Keep-alive messages are *heartbeats* and do not need to be acknowledged by the client.

```
{ "type": "ka" }
```

Subscription registration message

After `connection_ack` message is received by the client, subscription registration messages can be sent to AWS AppSync. This message is a stringified JSON object that contains the following fields:

- `"id": <string>`: ID of the subscription. This `id` must be unique for each subscription, otherwise the server will return an error indicating that the subscription `id` is duplicated.

- `"type": "start"`: A constant `<string>` parameter.
- `"payload": <Object>`: This contains the information relevant to the subscription.
  - `"data": <string>`: Stringified JSON object that contains GraphQL query and variables.
    - `"query": <string>`: GraphQL operation.
    - `"variables": <Object>`: Contains the variables for the query.
  - `"extensions": <Object>`: This contains authorization object.
- `"authorization": <Object>`: This contains the fields required for authorization.

Authorization object for subscription registration

The same rules in the Header parameter format based on AWS AppSync API authorization mode (p. 172) section apply for the authorization object. The only exception is for IAM, where the SigV4 signature information is slightly different. For more details, see the IAM example.

Example using Amazon Cognito user pools:

```
{
  "id": "ee849ef0-cf23-4cb8-9fcb-152ae4fd1e69",
  "payload": {
    "data": "{\"query\":\"subscription onCreateMessage {\\n onCreateMessage {\\n __typename
\\n message\\n }\\n }\",\"variables\":{}}",
      "extensions": {
        "authorization": {
          "Authorization":
 "eyEXAMPLEiJjbG5xb3A5eW5MK09QYXIrMTJEXAMPLEBieU5WNHhsQjhPVW9YMnM2WldvPSIsImFsZyI6IlEXAMPLEn0.eyJzdWIiO
qTCtrYeboUJ4luRSTPXaNewNeEXAMPLE14C6sfg05tO0fOMpiUwj9k19gtNCCMqoSsjtQoUweFnH4JYa5EXAMPLEVxOyQEQ4G7jQrt5
RWvW7yQU3sNQRLEXAMPLEcd0yufBiCYs3dfQxTTdvR1B6Wz6CD78lfNeKqfzzUn2beMoup2h6EXAMPLE4ow8cUPUPvG0DzRtHNMbWsk
          "host": "example1234567890000.appsync-api.us-east-1.amazonaws.com"
        }
      }
  },
  "type": "start"
}
```

Example using IAM:

```
{
  "id": "eEXAMPLE-cf23-1234-5678-152EXAMPLE69",
  "payload": {
    "data": "{\"query\":\"subscription onCreateMessage {\\n onCreateMessage {\\n __typename
\\n message\\n }\\n }\",\"variables\":{}}",
    "extensions": {
      "authorization": {
        "accept": "application/json, text/javascript",
        "content-type": "application/json; charset=UTF-8",
        "X-Amz-Security-Token":
 "AgEXAMPLEZ2luX2VjEAoaDmFwLXNvdXRoZWFEXAMPLEcwRQIgAh97Cljq7wOPL8KsxP3YtDuyc/9hAj8PhJ7Fvf38SgoCIQDhJEXA
+
+pEagWCveZUjKEn0zyUhBEXAMPLEjj//////////8BEXAMPLExODk2NDgyNzg1NSIMo1mWnpESWUoYw4BkKqEFSrm3DXuL8w
+ZbVc4JKjDP4vUCKNR6Le9C9pZp9PsW0NoFy3vLBUdAXEXAMPLEOVG8feXfiEEA+1khgFK/
wEtwR+9zF7NaMMMse07wN2gG2tH0eKMEXAMPLEQX+sMbytQo8iepP9PZOzlZsSFb/
dP5Q8hk6YEXAMPLEYcKZsTkDAq2uKFQ8mYUVA9EtQnNRiFLEY83aKvG/tqLWNnGlSNVx7SMcfovkFDqQamm
+88y1OwwAEYK7qcoceX6Z7GGcaYuIfGpaX2MCCELeQvZ+8WxEgOnIfz7GYvsYNjLZSaRnV4G
+ILY1F0QNW64S9Nvj+BwDg3ht2CrNvpwjVYlj9U3nmxE0UG5ne83LL5hhqMpm25kmL7enVgw2kQzmU2id4IKu0C/
WaoDRuO2F5zE63vJbxN8AYs7338+4B4HBb6BZ6OUgg96Q15RA41/
gIqxaVPxyTpDfTU5GfSLxocdYeniqqpFMtZG2n9d0u7GsQNcFkNcG3qDZm4tDo8tZbuym0a2VcF2E5hFEgXBa
+XLJCfXi/77OqAEjP0x7Qdk3B43p8KG/BaioP5RsV8zBGvH1zAgyPha2rN70/
tT13yrmPd5QYEfwzexjKrV4mWIuRg8NTHYSZJUaeyCwTom80VFUJXG
+GYTUyv5W22aBcnoRGiCiKEYTLOkgXecdKFTHmcIAejQ9Welr0a196Kq87w5KNMCkcCGFnwBNFLmfnbpNqT6rUBxxs3X5ntX9d8HVtS
```

```
aox0FtHX21eF6qIGT8j1z+l2opU+ggwUgkhUUgCH2TfqBj+MLMVVvpgqJsPKt582caFKArIFIvO
+9QupxLnEH2hz04TMTfnU6bQC6z1buVe7h
+tOLnh1YPFsLQ88anib/7TTC8k9DsBTq0ASe8R2GbSEsmO9qbbMwgEaYUhOKtGeyQsSJdhSk6XxXThrWL9EnwBCXDkICMqdntAxyyM9
+WgtPtKOOweDlCaRs3R2qXcbNgVhleMk4IWnF8D1695AenU1LwHjOJLkCjxgNFiWAFEPH9aEXAMPLExA==",
        "Authorization": "AWS4-HMAC-SHA256 Credential=XXXXXXXXXXXXXXXXXXX/20200401/
us-east-1/appsync/aws4_request, SignedHeaders=accept;content-
encoding;content-type;host;x-amz-date;x-amz-security-token,
 Signature=b90131a61a7c4318e1c35ead5dbfdeb46339a7585bbdbeceeaff51f4022eb1fd",
        "content-encoding": "amz-1.0",
        "host": "example1234567890000.appsync-api.us-east-1.amazonaws.com",
        "x-amz-date": "20200401T001010Z"
      }
    }
  },
  "type": "start"
}
```

The SigV4 signature does not need `/connect` to be appended to the url and `data` is replaced with the JSON stringified GraphQL operation. Following is an example of a SigV4 signature request:

```
{
  url: "https://example1234567890000.appsync-api.us-east-1.amazonaws.com/graphql",
  data: "{\"query\":\"subscription onCreateMessage {\\n onCreateMessage {\\n __typename\\n
 message\\n }\\n }\",\"variables\":{}}",
  method: "POST",
  headers: {
    "accept": "application/json, text/javascript",
    "content-encoding": "amz-1.0",
    "content-type": "application/json; charset=UTF-8",
  }
}
```

Subscription acknowledge message

After sending the subscription start message, the client should wait for AWS AppSync to send the `start_ack` message. `start_ack` indicates the subscription was successful. The message is the following string:

Subscription success example:

```
{
  "type": "start_ack",
  "id": "eEXAMPLE-cf23-1234-5678-152EXAMPLE69"
}
```

Error message

If connection init or subscription registration fails or if a subscription is terminated from the server, the server sends the following error message to the client:

- `"type": "error"`: A constant `<string>` parameter.
- `"id": <string>`: The `id` of the corresponding registered subscription, if relevant.
- `"payload" <Object>`: This object contains the corresponding error information.

Example:

```
{
  "type": "error",
  "payload": {
    "errors": [
      {
        "errorType": "LimitExceededError",
        "message": "Rate limit exceeded"
      }
    ]
  }
}
```

Processing data messages

When a client submits a mutation, AWS AppSync identifies all of the subscribers interested in it and sends a `"type":"data"` message to each, using the corresponding subscription `id` used in the `"start"` subscription operation. The client is expected to keep track of the subscription `id` it sends so that when a data message is received, the client can match it with the corresponding subscription.

- `"type": "data"`: A constant `<string>` parameter.
- `"id": <string>`: The `id` of the corresponding registered subscription.
- `"payload" <Object>`: This object contains data object with the subscription information.

Example:

```
{
  "type": "data",
  "id": "ee849ef0-cf23-4cb8-9fcb-152ae4fd1e69",
  "payload": {
    "data": {
      "onCreateMessage": {
        "__typename": "Message",
        "message": "test"
      }
    }
  }
}
```

Subscription unregistration message

When the App wants to stop listening to the subscription events, the client should send a message with the following stringified JSON object:

- `"type": "stop"`: A constant `<string>` parameter.
- `"id": <string>`: The `id` of the subscription that will be unregistered.

Example:

```
{
  "type":"stop",
  "id":"ee849ef0-cf23-4cb8-9fcb-152ae4fd1e69"
}
```

AWS AppSync sends back a confirmation message with the following stringified JSON object:

- `"type": "complete"`: A constant `<string>` parameter.
- `"id": <string>`: The id of the unregistered subscription.

No more messages will be sent for this particular subscription after the message is received.

Example:

```
{
  "type":"complete",
  "id":"eEXAMPLE-cf23-1234-5678-152EXAMPLE69"
}
```

Disconnecting the WebSocket

Before disconnecting, the client should have the necessary logic to check that no operation is currently in place through the WebSocket connection to avoid data loss. All subscriptions should be unregistered before disconnecting from the WebSocket.

Configuration and Settings

AWS AppSync supports several configuration mechanisms for your GraphQL API. The mechanisms include adding a cache between resolvers and data sources, advanced conflict detection and resolution strategies for synchronization, and logging and monitoring features. Using these enables you to optimize your API, provides comprehensive functionality to your mobile and web applications, and enables you to meet your organization's operational requirements.

Topics

Caching

AWS AppSync's server-side data caching capabilities reduce the need to directly access data sources by making data available in a high speed in-memory cache, improving performance and decreasing latency. In order to take advantage of server-side caching in your AppSync API, refer to this section to define the desired behavior.

AWS AppSync hosts Amazon ElastiCache Redis instances in the AppSync service accounts, in the same AWS Region as your AppSync API.

The following instance types are available:

small

1 vCPU, 1.5 GiB RAM, Low to moderate network performance

medium

2 vCPU, 3 GiB RAM, Low to moderate network performance

large

2 vCPU, 12.3 GiB RAM, Up to 10 Gigabit network performance

xlarge

4 vCPU, 25.05 GiB RAM, Up to 10 Gigabit network performance

2xlarge

8 vCPU, 50.47 GiB RAM, Up to 10 Gigabit network performance

4xlarge

16 vCPU, 101.38 GiB RAM, Up to 10 Gigabit network performance

8xlarge

32 vCPU, 203.26 GiB RAM, 10 Gigabit network performance; not available in all regions.

12xlarge

48 vCPU, 317.77 GiB RAM, 10 Gigabit network performance

Note
Historically, a specific instance type (such as `t2.medium`) was specified. As of July 2020, these legacy instance types will continue to be available, but their use is deprecated and discouraged. We recommend you use the generic instance types described here.

The following are the behaviors related to caching:

None

No server-side caching.

Full request caching

If the data is not in the cache, it will be retrieved from the data source and populate the cache until the TTL expiration. All subsequent requests to your API will be returned from the cache, which means data sources won't be contacted directly unless the TTL expires. As caching keys in this setting, we use the contents of the `$context.arguments` and `$context.identity` maps.

Per-resolver caching

With this setting, each resolver needs to be opted in explicitly for it to cache responses. A TTL and caching keys can be specified on the resolver. Caching keys that can be specified are values from the `$context.arguments`, `$context.source` and `$context.identity` maps. The TTL value is mandatory, but the caching keys are optional. If no caching keys are specified, the defaults are the contents of the `$context.arguments`, `$context.source` and `$context.identity` maps, similar to the above. For example, one might use *$context.arguments.id* or *$context.arguments.InputType.id*, *$context.source.id* and *$context.identity.sub* or *$context.identity.claims.username*. When no caching keys are specified and only a TTL, the behavior of the resolver is similar to the one above.

Cache time to live

This defines the amount of time cached entries will be stored in memory. The maximum TTL is 3600s (1h), after which entries will be automatically deleted.

Cache encryption comes in two flavors that are explained below. These are similar to the settings allowed by Amazon ElastiCache for Redis. The encryption settings can only be enabled when first enabling caching for your AppSync API.

- Encryption in transit: requests between AppSync, the cache, and data sources (except insecure HTTP data sources) will be encrypted at the network level. Because there is some processing needed to encrypt and decrypt the data at the endpoints, enabling in-transit encryption can have some performance impact.
- Encryption at rest: Data saved to disk from memory during swap operations will be encrypted at the cache instance. This setting also carries a performance impact.

In order to invalidate cache entries, a flush cache API call is available. This can be called either through the console or through the CLI.

For more information, see the ApiCache data type in in the AWS AppSync API Reference.

Conflict Detection and Sync

Versioned Data Sources

AWS AppSync currently supports versioning on DynamoDB data sources. Conflict Detection, Conflict Resolution, and Sync operations require a `Versioned` data source. When you enable versioning on a data source, AWS AppSync will automatically:

- Enhance items with object versioning metadata.
- Record changes made to items with AWS AppSync mutations to a *Delta* table.
- Maintain deleted items in the *Base* table with a "tombstone" for a configurable amount of time.

Versioned Data Source Configuration

When you enable versioning on a DynamoDB data source, you specify the following fields:

`BaseTableTTL`

The number of minutes to retain deleted items in the *Base* table with a "tombstone" - a metadata field indicating that the item has been deleted. You can set this value to *0* if you want items to be removed immediately when they are deleted. This field is required.

`DeltaSyncTableName`

The name of the table where changes made to items with AWS AppSync mutations are stored. This field is required.

`DeltaSyncTableTTL`

The number of minutes to retain items in the *Delta* table. This field is required.

Delta Sync Table

AWS AppSync currently supports Delta Sync Logging for mutations using `PutItem`, `UpdateItem`, and `DeleteItem` DynamoDB operations.

When an AWS AppSync mutation changes an item in a versioned data source, a record of that change will be stored in a *Delta* table that is optimized for incremental updates. You can choose to use different *Delta* tables (e.g. one per type, one per domain area) for other versioned data sources or a single *Delta* table for your API. AWS AppSync recommends against using a single *Delta* table for multiple APIs to avoid the collision of primary keys.

The schema required for this table is as follows:

`ds_pk`

A string value that is used as the partition key. It is constructed by concatenating the *Base* data source name and the ISO8601 format of the date the change occurred. (e.g. Comments:2019-01-01)

`ds_sk`

A string value that is used as the sort key. It is constructed by concatenating the IS08601 format of the time the change occurred, the primary key of the item, and the version of the item. The combination of these fields guarantees uniqueness for every entry in the Delta table (e.g. for a time of 09:30:00 and an ID of 1a and version of 2, this would be 09:30:00:1a:2)

`_ttl`

A numeric value that stores the timestamp, in epoch seconds, when an item should be removed from the *Delta* table. This value is determined by adding the `DeltaSyncTableTTL` value configured on the data source to the moment when the change occurred. This field should be configured as the DynamoDB TTL Attribute.

The IAM role configured for use with the *Base* table must also contain permission to operate on the *Delta* table. In this example, the permissions policy for a *Base* table called `Comments` and a *Delta* table called `ChangeLog` is displayed:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "dynamodb:DeleteItem",
                "dynamodb:GetItem",
                "dynamodb:PutItem",
                "dynamodb:Query",
                "dynamodb:Scan",
                "dynamodb:UpdateItem"
            ],
            "Resource": [
                "arn:aws:dynamodb:us-east-1:000000000000:table/Comments",
                "arn:aws:dynamodb:us-east-1:000000000000:table/Comments/*",
                "arn:aws:dynamodb:us-east-1:000000000000:table/ChangeLog",
                "arn:aws:dynamodb:us-east-1:000000000000:table/ChangeLog/*"
            ]
        }
    ]
}
```

Versioned Data Source Metadata

AWS AppSync manages metadata fields on `Versioned` data sources on your behalf. Modifying these fields yourself may cause errors in your application or data loss. These fields include:

`_version`

A monotonically increasing counter that is updated any time that a change occurs to an item.

`_lastChangedAt`

A numeric value that stores the timestamp, in epoch milliseconds, when an item was last modified.

`_deleted`

A Boolean “tombstone” value that indicates that an item has been deleted. This can be used by applications to evict deleted items from local data stores.

`_ttl`

A numeric value that stores the timestamp, in epoch seconds, when an item should be removed from the underlying data source.

`ds_pk`

A string value that is used as the partition key for *Delta* tables.

`ds_sk`

A string value that is used as the sort key for *Delta* tables.

These metadata fields will impact the overall size of items in the underlying data source. AWS AppSync recommends reserving *500 bytes + Max Primary Key Size* of storage for versioned data source metadata when designing your application. To use this metadata in client applications, include the `_version`, `_lastChangedAt`, and `_deleted` fields on your GraphQL types and in the selection set for mutations.

Conflict Detection and Resolution

When concurrent writes happen with AWS AppSync, you can configure Conflict Detection and Conflict Resolution strategies to handle updates appropriately. Conflict Detection determines if the mutation is in

conflict with the actual written item in the data source. Conflict Detection is enabled by setting the value in the SyncConfig for the `conflictDetection` field to `VERSION`.

Conflict Resolution is the action that is taken in the event that a conflict is detected. This is determined by setting the Conflict Handler field in the SyncConfig. There are three Conflict Resolution strategies:

- OPTIMISTIC_CONCURRENCY
- AUTOMERGE
- LAMBDA

Each of these Conflict Resolution strategies are detailed in depth below. *Note:* Synchronization cannot be enabled on `PIPELINE` resolvers.

Versions are automatically incremented by AppSync during write operations and should not be modified by clients or outside of a resolver configured with a version-enabled data source. Doing so will change the consistency behavior of the system and could result in data loss.

Optimistic Concurrency

Optimistic Concurrency is a conflict resolution strategy that AWS AppSync provides for versioned data sources. When the conflict resolver is set to Optimistic Concurrency, if an incoming mutation is detected to have a version that differs from the actual version of the object, the conflict handler will simply reject the incoming request. Inside the GraphQL response, the existing item on the server that has the latest version will be provided. The client is then expected to handle this conflict locally and retry the mutation with the updated version of the item.

Automerge

Automerge provides developers an easy way to configure a conflict resolution strategy without writing client-side logic to manually merge conflicts that were unable to be handled by other strategies. Automerge adheres to a strict rule set when merging data to resolve conflicts. The tenets of Automerge revolve around the underlying data type of the GraphQL field. They are as follows:

- Conflict on a scalar field: GraphQL scalar or any field that is not a collection (i.e List, Set, Map). Reject the incoming value for the scalar field and select the value existing in the server.
- Conflict on a list: GraphQL type and database type are lists. Concatenate the incoming list with the existing list in the server. The list values in the incoming mutation will be appended to the end of the list in the server. Duplicate values will be retained.
- Conflict on a set: GraphQL type is a list and database type is a Set. Apply a set union using incoming the set and the existing set in the server. This adheres to the properties of a Set, meaning no duplicate entries.
- When an incoming mutation adds a new field to the item, merge that on to the existing item.
- Conflict on a map: When the underlying data type in the database is a Map (i.e. key-value document), apply the above rules as it parses and processes each property of the Map.

Automerge is designed to automatically detect, merge, and retry requests with an updated version, absolving the client from needing to manually merge any conflicting data.

To show an example of how Automerge handles a Conflict on a Scalar type. We will use the following record as our starting point.

```
{
  "id" : 1,
  "name" : "Nadia",
```

```
  "jersey" : 5,
  "_version" : 4
}
```

Now an incoming mutation might be attempting to update the item but with an older version since the client has not synchronized with the server yet. That looks like this:

```
{
  "id" : 1,
  "name" : "Nadia",
  "jersey" : 55,
  "_version" : 2
}
```

Notice the outdated version of 2 in the incoming request. During this flow, Automerge will merge the data by rejecting the 'jersey' field update to '55' and keep the value at '5' resulting in the following image of the item being saved in the server.

```
{
  "id" : 1,
  "name" : "Nadia",
  "jersey" : 5,
  "_version" : 5 # version is incremented every time automerge performs a merge that is
 stored on the server.
}
```

Given the state of the item shown above at version 5, now suppose an incoming mutation that attempts to mutate the item with the following image:

```
{
  "id" : 1,
  "name" : "Shaggy",
  "jersey" : 5,
  "interests" : ["breakfast", "lunch", "dinner"] # underlying data type is a Set
  "points": [24, 30, 27] # underlying data type is a List
  "_version" : 3
}
```

There are three points of interest in the incoming mutation. The name, a scalar, has been changed but two new fields "interests", a Set, and "points", a List, have been added. In this scenario, a conflict will be detected due to the version mismatch. Automerge adheres to its properties and rejects the name change due to it being a scalar and add on the non-conflicting fields. This results in the item that is saved in the server to appear as follows.

```
{
  "id" : 1,
  "name" : "Nadia",
  "jersey" : 5,
  "interests" : ["breakfast", "lunch", "dinner"] # underlying data type is a Set
  "points": [24, 30, 27] # underlying data type is a List
  "_version" : 6
}
```

With the updated image of the item with version 6, now suppose an incoming mutation (with another version mismatch) tries to transform the item to the following:

```
{
  "id" : 1,
```

```
  "name" : "Nadia",
  "jersey" : 5,
  "interests" : ["breakfast", "lunch", "brunch"] # underlying data type is a Set
  "points": [30, 35] # underlying data type is a List
  "_version" : 5
}
```

Here we observe that the incoming field for “interests” has one duplicate value that exists in the server and two new values. In this case, since the underlying data type is a Set, Automerge will combine the values existing in the server with the ones in the incoming request and strip out any duplicates. Similarly there is a conflict on the “points” field where there is one duplicate value and one new value. But since the underlying data type here is a List, Automerge will simply append all values in the incoming request to the end of the values already existing in the server. The resulting merged image stored on the server would appear as follows:

```
{
  "id" : 1,
  "name" : "Nadia",
  "jersey" : 5,
  "interests" : ["breakfast", "lunch", "dinner", "brunch"] # underlying data type is a Set
  "points": [24, 30, 27, 30, 35] # underlying data type is a List
  "_version" : 7
}
```

Now let’s assume the item stored in the server appears as follows, at version 8.

```
{
  "id" : 1,
  "name" : "Nadia",
  "jersey" : 5,
  "interests" : ["breakfast", "lunch", "dinner", "brunch"] # underlying data type is a Set
  "points": [24, 30, 27, 30, 35] # underlying data type is a List
  "stats": {
      "ppg": "35.4",
      "apg": "6.3"
  }
  "_version" : 8
}
```

But an incoming request tries to update the item with the following image, once again with a version mismatch:

```
{
  "id" : 1,
  "name" : "Nadia",
  "stats": {
      "ppg": "25.7",
      "rpg": "6.9"
  }
  "_version" : 3
}
```

Now in this scenario, we can see that the fields that already exist in the server are missing (interests, points, jersey). In addition, the value for “ppg” within the map “stats” is being edited, a new value “rpg” is being added, and “apg” is omitted. Automerge preserve the fields that have been omitted (note: if fields are intended to be removed, then the request must be tried again with the matching version), and so they will not be lost. It will also apply the same rules to fields within maps and therefore the change to “ppg” will be rejected whereas “apg” is preserved and “rpg”, a new field”, is added on. The resulting item stored in the server will now appear as:

```
{
  "id" : 1,
  "name" : "Nadia",
  "jersey" : 5,
  "interests" : ["breakfast", "lunch", "dinner", "brunch"] # underlying data type is a Set
  "points": [24, 30, 27, 30, 35] # underlying data type is a List
  "stats": {
      "ppg": "35.4",
      "apg": "6.3",
      "rpg": "6.9"
  }
  "_version" : 9
}
```

Lambda

Conflict Resolution options:

- `RESOLVE`: Replace the existing item with new item supplied in response payload. You can only retry the same operation on a single item at a time. Currently supported for DynamoDB `PutItem` & `UpdateItem`.
- `REJECT`: Reject the mutation and returns an error with the existing item in the GraphQL response. Currently supported for DynamoDB `PutItem`, `UpdateItem`, & `DeleteItem`.
- `REMOVE`: Remove the existing item. Currently supported for DynamoDB `DeleteItem`.

The Lambda Invocation Request

The AWS AppSync DynamoDB resolver invokes the Lambda function specified in the `LambdaConflictHandlerArn`. It uses the same `service-role-arn` configured on the data source. The payload of the invocation has the following structure:

```
{
    "newItem": { ... },
    "existingItem": {... },
    "arguments": { ... },
    "resolver": { ... },
    "identity": { ... }
}
```

The fields are defined as follows:

`newItem`

The preview item, if the mutation succeeded.

`existingItem`

The item currently resided in DynamoDB table.

`arguments`

The arguments from the GraphQL mutation.

`resolver`

Information about the AWS AppSync resolver.

`identity`

Information about the caller. This field is set to null, if access with API key.

Example payload:

```
{
    "newItem": {
        "id": "1",
        "author": "Jeff",
        "title": "Foo Bar",
        "rating": 5,
        "comments": ["hello world"],
    },
    "existingItem": {
        "id": "1",
        "author": "Foo",
        "rating": 5,
        "comments": ["old comment"]
    },
    "arguments": {
        "id": "1",
        "author": "Jeff",
        "title": "Foo Bar",
        "comments": ["hello world"]
    },
    "resolver": {
        "tableName": "post-table",
        "awsRegion": "us-west-2",
        "parentType": "Mutation",
        "field": "updatePost"
    },
    "identity": {
         "accountId": "123456789012",
         "sourceIp": "x.x.x.x",
         "username": "AIDAAAAAAAAAAAAAAAAA",
         "userArn": "arn:aws:iam::123456789012:user/appsync"
    }
}
```

The Lambda Invocation Response

For `PutItem` and `UpdateItem` conflict resolution

`RESOLVE` the mutation. The response must be in the following format.

```
{
    "action": "RESOLVE",
    "item": { ... }
}
```

The `item` field represents an object that will be used to replace the existing item in the underlying data source. The primary key and sync metadata will be ignored if included in `item`.

`REJECT` the mutation. The response must be in the following format.

```
{
    "action": "REJECT"
}
```

For `DeleteItem` conflict resolution

`REMOVE` the item. The response must be in the following format.

```
{
```

```
    "action": "REMOVE"
}
```

`REJECT` the mutation. The response must be in the following format.

```
{
    "action": "REJECT"
}
```

The example Lambda function below checks who makes the call and the resolver name. If it is made by `jeffTheAdmin`, `REMOVE` the object for DeletePost resolver or `RESOLVE` the conflict with new item for Update/Put resolvers. If not, the mutation is `REJECT`.

```
exports.handler = async (event, context, callback) => {
    console.log("Event: "+ JSON.stringify(event));

    // Business logic goes here.
    var response;
    if ( event.identity.user == "jeffTheAdmin" ) {
        let resolver = event.resolver.field;

        switch(resolver) {
            case "deletePost":
                response = {
                    "action" : "REMOVE"
                }
                break;

            case "updatePost":
            case "createPost":
                response = {
                    "action" : "RESOLVE",
                    "item": event.newItem
                }
                break;
            default:
                response = { "action" : "REJECT" };
        }
    } else {
        response = { "action" : "REJECT" };
    }

    console.log("Response: "+ JSON.stringify(response));
    return response;
}
```

Errors

`ConflictUnhandled`

Conflict detection finds a version mismatch and the conflict handler rejects the mutation.

Example: Conflict resolution with an Optimistic Concurrency conflict handler. Or, Lambda conflict handler returned with `REJECT`.

`ConflictError`

An internal error occurs when trying to resolve a conflict.

Example: Lambda conflict handler returned a malformed response. Or, cannot invoke Lambda conflict handler because the supplied resource `LambdaConflictHandlerArn` is not found.

`MaxConflicts`

Max retry attempts were reached for conflict resolution.

Example: Too many concurrent requests on the same object. Before the conflict is resolved, the object is updated to a new version by another client.

`BadRequest`

Client tries to update metadata fields (`_version`, `_ttl`, `_lastChangedAt`, `_deleted`).

Example: Client tries to update _version of an object with an update mutation.

`DeltaSyncWriteError`

Failed to write delta sync record.

Example: Mutation succeeded, but an internal error occurred when trying to write to the delta sync table.

`InternalFailure`

An internal error occurred.

CloudWatch Logs

If an AWS AppSync API has enabled CloudWatch Logs with the logging settings set to Field-Level Logs `enabled` and log-level for the Field-Level Logs set to `ALL`, then AWS AppSync will emit Conflict Detection and Resolution information to the log group. For information about the format of the log messages, see the documentation for Conflict Detection and Sync Logging (p. 196).

Sync Operations

Versioned data sources support `Sync` operations that allow you to retrieve all the results from a DynamoDB table and then receive only the data altered since your last query (the delta updates). When AWS AppSync receives a request for a `Sync` operation, it uses the fields specified in the request to determine if the *Base* table or the *Delta* table should be accessed.

- If the `lastSync` field is not specified, a `Scan` on the *Base* table is performed.
- If the `lastSync` field is specified, but the value is before the `current moment - DeltaSyncTTL`, a `Scan` on the *Base* table is performed.
- If the `lastSync` field is specified, and the value is on or after the `current moment - DeltaSyncTTL`, a `Query` on the *Delta* table is performed.

AWS AppSync returns the `startedAt` field to the response mapping template for all `Sync` operations. The `startedAt` field is the moment, in epoch milliseconds, when the `Sync` operation started that you can store locally and use in another request. If a pagination token was included in the request, this value will be the same as the one returned by the request for the first page of results.

For information about the format for `Sync` mapping templates, see the mapping template reference (p. 281).

Monitoring and Logging

You can use Amazon CloudWatch to monitor and debug requests in AWS AppSync. Using AWS AppSync, you can use GraphQL to request data from the cloud. There are often times when you want to get

more information about the execution of your API. To help debug issues related to request execution of your GraphQL API, you can enable Amazon CloudWatch Logs to monitor API calls. After you enable by CloudWatch, AWS AppSync logs API calls in CloudWatch.

Setup and Configuration

You can enable logging on a GraphQL API automatically through the AWS AppSync console.

1. Sign in to the AWS AppSync console.
2. Choose **Settings** from the navigation panel.
3. Under **Logging**, click the toggle to **Enable Logs**.
4. When the console prompts you, provide or create a CloudWatch ARN role.
5. (Optional) Choose to configure the Field resolver log level from the list.
6. Choose **Save**. The logging is automatically configured for your API.

Manual Role Configuration

To enable CloudWatch Logs, you must grant AWS AppSync correct permissions to write logs to CloudWatch for your account. To do this, you need to provide a service role ARN so that AWS AppSync can assume this role when writing the logs.

First, navigate to the IAM console. Then create a new policy with the name **AWSAppSyncPushToCloudWatchLogsPolicy** that has the following definition:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "logs:CreateLogGroup",
                "logs:CreateLogStream",
                "logs:PutLogEvents"
            ],
            "Resource": "*"
        }
    ]
}
```

Next, create a new role with the name **AWSAppSyncPushToCloudWatchLogsRole**, and attach the above policy to this role. Edit the trust relationship for this role to have the following:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
        "Effect": "Allow",
        "Principal": {
            "Service": "appsync.amazonaws.com"
        },
        "Action": "sts:AssumeRole"
        }
    ]
}
```

Copy the role ARN and register this with AWS AppSync to enable writing into CloudWatch.

CloudWatch Metrics

You can use CloudWatch metrics to monitor and provide alerts about specific events that can be triggered by HTTP status codes or by latency, such as the overall GraphQL request and response latency. The following are the metrics that are emitted.

- **4XXError**

  The number of errors captured as a result of invalid requests due to an incorrect client configuration. Typically, these errors happen anywhere outside of the GraphQL execution. For example, this error can occur when the request includes an incorrect JSON payload or an incorrect query, when the service is throttled, or when the Auth settings are misconfigured.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of these errors.
- **5XXError**

  Errors encountered during the execution of a GraphQL query. For example, this could occur when a query request is initiated for an empty or incorrect schema. It can also occur when the Amazon Cognito user pool ID or AWS Region is invalid. Alternatively, this could also happen if AWS AppSync encounters an issue during an execution of a request.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of these errors.
- **Latency**

  The time between when AWS AppSync receives a request from a client and when it returns a response to the client. This doesn't include the network latency encountered for a response to reach the end devices.

  Unit: *Millisecond*. Use the Average statistic to evaluate expected latencies.

Real-Time Subscriptions

All metrics are emitted in one dimension: **GraphQLAPIId**. This means that all metrics are coupled with GraphQL API IDs. The following metrics are related to GrapQL subscriptions over pure WebSockets:

- **ConnectSuccess**

  The number of successful WebSocket connections to AWS AppSync. It is possible to have connections without subscriptions.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the successful connections.
- **ConnectClientError**

  The number of WebSocket connections that were rejected by AWS AppSync because of client-side errors. This could imply that the service is throttled or the Authorization settings are misconfigured.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the client-side connection errors.
- **ConnectServerError**

  The number of errors that originated from AWS AppSync while processing connections. This usually happens when an unexpected server-side issue occurs.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the server-side connection errors.
- **DisconnectSuccess**

  The number of successful WebSocket disconnections from AWS AppSync.

Unit: *Count*. Use the Sum statistic to get the total occurrences of the successful disconnections.

- **DisconnectClientError**

  The number of errors that originated from AWS AppSync while disconnecting WebSocket connections due to client-side errors.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the disconnection errors.
- **DisconnectServerError**

  The number of errors that originated from AWS AppSync while disconnecting WebSocket connections while processing connections. This usually happens when an unexpected server-side issue occurs.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the connection errors.
- **SubscribeSuccess**

  The number of subscriptions that were successfully registered to AWS AppSync through WebSocket. It is possible to have connections without subscriptions, but it isn't possible to have subscriptions without connections.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the successful subscriptions.
- **SubscribeClientError**

  The number of subscriptions that were rejected by AWS AppSync because of client-side errors. This can occur when a JSON payload is incorrect, the service is throttled, or the Authorization settings are misconfigured.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the client-side subscription errors.
- **SubscribeServerError**

  The number of errors that originated from AWS AppSync while processing subscriptions. This usually happens when an unexpected server-side issue occurs.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the server-side subscription errors.
- **UnsubscribeSuccess**

  The number of unsubscriptions that were successfully processed from AWS AppSync.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the successful unsubscriptions.
- **UnsubscribeClientError**

  The number of unsubscriptions that were rejected by AWS AppSync because of client-side errors.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the client-side unsubscription errors.
- **UnsubscribeServerError**

  The number of errors that originated from AWS AppSync while processing unsubscriptions. This usually happens when an unexpected server-side issue occurs.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the server-side unsubscription errors.
- **PublishDataMessageSuccess**

  The number of subscription event messages that were successfully published.

Unit: *Count*. Use the Sum statistic to get the total of the subscription event messages were successfully published.

- **PublishDataMessageClientError**

  The number of subscription event messages that failed to publish because of client-side errors.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the client-side publishing subscription events errors.
- **PublishDataMessageServerError**

  The number of errors that originated from AWS AppSync while publishing subscription event messages. This usually happens when an unexpected server-side issue occurs.

  Unit: *Count*. Use the Sum statistic to get the total occurrences of the server-side publishing subscription events errors.
- **PublishDataMessageSize**

  The size of subscription event messages published.

  Unit: *Bytes*.
- **ActiveConnection**

  The number of concurrent WebSocket connections from clients to AWS AppSync in 1 minute.

  Unit: *Count*. Use the Sum statistic to get the total opened connections.
- **ActiveSubscription**

  The number of concurrent subscriptions from clients in 1 minute.

  Unit: *Count*. Use the Sum statistic to get the total active subscriptions.
- **ConnectionDuration**

  The amount of time that the connection stays open.

  Unit: *Milliseconds*. Use the Average statistic to evaluate connection duration.

CloudWatch Logs

You can configure two types of logging on any new or existing GraphQL API: request-level and field-level.

Request-Level Logs

When enabled, the following information is logged:

- The request and response HTTP headers
- The GraphQL query that is being executed in the request
- The overall execution summary
- New and existing GraphQL subscriptions that are registered

Field-Level Logs

When enabled, the following information is logged:

- Generated Request Mapping with source and arguments for each field
- The transformed Response Mapping for each field, which includes the data as a result of resolving that field
- Tracing information for each field

If you turn on logging, AWS AppSync manages the CloudWatch Logs. The process includes creating log groups and log streams, and reporting to the log streams with these logs.

When you enable logging on a GraphQL API and make requests, AWS AppSync creates a log group and log streams under the log group. The log group is named following the `/aws/appsync/apis/{graphql_api_id}` format. Within each log group, the logs are further divided into log streams. These are ordered by **Last Event Time** as logged data is reported.

Every log event is tagged with the **x-amzn-RequestId** of that request. This helps you filter log events in CloudWatch to get all logged information pertaining to that request. You can get the RequestId from the response headers of every GraphQL AWS AppSync request.

The field-Level logging is configured with the following log levels:

- **NONE** - No field-level logs are captured.
- **ERROR - Logs the following information only for the fields that are in error:**
  - The error section in the server response
  - Field-level errors
  - The generated request/response functions that got resolved for error fields
- **ALL - The following information is logged for all fields in the query:**
  - Field-level tracing information
  - The generated request/response functions that got resolved for each field

Benefits of Enabling Monitoring

You can use logging and metrics to identify, troubleshoot, and optimize your GraphQL queries. For example, these will help you debug latency issues using the tracing information that is logged for each field in the query. To demonstrate this, suppose you are using one or more resolvers nested in a GraphQL query. A sample field execution in CloudWatch Logs might look similar to the following:

```
{
    "path": [
        "singlePost",
        "authors",
        0,
        "name"
    ],
    "parentType": "Post",
    "returnType": "String!",
    "fieldName": "name",
    "startOffset": 416563350,
    "duration": 11247
}
```

This might correspond to a GraphQL schema, similar to the following:

```
type Post {
  id: ID!
  name: String!
```

```
  authors: [Author]
}

type Author {
  id: ID!
  name: String!
}

type Query {
  singlePost(id:ID!): Post
}
```

In the log results above, **path** shows a single item in your data returned from running a query named `singlePost()`. In this example, it's representing the **name** field at the first index (0). **startOffset** gives an offset from the start of the GraphQL query execution. **duration** is the total time to resolve the field. These values can be useful to troubleshoot why data from a particular data source might be running slower than expected, or if a specific field is slowing down the entire query. For example, you might choose to increase provisioned throughput for an Amazon DynamoDB table, or remove a specific field from a query that is causing the overall execution to perform poorly.

As of May 8, 2019, AWS AppSync generates log events as fully structured JSON. This enables you to use log analytics services such as Amazon CloudWatch Logs Insights and Amazon Elasticsearch Service to understand the performance of your GraphQL requests and usage characteristics of your schema fields. For example, you can easily identify resolvers with large latencies that may be the root cause of a performance issue. You can also identify the most and least frequently used fields in your schema and assess the impact of deprecating GraphQL fields.

Conflict Detection and Sync Logging

If an AWS AppSync API has enabled CloudWatch Logs with the logging settings set to Field-Level Logs `enabled` and log-level for the Field-Level Logs set to `ALL`, then AWS AppSync will emit Conflict Detection and Resolution information to the log group. This will provide granular insight on what decisions the AWS AppSync API decided to take when a conflict was detected. To accomplish this, the following information will be provided in the logs:

`conflictType`

Details whether a conflict occurred due to a version mismatch or the customer-supplied condition.

`conflictHandlerConfigured`

States the conflict handler configured on the resolver at the time of the request.

`message`

Provides information on how the conflict was detected and resolved.

`syncAttempt`

The number of tries the server attempted in order to synchronize the data before ultimately rejecting the request.

`data`

If the conflict handler configured was `Automerge`, this field will be populated to show what decision Automerge took for each field. Actions provided can be:

- **REJECTED** - When Automerge rejects the incoming field value in favor of the value in the server.
- **ADDED** - When Automerge adds on the incoming field due to no pre-existing value in the server.
- **APPENDED** - When Automerge appends the incoming values to the values for the List that exists in the server.

- **MERGED** - When Automerge merges the incoming values to the values for the Set that exists in the server.

Log Type Reference

RequestSummary

- **requestId:** Unique identifier for the request.
- **graphQLAPIId:** ID of the GraphQL API making the request.
- **statusCode:** HTTP Status code response.
- **latency:** End-to-end latency of the request, in nanoseconds, as an integer.

```
{
     "logType": "RequestSummary",
     "requestId": "dbe87af3-c114-4b32-ae79-8af11f3f96f1",
     "graphQLAPIId": "pmo28inf75eepg63qxq4ekoeg4",
     "statusCode": 200,
     "latency": 242000000
}
```

ExecutionSummary

- **requestId:** Unique identifier for the request.
- **graphQLAPIId:** ID of the GraphQL API making the request.
- **startTime:** The start timestamp of GraphQL execution for the request, in RFC 3339 format.
- **endTime:** The end timestamp of GraphQL execution for the request, in RFC 3339 format.
- **duration:** The total elapsed GraphQL execution time, in nanoseconds, as an integer.
- **version:** The schema version of the ExecutionSummary.
- **parsing:**
    - **startOffset:** The start offset for parsing, in nanoseconds, relative to execution start, as an integer.
    - **duration:** The time spent parsing, in nanoseconds, as an integer.
- **validation:**
    - **startOffset:** The start offset for validation, in nanoseconds, relative to execution start, as an integer.
    - **duration:** The time spent performing validation, in nanoseconds, as an integer.

```
{
    "duration": 217406145,
    "logType": "ExecutionSummary",
    "requestId": "dbe87af3-c114-4b32-ae79-8af11f3f96f1",
    "startTime": "2019-01-01T06:06:18.956Z",
    "endTime": "2019-01-01T06:06:19.174Z",
    "parsing": {
        "startOffset": 49033,
        "duration": 34784
    },
    "version": 1,
    "validation": {
        "startOffset": 129048,
        "duration": 69126
```

```
    },
    "graphQLAPIId": "pmo28inf75eepg63qxq4ekoeg4"
}
```

Tracing

- **requestId:** Unique identifier for the request.
- **graphQLAPIId:** ID of the GraphQL API making the request.
- **startOffset:** The start offset for field resolution, in nanoseconds, relative to execution start, as an integer.
- **duration:** The time spent resolving the field, in nanoseconds, as an integer.
- **fieldName:** The name of the field being resolved.
- **parentType:** The parent type of the field being resolved.
- **returnType:** The return type of the field being resolved.
- **path:** A list of path segments, starting at the root of the response and ending with the field being resolved.
- **resolverArn:** The ARN of the resolver used for field resolution. Might not be present on nested fields.

```
{
    "duration": 216820346,
    "logType": "Tracing",
    "path": [
        "putItem"
    ],
    "fieldName": "putItem",
    "startOffset": 178156,
    "resolverArn": "arn:aws:appsync:us-east-1:111111111111:apis/pmo28inf75eepg63qxq4ekoeg4/
types/Mutation/fields/putItem",
    "requestId": "dbe87af3-c114-4b32-ae79-8af11f3f96f1",
    "parentType": "Mutation",
    "returnType": "Item",
    "graphQLAPIId": "pmo28inf75eepg63qxq4ekoeg4"
}
```

Analyzing Your Logs with Amazon CloudWatch Logs Insights

The following are examples of queries you can run to get actionable insights into the performance and health of your GraphQL operations. These examples are available as sample queries in the CloudWatch Logs Insights console. In the **Amazon CloudWatch console**, choose **Logs Insights**, select the AWS AppSync log group for your GraphQL API, and then choose **AWS AppSync queries** under **Sample queries**.

The following query returns the top 10 GraphQL requests with maximum latency:

```
  fields requestId, latency
| filter logType = "RequestSummary"
| limit 10
| sort latency desc
```

The following query returns the top 10 resolvers with maximum latency:

```
  fields resolverArn, duration
| filter logType = "Tracing"
```

```
| limit 10
| sort duration desc
```

The following query returns the most frequently invoked resolvers:

```
  fields ispresent(resolverArn) as isRes
| stats count() as invocationCount by resolverArn
| filter isRes and logType = "Tracing"
| limit 10
| sort invocationCount desc
```

The following query returns resolvers with the most errors in mapping templates:

```
  fields ispresent(resolverArn) as isRes
| stats count() as errorCount by resolverArn, logType
| filter isRes and (logType = "RequestMapping" or logType = "ResponseMapping") and
 fieldInError
| limit 10
| sort errorCount desc
```

The following query returns resolver latency statistics:

```
  fields ispresent(resolverArn) as isRes
| stats min(duration), max(duration), avg(duration) as avg_dur by resolverArn
| filter isRes and logType = "Tracing"
| limit 10
| sort avg_dur desc
```

The following query returns field latency statistics:

```
  stats min(duration), max(duration), avg(duration) as avg_dur
  by concat(parentType, '/', fieldName) as fieldKey
| filter logType = "Tracing"
| limit 10
| sort avg_dur desc
```

The results of CloudWatch Logs Insights queries can be exported to CloudWatch dashboards.

Analyze Your Logs with Amazon Elasticsearch Service

You can search, analyze, and visualize your AWS AppSync logs with Amazon Elasticsearch Service to identify performance bottlenecks and root cause of operational issues. You can identify resolvers with the maximum latency and errors. In addition, you can use Kibana to create dashboards with powerful visualizations. Kibana is an open source data visualization and exploration tool available in Amazon ES. Using Kibana dashboards, you can continuously monitor the performance and health of your GraphQL operations. For example, you can create dashboards that enable you to visualize the P90 latency of your GraphQL requests and drill down into the P90 latencies of each resolver.

When using Amazon ES, use **"cwl*"** as the filter pattern to search Elasticsearch indexes. Elasticsearch indexes the logs streamed from CloudWatch Logs with a prefix of **"cwl-"**. To differentiate AWS AppSync API logs from other CloudWatch logs sent to Elasticsearch, we recommend adding an additional filter expression of `graphQLAPIID.keyword=<AWS AppSync's GraphQL API Id>` to your search.

Log Format Migration

Log events generated by AWS AppSync on May 8, 2019 or later are formatted as fully structured JSON. If you want to analyze GraphQL requests prior to May 8, 2019, you can migrate older logs to fully

structured JSON using a script available in the GitHub Sample. If you need to use the log format prior to May 8, 2019, create a support ticket with the following settings: set **Type** to **Account Management** and then set **Category** to **General Account Question**.

You can also choose to enable metric filters in CloudWatch. You can then use these metric filters to turn log data into numerical CloudWatch metrics, so you can graph or set an alarm on them.

Tracing with AWS X-Ray

You can use AWS X-Ray to trace requests as they are executed in AWS AppSync. You can use X-Ray with AWS AppSync in all AWS Regions where X-Ray is available. X-Ray gives you a detailed overview of an entire GraphQL request. This enables you to analyze latencies in your APIs and their underlying resolvers and data sources. You can use an X-Ray service map to view the latency of a request, including any AWS services that are integrated with X-Ray. You can also configure sampling rules to tell X-Ray which requests to record, and at what sampling rates, according to criteria that you specify.

For more information about sampling in X-Ray, see Configuring Sampling Rules in the AWS X-Ray Console.

Setup and Configuration

You can enable X-Ray tracing for a GraphQL API through the AWS AppSync console.

1. Sign in to the AWS AppSync console.
2. Choose **Settings** from the navigation panel.
3. Under **X-Ray**, turn on **Enable X-Ray**.
4. Choose **Save**. X-Ray tracing is now enabled for your API.

If you're using the AWS CLI or AWS CloudFormation, you can also enable X-Ray tracing when you create a new AWS AppSync API, or update an existing AWS AppSync API, by setting the `xrayEnabled` property to `true`.

When X-Ray tracing is enabled for an AWS AppSync API, an AWS Identity and Access Management service-linked role is automatically created in your account with the appropriate permissions. This allows AWS AppSync to send traces to X-Ray in a secure way.

Tracing Your API with X-Ray

Sampling

By using sampling rules, you can control the amount of data that you record in AWS AppSync, and can modify sampling behavior on the fly without modifying or redeploying your code. For example, this rule samples requests to the GraphQL API with the API ID `3n572shhcpfokwhdnq1ogu59v6`.

- **Rule name** — `test-sample`
- **Priority** — `10`
- **Reservoir size** — `10`
- **Fixed rate** — `10`
- **Service name** — `*`
- **Service type** — `AWS::AppSync::GraphQLAPI`

- **HTTP method** — `*`
- **Resource ARN** — `arn:aws:appsync:us-west-2:123456789012:apis/3n572shhcpfokwhdnq1ogu59v6`
- **Host** — `*`

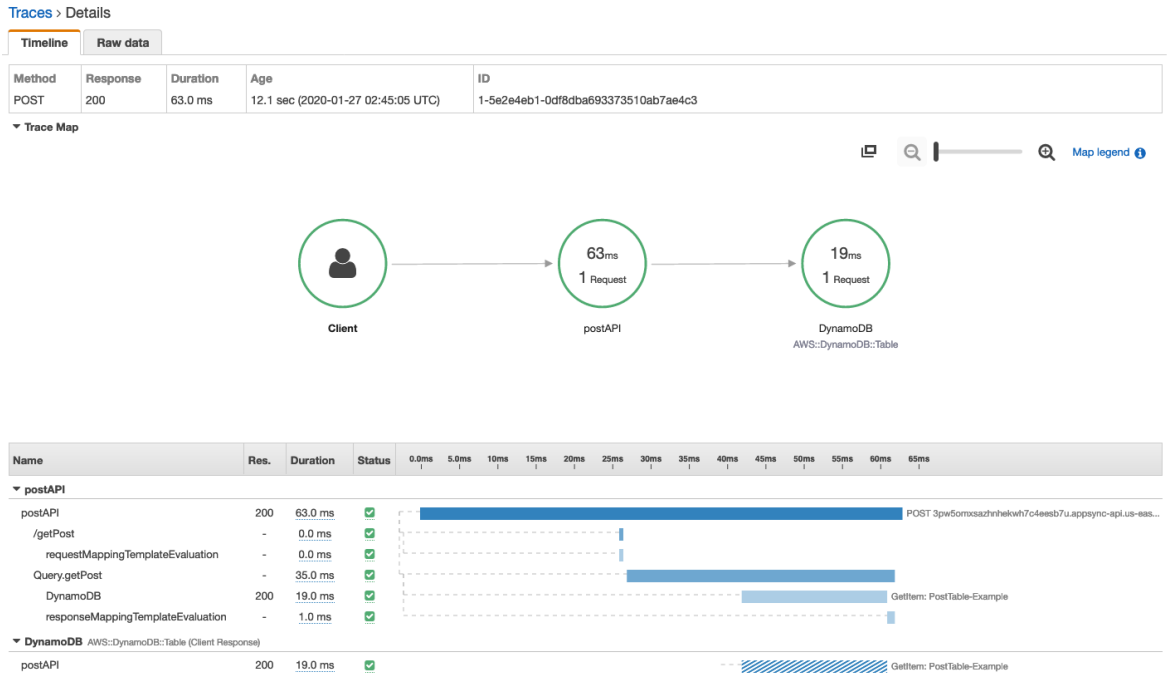
Understanding Traces

When you enable X-Ray tracing for your GraphQL API, you can use the X-Ray trace detail page to examine detailed latency information about requests made to your API. The following example shows the trace view along with the service map for this specific request. The request was made to an API called `postAPI` with a Post type, whose data is contained in an Amazon DynamoDB table called `PostTable-Example`.

The following trace image corresponds to the following GraphQL query:

```
query getPost {
    getPost(id: "1") {
      id
      title
    }
}
```

The resolver for the `getPost` query uses the underlying DynamoDB data source. The following trace view shows the call to DynamoDB, as well as the latencies of various parts of the query's execution:



- In the preceding image, `/getPost` represents the complete path to the element that is being resolved. In this case, because `getPost` is a field on the root `Query` type, it appears directly after the root of the path.
- `requestMappingTemplateEvaluation` represents the time spent by AWS AppSync evaluating the request mapping template for this element in the query.
- `Query.getPost` represents a type and field (in `Type.field` format). It can contain multiple subsegments, depending on the structure of the API and the request being traced.

- `DynamoDB` represents the data source that is attached to this resolver. It contains the latency for the network call to DynamoDB to resolve the field.
- `responseMappingTemplateEvaluation` represents the time spent by AWS AppSync evaluating the response mapping template for this element in the query.

When you view traces in X-Ray, you can get additional contextual and metadata information about the subsegments in the AWS AppSync segment by choosing the subsegments and exploring the detailed view.

For certain deeply nested or complex queries, note that the segment delivered to X-Ray by AWS AppSync can be larger than the maximum size allowed for segment documents, as defined in AWS X-Ray Segment Documents. X-Ray doesn't display segments that exceed the limit.

Logging AWS AppSync API Calls with AWS CloudTrail

AWS AppSync is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in AWS AppSync. CloudTrail captures all API calls for AWS AppSync as events. The calls captured include calls from the AWS AppSync console and from code calls to the AWS AppSync APIs. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for AWS AppSync. If you don't configure a trail, you can still view the most recent events in the CloudTrail console in **Event history**. Using the information collected by CloudTrail, you can determine the request that was made to AWS AppSync, the IP address from which the request was made, who made the request, when it was made, and additional details.

To learn more about CloudTrail, see the AWS CloudTrail User Guide.

AWS AppSync Information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When activity occurs in AWS AppSync, that activity is recorded in a CloudTrail event along with other AWS service events in **Event history**. You can view, search, and download recent events in your AWS account. For more information, see Viewing Events with CloudTrail Event History.

For an ongoing record of events in your AWS account, including events for AWS AppSync, create a trail. A *trail* enables CloudTrail to deliver log files to an Amazon S3 bucket. By default, when you create a trail in the console, the trail applies to all AWS Regions. The trail logs events from all Regions in the AWS partition and delivers the log files to the Amazon S3 bucket that you specify. Additionally, you can configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs. For more information, see the following:

- Overview for Creating a Trail
- CloudTrail Supported Services and Integrations
- Configuring Amazon SNS Notifications for CloudTrail
- Receiving CloudTrail Log Files from Multiple Regions and Receiving CloudTrail Log Files from Multiple Accounts

All AWS AppSync actions are logged by CloudTrail and are documented in the AWS AppSync API Reference. For example, calls to the `CreateGraphqlApi`, `CreateDataSource`, and `ListResolvers` actions generate entries in the CloudTrail log files.

Every event or log entry contains information about who generated the request. The identity information helps you determine the following:

- Whether the request was made with root or AWS Identity and Access Management (IAM) user credentials.
- Whether the request was made with temporary security credentials for a role or federated user.
- Whether the request was made by another AWS service.

For more information, see the CloudTrail userIdentity Element.

Understanding AWS AppSync Log File Entries

A trail is a configuration that enables delivery of events as log files to an Amazon S3 bucket that you specify. CloudTrail log files contain one or more log entries. An event represents a single request from any source and includes information about the requested action, the date and time of the action, request parameters, and so on. CloudTrail log files aren't an ordered stack trace of the public API calls, so they don't appear in any specific order.

The following example shows a CloudTrail log entry that demonstrates the `CreateApiKey` action.

```
{
  "Records": [{
    "eventVersion": "1.05",
    "userIdentity": {
      "type": "IAMUser",
      "principalId": "A1B2C3D4E5F6G7EXAMPLE",
      "arn": "arn:aws:iam::123456789012:user/Alice",
      "accountId": "123456789012",
      "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
      "userName": "Alice"
    },
    "eventTime": "2018-01-31T21:49:09Z",
    "eventSource": "appsync.amazonaws.com",
    "eventName": "CreateApiKey",
    "awsRegion": "us-west-2",
    "sourceIPAddress": "192.2.0.1",
    "userAgent": "aws-cli/1.11.72 Python/2.7.11 Darwin/16.7.0 botocore/1.5.35",
    "requestParameters": {
      "apiId": "a1b2c3d4e5f6g7h8i9jexample"
    },
    "responseElements": {
      "apiKey": {
      "id": "***",
      "expires": 1518037200000
      }
    },
    "requestID": "99999999-9999-9999-9999-999999999999",
    "eventID": "99999999-9999-9999-9999-999999999999",
    "readOnly": false,
    "eventType": "AwsApiCall",
    "recipientAccountId": "123456789012"
    }
  ]
}
```

The following example shows a CloudTrail log entry that demonstrates the `ListApiKeys` action.

```
{
  "Records": [{
    "eventVersion": "1.05",
```

```
    "userIdentity": {
      "type": "IAMUser",
      "principalId": "A1B2C3D4E5F6G7EXAMPLE",
      "arn": "arn:aws:iam::123456789012:user/Alice",
      "accountId": "123456789012",
      "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
      "userName": "Alice"
    },
    "eventTime": "2018-01-31T21:49:09Z",
    "eventSource": "appsync.amazonaws.com",
    "eventName": "ListApiKeys",
    "awsRegion": "us-west-2",
    "sourceIPAddress": "192.2.0.1",
    "userAgent": "aws-cli/1.11.72 Python/2.7.11 Darwin/16.7.0 botocore/1.5.35",
    "requestParameters": {
      "apiId": "a1b2c3d4e5f6g7h8i9jexample"
    },
    "responseElements": {
      "apiKeys": [
              {
                    "id": "***",
                    "expires": 1517954400000
              },
              {
                    "id": "***",
                    "expires": 1518037200000
              },
            ]
    },
    "requestID": "99999999-9999-9999-9999-999999999999",
    "eventID": "99999999-9999-9999-9999-999999999999",
    "readOnly": false,
    "eventType": "AwsApiCall",
    "recipientAccountId": "123456789012"
    }
  ]
}
```

The following example shows a CloudTrail log entry that demonstrates the `DeleteApiKey` action.

```
{
  "Records": [{
    "eventVersion": "1.05",
    "userIdentity": {
      "type": "IAMUser",
      "principalId": "A1B2C3D4E5F6G7EXAMPLE",
      "arn": "arn:aws:iam::123456789012:user/Alice",
      "accountId": "123456789012",
      "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
      "userName": "Alice"
    },
    "eventTime": "2018-01-31T21:49:09Z",
    "eventSource": "appsync.amazonaws.com",
    "eventName": "DeleteApiKey",
    "awsRegion": "us-west-2",
    "sourceIPAddress": "192.2.0.1",
    "userAgent": "aws-cli/1.11.72 Python/2.7.11 Darwin/16.7.0 botocore/1.5.35",
    "requestParameters": {
      "id": "***",
      "apiId": "a1b2c3d4e5f6g7h8i9jexample"
    },
    "responseElements": null,
    "requestID": "99999999-9999-9999-9999-999999999999",
    "eventID": "99999999-9999-9999-9999-999999999999",
    "readOnly": false,
```

```
    "eventType": "AwsApiCall",
    "recipientAccountId": "123456789012"
    }
  ]
}
```

Security

Topics

This section describes options for configuring security and data protection for your applications.

There are four ways you can authorize applications to interact with your AWS AppSync GraphQL API. You specify which authorization type you use by specifying one of the following authorization type values in your AWS AppSync API or CLI call:

- **`API_KEY`**

  For using API keys.
- **`AWS_IAM`**

  For using AWS Identity and Access Management (IAM) permissions.
- **`OPENID_CONNECT`**

  For using your OpenID Connect provider.
- **`AMAZON_COGNITO_USER_POOLS`**

  For using an Amazon Cognito user pool.

These basic authorization types work for most developers. For more advanced use cases, you can add additional authorization modes through the console, the CLI, and AWS CloudFormation. For additional authorization modes, AppSync provides an authorization type that takes the values listed above (that is, `API_KEY`, `AWS_IAM`, `OPENID_CONNECT`, `AMAZON_COGNITO_USER_POOLS`).

When you specify `API_KEY` or `AWS_IAM` as the main or default authorization type, you can't specify them again as one of the additional authorization modes. Similarly, you can't duplicate `API_KEY` and `AWS_IAM` inside the additional authorization modes. You can use multiple Amazon Cognito User Pools and OpenID Connect providers. However, you can't use duplicate Amazon Cognito User Pools or OpenID Connect providers between the default authorization mode and any of the additional authorization modes. You can specify different clients for your Amazon Cognito User Pool or OpenID Connect provider using the corresponding configuration regex.

API_KEY Authorization

Unauthenticated APIs require more strict throttling than authenticated APIs. One way to control throttling for unauthenticated GraphQL endpoints is through the use of API keys. An API key is a hard-

coded value in your application that is generated by the AWS AppSync service when you create an unauthenticated GraphQL endpoint. You can rotate API keys from the console, from the CLI, or from the AWS AppSync API Reference.

API keys are configurable for up to 365 days, and you can extend an existing expiration date for up to another 365 days from that day. API Keys are recommended for development purposes or use cases where it's safe to expose a public API.

On the client, the API key is specified by the header `x-api-key`.

For example, if your `API_KEY` is `'ABC123'`, you can send a GraphQL query via `curl` as follows:

```
$ curl -XPOST -H "Content-Type:application/graphql" -H "x-api-key:ABC123" -d '{ "query":
 "query { movies { id } }" }' https://YOURAPPSYNCENDPOINT/graphql
```

AWS_IAM Authorization

This authorization type enforces the AWS Signature Version 4 Signing Process on the GraphQL API. You can associate Identity and Access Management (IAM) access policies with this authorization type. Your application can leverage this association by using an access key (which consists of an access key ID and secret access key) or by using short-lived, temporary credentials provided by Amazon Cognito Federated Identities.

If you want a role that has access to perform all data operations:

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "appsync:GraphQL"
         ],
         "Resource": [
            "arn:aws:appsync:us-west-2:123456789012:apis/YourGraphQLApiId/*"
         ]
      }
   ]
}
```

You can find `YourGraphQLApiId` from the main API listing page in the AppSync console, directly under the name of your API. Alternatively you can retrieve it with the CLI: `aws appsync list-graphql-apis`

If you want to restrict access to just certain GraphQL operations, you can do this for the root `Query`, `Mutation`, and `Subscription` fields.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "appsync:GraphQL"
         ],
         "Resource": [
            "arn:aws:appsync:us-west-2:123456789012:apis/YourGraphQLApiId/types/Query/
fields/<Field-1>",
```

```
            "arn:aws:appsync:us-west-2:123456789012:apis/YourGraphQLApiId/types/Query/
fields/<Field-2>",
            "arn:aws:appsync:us-west-2:123456789012:apis/YourGraphQLApiId/types/Mutation/
fields/<Field-1>",
            "arn:aws:appsync:us-west-2:123456789012:apis/YourGraphQLApiId/types/
Subscription/fields/<Field-1>"
         ]
     }
   ]
}
```

For example, suppose you have the following schema and you want to restrict access to getting all posts:

```
schema {
   query: Query
   mutation: Mutation
}

type Query {
   posts:[Post!]!
}

type Mutation {
   addPost(id:ID!, title:String!):Post!
}
```

The corresponding IAM policy for a role (that you could attach to an Amazon Cognito identity pool, for example) would look like the following:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
            "appsync:GraphQL"
            ],
            "Resource": [
                "arn:aws:appsync:us-west-2:123456789012:apis/YourGraphQLApiId/types/Query/
fields/posts"
            ]
        }
    ]
}
```

OPENID_CONNECT Authorization

This authorization type enforces OpenID Connect (OIDC) tokens provided by an OIDC-compliant service. Your application can leverage users and privileges defined by your OIDC provider for controlling access.

An Issuer URL is the only required configuration value that you provide to AWS AppSync (for example, `https://auth.example.com`). This URL must be addressable over HTTPS. AWS AppSync appends `/.well-known/openid-configuration` to the issuer URL and locates the OpenID configuration at `https://auth.example.com/.well-known/openid-configuration` per the OpenID Connect Discovery specification. It expects to retrieve an RFC5785 compliant JSON document at this URL. This JSON document must contain a `jwks_uri` key, which points to the JSON Web Key Set (JWKS) document with the signing keys.

AWS AppSync requires the JWKS to contain JSON fields of `alg`, `kty`, and `kid`.

AWS AppSync supports RS256, RS384, and RS512 as signing algorithms. Tokens issued by the provider must include the time at which the token was issued (`iat`) and may include the time at which it was authenticated (`auth_time`). You can provide TTL values for issued time (`iatTTL`) and authentication time (`authTTL`) in your OpenID Connect configuration for additional validation. If your provider authorizes multiple applications, you can also provide a regular expression (`clientId`) that is used to authorize by client ID.

To validate multiple client IDs use the pipeline operator ("|") which is an "or" in regex. For example, if your OIDC application has four clients with client IDs such as 0A1S2D, 1F4G9H, 1J6L4B, 6GS5MG, to validate for only the first three client ids you would place 1F4G9H|1J6L4B|6GS5MG in the client ID field.

AMAZON_COGNITO_USER_POOLS Authorization

This authorization type enforces OIDC tokens provided by Amazon Cognito User Pools. Your application can leverage the users and groups in your user pools and associate these with GraphQL fields for controlling access.

When using Amazon Cognito User Pools, you can create groups that users belong to. This information is encoded in a JWT token that your application sends to AWS AppSync in an authorization header when sending GraphQL operations. You can use GraphQL directives on the schema to control which groups can invoke which resolvers on a field, thereby giving more controlled access to your customers.

For example, suppose you have the following GraphQL schema:

```
schema {
   query: Query
   mutation: Mutation
}

type Query {
   posts:[Post!]!
}

type Mutation {
   addPost(id:ID!, title:String!):Post!
}
...
```

If you have two groups in Amazon Cognito User Pools - bloggers and readers - and you want to restrict the readers so that they cannot add new entries, then your schema should look like this:

```
schema {
   query: Query
   mutation: Mutation
}
```

```
type Query {
   posts:[Post!]!
   @aws_auth(cognito_groups: ["Bloggers", "Readers"])
}

type Mutation {
   addPost(id:ID!, title:String!):Post!
   @aws_auth(cognito_groups: ["Bloggers"])
}
...
```

Note that you can omit the `@aws_auth` directive if you want to default to a specific grant-or-deny strategy on access. You can specify the grant-or-deny strategy in the user pool configuration when you create your GraphQL API via the console or via the following CLI command:

```
$ aws appsync --region us-west-2 create-graphql-api --authentication-type
 AMAZON_COGNITO_USER_POOLS  --name userpoolstest --user-pool-config '{ "userPoolId":"test",
 "defaultEffect":"ALLOW", "awsRegion":"us-west-2"}'
```

Using Additional Authorization Modes

When you add additional authorization modes, you can directly configure the authorization setting at the AWS AppSync GraphQL API level (that is, the `authenticationType` field that you can directly configure on the `GraphqlApi` object) and it acts as the default on the schema. This means that any type that doesn't have a specific directive has to pass the API level authorization setting.

At the schema level, you can specify additional authorization modes using directives on the schema. You can specify authorization modes on individual fields in the schema. For example, for `API_KEY` authorization you would use `@aws_api_key` on schema object type definitions/fields. The following directives are supported on schema fields and object type definitions:

- `@aws_api_key` - To specify the field is `API_KEY` authorized.
- `@aws_iam` - To specify that the field is `AWS_IAM` authorized.
- `@aws_oidc` - To specify that the field is `OPENID_CONNECT` authorized.
- `@aws_cognito_user_pools` - To specify that the field is `AMAZON_COGNITO_USER_POOLS` authorized.

You can't use the `@aws_auth` directive along with additional authorization modes. `@aws_auth` works only in the context of `AMAZON_COGNITO_USER_POOLS` authorization with no additional authorization modes. However, you can use the `@aws_cognito_user_pools` directive in place of the `@aws_auth` directive, using the same arguments. The main difference between the two is that you can specify `@aws_cognito_user_pools` on any field and object type definitions.

To understand how the additional authorization modes work and how they can be specified on a schema, let's have a look at the following schema:

```
schema {
   query: Query
   mutation: Mutation
}

type Query {
   getPost(id: ID): Post
   getAllPosts(): [Post]
   @aws_api_key
}

type Mutation {
   addPost(
      id: ID!
      author: String!
      title: String!
      content: String!
      url: String!
   ): Post!
}

type Post @aws_api_key @aws_iam {
```

```
   id: ID!
   author: String
   title: String
   content: String
   url: String
   ups: Int!
   downs: Int!
   version: Int!
}
...
```

For this schema, assume that `AWS_IAM` is the default authorization type on the AWS AppSync GraphQL API. This means that fields that don't have a directive are protected using `AWS_IAM`. For example, that's the case for the `getPost` field on the `Query` type. Schema directives enable you to use more than one authorization mode. For example, you can have `API_KEY` configured as an additional authorization mode on the AWS AppSync GraphQL API, and you can mark a field using the `@aws_api_key` directive (for example, `getAllPosts` in this example). Directives work at the field level so you need to give `API_KEY` access to the `Post` type too. You can do this either by marking each field in the `Post` type with a directive, or by marking the `Post` type with the `@aws_api_key` directive.

To further restrict access to fields in the `Post` type you can use directives against individual fields in the `Post` type as shown following.

For example, you can add a `restrictedContent` field to the `Post` type and restrict access to it by using the `@aws_iam` directive. `AWS_IAM` authenticated requests could access `restrictedContent`, however, `API_KEY` requests wouldn't be able to access it.

```
type Post @aws_api_key @aws_iam{
   id: ID!
   author: String
   title: String
   content: String
   url: String
   ups: Int!
   downs: Int!
   version: Int!
   restrictedContent: String!
   @aws_iam
}
...
```

Fine-Grained Access Control

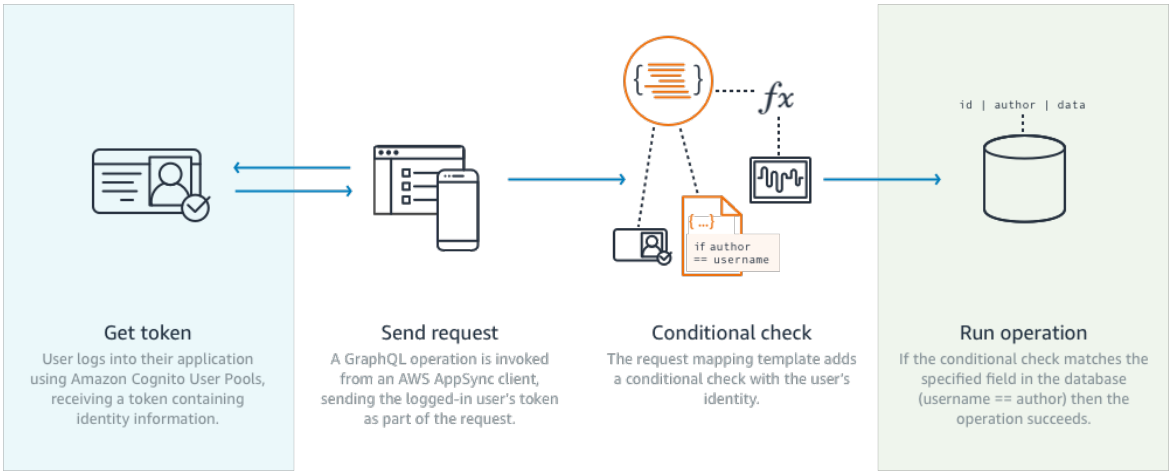
The preceding information demonstrates how to restrict or grant access to certain GraphQL fields. If you want to set access controls on the data based on certain conditions (for example, based on the user that's making a call and whether the user owns the data) you can use mapping templates in your resolvers. You can also perform more complex business logic, which we describe in Filtering Information (p. 213).

This section shows how to set access controls on your data using a DynamoDB resolver mapping template.

Before proceeding any further, if you're not familiar with mapping templates in AWS AppSync, you may want to review the Resolver Mapping Template Reference (p. 226) and the Resolver Mapping Template Reference for DynamoDB (p. 266).

In the following example using DynamoDB, suppose you're using the preceding blog post schema, and only users that created a post are allowed to edit it. The evaluation process would be for the user to gain credentials in their application, using Amazon Cognito User Pools for example, and then pass these

credentials as part of a GraphQL operation. The mapping template will then substitute a value from the credentials (like the username)in a conditional statement which will then be compared to a value in your database.



To add this functionality, add a GraphQL field of `editPost` as follows:

```
schema {
   query: Query
   mutation: Mutation
}

type Query {
   posts:[Post!]!
}

type Mutation {
   editPost(id:ID!, title:String, content:String):Post
   addPost(id:ID!, title:String!):Post!
}
...
```

The resolver mapping template for `editPost` (shown in an example at the end of this section) needs to perform a logical check against your data store to allow only the user that created a post to edit it. Since this is an edit operation, it corresponds to an `UpdateItem` in DynamoDB. You can perform a conditional check before performing this action, using context passed through for user identity validation. This is stored in an `Identity` object that has the following values:

```
{
   "accountId" : "12321434323",
   "cognitoIdentityPoolId" : "",
   "cognitoIdentityId" : "",
   "sourceIP" : "",
   "caller" : "ThisistheprincipalARN",
   "username" : "username",
   "userArn" : "Sameasabove"
}
```

To use this object in a DynamoDB`UpdateItem` call, you need to store the user identity information in the table for comparison. First, your `addPost` mutation needs to store the creator. Second, your `editPost` mutation needs to perform the conditional check before updating.

Here is an example of the request mapping template for `addPost` that stores the user identity as an `Author` column:

```
{
   "version" : "2017-02-28",
   "operation" : "PutItem",
   "key" : {
      "postId" : $util.dynamodb.toDynamoDBJson($context.arguments.id)
   },
   "attributeValues" : {
      "Author" : $util.dynamodb.toDynamoDBJson($context.identity.username)
      #foreach( $entry in $context.arguments.entrySet() )
         #if( $entry.key != "id" )
            ,"${entry.key}" : $util.dynamodb.toDynamoDBJson($entry.value)
         #end
      #end
   },
   "condition" : {
      "expression" : "attribute_not_exists(postId)"
   }
}
```

Note that the `Author` attribute is populated from the `Identity` object, which came from the application.

Finally, here is an example of the request mapping template for `editPost`, which only updates the content of the blog post if the request comes from the user that created the post:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        "id": $util.dynamodb.toDynamoDBJson($ctx.args.id),
    },
    "attributeValues" : $util.dynamodb.toMapValuesJson($ctx.args),
    "condition" : {
        "expression"       : "contains(#author,:expectedOwner)",
        "expressionNames" : {
            "#author" : "Author"
        },
        "expressionValues" : {
            ":expectedOwner" : $util.dynamodb.toDynamoDBJson($context.identity.username)
        }
    }
}
```

This example uses a `PutItem` that overwrites all values rather than an `UpdateItem`, which would be a bit more verbose in an example, but the same concept applies on the `condition` statement block.

Filtering Information

There may be cases where you cannot control the response from your data source, but you don't want to send unnecessary information to clients on a successful write or read to the data source. In these cases, you can filter information by using a response mapping template.

For example, suppose you don't have an appropriate index on your blog post DynamoDB table (such as an index on `Author`). You could run a `GetItem` query with the following mapping template:

```
{
   "version" : "2017-02-28",
   "operation" : "GetItem",
   "key" : {
```

```
        "postId" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    }
}
```

This returns all the values responses, even if the caller isn't the author who created the post. To prevent this from happening, you can perform the access check on the response mapping template in this case as follows:

```
{
   #if($context.result["Author"] == "$context.identity.username")
      $utils.toJson($context.result);
   #end
}
```

If the caller doesn't match this check, only a null response is returned.

Data source access

AWS AppSync communicates with data sources using Identity and Access Management (IAM) roles and access policies. If you are using an existing role, a Trust Policy needs to be added in order for AWS AppSync to assume the role. The trust relationship will look like below:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "appsync.amazonaws.com"
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

It's important to scope down the access policy on the role to only have permissions to act on the minimal set of resources necessary. When using the AppSync console to create a data source and create a role, this is done automatically for you. However when using a built in sample template from the IAM console to create a role outside of the AWS AppSync console the permissions will not be automatically scoped down on a resource and you should perform this action before moving your application to production.

Authorization Use Cases

In the Security (p. 206) section you learned about the different Authorization modes for protecting your API and an introduction was given on Fine Grained Authorization mechanisms to understand the concepts and flow. Since AWS AppSync allows you to perform logic full operations on data through the use of GraphQL Resolver Mapping Templates (p. 226), you can protect data on read or write in a very flexible manner using a combination of user identity, conditionals, and data injection.

If you're not familiar with editing AWS AppSync Resolvers, review the programming guide (p. 230).

Overview

Granting access to data in a system is traditionally done through an Access Control Matrix where the intersection of a row (resource) and column (user/role) is the permissions granted.

AWS AppSync uses resources in your own account and threads identity (user/role) information into the GraphQL request and response as a context object (p. 241), which you can use in the resolver. This means that permissions can be granted appropriately either on write or read operations based on the resolver logic. If this logic is at the resource level, for example only certain named users or groups can read/write to a specific database row, then that "authorization metadata" must be stored. AWS AppSync does not store any data so therefore you must store this authorization metadata with the resources so that permissions can be calculated. Authorization metadata is usually an attribute (column) in a DynamoDB table, such as an **owner** or list of users/groups. For example there could be **Readers** and **Writers** attributes.

From a high level, what this means is that if you are reading an individual item from a data source, you perform a conditional `#if () ... #end` statement in the response template after the resolver has read from the data source. The check will normally be using user or group values in `$context.identity` for membership checks against the authorization metadata returned from a read operation. For multiple records, such as lists returned from a table `Scan` or `Query`, you'll send the condition check as part of the operation to the data source using similar user or group values.

Similarly when writing data you'll apply a conditional statement to the action (like a `PutItem` or `UpdateItem` to see if the user or group making a mutation has permission. The conditional again will many times be using a value in `$context.identity` to compare against authorization metadata on that resource. For both request and response templates you can also use custom headers from clients to perform validation checks.

Reading Data

As outlined above the authorization metadata to perform a check must be stored with a resource or passed in to the GraphQL request (identity, header, etc.). To demonstrate this suppose you have the DynamoDB table below:

ID	Data	PeopleCanAccess	GroupsCanAccess	Owner
123	{my: data,...}	[Mary, Joe]	[Admins, Editors]	Nadia

The primary key is `id` and the data to be accessed is `Data`. The other columns are examples of checks you can perform for authorization. `Owner` would be a `String` while `PeopleCanAccess` and `GroupsCanAccess` would be `String Sets` as outlined in the Resolver Mapping Template Reference for DynamoDB (p. 266).

In the resolver mapping template overview (p. 226) the diagram shows how the response template contains not only the context object but also the results from the data source. For GraphQL queries of individual items, you can use the response template to check if the user is allowed to see these results or return an authorization error message. This is sometimes referred to as an "Authorization filter". For GraphQL queries returning lists, using a Scan or Query, it is more performant to perform the check on the request template and return data only if an authorization condition is satisfied. The implementation is then:

1. GetItem - authorization check for individual records. Done using `#if() ... #end` statements.
2. Scan/Query operations - authorization check is a `"filter":{"expression":...}` statement. Common checks are equality (`attribute = :input`) or checking if a value is in a list (`contains(attribute, :input)`).

In #2 the `attribute` in both statements represents the column name of the record in a table, such as `Owner` in our above example. You can alias this with a `#` sign and use `"expressionNames":{...}` but it's not mandatory. The `:input` is a reference to the value you're comparing to the database attribute, which you will define in `"expressionValues":{...}`. You'll see these examples below.

Use Case: Owner Can Read

Using the table above, if you only wanted to return data if `Owner == Nadia` for an individual read operation (`GetItem`) your template would look like:

```
#if($context.result["Owner"] == $context.identity.username)
    $utils.toJson($context.result)
#else
    $utils.unauthorized()
#end
```

A couple things to mention here which will be re-used in the remaining sections. First, the check uses `$context.identity.username` which will be the friendly user sign-up name if Amazon Cognito user pools is used and will be the user identity if AWS IAM is used (including Amazon Cognito Federated Identities). There are other values to store for an owner such as the unique "Amazon Cognito identity" value, which is useful when federating logins from multiple locations, and you should review the options available in the Resolver Mapping Template Context Reference (p. 241).

Second, the conditional else check responding with `$util.unauthorized()` is completely optional but recommended as a best practice when designing your GraphQL API.

Use Case: Hardcode Specific Access

```
// This checks if the user is part of the Admin group and makes the call
#foreach($group in $context.identity.claims.get("cognito:groups"))
    #if($group == "Admin")
        #set($inCognitoGroup = true)
    #end
#end
#if($inCognitoGroup)
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    },
    "attributeValues" : {
        "owner" : $util.dynamodb.toDynamoDBJson($context.identity.username)
        #foreach( $entry in $context.arguments.entrySet() )
            ,"${entry.key}" : $util.dynamodb.toDynamoDBJson($entry.value)
        #end
    }
}
#else
    $utils.unauthorized()
#end
```

Use Case: Filtering a List of Results

In the previous example you were able to perform a check against `$context.result` directly as it returned a single item, however some operations like a scan will return multiple items in `$context.result.items` where you need to perform the authorization filter and only return results that the user is allowed to see. Suppose the `Owner` field had the Amazon Cognito IdentityID this time set on the record, you could then use the following response mapping template to filter to only show those records that the user owned:

```
#set($myResults = [])
#foreach($item in $context.result.items)
```

```
    ##For userpools use $context.identity.username instead
    #if($item.Owner == $context.identity.cognitoIdentityId)
        #set($added = $myResults.add($item))
    #end
#end
$utils.toJson($myResults)
```

Use Case: Multiple People Can Read

Another popular authorization option is to allow a group of people to be able to read data. In the example below the `"filter":{"expression":...}` only returns values from a table scan if the user running the GraphQL query is listed in the set for `PeopleCanAccess`.

```
{
    "version" : "2017-02-28",
    "operation" : "Scan",
    "limit": #if(${context.arguments.count}) $util.toJson($context.arguments.count) #else
 20 #end,
    "nextToken": #if(${context.arguments.nextToken})
 $util.toJson($context.arguments.nextToken) #else null #end,
    "filter":{
        "expression": "contains(#peopleCanAccess, :value)",
        "expressionNames": {
                "#peopleCanAccess": "peopleCanAccess"
        },
        "expressionValues": {
                ":value": $util.dynamodb.toDynamoDBJson($context.identity.username)
        }
    }
}
```

Use Case: Group Can Read

Similar to the last use case, it may be that only people in one or more groups have rights to read certain items in a database. Use of the `"expression": "contains()"` operation is similar however it's a logical-OR of all the groups that a user might be a part of which needs to be accounted for in the set membership. In this case we build up a `$expression` statement below for each group the user is in and then pass this to the filter:

```
#set($expression = "")
#set($expressionValues = {})
#foreach($group in $context.identity.claims.get("cognito:groups"))
    #set( $expression = "${expression} contains(groupsCanAccess, :var$foreach.count )" )
    #set( $val = {})
    #set( $test = $val.put("S", $group))
    #set( $values = $expressionValues.put(":var$foreach.count", $val))
    #if ( $foreach.hasNext )
    #set( $expression = "${expression} OR" )
    #end
#end
{
    "version" : "2017-02-28",
    "operation" : "Scan",
    "limit": #if(${context.arguments.count}) $util.toJson($context.arguments.count) #else
 20 #end,
    "nextToken": #if(${context.arguments.nextToken})
 $util.toJson($context.arguments.nextToken) #else null #end,
    "filter":{
        "expression": "$expression",
        "expressionValues": $utils.toJson($expressionValues)
    }
```

```
}
```

Writing Data

Writing data on mutations is always controlled on the request mapping template. In the case of DynamoDB data sources, the key is to use an appropriate `"condition":{"expression"...}"` which performs validation against the authorization metadata in that table. In Security (p. 206), we provided an example you can use to check the `Author` field in a table. The use cases in this section explore more use cases.

Use Case: Multiple Owners

Using the example table diagram from earlier, suppose the `PeopleCanAccess` list

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    },
    "update" : {
        "expression" : "SET meta = :meta",
        "expressionValues": {
            ":meta" : $util.dynamodb.toDynamoDBJson($ctx.args.meta)
        }
    },
    "condition" : {
        "expression"       : "contains(Owner,:expectedOwner)",
        "expressionValues" : {
            ":expectedOwner" : $util.dynamodb.toDynamoDBJson($context.identity.username)
        }
    }
}
```

Use Case: Group Can Create New Record

```
#set($expression = "")
#set($expressionValues = {})
#foreach($group in $context.identity.claims.get("cognito:groups"))
    #set( $expression = "${expression} contains(groupsCanAccess, :var$foreach.count )" )
    #set( $val = {})
    #set( $test = $val.put("S", $group))
    #set( $values = $expressionValues.put(":var$foreach.count", $val))
    #if ( $foreach.hasNext )
    #set( $expression = "${expression} OR" )
    #end
#end
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        ## If your table's hash key is not named 'id', update it here. **
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
        ## If your table has a sort key, add it as an item here. **
    },
    "attributeValues" : {
        ## Add an item for each field you would like to store to Amazon DynamoDB. **
        "title" : $util.dynamodb.toDynamoDBJson($ctx.args.title),
        "content": $util.dynamodb.toDynamoDBJson($ctx.args.content),
        "owner": $util.dynamodb.toDynamoDBJson($context.identity.username)
```

```
    },
    "condition" : {
        "expression": $util.toJson("attribute_not_exists(id) AND $expression"),
        "expressionValues": $utils.toJson($expressionValues)
    }
}
```

Use Case: Group Can Update Existing Record

```
#set($expression = "")
#set($expressionValues = {})
#foreach($group in $context.identity.claims.get("cognito:groups"))
    #set( $expression = "${expression} contains(groupsCanAccess, :var$foreach.count )" )
    #set( $val = {})
    #set( $test = $val.put("S", $group))
    #set( $values = $expressionValues.put(":var$foreach.count", $val))
    #if ( $foreach.hasNext )
    #set( $expression = "${expression} OR" )
    #end
#end
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    },
    "update":{
                "expression" : "SET title = :title, content = :content",
        "expressionValues": {
            ":title" : $util.dynamodb.toDynamoDBJson($ctx.args.title),
            ":content" : $util.dynamodb.toDynamoDBJson($ctx.args.content)
        }
    },
    "condition" : {
        "expression": $util.toJson($expression),
        "expressionValues": $utils.toJson($expressionValues)
    }
}
```

Public and Private Records

With the conditional filters you can also choose to mark data as private, public or some other Boolean check. This can then be combined as part of an authorization filter inside the response template. Using this check is a nice way to temporarily hide data or remove it from view without trying to control group membership.

For example suppose you added an attribute on each item in your DynamoDB table called `public` with either a value of `yes` or `no`. The following response template could be used on a `GetItem` call to only display data if the user is in a group that has access AND if that data is marked as public:

```
#set($permissions = $context.result.GroupsCanAccess)
#set($claimPermissions = $context.identity.claims.get("cognito:groups"))

#foreach($per in $permissions)
    #foreach($cgroups in $claimPermissions)
        #if($cgroups == $per)
            #set($hasPermission = true)
        #end
    #end
#end
```

```
#if($hasPermission && $context.result.public == 'yes')
    $utils.toJson($context.result)
#else
    $utils.unauthorized()
#end
```

The above code could also use a logical OR (`||`) to allow people to read if they have permission to a record or if it's public:

```
#if($hasPermission || $context.result.public == 'yes')
    $utils.toJson($context.result)
#else
    $utils.unauthorized()
#end
```

In general, you will find the standard operators `==`, `!=`, `&&`, and `||` helpful when performing authorization checks.

Real-Time Data

You can apply Fine Grained Access Controls to GraphQL subscriptions at the time a client makes a subscription, using the same techniques described earlier in this documentation. You attach a resolver to the subscription field, at which point you can query data from a data source and perform conditional logic in either the request or response mapping template. You can also return additional data to the client, such as the initial results from a subscription, as long as the data structure matches that of the returned type in your GraphQL subscription.

Use Case: User Can Subscribe to Specific Conversations Only

A common use case for real-time data with GraphQL subscriptions is building a messaging or private chat application. When creating a chat application that has multiple users, conversations can occur between two people or among multiple people. These might be grouped into "rooms", which are private or public. As such, you would only want to authorize a user to subscribe to a conversation (which could be one to one or among a group) for which they have been granted access. For demonstration purposes, the sample below shows a simple use case of one user sending a private message to another. The setup has two Amazon DynamoDB tables:

- Messages table: (primary key) `toUser`, (sort key) `id`
- Permissions table: (primary key) `username`

The Messages table stores the actual messages that get sent via a GraphQL mutation. The Permissions table is checked by the GraphQL subscription for authorization at client connection time. The example below assumes you are using the following GraphQL schema:

```
input CreateUserPermissionsInput {
    user: String!
    isAuthorizedForSubscriptions: Boolean
}

type Message {
    id: ID
    toUser: String
    fromUser: String
    content: String
}

type MessageConnection {
    items: [Message]
```

```
    nextToken: String
}

type Mutation {
    sendMessage(toUser: String!, content: String!): Message
    createUserPermissions(input: CreateUserPermissionsInput!): UserPermissions
    updateUserPermissions(input: UpdateUserPermissionInput!): UserPermissions
}

type Query {
    getMyMessages(first: Int, after: String): MessageConnection
    getUserPermissions(user: String!): UserPermissions
}

type Subscription {
    newMessage(toUser: String!): Message
        @aws_subscribe(mutations: ["sendMessage"])
}

input UpdateUserPermissionInput {
    user: String!
    isAuthorizedForSubscriptions: Boolean
}

type UserPermissions {
    user: String
    isAuthorizedForSubscriptions: Boolean
}

schema {
    query: Query
    mutation: Mutation
    subscription: Subscription
}
```

Some of the standard operations, such as `createUserPermissions()`, are not covered below to illustrate the subscription resolvers, but are standard implementations of DynamoDB resolvers. Instead, we'll focus on subscription authorization flows with resolvers. To send a message from one user to another, attach a resolver to the `sendMessage()` field and select the **Messages** table data source with the following request template:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key" : {
        "toUser" : $util.dynamodb.toDynamoDBJson($ctx.args.toUser),
        "id" : $util.dynamodb.toDynamoDBJson($util.autoId())
    },
    "attributeValues" : {
        "fromUser" : $util.dynamodb.toDynamoDBJson($context.identity.username),
        "content" : $util.dynamodb.toDynamoDBJson($ctx.args.content),
    }
}
```

In this example, we use `$context.identity.username`. This returns user information for AWS Identity and Access Management or Amazon Cognito users. The response template is a simple passthrough of `$util.toJson($ctx.result)`. Save and go back to the schema page. Then attach a resolver for the `newMessage()` subscription, using the **Permissions** table as a data source and the following request mapping template:

```
{
    "version": "2018-05-29",
```

```
    "operation": "GetItem",
    "key": {
        "username": $util.dynamodb.toDynamoDBJson($ctx.identity.username),
    },
}
```

Then use the following response mapping template to perform your authorization checks using data from the **Permissions** table:

```
#if(! ${context.result})
    $utils.unauthorized()
#elseif(${context.identity.username} != ${context.arguments.toUser})
    $utils.unauthorized()
#elseif(! ${context.result.isAuthorizedForSubscriptions})
    $utils.unauthorized()
#else
##User is authorized, but we return null to continue
    null
#end
```

In this case, you're doing three authorization checks. The first ensures that a result is returned. The second ensures that the user isn't subscribing to messages that are meant for another person. The third ensures that the user is allowed to subscribe to any fields, by checking a DynamoDB attribute of `isAuthorizedForSubscriptions` stored as a `BOOL`.

To test things out, you could sign in to the AWS AppSync console using Amazon Cognito user pools and a user named "Nadia", and then run the following GraphQL subscription:

```
subscription AuthorizedSubscription {
    newMessage(toUser: "Nadia") {
        id
        toUser
        fromUser
        content
    }
}
```

If in the **Permissions** table there is a record for the `username` key attribute of `Nadia` with `isAuthorizedForSubscriptions` set to `true`, you'll see a successful response. If you try a different `username` in the `newMessage()` query above, an error will be returned.

Using AWS Web Application Firewall (WAF) to protect your APIs

AWS WAF is a web application firewall that helps protect web applications and APIs from attacks. It allows you to configure a set of rules, called a web access control list (web ACL), that allow, block, or monitor (count) web requests based on customizable web security rules and conditions that you define. When you integrate your AWS AppSync API with AWS WAF, you gain more control and visibility into the HTTP traffic accepted by your API. To learn more about AWS WAF, see How AWS WAF Works in the AWS WAF Developer Guide.

You can use AWS WAF to protect your AppSync API from common web exploits, such as SQL injection and cross-site scripting (XSS) attacks. These could affect API availability and performance, compromise security, or consume excessive resources. For example, you can create rules to allow or block requests from specified IP address ranges, requests from CIDR blocks, requests that originate from a specific country or region, requests that contain malicious SQL code, or requests that contain malicious script.

You can also create rules that match a specified string or a regular expression pattern in HTTP headers, method, query string, URI, and the request body (limited to the first 8 KB). Additionally, you can create rules to block attacks from specific user agents, bad bots, and content scrapers. For example, you can use rate-based rules to specify the number of web requests that are allowed by each client IP in a trailing, continuously updated, 5-minute period.

To learn more about the types of rules that are supported and additional AWS WAF features, see the AWS WAF Developer Guide and the AWS WAF API Reference.

Important
AWS WAF is your first line of defense against web exploits. When AWS WAF is enabled on an API, AWS WAF rules are evaluated before other access control features, such as API key authorization, IAM policies, OIDC tokens, and Amazon Cognito user pools.

Integrate an AppSync API with AWS WAF

You can integrate an Appsync API with AWS WAF using the AWS Management Console, the AWS CLI, AWS CloudFormation, or any other AWS compatible client.

To integrate an AWS AppSync API with AWS WAF

1. Create an AWS WAF web ACL. For detailed steps using the AWS WAF Console, see Creating a web ACL.
2. Define the rules for the web ACL. A rule or rules are defined in the process of creating the web ACL. For information about how to structure rules, see AWS WAF rules. For examples of useful rules you can define for your AWS AppSync API, see Creating rules for a web ACL (p. 223).
3. Associate the web ACL with an AWS AppSync API. You can perform this step in the AWS WAF Console or in the AppSync Console.
   - To associate the web ACL with an AWS AppSync API in the AWS WAF Console, follow the instructions for Associating or disassociating a Web ACL with an AWS resource in the AWS WAF Developer Guide.
   - To associate the web ACL with an AWS AppSync API in the AWS AppSync Console
     a. Sign in to the AWS Management Console and open the AppSync Console.
     b. Choose the API that you want to associate with a web ACL.
     c. In the navigation pane, choose **Settings**.
     d. In the **Web application firewall** section, turn on **Enable AWS WAF**.
     e. In the **Web ACL** dropdown list, choose the name of the web ACL to associate with your API.
     f. Choose **Save** to associate the web ACL with your API.

Note
After you create a web ACL in the AWS WAF Console, it can take a few minutes for the new web ACL to be available. If you do not see a newly created web ACL in the **Web application firewall** menu, wait a few minutes and retry the steps to associate the web ACL with your API.

After you associate a web ACL with an AWS AppSync API, you will manage the web ACL using the AWS WAF APIs. You do not need to re-associate the web ACL with your AWS AppSync API unless you want to associate the AWS AppSync API with a different web ACL.

Creating rules for a web ACL

Rules define how to inspect web requests and what to do when a web request matches the inspection criteria. Rules don't exist in AWS WAF on their own. You can access a rule by name in a rule group or

in the web ACL where it's defined. For more information, see AWS WAF rules. The following examples demonstrate how to define and associate rules that are useful for protecting an AppSync API.

Example web ACL rule to limit request body size

The following is an example of a rule that limits the body size of requests. This would be entered into the **Rule JSON editor** when creating a web ACL in the AWS WAF Console.

```
{
    "Name": "BodySizeRule",
    "Priority": 1,
    "RuleAction": {
        "Block": {}
    },
    "Statement": {
        "SizeConstraintStatement": {
            "ComparisonOperator": "GE",
            "FieldToMatch": {
                "Body": {}
            },
            "Size": 1024,
            "TextTransformations": [
                {
                    "Priority": 0,
                    "Type": "NONE"
                }
             ]
          }
       },
       "VisibilityConfig": {
           "CloudWatchMetricsEnabled": true,
           "MetricName": "BodySizeRule",
           "SampledRequestsEnabled": true
        }
    }
}
```

After you have created your web ACL using the preceding example rule, you must associate it with your AppSync API. As an alternative to using the AWS Management Console, you can perform this step in the AWS CLI by running the following command.

```
aws waf associate-web-acl --web-acl-id waf-web-acl-arn --resource-arn appsync-api-arn
```

It can take a few minutes for the changes to propagate, but after running this command, requests that contain a body larger than 1024 bytes will be rejected by AWS AppSync.

> **Note**
> After you create a new web ACL in the AWS WAF Console, it can take a few minutes for the web ACL to be available to associate with an API. If you run the CLI command and get a `WAFUnavailableEntityException` error, wait a few minutes and retry running the command.

Example web ACL rule to limit requests from a single IP address

The following is an example of a rule that throttles an AppSync API to 100 requests from a single IP address in a 5 minute period. This would be entered into the **Rule JSON editor** when creating a web ACL with a rate-based rule in the AWS WAF Console.

```
{
  "Name": "Throttle",
  "Priority": 0,
```

```
  "Action": {
    "Block": {}
  },
  "VisibilityConfig": {
    "SampledRequestsEnabled": true,
    "CloudWatchMetricsEnabled": true,
    "MetricName": "Throttle"
  },
  "Statement": {
    "RateBasedStatement": {
      "Limit": 100,
      "AggregateKeyType": "IP"
    }
  }
}
```

After you have created your web ACL using the preceding example rule, you must associate it with your AppSync API. You can perform this step in the AWS CLI by running the following command.

```
aws waf associate-web-acl --web-acl-id waf-web-acl-arn --resource-arn appsync-api-arn
```

Example web ACL rule to prevent all GraphQL introspection queries to an API

The following is an example of a rule that prevents all GraphQL introspection queries to an API. Any HTTP body that includes the string "__schema", which is present in all introspection queries, will be blocked. This would be entered into the **Rule JSON editor** when creating a web ACL in the AWS WAF Console.

```
{
  "Name": "BodyRule",
  "Priority": 5,
  "Action": {
    "Block": {}
  },
  "VisibilityConfig": {
    "SampledRequestsEnabled": true,
    "CloudWatchMetricsEnabled": true,
    "MetricName": "BodyRule"
  },
  "Statement": {
    "ByteMatchStatement": {
      "FieldToMatch": {
        "Body": {}
      },
      "PositionalConstraint": "CONTAINS",
      "SearchString": "__schema",
      "TextTransformations": [
        {
          "Type": "NONE",
          "Priority": 0
        }
      ]
    }
  }
}
```

After you have created your web ACL using the preceding example rule, you must associate it with your AppSync API. You can perform this step in the AWS CLI by running the following command.

```
aws waf associate-web-acl --web-acl-id waf-web-acl-arn --resource-arn appsync-api-arn
```

Resolver Mapping Template Reference

Topics

Resolver mapping template overview

AWS AppSync lets you respond to GraphQL requests by performing operations on your resources. For each GraphQL field you wish to run a query or mutation on, a resolver must be attached in order to communicate with a data source. The communication is typically through parameters or operations that are unique to the data source.

Resolvers are the connectors between GraphQl and a data source. They tell AWS AppSync how to translate an incoming GraphQL request into instructions for your backend data source, and how to translate the response from that data source back into a GraphQL response. They are written in Apache Velocity Template Language (VTL), which takes your request as input and outputs a JSON document containing the instructions for the resolver. You can use mapping templates for simple instructions, such as passing in arguments from GraphQL fields, or for more complex instructions, such as looping through arguments to build an item before inserting the item into DynamoDB.

There are two types of resolvers in AppSync which leverage mapping templates in slightly different ways: unit resolvers and pipeline resolvers.

Unit Resolvers

Unit Resolvers are self contained entities which include a request and response template only. Use these for simple, single operations such as listing items from a single data source.

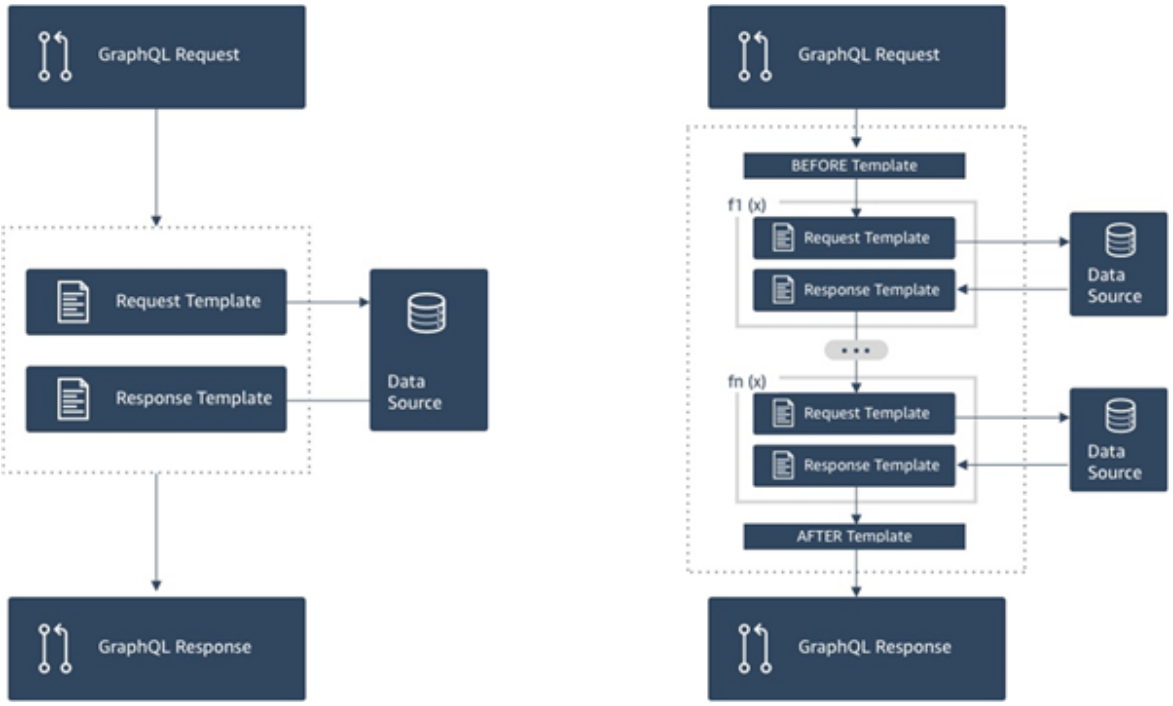
- Request templates: Take the incoming request after a GraphQL operation is parsed and convert it into a request configuration for the selected data source operation.
- Response templates: Interpret responses from your data source and map it to the shape of the GraphQL field output type.

Pipeline resolvers

Pipeline resolvers contain one or more *functions* which are performed in sequential order. Each function includes a request template and response template. A pipeline resolver also has a *before* template and an *after* template that surround the sequence of functions that the template contains. The *after* template maps to the GraphQL field output type. Pipeline resolvers differ from unit resolvers in the way that the response template maps output. A pipeline resolver can map to any output you want, including the input for another function or the *after* template of the pipeline resolver.

Pipeline resolver *functions* enable you to write common logic that you can reuse across multiple resolvers in your schema. Functions are attached directly to a data source, and like a unit resolver, contain the same request and response mapping template format.

The following diagram demonstrates the process flow of a unit resolver on the left and a pipeline resolver on the right.



Pipeline resolvers contain a superset of the functionality that unit resolvers support, and more, at the cost of a little more complexity.

Example template

For example, suppose you have a DynamoDB data source and a **Unit** resolver on a field named `getPost(id:ID!)` that returns a `Post` type with the following GraphQL query:

```
getPost(id:1){
    id
    title
    content
}
```

Your resolver template might look like the following:

```
    {
```

```
    "version" : "2018-05-29",
    "operation" : "GetItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    }
}
```

This would substitute the `id` input parameter value of `1` for `${ctx.args.id}` and generate the following JSON:

```
     {
    "version" : "2018-05-29",
    "operation" : "GetItem",
    "key" : {
        "id" : { "S" : "1" }
    }
}
```

AWS AppSync uses this template to generate instructions for communicating with DynamoDB and getting data (or performing other operations as appropriate). After the data returns, AWS AppSync runs it through an optional response mapping template, which you can use to perform data shaping or logic. For example, when we get the results back from DynamoDB, they might look like this:

```
{
        "id" : 1,
        "theTitle" : "AWS AppSync works offline!",
        "theContent-part1" : "It also has realtime functionality",
        "theContent-part2" : "using GraphQL"
}
```

You could choose to join two of the fields into a single field with the following response mapping template:

```
{
        "id" : $util.toJson($context.data.id),
        "title" : $util.toJson($context.data.theTitle),
        "content" : $util.toJson("${context.data.theContent-part1}
 ${context.data.theContent-part2}")
}
```

Here's how the data is shaped after the template is applied to the data:

```
{
        "id" : 1,
        "title" : "AWS AppSync works offline!",
        "content" : "It also has realtime functionality using GraphQL"
}
```

This data is given back as the response to a client as follows:

```
{
        "data": {
                "getPost":      {
                        "id" : 1,
                        "title" : "AWS AppSync works offline!",
                        "content" : "It also has realtime functionality using GraphQL"
                }
        }
```

```
}
```

Note that under most circumstances, response mapping templates are a simple passthrough of data, differing mostly if you are returning an individual item or a list of items. For an individual item the passthrough is:

```
$util.toJson($context.result)
```

For lists the passthrough is usually:

```
$util.toJson($context.result.items)
```

To see more examples of both unit and pipeline resolvers, see Resolver tutorials (p. 54).

Evaluated mapping template deserialization rules

Mapping templates evaluate to a string. In AWS AppSync, the output string must follow a JSON structure to be valid.

Additionally, the following deserialization rules are enforced.

Duplicate keys are not allowed in JSON objects

If the evaluated mapping template string represents a JSON object or contains an object that has duplicate keys, the mapping template returns the following error message:

```
Duplicate field 'aField' detected on Object. Duplicate JSON keys are not
allowed.
```

Example of a duplicate key in an evaluated request mapping template:

```
{
    "version": "2018-05-29",
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "postId": "1",
        "field": "getPost" ## key 'field' has been redefined
    }
}
```

To fix this error, do not redefine keys in JSON objects.

Trailing characters are not allowed in JSON objects

If the evaluated mapping template string represents a JSON object and contains trailing extraneous characters, the mapping template returns the following error message:

```
Trailing characters at the end of the JSON string are not allowed.
```

Example of trailing characters in an evaluated request mapping template:

```
{
    "version": "2018-05-29",
```

```
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "postId": "1",
    }
}extraneouschars
```

To fix this error, ensure evaluated templates strictly evaluate to JSON.

Resolver Mapping Template Programming Guide

This is a cookbook-style tutorial of programming with the Apache Velocity Template Language (VTL) in AWS AppSync. If you are familiar with other programming languages such as JavaScript, C, or Java, it should be fairly straightforward.

AWS AppSync uses VTL to translate GraphQL requests from clients into a request to your data source. Then it reverses the process to translate the data source response back into a GraphQL response. VTL is a logical template language that gives you the power to manipulate both the request and the response in the standard request/response flow of a web application, using techniques such as:

- Default values for new items
- Input validation and formatting
- Transforming and shaping data
- Iterating over lists, maps, and arrays to pluck out or alter values
- Filter/change responses based on user identity
- Complex authorization checks

For example, you might want to perform a phone number validation in the service on a GraphQL argument, or convert an input parameter to upper case before storing it in DynamoDB. Or maybe you want client systems to provide a code, as part of a GraphQL argument, JWT token claim, or HTTP header, and only respond with data if the code matches a specific string in a list. These are all logical checks you can perform with VTL in AWS AppSync.

VTL allows you to apply logic using programming techniques that might be familiar. However, it is bounded to run within the standard request/response flow to ensure that your GraphQL API is scalable as your user base grows. Because AWS AppSync also supports AWS Lambda as a resolver, you can write Lambda functions in your programming language of choice (Node.js, Python, Go, Java, etc.) if you need more flexibility.

Setup

A common technique when learning a language is to print out results (for example, `console.log(variable)` in JavaScript) to see what happens. In this tutorial, we demonstrate this by creating a simple GraphQL schema and passing a map of values to a Lambda function. The Lambda function prints out the values and then responds with them. This will enable you to understand the request/response flow and see different programming techniques.

Start by creating the following GraphQL schema:

```
type Query {
    get(id: ID, meta: String): Thing
}
```

```
type Thing {
    id: ID!
    title: String!
    meta: String
}

schema {
    query: Query
}
```

Now create the following AWS Lambda function, using Node.js as the language:

```
exports.handler = (event, context, callback) => {
    console.log('VTL details: ', event);
    callback(null, event);
};
```

In the **Data Sources** pane of the AWS AppSync console, add this Lambda function as a new data source. Navigate back to the **Schema** page of the console and click the **ATTACH** button on the right, next to the `get(...):Thing` query. For the request template, choose the existing template from the **Invoke and forward arguments** menu. For the response template, choose **Return Lambda result**.

Open Amazon CloudWatch Logs for your Lambda function in one location, and from the **Queries** tab of the AWS AppSync console, run the following GraphQL query:

```
query test {
  get(id:123 meta:"testing"){
    id
    meta
  }
}
```

The GraphQL response should contain `id:123` and `meta:testing`, because the Lambda function is echoing them back. After a few seconds, you should see a record in CloudWatch Logs with these details as well.

Variables

VTL uses references, which you can use to store or manipulate data. There are three types of references in VTL: variables, properties, and methods. Variables have a `$` sign in front of them and are created with the `#set` directive:

```
#set($var = "a string")
```

Variables store similar types that you're familiar with from other languages, such as numbers, strings, arrays, lists, and maps. You might have noticed a JSON payload being sent in the default request template for Lambda resolvers:

```
"payload": $util.toJson($context.arguments)
```

A couple of things to notice here - first, AWS AppSync provides several convenience functions for common operations. In this example, `$util.toJson` converts a variable to JSON. Second, the variable `$context.arguments` is automatically populated from a GraphQL request as a map object. You can create a new map as follows:

```
#set( $myMap = {
  "id": $context.arguments.id,
  "meta": "stuff",
  "upperMeta" : $context.arguments.meta.toUpperCase()
} )
```

You have now created a variable named `$myMap`, which has keys of `id`, `meta`, and `upperMeta`. This also demonstrates a few things:

- `id` is populated with a key from the GraphQL arguments. This is common in VTL to grab arguments from clients.
- `meta` is hardcoded with a value, showcasing default values.
- `upperMeta` is transforming the `meta` argument using a method `.toUpperCase()`.

Put the previous code at the top of your request template and change the `payload` to use the new `$myMap` variable:

```
"payload": $util.toJson($myMap)
```

Run your Lambda function, and you can see the response change as well as this data in CloudWatch logs. As you walk through the rest of this tutorial, we will keep populating `$myMap` so you can run similar tests.

You can also set *properties_* on your variables. These could be simple strings, arrays, or JSON:

```
#set($myMap.myProperty = "ABC")
#set($myMap.arrProperty = ["Write", "Some", "GraphQL"])
#set($myMap.jsonProperty = {
    "AppSync" : "Offline and Realtime",
    "Cognito" : "AuthN and AuthZ"
})
```

Quiet References

Because VTL is a templating language, by default, every reference you give it will do a `.toString()`. If the reference is undefined, it prints the actual reference representation, as a string. For example:

```
#set($myValue = 5)
##Prints '5'
$myValue

##Prints '$somethingelse'
$somethingelse
```

To address this, VTL has a *quiet reference* or *silent reference* syntax, which tells the template engine to suppress this behavior. The syntax for this is `$!{}`. For example, if we changed the previous code slightly to use `$!{somethingelse}`, the printing is suppressed:

```
#set($myValue = 5)
##Prints '5'
$myValue

##Nothing prints out
$!{somethingelse}
```

Calling Methods

In an earlier example, we showed you how to create a variable and simultaneously set values. You can also do this in two steps by adding data to your map as shown following:

```
#set ($myMap = {})
#set ($myList = [])

##Nothing prints out
$!{myMap.put("id", "first value")}
##Prints "first value"
$!{myMap.put("id", "another value")}
##Prints true
$!{myList.add("something")}
```

HOWEVER there is something to know about this behavior. Although the quiet reference notation `$!{}` allows you to call methods, as above, it won't suppress the returned value of the executed method. This is why we noted `##Prints "first value"` and `##Prints true` above. This can cause errors when you're iterating over maps or lists, such as inserting a value where a key already exists, because the output adds unexpected strings to the template upon evaluation.

The workaround to this is sometimes to call the methods using a `#set` directive and ignore the variable. For example:

```
#set ($myMap = {})
#set($discard = $myMap.put("id", "first value"))
```

You might use this technique in your templates, as it prevents the unexpected strings from being printed in the template. AWS AppSync provides an alternative convenience function that offers the same behavior in a more succinct notation. This enables you to not have to think about these implementation specifics. You can access this function under `$util.quiet()` or its alias `$util.qr()`. For example:

```
#set ($myMap = {})
#set ($myList = [])

##Nothing prints out
$util.quiet($myMap.put("id", "first value"))
##Nothing prints out
$util.qr($myList.add("something"))
```

Strings

As with many programming languages, strings can be difficult to deal with, especially when you want to build them from variables. There are some common things that come up with VTL.

Suppose you are inserting data as a string to a data source like DynamoDB, but it is populated from a variable, like a GraphQL argument. A string will have double quotation marks, and to reference the variable in a string you just need `"${}"` (so no `!` as in quiet reference notation). This is similar to a template literal in JavaScript: https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Template_literals

```
#set($firstname = "Jeff")
$!{myMap.put("Firstname", "${firstname}")}
```

You can see this in DynamoDB request templates, like `"author": { "S" : "${context.arguments.author}"}` when using arguments from GraphQL clients, or for automatic

ID generation like `"id" : { "S" : "$utils.autoId()"}`. This means that you can reference a variable or the result of a method inside a string to populate data.

You can also use public methods of the Java String class, such as pulling out a substring:

```
#set($bigstring = "This is a long string, I want to pull out everything after the comma")
#set ($comma = $bigstring.indexOf(','))
#set ($comma = $comma +2)
#set ($substring = $bigstring.substring($comma))

$util.qr($myMap.put("substring", "${substring}"))
```

String concatenation is also a very common task. You can do this with variable references alone or with static values:

```
#set($s1 = "Hello")
#set($s2 = " World")

$util.qr($myMap.put("concat","$s1$s2"))
$util.qr($myMap.put("concat2","Second $s1 World"))
```

Loops

Now that you have created variables and called methods, you can add some logic to your code. Unlike other languages, VTL allows only loops, where the number of iterations is predetermined. There is no `do..while` in Velocity. This design ensures that the evaluation process always terminates, and provides bounds for scalability when your GraphQL operations execute.

Loops are created with a `#foreach` and require you to supply a **loop variable** and an **iterable object** such as an array, list, map, or collection. A classic programming example with a `#foreach` loop is to loop over the items in a collection and print them out, so in our case we pluck them out and add them to the map:

```
#set($start = 0)
#set($end = 5)
#set($range = [$start..$end])

#foreach($i in $range)
   ##$util.qr($myMap.put($i, "abc"))
   ##$util.qr($myMap.put($i, $i.toString()+"foo")) ##Concat variable with string
   $util.qr($myMap.put($i, "${i}foo"))     ##Reference a variable in a string with
 "${varname}"
#end
```

This example shows a few things. The first is using variables with the range `[..]` operator to create an iterable object. Then each item is referenced by a variable `$i` that you can operate with. In the previous example, you also see **Comments** that are denoted with a double pound `##`. This also showcases using the loop variable in both the keys or the values, as well as different methods of concatenation using strings.

Notice that `$i` is an integer, so you can call a `.toString()` method. For GraphQL types of INT, this can be handy.

You can also use a range operator directly, for example:

```
#foreach($item in [1..5])
    ...
```

```
#end
```

Arrays

You have been manipulating a map up to this point, but arrays are also common in VTL. With arrays you also have access to some underlying methods such as `.isEmpty()`, `.size()`, `.set()`, `.get()`, and `.add()`, as shown below:

```
#set($array = [])
#set($idx = 0)

##adding elements
$util.qr($array.add("element in array"))
$util.qr($myMap.put("array", $array[$idx]))

##initialize array vals on create
#set($arr2 = [42, "a string", 21, "test"])

$util.qr($myMap.put("arr2", $arr2[$idx]))
$util.qr($myMap.put("isEmpty", $array.isEmpty()))  ##isEmpty == false
$util.qr($myMap.put("size", $array.size()))

##Get and set items in an array
$util.qr($myMap.put("set", $array.set(0, 'changing array value')))
$util.qr($myMap.put("get", $array.get(0)))
```

The previous example used array index notation to retrieve an element with `arr2[$idx]`. You can look up by name from a Map/dictionary in a similar way:

```
#set($result = {
    "Author" : "Nadia",
    "Topic" : "GraphQL"
})

$util.qr($myMap.put("Author", $result["Author"]))
```

This is very common when filtering results coming back from data sources in Response Templates when using conditionals.

Conditional Checks

The earlier section with `#foreach` showcased some examples of using logic to transform data with VTL. You an also apply conditional checks to evaluate data at runtime:

```
#if(!$array.isEmpty())
    $util.qr($myMap.put("ifCheck", "Array not empty"))
#else
    $util.qr($myMap.put("ifCheck", "Your array is empty"))
#end
```

The above `#if()` check of a Boolean expression is nice, but you can also use operators and `#elseif()` for branching:

```
#if ($arr2.size() == 0)
    $util.qr($myMap.put("elseIfCheck", "You forgot to put anything into this array!"))
#elseif ($arr2.size() == 1)
    $util.qr($myMap.put("elseIfCheck", "Good start but please add more stuff"))
```

```
#else
    $util.qr($myMap.put("elseIfCheck", "Good job!"))
#end
```

These two examples showed negation(!) and equality (==). We can also use ||, &&, >, <, >=, <=, and !=.

```
#set($T = true)
#set($F = false)

#if ($T || $F)
  $util.qr($myMap.put("OR", "TRUE"))
#end

#if ($T && $F)
  $util.qr($myMap.put("AND", "TRUE"))
#end
```

Note: Only `Boolean.FALSE` and `null` are considered false in conditionals. Zero (0) and empty strings (“”) are not equivalent to false.

Operators

No programming language would be complete without some operators to perform some mathematical actions. Here are a few examples to get you started:

```
#set($x = 5)
#set($y = 7)
#set($z = $x + $y)
#set($x-y = $x - $y)
#set($xy = $x * $y)
#set($xDIVy = $x / $y)
#set($xMODy = $x % $y)

$util.qr($myMap.put("z", $z))
$util.qr($myMap.put("x-y", $x-y))
$util.qr($myMap.put("x*y", $xy))
$util.qr($myMap.put("x/y", $xDIVy))
$util.qr($myMap.put("x|y", $xMODy))
```

Loops and Conditionals Together

It is very common when transforming data in VTL, such as before writing or reading from a data source, to loop over objects and then perform checks before performing an action. Combining some of the tools from the previous sections gives you a lot of functionality. One handy tool is knowing that `#foreach` automatically provides you with a `.count` on each item:

```
#foreach ($item in $arr2)
  #set($idx = "item" + $foreach.count)
  $util.qr($myMap.put($idx, $item))
#end
```

For example, maybe you want to just pluck out values from a map if it is under a certain size. Using the count along with conditionals and the `#break` statement allows you to do this:

```
#set($hashmap = {
  "DynamoDB" : "https://aws.amazon.com/dynamodb/",
  "Amplify" : "https://github.com/aws/aws-amplify",
  "DynamoDB2" : "https://aws.amazon.com/dynamodb/",
```

```
  "Amplify2" : "https://github.com/aws/aws-amplify"
})

#foreach ($key in $hashmap.keySet())
    #if($foreach.count > 2)
    #break
  #end
    $util.qr($myMap.put($key, $hashmap.get($key)))
#end
```

The previous `#foreach` is iterated over with `.keySet()`, which you can use on maps. This gives you access to get the `$key` and reference the value with a `.get($key)`. GraphQL arguments from clients in AWS AppSync are stored as a map. They can also be iterated through with `.entrySet()`, which you can then access both keys and values as a Set, and either populate other variables or perform complex conditional checks, such as validation or transformation of input:

```
#foreach( $entry in $context.arguments.entrySet() )
#if ($entry.key == "XYZ" && $entry.value == "BAD")
    #set($myvar = "...")
  #else
    #break
  #end
#end
```

Other common examples are autopopulating default information, like the initial object versions when synchronizing data (very important in conflict resolution) or the default owner of an object for authorization checks - Mary created this blog post, so:

```
#set($myMap.owner ="Mary") and default ownership

#set($myMap.defaultOwners = ["Admins", "Editors"]``
```

Context

Now that you are more familiar with performing logical checks in AWS AWS AppSync resolvers with VTL, take a look at the context object:

```
$util.qr($myMap.put("context", $context))
```

This contains all of the information that you can access in your GraphQL request. For a detailed explanation, see the context reference (p. 241).

Filtering

So far in this tutorial all information from your Lambda function has been returned to the GraphQL query with a very simple JSON transformation:

```
$util.toJson($context.result)
```

The VTL logic is just as powerful when you get responses from a data source, especially when doing authorization checks on resources. Let's walk through some examples. First try changing your response template like so:

```
#set($data = {
    "id" : "456",
```

```
    "meta" : "Valid Response"
})

$util.toJson($data)
```

No matter what happens with your GraphQL operation, hardcoded values are returned back to the client. Change this slightly so that the `meta` field is populated from the Lambda response, set earlier in the tutorial in the `elseIfCheck` value when learning about conditionals:

```
#set($data = {
    "id" : "456"
})

#foreach($item in $context.result.entrySet())
    #if($item.key == "elseIfCheck")
        $util.qr($data.put("meta", $item.value))
    #end
#end

$util.toJson($data)
```

`$context.result` is a map, so you can use `entrySet()` to perform logic on either the keys or the values returned. Because `$context.identity` contains information on the user that performed the GraphQL operation, if you return authorization information from the data source, then you can decide to return all, partial, or no data to a user based on your logic. Change your response template to look like the following:

```
#if($context.result["id"] == 123)
    $util.toJson($context.result)
  #else
    $util.unauthorized()
#end
```

If you run your GraphQL query, the data will be returned as normal. However, if you change the id argument to something other than 123 (`query test { get(id:456 meta:"badrequest"){} }`), you will get an authorization failure message.

You can find more examples of authorization scenarios in the authorization use cases (p. 214) section.

Appendix - Template Sample

If you followed along with the tutorial, you may have built out this template step by step. In case you haven't, we include it below to copy for testing.

Request Template

```
#set( $myMap = {
  "id": $context.arguments.id,
  "meta": "stuff",
  "upperMeta" : "$context.arguments.meta.toUpperCase()"
} )

##This is how you would do it in two steps with a "quiet reference" and you can use it for
 invoking methods, such as .put() to add items to a Map
#set ($myMap2 = {})
$util.qr($myMap2.put("id", "first value"))

## Properties are created with a dot notation
#set($myMap.myProperty = "ABC")
#set($myMap.arrProperty = ["Write", "Some", "GraphQL"])
```

```
#set($myMap.jsonProperty = {
    "AppSync" : "Offline and Realtime",
    "Cognito" : "AuthN and AuthZ"
})

##When you are inside a string and just have ${} without ! it means stuff inside curly
 braces are a reference
#set($firstname = "Jeff")
$util.qr($myMap.put("Firstname", "${firstname}"))

#set($bigstring = "This is a long string, I want to pull out everything after the comma")
#set ($comma = $bigstring.indexOf(','))
#set ($comma = $comma +2)
#set ($substring = $bigstring.substring($comma))
$util.qr($myMap.put("substring", "${substring}"))

##Classic for-each loop over N items:
#set($start = 0)
#set($end = 5)
#set($range = [$start..$end])
#foreach($i in $range)          ##Can also use range operator directly like #foreach($item
 in [1...5])
   ##$util.qr($myMap.put($i, "abc"))
   ##$util.qr($myMap.put($i, $i.toString()+"foo")) ##Concat variable with string
   $util.qr($myMap.put($i, "${i}foo"))     ##Reference a variable in a string with
 "${varname)"
#end

##Operatorsdoesn't work
#set($x = 5)
#set($y = 7)
#set($z = $x + $y)
#set($x-y = $x - $y)
#set($xy = $x * $y)
#set($xDIVy = $x / $y)
#set($xMODy = $x % $y)
$util.qr($myMap.put("z", $z))
$util.qr($myMap.put("x-y", $x-y))
$util.qr($myMap.put("x*y", $xy))
$util.qr($myMap.put("x/y", $xDIVy))
$util.qr($myMap.put("x|y", $xMODy))

##arrays
#set($array = ["first"])
#set($idx = 0)
$util.qr($myMap.put("array", $array[$idx]))
##initialize array vals on create
#set($arr2 = [42, "a string", 21, "test"])
$util.qr($myMap.put("arr2", $arr2[$idx]))
$util.qr($myMap.put("isEmpty", $array.isEmpty()))  ##Returns false
$util.qr($myMap.put("size", $array.size()))
##Get and set items in an array
$util.qr($myMap.put("set", $array.set(0, 'changing array value')))
$util.qr($myMap.put("get", $array.get(0)))

##Lookup by name from a Map/dictionary in a similar way:
#set($result = {
    "Author" : "Nadia",
    "Topic" : "GraphQL"
})
$util.qr($myMap.put("Author", $result["Author"]))


##Conditional examples
#if(!$array.isEmpty())
$util.qr($myMap.put("ifCheck", "Array not empty"))
```

```
#else
$util.qr($myMap.put("ifCheck", "Your array is empty"))
#end

#if ($arr2.size() == 0)
$util.qr($myMap.put("elseIfCheck", "You forgot to put anything into this array!"))
#elseif ($arr2.size() == 1)
$util.qr($myMap.put("elseIfCheck", "Good start but please add more stuff"))
#else
$util.qr($myMap.put("elseIfCheck", "Good job!"))
#end

##Above showed negation(!) and equality (==), we can also use OR, AND, >, <, >=, <=, and !=
#set($T = true)
#set($F = false)
#if ($T || $F)
  $util.qr($myMap.put("OR", "TRUE"))
#end

#if ($T && $F)
  $util.qr($myMap.put("AND", "TRUE"))
#end

##Using the foreach loop counter - $foreach.count
#foreach ($item in $arr2)
  #set($idx = "item" + $foreach.count)
  $util.qr($myMap.put($idx, $item))
#end

##Using a Map and plucking out keys/vals
#set($hashmap = {
    "DynamoDB" : "https://aws.amazon.com/dynamodb/",
    "Amplify" : "https://github.com/aws/aws-amplify",
    "DynamoDB2" : "https://aws.amazon.com/dynamodb/",
    "Amplify2" : "https://github.com/aws/aws-amplify"
})

#foreach ($key in $hashmap.keySet())
    #if($foreach.count > 2)
        #break
    #end
    $util.qr($myMap.put($key, $hashmap.get($key)))
#end

##concatenate strings
#set($s1 = "Hello")
#set($s2 = " World")
$util.qr($myMap.put("concat","$s1$s2"))
$util.qr($myMap.put("concat2","Second $s1 World"))

$util.qr($myMap.put("context", $context))

{
    "version" : "2017-02-28",
    "operation": "Invoke",
    "payload": $util.toJson($myMap)
}
```

Response Template

```
#set($data = {
"id" : "456"
})
#foreach($item in $context.result.entrySet())   ##$context.result is a MAP so we use
 entrySet()
```

```
    #if($item.key == "ifCheck")
        $util.qr($data.put("meta", "$item.value"))
    #end
#end

##Uncomment this out if you want to test and remove the below #if check
##$util.toJson($data)

#if($context.result["id"] == 123)
    $util.toJson($context.result)
  #else
    $util.unauthorized()
#end
```

Resolver Mapping Template Context Reference

AWS AppSync defines a set of variables and functions for working with resolver mapping templates. This makes logical operations on data easier with GraphQL. This document describes those functions and provides examples for working with templates.

Accessing the `$context`

The `$context` variable is a map that holds all of the contextual information for your resolver invocation. It has the following structure:

```
{
   "arguments" : { ... },
   "source" : { ... },
   "result" : { ... },
   "identity" : { ... },
   "request" : { ... },
   "info": { ... }
}
```

Note: If you're trying to access a dictionary/map entry (such as an entry in `context`) by its key to retrieve the value, the Velocity Template Language (VTL) allows for you to directly use the notation `<dictionary-element>.<key-name>`. However, this might not work for all cases, such as when the key names have special characters (for example, an underscore "_"). We recommend that you always use `<dictionary-element>.get("<key-name>")` notation.

Each field in the `$context` map is defined as follows:

`arguments`

A map that contains all GraphQL arguments for this field.

`identity`

An object that contains information about the caller. For more information about the structure of this field, see Identity (p. 243).

`source`

A map that contains the resolution of the parent field.

`stash`

The stash is a map that is made available inside each resolver and function mapping template. The same stash instance lives through a single resolver execution. This means that you can use the stash

to pass arbitrary data across request and response mapping templates, and across functions in a pipeline resolver. The stash exposes the same methods as the Java Map data structure.

result

A container for the results of this resolver. This field is only available to response mapping templates.

For example, if you're resolving the `author` field of the following query:

```
query {
    getPost(id: 1234) {
        postId
        title
        content
        author {
            id
            name
        }
    }
}
```

Then the full `$context` variable that is available when processing a response mapping template might be:

```
{
  "arguments" : {
    id: "1234"
  },
  "source": {},
  "result" : {
      "postId": "1234",
      "title": "Some title",
      "content": "Some content",
      "author": {
        "id": "5678",
        "name": "Author Name"
      }
  },
  "identity" : {
      "sourceIp" : ["x.x.x.x"],
      "userArn" : "arn:aws:iam::123456789012:user/appsync",
      "accountId" : "123456789012",
      "user" : "AIDAAAAAAAAAAAAAAAAA"
  }
}
```

prev.result

It represents the result of whatever previous operation was executed in a pipeline resolver. If the previous operation was the pipeline resolver request mapping template, then `$ctx.prev.result` represents the output of the evaluation of the template, and is made available to the first function in the pipeline. If the previous operation was the first function, then `$ctx.prev.result` represents the output of the first function, and is made available to the second function in the pipeline. If the previous operation was the last function, then `$ctx.prev.result` represents the output of the first function, and is made available to the pipeline resolver response mapping template.

info

An object that contains information about the GraphQL request. For the structure of this field, see Info (p. 245).

Identity

The `identity` section contains information about the caller. The shape of this section depends on the authorization type of your AWS AppSync API.

For more information about this section and how it can be used, see Security (p. 206).

`API_KEY` authorization

The `identity` field isn't populated.

`AWS_IAM` authorization

The `identity` has the following shape:

```
{
    "accountId" : "string",
    "cognitoIdentityPoolId" : "string",
    "cognitoIdentityId" : "string",
    "sourceIp" : ["string"],
    "username" : "string", // IAM user principal
    "userArn" : "string",
    "cognitoIdentityAuthType" : "string", // authenticated/unauthenticated based on the
 identity type
    "cognitoIdentityAuthProvider" : "string" // the auth provider that was used to
 obtain the credentials
}
```

`AMAZON_COGNITO_USER_POOLS` authorization

The `identity` has the following shape:

```
{
    "sub" : "uuid",
    "issuer" : "string",
    "username" : "string"
    "claims" : { ... },
    "sourceIp" : ["x.x.x.x"],
    "defaultAuthStrategy" : "string"
}
```

Each field is defined as follows:

`accountId`

The AWS account ID of the caller.

`claims`

The claims that the user has.

`cognitoIdentityAuthType`

Either authenticated or unauthenticated based on the identity type.

`cognitoIdentityAuthProvider`

A comma separated list of external identity provider information used in obtaining the credentials used to sign the request.

`cognitoIdentityId`

The Amazon Cognito identity ID of the caller.

cognitoIdentityPoolId

The Amazon Cognito identity pool ID associated with the caller.

defaultAuthStrategy

The default authorization strategy for this caller (ALLOW or DENY).

issuer

The token issuer.

sourceIp

The source IP address of the caller received by AWS AppSync. If the request doesn't include the x-forwarded-for header, the source IP value contains only a single IP address from the TCP connection. If the request includes a x-forwarded-for header, the source IP is a list of IP addresses from the x-forwarded-for header, in addition to the IP address from the TCP connection.

sub

The UUID of the authenticated user.

user

The IAM user.

userArn

The ARN of the IAM user.

username

The user name of the authenticated user. In the case of AMAZON_COGNITO_USER_POOLS authorization, the value of *username* is the value of attribute *cognito:username*. In the case of AWS_IAM authorization, the value of *username* is the value of the AWS user principal. We recommend that you use cognitoIdentityId if you're using *AWS IAM* authorization with credentials vended from Amazon Cognito identity pools.

Access Request Headers

AWS AppSync supports passing custom headers from clients and accessing them in your GraphQL resolvers by using $context.request.headers. You can then use the header values for actions like inserting data to a data source or even authorization checks. Single or multiple request headers can be used, as shown in the following examples using $curl with an API key from the command line:

Single Header Example

Suppose you set a header of custom with a value of nadia like the following:

```
curl -XPOST -H "Content-Type:application/graphql" -H "custom:nadia" -H "x-api-key:<API-KEY-
VALUE>" -d '{"query":"mutation { createEvent(name: \"demo\", when: \"Next Friday!\", where:
 \"Here!\") {id name when where description}}"}' https://<ENDPOINT>/graphql
```

This could then be accessed with $context.request.headers.custom. For example, it might be in the following VTL for DynamoDB:

```
"custom": $util.dynamodb.toDynamoDBJson($context.request.headers.custom)
```

Multiple Header Example

You can also pass multiple headers in a single request and access these in the resolver mapping template. For example, if the `custom` header was set with two values:

```
curl -XPOST -H "Content-Type:application/graphql" -H "custom:bailey" -H "custom:nadia"
 -H "x-api-key:<API-KEY-VALUE>" -d '{"query":"mutation { createEvent(name: \"demo\",
 when: \"Next Friday!\", where: \"Here!\") {id name when where description}}"}' https://
<ENDPOINT>/graphql
```

You could then access these as an array, such as `$context.request.headers.custom[1]"`.

Note: AWS AppSync doesn't expose the cookie header in `$context.request.headers`.

Info

The `info` section contains information about the GraphQL request.

The `info` has the following shape:

```
{
    "fieldName": "string",
    "parentTypeName": "string",
    "variables": { ... },
    "selectionSetList": ["string"],
    "selectionSetGraphQL": "string"
}
```

Each field is defined as follows:

`fieldName`

The name of the field that is currently being resolved.

`parentTypeName`

The name of the parent type for the field that is currently being resolved.

`variables`

A map which holds all variables that are passed into the GraphQL request.

`selectionSetList`

A list representation of the fields in the GraphQL selection set. Fields that are aliased will only be referenced by the alias name, not the field name. The following example shows this in detail.

`selectionSetGraphQL`

A string representation of the selection set, formatted as GraphQL schema definition language (SDL). Although fragments aren't be merged into the selection set, inline fragments are preserved, as shown in the following example.

Note: When using `$utils.toJson()` on `context.info`, the values returned by `selectionSetGraphQL` and `selectionSetList` will not be serialized by default.

For example, if you are resolving the `getPost` field of the following query:

```
query {
```

```
  getPost(id: $postId) {
    postId
    title
    secondTitle: title
    content
    author(id: $authorId) {
      authorId
      name
    }
    secondAuthor(id: "789") {
      authorId
    }
    ... on Post {
      inlineFrag: comments: {
        id
      }
    }
    ... postFrag
  }
}

fragment postFrag on Post {
  postFrag: comments: {
    id
  }
}
```

Then the full `$context.info` variable that is available when processing a mapping template might be:

```
{
  "fieldName": "getPost",
  "parentTypeName": "Query",
  "variables": {
    "postId": "123",
    "authorId": "456"
  },
  "selectionSetList": [
    "postId",
    "title",
    "secondTitle"
    "content",
    "author",
    "author/authorId",
    "author/name",
    "secondAuthor",
    "secondAuthor/authorId",
    "inlineFragComments",
    "inlineFragComments/id",
    "postFragComments",
    "postFragComments/id"
  ],
  "selectionSetGraphQL": "{\n  getPost(id: $postId) {\n    postId\n    title\n
 secondTitle: title\n    content\n    author(id: $authorId) {\n      authorId\n      name
\n    }\n    secondAuthor(id: \"789\") {\n      authorId\n    }\n    ... on Post {\n
 inlineFrag: comments {\n        id\n      }\n    }\n    ... postFrag\n  }\n}"
}
```

Note: `selectionSetList` only exposes fields that belong to the current type. If the current type is an interface or union, only selected fields that belong to the interface will be exposed. For example, given the following schema:

```
type Query {
    node(id: ID!): Node
```

```
}

interface Node {
    id: ID
}

type Post implements Node {
    id: ID
    title: String
    author: String
}

type Blog implements Node {
    id: ID
    title: String
    category: String
}
```

and query:

```
query {
    node(id: "post1") {
        id
        ... on Post {
            title
        }

        ... on Blog {
            title
        }
    }
}
```

When calling `$ctx.info.selectionSetList` at the `Query.node` field resolution, only `id` will be exposed:

```
"selectionSetList": [
    "id"
]
```

Sanitizing inputs

Applications must sanitize untrusted inputs to prevent any external party from using an application outside of its intended use. As the `$context` contains user inputs in properties such as `$context.arguments`, `$context.identity`, `$context.result`, `$context.info.variables` and `$context.request.headers`, care must be taken to sanitize their values in mapping templates.

Since mapping templates represent JSON, input sanitization takes the form of escaping JSON reserved characters from strings that represent user inputs. It is best practice to use the `$util.toJson()` utility to escape JSON reserved characters from sensitive string values when placing them into a mapping template.

For example, in the Lambda request mapping template below, because we accessed an unsafe customer input string (`$context.arguments.id`), we wrapped it with `$util.toJson()` to prevent unescaped JSON characters from breaking the JSON template.

```
{
    "version": "2017-02-28",
    "operation": "Invoke",
```

```
    "payload": {
        "field": "getPost",
        "postId": $util.toJson($context.arguments.id)
    }
}
```

As opposed to the mapping template below, where we insert directly `$context.arguments.id` without sanitization. This will not work for strings containing unescaped double quotes or other JSON reserved characters and may leave your template open to failure.

```
## DO NOT DO THIS
{
    "version": "2017-02-28",
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "postId": "$context.arguments.id" ## Unsafe! Do not insert $context string values
 without escaping JSON characters.
    }
}
```

Resolver mapping template utility reference

AWS AppSync defines a set of utilities which can be leveraged within a GraphQL resolver to simplify interactions with data sources. Some of these utilities are general to be used with any data source, such as the generation of IDs or timestamps, while others are specific to a data source itself.

Utility helpers in $util

The `$util` variable contains general utility methods that make it easier to work with data.

Unless otherwise specified, all utilities use the UTF-8 character set.

`$util.qr()` and `$util.quiet()`

Executes a VTL statement while suppressing the returned value of the execution. This is useful if you wish to run methods without using temporary placeholders such as adding items to a map, etc. For example:

```
#set ($myMap = {})
#set($discard = $myMap.put("id", "first value"))
```

Becomes:

```
#set ($myMap = {})
$util.qr($myMap.put("id", "first value"))
```

`$util.escapeJavaScript(String) : String`

Returns the input string as a JavaScript escaped string.

`$util.urlEncode(String) : String`

Returns the input string as an `application/x-www-form-urlencoded` encoded string.

`$util.urlDecode(String) : String`

Decodes an `application/x-www-form-urlencoded` encoded string back to its non-encoded form.

`$util.base64Encode( byte[] ) : String`

Encodes the input into a base64-encoded string.

`$util.base64Decode(String) : byte[]`

Decodes the data from a base64-encoded string.

`$util.parseJson(String) : Object`

Takes "stringified" JSON and returns an object representation of the result.

`$util.toJson(Object) : String`

Takes an object and returns a "stringified" JSON representation of that object.

`$util.autoId() : String`

Returns a 128-bit randomly generated UUID.

`$util.unauthorized()`

Throws `Unauthorized` for the field being resolved. This can be used in request or response mapping templates to decide if the caller should be allowed to resolve the field.

`$util.error(String)`

Throws a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result.

`$util.error(String, String)`

Throws a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result. Additionally, an `errorType` can be specified.

`$util.error(String, String, Object)`

Throws a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result. Additionally, an `errorType` and a `data` field can be specified. The `data` value will be added to the corresponding `error` block inside `errors` in the GraphQL response. **Note**: `data` will be filtered based on the query selection set.

`$util.error(String, String, Object, Object)`

Throws a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result. Additionally, an `errorType` field, a `data` field, and a `errorInfo` field can be specified. The `data` value will be added to the corresponding `error` block inside `errors` in the GraphQL response. **Note**: `data` will be filtered based on the query selection set. The `errorInfo` value will be added to the corresponding `error` block inside `errors` in the GraphQL response. **Note**: `errorInfo` will **NOT** be filtered based on the query selection set.

`$util.appendError(String)`

Appends a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result. Unlike `$util.error(String)`, the template evaluation will not be interrupted, so that data can be returned to the caller.

`$util.appendError(String, String)`

Appends a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result. Additionally, an `errorType` can

be specified. Unlike `$util.error(String, String)`, the template evaluation will not be interrupted, so that data can be returned to the caller.

`$util.appendError(String, String, Object)`

Appends a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result. Additionally, an `errorType` and a `data` field can be specified. Unlike `$util.error(String, String, Object)`, the template evaluation will not be interrupted, so that data can be returned to the caller. The `data` value will be added to the corresponding `error` block inside `errors` in the GraphQL response. **Note**: `data` will be filtered based on the query selection set.

`$util.appendError(String, String, Object, Object)`

Appends a custom error. This can be used in request or response mapping templates if the template detects an error with the request or with the invocation result. Additionally, an `errorType` field, a `data` field, and a `errorInfo` field can be specified. Unlike `$util.error(String, String, Object, Object)`, the template evaluation will not be interrupted, so that data can be returned to the caller. The `data` value will be added to the corresponding `error` block inside `errors` in the GraphQL response. **Note**: `data` will be filtered based on the query selection set. The `errorInfo` value will be added to the corresponding `error` block inside `errors` in the GraphQL response. **Note**: `errorInfo` will **NOT** be filtered based on the query selection set.

`$util.validate(boolean, String) : void`

If the condition is false, throw a CustomTemplateException with the specified message.

`$util.validate(boolean, String, String) : void`

If the condition is false, throw a CustomTemplateException with the specified message and error type.

`$util.validate(boolean, String, String, Object) : void`

If the condition is false, throw a CustomTemplateException with the specified message and error type, as well as data to return in the response.

`$util.isNull(Object) : boolean`

Returns true if the supplied object is null.

`$util.isNullOrEmpty(String) : boolean`

Returns true if the supplied data is null or an empty string. Otherwise, returns false.

`$util.isNullOrBlank(String) : boolean`

Returns true if the supplied data is null or a blank string. Otherwise, returns false.

`$util.defaultIfNull(Object, Object) : Object`

Returns the first Object if it is not null. Otherwise, returns second object as a “default Object”.

`$util.defaultIfNullOrEmpty(String, String) : String`

Returns the first String if it is not null or empty. Otherwise, returns second String as a “default String”.

`$util.defaultIfNullOrBlank(String, String) : String`

Returns the first String if it is not null or blank. Otherwise, returns second String as a “default String”.

`$util.isString(Object) : boolean`

Returns true if Object is a String.

`$util.isNumber(Object) : boolean`

Returns true if Object is a Number.

`$util.isBoolean(Object) : boolean`

Returns true if Object is a Boolean.

`$util.isList(Object) : boolean`

Returns true if Object is a List.

`$util.isMap(Object) : boolean`

Returns true if Object is a Map.

`$util.typeOf(Object) : String`

Returns a String describing the type of the Object. Supported type identifications are: “Null”, “Number”, “String”, “Map”, “List”, “Boolean”. If a type cannot be identified, the return type is “Object”.

`$util.matches(String, String) : Boolean`

Returns true if the specified pattern in the first argument matches the supplied data in the second argument. The pattern must be a regular expression such as `$util.matches("a*b", "aaaaab")`. The functionality is based on Pattern, which you can reference for further documentation.

`$util.authType() : String`

Returns a String describing the multi-auth type being used by a request, returning back either "IAM Authorization", "User Pool Authorization", "Open ID Connect Authorization", or "API Key Authorization".

AWS AppSync directives

AppSync exposes directives to facilitate developer productivity when writing Velocity.

`#return(Object)` The `#return` directive comes handy if you need to return prematurely from any mapping template. `#return` is analogous to the *return* keyword in programming languages, as it will return from the closest scoped block of logic. What this means is using `#return` inside a resolver mapping template will return from the resolver. Additionally, using `#return` from a function mapping template will return from the function and will continue the execution to either the next function in the pipeline or the resolver response mapping template.

`#return` Same as `#return(Object)` but `null` will be returned instead.

Time helpers in $util.time

The `$util.time` variable contains datetime methods to help generate timestamps, convert between datetime formats, and parse datetime strings. The syntax for datetime formats is based on DateTimeFormatter which you can reference for further documentation. Below we provide some examples, as well as a list of available methods and descriptions.

Standalone function examples

```
$util.time.nowISO8601()                                          :
 2018-02-06T19:01:35.749Z
```

```
$util.time.nowEpochSeconds()                                          : 1517943695
$util.time.nowEpochMilliSeconds()                                     : 1517943695750
$util.time.nowFormatted("yyyy-MM-dd HH:mm:ssZ")                       : 2018-02-06
 19:01:35+0000
$util.time.nowFormatted("yyyy-MM-dd HH:mm:ssZ", "+08:00")             : 2018-02-07
 03:01:35+0800
$util.time.nowFormatted("yyyy-MM-dd HH:mm:ssZ", "Australia/Perth") : 2018-02-07
 03:01:35+0800
```

Conversion examples

```
#set( $nowEpochMillis = 1517943695758 )
$util.time.epochMilliSecondsToSeconds($nowEpochMillis)
  : 1517943695
$util.time.epochMilliSecondsToISO8601($nowEpochMillis)
  : 2018-02-06T19:01:35.758Z
$util.time.epochMilliSecondsToFormatted($nowEpochMillis, "yyyy-MM-dd HH:mm:ssZ")
  : 2018-02-06 19:01:35+0000
$util.time.epochMilliSecondsToFormatted($nowEpochMillis, "yyyy-MM-dd HH:mm:ssZ",
 "+08:00") : 2018-02-07 03:01:35+0800
```

Parsing examples

```
$util.time.parseISO8601ToEpochMilliSeconds("2018-02-01T17:21:05.180+08:00")
          : 1517476865180
$util.time.parseFormattedToEpochMilliSeconds("2018-02-02 01:19:22+0800", "yyyy-MM-dd
 HH:mm:ssZ")     : 1517505562000
$util.time.parseFormattedToEpochMilliSeconds("2018-02-02 01:19:22", "yyyy-MM-dd HH:mm:ss",
 "+08:00") : 1517505562000
```

Usage with AWS scalars

The following formats are compatible with `AWSDate`, `AWSDateTime`, and `AWSTime`.

```
$util.time.nowFormatted("yyyy-MM-dd[XXX]", "-07:00:30")               : 2018-07-11-07:00
$util.time.nowFormatted("yyyy-MM-dd'T'HH:mm:ss[XXXXX]", "-07:00:30")  :
 2018-07-11T15:14:15-07:00:30
```

`$util.time.nowISO8601() : String`

Returns a String representation of UTC in ISO8601 format.

`$util.time.nowEpochSeconds() : long`

Returns the number of seconds from the epoch of 1970-01-01T00:00:00Z to now.

`$util.time.nowEpochMilliSeconds() : long`

Returns the number of milliseconds from the epoch of 1970-01-01T00:00:00Z to now.

`$util.time.nowFormatted(String) : String`

Returns a string of the current timestamp in UTC using the specified format from a String input type.

`$util.time.nowFormatted(String, String) : String`

Returns a string of the current timestamp for a timezone using the specified format and timezone from String input types.

`$util.time.parseFormattedToEpochMilliSeconds(String, String) : Long`

Parses a timestamp passed as a String, along with a format, and return the timestamp as milliseconds since epoch.

`$util.time.parseFormattedToEpochMilliSeconds(String, String, String) : Long`

Parses a timestamp passed as a String, along with a format and time zone, and return the timestamp as milliseconds since epoch.

`$util.time.parseISO8601ToEpochMilliSeconds(String) : Long`

Parses an ISO8601 timestamp, passed as a String, and return the timestamp as milliseconds since epoch.

`$util.time.epochMilliSecondsToSeconds(long) : long`

Converts an epoch milliseconds timestamp to an epoch seconds timestamp.

`$util.time.epochMilliSecondsToISO8601(long) : String`

Converts a epoch milliseconds timestamp to an ISO8601 timestamp.

`$util.time.epochMilliSecondsToFormatted(long, String) : String`

Converts a epoch milliseconds timestamp, passed as long, to a timestamp formatted according to the supplied format in UTC.

`$util.time.epochMilliSecondsToFormatted(long, String, String) : String`

Converts a epoch milliseconds timestamp, passed as a long, to a timestamp formatted according to the supplied format in the supplied timezone.

List helpers in $util.list

`$util.list` contains methods to help with common List operations, such as removing or retaining items from a list for filtering use cases.

`$util.list.copyAndRetainAll(List, List) : List`

Makes a shallow copy of the supplied list in the first argument, retaining only the items specified in the second argument, if they are present. All other items will be removed from the copy.

`$util.list.copyAndRemoveAll(List, List) : List`

Makes a shallow copy of the supplied list in the first argument, removing any items where the item is specified in the second argument, if they are present. All other items will be retained in the copy.

`$util.list.sortList(List, Boolean, String) : List`

Sorts a list of objects, which is provided in the first argument. If the second argument is true, the list is sorted in a descending manner; if the second argument is false, the list is sorted in an ascending manner. The third argument is the string name of the property used to sort a list of custom objects. If it's a list of just Strings, Integers, Floats, or Doubles, the third argument can be any random string. If all of the objects are not from the same class, the original list is returned. Only lists containing a maximum of 1000 objects are supported. The following is an example of this utility's usage:

```
 INPUT:      $util.list.sortList([{"description":"youngest", "age":5},
{"description":"middle", "age":45}, {"description":"oldest", "age":85}], false,
 "description")
```

```
OUTPUT:     [{"description":"middle", "age":45}, {"description":"oldest", "age":85},
{"description":"youngest", "age":5}]
```

Map helpers in $util.map

`$util.map` contains methods to help with common Map operations, such as removing or retaining items from a Map for filtering use cases.

`$util.map.copyAndRetainAllKeys(Map, List) : Map`

Makes a shallow copy of the first map, retaining only the keys specified in the list, if they are present. All other keys will be removed from the copy.

`$util.map.copyAndRemoveAllKeys(Map, List) : Map`

Makes a shallow copy of the first map, removing any entries where the key is specified in the list, if they are present. All other keys will be retained in the copy.

DynamoDB helpers in $util.dynamodb

`$util.dynamodb` contains helper methods that make it easier to write and read data to Amazon DynamoDB, such as automatic type mapping and formatting. These methods are designed to make mapping primitive types and Lists to the proper DynamoDB input format automatically, which is a `Map` of the format `{ "TYPE" : VALUE }`.

For example, previously, a request mapping template to create a new item in DynamoDB might have looked like this:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key": {
        "id" : { "S" : "$util.autoId()" }
    },
    "attributeValues" : {
         "title" : { "S" : $util.toJson($ctx.args.title) },
         "author" : { "S" : $util.toJson($ctx.args.author) },
         "version" : { "N", $util.toJson($ctx.args.version) }
    }
}
```

If we wanted to add fields to the object we would have to update the GraphQL query in the schema, as well as the request mapping template. However, we can now restructure our request mapping template so it automatically picks up new fields added in our schema and adds them to DynamoDB with the correct types:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key": {
        "id" : $util.dynamodb.toDynamoDBJson($util.autoId())
    },
    "attributeValues" : $util.dynamodb.toMapValuesJson($ctx.args)
}
```

In the previous example, we are using the `$util.dynamodb.toDynamoDBJson(...)` helper to automatically take the generated id and convert it to the DynamoDB representation of a string attribute.

We then take all the arguments and convert them to their DynamoDB representations and output them to the `attributeValues` field in the template.

Each helper has two versions: a version that returns an object (for example, `$util.dynamodb.toString(...)`), and a version that returns the object as a JSON string (for example, `$util.dynamodb.toStringJson(...)`). In the previous example, we used the version that returns the data as a JSON string. If you want to manipulate the object before it's used in the template, you can choose to return an object instead, as shown following:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key": {
        "id" : $util.dynamodb.toDynamoDBJson($util.autoId())
    },

    #set( $myFoo = $util.dynamodb.toMapValues($ctx.args) )
    #set( $myFoo.version = $util.dynamodb.toNumber(1) )
    #set( $myFoo.timestamp = $util.dynamodb.toString($util.time.nowISO8601()))

    "attributeValues" : $util.toJson($myFoo)
}
```

In the previous example, we are returning the converted arguments as a map instead of a JSON string, and are then adding the `version` and `timestamp` fields before finally outputting them to the `attributeValues` field in the template using `$util.toJson(...)`.

The JSON version of each of the helpers is equivalent to wrapping the non-JSON version in `$util.toJson(...)`. For example, the following statements are exactly the same:

```
$util.toStringJson("Hello, World!")
$util.toJson($util.toString("Hello, World!"))
```

`$util.dynamodb.toDynamoDB(Object) : Map`

General object conversion tool for DynamoDB that converts input objects to the appropriate DynamoDB representation. It's opinionated about how it represents some types: e.g., it will use lists ("L") rather than sets ("SS", "NS", "BS"). This returns an object that describes the DynamoDB attribute value.

String example:

```
Input:      $util.dynamodb.toDynamoDB("foo")
Output:     { "S" : "foo" }
```

Number example:

```
Input:      $util.dynamodb.toDynamoDB(12345)
Output:     { "N" : 12345 }
```

Boolean example:

```
Input:      $util.dynamodb.toDynamoDB(true)
Output:     { "BOOL" : true }
```

List example:

```
Input:      $util.dynamodb.toDynamoDB([ "foo", 123, { "bar" : "baz" } ])
Output:     {
               "L" : [
                   { "S" : "foo" },
                   { "N" : 123 },
                   {
                       "M" : {
                           "bar" : { "S" : "baz" }
                       }
                   }
               ]
           }
```

Map example:

```
Input:      $util.dynamodb.toDynamoDB({ "foo": "bar", "baz" : 1234, "beep":
 [ "boop"] })
Output:     {
               "M" : {
                   "foo"  : { "S" : "bar" },
                   "baz"  : { "N" : 1234 },
                   "beep" : {
                       "L" : [
                           { "S" : "boop" }
                       ]
                   }
               }
           }
```

`$util.dynamodb.toDynamoDBJson(Object) : String`

The same as `$util.dynamodb.toDynamoDB(Object) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

`$util.dynamodb.toString(String) : String`

Convert an input string to the DynamoDB string format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toString("foo")
Output:     { "S" : "foo" }
```

`$util.dynamodb.toStringJson(String) : Map`

The same as `$util.dynamodb.toString(String) : String`, but returns the DynamoDB attribute value as a JSON encoded string.

`$util.dynamodb.toStringSet(List<String>) : Map`

Converts a lists with Strings to the DynamoDB string set format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toStringSet([ "foo", "bar", "baz" ])
Output:     { "SS" : [ "foo", "bar", "baz" ] }
```

`$util.dynamodb.toStringSetJson(List<String>) : String`

The same as `$util.dynamodb.toStringSet(List<String>) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toNumber(Number) : Map

Converts a number to the DynamoDB number format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toNumber(12345)
Output:     { "N" : 12345 }
```

$util.dynamodb.toNumberJson(Number) : String

The same as `$util.dynamodb.toNumber(Number) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toNumberSet(List<Number>) : Map

Converts a list of numbers to the DynamoDB number set format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toNumberSet([ 1, 23, 4.56 ])
Output:     { "NS" : [ 1, 23, 4.56 ] }
```

$util.dynamodb.toNumberSetJson(List<Number>) : String

The same as `$util.dynamodb.toNumberSet(List<Number>) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toBinary(String) : Map

Converts binary data encoded as a base64 string to DynamoDB binary format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toBinary("foo")
Output:     { "B" : "foo" }
```

$util.dynamodb.toBinaryJson(String) : String

The same as `$util.dynamodb.toBinary(String) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toBinarySet(List<String>) : Map

Converts a list of binary data encoded as base64 strings to DynamoDB binary set format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toBinarySet([ "foo", "bar", "baz" ])
Output:     { "BS" : [ "foo", "bar", "baz" ] }
```

$util.dynamodb.toBinarySetJson(List<String>) : String

The same as `$util.dynamodb.toBinarySet(List<String>) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toBoolean(boolean) : Map

Converts a boolean to the appropriate DynamoDB boolean format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toBoolean(true)
```

```
Output:     { "BOOL" : true }
```

$util.dynamodb.toBooleanJson(boolean) : String

The same as `$util.dynamodb.toBoolean(boolean) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toNull() : Map

Returns a null in DynamoDB null format. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toNull()
Output:     { "NULL" : null }
```

$util.dynamodb.toNullJson() : String

The same as `$util.dynamodb.toNull() : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toList(List) : Map

Converts a list of object to DynamoDB list format. Each item in the list is also converted to its appropriate DynamoDB format. It's opinionated about how it represents some of the nested objects: e.g., it will use lists ("L") rather than sets ("SS", "NS", "BS"). This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toList([ "foo", 123, { "bar" : "baz" } ])
Output:     {
               "L" : [
                   { "S" : "foo" },
                   { "N" : 123 },
                   {
                       "M" : {
                           "bar" : { "S" : "baz" }
                       }
                   }
               ]
           }
```

$util.dynamodb.toListJson(List) : String

The same as `$util.dynamodb.toList(List) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toMap(Map) : Map

Converts a map to DynamoDB map format. Each value in the map is also converted to its appropriate DynamoDB format. It's opinionated about how it represents some of the nested objects: e.g., it will use lists ("L") rather than sets ("SS", "NS", "BS"). This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toMap({ "foo": "bar", "baz" : 1234, "beep": [ "boop"] })
Output:     {
               "M" : {
                   "foo"  : { "S" : "bar" },
                   "baz"  : { "N" : 1234 },
                   "beep" : {
                       "L" : [
                           { "S" : "boop" }
                       ]
```

```
                    }
                }
            }
```

$util.dynamodb.toMapJson(Map) : String

The same as `$util.dynamodb.toMap(Map) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toMapValues(Map) : Map

Creates a copy of the map where each value has been converted to its appropriate DynamoDB format. It's opinionated about how it represents some of the nested objects: e.g., it will use lists ("L") rather than sets ("SS", "NS", "BS").

```
Input:      $util.dynamodb.toMapValues({ "foo": "bar", "baz" : 1234, "beep":
 [ "boop"] })
Output:     {
               "foo"  : { "S" : "bar" },
               "baz"  : { "N" : 1234 },
               "beep" : {
                   "L" : [
                       { "S" : "boop" }
                   ]
               }
           }
```

Note: this is slightly different to `$util.dynamodb.toMap(Map) : Map` as it returns only the contents of the DynamoDB attribute value, but not the whole attribute value itself. For example, the following statements are exactly the same:

```
$util.dynamodb.toMapValues($map)
$util.dynamodb.toMap($map).get("M")
```

$util.dynamodb.toMapValuesJson(Map) : String

The same as `$util.dynamodb.toMapValues(Map) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toS3Object(String key, String bucket, String region) : Map

Converts the key, bucket and region into the DynamoDB S3 Object representation. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toS3Object("foo", "bar", region = "baz")
Output:     { "S" : "{ \"s3\" : { \"key\" : \"foo", \"bucket\" : \"bar", \"region\" :
 \"baz" } }" }
```

$util.dynamodb.toS3ObjectJson(String key, String bucket, String region) : String

The same as `$util.dynamodb.toS3Object(String key, String bucket, String region) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

$util.dynamodb.toS3Object(String key, String bucket, String region, String version) : Map

Converts the key, bucket, region and optional version into the DynamoDB S3 Object representation. This returns an object that describes the DynamoDB attribute value.

```
Input:      $util.dynamodb.toS3Object("foo", "bar", "baz", "beep")
Output:     { "S" : "{ \"s3\" : { \"key\" : \"foo\", \"bucket\" : \"bar\", \"region\" :
 \"baz\", \"version\" = \"beep\" } }" }
```

`$util.dynamodb.toS3ObjectJson(String key, String bucket, String region, String version) : String`

The same as `$util.dynamodb.toS3Object(String key, String bucket, String region, String version) : Map`, but returns the DynamoDB attribute value as a JSON encoded string.

`$util.dynamodb.fromS3ObjectJson(String) : Map`

Accepts the string value of a DynamoDB S3 Object and returns a map that contains the key, bucket, region and optional version.

```
Input:      $util.dynamodb.fromS3ObjectJson({ "S" : "{ \"s3\" : { \"key\" : \"foo\",
 \"bucket\" : \"bar\", \"region\" : \"baz\", \"version\" = \"beep\" } }" })
Output:     { "key" : "foo", "bucket" : "bar", "region" : "baz", "version" : "beep" }
```

RDS helpers in $util.rds

`$util.rds.toJsonString(String serializedSQLResult): String`

Returns a `String` by transforming the *stringified* raw RDS Data API result format to a more concise string. The returning string is a serialized list of lists of SQL records of the result set. Every record is represented as a collection of key-value pairs. The keys are the corresponding column names.

An empty list is returned if the corresponding statement in the input was a SQL query that would cause a mutation (for example INSERT, UPDATE, DELETE). For example, the query `select * from Books limit 2` provides the raw result from the RDS Data API:

```
{
    "sqlStatementResults": [
        {
            "numberOfRecordsUpdated": 0,
            "records": [
                [
                    {
                        "stringValue": "Mark Twain"
                    },
                    {
                        "stringValue": "Adventures of Huckleberry Finn"
                    },
                    {
                        "stringValue": "978-1948132817"
                    }
                ],
                [
                    {
                        "stringValue": "Jack London"
                    },
                    {
                        "stringValue": "The Call of the Wild"
                    },
                    {
                        "stringValue": "978-1948132275"
                    }
                ]
```

```
            ],
            "columnMetadata": [
                {
                    "isSigned": false,
                    "isCurrency": false,
                    "label": "author",
                    "precision": 200,
                    "typeName": "VARCHAR",
                    "scale": 0,
                    "isAutoIncrement": false,
                    "isCaseSensitive": false,
                    "schemaName": "",
                    "tableName": "Books",
                    "type": 12,
                    "nullable": 0,
                    "arrayBaseColumnType": 0,
                    "name": "author"
                },
                {
                    "isSigned": false,
                    "isCurrency": false,
                    "label": "title",
                    "precision": 200,
                    "typeName": "VARCHAR",
                    "scale": 0,
                    "isAutoIncrement": false,
                    "isCaseSensitive": false,
                    "schemaName": "",
                    "tableName": "Books",
                    "type": 12,
                    "nullable": 0,
                    "arrayBaseColumnType": 0,
                    "name": "title"
                },
                {
                    "isSigned": false,
                    "isCurrency": false,
                    "label": "ISBN-13",
                    "precision": 15,
                    "typeName": "VARCHAR",
                    "scale": 0,
                    "isAutoIncrement": false,
                    "isCaseSensitive": false,
                    "schemaName": "",
                    "tableName": "Books",
                    "type": 12,
                    "nullable": 0,
                    "arrayBaseColumnType": 0,
                    "name": "ISBN-13"
                }
            ]
        }
    ]
}
```

The `utils.rds.toJsonString` will be:

```
[
  {
    "author": "Mark Twain",
    "title": "Adventures of Huckleberry Finn",
    "ISBN-13": "978-1948132817"
  },
  {
    "author": "Jack London",
```

```
    "title": "The Call of the Wild",
    "ISBN-13": "978-1948132275"
  },
]
```

`$util.rds.toJsonObject(String serializedSQLResult): Object`

Same as `utils.rds.toJsonString` but with the result to be a JSON `Object`.

HTTP helpers in $utils.http

`$utils.http` contains helper methods that make it easier to deal with http request parameters.

`$utils.http.copyHeaders(Map) : Map`

Copies the header from the map without the restricted set of HTTP header. This is useful for forwarding Request headers to your downstream HTTP endpoint.

```
{
    ...
    "params": {
        ...
        "headers": $utils.http.copyHeaders($ctx.request.headers),
        ...
    },
    ...
}
```

XML helpers in $utils.xml

`$utils.xml` contains helper methods that make it easier to translate XML responses to JSON or a Dictionary.

`$utils.xml.toMap(String) : Map`

Converts an XML String to a Dictionary.

```
Input:

<?xml version="1.0" encoding="UTF-8"?>
<posts>
<post>
  <id>1</id>
  <title>Getting Started with GraphQL</title>
</post>
</posts>

Output (JSON representation):

{
  "posts":{
    "post":{
      "id":1,
      "title":"Getting Started with GraphQL"
    }
  }
}
```

```
Input:

<?xml version="1.0" encoding="UTF-8"?>
<posts>
<post>
  <id>1</id>
  <title>Getting Started with GraphQL</title>
</post>
<post>
  <id>2</id>
  <title>Getting Started with AWS AppSync</title>
</post>
</posts>

Output (JSON representation):

{
  "posts":{
    "post":[
        {
          "id":1,
          "title":"Getting Started with GraphQL"
        },
        {
          "id":2,
          "title":"Getting Started with AWS AppSync"
        }
    ]
  }
}
```

`$utils.xml.toJsonString(String) : String`

Converts an XML string to a JSON string. This is similar to *toMap* except that the output is a string. This is useful if you want to directly convert and return the XML response from an HTTP object to JSON.

`$utils.xml.toJsonString(String, boolean) : String`

Converts an XML string to a JSON string with an optional boolean parameter to determine if you want to string encode the JSON.

Transformation helpers in $utils.transform

`$utils.transform` contains helper methods that make it easier to perform complex operations against data sources, such as Amazon DynamoDB filter operations.

`$util.transform.toDynamoDBFilterExpression(Map) : Map`

Converts an input string to a filter expression for use with Amazon DynamoDB.

```
Input:

$util.transform.toDynamoDBFilterExpression({
    "title":{
      "contains":"Hello World"
    }
  })

Output:
```

```
{
    "expression" : "contains(#title, :title_contains)"
    "expressionNames" : {
        "#title" : "title",
    },
    "expressionValues" : {
        ":title_contains" : { "S" : "Hello World" }
    },
}
```

`$util.transform.toElasticsearchQueryDSL(Map) : Map`

Converts the given input into its equivalent Elasticsearch Query DSL expression, returning it as a JSON string.

```
Input:

$util.transform.toElasticsearchQueryDSL({
    "upvotes":{
        "ne":15,
        "range":[
            10,
            20
        ]
    },
    "title":{
        "eq":"hihihi",
        "wildcard":"h*i"
    }
  })

Output:
{
    "bool":{
      "must":[
          {
            "bool":{
              "must":[
                  {
                    "bool":{
                      "must_not":{
                        "term":{
                          "upvotes":15
                        }
                      }
                    }
                  },
                  {
                    "range":{
                      "upvotes":{
                        "gte":10,
                        "lte":20
                      }
                    }
                  }
              ]
            }
          },
          {
            "bool":{
              "must":[
                  {
                    "term":{
                      "title":"hihihi"
```

```
                    }
                  },
                  {
                  "wildcard":{
                      "title":"h*i"
                    }
                  }
              ]
            }
          }
      ]
    }
}
```

The default Operator is assumed to be AND.

Math helpers in $util.math

`$util.math` contains methods to help with common Math operations.

`$util.math.roundNum(Double) : Integer`

Takes a double and rounds it to the nearest integer.

`$util.math.minVal(Double, Double) : Double`

Takes two doubles and returns the minimum value between the two doubles.

`$util.math.maxVal(Double, Double) : Double`

Takes two doubles and returns the maximum value between the two doubles.

`$util.math.randomDouble() : Double`

Returns a random double between 0 and 1.

> **Important**
> This function shouldn't be used for anything that needs high entropy randomness (for example, cryptography).

`$util.math.randomWithinRange(Integer, Integer) : Integer`

Returns a random integer value within the specified range, with the first argument specifying the lower value of the range and the second argument specifying the upper value of the range.

> **Important**
> This function shouldn't be used for anything that needs high entropy randomness (for example, cryptography).

String helpers in $util.str

`$util.str` contains methods to help with common String operations.

`$util.str.toUpper(String) : String`

Takes a string and converts it to be entirely uppercase.

`$util.str.toLower(String) : String`

Takes a string and converts it to be entirely lowercase.

`$util.str.toReplace(String, String, String) : String`

Replaces a substring within a string with another string. The first argument specifies the string on which to perform the replacement operation. The second argument specifies the substring to replace. The third argument specifies the string to replace the second argument with. The following is an example of this utility's usage:

```
INPUT:      $util.str.toReplace("hello world", "hello", "mellow")
OUTPUT:     "mellow world"
```

`$util.str.normalize(String, String) : String`

Normalizes a string using one of the four unicode normalization forms: NFC, NFD, NFKC, or NFKD. The first argument is the string to normalize. The second argument is either "nfc", "nfd", "nfkc", or "nfkd" specifying the normalization type to use for the normalization process.

Resolver Mapping Template Reference for DynamoDB

The AWS AppSync DynamoDB resolver enables you to use GraphQL to store and retrieve data in existing Amazon DynamoDB tables in your account. This resolver works by enabling you to map an incoming GraphQL request into a DynamoDB call, and then map the DynamoDB response back to GraphQL. This section describes the mapping templates for supported DynamoDB operations.

Topics

GetItem

The `GetItem` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `GetItem` request to DynamoDB, and enables you to specify:

- The key of the item in DynamoDB
- Whether to use a consistent read or not

The `GetItem` mapping document has the following structure:

```
{
    "version" : "2017-02-28",
    "operation" : "GetItem",
    "key" : {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "consistentRead" : true
}
```

The fields are defined as follows:

`version`

The template definition version. `2017-02-28` and `2018-05-29` are currently supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `GetItem` DynamoDB operation, this must be set to `GetItem`. This value is required.

`key`

The key of the item in DynamoDB. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This value is required.

`consistentRead`

Whether or not to perform a strongly consistent read with DynamoDB. This is optional, and defaults to `false`.

The item returned from DynamoDB is automatically converted into GraphQL and JSON primitive types, and is available in the mapping context (`$context.result`).

For more information about DynamoDB type conversion, see Type System (Response Mapping) (p. 301).

For more information about response mapping templates, see Resolver Mapping Template Overview (p. 226).

Example

Following is a mapping template for a GraphQL query `getThing(foo: String!, bar: String!)`:

```
{
    "version" : "2017-02-28",
    "operation" : "GetItem",
    "key" : {
        "foo" : $util.dynamodb.toDynamoDBJson($ctx.args.foo),
        "bar" : $util.dynamodb.toDynamoDBJson($ctx.args.bar)
    },
    "consistentRead" : true
```

```
}
```

For more information about the DynamoDB `GetItem` API, see the DynamoDB API documentation.

PutItem

The `PutItem` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `PutItem` request to DynamoDB, and enables you to specify the following:

- The key of the item in DynamoDB
- The full contents of the item (composed of `key` and `attributeValues`)
- Conditions for the operation to succeed

The `PutItem` mapping document has the following structure:

```
{
    "version" : "2018-05-29",
    "operation" : "PutItem",
    "key": {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "attributeValues" : {
        "baz" : ... typed value
    },
    "condition" : {
       ...
    },
    "_version" : 1
}
```

The fields are defined as follows:

`version`

The template definition version. `2017-02-28` and `2018-05-29` are currently supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `PutItem` DynamoDB operation, this must be set to `PutItem`. This value is required.

`key`

The key of the item in DynamoDB. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This value is required.

`attributeValues`

The rest of the attributes of the item to be put into DynamoDB. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This field is optional.

`condition`

A condition to determine if the request should succeed or not, based on the state of the object already in DynamoDB. If no condition is specified, the `PutItem` request overwrites any existing entry for that item. For more information about conditions, see Condition Expressions (p. 304). This value is optional.

`_version`

A numeric value that represents the latest known version of an item. This value is optional. This field is used for *Conflict Detection* and is only supported on versioned data sources.

The item written to DynamoDB is automatically converted into GraphQL and JSON primitive types and is available in the mapping context (`$context.result`).

For more information about DynamoDB type conversion, see Type System (Response Mapping) (p. 301).

For more information about response mapping templates, see Resolver Mapping Template Overview (p. 226).

Example 1

Following is a mapping template for a GraphQL mutation `updateThing(foo: String!, bar: String!, name: String!, version: Int!)`.

If no item with the specified key exists, it's created. If an item already exists with the specified key, it's overwritten.

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key": {
        "foo" : $util.dynamodb.toDynamoDBJson($ctx.args.foo),
        "bar" : $util.dynamodb.toDynamoDBJson($ctx.args.bar)
    },
    "attributeValues" : {
        "name"    : $util.dynamodb.toDynamoDBJson($ctx.args.name),
        "version" : $util.dynamodb.toDynamoDBJson($ctx.args.version)
    }
}
```

Example 2

Following is a mapping template for a GraphQL mutation `updateThing(foo: String!, bar: String!, name: String!, expectedVersion: Int!)`.

This example checks to be sure the item currently in DynamoDB has the `version` field set to `expectedVersion`.

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key": {
        "foo" : $util.dynamodb.toDynamoDBJson($ctx.args.foo),
        "bar" : $util.dynamodb.toDynamoDBJson($ctx.args.bar)
    },
    "attributeValues" : {
        "name"    : $util.dynamodb.toDynamoDBJson($ctx.args.name),
        #set( $newVersion = $context.arguments.expectedVersion + 1 )
        "version" : $util.dynamodb.toDynamoDBJson($newVersion)
    },
    "condition" : {
        "expression" : "version = :expectedVersion",
        "expressionValues" : {
            ":expectedVersion" : $util.dynamodb.toDynamoDBJson($expectedVersion)
        }
    }
```

```
}
```

For more information about the DynamoDB `PutItem` API, see the DynamoDB API documentation.

UpdateItem

The `UpdateItem` request mapping document enables you to tell the AWS AppSync DynamoDB resolver to make a `UpdateItem` request to DynamoDB, and allows you to specify the following:

- The key of the item in DynamoDB
- An update expression describing how to update the item in DynamoDB
- Conditions for the operation to succeed

The `UpdateItem` mapping document has the following structure:

```
{
    "version" : "2018-05-29",
    "operation" : "UpdateItem",
    "key": {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "update" : {
        "expression" : "someExpression"
        "expressionNames" : {
           "#foo" : "foo"
       },
       "expressionValues" : {
           ":bar" : ... typed value
       }
    },
    "condition" : {
        ...
    },
    "_version" : 1
}
```

The fields are defined as follows:

`version`

The template definition version. `2017-02-28` and `2018-05-29` are currently supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `UpdateItem` DynamoDB operation, this must be set to `UpdateItem`. This value is required.

`key`

The key of the item in DynamoDB. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about specifying a “typed value”, see Type System (Request Mapping) (p. 297). This value is required.

`update`

The `update` section lets you specify an update expression that describes how to update the item in DynamoDB. For more information about how to write update expressions, see the DynamoDB UpdateExpressions documentation . This section is required.

The `update` section has three components:

`expression`

The update expression. This value is required.

`expressionNames`

The substitutions for expression attribute *name* placeholders, in the form of key-value pairs. The key corresponds to a name placeholder used in the `expression`, and the value must be a string corresponding to the attribute name of the item in DynamoDB. This field is optional, and should only be populated with substitutions for expression attribute name placeholders used in the `expression`.

`expressionValues`

The substitutions for expression attribute *value* placeholders, in the form of key-value pairs. The key corresponds to a value placeholder used in the `expression`, and the value must be a typed value. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This must be specified. This field is optional, and should only be populated with substitutions for expression attribute value placeholders used in the `expression`.

`condition`

A condition to determine if the request should succeed or not, based on the state of the object already in DynamoDB. If no condition is specified, the `UpdateItem` request updates the existing entry regardless of its current state. For more information about conditions, see Condition Expressions (p. 304). This value is optional.

`_version`

A numeric value that represents the latest known version of an item. This value is optional. This field is used for *Conflict Detection* and is only supported on versioned data sources.

The item updated in DynamoDB is automatically converted into GraphQL and JSON primitive types and is available in the mapping context (`$context.result`).

For more information about DynamoDB type conversion, see Type System (Response Mapping) (p. 301).

For more information about response mapping templates, see Resolver Mapping Template Overview (p. 226).

Example 1

Following is a mapping template for the GraphQL mutation `upvote(id: ID!)`.

In this example, an item in DynamoDB has its `upvotes` and `version` fields incremented by 1.

```
{
    "version" : "2017-02-28",
    "operation" : "UpdateItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    },
    "update" : {
        "expression" : "ADD #votefield :plusOne, version :plusOne",
        "expressionNames" : {
            "#votefield" : "upvotes"
        },
        "expressionValues" : {
            ":plusOne" : { "N" : 1 }
        }
    }
```

```
}
```

Example 2

Following is a mapping template for a GraphQL mutation `updateItem(id: ID!, title: String, author: String, expectedVersion: Int!)`.

This is a complex example that inspects the arguments and dynamically generates the update expression that only includes the arguments that have been provided by the client. For example, if `title` and `author` are omitted, they are not updated. If an argument is specified but its value is `null`, then that field is deleted from the object in DynamoDB. Finally, the operation has a condition, which verifies whether the item currently in DynamoDB has the `version` field set to `expectedVersion`:

```
{
    "version" : "2017-02-28",

    "operation" : "UpdateItem",

    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    },

    ## Set up some space to keep track of things we're updating **
    #set( $expNames  = {} )
    #set( $expValues = {} )
    #set( $expSet = {} )
    #set( $expAdd = {} )
    #set( $expRemove = [] )

    ## Increment "version" by 1 **
    $!{expAdd.put("version", ":newVersion")}
    $!{expValues.put(":newVersion", { "N" : 1 })}

    ## Iterate through each argument, skipping "id" and "expectedVersion" **
    #foreach( $entry in $context.arguments.entrySet() )
        #if( $entry.key != "id" && $entry.key != "expectedVersion" )
            #if( (!$entry.value) && ("$!{entry.value}" == "") )
                ## If the argument is set to "null", then remove that attribute from the
 item in DynamoDB **

                #set( $discard = ${expRemove.add("#${entry.key}")} )
                $!{expNames.put("#${entry.key}", "$entry.key")}
            #else
                ## Otherwise set (or update) the attribute on the item in DynamoDB **

                $!{expSet.put("#${entry.key}", ":${entry.key}")}
                $!{expNames.put("#${entry.key}", "$entry.key")}

                #if( $entry.key == "ups" || $entry.key == "downs" )
                    $!{expValues.put(":${entry.key}", { "N" : $entry.value })}
                #else
                    $!{expValues.put(":${entry.key}", { "S" : "${entry.value}" })}
                #end
            #end
        #end
    #end

    ## Start building the update expression, starting with attributes we're going to SET **
    #set( $expression = "" )
    #if( !${expSet.isEmpty()} )
        #set( $expression = "SET" )
        #foreach( $entry in $expSet.entrySet() )
            #set( $expression = "${expression} ${entry.key} = ${entry.value}" )
```

```
            #if ( $foreach.hasNext )
                #set( $expression = "${expression}," )
            #end
        #end
    #end

    ## Continue building the update expression, adding attributes we're going to ADD **
    #if( !${expAdd.isEmpty()} )
        #set( $expression = "${expression} ADD" )
        #foreach( $entry in $expAdd.entrySet() )
            #set( $expression = "${expression} ${entry.key} ${entry.value}" )
            #if ( $foreach.hasNext )
                #set( $expression = "${expression}," )
            #end
        #end
    #end

    ## Continue building the update expression, adding attributes we're going to REMOVE **
    #if( !${expRemove.isEmpty()} )
        #set( $expression = "${expression} REMOVE" )

        #foreach( $entry in $expRemove )
            #set( $expression = "${expression} ${entry}" )
            #if ( $foreach.hasNext )
                #set( $expression = "${expression}," )
            #end
        #end
    #end

    ## Finally, write the update expression into the document, along with any
 expressionNames and expressionValues **
    "update" : {
        "expression" : "${expression}"
        #if( !${expNames.isEmpty()} )
            ,"expressionNames" : $utils.toJson($expNames)
        #end
        #if( !${expValues.isEmpty()} )
            ,"expressionValues" : $utils.toJson($expValues)
        #end
    },

    "condition" : {
        "expression"       : "version = :expectedVersion",
        "expressionValues" : {
            ":expectedVersion" : $util.dynamodb.toDynamoDBJson($ctx.args.expectedVersion)
        }
    }
}
```

For more information about the DynamoDB `UpdateItem` API, see the DynamoDB API documentation.

DeleteItem

The `DeleteItem` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `DeleteItem` request to DynamoDB, and enables you to specify the following:

- The key of the item in DynamoDB
- Conditions for the operation to succeed

The `DeleteItem` mapping document has the following structure:

```
{
```

```
    "version" : "2018-05-29",
    "operation" : "DeleteItem",
    "key": {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "condition" : {
        ...
    },
    "_version" : 1
}
```

The fields are defined as follows:

`version`

The template definition version. `2017-02-28` and `2018-05-29` are currently supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `DeleteItem` DynamoDB operation, this must be set to `DeleteItem`. This value is required.

`key`

The key of the item in DynamoDB. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about specifying a "typed value", see Type System (Request Mapping) (p. 297). This value is required.

`condition`

A condition to determine if the request should succeed or not, based on the state of the object already in DynamoDB. If no condition is specified, the `DeleteItem` request deletes an item regardless of its current state. For more information about conditions, see Condition Expressions (p. 304). This value is optional.

`_version`

A numeric value that represents the latest known version of an item. This value is optional. This field is used for *Conflict Detection* and is only supported on versioned data sources.

The item deleted from DynamoDB is automatically converted into GraphQL and JSON primitive types and is available in the mapping context (`$context.result`).

For more information about DynamoDB type conversion, see Type System (Response Mapping) (p. 301).

For more information about response mapping templates, see Resolver Mapping Template Overview (p. 226).

Example 1

Following is a mapping template for a GraphQL mutation `deleteItem(id: ID!)`. If an item exists with this ID, it's deleted.

```
{
    "version" : "2017-02-28",
    "operation" : "DeleteItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    }
```

```
}
```

Example 2

Following is a mapping template for a GraphQL mutation `deleteItem(id: ID!, expectedVersion: Int!)`. If an item exists with this ID, it's deleted, but only if its `version` field set to `expectedVersion`:

```
{
    "version" : "2017-02-28",
    "operation" : "DeleteItem",
    "key" : {
        "id" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    },
    "condition" : {
        "expression"       : "attribute_not_exists(id) OR version = :expectedVersion",
        "expressionValues" : {
            ":expectedVersion" : $util.dynamodb.toDynamoDBJson($expectedVersion)
        }
    }
}
```

For more information about the DynamoDB `DeleteItem` API, see the DynamoDB API documentation.

Query

The `Query` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `Query` request to DynamoDB, and enables you to specify the following:

- Key expression
- Which index to use
- Any additional filter
- How many items to return
- Whether to use consistent reads
- query direction (forward or backward)
- Pagination token

The `Query` mapping document has the following structure:

```
{
    "version" : "2017-02-28",
    "operation" : "Query",
    "query" : {
        "expression" : "some expression",
        "expressionNames" : {
            "#foo" : "foo"
        },
        "expressionValues" : {
            ":bar" : ... typed value
        }
    },
    "index" : "fooIndex",
    "nextToken" : "a pagination token",
    "limit" : 10,
    "scanIndexForward" : true,
    "consistentRead" : false,
```

```
    "select" : "ALL_ATTRIBUTES",
    "filter" : {
        ...
    }
}
```

The fields are defined as follows:

`version`

The template definition version. `2017-02-28` and `2018-05-29` are currently supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `Query` DynamoDB operation, this must be set to `Query`. This value is required.

`query`

The `query` section lets you specify a key condition expression that describes which items to retrieve from DynamoDB. For more information about how to write key condition expressions, see the DynamoDB KeyConditions documentation . This section must be specified.

`expression`

The query expression. This field must be specified.

`expressionNames`

The substitutions for expression attribute *name* placeholders, in the form of key-value pairs. The key corresponds to a name placeholder used in the `expression`, and the value must be a string corresponding to the attribute name of the item in DynamoDB. This field is optional, and should only be populated with substitutions for expression attribute name placeholders used in the `expression`.

`expressionValues`

The substitutions for expression attribute *value* placeholders, in the form of key-value pairs. The key corresponds to a value placeholder used in the `expression`, and the value must be a typed value. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This value is required. This field is optional, and should only be populated with substitutions for expression attribute value placeholders used in the `expression`.

`filter`

An additional filter that can be used to filter the results from DynamoDB before they are returned. For more information about filters, see Filters (p. 304). This field is optional.

`index`

The name of the index to query. The DynamoDB query operation allows you to scan on Local Secondary Indexes and Global Secondary Indexes in addition to the primary key index for a hash key. If specified, this tells DynamoDB to query the specified index. If omitted, the primary key index is queried.

`nextToken`

The pagination token to continue a previous query. This would have been obtained from a previous query. This field is optional.

`limit`

The maximum number of items to evaluate (not necessarily the number of matching items). This field is optional.

scanIndexForward

A boolean indicating whether to query forwards or backwards. This field is optional, and defaults to `true`.

consistentRead

A boolean indicating whether to use consistent reads when querying DynamoDB. This field is optional, and defaults to `false`.

select

By default, the AWS AppSync DynamoDB resolver only returns attributes that are projected into the index. If more attributes are required, you can set this field. This field is optional. The supported values are:

ALL_ATTRIBUTES

Returns all of the item attributes from the specified table or index. If you query a local secondary index, DynamoDB fetches the entire item from the parent table for each matching item in the index. If the index is configured to project all item attributes, all of the data can be obtained from the local secondary index and no fetching is required.

ALL_PROJECTED_ATTRIBUTES

Allowed only when querying an index. Retrieves all attributes that have been projected into the index. If the index is configured to project all attributes, this return value is equivalent to specifying `ALL_ATTRIBUTES`.

The results from DynamoDB are automatically converted into GraphQL and JSON primitive types and are available in the mapping context (`$context.result`).

For more information about DynamoDB type conversion, see Type System (Response Mapping) (p. 301).

For more information about response mapping templates, see Resolver Mapping Template Overview (p. 226).

The results have the following structure:

```
{
    items = [ ... ],
    nextToken = "a pagination token",
    scannedCount = 10
}
```

The fields are defined as follows:

items

A list containing the items returned by the DynamoDB query.

nextToken

If there might be more results, `nextToken` contains a pagination token that you can use in another request. Note that AWS AppSync encrypts and obfuscates the pagination token returned from DynamoDB. This prevents your table data from being inadvertently leaked to the caller. Also note that these pagination tokens cannot be used across different resolvers.

scannedCount

The number of items that matched the query condition expression, before a filter expression (if present) was applied.

Example

Following is a mapping template for a GraphQL query `getPosts(owner: ID!)`.

In this example, a global secondary index on a table is queried to return all posts owned by the specified ID.

```
{
    "version" : "2017-02-28",
    "operation" : "Query",
    "query" : {
        "expression" : "ownerId = :ownerId",
        "expressionValues" : {
            ":ownerId" : $util.dynamodb.toDynamoDBJson($context.arguments.owner)
        }
    }
    "index" : "owner-index"
}
```

For more information about the DynamoDB `Query` API, see the DynamoDB API documentation.

Scan

The `Scan` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `Scan` request to DynamoDB, and enables you to specify the following:

- A filter to exclude results
- Which index to use
- How many items to return
- Whether to use consistent reads
- Pagination token
- Parallel scans

The `Scan` mapping document has the following structure:

```
{
    "version" : "2017-02-28",
    "operation" : "Scan",
    "index" : "fooIndex",
    "limit" : 10,
    "consistentRead" : false,
    "nextToken" : "aPaginationToken",
    "totalSegments" : 10,
    "segment" : 1,
    "filter" : {
        ...
    }
}
```

The fields are defined as follows:

`version`

The template definition version. `2017-02-28` and `2018-05-29` are currently supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `Scan` DynamoDB operation, this must be set to `Scan`. This value is required.

`filter`

A filter that can be used to filter the results from DynamoDB before they are returned. For more information about filters, see Filters (p. 304). This field is optional.

`index`

The name of the index to query. The DynamoDB query operation allows you to scan on Local Secondary Indexes and Global Secondary Indexes in addition to the primary key index for a hash key. If specified, this tells DynamoDB to query the specified index. If omitted, the primary key index is queried.

`limit`

The maximum number of items to evaluate at a single time. This field is optional.

`consistentRead`

A Boolean that indicates whether to use consistent reads when querying DynamoDB. This field is optional, and defaults to `false`.

`nextToken`

The pagination token to continue a previous query. This would have been obtained from a previous query. This field is optional.

`select`

By default, the AWS AppSync DynamoDB resolver only returns whatever attributes are projected into the index. If more attributes are required, then this field can be set. This field is optional. The supported values are:

`ALL_ATTRIBUTES`

Returns all of the item attributes from the specified table or index. If you query a local secondary index, DynamoDB fetches the entire item from the parent table for each matching item in the index. If the index is configured to project all item attributes, all of the data can be obtained from the local secondary index and no fetching is required.

`ALL_PROJECTED_ATTRIBUTES`

Allowed only when querying an index. Retrieves all attributes that have been projected into the index. If the index is configured to project all attributes, this return value is equivalent to specifying `ALL_ATTRIBUTES`.

`totalSegments`

The number of segments to partition the table by when performing a parallel scan. This field is optional, but must be specified if `segment` is specified.

`segment`

The table segment in this operation when performing a parallel scan. This field is optional, but must be specified if `totalSegments` is specified.

The results returned by the DynamoDB scan are automatically converted into GraphQL and JSON primitive types and is available in the mapping context (`$context.result`).

For more information about DynamoDB type conversion, see Type System (Response Mapping) (p. 301).

For more information about response mapping templates, see Resolver Mapping Template Overview (p. 226).

The results have the following structure:

```
{
    items = [ ... ],
    nextToken = "a pagination token",
    scannedCount = 10
}
```

The fields are defined as follows:

`items`

A list containing the items returned by the DynamoDB scan.

`nextToken`

If there might be more results, `nextToken` contains a pagination token that you can use in another request. AWS AppSync encrypts and obfuscates the pagination token returned from DynamoDB. This prevents your table data from being inadvertently leaked to the caller. Also, these pagination tokens can't be used across different resolvers.

`scannedCount`

The number of items that were retrieved by DynamoDB before a filter expression (if present) was applied.

Example 1

Following is a mapping template for the GraphQL query: `allPosts`.

In this example, all entries in the table are returned.

```
{
    "version" : "2017-02-28",
    "operation" : "Scan"
}
```

Example 2

Following is a mapping template for the GraphQL query: `postsMatching(title: String!)`.

In this example, all entries in the table are returned where the title starts with the `title` argument.

```
{
    "version" : "2017-02-28",
    "operation" : "Scan",
    "filter" : {
        "expression" : "begins_with(title, :title)",
        "expressionValues" : {
            ":title" : $util.dynamodb.toDynamoDBJson($context.arguments.title)
        },
    }
}
```

For more information about the DynamoDB `Scan` API, see the DynamoDB API documentation.

Sync

The `Sync` request mapping document lets you retrieve all the results from a DynamoDB table and then receive only the data altered since your last query (the delta updates). `Sync` requests can only be made to versioned DynamoDB data sources. You can specify the following:

- A filter to exclude results
- How many items to return
- Pagination Token
- When your last `Sync` operation was started

The `Sync` mapping document has the following structure:

```
{
    "version" : "2018-05-29",
    "operation" : "Sync",
    "limit" : 10,
    "nextToken" : "aPaginationToken",
    "lastSync" :  1550000000000,
    "filter" : {
        ...
    }
}
```

The fields are defined as follows:

`version`

The template definition version. Only `2018-05-29` is currently supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `Sync` operation, this must be set to `Sync`. This value is required.

`filter`

A filter that can be used to filter the results from DynamoDB before they are returned. For more information about filters, see Filters (p. 304). This field is optional.

`limit`

The maximum number of items to evaluate at a single time. This field is optional. If omitted, the default limit will be set to `100` items. The maximum value for this field is `1000` items.

`nextToken`

The pagination token to continue a previous query. This would have been obtained from a previous query. This field is optional.

`lastSync`

The moment, in epoch milliseconds, when the last successful `Sync` operation started. If specified, only items that have changed after `lastSync` are returned. This field is optional, and should only be populated after retrieving all pages from an initial `Sync` operation. If omitted, results from the *Base* table will be returned, otherwise, results from the *Delta* table will be returned.

The results returned by the DynamoDB sync are automatically converted into GraphQL and JSON primitive types and are available in the mapping context (`$context.result`).

For more information about DynamoDB type conversion, see Type System (Response Mapping) (p. 301).

For more information about response mapping templates, see Resolver Mapping Template Overview (p. 226).

The results have the following structure:

```
{
    items = [ ... ],
    nextToken = "a pagination token",
    scannedCount = 10,
    startedAt = 1550000000000
}
```

The fields are defined as follows:

`items`

A list containing the items returned by the sync.

`nextToken`

If there might be more results, `nextToken` contains a pagination token that you can use in another request. AWS AppSync encrypts and obfuscates the pagination token returned from DynamoDB. This prevents your table data from being inadvertently leaked to the caller. Also, these pagination tokens can't be used across different resolvers.

`scannedCount`

The number of items that were retrieved by DynamoDB before a filter expression (if present) was applied.

`startedAt`

The moment, in epoch milliseconds, when the sync operation started that you can store locally and use in another request as your `lastSync` argument. If a pagination token was included in the request, this value will be the same as the one returned by the request for the first page of results.

Example 1

Following is a mapping template for the GraphQL query: `syncPosts(nextToken: String, lastSync: AWSTimestamp)`.

In this example, if `lastSync` is omitted, all entries in the base table are returned. If `lastSync` is supplied, only the entries in the delta sync table that have changed since `lastSync` are returned.

```
{
    "version" : "2018-05-29",
    "operation" : "Sync",
    "limit": 100,
    "nextToken": $util.toJson($util.defaultIfNull($ctx.args.nextToken, null)),
    "lastSync": $util.toJson($util.defaultIfNull($ctx.args.lastSync, null))
}
```

BatchGetItem

The `BatchGetItem` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `BatchGetItem` request to DynamoDB to retrieve multiple items, potentially across multiple tables. For this request template, you must specify the following:

- The table names where to retrieve the items from
- The keys of the items to retrieve from each table

The DynamoDB`BatchGetItem` limits apply and **no condition expression** can be provided.

The `BatchGetItem` mapping document has the following structure:

```
{
    "version" : "2018-05-29",
    "operation" : "BatchGetItem",
    "tables" : {
        "table1": {
           "keys": [
              ## Item to retrieve Key
              {
                   "foo" : ... typed value,
                   "bar" : ... typed value
              },
              ## Item2 to retrieve Key
              {
                   "foo" : ... typed value,
                   "bar" : ... typed value
              }
            ],
            "consistentRead": true|false
        },
        "table2": {
           "keys": [
              ## Item3 to retrieve Key
              {
                   "foo" : ... typed value,
                   "bar" : ... typed value
              },
              ## Item4 to retrieve Key
              {
                   "foo" : ... typed value,
                   "bar" : ... typed value
              }
            ],
            "consistentRead": true|false
        }
    }
}
```

The fields are defined as follows:

`version`

The template definition version. Only `2018-05-29` is supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `BatchGetItem`DynamoDB operation, this must be set to `BatchGetItem`. This value is required.

`tables`

The DynamoDB tables to retrieve the items from. The value is a map where table names are specified as the keys of the map. At least one table must be provided. This `tables` value is required.

`keys`

List of DynamoDB keys representing the primary key of the items to retrieve. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure.

For more information about how to specify a “typed value”, see Type System (Request Mapping) (p. 297).

`consistentRead`

Whether to use a consistent read when executing a *GetItem* operation. This value is optional and defaults to *false*.

Things to remember:

- If an item has not been retrieved from the table, a *null* element appears in the data block for that table.
- Invocation results are sorted per table, based on the order they were provided inside the request mapping template.
- Each Get command inside a `BatchGetItem` is atomic, however, a batch can be partially processed. If a batch is partially processed due to an error, the unprocessed keys are returned as part of the invocation result inside the *unprocessedKeys* block.
- `BatchGetItem` is limited to 100 keys.

For the following example request mapping template:

```
{
  "version": "2018-05-29",
  "operation": "BatchGetItem",
  "tables": {
    "authors": [
        {
          "author_id": {
            "S": "a1"
          }
        },
    ],
    "posts": [
        {
          "author_id": {
            "S": "a1"
          },
          "post_id": {
            "S": "p2"
          }
        }
    ],
  }
}
```

The invocation result available in `$ctx.result` is as follows:

```
{
   "data": {
     "authors": [null],
     "posts": [
        # Was retrieved
        {
          "author_id": "a1",
          "post_id": "p2",
          "post_title": "title",
          "post_description": "description",
        }
     ]
```

```
  },
  "unprocessedKeys": {
    "authors": [
       # This item was not processed due to an error
       {
         "author_id": "a1"
       }
     ],
    "posts": []
  }
}
```

The `$ctx.error` contains details about the error. The keys **data**, **unprocessedKeys**, and each table key that was provided in the request mapping template are guaranteed to be present in the invocation result. Items that have been deleted appear in the **data** block. Items that haven't been processed are marked as *null* inside the data block and are placed inside the **unprocessedKeys** block.

For a more complete example, follow the DynamoDB Batch tutorial with AppSync here Tutorial: DynamoDB Batch Resolvers (p. 113).

BatchDeleteItem

The `BatchDeleteItem` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `BatchWriteItem` request to DynamoDB to delete multiple items, potentially across multiple tables. For this request template, you must specify the following:

- The table names where to delete the items from
- The keys of the items to delete from each table

The DynamoDB`BatchWriteItem` limits apply and **no condition expression** can be provided.

The `BatchDeleteItem` mapping document has the following structure:

```
{
    "version" : "2018-05-29",
    "operation" : "BatchDeleteItem",
    "tables" : {
        "table1": [
        ## Item to delete Key
        {
             "foo" : ... typed value,
             "bar" : ... typed value
        },
        ## Item2 to delete Key
        {
             "foo" : ... typed value,
             "bar" : ... typed value
        }],
        "table2": [
        ## Item3 to delete Key
        {
             "foo" : ... typed value,
             "bar" : ... typed value
        },
        ## Item4 to delete Key
        {
             "foo" : ... typed value,
             "bar" : ... typed value
        }],
    }
```

```
}
```

The fields are defined as follows:

`version`

The template definition version. Only `2018-05-29` is supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `BatchDeleteItem` DynamoDB operation, this must be set to `BatchDeleteItem`. This value is required.

`tables`

The DynamoDB tables to delete the items from. Each table is a list of DynamoDB keys representing the primary key of the items to delete. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). At least one table must be provided. This `tables` value is required.

Things to remember:

- Contrary to the `DeleteItem` operation, the fully deleted item isn't returned in the response. Only the passed key is returned.
- If an item has not been deleted from the table, a *null* element appears in the data block for that table.
- Invocation results are sorted per table, based on the order they were provided inside the request mapping template.
- Each delete command inside a `BatchDeleteItem` is atomic. However a batch can be partially processed. If a batch is partially processed due to an error, the unprocessed keys are returned as part of the invocation result inside the *unprocessedKeys* block.
- `BatchDeleteItem` is limited to 25 keys.

For the following example request mapping template:

```
{
  "version": "2018-05-29",
  "operation": "BatchDeleteItem",
  "tables": {
    "authors": [
        {
          "author_id": {
            "S": "a1"
          }
        },
    ],
    "posts": [
        {
          "author_id": {
            "S": "a1"
          },
          "post_id": {
            "S": "p2"
          }
        }
    ],
  }
}
```

The invocation result available in `$ctx.result` is as follows:

```
{
   "data": {
     "authors": [null],
     "posts": [
        # Was deleted
        {
          "author_id": "a1",
          "post_id": "p2"
        }
     ]
   },
   "unprocessedKeys": {
     "authors": [
        # This key was not processed due to an error
        {
          "author_id": "a1"
        }
      ],
     "posts": []
   }
}
```

The `$ctx.error` contains details about the error. The keys **data**, **unprocessedKeys**, and each table key that was provided in the request mapping template are guaranteed to be present in the invocation result. Items that have been deleted are present in the **data** block. Items that haven't been processed are marked as null inside the data block and are placed inside the **unprocessedKeys** block.

For a more complete example, follow the DynamoDB Batch tutorial with AppSync here Tutorial: DynamoDB Batch Resolvers (p. 113).

BatchPutItem

The `BatchPutItem` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `BatchWriteItem` request to DynamoDB to put multiple items, potentially across multiple tables. For this request template, you must specify the following:

- The table names where to put the items in
- The full items to put in each table

The DynamoDB`BatchWriteItem` limits apply and **no condition expression** can be provided.

The `BatchPutItem` mapping document has the following structure:

```
{
    "version" : "2018-05-29",
    "operation" : "BatchPutItem",
    "tables" : {
        "table1": [
        ## Item to put
        {
             "foo" : ... typed value,
             "bar" : ... typed value
        },
        ## Item2 to put
        {
             "foo" : ... typed value,
             "bar" : ... typed value
```

```
        }],
        "table2": [
        ## Item3 to put
        {
             "foo" : ... typed value,
             "bar" : ... typed value
        },
        ## Item4 to put
        {
             "foo" : ... typed value,
             "bar" : ... typed value
        }],
    }
}
```

The fields are defined as follows:

`version`

The template definition version. Only `2018-05-29` is supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `BatchPutItem` DynamoDB operation, this must be set to `BatchPutItem`. This value is required.

`tables`

The DynamoDB tables to put the items in. Each table entry represents a list of DynamoDB items to insert for this specific table. At least one table must be provided. This value is required.

Things to remember:

- The fully inserted items are returned in the response, if successful.
- If an item hasn't been inserted in the table, a *null* element is displayed in the data block for that table.
- The inserted items are sorted per table, based on the order they were provided inside the request mapping template.
- Each put command inside a `BatchPutItem` is atomic, however, a batch can be partially processed. If a batch is partially processed due to an error, the unprocessed keys are returned as part of the invocation result inside the *unprocessedKeys* block.
- `BatchPutItem` is limited to 25 items.

For the following example request mapping template:

```
{
  "version": "2018-05-29",
  "operation": "BatchPutItem",
  "tables": {
    "authors": [
        {
          "author_id": {
            "S": "a1"
          },
          "author_name": {
            "S": "a1_name"
          }
        },
    ],
    "posts": [
        {
```

```
          "author_id": {
            "S": "a1"
          },
          "post_id": {
            "S": "p2"
          },
          "post_title": {
            "S": "title"
          }
        }
    ],
  }
}
```

The invocation result available in `$ctx.result` is as follows:

```
{
   "data": {
     "authors": [
         null
     ],
     "posts": [
        # Was inserted
        {
          "author_id": "a1",
          "post_id": "p2",
          "post_title": "title"
        }
     ]
   },
   "unprocessedItems": {
     "authors": [
        # This item was not processed due to an error
        {
          "author_id": "a1",
          "author_name": "a1_name"
        }
      ],
     "posts": []
   }
}
```

The `$ctx.error` contains details about the error. The keys **data**, **unprocessedItems**, and each table key that was provided in the request mapping template are guaranteed to be present in the invocation result. Items that have been inserted are in the **data** block. Items that haven't been processed are marked as *null* inside the data block and are placed inside the **unprocessedItems** block.

For a more complete example, follow the DynamoDB Batch tutorial with AppSync here Tutorial: DynamoDB Batch Resolvers (p. 113).

TransactGetItems

The `TransactGetItems` request mapping document lets you to tell the AWS AppSync DynamoDB resolver to make a `TransactGetItems` request to DynamoDB to retrieve multiple items, potentially across multiple tables. For this request template, you must specify the following:

- The table name of each request item where to retrieve the item from
- The key of each request item to retrieve from each table

The DynamoDB `TransactGetItems` limits apply and **no condition expression** can be provided.

The `TransactGetItems` mapping document has the following structure:

```
{
    "version": "2018-05-29",
    "operation": "TransactGetItems",
    "transactItems": [
       ## First request item
       {
           "table": "table1",
           "key": {
               "foo": ... typed value,
               "bar": ... typed value
           }
       },
       ## Second request item
       {
           "table": "table2",
           "key": {
               "foo": ... typed value,
               "bar": ... typed value
           }
       }
    ]
}
```

The fields are defined as follows:

`version`

The template definition version. Only `2018-05-29` is supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `TransactGetItems` DynamoDB operation, this must be set to `TransactGetItems`. This value is required.

`transactItems`

The request items to include. The value is an array of request items. At least one request item must be provided. This `transactItems` value is required.

`table`

The DynamoDB table to retrieve the item from. The value is a string of the table name. This `table` value is required.

`key`

The DynamoDB key representing the primary key of the item to retrieve. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297).

Things to remember:

- If a transaction succeeds, the order of retrieved items in the `items` block will be the same as the order of request items.
- Transactions are performed in an all-or-nothing way. If any request item causes an error, the whole transaction will not be performed and error details will be returned.
- A request item being unable to be retrieved is not an error. Instead, a *null* element appears in the *items* block in the corresponding position.

- If the error of a transaction is *TransactionCanceledException*, the `cancellationReasons` block will be populated. The order of cancellation reasons in `cancellationReasons` block will be the same as the order of request items.
- `TransactGetItems` is limited to 25 request items.

For the following example request mapping template:

```
{
    "version": "2018-05-29",
    "operation": "TransactGetItems",
    "transactItems": [
       ## First request item
       {
           "table": "posts",
           "key": {
               "post_id": {
                 "S": "p1"
               }
           }
       },
       ## Second request item
       {
           "table": "authors",
           "key": {
               "author_id": {
                 "S": a1
               }
           }
       }
    ]
}
```

If the transaction succeeds and only the first requested item is retrieved, the invocation result available in `$ctx.result` is as follows:

```
{
    "items": [
       {
           // Attributes of the first requested item
           "post_id": "p1",
           "post_title": "title",
           "post_description": "description"
       },
       // Could not retrieve the second requested item
       null,
    ],
    "cancellationReasons": null
}
```

If the transaction fails due to *TransactionCanceledException* caused by the first request item, the invocation result available in `$ctx.result` is as follows:

```
{
    "items": null,
    "cancellationReasons": [
       {
           "type":"Sample error type",
           "message":"Sample error message"
       },
       {
           "type":"None",
```

```
            "message":"None"
        }
    ]
}
```

The `$ctx.error` contains details about the error. The keys **items** and **cancellationReasons** are guaranteed to be present in `$ctx.result`.

For a more complete example, follow the DynamoDB Transaction tutorial with AppSync here Tutorial: DynamoDB Transaction Resolvers (p. 126).

TransactWriteItems

The `TransactWriteItems` request mapping document lets you tell the AWS AppSync DynamoDB resolver to make a `TransactWriteItems` request to DynamoDB to write multiple items, potentially to multiple tables. For this request template, you must specify the following:

- The destination table name of each request item
- The operation of each request item to perform. There are four types of operations that are supported: *PutItem*, *UpdateItem*, *DeleteItem*, and *ConditionCheck*
- The key of each request item to write

The DynamoDB `TransactWriteItems` limits apply.

The `TransactWriteItems` mapping document has the following structure:

```
{
    "version": "2018-05-29",
    "operation": "TransactWriteItems",
    "transactItems": [
       {
            "table": "table1",
            "operation": "PutItem",
            "key": {
                "foo": ... typed value,
                "bar": ... typed value
            },
            "attributeValues": {
                "baz": ... typed value
            },
            "condition": {
                "expression": "someExpression",
                "expressionNames": {
                    "#foo": "foo"
                },
                "expressionValues": {
                    ":bar": ... typed value
                },
                "returnValuesOnConditionCheckFailure": true|false
            }
       },
       {
            "table":"table2",
            "operation": "UpdateItem",
            "key": {
                "foo": ... typed value,
                "bar": ... typed value
            },
            "update": {
                "expression": "someExpression",
                "expressionNames": {
```

```
                    "#foo": "foo"
                },
                "expressionValues": {
                    ":bar": ... typed value
                }
            },
            "condition": {
                "expression": "someExpression",
                "expressionNames": {
                    "#foo":"foo"
                },
                "expressionValues": {
                    ":bar": ... typed value
                },
                "returnValuesOnConditionCheckFailure": true|false
            }
        },
        {
            "table": "table3",
            "operation": "DeleteItem",
            "key":{
                "foo": ... typed value,
                "bar": ... typed value
            },
            "condition":{
                "expression": "someExpression",
                "expressionNames": {
                    "#foo": "foo"
                },
                "expressionValues": {
                    ":bar": ... typed value
                },
                "returnValuesOnConditionCheckFailure": true|false
            }
        },
        {
            "table": "table4",
            "operation": "ConditionCheck",
            "key":{
                "foo": ... typed value,
                "bar": ... typed value
            },
            "condition":{
                "expression": "someExpression",
                "expressionNames": {
                    "#foo": "foo"
                },
                "expressionValues": {
                    ":bar": ... typed value
                },
                "returnValuesOnConditionCheckFailure": true|false
            }
        }
    ]
}
```

The fields are defined as follows:

`version`

The template definition version. Only `2018-05-29` is supported. This value is required.

`operation`

The DynamoDB operation to perform. To perform the `TransactWriteItems` DynamoDB operation, this must be set to `TransactWriteItems`. This value is required.

`transactItems`

The request items to include. The value is an array of request items. At least one request item must be provided. This `transactItems` value is required.

For `PutItem`, the fields are defined as follows:

`table`

The destination DynamoDB table. The value is a string of the table name. This `table` value is required.

`operation`

The DynamoDB operation to perform. To perform the `PutItem` DynamoDB operation, this must be set to `PutItem`. This value is required.

`key`

The DynamoDB key representing the primary key of the item to put. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This value is required.

`attributeValues`

The rest of the attributes of the item to be put into DynamoDB. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This field is optional.

`condition`

A condition to determine if the request should succeed or not, based on the state of the object already in DynamoDB. If no condition is specified, the `PutItem` request overwrites any existing entry for that item. You can specify whether to retrieve the existing item back when condition check fails. For more information about transactional conditions, see Transaction Condition Expressions (p. 313). This value is optional.

For `UpdateItem`, the fields are defined as follows:

`table`

The DynamoDB table to update. The value is a string of the table name. This `table` value is required.

`operation`

The DynamoDB operation to perform. To perform the `UpdateItem` DynamoDB operation, this must be set to `UpdateItem`. This value is required.

`key`

The DynamoDB key representing the primary key of the item to update. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This value is required.

`update`

The `update` section lets you specify an update expression that describes how to update the item in DynamoDB. For more information about how to write update expressions, see the DynamoDB UpdateExpressions documentation . This section is required.

`condition`

A condition to determine if the request should succeed or not, based on the state of the object already in DynamoDB. If no condition is specified, the `UpdateItem` request updates the existing entry regardless of its current state. You can specify whether to retrieve the

existing item back when condition check fails. For more information about transactional conditions, see Transaction Condition Expressions (p. 313). This value is optional.

For `DeleteItem`, the fields are defined as follows:

`table`

The DynamoDB table in which to delete the item. The value is a string of the table name. This `table` value is required.

`operation`

The DynamoDB operation to perform. To perform the `DeleteItem` DynamoDB operation, this must be set to `DeleteItem`. This value is required.

`key`

The DynamoDB key representing the primary key of the item to delete. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a “typed value”, see Type System (Request Mapping) (p. 297). This value is required.

`condition`

A condition to determine if the request should succeed or not, based on the state of the object already in DynamoDB. If no condition is specified, the `DeleteItem` request deletes an item regardless of its current state. You can specify whether to retrieve the existing item back when condition check fails. For more information about transactional conditions, see Transaction Condition Expressions (p. 313). This value is optional.

For `ConditionCheck`, the fields are defined as follows:

`table`

The DynamoDB table in which to check the condition. The value is a string of the table name. This `table` value is required.

`operation`

The DynamoDB operation to perform. To perform the `ConditionCheck` DynamoDB operation, this must be set to `ConditionCheck`. This value is required.

`key`

The DynamoDB key representing the primary key of the item to condition check. DynamoDB items may have a single hash key, or a hash key and sort key, depending on the table structure. For more information about how to specify a “typed value”, see Type System (Request Mapping) (p. 297). This value is required.

`condition`

A condition to determine if the request should succeed or not, based on the state of the object already in DynamoDB. You can specify whether to retrieve the existing item back when condition check fails. For more information about transactional conditions, see Transaction Condition Expressions (p. 313). This value is required.

Things to remember:

- Only keys of request items are returned in the response, if successful. The order of keys will be the same as the order of request items.
- Transactions are performed in an all-or-nothing way. If any request item causes an error, the whole transaction will not be performed and error details will be returned.
- No two request items can target the same item. Otherwise they will cause *TransactionCanceledException* error.

- If the error of a transaction is *TransactionCanceledException*, the `cancellationReasons` block will be populated. If a request item's condition check fails **and** you did not specify `returnValuesOnConditionCheckFailure` to be `false`, the item existing in the table will be retrieved and stored in `item` at the corresponding position of `cancellationReasons` block.
- `TransactWriteItems` is limited to 25 request items.

For the following example request mapping template:

```
{
    "version": "2018-05-29",
    "operation": "TransactWriteItems",
    "transactItems": [
       {
           "table": "posts",
           "operation": "PutItem",
           "key": {
               "post_id": {
                   "S": "p1"
               }
           },
           "attributeValues": {
               "post_title": {
                   "S": "New title"
               },
               "post_description": {
                   "S": "New description"
               }
           },
           "condition": {
               "expression": "post_title = :post_title",
               "expressionValues": {
                   ":post_title": {
                       "S": "Expected old title"
                   }
               }
           }
       },
       {
           "table":"authors",
           "operation": "UpdateItem",
           "key": {
               "author_id": {
                   "S": "a1"
               },
           },
           "update": {
               "expression": "SET author_name = :author_name",
               "expressionValues": {
                   ":author_name": {
                       "S": "New name"
                   }
               }
           },
       }
    ]
}
```

If the transaction succeeds, the invocation result available in `$ctx.result` is as follows:

```
{
    "keys": [
       // Key of the PutItem request
```

```
        {
            "post_id": "p1",
        },
        // Key of the UpdateItem request
        {
            "author_id": "a1"
        }
    ],
    "cancellationReasons": null
}
```

If the transaction fails due to condition check failure of the PutItem request, the invocation result available in `$ctx.result` is as follows:

```
{
    "keys": null,
    "cancellationReasons": [
        {
            "item": {
                "post_id": "p1",
                "post_title": "Actual old title",
                "post_description": "Old description"
            },
            "type": "ConditionCheckFailed",
            "message": "The condition check failed."
        },
        {
            "type": "None",
            "message": "None"
        }
    ]
}
```

The `$ctx.error` contains details about the error. The keys **keys** and **cancellationReasons** are guaranteed to be present in `$ctx.result`.

For a more complete example, follow the DynamoDB Transaction tutorial with AppSync here Tutorial: DynamoDB Transaction Resolvers (p. 126).

Type System (Request Mapping)

When using the AWS AppSync DynamoDB resolver to call your DynamoDB tables, AWS AppSync needs to know the type of each value to use in that call. This is because DynamoDB supports more type primitives than GraphQL or JSON (such as sets and binary data). AWS AppSync needs some hints when translating between GraphQL and DynamoDB, otherwise it would have to make some assumptions on how data is structured in your table.

For more information about DynamoDB data types, see the DynamoDBData Type Descriptors and Data Types documentation.

A DynamoDB value is represented by a JSON object containing a single key-value pair. The key specifies the DynamoDB type, and the value specifies the value itself. In the following example, the key `S` denotes that the value is a string, and the value `identifier` is the string value itself.

```
{ "S" : "identifier" }
```

Note that the JSON object cannot have more than one key-value pair. If more than one key-value pair is specified, the request mapping document isn't parsed.

A DynamoDB value is used anywhere in a request mapping document where you need to specify a value. Some places where you need to do this include: `key` and `attributeValue` sections, and the `expressionValues` section of expression sections. In the following example, the DynamoDB String value `identifier` is being assigned to the `id` field in a `key` section (perhaps in a `GetItem` request mapping document).

```
"key" : {
   "id" : { "S" : "identifier" }
}
```

Supported Types

AWS AppSync supports the following DynamoDB scalar, document, and set types:

String type `S`

A single string value. A DynamoDB String value is denoted by:

```
{ "S" : "some string" }
```

An example usage is:

```
"key" : {
   "id" : { "S" : "some string" }
}
```

String set type `SS`

A set of string values. A DynamoDB String Set value is denoted by:

```
{ "SS" : [ "first value", "second value", ... ] }
```

An example usage is:

```
"attributeValues" : {
   "phoneNumbers" : { "SS" : [ "+1 555 123 4567", "+1 555 234 5678" ] }
}
```

Number type `N`

A single numeric value. A DynamoDB Number value is denoted by:

```
{ "N" : 1234 }
```

An example usage is:

```
"expressionValues" : {
   ":expectedVersion" : { "N" : 1 }
}
```

Number set type `NS`

A set of number values. A DynamoDB Number Set value is denoted by:

```
{ "NS" : [ 1, 2.3, 4 ... ] }
```

An example usage is:

```
"attributeValues" : {
   "sensorReadings" : { "NS" : [ 67.8, 12.2, 70 ] }
}
```

Binary type `B`

A binary value. A DynamoDB Binary value is denoted by:

```
{ "B" : "SGVsbG8sIFdvcmxkIQo=" }
```

Note that the value is actually a string, where the string is the base64-encoded representation of the binary data. AWS AppSync decodes this string back into its binary value before sending it to DynamoDB. AWS AppSync uses the base64 decoding scheme as defined by RFC 2045: any character that isn't in the base64 alphabet is ignored.

An example usage is:

```
"attributeValues" : {
   "binaryMessage" : { "B" : "SGVsbG8sIFdvcmxkIQo=" }
}
```

Binary set type `BS`

A set of binary values. A DynamoDB Binary Set value is denoted by:

```
{ "BS" : [ "SGVsbG8sIFdvcmxkIQo=", "SG93IGFyZSB5b3U/Cg==" ... ] }
```

Note that the value is actually a string, where the string is the base64-encoded representation of the binary data. AWS AppSync decodes this string back into its binary value before sending it to DynamoDB. AWS AppSync uses the base64 decoding scheme as defined by RFC 2045: any character that is not in the base64 alphabet is ignored.

An example usage is:

```
"attributeValues" : {
   "binaryMessages" : { "BS" : [ "SGVsbG8sIFdvcmxkIQo=", "SG93IGFyZSB5b3U/Cg==" ] }
}
```

Boolean type `BOOL`

A Boolean value. A DynamoDB Boolean value is denoted by:

```
{ "BOOL" : true }
```

Note that only `true` and `false` are valid values.

An example usage is:

```
"attributeValues" : {
```

```
   "orderComplete" : { "BOOL" : false }
}
```

List type `L`

A list of any other supported DynamoDB value. A DynamoDB List value is denoted by:

```
{ "L" : [ ... ] }
```

Note that the value is a compound value, where the list can contain zero or more of any supported DynamoDB value (including other lists). The list can also contain a mix of different types.

An example usage is:

```
{ "L" : [
      { "S"  : "A string value" },
      { "N"  : 1 },
      { "SS" : [ "Another string value", "Even more string values!" ] }
   ]
}
```

Map type `M`

Representing an unordered collection of key-value pairs of other supported DynamoDB values. A DynamoDB Map value is denoted by:

```
{ "M" : { ... } }
```

Note that a map can contain zero or more key-value pairs. The key must be a string, and the value can be any supported DynamoDB value (including other maps). The map can also contain a mix of different types.

An example usage is:

```
{ "M" : {
      "someString" : { "S"  : "A string value" },
      "someNumber" : { "N"  : 1 },
      "stringSet"  : { "SS" : [ "Another string value", "Even more string values!" ] }
   }
}
```

Null type `NULL`

A null value. A DynamoDB Null value is denoted by:

```
{ "NULL" : null }
```

An example usage is:

```
"attributeValues" : {
   "phoneNumbers" : { "NULL" : null }
}
```

For more information about each type, see the DynamoDB documentation .

Type System (Response Mapping)

When receiving a response from DynamoDB, AWS AppSync automatically converts it into GraphQL and JSON primitive types. Each attribute in DynamoDB is decoded and returned in the response mapping context.

For example, if DynamoDB returns the following:

```
{
    "id" : { "S" : "1234" },
    "name" : { "S" : "Nadia" },
    "age" : { "N" : 25 }
}
```

Then the AWS AppSync DynamoDB resolver converts it into GraphQL and JSON types as:

```
{
    "id" : "1234",
    "name" : "Nadia",
    "age" : 25
}
```

This section explains how AWS AppSync converts the following DynamoDB scalar, document, and set types:

String type `S`

A single string value. A DynamoDB String value is returned as a string.

For example, if DynamoDB returned the following DynamoDB String value:

```
{ "S" : "some string" }
```

AWS AppSync converts it to a string:

```
"some string"
```

String set type `SS`

A set of string values. A DynamoDB String Set value is returned as a list of strings.

For example, if DynamoDB returned the following DynamoDB String Set value:

```
{ "SS" : [ "first value", "second value", ... ] }
```

AWS AppSync converts it to a list of strings:

```
[ "+1 555 123 4567", "+1 555 234 5678" ]
```

Number type `N`

A single numeric value. A DynamoDB Number value is returned as a number.

For example, if DynamoDB returned the following DynamoDB Number value:

```
{ "N" : 1234 }
```

AWS AppSync converts it to a number:

```
1234
```

Number set type `NS`

A set of number values. A DynamoDB Number Set value is returned as a list of numbers.

For example, if DynamoDB returned the following DynamoDB Number Set value:

```
{ "NS" : [ 67.8, 12.2, 70 ] }
```

AWS AppSync converts it to a list of numbers:

```
[ 67.8, 12.2, 70 ]
```

Binary type `B`

A binary value. A DynamoDB Binary value is returned as a string containing the base64 representation of that value.

For example, if DynamoDB returned the following DynamoDB Binary value:

```
{ "B" : "SGVsbG8sIFdvcmxkIQo=" }
```

AWS AppSync converts it to a string containing the base64 representation of the value:

```
"SGVsbG8sIFdvcmxkIQo="
```

Note that the binary data is encoded in the base64 encoding scheme as specified in RFC 4648 and RFC 2045.

Binary set type `BS`

A set of binary values. A DynamoDB Binary Set value is returned as a list of strings containing the base64 representation of the values.

For example, if DynamoDB returned the following DynamoDB Binary Set value:

```
{ "BS" : [ "SGVsbG8sIFdvcmxkIQo=", "SG93IGFyZSB5b3U/Cg==" ... ] }
```

AWS AppSync converts it to a list of strings containing the base64 representation of the values:

```
[ "SGVsbG8sIFdvcmxkIQo=", "SG93IGFyZSB5b3U/Cg==" ... ]
```

Note that the binary data is encoded in the base64 encoding scheme as specified in RFC 4648 and RFC 2045.

Boolean type `BOOL`

A Boolean value. A DynamoDB Boolean value is returned as a Boolean.

For example, if DynamoDB returned the following DynamoDB Boolean value:

```
{ "BOOL" : true }
```

AWS AppSync converts it to a Boolean:

```
true
```

List type `L`

A list of any other supported DynamoDB value. A DynamoDB List value is returned as a list of values, where each inner value is also converted.

For example, if DynamoDB returned the following DynamoDB List value:

```
{ "L" : [
      { "S"  : "A string value" },
      { "N"  : 1 },
      { "SS" : [ "Another string value", "Even more string values!" ] }
   ]
}
```

AWS AppSync converts it to a list of converted values:

```
[ "A string value", 1, [ "Another string value", "Even more string values!" ] ]
```

Map type `M`

A key/value collection of any other supported DynamoDB value. A DynamoDB Map value is returned as a JSON object, where each key/value is also converted.

For example, if DynamoDB returned the following DynamoDB Map value:

```
{ "M" : {
      "someString" : { "S"  : "A string value" },
      "someNumber" : { "N"  : 1 },
      "stringSet"  : { "SS" : [ "Another string value", "Even more string values!" ] }
   }
}
```

AWS AppSync converts it to a JSON object:

```
{
   "someString" : "A string value",
   "someNumber" : 1,
   "stringSet"  : [ "Another string value", "Even more string values!" ]
}
```

Null type `NULL`

A null value.

For example, if DynamoDB returned the following DynamoDB Null value:

```
{ "NULL" : null }
```

AWS AppSync converts it to a null:

```
null
```

Filters

When querying objects in DynamoDB using the `Query` and `Scan` operations, you can optionally specify a `filter` that evaluates the results and returns only the desired values.

The filter mapping section of a `Query` or `Scan` mapping document has the following structure:

```
"filter" : {
    "expression" : "filter expression"
    "expressionNames" : {
        "#name" : "name",
    },
    "expressionValues" : {
        ":value" : ... typed value
    },
}
```

The fields are defined as follows:

`expression`

The query expression. For more information about how to write filter expressions, see the DynamoDB QueryFilter and DynamoDB ScanFilter documentation. This field must be specified.

`expressionNames`

The substitutions for expression attribute *name* placeholders, in the form of key-value pairs. The key corresponds to a name placeholder used in the `expression`. The value must be a string that corresponds to the attribute name of the item in DynamoDB. This field is optional, and should only be populated with substitutions for expression attribute name placeholders used in the `expression`.

`expressionValues`

The substitutions for expression attribute *value* placeholders, in the form of key-value pairs. The key corresponds to a value placeholder used in the `expression`, and the value must be a typed value. For more information about how to specify a "typed value", see Type System (Request Mapping) (p. 297). This must be specified. This field is optional, and should only be populated with substitutions for expression attribute value placeholders used in the `expression`.

Example

Following is a filter section for a mapping template, where entries retrieved from DynamoDB are only returned if the title starts with the `title` argument.

```
"filter" : {
    "expression" : "begins_with(#title, :title)",
    "expressionNames" : {
        "#title" : "title"
    },
    "expressionValues" : {
        ":title" : $util.dynamodb.toDynamoDBJson($context.arguments.title)
    }
}
```

Condition Expressions

When you mutate objects in DynamoDB by using the `PutItem`, `UpdateItem`, and `DeleteItem` DynamoDB operations, you can optionally specify a condition expression that controls whether the

request should succeed or not, based on the state of the object already in DynamoDB before the operation is performed.

The AWS AppSync DynamoDB resolver allows a condition expression to be specified in `PutItem`, `UpdateItem`, and `DeleteItem` request mapping documents, and also a strategy to follow if the condition fails and the object was not updated.

Example 1

The following `PutItem` mapping document doesn't have a condition expression. As a result, it puts an item in DynamoDB even if an item with the same key already exists, thereby overwriting the existing item.

```
{
   "version" : "2017-02-28",
   "operation" : "PutItem",
   "key" : {
      "id" : { "S" : "1" }
   }
}
```

Example 2

The following `PutItem` mapping document does have a condition expression that allows the operation succeed only if an item with the same key does *not* exist in DynamoDB.

```
{
   "version" : "2017-02-28",
   "operation" : "PutItem",
   "key" : {
      "id" : { "S" : "1" }
   },
   "condition" : {
      "expression" : "attribute_not_exists(id)"
   }
}
```

By default, if the condition check fails, the AWS AppSync DynamoDB resolver returns an error for the mutation and the current value of the object in DynamoDB in a `data` field in the `error` section of the GraphQL response. However, the AWS AppSync DynamoDB resolver offers some additional features to help developers handle some common edge cases:

- If AWS AppSync DynamoDB resolver can determine that the current value in DynamoDB matches the desired result, it treats the operation as if it succeeded anyway.
- Instead of returning an error, you can configure the resolver to invoke a custom Lambda function to decide how the AWS AppSync DynamoDB resolver should handle the failure.

These are described in greater detail in the Handling a Condition Check Failure (p. 307) section.

For more information about DynamoDB conditions expressions, see the DynamoDB ConditionExpressions documentation .

Specifying a Condition

The `PutItem`, `UpdateItem`, and `DeleteItem` request mapping documents all allow an optional `condition` section to be specified. If omitted, no condition check is made. If specified, the condition must be true for the operation to succeed.

A `condition` section has the following structure:

```
"condition" : {
    "expression" : "someExpression"
    "expressionNames" : {
        "#foo" : "foo"
    },
    "expressionValues" : {
        ":bar" : ... typed value
    },
    "equalsIgnore" : [ "version" ],
    "consistentRead" : true,
    "conditionalCheckFailedHandler" : {
        "strategy" : "Custom",
        "lambdaArn" : "arn:..."
    }
}
```

The following fields specify the condition:

`expression`

The update expression itself. For more information about how to write condition expressions, see the DynamoDB ConditionExpressions documentation . This field must be specified.

`expressionNames`

The substitutions for expression attribute name placeholders, in the form of key-value pairs. The key corresponds to a name placeholder used in the *expression*, and the value must be a string corresponding to the attribute name of the item in DynamoDB. This field is optional, and should only be populated with substitutions for expression attribute name placeholders used in the *expression*.

`expressionValues`

The substitutions for expression attribute value placeholders, in the form of key-value pairs. The key corresponds to a value placeholder used in the expression, and the value must be a typed value. For more information about how to specify a “typed value”, see Type System (request mapping). This must be specified. This field is optional, and should only be populated with substitutions for expression attribute value placeholders used in the expression.

The remaining fields tell the AWS AppSync DynamoDB resolver how to handle a condition check failure:

`equalsIgnore`

When a condition check fails when using the `PutItem` operation, the AWS AppSync DynamoDB resolver compares the item currently in DynamoDB against the item it tried to write. If they are the same, it treats the operation as it if succeeded anyway. You can use the `equalsIgnore` field to specify a list of attributes that AWS AppSync should ignore when performing that comparison. For example, if the only difference was a `version` attribute, it treats the operation as it if succeeded. This field is optional.

`consistentRead`

When a condition check fails, AWS AppSync gets the current value of the item from DynamoDB using a strongly consistent read. You can use this field to tell the AWS AppSync DynamoDB resolver to use an eventually consistent read instead. This field is optional, and defaults to `true`.

`conditionalCheckFailedHandler`

This section allows you to specify how the AWS AppSync DynamoDB resolver treats a condition check failure after it has compared the current value in DynamoDB against the expected result. This section is optional. If omitted, it defaults to a strategy of `Reject`.

`strategy`

The strategy the AWS AppSync DynamoDB resolver takes after it has compared the current value in DynamoDB against the expected result. This field is required and has the following possible values:

`Reject`

The mutation fails, and an error for the mutation and the current value of the object in DynamoDB in a `data` field in the `error` section of the GraphQL response.

`Custom`

The AWS AppSync DynamoDB resolver invokes a custom Lambda function to decide how to handle the condition check failure. When the `strategy` is set to `Custom`, the `lambdaArn` field must contain the ARN of the Lambda function to invoke.

`lambdaArn`

The ARN of the Lambda function to invoke that determines how the AWS AppSync DynamoDB resolver should handle the condition check failure. This field must only be specified when `strategy` is set to `Custom`. For more information about how to use this feature, see Handling a Condition Check Failure (p. 307).

Handling a Condition Check Failure

By default, when a condition check fails, the AWS AppSync DynamoDB resolver returns an error for the mutation and the current value of the object in DynamoDB in a `data` field in the `error` section of the GraphQL response. However, the AWS AppSync DynamoDB resolver offers some additional features to help developers handle some common edge cases:

- If AWS AppSync DynamoDB resolver can determine that the current value in DynamoDB matches the desired result, it treats the operation as if it succeeded anyway.
- Instead of returning an error, you can configure the resolver to invoke a custom Lambda function to decide how the AWS AppSync DynamoDB resolver should handle the failure.

The flowchart for this process is:

Checking for the Desired Result

When the condition check fails, the AWS AppSync DynamoDB resolver performs a `GetItem` DynamoDB request to get the current value of the item from DynamoDB. By default, it uses a strongly consistent read, however this can be configured using the `consistentRead` field in the `condition` block and compare it against the expected result:

- For the `PutItem` operation, the AWS AppSync DynamoDB resolver compares the current value against the one it attempted to write, excluding any attributes listed in `equalsIgnore` from the comparison. If the items are the same, it treats the operation as successful and returns the item that was retrieved from DynamoDB. Otherwise, it follows the configured strategy.

  For example, if the `PutItem` request mapping document looked like the following:

```
{
   "version" : "2017-02-28",
   "operation" : "PutItem",
   "key" : {
      "id" : { "S" : "1" }
```

```
    },
    "attributeValues" : {
       "name" : { "S" : "Steve" },
       "version" : { "N" : 2 }
    },
    "condition" : {
       "expression" : "version = :expectedVersion",
       "expressionValues" : {
           ":expectedVersion" : { "N" : 1 }
       },
       "equalsIgnore": [ "version" ]
    }
}
```

And the item currently in DynamoDB looked like the following:

```
{
   "id" : { "S" : "1" },
   "name" : { "S" : "Steve" },
   "version" : { "N" : 8 }
}
```

The AWS AppSync DynamoDB resolver would compare the item it tried to write against the current value, see that the only difference was the `version` field, but because it's configured to ignore the `version` field, it treats the operation as successful and returns the item that was retrieved from DynamoDB.

- For the `DeleteItem` operation, the AWS AppSync DynamoDB resolver checks to verify that an item was returned from DynamoDB. If no item was returned, it treats the operation as successful. Otherwise, it follows the configured strategy.
- For the `UpdateItem` operation, the AWS AppSync DynamoDB resolver does not have enough information to determine if the item currently in DynamoDB matches the expected result, and therefore follows the configured strategy.

If the current state of the object in DynamoDB is different from the expected result, the AWS AppSync DynamoDB resolver follows the configured strategy, to either reject the mutation or invoke a Lambda function to determine what to do next.

Following the "Reject" Strategy

When following the `Reject` strategy, the AWS AppSync DynamoDB resolver returns an error for the mutation, and the current value of the object in DynamoDB is also returned in a `data` field in the `error` section of the GraphQL response. The item returned from DynamoDB is put through the response mapping template to translate it into a format the client expects, and it is filtered by the selection set.

For example, given the following mutation request:

```
mutation {
    updatePerson(id: 1, name: "Steve", expectedVersion: 1) {
        Name
        theVersion
    }
}
```

If the item returned from DynamoDB looks like the following:

```
{
   "id" : { "S" : "1" },
```

```
   "name" : { "S" : "Steve" },
   "version" : { "N" : 8 }
}
```

And the response mapping template looks like the following:

```
{
   "id" : $util.toJson($context.result.id),
   "Name" : $util.toJson($context.result.name),
   "theVersion" : $util.toJson($context.result.version)
}
```

The GraphQL response looks like the following:

```
{
  "data": null,
  "errors": [
    {
      "message": "The conditional request failed (Service: AmazonDynamoDBv2;
 Status Code: 400; Error Code: ConditionalCheckFailedException; Request ID:
 ABCDEFGHIJKLMNOPQRSTUVWXYZABCDEFGHIJKLMNOPQRSTUVWXYZ)"
      "errorType": "DynamoDB:ConditionalCheckFailedException",
      "data": {
        "Name": "Steve",
        "theVersion": 8
      },
      ...
    }
  ]
}
```

Also, if any fields in the returned object are filled by other resolvers and the mutation had succeeded, they won't be resolved when the object is returned in the `error` section.

Following the "Custom" Strategy

When following the `Custom` strategy, the AWS AppSync DynamoDB resolver invokes a Lambda function to decide what to do next. The Lambda function chooses one of the following options:

- `reject` the mutation. This tells the AWS AppSync DynamoDB resolver to behave as if the configured strategy was `Reject`, returning an error for the mutation and the current value of the object in DynamoDB as described in the previous section.
- `discard` the mutation. This tells the AWS AppSync DynamoDB resolver to silently ignore the condition check failure and returns the value in DynamoDB.
- `retry` the mutation. This tells the AWS AppSync DynamoDB resolver to retry the mutation with a new request mapping document.

The Lambda invocation request

The AWS AppSync DynamoDB resolver invokes the Lambda function specified in the `lambdaArn`. It uses the same `service-role-arn` configured on the data source. The payload of the invocation has the following structure:

```
{
    "arguments": { ... },
    "requestMapping": {... },
    "currentValue": { ... },
```

```
    "resolver": { ... },
    "identity": { ... }
}
```

The fields are defined as follows:

`arguments`

The arguments from the GraphQL mutation. This is the same as the arguments available to the request mapping document in `$context.arguments`.

`requestMapping`

The request mapping document for this operation.

`currentValue`

The current value of the object in DynamoDB.

`resolver`

Information about the AWS AppSync resolver.

`identity`

Information about the caller. This is the same as the identity information available to the request mapping document in `$context.identity`.

A full example of the payload:

```
{
    "arguments": {
        "id": "1",
        "name": "Steve",
        "expectedVersion": 1
    },
    "requestMapping": {
        "version" : "2017-02-28",
        "operation" : "PutItem",
        "key" : {
           "id" : { "S" : "1" }
        },
        "attributeValues" : {
           "name" : { "S" : "Steve" },
           "version" : { "N" : 2 }
        },
        "condition" : {
           "expression" : "version = :expectedVersion",
           "expressionValues" : {
               ":expectedVersion" : { "N" : 1 }
           },
           "equalsIgnore": [ "version" ]
        }
    },
    "currentValue": {
        "id" : { "S" : "1" },
        "name" : { "S" : "Steve" },
        "version" : { "N" : 8 }
    },
    "resolver": {
        "tableName": "People",
        "awsRegion": "us-west-2",
        "parentType": "Mutation",
        "field": "updatePerson",
```

```
        "outputType": "Person"
    },
    "identity": {
        "accountId": "123456789012",
        "sourceIp": "x.x.x.x",
        "user": "AIDAAAAAAAAAAAAAAAAA",
        "userArn": "arn:aws:iam::123456789012:user/appsync"
    }
}
```

The Lambda Invocation Response

The Lambda function can inspect the invocation payload and apply any business logic to decide how the AWS AppSync DynamoDB resolver should handle the failure. There are three options for handling the condition check failure:

- `reject` the mutation. The response payload for this option must have this structure:

```
{
    "action": "reject"
}
```

  This tells the AWS AppSync DynamoDB resolver to behave as if the configured strategy was `Reject`, returning an error for the mutation and the current value of the object in DynamoDB, as described in the section above.
- `discard` the mutation. The response payload for this option must have this structure:

```
{
    "action": "discard"
}
```

  This tells the AWS AppSync DynamoDB resolver to silently ignore the condition check failure and returns the value in DynamoDB.
- `retry` the mutation. The response payload for this option must have this structure:

```
{
    "action": "retry",
    "retryMapping": { ... }
}
```

  This tells the AWS AppSync DynamoDB resolver to retry the mutation with a new request mapping document. The structure of the `retryMapping` section depends on the DynamoDB operation, and is a subset of the full request mapping document for that operation.

  For `PutItem`, the `retryMapping` section has the following structure. For a description of the `attributeValues` field, see PutItem (p. 268).

```
{
    "attributeValues": { ... },
    "condition": {
        "equalsIgnore" = [ ... ],
        "consistentRead" = true
    }
}
```

  For `UpdateItem`, the `retryMapping` section has the following structure. For a description of the `update` section, see UpdateItem (p. 270).

```
{
    "update" : {
        "expression" : "someExpression"
        "expressionNames" : {
            "#foo" : "foo"
        },
        "expressionValues" : {
            ":bar" : ... typed value
        }
    },
    "condition": {
        "consistentRead" = true
    }
}
```

For `DeleteItem`, the `retryMapping` section has the following structure.

```
{
    "condition": {
        "consistentRead" = true
    }
}
```

There is no way to specify a different operation or key to work on. The AWS AppSync DynamoDB resolver only allows retries of the same operation on the same object. Also, the `condition` section doesn't allow a `conditionalCheckFailedHandler` to be specified. If the retry fails, the AWS AppSync DynamoDB resolver follows the `Reject` strategy.

Here is an example Lambda function to deal with a failed `PutItem` request. The business logic looks at who made the call. If it was made by `jeffTheAdmin`, it retries the request, updating the `version` and `expectedVersion` from the item currently in DynamoDB. Otherwise, it rejects the mutation.

```
exports.handler = (event, context, callback) => {
    console.log("Event: "+ JSON.stringify(event));

    // Business logic goes here.

    var response;
    if ( event.identity.user == "jeffTheAdmin" ) {
        response = {
            "action" : "retry",
            "retryMapping" : {
                "attributeValues" : event.requestMapping.attributeValues,
                "condition" : {
                    "expression" : event.requestMapping.condition.expression,
                    "expressionValues" : event.requestMapping.condition.expressionValues
                }
            }
        }
        response.retryMapping.attributeValues.version = { "N" :
 event.currentValue.version.N + 1 }
        response.retryMapping.condition.expressionValues[':expectedVersion'] =
 event.currentValue.version

    } else {
        response = { "action" : "reject" }
    }

    console.log("Response: "+ JSON.stringify(response))
    callback(null, response)
```

```
};
```

Transaction Condition Expressions

Transaction condition expressions are available in request mapping templates of all four types of operations in `TransactWriteItems`, namely, `PutItem`, `DeleteItem`, `UpdateItem`, and `ConditionCheck`.

For `PutItem`, `DeleteItem`, and `UpdateItem`, transaction condition expression is optional. For `ConditionCheck`, transaction condition expression is required.

Example 1

The following transactional `DeleteItem` mapping document does not have a condition expression. As a result, it deletes the item in DynamoDB.

```
{
   "version": "2018-05-29",
   "operation": "TransactWriteItems",
   "transactItems": [
      {
         "table": "posts",
         "operation": "DeleteItem",
         "key": {
            "id": { "S" : "1" }
         }
      }
   ]
}
```

Example 2

The following transactional `DeleteItem` mapping document does have a transaction condition expression that allows the operation succeed only if the author of that post equals certain name.

```
{
   "version": "2018-05-29",
   "operation": "TransactWriteItems",
   "transactItems": [
      {
         "table": "posts",
         "operation": "DeleteItem",
         "key": {
            "id": { "S" : "1" }
         }
         "condition": {
            "expression": "author = :author",
            "expressionValues": {
               ":author": { "S" : "Chunyan" }
            }
         }
      }
   ]
}
```

If the condition check fails, it will cause `TransactionCanceledException` and the error detail will be returned in `$ctx.result.cancellationReasons`. Note that by default, the old item in DynamoDB that made condition check fail will be returned in `$ctx.result.cancellationReasons`

Specifying a Condition

The `PutItem`, `UpdateItem`, and `DeleteItem` request mapping documents all allow an optional `condition` section to be specified. If omitted, no condition check is made. If specified, the condition must be true for the operation to succeed. The `ConditionCheck` must have a `condition` section to be specified. The condition must be true for the whole transaction to succeed.

A `condition` section has the following structure:

```
"condition": {
    "expression": "someExpression",
    "expressionNames": {
        "#foo": "foo"
    },
    "expressionValues": {
        ":bar": ... typed value
    },
    "returnValuesOnConditionCheckFailure": false
}
```

The following fields specify the condition:

`expression`

The update expression itself. For more information about how to write condition expressions, see the DynamoDB ConditionExpressions documentation . This field must be specified.

`expressionNames`

The substitutions for expression attribute name placeholders, in the form of key-value pairs. The key corresponds to a name placeholder used in the *expression*, and the value must be a string corresponding to the attribute name of the item in DynamoDB. This field is optional, and should only be populated with substitutions for expression attribute name placeholders used in the *expression*.

`expressionValues`

The substitutions for expression attribute value placeholders, in the form of key-value pairs. The key corresponds to a value placeholder used in the expression, and the value must be a typed value. For more information about how to specify a “typed value”, see Type System (request mapping). This must be specified. This field is optional, and should only be populated with substitutions for expression attribute value placeholders used in the expression.

`returnValuesOnConditionCheckFailure`

Specify whether to retrieve the item in DynamoDB back when a condition check fails. The retrieved item will be in `$ctx.result.cancellationReasons[$index].item`, where `$index` is the index of the request item that failed the condition check. Defaults to be true.

Resolver mapping template reference for RDS

The AWS Appsync RDS resolver mapping templates allow developers to send SQL queries to a Data API for Amazon Aurora Serverless and get back the result of these queries.

Request mapping template

The RDS request mapping template is fairly simple:

```
{
```

```
    "version": "2018-05-29",
    "statements": [],
    "variableMap": {}
}
```

Here is the JSON schema representation of the RDS request mapping template, once resolved.

```
{
    "definitions": {},
    "$schema": "https://json-schema.org/draft-07/schema#",
    "$id": "https://example.com/root.json",
    "type": "object",
    "title": "The Root Schema",
    "required": [
        "version",
        "statements",
        "variableMap"
    ],
    "properties": {
        "version": {
            "$id": "#/properties/version",
            "type": "string",
            "title": "The Version Schema",
            "default": "",
            "examples": [
                "2018-05-29"
            ],
            "enum": [
                "2018-05-29"
            ],
            "pattern": "^(.*)$"
        },
        "statements": {
            "$id": "#/properties/statements",
            "type": "array",
            "title": "The Statements Schema",
            "items": {
                "$id": "#/properties/statements/items",
                "type": "string",
                "title": "The Items Schema",
                "default": "",
                "examples": [
                    "SELECT * from BOOKS"
                ],
                "pattern": "^(.*)$"
            }
        },
        "variableMap": {
            "$id": "#/properties/variableMap",
            "type": "object",
            "title": "The Variablemap Schema"
        }
    }
}
```

The following is an example of the request mapping template with a static query:

```
{
    "version": "2018-05-29",
    "statements": [
        "select title, isbn13 from BOOKS where author = 'Mark Twain'"
    ]
}
```

Version

Common to all request mapping templates, the version field defines the version that the template uses. The version field is required. The value “2018-05-29” is the only version supported for the Amazon RDS mapping templates.

```
"version": "2018-05-29"
```

Statements

The statements array is a placeholder for the developer provided queries. Currently, up to two queries per request mapping template are supported. The following is possible:

```
{
    "version": "2018-05-29",
    "statements": [
            $util.toJson("insert into BOOKS VALUES ('$ctx.args.newBook.author',
 '$ctx.args.newBook.title', '$ctx.args.newBook.ISBN13')"),
            $util.toJson("select * from BOOKS WHERE isbn13 = '$ctx.args.newBook.isbn13'")
    ]
}
```

AWS AppSync supports up to two statements per request mapping template.

VariableMap

The variableMap is an optional field which contains aliases that can be used to make the SQL statements shorter and more readable. For example the following is possible:

```
{
    "version": "2018-05-29",
    "statements": [
        "insert into BOOKS VALUES (:AUTHOR, :TITLE, :ISBN13)",
        "select * from BOOKS WHERE isbn13 = :ISBN13"
    ],
    "variableMap": {
        ":AUTHOR": $util.toJson($ctx.args.newBook.author),
        ":TITLE": $util.toJson($ctx.args.newBook.title),
        ":ISBN13": $util.toJson($ctx.args.newBook.isbn13)
    }
}
```

AWS AppSync will use the variable map value to construct the queries that are sent to the Amazon Aurora Serverless Data API. For example the two queries that AWS Appsync will send to Amazon RDS will be (assuming “`$ctx.args.newBook.author"='Mark Twain'`, `"$ctx.args.newBook.title"='Adventures of Huckleberry Finn'` and `"$ctx.args.newBook.isbn13"='978-1948132817'`):

```
INSERT INTO BOOKS VALUES ('Mark Twain', 'Adventures of Huckleberry Finn',
 '978-1948132817');
```

and

```
SELECT from BOOKS where isb13='978-1948132817';
```

Resolver Mapping Template Reference for Elasticsearch

The AWS AppSync resolver for Amazon Elasticsearch Service enables you to use GraphQL to store and retrieve data in existing Amazon ES domains in your account. This resolver works by allowing you to map an incoming GraphQL request into an Amazon ES request, and then map the Amazon ES response back to GraphQL. This section describes the mapping templates for the supported Amazon ES operations.

Request Mapping Template

Most Amazon ES request mapping templates have a common structure where just a few pieces change. The following example runs a search against an Amazon ES domain, where documents are of type `post` and are indexed under `id`. The search parameters are defined in the `body` section, with many of the common query clauses being defined in the `query` field. This example will search for documents containing `"Nadia"`, or `"Bailey"`, or both, in the `author` field of a document:

```
{
    "version":"2017-02-28",
    "operation":"GET",
    "path":"/id/post/_search",
    "params":{
        "headers":{},
        "queryString":{},
        "body":{
            "from":0,
            "size":50,
            "query" : {
                "bool" : {
                    "should" : [
                        {"match" : { "author" : "Nadia" }},
                        {"match" : { "author" : "Bailey" }}
                    ]
                }
            }
        }
    }
}
```

For more information on query options, see the Elasticsearch Query DSL Reference.

Response Mapping Template

As with other data sources, Amazon ES sends a response to AWS AppSync that needs to be converted to GraphQL. The shape of an Amazon ES response can be seen in the Elasticsearch Request Body Search DSL Reference.

Most GraphQL queries are looking for the `_source` field from an Amazon ES response. Because you can do searches to return either an individual document or a list of documents, there are two common response mapping templates used in Amazon ES:

List of Results

```
[
    #foreach($entry in $context.result.hits.hits)
      #if( $velocityCount > 1 ) , #end
        $utils.toJson($entry.get("_source"))
    #end
```

```
]
```

Individual Item

```
$utils.toJson($context.result.get("_source"))
```

operation field

(REQUEST Mapping Template only)

HTTP method or verb (GET, POST, PUT, HEAD or DELETE) that AWS AppSync sends to the Amazon ES domain. Both the key and the value must be a string.

```
"operation" : "PUT"
```

path field

(REQUEST Mapping Template only)

The search path for an Amazon ES request from AWS AppSync. This forms a URL for the operation's HTTP verb. Both the key and the value must be strings.

```
"path" : "/indexname/type"

"path" : "/indexname/type/_search"
```

When the mapping template is evaluated, this path is sent as part of the HTTP request, including the Amazon ES domain. For example, the previous example might translate to:

```
GET https://elasticsearch-domain-name.REGION.es.amazonaws.com/indexname/type/_search
```

params field

(REQUEST Mapping Template only)

Used to specify what action your search performs, most commonly by setting the **query** value inside of the **body**. However, there are several other capabilities that can be configured, such as the formatting of responses.

- **headers**

  The header information, as key-value pairs. Both the key and the value must be strings. For example:

  ```
  "headers" : {
      "Content-Type" : "JSON"
  }
  ```

  Note: AWS AppSync currently supports only JSON as a `Content-Type`.
- **queryString**

  Key-value pairs that specify common options, such as code formatting for JSON responses. Both the key and the value must be a string. For example, if you want to get pretty-formatted JSON, you would use:

```
"queryString" : {
    "pretty" : "true"
}
```

- **body**

  This is the main part of your request, allowing AWS AppSync to craft a well-formed search request to your Amazon ES domain. The key must be a string comprised of an object. A couple of demonstrations are shown below.

Example 1

Return all documents with a city matching “seattle”:

```
"body":{
    "from":0,
    "size":50,
    "query" : {
        "match" : {
            "city" : "seattle"
        }
    }
}
```

Example 2

Return all documents matching “washington” as the city or the state:

```
"body":{
    "from":0,
    "size":50,
    "query" : {
        "multi_match" : {
            "query" : "washington",
            "fields" : ["city", "state"]
        }
    }
}
```

Passing Variables

(REQUEST Mapping Template only)

You can also pass variables as part of evaluation in the VTL statement. For example, suppose you had a GraphQL query such as the following:

```
query {
    searchForState(state: "washington"){
        ...
    }
}
```

The mapping template could take the state as an argument:

```
"body":{
    "from":0,
    "size":50,
```

```
    "query" : {
        "multi_match" : {
            "query" : "$context.arguments.state",
            "fields" : ["city", "state"]
        }
    }
}
```

For a list of utilities you can include in the VTL, see Access Request Headers (p. 244).

Resolver mapping template reference for Lambda

The AWS AppSync Lambda resolver mapping templates enable you to shape requests from AWS AppSync to AWS Lambda functions located in your account, and responses from your Lambda functions back to AWS AppSync. Mapping templates also enable you to give hints to AWS AppSync about the nature of the operation to be invoked. This section describes the different mapping templates for the supported AWS Lambda operations.

Request mapping template

The Lambda request mapping template is fairly simple and allows as much context information as possible to pass to your Lambda function.

```
{
   "version": string,
   "operation": Invoke|BatchInvoke,
   "payload": any type
}
```

Here is the JSON schema representation of the Lambda request mapping template, once resolved.

```
{
    "definitions": {},
    "$schema": "https://json-schema.org/draft-06/schema#",
    "$id": "https://aws.amazon.com/appsync/request-mapping-template.json",
    "type": "object",
    "properties": {
        "version": {
            "$id": "/properties/version",
            "type": "string",
            "enum": [
                "2018-05-29"
            ],
            "title": "The Mapping template version.",
            "default": "2018-05-29"
        },
        "operation": {
            "$id": "/properties/operation",
            "type": "string",
            "enum": [
                "Invoke",
                "BatchInvoke"
            ],
            "title": "The Mapping template operation.",
            "description": "What operation to execute.",
            "default": "Invoke"
        },
        "payload": {}
```

```
    },
    "required": [
        "version",
        "operation"
    ],
    "additionalProperties": false
}
```

Here is an example where we chose to pass the `field` value, and the GraphQL field arguments from the context.

```
{
    "version": "2018-05-29",
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "arguments": $util.toJson($context.arguments)
    }
}
```

The entire mapping document will be passed as input to your Lambda function, so that the previous example would now look like the following:

```
{
    "version": "2018-05-29",
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "arguments": {
            "id": "postId1"
        }
    }
}
```

Version

Common to all request mapping templates, `version` defines the version that the template uses. `version` is required.

```
"version": "2018-05-29"
```

Operation

The Lambda data source allows you to define two operations, `Invoke` and `BatchInvoke`. The `Invoke` lets AWS AppSync know to call your Lambda function for every GraphQL field resolver, while `BatchInvoke` instructs AWS AppSync to batch requests for the current GraphQL field.

`operation` is required.

For **Invoke**, the resolved request mapping template exactly matches the input payload of the Lambda function. So the following sample template:

```
{
    "version": "2018-05-29",
    "operation": "Invoke",
    "payload": {
        "arguments": $util.toJson($context.arguments)
    }
```

```
}
```

is resolved and passed to the Lambda function, as follows:

```
{
    "version": "2018-05-29",
    "operation": "Invoke",
    "payload": {
        "arguments": {
            "id": "postId1"
        }
    }
}
```

For **BatchInvoke**, the mapping template is applied for every field resolver in the batch. For conciseness, AWS AppSync merges all of the resolved mapping template `payload` values into a list under a single object matching the mapping template.

The following example template shows the merge:

```
{
    "version": "2018-05-29",
    "operation": "BatchInvoke",
    "payload": $util.toJson($context)
}
```

This template is resolved into the following mapping document:

```
{
    "version": "2018-05-29",
    "operation": "BatchInvoke",
    "payload": [
        {...}, // context for batch item 1
        {...}, // context for batch item 2
        {...}  // context for batch item 3
    ]
}
```

where each element of the `payload` list corresponds to a single batch item. The Lambda function is also expected to return a list-shaped response, matching the order of the items sent in the request, as follows:

```
[
    { "data": {...}, "errorMessage": null, "errorType": null }, // result for batch item 1
    { "data": {...}, "errorMessage": null, "errorType": null }, // result for batch item 2
    { "data": {...}, "errorMessage": null, "errorType": null }  // result for batch item 3
]
```

`operation` is required.

Payload

The `payload` field is a container that you can use to pass any well-formed JSON to the Lambda function.

If the `operation` field is set to `BatchInvoke`, AWS AppSync will wrap the existing `payload` values into a list.

`payload` is optional.

Response mapping template

As with other data sources, your Lambda function sends a response to AWS AppSync that needs to be converted to a GraphQL type.

The result of the Lambda function will be set on the `context` object that is available via the VTL `$context.result` property.

If the shape of your Lambda function response exactly matches the shape of the GraphQL type, you can forward the response using the following response mapping template:

```
$util.toJson($context.result)
```

There are no required fields or shape restrictions that apply to the response mapping template. However, because GraphQL is strongly typed, the resolved mapping template must match the expected GraphQL type.

Lambda function batched response

If the `operation` field is set to `BatchInvoke`, AWS AppSync expects a list of items back from the Lambda function. In order for AWS AppSync to map each result back to the original request item, the response list must match in size and order. It is ok to have `null` items in the response list; `$ctx.result` will be set to *null* accordingly.

Direct Lambda resolvers

If you wish to circumvent the use of mapping templates entirely, AWS AppSync can provide a default payload to your Lamdba function and a default of a Lambda function's response to a GraphQL type. You can choose to provide a request template, a response template, or neither and AWS AppSync handles it accordingly.

Direct Lambda request mapping template

When the request mapping template is not provided, AWS AppSync will send the Context object directly to your Lambda function as an `Invoke` operation. For more information about the structure of the Context object, see Context (p. 241).

Direct Lambda response mapping template

When the response mapping template is not provided, AWS AppSync will do one of two things upon receiving your Lambda function's response. If you did not provide a request mapping template, or if you provided a request mapping template with the version "2018-05-29", the response logic functions equivalent to the following response mapping template:

```
#if($ctx.error)
     $util.error($ctx.error.message, $ctx.error.type, $ctx.result)
 #end
 $util.toJson($ctx.result)
```

If you provided a template with the version "2017-02-28", the response logic functions equivalent to the following response mapping template:

```
$util.toJson($ctx.result)
```

Superficially, the mapping template bypass operates similarly to using certain mapping templates, as shown in the preceding examples. However, behind the scenes, the evaluation of the mapping

templates are circumvented entirely. Because the template evaluation step is bypassed, in some scenarios applications might experience less overhead and latency during the response when compared to a Lambda function with a response mapping template that needs to be evaluated.

Custom error handling in Direct Lambda resolver responses

You can customize error responses from Lambda functions that are invoked by Direct Lambda resolvers by raising a custom exception. The following example demonstrates how to create a custom exception using JavaScript.

```
class CustomException extends Error {
    constructor(message) {
        super(message);
        this.name = "CustomException";
    }
}

throw new CustomException("Custom message");
```

When exceptions are raised, the `errorType` and `errorMessage` will be the `name` and `message`, respectively, of the custom error that is thrown.

If `errorType` is `UnauthorizedException`, AWS AppSync returns the default message (`"You are not authorized to make this call."`) instead of a custom message.

The following is an example GraphQL response that demonstrates a custom `errorType`.

```
{
  "data": {
    "query": null
  },
  "errors": [
    {
      "path": [
        "query"
      ],
      "data": null,
      "errorType": "CustomException",
      "errorInfo": null,
      "locations": [
        {
          "line": 5,
          "column": 10,
          "sourceName": null
        }
      ],
      "message": "Custom Message"
    }
  ]
}
```

Resolver mapping template reference for None data source

The AWS AppSync resolver mapping template used with the data source of type *None*, enables you to shape requests for AWS AppSync local operations.

Request mapping template

The mapping template is simple and enables you to pass as much context information as possible via the `payload` field.

```
{
   "version": string,
   "payload": any type
}
```

Here is the JSON schema representation of the request mapping template, once resolved:

```
{
    "definitions": {},
    "$schema": "https://json-schema.org/draft-06/schema#",
    "$id": "https://aws.amazon.com/appsync/request-mapping-template.json",
    "type": "object",
    "properties": {
        "version": {
            "$id": "/properties/version",
            "type": "string",
            "enum": [
                "2018-05-29"
            ],
            "title": "The Mapping template version.",
            "default": "2018-05-29"
        },
        "payload": {}
    },
    "required": [
        "version"
    ],
    "additionalProperties": false
}
```

Here is an example where the field arguments are passed via the VTL context property `$context.arguments`:

```
{
    "version": "2018-05-29",
    "payload": $util.toJson($context.arguments)
}
```

The value of the `payload` field will be forwarded to the response mapping template and available on the VTL context property (`$context.result`).

This is an example representing the interpolated value of the `payload` field:

```
{
    "id": "postId1"
}
```

Version

Common to all request mapping templates, the `version` field defines the version used by the template.

The `version` field is required.

Example:

```
"version": "2018-05-29"
```

Payload

The `payload` field is a container that can be used to pass any well-formed JSON to the response mapping template.

The `payload` field is optional.

Response mapping template

Because there is no data source, the value of the `payload` field will be forwarded to the response mapping template and set on the `context` object that is available via the VTL `$context.result` property.

If the shape of the `payload` field value exactly matches the shape of the GraphQL type, you can forward the response using the following response mapping template:

```
$util.toJson($context.result)
```

There are no required fields or shape restrictions that apply to the response mapping template. However, because GraphQL is strongly typed, the resolved mapping template must match the expected GraphQL type.

Resolver Mapping Template Reference for HTTP

The AWS AppSync HTTP resolver mapping templates enable you to send requests from AWS AppSync to any HTTP endpoint, and responses from your HTTP endpoint back to AWS AppSync. By using mapping templates, you can provide hints to AWS AppSync about the nature of the operation to be invoked. This section describes the different mapping templates for the supported HTTP resolver.

Request Mapping Template

```
{
    "version": "2018-05-29",
    "method": "PUT|POST|GET|DELETE|PATCH",
    "params": {
        "query": Map,
        "headers": Map,
        "body": string
    },
    "resourcePath": string
}
```

After the HTTP request mapping template is resolved, the JSON schema representation of the request mapping template looks like the following:

```
{
    "$id": "https://aws.amazon.com/appsync/request-mapping-template.json",
    "type": "object",
    "properties": {
```

```
        "version": {
        "$id": "/properties/version",
        "type": "string",
        "title": "The Version Schema ",
        "default": "",
        "examples": [
            "2018-05-29"
        ],
        "enum": [
            "2018-05-29"
        ]
        },
        "method": {
        "$id": "/properties/method",
        "type": "string",
        "title": "The Method Schema ",
        "default": "",
        "examples": [
            "PUT|POST|GET|DELETE|PATCH"
        ],
        "enum": [
            "PUT",
            "PATCH",
            "POST",
            "DELETE",
            "GET"
        ]
        },
        "params": {
        "$id": "/properties/params",
        "type": "object",
        "properties": {
            "query": {
            "$id": "/properties/params/properties/query",
            "type": "object"
            },
            "headers": {
            "$id": "/properties/params/properties/headers",
            "type": "object"
            },
            "body": {
            "$id": "/properties/params/properties/body",
            "type": "string",
            "title": "The Body Schema ",
            "default": "",
            "examples": [
                ""
            ]
            }
        }
        },
        "resourcePath": {
        "$id": "/properties/resourcePath",
        "type": "string",
        "title": "The Resourcepath Schema ",
        "default": "",
        "examples": [
            ""
        ]
        }
    },
    "required": [
        "version",
        "method",
        "resourcePath"
    ]
```

```
}
```

Following is an example of an HTTP POST request, with a `text/plain` body:

```
{
    "version": "2018-05-29",
    "method": "POST",
    "params": {
        "headers":{
        "Content-Type":"text/plain"
        },
        "body":"this is an example of text body"
    },
    "resourcePath": "/"
}
```

Version

Request mapping template only

Defines the version that the template uses. `version` is common to all request mapping templates and is required.

```
"version": "2018-05-29"
```

Method

Request mapping template only

HTTP method or verb (GET, POST, PUT, PATCH, or DELETE) that AWS AppSync sends to the HTTP endpoint.

```
"method": "PUT"
```

ResourcePath

Request mapping template only

The resource path that you want to access. Along with the endpoint in the HTTP data source, the resource path forms the URL that the AWS AppSync service makes a request to.

```
"resourcePath": "/v1/users"
```

When the mapping template is evaluated, this path is sent as part of the HTTP request, including the HTTP endpoint. For example, the previous example might translate to the following:

```
PUT <endpoint>/v1/users
```

Params Field

Request mapping template only

Used to specify what action your search performs, most commonly by setting the **query** value inside the **body**. However, there are several other capabilities that can be configured, such as the formatting of responses.

headers

The header information, as key-value pairs. Both the key and the value must be strings.

For example:

```
"headers" : {
    "Content-Type" : "application/json"
}
```

Currently supported `Content-Type` headers are:

```
text/*
application/xml
application/json
application/soap+xml
application/x-amz-json-1.0
application/x-amz-json-1.1
application/vnd.api+json
application/x-ndjson
```

Note: You can't set the following HTTP headers:

```
HOST
CONNECTION
USER-AGENT
EXPECTATION
TRANSFER_ENCODING
CONTENT_LENGTH
```

query

Key-value pairs that specify common options, such as code formatting for JSON responses. Both the key and the value must be a string. The following example shows how you can send a query string as `?type=json`:

```
"query" : {
    "type" : "json"
}
```

body

The body contains the HTTP request body that you choose to set. The request body is always a UTF-8 encoded string unless the content type specifies the charset.

```
"body":"body string"
```

Certificate Authorities (CA) Recognized by AWS AppSync for HTTPS Endpoints

At this time, self-signed certificates are not supported by HTTP resolvers when using HTTPS. AWS AppSync recognizes the following Certificate Authorities when resolving SSL/TLS certificates for HTTPS:

Note
Let's Encrypt is accepted via the *identrust* and *isrgrootx1* certificates. No action on your part is required if you use Let's Encrypt.

Known root certificates in AWS AppSync

Name	Date	SHA1 Fingerprint
digicertassuredidrootca	*Apr 21, 2018*	05:63:B8:63:0D:62:D7:5A:BB:C8:AB:1E:4B:DF:B5:A8:99:B2:4
trustcenterclass2caii	*Apr 21, 2018*	AE:50:83:ED:7C:F4:5C:BC:8F:61:C6:21:FE:68:5D:79:42:21:1
thawtepremiumserverca	*Apr 21, 2018*	E0:AB:05:94:20:72:54:93:05:60:62:02:36:70:F7:CD:2E:FC:6
cia-crt-g3-02-ca	*Nov 23, 2016*	96:4A:BB:A7:BD:DA:FC:97:34:C0:0A:2D:F0:05:98:F7:E6:C6:6
swisssignplatinumg2ca	*Apr 21, 2018*	56:E0:FA:C0:3B:8F:18:23:55:18:E5:D3:11:CA:E8:C2:43:31:A
swisssignsilverg2ca	*Apr 21, 2018*	9B:AA:E5:9F:56:EE:21:CB:43:5A:BE:25:93:DF:A7:F0:40:D1:1
thawteserverca	*Apr 21, 2018*	9F:AD:91:A6:CE:6A:C6:C5:00:47:C4:4E:C9:D4:A5:0D:92:D8:4
equifaxsecureebusinessca1	*Apr 21, 2018*	AE:E6:3D:70:E3:76:FB:C7:3A:EB:B0:A1:C1:D4:C4:7A:A7:40:E
securetrustca	*Apr 21, 2018*	87:82:C6:C3:04:35:3B:CF:D2:96:92:D2:59:3E:7D:44:D9:34:E
utnuserfirstclientauthemailca	*Apr 21, 2018*	B1:72:B1:A5:6D:95:F9:1F:E5:02:87:E1:4D:37:EA:6A:44:63:7
thawtepersonalfreemailca	*Apr 21, 2018*	E6:18:83:AE:84:CA:C1:C1:CD:52:AD:E8:E9:25:2B:45:A6:4F:E
affirmtrustnetworkingca	*Apr 21, 2018*	29:36:21:02:8B:20:ED:02:F5:66:C5:32:D1:D6:ED:90:9F:45:0
entrustevca	*Apr 21, 2018*	B3:1E:B1:B7:40:E3:6C:84:02:DA:DC:37:D4:4D:F5:D4:67:49:5
utnuserfirsthardwareca	*Apr 21, 2018*	04:83:ED:33:99:AC:36:08:05:87:22:ED:BC:5E:46:00:E3:BE:E
certumca	*Apr 21, 2018*	62:52:DC:40:F7:11:43:A2:2F:DE:9E:F7:34:8E:06:42:51:B1:8
addtrustclass1ca	*Apr 21, 2018*	CC:AB:0E:A0:4C:23:01:D6:69:7B:DD:37:9F:CD:12:EB:24:E3:9
entrustrootcag2	*Apr 21, 2018*	8C:F4:27:FD:79:0C:3A:D1:66:06:8D:E8:1E:57:EF:BB:93:22:7
equifaxsecureca	*Apr 21, 2018*	D2:32:09:AD:23:D3:14:23:21:74:E4:0D:7F:9D:62:13:97:86:6
quovadisrootca3	*Apr 21, 2018*	1F:49:14:F7:D8:74:95:1D:DD:AE:02:C0:BE:FD:3A:2D:82:75:5
quovadisrootca2	*Apr 21, 2018*	CA:3A:FB:CF:12:40:36:4B:44:B2:16:20:88:80:48:39:19:93:7
digicertglobalrootg2	*Apr 21, 2018*	DF:3C:24:F9:BF:D6:66:76:1B:26:80:73:FE:06:D1:CC:8D:4F:8
digicerthighassuranceevrootca	*Apr 21, 2018*	5F:B7:EE:06:33:E2:59:DB:AD:0C:4C:9A:E6:D3:8F:1A:61:C7:D
secomvalicertclass1ca	*Apr 21, 2018*	E5:DF:74:3C:B6:01:C4:9B:98:43:DC:AB:8C:E8:6A:81:10:9F:E
equifaxsecureglobalebusinessca1	*Apr 21, 2018*	3A:74:CB:7A:47:DB:70:DE:89:1F:24:35:98:64:B8:2D:82:BD:1
geotrustuniversalca	*Apr 21, 2018*	E6:21:F3:35:43:79:05:9A:4B:68:30:9D:8A:2F:74:22:15:87:E
deprecateditsecca	*Jan 27, 2012*	12:12:0B:03:0E:15:14:54:F4:DD:B3:F5:DE:13:6E:83:5A:29:7
verisignclass3ca	*Apr 21, 2018*	A1:DB:63:93:91:6F:17:E4:18:55:09:40:04:15:C7:02:40:B0:A
thawteprimaryrootcag3	*Apr 21, 2018*	F1:8B:53:8D:1B:E9:03:B6:A6:F0:56:43:5B:17:15:89:CA:F3:6
thawteprimaryrootcag2	*Apr 21, 2018*	AA:DB:BC:22:23:8F:C4:01:A1:27:BB:38:DD:F4:1D:DB:08:9E:E
deutschetelekomrootca2	*Apr 21, 2018*	85:A4:08:C0:9C:19:3E:5D:51:58:7D:CD:D6:13:30:FD:8C:DE:3

Name	Date	SHA1 Fingerprint
buypassclass3ca	*Apr 21, 2018*	DA:FA:F7:FA:66:84:EC:06:8F:14:50:BD:C7:C2:81:A5:BC:A9:6
utnuserfirstobjectca	*Apr 21, 2018*	E1:2D:FB:4B:41:D7:D9:C3:2B:30:51:4B:AC:1D:81:D8:38:5E:2
geotrustprimaryca	*Apr 21, 2018*	32:3C:11:8E:1B:F7:B8:B6:52:54:E2:E2:10:0D:D6:02:90:37:F
buypassclass2ca	*Apr 21, 2018*	49:0A:75:74:DE:87:0A:47:FE:58:EE:F6:C7:6B:EB:C6:0B:12:4
baltimorecodesigningca	*Apr 21, 2018*	30:46:D8:C8:88:FF:69:30:C3:4A:FC:CD:49:27:08:7C:60:56:7
verisignclass1ca	*Apr 21, 2018*	CE:6A:64:A3:09:E4:2F:BB:D9:85:1C:45:3E:64:09:EA:E8:7D:6
baltimorecybertrustca	*Apr 21, 2018*	D4:DE:20:D0:5E:66:FC:53:FE:1A:50:88:2C:78:DB:28:52:CA:E
starfieldclass2ca	*Apr 21, 2018*	AD:7E:1C:28:B0:64:EF:8F:60:03:40:20:14:C3:D0:E3:37:0E:E
camerfirmachamberscommerceca	*Apr 21, 2018*	6E:3A:55:A4:19:0C:19:5C:93:84:3C:C0:DB:72:2E:31:30:61:F
ttelesecglobalrootclass3ca	*Apr 21, 2018*	55:A6:72:3E:CB:F2:EC:CD:C3:23:74:70:19:9D:2A:BE:11:E3:8
verisignclass3g5ca	*Apr 21, 2018*	4E:B6:D5:78:49:9B:1C:CF:5F:58:1E:AD:56:BE:3D:9B:67:44:A
ttelesecglobalrootclass2ca	*Apr 21, 2018*	59:0D:2D:7D:88:4F:40:2E:61:7E:A5:62:32:17:65:CF:17:D8:9
trustcenteruniversalcai	*Apr 21, 2018*	6B:2F:34:AD:89:58:BE:62:FD:B0:6B:5C:CE:BB:9D:D9:4F:4E:3
verisignclass3g4ca	*Apr 21, 2018*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:6
verisignclass3g3ca	*Apr 21, 2018*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:5
xrampglobalca	*Apr 21, 2018*	B8:01:86:D1:EB:9C:86:A5:41:04:CF:30:54:F3:4C:52:B7:E5:5
amzninternalrootca	*Dec 12, 2008*	A7:B7:F6:15:8A:FF:1E:C8:85:13:38:BC:93:EB:A2:AB:A4:09:F
certplusclass3pprimaryca	*Apr 21, 2018*	21:6B:2A:29:E6:2A:00:CE:82:01:46:D8:24:41:41:B9:25:11:F
certumtrustednetworkca	*Apr 21, 2018*	07:E0:32:E0:20:B7:2C:3F:19:2F:06:28:A2:59:3A:19:A7:0F:0
verisignclass3g2ca	*Apr 21, 2018*	85:37:1C:A6:E5:50:14:3D:CE:28:03:47:1B:DE:3A:09:E8:F8:7
globalsignr3ca	*Apr 21, 2018*	D6:9B:56:11:48:F0:1C:77:C5:45:78:C1:09:26:DF:5B:85:69:7
utndatacorpsgcca	*Apr 21, 2018*	58:11:9F:0E:12:82:87:EA:50:FD:D9:87:45:6F:4F:78:DC:FA:D
secomscrootca2	*Apr 21, 2018*	5F:3B:8C:F2:F8:10:B3:7D:78:B4:CE:EC:19:19:C3:73:34:B9:0
gtecybertrustglobalca	*Apr 21, 2018*	97:81:79:50:D8:1C:96:70:CC:34:D8:09:CF:79:44:31:36:7E:F
secomscrootca1	*Apr 21, 2018*	36:B1:2B:49:F9:81:9E:D7:4C:9E:BC:38:0F:C6:56:8F:5D:AC:F
affirmtrustcommercialca	*Apr 21, 2018*	F9:B5:B6:32:45:5F:9C:BE:EC:57:5F:80:DC:E9:6E:2C:C7:B2:7
trustcenterclass4caii	*Apr 21, 2018*	A6:9A:91:FD:05:7F:13:6A:42:63:0B:B1:76:0D:2D:51:12:0C:1
verisignuniversalrootca	*Apr 21, 2018*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:0
globalsignr2ca	*Apr 21, 2018*	75:E0:AB:B6:13:85:12:27:1C:04:F8:5F:DD:DE:38:E4:B7:24:2
certplusclass2primaryca	*Apr 21, 2018*	74:20:74:41:72:9C:DD:92:EC:79:31:D8:23:10:8D:C2:81:92:F

Name	Date	SHA1 Fingerprint
digicertglobalrootca	*Apr 21, 2018*	A8:98:5D:3A:65:E5:E5:C4:B2:D7:D6:6D:40:C6:DD:2F:B1:9C:5
globalsignca	*Apr 21, 2018*	B1:BC:96:8B:D4:F4:9D:62:2A:A8:9A:81:F2:15:01:52:A4:1D:8
thawteprimaryrootca	*Apr 21, 2018*	91:C6:D6:EE:3E:8A:C8:63:84:E5:48:C2:99:29:5C:75:6C:81:7
starfieldrootg2ca	*Apr 21, 2018*	B5:1C:06:7C:EE:2B:0C:3D:F8:55:AB:2D:92:F4:FE:39:D4:E7:0
geotrustglobalca	*Apr 21, 2018*	DE:28:F4:A4:FF:E5:B9:2F:A3:C5:03:D1:A3:49:A7:F9:96:2A:8
soneraclass2ca	*Apr 21, 2018*	37:F7:6D:E6:07:7C:90:C5:B1:3E:93:1A:B7:41:10:B4:F2:E4:9
verisigntsaca	*Apr 21, 2018*	20:CE:B1:F0:F5:1C:0E:19:A9:F3:8D:B1:AA:8E:03:8C:AA:7A:0
soneraclass1ca	*Apr 21, 2018*	07:47:22:01:99:CE:74:B9:7C:B0:3D:79:B2:64:A2:C8:55:E9:3
quovadisrootca	*Apr 21, 2018*	DE:3F:40:BD:50:93:D3:9B:6C:60:F6:DA:BC:07:62:01:00:89:7
affirmtrustpremiumecccaApr 21, 2018		B8:23:6B:00:2F:1D:16:86:53:01:55:6C:11:A4:37:CA:EB:FF:0
starfieldservicesrootg2caApr 21, 2018		92:5A:8F:8D:2C:6D:04:E0:66:5F:59:6A:FF:22:D8:63:E8:25:6
valicertclass2ca	*Apr 21, 2018*	31:7A:2A:D0:7F:2B:33:5E:F5:A1:C3:4E:4B:57:E8:B7:D8:F1:F
comodoaaaca	*Apr 21, 2018*	D1:EB:23:A4:6D:17:D6:8F:D9:25:64:C2:F1:F1:60:17:64:D8:F
aolrootca2	*Apr 21, 2018*	85:B5:FF:67:9B:0C:79:96:1F:C8:6E:44:22:00:46:13:DB:17:9
keynectisrootca	*Apr 21, 2018*	9C:61:5C:4D:4D:85:10:3A:53:26:C2:4D:BA:EA:E4:A2:D2:D5:0
addtrustqualifiedca	*Apr 21, 2018*	4D:23:78:EC:91:95:39:B5:00:7F:75:8F:03:3B:21:1E:C5:4D:8
aolrootca1	*Apr 21, 2018*	39:21:C1:15:C1:5D:0E:CA:5C:CB:5B:C4:F0:7D:21:D8:05:0B:5
verisignclass2g3ca	*Apr 21, 2018*	61:EF:43:D7:7F:CA:D4:61:51:BC:98:E0:C3:59:12:AF:9F:EB:6
addtrustexternalca	*Apr 21, 2018*	02:FA:F3:E2:91:43:54:68:60:78:57:69:4D:F5:E4:5B:68:85:1
verisignclass2g2ca	*Apr 21, 2018*	B3:EA:C4:47:76:C9:C8:1C:EA:F2:9D:95:B6:CC:A0:08:1B:67:F
geotrustprimarycag3	*Apr 21, 2018*	03:9E:ED:B8:0B:E7:A0:3C:69:53:89:3B:20:D2:D9:32:3A:4C:2
geotrustprimarycag2	*Apr 21, 2018*	8D:17:84:D5:37:F3:03:7D:EC:70:FE:57:8B:51:9A:99:E6:10:D
swisssigngoldg2ca	*Apr 21, 2018*	D8:C5:38:8A:B7:30:1B:1B:6E:D4:7A:E6:45:25:3A:6F:9F:1A:2
entrust2048ca	*Apr 21, 2018*	50:30:06:09:1D:97:D4:F5:AE:39:F7:CB:E7:92:7D:7D:65:2D:3
chunghwaepkirootca	*Apr 21, 2018*	67:65:0D:F1:7E:8E:7E:5B:82:40:A4:F4:56:4B:CF:E2:3D:69:C
camerfirmachambersignca	*Apr 21, 2018*	4A:BD:EE:EC:95:0D:35:9C:89:AE:C7:52:A1:2C:5B:29:F6:D6:A
camerfirmachambersca	*Apr 21, 2018*	78:6A:74:AC:76:AB:14:7F:9C:6A:30:50:BA:9E:A8:7E:FE:9A:C
godaddyclass2ca	*Apr 21, 2018*	27:96:BA:E6:3F:18:01:E2:77:26:1B:A0:D7:77:70:02:8F:20:E
affirmtrustpremiumca	*Apr 21, 2018*	D8:A6:33:2C:E0:03:6F:B1:85:F6:63:4F:7D:6A:06:65:26:32:2
verisignclass1g3ca	*Apr 21, 2018*	20:42:85:DC:F7:EB:76:41:95:57:8E:13:6B:D4:B7:D1:E9:8E:4
secomevrootca1	*Apr 21, 2018*	FE:B8:C4:32:DC:F9:76:9A:CE:AE:3D:D8:90:8F:FD:28:86:65:6

Name	Date	SHA1 Fingerprint
verisignclass1g2ca	*Apr 21, 2018*	27:3E:E1:24:57:FD:C4:F9:0C:55:E8:2B:56:16:7F:62:F5:32:
amzninternalinfoseccag3	*Feb 27, 2015*	B9:B1:CA:38:F7:BF:9C:D2:D4:95:E7:B6:5E:75:32:9B:A8:78:
cia-crt-g3-01-ca	*Nov 23, 2016*	2B:EE:2C:BA:A3:1D:B5:FE:60:40:41:95:08:ED:46:82:39:4D:
godaddyrootg2ca	*Apr 21, 2018*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:
digicertassuredidrootca	*Apr 21, 2018*	05:63:B8:63:0D:62:D7:5A:BB:C8:AB:1E:4B:DF:B5:A8:99:B2:
microseceszignorootca2009	*Apr 21, 2018*	89:DF:74:FE:5C:F4:0F:4A:80:F9:E3:37:7D:54:DA:91:E1:01:
affirmtrustcommercial	*Apr 21, 2018*	F9:B5:B6:32:45:5F:9C:BE:EC:57:5F:80:DC:E9:6E:2C:C7:B2:
comodoecccertificationauthority	*Apr 21, 2018*	9F:74:4E:9F:2B:4D:BA:EC:0F:31:2C:50:B6:56:3B:8E:2D:93:
cadisigrootr2	*Apr 21, 2018*	B5:61:EB:EA:A4:DE:E4:25:4B:69:1A:98:A5:57:47:C2:34:C7:
swisssignsilvercag2	*Apr 21, 2018*	9B:AA:E5:9F:56:EE:21:CB:43:5A:BE:25:93:DF:A7:F0:40:D1:
securetrustca	*Apr 21, 2018*	87:82:C6:C3:04:35:3B:CF:D2:96:92:D2:59:3E:7D:44:D9:34:
cadisigrootr1	*Apr 21, 2018*	8E:1C:74:F8:A6:20:B9:E5:8A:F4:61:FA:EC:2B:47:56:51:1A:
accvraiz1	*Apr 21, 2018*	93:05:7A:88:15:C6:4F:CE:88:2F:FA:91:16:52:28:78:BC:53:
entrustrootcertificationauthority	*Apr 21, 2018*	B3:1E:B1:B7:40:E3:6C:84:02:DA:DC:37:D4:4D:F5:D4:67:49:
camerfirmaglobalchambersignroot	*Apr 21, 2018*	33:9B:6B:14:50:24:9B:55:7A:01:87:72:84:D9:E0:2F:C3:D2:
dstacescax6	*Apr 21, 2018*	40:54:DA:6F:1C:3F:40:74:AC:ED:0F:EC:CD:DB:79:D1:53:FB:
identrustpublicsectorrootca1	*Apr 21, 2018*	BA:29:41:60:77:98:3F:F4:F3:EF:F2:31:05:3B:2E:EA:6D:4D:
starfieldrootcertificateauthorityg2	*Apr 21, 2018*	B5:1C:06:7C:EE:2B:0C:3D:F8:55:AB:2D:92:F4:FE:39:D4:E7:
secureglobalca	*Apr 21, 2018*	3A:44:73:5A:E5:81:90:1F:24:86:61:46:1E:3B:9C:C4:5F:F5:
eecertificationcentrerootca	*Apr 21, 2018*	C9:A8:B9:E7:55:80:5E:58:E3:53:77:A7:25:EB:AF:C3:7B:27:
opentrustrootcag3	*Apr 21, 2018*	6E:26:64:F3:56:BF:34:55:BF:D1:93:3F:7C:01:DE:D8:13:DA:
teliasonerarootcav1	*Apr 21, 2018*	43:13:BB:96:F1:D5:86:9B:C1:4E:6A:92:F6:CF:F6:34:69:87:
autoridaddecertificacionfirmaprofesionalcifa62634068	*Apr 21, 2018*	AE:C5:FB:3F:C8:E1:BF:C4:E5:4F:03:07:5A:9A:E8:00:B7:F7:
opentrustrootcag2	*Apr 21, 2018*	79:5F:88:60:C5:AB:7C:3D:92:E6:CB:F4:8D:E1:45:CD:11:EF:
opentrustrootcag1	*Apr 21, 2018*	79:91:E8:34:F7:E2:EE:DD:08:95:01:52:E9:55:2D:14:E9:58:
globalsigneccrootcar5	*Apr 21, 2018*	1F:24:C6:30:CD:A4:18:EF:20:69:FF:AD:4F:DD:5F:46:3A:1B:
globalsigneccrootcar4	*Apr 21, 2018*	69:69:56:2E:40:80:F4:24:A1:E7:19:9F:14:BA:F3:EE:58:AB:
izenpecom	*Apr 21, 2018*	2F:78:3D:25:52:18:A7:4A:65:39:71:B5:2C:A2:9C:45:15:6F:
turktrustelektroniksertifikahizmetsaglayicisih5	*Apr 21, 2018*	C4:18:F6:4D:46:D1:DF:00:3D:27:30:13:72:43:A9:12:11:C6:
gdcatrustauthr5root	*Apr 21, 2018*	0F:36:38:5B:81:1A:25:C3:9B:31:4E:83:CA:E9:34:66:70:CC:

Name	Date	SHA1 Fingerprint
dtrustrootclass3ca22009	*Apr 21, 2018*	58:E8:AB:B0:36:15:33:FB:80:F7:9B:1B:6D:29:D3:FF:8D:5F:0
quovadisrootca3	*Apr 21, 2018*	1F:49:14:F7:D8:74:95:1D:DD:AE:02:C0:BE:FD:3A:2D:82:75:5
quovadisrootca2	*Apr 21, 2018*	CA:3A:FB:CF:12:40:36:4B:44:B2:16:20:88:80:48:39:19:93:7
geotrustprimarycertificationauthorityg3	*Apr 21, 2018*	03:9E:ED:B8:0B:E7:A0:3C:69:53:89:3B:20:D2:D9:32:3A:4C:2
geotrustprimarycertificationauthorityg2	*Apr 21, 2018*	23:E5:94:94:51:95:F2:41:48:03:B4:D5:64:D2:A3:A3:F5:D8:8
oistewisekeyglobalrootgpca	*Apr 21, 2018*	0F:F9:40:76:18:D3:D7:6A:4B:98:F0:A8:35:9E:0C:FD:27:AC:0
addtrustexternalroot	*Apr 21, 2018*	02:FA:F3:E2:91:43:54:68:60:78:57:69:4D:F5:E4:5B:68:85:1
chambersofcommerceroot2008	*Apr 21, 2018*	78:6A:74:AC:76:AB:14:7F:9C:6A:30:50:BA:9E:A8:7E:FE:9A:0
digicertglobalrootg3	*Apr 21, 2018*	7E:04:DE:89:6A:3E:66:6D:00:E6:87:D3:3F:FA:D9:3B:E8:3D:3
comodoaaaservicesroot	*Apr 21, 2018*	D1:EB:23:A4:6D:17:D6:8F:D9:25:64:C2:F1:F1:60:17:64:D8:E
digicertglobalrootg2	*Apr 21, 2018*	DF:3C:24:F9:BF:D6:66:76:1B:26:80:73:FE:06:D1:CC:8D:4F:8
certinomisrootca	*Apr 21, 2018*	9D:70:BB:01:A5:A4:A0:18:11:2E:F7:1C:01:B9:32:C5:34:E7:8
oistewisekeyglobalrootgbca	*Apr 21, 2018*	59:22:A1:E1:5A:EA:16:35:21:F8:98:39:6A:46:46:B0:44:1B:0
dstrootcax3	*Apr 21, 2018*	DA:C9:02:4F:54:D8:F6:DF:94:93:5F:B1:73:26:38:CA:6A:D7:7
certigna	*Apr 21, 2018*	B1:2E:13:63:45:86:A4:6F:1A:B2:60:68:37:58:2D:C4:AC:FD:9
digicerthighassuranceevrootca	*Apr 21, 2018*	5F:B7:EE:06:33:E2:59:DB:AD:0C:4C:9A:E6:D3:8F:1A:61:C7:D
soneraclass2rootca	*Apr 21, 2018*	37:F7:6D:E6:07:7C:90:C5:B1:3E:93:1A:B7:41:10:B4:F2:E4:9
trustcorrootcertca2	*Apr 21, 2018*	B8:BE:6D:CB:56:F1:55:B9:63:D4:12:CA:4E:06:34:C7:94:B2:1
usertrustrsacertificationauthority	*Apr 21, 2018*	2B:8F:1B:57:33:0D:BB:A2:D0:7A:6C:51:F7:0E:E9:0D:DA:B9:A
trustcorrootcertca1	*Apr 21, 2018*	FF:BD:CD:E7:82:C8:43:5E:3C:6F:26:86:5C:CA:A8:3A:45:5B:C
geotrustuniversalca	*Apr 21, 2018*	E6:21:F3:35:43:79:05:9A:4B:68:30:9D:8A:2F:74:22:15:87:E
certsignrootca	*Apr 21, 2018*	FA:B7:EE:36:97:26:62:FB:2D:B0:2A:F6:BF:03:FD:E8:7C:4B:2
amazonrootca4	*Apr 21, 2018*	F6:10:84:07:D6:F8:BB:67:98:0C:C2:E2:44:C2:EB:AE:1C:EF:6
amazonrootca3	*Apr 21, 2018*	0D:44:DD:8C:3C:8C:1A:1A:58:75:64:81:E9:0F:2E:2A:FF:B3:D
amazonrootca2	*Apr 21, 2018*	5A:8C:EF:45:D7:A6:98:59:76:7A:8C:8B:44:96:B5:78:CF:47:4
verisignuniversalrootcertificationauthority	*Apr 21, 2018*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:0
amazonrootca1	*Apr 21, 2018*	8D:A7:F9:65:EC:5E:FC:37:91:0F:1C:6E:59:FD:C1:CC:6A:6E:D
networksolutionscertificateauthority	*Apr 21, 2018*	74:F8:A3:C3:EF:E7:B3:90:06:4B:83:90:3C:21:64:60:20:E5:D
thawteprimaryrootcag3	*Apr 21, 2018*	F1:8B:53:8D:1B:E9:03:B6:A6:F0:56:43:5B:17:15:89:CA:F3:6
affirmtrustnetworking	*Apr 21, 2018*	29:36:21:02:8B:20:ED:02:F5:66:C5:32:D1:D6:ED:90:9F:45:0
thawteprimaryrootcag2	*Apr 21, 2018*	AA:DB:BC:22:23:8F:C4:01:A1:27:BB:38:DD:F4:1D:DB:08:9E:F

Name	Date	SHA1 Fingerprint
trustcoreca1	*Apr 21, 2018*	58:D1:DF:95:95:67:6B:63:C0:F0:5B:1C:17:4D:8B:84:0B:C8:7
deutschetelekomrootca2	*Apr 21, 2018*	85:A4:08:C0:9C:19:3E:5D:51:58:7D:CD:D6:13:30:FD:8C:DE:3
godaddyrootcertificateauthorityg2	*Apr 21, 2018*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:E
entrustrootcertificationauthorityec1	*Apr 21, 2018*	20:D8:06:40:DF:9B:25:F5:12:25:3A:11:EA:F7:59:8A:EB:14:E
szafirrootca2	*Apr 21, 2018*	E2:52:FA:95:3F:ED:DB:24:60:BD:6E:28:F3:9C:CC:CF:5E:B3:3
tubitakkamusmsslkoksertifikasisurum1	*Apr 21, 2018*	01:43:64:9B:EC:CE:27:EC:ED:3A:3F:0B:8F:0D:E4:E8:91:DD:E
buypassclass3rootca	*Apr 21, 2018*	DA:FA:F7:FA:66:84:EC:06:8F:14:50:BD:C7:C2:81:A5:BC:A9:6
comodorsacertificationauthority	*Apr 21, 2018*	AF:E5:D2:44:A8:D1:19:42:30:FF:47:9F:E2:F8:97:BB:CD:7A:8
netlockaranyclassgoldfoanusitvany	*Apr 21, 2018*	06:08:3F:59:3F:15:A1:04:A0:69:A4:6B:A9:03:D0:06:B7:97:0
securitycommunicationrootca1	*Apr 21, 2018*	5F:3B:8C:F2:F8:10:B3:7D:78:B4:CE:EC:19:19:C3:73:34:B9:C
dtrustrootclass3ca2ev2009	*Apr 21, 2018*	96:C9:1B:0B:95:B4:10:98:42:FA:D0:D8:22:79:FE:60:FA:B9:1
starfieldclass2ca	*Apr 21, 2018*	AD:7E:1C:28:B0:64:EF:8F:60:03:40:20:14:C3:D0:E3:37:0E:E
pscprocert	*Apr 21, 2018*	70:C1:8D:74:B4:28:81:0A:E4:FD:A5:75:D7:01:9F:99:B0:3D:5
actalisauthenticationrootca	*Apr 21, 2018*	F3:73:B3:87:06:5A:28:84:8A:F2:F3:4A:CE:19:2B:DD:C7:8E:9
staatdernederlandenrootcag3	*Apr 21, 2018*	D8:EB:6B:41:51:92:59:E0:F3:E7:85:00:C0:3D:B6:88:97:C9:E
cfcaevroot	*Apr 21, 2018*	E2:B8:29:4B:55:84:AB:6B:58:C2:90:46:6C:AC:3F:B8:39:8F:8
digicerttrustedrootg4	*Apr 21, 2018*	DD:FB:16:CD:49:31:C9:73:A2:03:7D:3F:C8:3A:4D:7D:77:5D:0
staatdernederlandenrootcag2	*Apr 21, 2018*	59:AF:82:79:91:86:C7:B4:75:07:CB:CF:03:57:46:EB:04:DD:E
securitycommunicationevrootca2	*Apr 21, 2018*	FE:B8:C4:32:DC:F9:76:9A:CE:AE:3D:D8:90:8F:FD:28:86:65:6
globalsignrootcar3	*Apr 21, 2018*	D6:9B:56:11:48:F0:1C:77:C5:45:78:C1:09:26:DF:5B:85:69:7
globalsignrootcar2	*Apr 21, 2018*	75:E0:AB:B6:13:85:12:27:1C:04:F8:5F:DD:DE:38:E4:B7:24:2
certumtrustednetworkca2	*Apr 21, 2018*	D3:DD:48:3E:2B:BF:4C:05:E8:AF:10:F5:FA:76:26:CF:D3:DC:3
acraizfnmtrcm	*Apr 21, 2018*	EC:50:35:07:B2:15:C4:95:62:19:E2:A8:9A:5B:42:99:2C:4C:2
hellenicacademicandresearchinstitutionsecca2015	*Apr 21, 2018*	9F:F1:71:8D:92:D5:9A:F3:7D:74:97:B4:BC:6F:84:68:0B:BA:E
certplusrootcag2	*Apr 21, 2018*	4F:65:8E:1F:E9:06:D8:28:02:E9:54:47:41:C9:54:25:5D:69:C
twcarootcertificationauthority	*Apr 21, 2018*	CF:9E:87:6D:D3:EB:FC:42:26:97:A3:B5:A3:7A:A0:76:A9:06:2
twcaglobalrootca	*Apr 21, 2018*	9C:BB:48:53:F6:A4:F6:D3:52:A4:E8:32:52:55:60:13:F5:AD:A
certplusrootcag1	*Apr 21, 2018*	22:FD:D0:B7:FD:A2:4E:0D:AC:49:2C:A0:AC:A6:7B:6A:1F:E3:E
geotrustuniversalca2	*Apr 21, 2018*	37:9A:19:7B:41:85:45:35:0C:A6:03:69:F3:3C:2E:AF:47:4F:2
baltimorecybertrustroot	*Apr 21, 2018*	D4:DE:20:D0:5E:66:FC:53:FE:1A:50:88:2C:78:DB:28:52:CA:E
buypassclass2rootca	*Apr 21, 2018*	49:0A:75:74:DE:87:0A:47:FE:58:EE:F6:C7:6B:EB:C6:0B:12:4

Name	Date	SHA1 Fingerprint
certumtrustednetworkca	*Apr 21, 2018*	07:E0:32:E0:20:B7:2C:3F:19:2F:06:28:A2:59:3A:19:A7:0F:C
digicertassuredidrootg3	*Apr 21, 2018*	F5:17:A2:4F:9A:48:C6:C9:F8:A2:00:26:9F:DC:0F:48:2C:AB:3
digicertassuredidrootg2	*Apr 21, 2018*	A1:4B:48:D9:43:EE:0A:0E:40:90:4F:3C:E0:A4:C0:91:93:51:5
isrgrootx1	*Apr 21, 2018*	CA:BD:2A:79:A1:07:6A:31:F2:1D:25:36:35:CB:03:9D:43:29:A
entrustnetpremium2048secureserverca	*Apr 21, 2018*	50:30:06:09:1D:97:D4:F5:AE:39:F7:CB:E7:92:7D:7D:65:2D:3
certplusclass2primaryca	*Apr 21, 2018*	74:20:74:41:72:9C:DD:92:EC:79:31:D8:23:10:8D:C2:81:92:E
digicertglobalrootca	*Apr 21, 2018*	A8:98:5D:3A:65:E5:E5:C4:B2:D7:D6:6D:40:C6:DD:2F:B1:9C:5
entrustrootcertificationauthorityg2	*Apr 21, 2018*	8C:F4:27:FD:79:0C:3A:D1:66:06:8D:E8:1E:57:EF:BB:93:22:7
starfieldservicesrootcertificateauthority-g2	*Apr 21, 2018*	92:5A:8F:8D:2C:6D:04:E0:66:5F:59:6A:FF:22:D8:63:E8:25:6
thawteprimaryrootca	*Apr 21, 2018*	91:C6:D6:EE:3E:8A:C8:63:84:E5:48:C2:99:29:5C:75:6C:81:7
atostrustedroot2011	*Apr 21, 2018*	2B:B1:F5:3E:55:0C:1D:C5:F1:D4:E6:B7:6A:46:4B:55:06:02:A
geotrustglobalca	*Apr 21, 2018*	DE:28:F4:A4:FF:E5:B9:2F:A3:C5:03:D1:A3:49:A7:F9:96:2A:8
luxtrustglobalroot2	*Apr 21, 2018*	1E:0E:56:19:0A:D1:8B:25:98:B2:04:44:FF:66:8A:04:17:99:5
etugracertificationauthority	*Apr 21, 2018*	51:C6:E7:08:49:06:6E:F3:92:D4:5C:A0:0D:6D:A3:62:8F:C3:5
visaecommerceroot	*Apr 21, 2018*	70:17:9B:86:8C:00:A4:FA:60:91:52:22:3F:9F:3E:32:BD:E0:0
quovadisrootca	*Apr 21, 2018*	DE:3F:40:BD:50:93:D3:9B:6C:60:F6:DA:BC:07:62:01:00:89:7
identrustcommercialrootca1	*Apr 21, 2018*	DF:71:7E:AA:4A:D9:4E:C9:55:84:99:60:2D:48:DE:5F:BC:F0:3
staatdernederlandenevrootca	*Apr 21, 2018*	76:E2:7E:C1:4F:DB:82:C1:C0:A6:75:B5:05:BE:3D:29:B4:ED:D
ttelesecglobalrootclass3	*Apr 21, 2018*	55:A6:72:3E:CB:F2:EC:CD:C3:23:74:70:19:9D:2A:BE:11:E3:8
ttelesecglobalrootclass2	*Apr 21, 2018*	59:0D:2D:7D:88:4F:40:2E:61:7E:A5:62:32:17:65:CF:17:D8:9
comodocertificationauthority	*Apr 21, 2018*	66:31:BF:9E:F7:4F:9E:B6:C9:D5:A6:0C:BA:6A:BE:D1:F7:BD:E
securitycommunicationrootca	*Apr 21, 2018*	36:B1:2B:49:F9:81:9E:D7:4C:9E:BC:38:0F:C6:56:8F:5D:AC:B
quovadisrootca3g3	*Apr 21, 2018*	48:12:BD:92:3C:A8:C4:39:06:E7:30:6D:27:96:E6:A4:CF:22:2
xrampglobalcaroot	*Apr 21, 2018*	B8:01:86:D1:EB:9C:86:A5:41:04:CF:30:54:F3:4C:52:B7:E5:5
securesignrootca11	*Apr 21, 2018*	3B:C4:9F:48:F8:F3:73:A0:9C:1E:BD:F8:5B:B1:C3:65:C7:D8:1
affirmtrustpremium	*Apr 21, 2018*	D8:A6:33:2C:E0:03:6F:B1:85:F6:63:4F:7D:6A:06:65:26:32:2
globalsignrootca	*Apr 21, 2018*	B1:BC:96:8B:D4:F4:9D:62:2A:A8:9A:81:F2:15:01:52:A4:1D:8
swisssigngoldcag2	*Apr 21, 2018*	D8:C5:38:8A:B7:30:1B:1B:6E:D4:7A:E6:45:25:3A:6F:9F:1A:2
quovadisrootca2g3	*Apr 21, 2018*	09:3C:61:F3:8B:8B:DC:7D:55:DF:75:38:02:05:00:E1:25:F5:C
affirmtrustpremiumecc	*Apr 21, 2018*	B8:23:6B:00:2F:1D:16:86:53:01:55:6C:11:A4:37:CA:EB:FF:C
geotrustprimarycertificationauthority	*Apr 21, 2018*	32:3C:11:8E:1B:F7:B8:B6:52:54:E2:E2:10:0D:D6:02:90:37:F

Name	Date	SHA1 Fingerprint
quovadisrootca1g3	*Apr 21, 2018*	1B:8E:EA:57:96:29:1A:C9:39:EA:B8:0A:81:1A:73:73:C0:93:7
hongkongpostrootca1	*Apr 21, 2018*	D6:DA:A8:20:8D:09:D2:15:4D:24:B5:2F:CB:34:6E:B2:58:B2:8
usertrustecccertificationauthority	*Apr 21, 2018*	D1:CB:CA:5D:B2:D5:2A:7F:69:3B:67:4D:E5:F0:5A:1D:0C:95:7
cybertrustglobalroot	*Apr 21, 2018*	5F:43:E5:B1:BF:F8:78:8C:AC:1C:C7:CA:4A:9A:C6:22:2B:CC:3
godaddyclass2ca	*Apr 21, 2018*	27:96:BA:E6:3F:18:01:E2:77:26:1B:A0:D7:77:70:02:8F:20:E
hellenicacademicandresearchinstitutionsrootca2015	*Apr 21, 2018*	01:0C:06:95:A6:98:19:14:FF:BF:5F:C6:B0:B6:95:EA:29:E9:1
ecacc	*Apr 21, 2018*	28:90:3A:63:5B:52:80:FA:E6:77:4C:0B:6D:A7:D6:BA:A6:4A:F
hellenicacademicandresearchinstitutionsca2011	*Apr 21, 2018*	FE:45:65:9B:79:03:5B:98:A1:61:B5:51:2E:AC:DA:58:09:48:2
verisignclass3publicprimarycertificationauthority	*Apr 21, 2018*	74:2C:31:92:E6:07:E4:24:EB:45:49:54:2B:E1:BB:C5:3E:61:7
verisignclass3publicprimarycertificationauthority-g4	*Apr 21, 2018*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:6
verisignclass3publicprimarycertificationauthority-g3	*Apr 21, 2018*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:5
trustisfpsrootca	*Apr 21, 2018*	3B:C0:38:0B:33:C3:F6:A6:0C:86:15:22:93:D9:DF:F5:4B:81:C
epkirootcertificationauthority	*Apr 21, 2018*	67:65:0D:F1:7E:8E:7E:5B:82:40:A4:F4:56:4B:CF:E2:3D:69:C
globalchambersignroot2008	*Apr 21, 2018*	4A:BD:EE:EC:95:0D:35:9C:89:AE:C7:52:A1:2C:5B:29:F6:D6:A
camerfirmachambersofcommerceroot	*Apr 21, 2018*	6E:3A:55:A4:19:0C:19:5C:93:84:3C:C0:DB:72:2E:31:30:61:F
mozillacert81.pem	*Mar 13, 2014*	07:E0:32:E0:20:B7:2C:3F:19:2F:06:28:A2:59:3A:19:A7:0F:C
mozillacert99.pem	*Mar 13, 2014*	F1:7F:6F:B6:31:DC:99:E3:A3:C8:7F:FE:1C:F1:81:10:88:D9:6
mozillacert145.pem	*Mar 13, 2014*	10:1D:FA:3F:D5:0B:CB:BB:9B:B5:60:0C:19:55:A4:1A:F4:73:3
mozillacert37.pem	*Mar 13, 2014*	B1:2E:13:63:45:86:A4:6F:1A:B2:60:68:37:58:2D:C4:AC:FD:9
mozillacert4.pem	*Mar 13, 2014*	E3:92:51:2F:0A:CF:F5:05:DF:F6:DE:06:7F:75:37:E1:65:EA:5
mozillacert70.pem	*Mar 13, 2014*	78:6A:74:AC:76:AB:14:7F:9C:6A:30:50:BA:9E:A8:7E:FE:9A:C
mozillacert88.pem	*Mar 13, 2014*	FE:45:65:9B:79:03:5B:98:A1:61:B5:51:2E:AC:DA:58:09:48:2
mozillacert134.pem	*Mar 13, 2014*	70:17:9B:86:8C:00:A4:FA:60:91:52:22:3F:9F:3E:32:BD:E0:C
mozillacert26.pem	*Mar 13, 2014*	87:82:C6:C3:04:35:3B:CF:D2:96:92:D2:59:3E:7D:44:D9:34:F
mozillacert77.pem	*Mar 13, 2014*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:5

Name	Date	SHA1 Fingerprint
mozillacert123.pem	*Mar 13, 2014*	2A:B6:28:48:5E:78:FB:F3:AD:9E:79:10:DD:6B:DF:99:72:2C:9
mozillacert15.pem	*Mar 13, 2014*	74:20:74:41:72:9C:DD:92:EC:79:31:D8:23:10:8D:C2:81:92:F
mozillacert66.pem	*Mar 13, 2014*	DD:E1:D2:A9:01:80:2E:1D:87:5E:84:B3:80:7E:4B:B1:FD:99:4
mozillacert112.pem	*Mar 13, 2014*	43:13:BB:96:F1:D5:86:9B:C1:4E:6A:92:F6:CF:F6:34:69:87:8
mozillacert55.pem	*Mar 13, 2014*	AA:DB:BC:22:23:8F:C4:01:A1:27:BB:38:DD:F4:1D:DB:08:9E:F
mozillacert101.pem	*Mar 13, 2014*	99:A6:9B:E6:1A:FE:88:6B:4D:2B:82:00:7C:B8:54:FC:31:7E:1
mozillacert119.pem	*Mar 13, 2014*	75:E0:AB:B6:13:85:12:27:1C:04:F8:5F:DD:DE:38:E4:B7:24:2
mozillacert44.pem	*Mar 13, 2014*	5F:43:E5:B1:BF:F8:78:8C:AC:1C:C7:CA:4A:9A:C6:22:2B:CC:3
mozillacert108.pem	*Mar 13, 2014*	B1:BC:96:8B:D4:F4:9D:62:2A:A8:9A:81:F2:15:01:52:A4:1D:8
mozillacert95.pem	*Mar 13, 2014*	DA:FA:F7:FA:66:84:EC:06:8F:14:50:BD:C7:C2:81:A5:BC:A9:6
mozillacert141.pem	*Mar 13, 2014*	31:7A:2A:D0:7F:2B:33:5E:F5:A1:C3:4E:4B:57:E8:B7:D8:F1:F
mozillacert33.pem	*Mar 13, 2014*	FE:B8:C4:32:DC:F9:76:9A:CE:AE:3D:D8:90:8F:FD:28:86:65:6
mozillacert0.pem	*Mar 13, 2014*	97:81:79:50:D8:1C:96:70:CC:34:D8:09:CF:79:44:31:36:7E:F
mozillacert84.pem	*Mar 13, 2014*	D3:C0:63:F2:19:ED:07:3E:34:AD:5D:75:0B:32:76:29:FF:D5:9
mozillacert130.pem	*Mar 13, 2014*	E5:DF:74:3C:B6:01:C4:9B:98:43:DC:AB:8C:E8:6A:81:10:9F:F
mozillacert148.pem	*Mar 13, 2014*	04:83:ED:33:99:AC:36:08:05:87:22:ED:BC:5E:46:00:E3:BE:F
mozillacert22.pem	*Mar 13, 2014*	32:3C:11:8E:1B:F7:B8:B6:52:54:E2:E2:10:0D:D6:02:90:37:F
mozillacert7.pem	*Mar 13, 2014*	AD:7E:1C:28:B0:64:EF:8F:60:03:40:20:14:C3:D0:E3:37:0E:F
mozillacert73.pem	*Mar 13, 2014*	B5:1C:06:7C:EE:2B:0C:3D:F8:55:AB:2D:92:F4:FE:39:D4:E7:0
mozillacert137.pem	*Mar 13, 2014*	4A:65:D5:F4:1D:EF:39:B8:B8:90:4A:4A:D3:64:81:33:CF:C7:A

Name	Date	SHA1 Fingerprint
mozillacert11.pem	*Mar 13, 2014*	05:63:B8:63:0D:62:D7:5A:BB:C8:AB:1E:4B:DF:B5:A8:99:B2:4
mozillacert29.pem	*Mar 13, 2014*	74:F8:A3:C3:EF:E7:B3:90:06:4B:83:90:3C:21:64:60:20:E5:I
mozillacert62.pem	*Mar 13, 2014*	A1:DB:63:93:91:6F:17:E4:18:55:09:40:04:15:C7:02:40:B0:A
mozillacert126.pem	*Mar 13, 2014*	25:01:90:19:CF:FB:D9:99:1C:B7:68:25:74:8D:94:5F:30:93:9
mozillacert18.pem	*Mar 13, 2014*	79:98:A3:08:E1:4D:65:85:E6:C2:1E:15:3A:71:9F:BA:5A:D3:4
mozillacert51.pem	*Mar 13, 2014*	FA:B7:EE:36:97:26:62:FB:2D:B0:2A:F6:BF:03:FD:E8:7C:4B:2
mozillacert69.pem	*Mar 13, 2014*	2F:78:3D:25:52:18:A7:4A:65:39:71:B5:2C:A2:9C:45:15:6F:E
mozillacert115.pem	*Mar 13, 2014*	59:0D:2D:7D:88:4F:40:2E:61:7E:A5:62:32:17:65:CF:17:D8:9
mozillacert40.pem	*Mar 13, 2014*	80:25:EF:F4:6E:70:C8:D4:72:24:65:84:FE:40:3B:8A:8D:6A:D
mozillacert58.pem	*Mar 13, 2014*	8D:17:84:D5:37:F3:03:7D:EC:70:FE:57:8B:51:9A:99:E6:10:D
mozillacert104.pem	*Mar 13, 2014*	4F:99:AA:93:FB:2B:D1:37:26:A1:99:4A:CE:7F:F0:05:F2:93:5
mozillacert91.pem	*Mar 13, 2014*	3B:C0:38:0B:33:C3:F6:A6:0C:86:15:22:93:D9:DF:F5:4B:81:0
mozillacert47.pem	*Mar 13, 2014*	1B:4B:39:61:26:27:6B:64:91:A2:68:6D:D7:02:43:21:2D:1F:1
mozillacert80.pem	*Mar 13, 2014*	B8:23:6B:00:2F:1D:16:86:53:01:55:6C:11:A4:37:CA:EB:FF:C
mozillacert98.pem	*Mar 13, 2014*	C9:A8:B9:E7:55:80:5E:58:E3:53:77:A7:25:EB:AF:C3:7B:27:C
mozillacert144.pem	*Mar 13, 2014*	37:F7:6D:E6:07:7C:90:C5:B1:3E:93:1A:B7:41:10:B4:F2:E4:9
mozillacert36.pem	*Mar 13, 2014*	23:88:C9:D3:71:CC:9E:96:3D:FF:7D:3C:A7:CE:FC:D6:25:EC:1
mozillacert3.pem	*Mar 13, 2014*	87:9F:4B:EE:05:DF:98:58:3B:E3:60:D6:33:E7:0D:3F:FE:98:7
mozillacert87.pem	*Mar 13, 2014*	5F:3B:8C:F2:F8:10:B3:7D:78:B4:CE:EC:19:19:C3:73:34:B9:C
mozillacert133.pem	*Mar 13, 2014*	85:B5:FF:67:9B:0C:79:96:1F:C8:6E:44:22:00:46:13:DB:17:9

Name	Date	SHA1 Fingerprint
mozillacert25.pem	*Mar 13, 2014*	4E:B6:D5:78:49:9B:1C:CF:5F:58:1E:AD:56:BE:3D:9B:67:44:A
mozillacert76.pem	*Mar 13, 2014*	F9:B5:B6:32:45:5F:9C:BE:EC:57:5F:80:DC:E9:6E:2C:C7:B2:7
mozillacert122.pem	*Mar 13, 2014*	02:FA:F3:E2:91:43:54:68:60:78:57:69:4D:F5:E4:5B:68:85:1
mozillacert14.pem	*Mar 13, 2014*	5F:B7:EE:06:33:E2:59:DB:AD:0C:4C:9A:E6:D3:8F:1A:61:C7:D
mozillacert65.pem	*Mar 13, 2014*	69:BD:8C:F4:9C:D3:00:FB:59:2E:17:93:CA:55:6A:F3:EC:AA:3
mozillacert111.pem	*Mar 13, 2014*	9C:BB:48:53:F6:A4:F6:D3:52:A4:E8:32:52:55:60:13:F5:AD:A
mozillacert129.pem	*Mar 13, 2014*	E6:21:F3:35:43:79:05:9A:4B:68:30:9D:8A:2F:74:22:15:87:B
mozillacert54.pem	*Mar 13, 2014*	03:9E:ED:B8:0B:E7:A0:3C:69:53:89:3B:20:D2:D9:32:3A:4C:2
mozillacert100.pem	*Mar 13, 2014*	58:E8:AB:B0:36:15:33:FB:80:F7:9B:1B:6D:29:D3:FF:8D:5F:0
mozillacert118.pem	*Mar 13, 2014*	7E:78:4A:10:1C:82:65:CC:2D:E1:F1:6D:47:B4:40:CA:D9:0A:1
mozillacert151.pem	*Mar 13, 2014*	AC:ED:5F:65:53:FD:25:CE:01:5F:1F:7A:48:3B:6A:74:9F:61:7
mozillacert43.pem	*Mar 13, 2014*	F9:CD:0E:2C:DA:76:24:C1:8F:BD:F0:F0:AB:B6:45:B8:F7:FE:D
mozillacert107.pem	*Mar 13, 2014*	8E:1C:74:F8:A6:20:B9:E5:8A:F4:61:FA:EC:2B:47:56:51:1A:5
mozillacert94.pem	*Mar 13, 2014*	49:0A:75:74:DE:87:0A:47:FE:58:EE:F6:C7:6B:EB:C6:0B:12:4
mozillacert140.pem	*Mar 13, 2014*	CA:3A:FB:CF:12:40:36:4B:44:B2:16:20:88:80:48:39:19:93:7
mozillacert32.pem	*Mar 13, 2014*	60:D6:89:74:B5:C2:65:9E:8A:0F:C1:88:7C:88:D2:46:69:1B:1
mozillacert83.pem	*Mar 13, 2014*	A0:73:E5:C5:BD:43:61:0D:86:4C:21:13:0A:85:58:57:CC:9C:B
mozillacert147.pem	*Mar 13, 2014*	58:11:9F:0E:12:82:87:EA:50:FD:D9:87:45:6F:4F:78:DC:FA:D
mozillacert21.pem	*Mar 13, 2014*	9B:AA:E5:9F:56:EE:21:CB:43:5A:BE:25:93:DF:A7:F0:40:D1:1
mozillacert39.pem	*Mar 13, 2014*	AE:50:83:ED:7C:F4:5C:BC:8F:61:C6:21:FE:68:5D:79:42:21:1

Name	Date	SHA1 Fingerprint
mozillacert6.pem	*Mar 13, 2014*	27:96:BA:E6:3F:18:01:E2:77:26:1B:A0:D7:77:70:02:8F:20:
mozillacert72.pem	*Mar 13, 2014*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:
mozillacert136.pem	*Mar 13, 2014*	D1:EB:23:A4:6D:17:D6:8F:D9:25:64:C2:F1:F1:60:17:64:D8:
mozillacert10.pem	*Mar 13, 2014*	5F:3A:FC:0A:8B:64:F6:86:67:34:74:DF:7E:A9:A2:FE:F9:FA:
mozillacert28.pem	*Mar 13, 2014*	66:31:BF:9E:F7:4F:9E:B6:C9:D5:A6:0C:BA:6A:BE:D1:F7:BD:
mozillacert61.pem	*Mar 13, 2014*	E0:B4:32:2E:B2:F6:A5:68:B6:54:53:84:48:18:4A:50:36:87:
mozillacert79.pem	*Mar 13, 2014*	D8:A6:33:2C:E0:03:6F:B1:85:F6:63:4F:7D:6A:06:65:26:32:
mozillacert125.pem	*Mar 13, 2014*	B3:1E:B1:B7:40:E3:6C:84:02:DA:DC:37:D4:4D:F5:D4:67:49:
mozillacert17.pem	*Mar 13, 2014*	40:54:DA:6F:1C:3F:40:74:AC:ED:0F:EC:CD:DB:79:D1:53:FB:
mozillacert50.pem	*Mar 13, 2014*	8C:96:BA:EB:DD:2B:07:07:48:EE:30:32:66:A0:F3:98:6E:7C:
mozillacert68.pem	*Mar 13, 2014*	AE:C5:FB:3F:C8:E1:BF:C4:E5:4F:03:07:5A:9A:E8:00:B7:F7:
mozillacert114.pem	*Mar 13, 2014*	51:C6:E7:08:49:06:6E:F3:92:D4:5C:A0:0D:6D:A3:62:8F:C3:
mozillacert57.pem	*Mar 13, 2014*	D6:DA:A8:20:8D:09:D2:15:4D:24:B5:2F:CB:34:6E:B2:58:B2:
mozillacert103.pem	*Mar 13, 2014*	70:C1:8D:74:B4:28:81:0A:E4:FD:A5:75:D7:01:9F:99:B0:3D:
mozillacert90.pem	*Mar 13, 2014*	F3:73:B3:87:06:5A:28:84:8A:F2:F3:4A:CE:19:2B:DD:C7:8E:
mozillacert46.pem	*Mar 13, 2014*	40:9D:4B:D9:17:B5:5C:27:B6:9B:64:CB:98:22:44:0D:CD:09:
mozillacert97.pem	*Mar 13, 2014*	85:37:1C:A6:E5:50:14:3D:CE:28:03:47:1B:DE:3A:09:E8:F8:
mozillacert143.pem	*Mar 13, 2014*	36:B1:2B:49:F9:81:9E:D7:4C:9E:BC:38:0F:C6:56:8F:5D:AC:
mozillacert35.pem	*Mar 13, 2014*	2A:C8:D5:8B:57:CE:BF:2F:49:AF:F2:FC:76:8F:51:14:62:90:
mozillacert2.pem	*Mar 13, 2014*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:

Name	Date	SHA1 Fingerprint
mozillacert86.pem	*Mar 13, 2014*	74:2C:31:92:E6:07:E4:24:EB:45:49:54:2B:E1:BB:C5:3E:61:
mozillacert132.pem	*Mar 13, 2014*	39:21:C1:15:C1:5D:0E:CA:5C:CB:5B:C4:F0:7D:21:D8:05:0B:
mozillacert24.pem	*Mar 13, 2014*	59:AF:82:79:91:86:C7:B4:75:07:CB:CF:03:57:46:EB:04:DD:
mozillacert9.pem	*Mar 13, 2014*	F4:8B:11:BF:DE:AB:BE:94:54:20:71:E6:41:DE:6B:BE:88:2B:
mozillacert75.pem	*Mar 13, 2014*	D2:32:09:AD:23:D3:14:23:21:74:E4:0D:7F:9D:62:13:97:86:
mozillacert121.pem	*Mar 13, 2014*	CC:AB:0E:A0:4C:23:01:D6:69:7B:DD:37:9F:CD:12:EB:24:E3:
mozillacert139.pem	*Mar 13, 2014*	DE:3F:40:BD:50:93:D3:9B:6C:60:F6:DA:BC:07:62:01:00:89:
mozillacert13.pem	*Mar 13, 2014*	06:08:3F:59:3F:15:A1:04:A0:69:A4:6B:A9:03:D0:06:B7:97:
mozillacert64.pem	*Mar 13, 2014*	62:7F:8D:78:27:65:63:99:D2:7D:7F:90:44:C9:FE:B3:F3:3E:
mozillacert110.pem	*Mar 13, 2014*	93:05:7A:88:15:C6:4F:CE:88:2F:FA:91:16:52:28:78:BC:53:
mozillacert128.pem	*Mar 13, 2014*	A9:E9:78:08:14:37:58:88:F2:05:19:B0:6D:2B:0D:2B:60:16:
mozillacert53.pem	*Mar 13, 2014*	7F:8A:B0:CF:D0:51:87:6A:66:F3:36:0F:47:C8:8D:8C:D3:35:
mozillacert117.pem	*Mar 13, 2014*	D4:DE:20:D0:5E:66:FC:53:FE:1A:50:88:2C:78:DB:28:52:CA:
mozillacert150.pem	*Mar 13, 2014*	33:9B:6B:14:50:24:9B:55:7A:01:87:72:84:D9:E0:2F:C3:D2:
mozillacert42.pem	*Mar 13, 2014*	85:A4:08:C0:9C:19:3E:5D:51:58:7D:CD:D6:13:30:FD:8C:DE:
mozillacert106.pem	*Mar 13, 2014*	E7:A1:90:29:D3:D5:52:DC:0D:0F:C6:92:D3:EA:88:0D:15:2E:
mozillacert93.pem	*Mar 13, 2014*	31:F1:FD:68:22:63:20:EE:C6:3B:3F:9D:EA:4A:3E:53:7C:7C:
mozillacert31.pem	*Mar 13, 2014*	9F:74:4E:9F:2B:4D:BA:EC:0F:31:2C:50:B6:56:3B:8E:2D:93:
mozillacert49.pem	*Mar 13, 2014*	61:57:3A:11:DF:0E:D8:7E:D5:92:65:22:EA:D0:56:D7:44:B3:
mozillacert82.pem	*Mar 13, 2014*	2E:14:DA:EC:28:F0:FA:1E:8E:38:9A:4E:AB:EB:26:C0:0A:D3:

Name	Date	SHA1 Fingerprint
mozillacert146.pem	*Mar 13, 2014*	21:FC:BD:8E:7F:6C:AF:05:1B:D1:B3:43:EC:A8:E7:61:47:F2:C
mozillacert20.pem	*Mar 13, 2014*	D8:C5:38:8A:B7:30:1B:1B:6E:D4:7A:E6:45:25:3A:6F:9F:1A:2
mozillacert38.pem	*Mar 13, 2014*	CB:A1:C5:F8:B0:E3:5E:B8:B9:45:12:D3:F9:34:A2:E9:06:10:D
mozillacert5.pem	*Mar 13, 2014*	B8:01:86:D1:EB:9C:86:A5:41:04:CF:30:54:F3:4C:52:B7:E5:5
mozillacert71.pem	*Mar 13, 2014*	4A:BD:EE:EC:95:0D:35:9C:89:AE:C7:52:A1:2C:5B:29:F6:D6:A
mozillacert89.pem	*Mar 13, 2014*	C8:EC:8C:87:92:69:CB:4B:AB:39:E9:8D:7E:57:67:F3:14:95:7
mozillacert135.pem	*Mar 13, 2014*	62:52:DC:40:F7:11:43:A2:2F:DE:9E:F7:34:8E:06:42:51:B1:8
mozillacert27.pem	*Mar 13, 2014*	3A:44:73:5A:E5:81:90:1F:24:86:61:46:1E:3B:9C:C4:5F:F5:3
mozillacert60.pem	*Mar 13, 2014*	3B:C4:9F:48:F8:F3:73:A0:9C:1E:BD:F8:5B:B1:C3:65:C7:D8:1
mozillacert78.pem	*Mar 13, 2014*	29:36:21:02:8B:20:ED:02:F5:66:C5:32:D1:D6:ED:90:9F:45:0
mozillacert124.pem	*Mar 13, 2014*	4D:23:78:EC:91:95:39:B5:00:7F:75:8F:03:3B:21:1E:C5:4D:8
mozillacert16.pem	*Mar 13, 2014*	DA:C9:02:4F:54:D8:F6:DF:94:93:5F:B1:73:26:38:CA:6A:D7:7
mozillacert67.pem	*Mar 13, 2014*	D6:9B:56:11:48:F0:1C:77:C5:45:78:C1:09:26:DF:5B:85:69:7
mozillacert113.pem	*Mar 13, 2014*	50:30:06:09:1D:97:D4:F5:AE:39:F7:CB:E7:92:7D:7D:65:2D:3
mozillacert56.pem	*Mar 13, 2014*	F1:8B:53:8D:1B:E9:03:B6:A6:F0:56:43:5B:17:15:89:CA:F3:6
mozillacert102.pem	*Mar 13, 2014*	96:C9:1B:0B:95:B4:10:98:42:FA:D0:D8:22:79:FE:60:FA:B9:1
mozillacert45.pem	*Mar 13, 2014*	67:65:0D:F1:7E:8E:7E:5B:82:40:A4:F4:56:4B:CF:E2:3D:69:C
mozillacert109.pem	*Mar 13, 2014*	B5:61:EB:EA:A4:DE:E4:25:4B:69:1A:98:A5:57:47:C2:34:C7:D
mozillacert96.pem	*Mar 13, 2014*	55:A6:72:3E:CB:F2:EC:CD:C3:23:74:70:19:9D:2A:BE:11:E3:8
mozillacert142.pem	*Mar 13, 2014*	1F:49:14:F7:D8:74:95:1D:DD:AE:02:C0:BE:FD:3A:2D:82:75:5

Name	Date	SHA1 Fingerprint
mozillacert34.pem	*Mar 13, 2014*	59:22:A1:E1:5A:EA:16:35:21:F8:98:39:6A:46:46:B0:44:1B:C
mozillacert1.pem	*Mar 13, 2014*	23:E5:94:94:51:95:F2:41:48:03:B4:D5:64:D2:A3:A3:F5:D8:8
mozillacert85.pem	*Mar 13, 2014*	CF:9E:87:6D:D3:EB:FC:42:26:97:A3:B5:A3:7A:A0:76:A9:06:2
mozillacert131.pem	*Mar 13, 2014*	37:9A:19:7B:41:85:45:35:0C:A6:03:69:F3:3C:2E:AF:47:4F:2
mozillacert149.pem	*Mar 13, 2014*	6E:3A:55:A4:19:0C:19:5C:93:84:3C:C0:DB:72:2E:31:30:61:F
mozillacert23.pem	*Mar 13, 2014*	91:C6:D6:EE:3E:8A:C8:63:84:E5:48:C2:99:29:5C:75:6C:81:7
mozillacert8.pem	*Mar 13, 2014*	3E:2B:F7:F2:03:1B:96:F3:8C:E6:C4:D8:A8:5D:3E:2D:58:47:6
mozillacert74.pem	*Mar 13, 2014*	92:5A:8F:8D:2C:6D:04:E0:66:5F:59:6A:FF:22:D8:63:E8:25:6
mozillacert120.pem	*Mar 13, 2014*	DA:40:18:8B:91:89:A3:ED:EE:AE:DA:97:FE:2F:9D:F5:B7:D1:8
mozillacert138.pem	*Mar 13, 2014*	E1:9F:E3:0E:8B:84:60:9E:80:9B:17:0D:72:A8:C5:BA:6E:14:0
mozillacert12.pem	*Mar 13, 2014*	A8:98:5D:3A:65:E5:E5:C4:B2:D7:D6:6D:40:C6:DD:2F:B1:9C:5
mozillacert63.pem	*Mar 13, 2014*	89:DF:74:FE:5C:F4:0F:4A:80:F9:E3:37:7D:54:DA:91:E1:01:3
mozillacert127.pem	*Mar 13, 2014*	DE:28:F4:A4:FF:E5:B9:2F:A3:C5:03:D1:A3:49:A7:F9:96:2A:8
mozillacert19.pem	*Mar 13, 2014*	B4:35:D4:E1:11:9D:1C:66:90:A7:49:EB:B3:94:BD:63:7B:A7:8
mozillacert52.pem	*Mar 13, 2014*	8B:AF:4C:9B:1D:F0:2A:92:F7:DA:12:8E:B9:1B:AC:F4:98:60:4
mozillacert116.pem	*Mar 13, 2014*	2B:B1:F5:3E:55:0C:1D:C5:F1:D4:E6:B7:6A:46:4B:55:06:02:A
mozillacert41.pem	*Mar 13, 2014*	6B:2F:34:AD:89:58:BE:62:FD:B0:6B:5C:CE:BB:9D:D9:4F:4E:3
mozillacert59.pem	*Mar 13, 2014*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:0
mozillacert105.pem	*Mar 13, 2014*	77:47:4F:C6:30:E4:0F:4C:47:64:3F:84:BA:B8:C6:95:4A:8A:4
mozillacert92.pem	*Mar 13, 2014*	A3:F1:33:3F:E2:42:BF:CF:C5:D1:4E:8F:39:42:98:40:68:10:I

Name	Date	SHA1 Fingerprint
mozillacert30.pem	*Mar 13, 2014*	E7:B4:F6:9D:61:EC:90:69:DB:7E:90:A7:40:1A:3C:F4:7D:4F:
mozillacert48.pem	*Mar 13, 2014*	A0:A1:AB:90:C9:FC:84:7B:3B:12:61:E8:97:7D:5F:D3:22:61:
verisignc4g2.pem	*Mar 20, 2014*	0B:77:BE:BB:CB:7A:A2:47:05:DE:CC:0F:BD:6A:02:FC:7A:BD:
verisignc2g3.pem	*Mar 20, 2014*	61:EF:43:D7:7F:CA:D4:61:51:BC:98:E0:C3:59:12:AF:9F:EB:
verisignc1g6.pem	*Dec 31, 2014*	51:7F:61:1E:29:91:6B:53:82:FB:72:E7:44:D9:8D:C3:CC:53:
verisignc2g2.pem	*Mar 20, 2014*	B3:EA:C4:47:76:C9:C8:1C:EA:F2:9D:95:B6:CC:A0:08:1B:67:
verisignroot.pem	*Mar 20, 2014*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:
verisignc2g1.pem	*Mar 20, 2014*	67:82:AA:E0:ED:EE:E2:1A:58:39:D3:C0:CD:14:68:0A:4F:60:
verisignc3g5.pem	*Mar 20, 2014*	4E:B6:D5:78:49:9B:1C:CF:5F:58:1E:AD:56:BE:3D:9B:67:44:
verisignc1g3.pem	*Mar 20, 2014*	20:42:85:DC:F7:EB:76:41:95:57:8E:13:6B:D4:B7:D1:E9:8E:
verisignc3g4.pem	*Mar 20, 2014*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:
verisignc1g2.pem	*Mar 20, 2014*	27:3E:E1:24:57:FD:C4:F9:0C:55:E8:2B:56:16:7F:62:F5:32:
verisignc3g3.pem	*Mar 20, 2014*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:
verisignc1g1.pem	*Mar 20, 2014*	90:AE:A2:69:85:FF:14:80:4C:43:49:52:EC:E9:60:84:77:AF:
verisignc3g2.pem	*Mar 20, 2014*	85:37:1C:A6:E5:50:14:3D:CE:28:03:47:1B:DE:3A:09:E8:F8:
verisignc3g1.pem	*Mar 20, 2014*	A1:DB:63:93:91:6F:17:E4:18:55:09:40:04:15:C7:02:40:B0:
verisignc2g6.pem	*Dec 31, 2014*	40:B3:31:A0:E9:BF:E8:55:BC:39:93:CA:70:4F:4E:C2:51:D4:
verisignc4g3.pem	*Mar 20, 2014*	C8:EC:8C:87:92:69:CB:4B:AB:39:E9:8D:7E:57:67:F3:14:95:
gdroot-g2.pem	*Dec 31, 2014*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:
gd-class2-root.pem	*Dec 31, 2014*	27:96:BA:E6:3F:18:01:E2:77:26:1B:A0:D7:77:70:02:8F:20:

Name	Date	SHA1 Fingerprint
gd_bundle-g2.pem	*Dec 31, 2014*	27:AC:93:69:FA:F2:52:07:BB:26:27:CE:FA:CC:BE:4E:F9:C3:1
dstacescax6	*Jun 18, 2018*	40:54:DA:6F:1C:3F:40:74:AC:ED:0F:EC:CD:DB:79:D1:53:FB:9
gd_bundle-g2.pem	*Jun 18, 2018*	27:AC:93:69:FA:F2:52:07:BB:26:27:CE:FA:CC:BE:4E:F9:C3:1
verisignc4g3.pem	*Jun 18, 2018*	C8:EC:8C:87:92:69:CB:4B:AB:39:E9:8D:7E:57:67:F3:14:95:7
swisssignplatinumg2ca	*Apr 21, 2018*	56:E0:FA:C0:3B:8F:18:23:55:18:E5:D3:11:CA:E8:C2:43:31:A
geotrustprimarycertificationauthorityg3	*Jun 18, 2018*	03:9E:ED:B8:0B:E7:A0:3C:69:53:89:3B:20:D2:D9:32:3A:4C:2
geotrustprimarycertificationauthority	*Jun 18, 2018*	32:3C:11:8E:1B:F7:B8:B6:52:54:E2:E2:10:0D:D6:02:90:37:F0
buypassclass2rootca	*Jun 18, 2018*	49:0A:75:74:DE:87:0A:47:FE:58:EE:F6:C7:6B:EB:C6:0B:12:4
camerfirmachambersofcommerceroot	*Jun 18, 2018*	6E:3A:55:A4:19:0C:19:5C:93:84:3C:C0:DB:72:2E:31:30:61:F
mozillacert20.pem	*Jun 18, 2018*	D8:C5:38:8A:B7:30:1B:1B:6E:D4:7A:E6:45:25:3A:6F:9F:1A:2
mozillacert12.pem	*Jun 18, 2018*	A8:98:5D:3A:65:E5:E5:C4:B2:D7:D6:6D:40:C6:DD:2F:B1:9C:5
mozillacert90.pem	*Jun 18, 2018*	F3:73:B3:87:06:5A:28:84:8A:F2:F3:4A:CE:19:2B:DD:C7:8E:9
mozillacert82.pem	*Jun 18, 2018*	2E:14:DA:EC:28:F0:FA:1E:8E:38:9A:4E:AB:EB:26:C0:0A:D3:8
mozillacert140.pem	*Jun 18, 2018*	CA:3A:FB:CF:12:40:36:4B:44:B2:16:20:88:80:48:39:19:93:7
mozillacert74.pem	*Jun 18, 2018*	92:5A:8F:8D:2C:6D:04:E0:66:5F:59:6A:FF:22:D8:63:E8:25:6
mozillacert132.pem	*Jun 18, 2018*	39:21:C1:15:C1:5D:0E:CA:5C:CB:5B:C4:F0:7D:21:D8:05:0B:5
mozillacert66.pem	*Jun 18, 2018*	DD:E1:D2:A9:01:80:2E:1D:87:5E:84:B3:80:7E:4B:B1:FD:99:4
mozillacert124.pem	*Jun 18, 2018*	4D:23:78:EC:91:95:39:B5:00:7F:75:8F:03:3B:21:1E:C5:4D:8
mozillacert58.pem	*Jun 18, 2018*	8D:17:84:D5:37:F3:03:7D:EC:70:FE:57:8B:51:9A:99:E6:10:D
securitycommunicationrootca2	*Jun 18, 2018*	5F:3B:8C:F2:F8:10:B3:7D:78:B4:CE:EC:19:19:C3:73:34:B9:C
mozillacert116.pem	*Jun 18, 2018*	2B:B1:F5:3E:55:0C:1D:C5:F1:D4:E6:B7:6A:46:4B:55:06:02:A
mozillacert108.pem	*Jun 18, 2018*	B1:BC:96:8B:D4:F4:9D:62:2A:A8:9A:81:F2:15:01:52:A4:1D:8
certigna	*Jun 18, 2018*	B1:2E:13:63:45:86:A4:6F:1A:B2:60:68:37:58:2D:C4:AC:FD:9
mozillacert3.pem	*Jun 18, 2018*	87:9F:4B:EE:05:DF:98:58:3B:E3:60:D6:33:E7:0D:3F:FE:98:7
verisignc1g1.pem	*Jun 18, 2018*	90:AE:A2:69:85:FF:14:80:4C:43:49:52:EC:E9:60:84:77:AF:5
verisignc4g2.pem	*Jun 18, 2018*	0B:77:BE:BB:CB:7A:A2:47:05:DE:CC:0F:BD:6A:02:FC:7A:BD:9
deutschetelekomrootca2	*Jun 18, 2018*	85:A4:08:C0:9C:19:3E:5D:51:58:7D:CD:D6:13:30:FD:8C:DE:3
starfieldrootg2ca	*Apr 21, 2018*	B5:1C:06:7C:EE:2B:0C:3D:F8:55:AB:2D:92:F4:FE:39:D4:E7:0
comodoecccertificationauthority	*Jun 18, 2018*	9F:74:4E:9F:2B:4D:BA:EC:0F:31:2C:50:B6:56:3B:8E:2D:93:0
digicertglobalrootg3	*Jun 18, 2018*	7E:04:DE:89:6A:3E:66:6D:00:E6:87:D3:3F:FA:D9:3B:E8:3D:3

Name	Date	SHA1 Fingerprint
digicertglobalrootg2	*Jun 18, 2018*	DF:3C:24:F9:BF:D6:66:76:1B:26:80:73:FE:06:D1:CC:8D:4F:8
mozillacert11.pem	*Jun 18, 2018*	05:63:B8:63:0D:62:D7:5A:BB:C8:AB:1E:4B:DF:B5:A8:99:B2:4
mozillacert81.pem	*Jun 18, 2018*	07:E0:32:E0:20:B7:2C:3F:19:2F:06:28:A2:59:3A:19:A7:0F:0
mozillacert73.pem	*Jun 18, 2018*	B5:1C:06:7C:EE:2B:0C:3D:F8:55:AB:2D:92:F4:FE:39:D4:E7:0
szafirrootca2	*Jun 18, 2018*	E2:52:FA:95:3F:ED:DB:24:60:BD:6E:28:F3:9C:CC:CF:5E:B3:3
mozillacert131.pem	*Jun 18, 2018*	37:9A:19:7B:41:85:45:35:0C:A6:03:69:F3:3C:2E:AF:47:4F:2
ecacc	*Jun 18, 2018*	28:90:3A:63:5B:52:80:FA:E6:77:4C:0B:6D:A7:D6:BA:A6:4A:F
mozillacert65.pem	*Jun 18, 2018*	69:BD:8C:F4:9C:D3:00:FB:59:2E:17:93:CA:55:6A:F3:EC:AA:3
turktrustelektroniksertifikahizmetsaglayicis4	*Jun 18, 2018*	C4:18:F6:4D:46:D1:DF:00:3D:27:30:13:72:43:A9:12:11:C6:7
mozillacert123.pem	*Jun 18, 2018*	2A:B6:28:48:5E:78:FB:F3:AD:9E:79:10:DD:6B:DF:99:72:2C:9
mozillacert57.pem	*Jun 18, 2018*	D6:DA:A8:20:8D:09:D2:15:4D:24:B5:2F:CB:34:6E:B2:58:B2:8
mozillacert115.pem	*Jun 18, 2018*	59:0D:2D:7D:88:4F:40:2E:61:7E:A5:62:32:17:65:CF:17:D8:9
mozillacert49.pem	*Jun 18, 2018*	61:57:3A:11:DF:0E:D8:7E:D5:92:65:22:EA:D0:56:D7:44:B3:2
mozillacert107.pem	*Jun 18, 2018*	8E:1C:74:F8:A6:20:B9:E5:8A:F4:61:FA:EC:2B:47:56:51:1A:5
verisignclass3g4ca	*Apr 21, 2018*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:6
securetrustca	*Jun 18, 2018*	87:82:C6:C3:04:35:3B:CF:D2:96:92:D2:59:3E:7D:44:D9:34:F
mozillacert2.pem	*Jun 18, 2018*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:6
buypassclass2ca	*Apr 21, 2018*	49:0A:75:74:DE:87:0A:47:FE:58:EE:F6:C7:6B:EB:C6:0B:12:4
secomscrootca2	*Apr 21, 2018*	5F:3B:8C:F2:F8:10:B3:7D:78:B4:CE:EC:19:19:C3:73:34:B9:C
secomscrootca1	*Apr 21, 2018*	36:B1:2B:49:F9:81:9E:D7:4C:9E:BC:38:0F:C6:56:8F:5D:AC:F
trustisfpsrootca	*Jun 18, 2018*	3B:C0:38:0B:33:C3:F6:A6:0C:86:15:22:93:D9:DF:F5:4B:81:C
hongkongpostrootca1	*Jun 18, 2018*	D6:DA:A8:20:8D:09:D2:15:4D:24:B5:2F:CB:34:6E:B2:58:B2:8
certsignrootca	*Jun 18, 2018*	FA:B7:EE:36:97:26:62:FB:2D:B0:2A:F6:BF:03:FD:E8:7C:4B:2
geotrustprimaryca	*Apr 21, 2018*	32:3C:11:8E:1B:F7:B8:B6:52:54:E2:E2:10:0D:D6:02:90:37:F
twcaglobalrootca	*Jun 18, 2018*	9C:BB:48:53:F6:A4:F6:D3:52:A4:E8:32:52:55:60:13:F5:AD:A
camerfirmachambersca	*Apr 21, 2018*	78:6A:74:AC:76:AB:14:7F:9C:6A:30:50:BA:9E:A8:7E:FE:9A:C
mozillacert10.pem	*Jun 18, 2018*	5F:3A:FC:0A:8B:64:F6:86:67:34:74:DF:7E:A9:A2:FE:F9:FA:7
mozillacert80.pem	*Jun 18, 2018*	B8:23:6B:00:2F:1D:16:86:53:01:55:6C:11:A4:37:CA:EB:FF:C
mozillacert72.pem	*Jun 18, 2018*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:E
comodoaaaca	*Apr 21, 2018*	D1:EB:23:A4:6D:17:D6:8F:D9:25:64:C2:F1:F1:60:17:64:D8:E
mozillacert130.pem	*Jun 18, 2018*	E5:DF:74:3C:B6:01:C4:9B:98:43:DC:AB:8C:E8:6A:81:10:9F:E

Name	Date	SHA1 Fingerprint
mozillacert64.pem	*Jun 18, 2018*	62:7F:8D:78:27:65:63:99:D2:7D:7F:90:44:C9:FE:B3:F3:3E:E
mozillacert122.pem	*Jun 18, 2018*	02:FA:F3:E2:91:43:54:68:60:78:57:69:4D:F5:E4:5B:68:85:1
mozillacert56.pem	*Jun 18, 2018*	F1:8B:53:8D:1B:E9:03:B6:A6:F0:56:43:5B:17:15:89:CA:F3:6
equifaxsecureebusinessca1	*Apr 21, 2018*	AE:E6:3D:70:E3:76:FB:C7:3A:EB:B0:A1:C1:D4:C4:7A:A7:40:E
camerfirmachambersignca	*Apr 21, 2018*	4A:BD:EE:EC:95:0D:35:9C:89:AE:C7:52:A1:2C:5B:29:F6:D6:A
mozillacert114.pem	*Jun 18, 2018*	51:C6:E7:08:49:06:6E:F3:92:D4:5C:A0:0D:6D:A3:62:8F:C3:5
mozillacert48.pem	*Jun 18, 2018*	A0:A1:AB:90:C9:FC:84:7B:3B:12:61:E8:97:7D:5F:D3:22:61:D
pscprocert	*Jun 18, 2018*	70:C1:8D:74:B4:28:81:0A:E4:FD:A5:75:D7:01:9F:99:B0:3D:5
mozillacert106.pem	*Jun 18, 2018*	E7:A1:90:29:D3:D5:52:DC:0D:0F:C6:92:D3:EA:88:0D:15:2E:1
mozillacert1.pem	*Jun 18, 2018*	23:E5:94:94:51:95:F2:41:48:03:B4:D5:64:D2:A3:A3:F5:D8:8
eecertificationcentreroot1	*Jun 18, 2018*	C9:A8:B9:E7:55:80:5E:58:E3:53:77:A7:25:EB:AF:C3:7B:27:C
digicertglobalrootca	*Jun 18, 2018*	A8:98:5D:3A:65:E5:E5:C4:B2:D7:D6:6D:40:C6:DD:2F:B1:9C:5
thawteprimaryrootcag3	*Jun 18, 2018*	F1:8B:53:8D:1B:E9:03:B6:A6:F0:56:43:5B:17:15:89:CA:F3:6
thawteprimaryrootcag2	*Jun 18, 2018*	AA:DB:BC:22:23:8F:C4:01:A1:27:BB:38:DD:F4:1D:DB:08:9E:E
entrustrootcertificationauthorityec1	*Jun 18, 2018*	20:D8:06:40:DF:9B:25:F5:12:25:3A:11:EA:F7:59:8A:EB:14:E
valicertclass2ca	*Apr 21, 2018*	31:7A:2A:D0:7F:2B:33:5E:F5:A1:C3:4E:4B:57:E8:B7:D8:F1:E
globalchambersignroot2008	*Jun 18, 2018*	4A:BD:EE:EC:95:0D:35:9C:89:AE:C7:52:A1:2C:5B:29:F6:D6:A
amazonrootca4	*Jun 18, 2018*	F6:10:84:07:D6:F8:BB:67:98:0C:C2:E2:44:C2:EB:AE:1C:EF:6
gd-class2-root.pem	*Jun 18, 2018*	27:96:BA:E6:3F:18:01:E2:77:26:1B:A0:D7:77:70:02:8F:20:E
amazonrootca3	*Jun 18, 2018*	0D:44:DD:8C:3C:8C:1A:1A:58:75:64:81:E9:0F:2E:2A:FF:B3:D
amazonrootca2	*Jun 18, 2018*	5A:8C:EF:45:D7:A6:98:59:76:7A:8C:8B:44:96:B5:78:CF:47:4
securitycommunicationrootca	*Jun 18, 2018*	36:B1:2B:49:F9:81:9E:D7:4C:9E:BC:38:0F:C6:56:8F:5D:AC:E
amazonrootca1	*Jun 18, 2018*	8D:A7:F9:65:EC:5E:FC:37:91:0F:1C:6E:59:FD:C1:CC:6A:6E:D
acraizfnmtrcm	*Jun 18, 2018*	EC:50:35:07:B2:15:C4:95:62:19:E2:A8:9A:5B:42:99:2C:4C:2
quovadisrootca3g3	*Jun 18, 2018*	48:12:BD:92:3C:A8:C4:39:06:E7:30:6D:27:96:E6:A4:CF:22:2
certplusrootcag2	*Jun 18, 2018*	4F:65:8E:1F:E9:06:D8:28:02:E9:54:47:41:C9:54:25:5D:69:C
certplusrootcag1	*Jun 18, 2018*	22:FD:D0:B7:FD:A2:4E:0D:AC:49:2C:A0:AC:A6:7B:6A:1F:E3:E
mozillacert71.pem	*Jun 18, 2018*	4A:BD:EE:EC:95:0D:35:9C:89:AE:C7:52:A1:2C:5B:29:F6:D6:A
mozillacert63.pem	*Jun 18, 2018*	89:DF:74:FE:5C:F4:0F:4A:80:F9:E3:37:7D:54:DA:91:E1:01:3
mozillacert121.pem	*Jun 18, 2018*	CC:AB:0E:A0:4C:23:01:D6:69:7B:DD:37:9F:CD:12:EB:24:E3:9
ttelesecglobalrootclass3ca	*Apr 21, 2018*	55:A6:72:3E:CB:F2:EC:CD:C3:23:74:70:19:9D:2A:BE:11:E3:8

Name	Date	SHA1 Fingerprint
mozillacert55.pem	*Jun 18, 2018*	AA:DB:BC:22:23:8F:C4:01:A1:27:BB:38:DD:F4:1D:DB:08:9E:E
mozillacert113.pem	*Jun 18, 2018*	50:30:06:09:1D:97:D4:F5:AE:39:F7:CB:E7:92:7D:7D:65:2D:3
baltimorecybertrustca	*Apr 21, 2018*	D4:DE:20:D0:5E:66:FC:53:FE:1A:50:88:2C:78:DB:28:52:CA:E
mozillacert47.pem	*Jun 18, 2018*	1B:4B:39:61:26:27:6B:64:91:A2:68:6D:D7:02:43:21:2D:1F:1
mozillacert105.pem	*Jun 18, 2018*	77:47:4F:C6:30:E4:0F:4C:47:64:3F:84:BA:B8:C6:95:4A:8A:4
mozillacert39.pem	*Jun 18, 2018*	AE:50:83:ED:7C:F4:5C:BC:8F:61:C6:21:FE:68:5D:79:42:21:1
usertrustecccertificationauthority	*Jun 18, 2018*	D1:CB:CA:5D:B2:D5:2A:7F:69:3B:67:4D:E5:F0:5A:1D:0C:95:7
mozillacert0.pem	*Jun 18, 2018*	97:81:79:50:D8:1C:96:70:CC:34:D8:09:CF:79:44:31:36:7E:F
securitycommunicationevrootca1	*Jun 18, 2018*	FE:B8:C4:32:DC:F9:76:9A:CE:AE:3D:D8:90:8F:FD:28:86:65:6
verisignc3g5.pem	*Jun 18, 2018*	4E:B6:D5:78:49:9B:1C:CF:5F:58:1E:AD:56:BE:3D:9B:67:44:A
globalsignr3ca	*Apr 21, 2018*	D6:9B:56:11:48:F0:1C:77:C5:45:78:C1:09:26:DF:5B:85:69:7
trustcoreca1	*Jun 18, 2018*	58:D1:DF:95:95:67:6B:63:C0:F0:5B:1C:17:4D:8B:84:0B:C8:7
equifaxsecureglobalebusinessca1	*Apr 21, 2018*	3A:74:CB:7A:47:DB:70:DE:89:1F:24:35:98:64:B8:2D:82:BD:1
geotrustuniversalca	*Jun 18, 2018*	E6:21:F3:35:43:79:05:9A:4B:68:30:9D:8A:2F:74:22:15:87:F
affirmtrustpremiumca	*Apr 21, 2018*	D8:A6:33:2C:E0:03:6F:B1:85:F6:63:4F:7D:6A:06:65:26:32:2
staatdernederlandenrootcag3	*Jun 18, 2018*	D8:EB:6B:41:51:92:59:E0:F3:E7:85:00:C0:3D:B6:88:97:C9:E
staatdernederlandenrootcag2	*Jun 18, 2018*	59:AF:82:79:91:86:C7:B4:75:07:CB:CF:03:57:46:EB:04:DD:F
mozillacert70.pem	*Jun 18, 2018*	78:6A:74:AC:76:AB:14:7F:9C:6A:30:50:BA:9E:A8:7E:FE:9A:C
secomevrootca1	*Apr 21, 2018*	FE:B8:C4:32:DC:F9:76:9A:CE:AE:3D:D8:90:8F:FD:28:86:65:6
geotrustglobalca	*Jun 18, 2018*	DE:28:F4:A4:FF:E5:B9:2F:A3:C5:03:D1:A3:49:A7:F9:96:2A:8
mozillacert62.pem	*Jun 18, 2018*	A1:DB:63:93:91:6F:17:E4:18:55:09:40:04:15:C7:02:40:B0:A
mozillacert120.pem	*Jun 18, 2018*	DA:40:18:8B:91:89:A3:ED:EE:AE:DA:97:FE:2F:9D:F5:B7:D1:8
mozillacert54.pem	*Jun 18, 2018*	03:9E:ED:B8:0B:E7:A0:3C:69:53:89:3B:20:D2:D9:32:3A:4C:2
mozillacert112.pem	*Jun 18, 2018*	43:13:BB:96:F1:D5:86:9B:C1:4E:6A:92:F6:CF:F6:34:69:87:8
mozillacert46.pem	*Jun 18, 2018*	40:9D:4B:D9:17:B5:5C:27:B6:9B:64:CB:98:22:44:0D:CD:09:F
swisssigngoldcag2	*Jun 18, 2018*	D8:C5:38:8A:B7:30:1B:1B:6E:D4:7A:E6:45:25:3A:6F:9F:1A:2
mozillacert104.pem	*Jun 18, 2018*	4F:99:AA:93:FB:2B:D1:37:26:A1:99:4A:CE:7F:F0:05:F2:93:5
mozillacert38.pem	*Jun 18, 2018*	CB:A1:C5:F8:B0:E3:5E:B8:B9:45:12:D3:F9:34:A2:E9:06:10:D
certplusclass3pprimaryca	*Apr 21, 2018*	21:6B:2A:29:E6:2A:00:CE:82:01:46:D8:24:41:41:B9:25:11:F
entrustrootcertificationauthorityg2	*Jun 18, 2018*	3C:F4:27:FD:79:0C:3A:D1:66:06:8D:E8:1E:57:EF:BB:93:22:7
godaddyrootg2ca	*Apr 21, 2018*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:F

Name	Date	SHA1 Fingerprint
cfcaevroot	*Jun 18, 2018*	E2:B8:29:4B:55:84:AB:6B:58:C2:90:46:6C:AC:3F:B8:39:8F:8
verisignc3g4.pem	*Jun 18, 2018*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:6
geotrustuniversalca2	*Jun 18, 2018*	37:9A:19:7B:41:85:45:35:0C:A6:03:69:F3:3C:2E:AF:47:4F:2
starfieldservicesrootg2ca	*Apr 21, 2018*	92:5A:8F:8D:2C:6D:04:E0:66:5F:59:6A:FF:22:D8:63:E8:25:6
digicerthighassuranceevrootca	*Jun 18, 2018*	5F:B7:EE:06:33:E2:59:DB:AD:0C:4C:9A:E6:D3:8F:1A:61:C7:D
entrustnetpremium2048secureserverca	*Jun 18, 2018*	50:30:06:09:1D:97:D4:F5:AE:39:F7:CB:E7:92:7D:7D:65:2D:3
camerfirmaglobalchambersignroot	*Jun 18, 2018*	33:9B:6B:14:50:24:9B:55:7A:01:87:72:84:D9:E0:2F:C3:D2:D
verisignclass3g3ca	*Apr 21, 2018*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:5
godaddyclass2ca	*Jun 18, 2018*	27:96:BA:E6:3F:18:01:E2:77:26:1B:A0:D7:77:70:02:8F:20:E
mozillacert61.pem	*Jun 18, 2018*	E0:B4:32:2E:B2:F6:A5:68:B6:54:53:84:48:18:4A:50:36:87:4
mozillacert53.pem	*Jun 18, 2018*	7F:8A:B0:CF:D0:51:87:6A:66:F3:36:0F:47:C8:8D:8C:D3:35:F
atostrustedroot2011	*Jun 18, 2018*	2B:B1:F5:3E:55:0C:1D:C5:F1:D4:E6:B7:6A:46:4B:55:06:02:A
mozillacert111.pem	*Jun 18, 2018*	9C:BB:48:53:F6:A4:F6:D3:52:A4:E8:32:52:55:60:13:F5:AD:A
staatdernederlandenevrootca	*Jun 18, 2018*	76:E2:7E:C1:4F:DB:82:C1:C0:A6:75:B5:05:BE:3D:29:B4:ED:D
mozillacert45.pem	*Jun 18, 2018*	67:65:0D:F1:7E:8E:7E:5B:82:40:A4:F4:56:4B:CF:E2:3D:69:C
mozillacert103.pem	*Jun 18, 2018*	70:C1:8D:74:B4:28:81:0A:E4:FD:A5:75:D7:01:9F:99:B0:3D:5
mozillacert37.pem	*Jun 18, 2018*	B1:2E:13:63:45:86:A4:6F:1A:B2:60:68:37:58:2D:C4:AC:FD:9
mozillacert29.pem	*Jun 18, 2018*	74:F8:A3:C3:EF:E7:B3:90:06:4B:83:90:3C:21:64:60:20:E5:D
izenpecom	*Jun 18, 2018*	2F:78:3D:25:52:18:A7:4A:65:39:71:B5:2C:A2:9C:45:15:6F:E
comodorsacertificationauthority	*Jun 18, 2018*	AF:E5:D2:44:A8:D1:19:42:30:FF:47:9F:E2:F8:97:BB:CD:7A:8
mozillacert99.pem	*Jun 18, 2018*	F1:7F:6F:B6:31:DC:99:E3:A3:C8:7F:FE:1C:F1:81:10:88:D9:6
mozillacert149.pem	*Jun 18, 2018*	6E:3A:55:A4:19:0C:19:5C:93:84:3C:C0:DB:72:2E:31:30:61:F
utnuserfirstobjectca	*Apr 21, 2018*	E1:2D:FB:4B:41:D7:D9:C3:2B:30:51:4B:AC:1D:81:D8:38:5E:2
verisignc3g3.pem	*Jun 18, 2018*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:5
dstrootcax3	*Jun 18, 2018*	DA:C9:02:4F:54:D8:F6:DF:94:93:5F:B1:73:26:38:CA:6A:D7:7
addtrustexternalroot	*Jun 18, 2018*	02:FA:F3:E2:91:43:54:68:60:78:57:69:4D:F5:E4:5B:68:85:1
certumtrustednetworkca	*Jun 18, 2018*	07:E0:32:E0:20:B7:2C:3F:19:2F:06:28:A2:59:3A:19:A7:0F:C
affirmtrustpremiumecc	*Jun 18, 2018*	B8:23:6B:00:2F:1D:16:86:53:01:55:6C:11:A4:37:CA:EB:FF:C
starfieldclass2ca	*Jun 18, 2018*	AD:7E:1C:28:B0:64:EF:8F:60:03:40:20:14:C3:D0:E3:37:0E:F
actalisauthenticationrootca	*Jun 18, 2018*	F3:73:B3:87:06:5A:28:84:8A:F2:F3:4A:CE:19:2B:DD:C7:8E:9
verisignclass2g3ca	*Apr 21, 2018*	61:EF:43:D7:7F:CA:D4:61:51:BC:98:E0:C3:59:12:AF:9F:EB:6

Name	Date	SHA1 Fingerprint
isrgrootx1	*Jun 18, 2018*	CA:BD:2A:79:A1:07:6A:31:F2:1D:25:36:35:CB:03:9D:43:29:A
godaddyrootcertificateauthorityg2	*Jun 18, 2018*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:E
mozillacert60.pem	*Jun 18, 2018*	3B:C4:9F:48:F8:F3:73:A0:9C:1E:BD:F8:5B:B1:C3:65:C7:D8:1
chunghwaepkirootca	*Apr 21, 2018*	67:65:0D:F1:7E:8E:7E:5B:82:40:A4:F4:56:4B:CF:E2:3D:69:C
mozillacert52.pem	*Jun 18, 2018*	8B:AF:4C:9B:1D:F0:2A:92:F7:DA:12:8E:B9:1B:AC:F4:98:60:4
microsecezignorootca2009	*Jun 18, 2018*	89:DF:74:FE:5C:F4:0F:4A:80:F9:E3:37:7D:54:DA:91:E1:01:3
securesignrootca11	*Jun 18, 2018*	3B:C4:9F:48:F8:F3:73:A0:9C:1E:BD:F8:5B:B1:C3:65:C7:D8:1
mozillacert110.pem	*Jun 18, 2018*	93:05:7A:88:15:C6:4F:CE:88:2F:FA:91:16:52:28:78:BC:53:6
mozillacert44.pem	*Jun 18, 2018*	5F:43:E5:B1:BF:F8:78:8C:AC:1C:C7:CA:4A:9A:C6:22:2B:CC:3
mozillacert102.pem	*Jun 18, 2018*	96:C9:1B:0B:95:B4:10:98:42:FA:D0:D8:22:79:FE:60:FA:B9:1
mozillacert36.pem	*Jun 18, 2018*	23:88:C9:D3:71:CC:9E:96:3D:FF:7D:3C:A7:CE:FC:D6:25:EC:1
mozillacert28.pem	*Jun 18, 2018*	66:31:BF:9E:F7:4F:9E:B6:C9:D5:A6:0C:BA:6A:BE:D1:F7:BD:E
baltimorecybertrustroot	*Jun 18, 2018*	D4:DE:20:D0:5E:66:FC:53:FE:1A:50:88:2C:78:DB:28:52:CA:E
amzninternalrootca	*Dec 12, 2008*	A7:B7:F6:15:8A:FF:1E:C8:85:13:38:BC:93:EB:A2:AB:A4:09:E
mozillacert98.pem	*Jun 18, 2018*	C9:A8:B9:E7:55:80:5E:58:E3:53:77:A7:25:EB:AF:C3:7B:27:C
mozillacert148.pem	*Jun 18, 2018*	04:83:ED:33:99:AC:36:08:05:87:22:ED:BC:5E:46:00:E3:BE:E
verisignc3g2.pem	*Jun 18, 2018*	85:37:1C:A6:E5:50:14:3D:CE:28:03:47:1B:DE:3A:09:E8:F8:7
quovadisrootca2g3	*Jun 18, 2018*	09:3C:61:F3:8B:8B:DC:7D:55:DF:75:38:02:05:00:E1:25:F5:C
geotrustprimarycertificationauthority	*Jun 18, 2018*	32:3C:11:8E:1B:F7:B8:B6:52:54:E2:E2:10:0D:D6:02:90:37:E
opentrustrootcag3	*Jun 18, 2018*	6E:26:64:F3:56:BF:34:55:BF:D1:93:3F:7C:01:DE:D8:13:DA:8
opentrustrootcag2	*Jun 18, 2018*	79:5F:88:60:C5:AB:7C:3D:92:E6:CB:F4:8D:E1:45:CD:11:EF:6
opentrustrootcag1	*Jun 18, 2018*	79:91:E8:34:F7:E2:EE:DD:08:95:01:52:E9:55:2D:14:E9:58:D
verisignclass3ca	*Apr 21, 2018*	A1:DB:63:93:91:6F:17:E4:18:55:09:40:04:15:C7:02:40:B0:A
globalsignca	*Apr 21, 2018*	B1:BC:96:8B:D4:F4:9D:62:2A:A8:9A:81:F2:15:01:52:A4:1D:8
ttelesecglobalrootclass2ca	*Apr 21, 2018*	59:0D:2D:7D:88:4F:40:2E:61:7E:A5:62:32:17:65:CF:17:D8:9
verisignclass1g3ca	*Apr 21, 2018*	20:42:85:DC:F7:EB:76:41:95:57:8E:13:6B:D4:B7:D1:E9:8E:4
verisignuniversalrootca	*Apr 21, 2018*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:C
soneraclass2ca	*Apr 21, 2018*	37:F7:6D:E6:07:7C:90:C5:B1:3E:93:1A:B7:41:10:B4:F2:E4:9
starfieldservicesrootcertificateauthorityg2	*Jun 18, 2018*	92:5A:8F:8D:2C:6D:04:E0:66:5F:59:6A:FF:22:D8:63:E8:25:6
mozillacert51.pem	*Jun 18, 2018*	FA:B7:EE:36:97:26:62:FB:2D:B0:2A:F6:BF:03:FD:E8:7C:4B:2

Name	Date	SHA1 Fingerprint
mozillacert43.pem	*Jun 18, 2018*	F9:CD:0E:2C:DA:76:24:C1:8F:BD:F0:F0:AB:B6:45:B8:F7:FE:D
mozillacert101.pem	*Jun 18, 2018*	99:A6:9B:E6:1A:FE:88:6B:4D:2B:82:00:7C:B8:54:FC:31:7E:1
mozillacert35.pem	*Jun 18, 2018*	2A:C8:D5:8B:57:CE:BF:2F:49:AF:F2:FC:76:8F:51:14:62:90:7
globalsignr2ca	*Apr 21, 2018*	75:E0:AB:B6:13:85:12:27:1C:04:F8:5F:DD:DE:38:E4:B7:24:2
mozillacert27.pem	*Jun 18, 2018*	3A:44:73:5A:E5:81:90:1F:24:86:61:46:1E:3B:9C:C4:5F:F5:3
affirmtrustpremium	*Jun 18, 2018*	D8:A6:33:2C:E0:03:6F:B1:85:F6:63:4F:7D:6A:06:65:26:32:2
mozillacert19.pem	*Jun 18, 2018*	B4:35:D4:E1:11:9D:1C:66:90:A7:49:EB:B3:94:BD:63:7B:A7:8
mozillacert97.pem	*Jun 18, 2018*	85:37:1C:A6:E5:50:14:3D:CE:28:03:47:1B:DE:3A:09:E8:F8:7
netlockaranyclassgoldfoutanusitvany	*Jun 18, 2018*	06:08:3F:59:3F:15:A1:04:A0:69:A4:6B:A9:03:D0:06:B7:97:0
mozillacert89.pem	*Jun 18, 2018*	C8:EC:8C:87:92:69:CB:4B:AB:39:E9:8D:7E:57:67:F3:14:95:7
verisignroot.pem	*Jun 18, 2018*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:0
mozillacert147.pem	*Jun 18, 2018*	58:11:9F:0E:12:82:87:EA:50:FD:D9:87:45:6F:4F:78:DC:FA:D
aolrootca2	*Apr 21, 2018*	85:B5:FF:67:9B:0C:79:96:1F:C8:6E:44:22:00:46:13:DB:17:9
cia-crt-g3-01-ca	*Nov 23, 2016*	2B:EE:2C:BA:A3:1D:B5:FE:60:40:41:95:08:ED:46:82:39:4D:E
aolrootca1	*Apr 21, 2018*	39:21:C1:15:C1:5D:0E:CA:5C:CB:5B:C4:F0:7D:21:D8:05:0B:5
verisignc3g1.pem	*Jun 18, 2018*	A1:DB:63:93:91:6F:17:E4:18:55:09:40:04:15:C7:02:40:B0:A
mozillacert139.pem	*Jun 18, 2018*	DE:3F:40:BD:50:93:D3:9B:6C:60:F6:DA:BC:07:62:01:00:89:7
soneraclass2rootca	*Jun 18, 2018*	37:F7:6D:E6:07:7C:90:C5:B1:3E:93:1A:B7:41:10:B4:F2:E4:9
swisssignsilverg2ca	*Apr 21, 2018*	9B:AA:E5:9F:56:EE:21:CB:43:5A:BE:25:93:DF:A7:F0:40:D1:1
thawteprimaryrootca	*Jun 18, 2018*	91:C6:D6:EE:3E:8A:C8:63:84:E5:48:C2:99:29:5C:75:6C:81:7
gdcatrustauthr5root	*Jun 18, 2018*	0F:36:38:5B:81:1A:25:C3:9B:31:4E:83:CA:E9:34:66:70:CC:7
trustcenterclass4caii	*Apr 21, 2018*	A6:9A:91:FD:05:7F:13:6A:42:63:0B:B1:76:0D:2D:51:12:0C:1
usertrustrsacertificationauthority	*Jun 18, 2018*	2B:8F:1B:57:33:0D:BB:A2:D0:7A:6C:51:F7:0E:E9:0D:DA:B9:A
digicertassuredidrootg3	*Jun 18, 2018*	F5:17:A2:4F:9A:48:C6:C9:F8:A2:00:26:9F:DC:0F:48:2C:AB:3
digicertassuredidrootg2	*Jun 18, 2018*	A1:4B:48:D9:43:EE:0A:0E:40:90:4F:3C:E0:A4:C0:91:93:51:5
mozillacert50.pem	*Jun 18, 2018*	8C:96:BA:EB:DD:2B:07:07:48:EE:30:32:66:A0:F3:98:6E:7C:A
mozillacert42.pem	*Jun 18, 2018*	85:A4:08:C0:9C:19:3E:5D:51:58:7D:CD:D6:13:30:FD:8C:DE:3
mozillacert100.pem	*Jun 18, 2018*	58:E8:AB:B0:36:15:33:FB:80:F7:9B:1B:6D:29:D3:FF:8D:5F:0
mozillacert34.pem	*Jun 18, 2018*	59:22:A1:E1:5A:EA:16:35:21:F8:98:39:6A:46:46:B0:44:1B:0
affirmtrustcommercialca	*Apr 21, 2018*	F9:B5:B6:32:45:5F:9C:BE:EC:57:5F:80:DC:E9:6E:2C:C7:B2:7

Name	Date	SHA1 Fingerprint
mozillacert26.pem	*Jun 18, 2018*	87:82:C6:C3:04:35:3B:CF:D2:96:92:D2:59:3E:7D:44:D9:34:F
globalsigneccrootcar5	*Jun 18, 2018*	1F:24:C6:30:CD:A4:18:EF:20:69:FF:AD:4F:DD:5F:46:3A:1B:6
globalsigneccrootcar4	*Jun 18, 2018*	69:69:56:2E:40:80:F4:24:A1:E7:19:9F:14:BA:F3:EE:58:AB:6
buypassclass3rootca	*Jun 18, 2018*	DA:FA:F7:FA:66:84:EC:06:8F:14:50:BD:C7:C2:81:A5:BC:A9:6
mozillacert18.pem	*Jun 18, 2018*	79:98:A3:08:E1:4D:65:85:E6:C2:1E:15:3A:71:9F:BA:5A:D3:4
mozillacert96.pem	*Jun 18, 2018*	55:A6:72:3E:CB:F2:EC:CD:C3:23:74:70:19:9D:2A:BE:11:E3:8
verisignc2g6.pem	*Jun 18, 2018*	40:B3:31:A0:E9:BF:E8:55:BC:39:93:CA:70:4F:4E:C2:51:D4:1
secomvalicertclass1ca	*Apr 21, 2018*	E5:DF:74:3C:B6:01:C4:9B:98:43:DC:AB:8C:E8:6A:81:10:9F:F
mozillacert88.pem	*Jun 18, 2018*	FE:45:65:9B:79:03:5B:98:A1:61:B5:51:2E:AC:DA:58:09:48:2
accvraiz1	*Jun 18, 2018*	93:05:7A:88:15:C6:4F:CE:88:2F:FA:91:16:52:28:78:BC:53:6
mozillacert146.pem	*Jun 18, 2018*	21:FC:BD:8E:7F:6C:AF:05:1B:D1:B3:43:EC:A8:E7:61:47:F2:0
mozillacert138.pem	*Jun 18, 2018*	E1:9F:E3:0E:8B:84:60:9E:80:9B:17:0D:72:A8:C5:BA:6E:14:0
verisignclass3g2ca	*Apr 21, 2018*	85:37:1C:A6:E5:50:14:3D:CE:28:03:47:1B:DE:3A:09:E8:F8:7
dtrustrootclass3ca2ev2009	*Jun 18, 2018*	96:C9:1B:0B:95:B4:10:98:42:FA:D0:D8:22:79:FE:60:FA:B9:1
xrampglobalca	*Apr 21, 2018*	B8:01:86:D1:EB:9C:86:A5:41:04:CF:30:54:F3:4C:52:B7:E5:5
mozillacert9.pem	*Jun 18, 2018*	F4:8B:11:BF:DE:AB:BE:94:54:20:71:E6:41:DE:6B:BE:88:2B:4
verisignuniversalrootcertificationauthority	*Jun 18, 2018*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:0
tubitakkamusmsslkoksertifikasisurum1	*Jun 18, 2018*	01:43:64:9B:EC:CE:27:EC:ED:3A:3F:0B:8F:0D:E4:E8:91:DD:E
mozillacert41.pem	*Jun 18, 2018*	6B:2F:34:AD:89:58:BE:62:FD:B0:6B:5C:CE:BB:9D:D9:4F:4E:3
mozillacert33.pem	*Jun 18, 2018*	FE:B8:C4:32:DC:F9:76:9A:CE:AE:3D:D8:90:8F:FD:28:86:65:6
mozillacert25.pem	*Jun 18, 2018*	4E:B6:D5:78:49:9B:1C:CF:5F:58:1E:AD:56:BE:3D:9B:67:44:A
mozillacert17.pem	*Jun 18, 2018*	40:54:DA:6F:1C:3F:40:74:AC:ED:0F:EC:CD:DB:79:D1:53:FB:9
mozillacert95.pem	*Jun 18, 2018*	DA:FA:F7:FA:66:84:EC:06:8F:14:50:BD:C7:C2:81:A5:BC:A9:6
affirmtrustpremiumeccca	*Apr 21, 2018*	B8:23:6B:00:2F:1D:16:86:53:01:55:6C:11:A4:37:CA:EB:FF:C
mozillacert87.pem	*Jun 18, 2018*	5F:3B:8C:F2:F8:10:B3:7D:78:B4:CE:EC:19:19:C3:73:34:B9:C
mozillacert145.pem	*Jun 18, 2018*	10:1D:FA:3F:D5:0B:CB:BB:9B:B5:60:0C:19:55:A4:1A:F4:73:3
mozillacert79.pem	*Jun 18, 2018*	D8:A6:33:2C:E0:03:6F:B1:85:F6:63:4F:7D:6A:06:65:26:32:2
mozillacert137.pem	*Jun 18, 2018*	4A:65:D5:F4:1D:EF:39:B8:B8:90:4A:4A:D3:64:81:33:CF:C7:A
digicertassuredidrootca	*Jun 18, 2018*	05:63:B8:63:0D:62:D7:5A:BB:C8:AB:1E:4B:DF:B5:A8:99:B2:4
addtrustqualifiedca	*Apr 21, 2018*	4D:23:78:EC:91:95:39:B5:00:7F:75:8F:03:3B:21:1E:C5:4D:8
mozillacert129.pem	*Jun 18, 2018*	E6:21:F3:35:43:79:05:9A:4B:68:30:9D:8A:2F:74:22:15:87:E

Name	Date	SHA1 Fingerprint
verisignclass2g2ca	*Apr 21, 2018*	B3:EA:C4:47:76:C9:C8:1C:EA:F2:9D:95:B6:CC:A0:08:1B:67:E
baltimorecodesigningca	*Apr 21, 2018*	30:46:D8:C8:88:FF:69:30:C3:4A:FC:CD:49:27:08:7C:60:56:7
luxtrustglobalroot2	*Jun 18, 2018*	1E:0E:56:19:0A:D1:8B:25:98:B2:04:44:FF:66:8A:04:17:99:5
visaecommerceroot	*Jun 18, 2018*	70:17:9B:86:8C:00:A4:FA:60:91:52:22:3F:9F:3E:32:BD:E0:0
oistewisekeyglobalrootgbca	*Jun 18, 2018*	0F:F9:40:76:18:D3:D7:6A:4B:98:F0:A8:35:9E:0C:FD:27:AC:C
mozillacert8.pem	*Jun 18, 2018*	3E:2B:F7:F2:03:1B:96:F3:8C:E6:C4:D8:A8:5D:3E:2D:58:47:6
comodocertificationauthority	*Jun 18, 2018*	66:31:BF:9E:F7:4F:9E:B6:C9:D5:A6:0C:BA:6A:BE:D1:F7:BD:E
cia-crt-g3-02-ca	*Nov 23, 2016*	96:4A:BB:A7:BD:DA:FC:97:34:C0:0A:2D:F0:05:98:F7:E6:C6:6
verisignc1g6.pem	*Jun 18, 2018*	51:7F:61:1E:29:91:6B:53:82:FB:72:E7:44:D9:8D:C3:CC:53:6
trustcenterclass2caii	*Apr 21, 2018*	AE:50:83:ED:7C:F4:5C:BC:8F:61:C6:21:FE:68:5D:79:42:21:1
quovadisrootca1g3	*Jun 18, 2018*	1B:8E:EA:57:96:29:1A:C9:39:EA:B8:0A:81:1A:73:73:C0:93:7
mozillacert40.pem	*Jun 18, 2018*	80:25:EF:F4:6E:70:C8:D4:72:24:65:84:FE:40:3B:8A:8D:6A:D
cadisigrootr2	*Jun 18, 2018*	B5:61:EB:EA:A4:DE:E4:25:4B:69:1A:98:A5:57:47:C2:34:C7:D
cadisigrootr1	*Jun 18, 2018*	8E:1C:74:F8:A6:20:B9:E5:8A:F4:61:FA:EC:2B:47:56:51:1A:5
mozillacert32.pem	*Jun 18, 2018*	60:D6:89:74:B5:C2:65:9E:8A:0F:C1:88:7C:88:D2:46:69:1B:1
utndatacorpsgcca	*Apr 21, 2018*	58:11:9F:0E:12:82:87:EA:50:FD:D9:87:45:6F:4F:78:DC:FA:D
mozillacert24.pem	*Jun 18, 2018*	59:AF:82:79:91:86:C7:B4:75:07:CB:CF:03:57:46:EB:04:DD:B
addtrustclass1ca	*Apr 21, 2018*	CC:AB:0E:A0:4C:23:01:D6:69:7B:DD:37:9F:CD:12:EB:24:E3:9
mozillacert16.pem	*Jun 18, 2018*	DA:C9:02:4F:54:D8:F6:DF:94:93:5F:B1:73:26:38:CA:6A:D7:7
affirmtrustnetworkingca	*Apr 21, 2018*	29:36:21:02:8B:20:ED:02:F5:66:C5:32:D1:D6:ED:90:9F:45:0
mozillacert94.pem	*Jun 18, 2018*	49:0A:75:74:DE:87:0A:47:FE:58:EE:F6:C7:6B:EB:C6:0B:12:4
mozillacert86.pem	*Jun 18, 2018*	74:2C:31:92:E6:07:E4:24:EB:45:49:54:2B:E1:BB:C5:3E:61:7
mozillacert144.pem	*Jun 18, 2018*	37:F7:6D:E6:07:7C:90:C5:B1:3E:93:1A:B7:41:10:B4:F2:E4:9
mozillacert78.pem	*Jun 18, 2018*	29:36:21:02:8B:20:ED:02:F5:66:C5:32:D1:D6:ED:90:9F:45:0
mozillacert136.pem	*Jun 18, 2018*	D1:EB:23:A4:6D:17:D6:8F:D9:25:64:C2:F1:F1:60:17:64:D8:E
mozillacert128.pem	*Jun 18, 2018*	A9:E9:78:08:14:37:58:88:F2:05:19:B0:6D:2B:0D:2B:60:16:9
verisignclass1g2ca	*Apr 21, 2018*	27:3E:E1:24:57:FD:C4:F9:0C:55:E8:2B:56:16:7F:62:F5:32:E
hellenicacademicandresearchinstitutionsrootca2015	*Jun 18, 2018*	01:0C:06:95:A6:98:19:14:FF:BF:5F:C6:B0:B6:95:EA:29:E9:1
soneraclass1ca	*Apr 21, 2018*	07:47:22:01:99:CE:74:B9:7C:B0:3D:79:B2:64:A2:C8:55:E9:3
hellenicacademicandresearchinstitutionsrootca2011	*Jun 18, 2018*	FE:45:65:9B:79:03:5B:98:A1:61:B5:51:2E:AC:DA:58:09:48:2

Name	Date	SHA1 Fingerprint
certumtrustednetworkca2	*Jun 18, 2018*	D3:DD:48:3E:2B:BF:4C:05:E8:AF:10:F5:FA:76:26:CF:D3:DC:3
equifaxsecureca	*Apr 21, 2018*	D2:32:09:AD:23:D3:14:23:21:74:E4:0D:7F:9D:62:13:97:86:6
thawteserverca	*Apr 21, 2018*	9F:AD:91:A6:CE:6A:C6:C5:00:47:C4:4E:C9:D4:A5:0D:92:D8:4
mozillacert7.pem	*Jun 18, 2018*	AD:7E:1C:28:B0:64:EF:8F:60:03:40:20:14:C3:D0:E3:37:0E:F
affirmtrustnetworking	*Jun 18, 2018*	29:36:21:02:8B:20:ED:02:F5:66:C5:32:D1:D6:ED:90:9F:45:0
deprecateditsecca	*Jan 27, 2012*	12:12:0B:03:0E:15:14:54:F4:DD:B3:F5:DE:13:6E:83:5A:29:7
globalsignrootcar3	*Jun 18, 2018*	D6:9B:56:11:48:F0:1C:77:C5:45:78:C1:09:26:DF:5B:85:69:7
globalsignrootcar2	*Jun 18, 2018*	75:E0:AB:B6:13:85:12:27:1C:04:F8:5F:DD:DE:38:E4:B7:24:2
quovadisrootca	*Jun 18, 2018*	DE:3F:40:BD:50:93:D3:9B:6C:60:F6:DA:BC:07:62:01:00:89:7
mozillacert31.pem	*Jun 18, 2018*	9F:74:4E:9F:2B:4D:BA:EC:0F:31:2C:50:B6:56:3B:8E:2D:93:C
entrustrootcertificationauthority	*Jun 18, 2018*	B3:1E:B1:B7:40:E3:6C:84:02:DA:DC:37:D4:4D:F5:D4:67:49:5
mozillacert23.pem	*Jun 18, 2018*	91:C6:D6:EE:3E:8A:C8:63:84:E5:48:C2:99:29:5C:75:6C:81:7
mozillacert15.pem	*Jun 18, 2018*	74:20:74:41:72:9C:DD:92:EC:79:31:D8:23:10:8D:C2:81:92:F
verisignc2g3.pem	*Jun 18, 2018*	61:EF:43:D7:7F:CA:D4:61:51:BC:98:E0:C3:59:12:AF:9F:EB:6
mozillacert93.pem	*Jun 18, 2018*	31:F1:FD:68:22:63:20:EE:C6:3B:3F:9D:EA:4A:3E:53:7C:7C:3
mozillacert151.pem	*Jun 18, 2018*	AC:ED:5F:65:53:FD:25:CE:01:5F:1F:7A:48:3B:6A:74:9F:61:7
mozillacert85.pem	*Jun 18, 2018*	CF:9E:87:6D:D3:EB:FC:42:26:97:A3:B5:A3:7A:A0:76:A9:06:2
certplusclass2primaryca	*Jun 18, 2018*	74:20:74:41:72:9C:DD:92:EC:79:31:D8:23:10:8D:C2:81:92:F
mozillacert143.pem	*Jun 18, 2018*	36:B1:2B:49:F9:81:9E:D7:4C:9E:BC:38:0F:C6:56:8F:5D:AC:F
mozillacert77.pem	*Jun 18, 2018*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:5
mozillacert135.pem	*Jun 18, 2018*	62:52:DC:40:F7:11:43:A2:2F:DE:9E:F7:34:8E:06:42:51:B1:8
mozillacert69.pem	*Jun 18, 2018*	2F:78:3D:25:52:18:A7:4A:65:39:71:B5:2C:A2:9C:45:15:6F:F
mozillacert127.pem	*Jun 18, 2018*	DE:28:F4:A4:FF:E5:B9:2F:A3:C5:03:D1:A3:49:A7:F9:96:2A:8
mozillacert119.pem	*Jun 18, 2018*	75:E0:AB:B6:13:85:12:27:1C:04:F8:5F:DD:DE:38:E4:B7:24:2
geotrustprimarycag3	*Apr 21, 2018*	03:9E:ED:B8:0B:E7:A0:3C:69:53:89:3B:20:D2:D9:32:3A:4C:2
identrustpublicsectorrootca1	*Jun 18, 2018*	BA:29:41:60:77:98:3F:F4:F3:EF:F2:31:05:3B:2E:EA:6D:4D:4
geotrustprimarycag2	*Apr 21, 2018*	8D:17:84:D5:37:F3:03:7D:EC:70:FE:57:8B:51:9A:99:E6:10:D
trustcorrootcertca2	*Jun 18, 2018*	B8:BE:6D:CB:56:F1:55:B9:63:D4:12:CA:4E:06:34:C7:94:B2:1
mozillacert6.pem	*Jun 18, 2018*	27:96:BA:E6:3F:18:01:E2:77:26:1B:A0:D7:77:70:02:8F:20:E
trustcorrootcertca1	*Jun 18, 2018*	FF:BD:CD:E7:82:C8:43:5E:3C:6F:26:86:5C:CA:A8:3A:45:5B:C
networksolutionscertificateauthority	*Jun 18, 2018*	74:F8:A3:C3:EF:E7:B3:90:06:4B:83:90:3C:21:64:60:20:E5:D

Name	Date	SHA1 Fingerprint
twcarootcertificationauthority	*Jun 18, 2018*	CF:9E:87:6D:D3:EB:FC:42:26:97:A3:B5:A3:7A:A0:76:A9:06:2
addtrustexternalca	*Apr 21, 2018*	02:FA:F3:E2:91:43:54:68:60:78:57:69:4D:F5:E4:5B:68:85:1
verisignclass3g5ca	*Apr 21, 2018*	4E:B6:D5:78:49:9B:1C:CF:5F:58:1E:AD:56:BE:3D:9B:67:44:A
autoridaddecertificacionfirmaprofesional	*Jun 18, 2018*	AE:C5:FB:3F:C8:E1:BF:C4:E5:4F:03:07:5A:9A:E8:00:B7:F7:F
hellenicacademicandresearchinstitutionsecc	*Jun 18, 2018*	9F:F1:71:8D:92:D5:9A:F3:7D:74:97:B4:BC:6F:84:68:0B:BA:F
verisigntsaca	*Apr 21, 2018*	20:CE:B1:F0:F5:1C:0E:19:A9:F3:8D:B1:AA:8E:03:8C:AA:7A:C
utnuserfirsthardwareca	*Apr 21, 2018*	04:83:ED:33:99:AC:36:08:05:87:22:ED:BC:5E:46:00:E3:BE:F
identrustcommercialrootca1	*Jun 18, 2018*	DF:71:7E:AA:4A:D9:4E:C9:55:84:99:60:2D:48:DE:5F:BC:F0:3
dtrustrootclass3ca22009	*Jun 18, 2018*	58:E8:AB:B0:36:15:33:FB:80:F7:9B:1B:6D:29:D3:FF:8D:5F:C
epkirootcertificationauthority	*Jun 18, 2018*	67:65:0D:F1:7E:8E:7E:5B:82:40:A4:F4:56:4B:CF:E2:3D:69:C
mozillacert30.pem	*Jun 18, 2018*	E7:B4:F6:9D:61:EC:90:69:DB:7E:90:A7:40:1A:3C:F4:7D:4F:F
teliasonerarootcav1	*Jun 18, 2018*	43:13:BB:96:F1:D5:86:9B:C1:4E:6A:92:F6:CF:F6:34:69:87:8
buypassclass3ca	*Apr 21, 2018*	DA:FA:F7:FA:66:84:EC:06:8F:14:50:BD:C7:C2:81:A5:BC:A9:6
mozillacert22.pem	*Jun 18, 2018*	32:3C:11:8E:1B:F7:B8:B6:52:54:E2:E2:10:0D:D6:02:90:37:F
mozillacert14.pem	*Jun 18, 2018*	5F:B7:EE:06:33:E2:59:DB:AD:0C:4C:9A:E6:D3:8F:1A:61:C7:D
verisignc2g2.pem	*Jun 18, 2018*	B3:EA:C4:47:76:C9:C8:1C:EA:F2:9D:95:B6:CC:A0:08:1B:67:E
certumca	*Apr 21, 2018*	62:52:DC:40:F7:11:43:A2:2F:DE:9E:F7:34:8E:06:42:51:B1:8
mozillacert92.pem	*Jun 18, 2018*	A3:F1:33:3F:E2:42:BF:CF:C5:D1:4E:8F:39:42:98:40:68:10:D
mozillacert150.pem	*Jun 18, 2018*	33:9B:6B:14:50:24:9B:55:7A:01:87:72:84:D9:E0:2F:C3:D2:D
mozillacert84.pem	*Jun 18, 2018*	D3:C0:63:F2:19:ED:07:3E:34:AD:5D:75:0B:32:76:29:FF:D5:9
ttelesecglobalrootclass3	*Jun 18, 2018*	55:A6:72:3E:CB:F2:EC:CD:C3:23:74:70:19:9D:2A:BE:11:E3:8
globalsignrootca	*Jun 18, 2018*	B1:BC:96:8B:D4:F4:9D:62:2A:A8:9A:81:F2:15:01:52:A4:1D:8
ttelesecglobalrootclass2	*Jun 18, 2018*	59:0D:2D:7D:88:4F:40:2E:61:7E:A5:62:32:17:65:CF:17:D8:9
mozillacert142.pem	*Jun 18, 2018*	1F:49:14:F7:D8:74:95:1D:DD:AE:02:C0:BE:FD:3A:2D:82:75:5
mozillacert76.pem	*Jun 18, 2018*	F9:B5:B6:32:45:5F:9C:BE:EC:57:5F:80:DC:E9:6E:2C:C7:B2:7
mozillacert134.pem	*Jun 18, 2018*	70:17:9B:86:8C:00:A4:FA:60:91:52:22:3F:9F:3E:32:BD:E0:0
mozillacert68.pem	*Jun 18, 2018*	AE:C5:FB:3F:C8:E1:BF:C4:E5:4F:03:07:5A:9A:E8:00:B7:F7:F
etugracertificationauthority	*Jun 18, 2018*	51:C6:E7:08:49:06:6E:F3:92:D4:5C:A0:0D:6D:A3:62:8F:C3:5
mozillacert126.pem	*Jun 18, 2018*	25:01:90:19:CF:FB:D9:99:1C:B7:68:25:74:8D:94:5F:30:93:9
keynectisrootca	*Apr 21, 2018*	9C:61:5C:4D:4D:85:10:3A:53:26:C2:4D:BA:EA:E4:A2:D2:D5:0
mozillacert118.pem	*Jun 18, 2018*	7E:78:4A:10:1C:82:65:CC:2D:E1:F1:6D:47:B4:40:CA:D9:0A:1

Name	Date	SHA1 Fingerprint
quovadisrootca3	*Jun 18, 2018*	1F:49:14:F7:D8:74:95:1D:DD:AE:02:C0:BE:FD:3A:2D:82:75:5
quovadisrootca2	*Jun 18, 2018*	CA:3A:FB:CF:12:40:36:4B:44:B2:16:20:88:80:48:39:19:93:7
mozillacert5.pem	*Jun 18, 2018*	B8:01:86:D1:EB:9C:86:A5:41:04:CF:30:54:F3:4C:52:B7:E5:5
verisignc1g3.pem	*Jun 18, 2018*	20:42:85:DC:F7:EB:76:41:95:57:8E:13:6B:D4:B7:D1:E9:8E:4
cybertrustglobalroot	*Jun 18, 2018*	5F:43:E5:B1:BF:F8:78:8C:AC:1C:C7:CA:4A:9A:C6:22:2B:CC:3
amzninternalinfoseccag3	*Feb 27, 2015*	B9:B1:CA:38:F7:BF:9C:D2:D4:95:E7:B6:5E:75:32:9B:A8:78:2
starfieldrootcertificateauthorityg2	*Jun 18, 2018*	25:1C:06:7C:EE:2B:0C:3D:F8:55:AB:2D:92:F4:FE:39:D4:E7:0
entrust2048ca	*Apr 21, 2018*	50:30:06:09:1D:97:D4:F5:AE:39:F7:CB:E7:92:7D:7D:65:2D:3
swisssignsilvercag2	*Jun 18, 2018*	9B:AA:E5:9F:56:EE:21:CB:43:5A:BE:25:93:DF:A7:F0:40:D1:1
affirmtrustcommercial	*Jun 18, 2018*	F9:B5:B6:32:45:5F:9C:BE:EC:57:5F:80:DC:E9:6E:2C:C7:B2:7
certinomisrootca	*Jun 18, 2018*	9D:70:BB:01:A5:A4:A0:18:11:2E:F7:1C:01:B9:32:C5:34:E7:8
xrampglobalcaroot	*Jun 18, 2018*	B8:01:86:D1:EB:9C:86:A5:41:04:CF:30:54:F3:4C:52:B7:E5:5
secureglobalca	*Jun 18, 2018*	3A:44:73:5A:E5:81:90:1F:24:86:61:46:1E:3B:9C:C4:5F:F5:3
swisssigngoldg2ca	*Apr 21, 2018*	D8:C5:38:8A:B7:30:1B:1B:6E:D4:7A:E6:45:25:3A:6F:9F:1A:2
mozillacert21.pem	*Jun 18, 2018*	9B:AA:E5:9F:56:EE:21:CB:43:5A:BE:25:93:DF:A7:F0:40:D1:1
mozillacert13.pem	*Jun 18, 2018*	06:08:3F:59:3F:15:A1:04:A0:69:A4:6B:A9:03:D0:06:B7:97:0
verisignc2g1.pem	*Jun 18, 2018*	67:82:AA:E0:ED:EE:E2:1A:58:39:D3:C0:CD:14:68:0A:4F:60:1
mozillacert91.pem	*Jun 18, 2018*	3B:C0:38:0B:33:C3:F6:A6:0C:86:15:22:93:D9:DF:F5:4B:81:0
oistewisekeyglobalrootgca	*Jun 18, 2018*	59:22:A1:E1:5A:EA:16:35:21:F8:98:39:6A:46:46:B0:44:1B:0
mozillacert83.pem	*Jun 18, 2018*	A0:73:E5:C5:BD:43:61:0D:86:4C:21:13:0A:85:58:57:CC:9C:F
entrustevca	*Apr 21, 2018*	B3:1E:B1:B7:40:E3:6C:84:02:DA:DC:37:D4:4D:F5:D4:67:49:5
mozillacert141.pem	*Jun 18, 2018*	31:7A:2A:D0:7F:2B:33:5E:F5:A1:C3:4E:4B:57:E8:B7:D8:F1:F
mozillacert75.pem	*Jun 18, 2018*	D2:32:09:AD:23:D3:14:23:21:74:E4:0D:7F:9D:62:13:97:86:6
mozillacert133.pem	*Jun 18, 2018*	85:B5:FF:67:9B:0C:79:96:1F:C8:6E:44:22:00:46:13:DB:17:9
mozillacert67.pem	*Jun 18, 2018*	D6:9B:56:11:48:F0:1C:77:C5:45:78:C1:09:26:DF:5B:85:69:7
mozillacert125.pem	*Jun 18, 2018*	B3:1E:B1:B7:40:E3:6C:84:02:DA:DC:37:D4:4D:F5:D4:67:49:5
mozillacert59.pem	*Jun 18, 2018*	36:79:CA:35:66:87:72:30:4D:30:A5:FB:87:3B:0F:A7:7B:B7:0
thawtepremiumserverca	*Apr 21, 2018*	E0:AB:05:94:20:72:54:93:05:60:62:02:36:70:F7:CD:2E:FC:6
mozillacert117.pem	*Jun 18, 2018*	D4:DE:20:D0:5E:66:FC:53:FE:1A:50:88:2C:78:DB:28:52:CA:E
utnuserfirstclientauthemailca	*Apr 21, 2018*	B1:72:B1:A5:6D:95:F9:1F:E5:02:87:E1:4D:37:EA:6A:44:63:7
entrustrootcag2	*Apr 21, 2018*	8C:F4:27:FD:79:0C:3A:D1:66:06:8D:E8:1E:57:EF:BB:93:22:7

Name	Date	SHA1 Fingerprint
mozillacert109.pem	*Jun 18, 2018*	B5:61:EB:EA:A4:DE:E4:25:4B:69:1A:98:A5:57:47:C2:34:C7:
digicerttrustedrootg4	*Jun 18, 2018*	DD:FB:16:CD:49:31:C9:73:A2:03:7D:3F:C8:3A:4D:7D:77:5D:
gdroot-g2.pem	*Jun 18, 2018*	47:BE:AB:C9:22:EA:E8:0E:78:78:34:62:A7:9F:45:C2:54:FD:
comodoaaaservicesroot	*Jun 18, 2018*	D1:EB:23:A4:6D:17:D6:8F:D9:25:64:C2:F1:F1:60:17:64:D8:
mozillacert4.pem	*Jun 18, 2018*	E3:92:51:2F:0A:CF:F5:05:DF:F6:DE:06:7F:75:37:E1:65:EA:
verisignclass3publicprimarycertificationauthorityg5	*Jun 18, 2018*	4E:B6:D5:78:49:9B:1C:CF:5F:58:1E:AD:56:BE:3D:9B:67:44:
chambersofcommerceroot2008	*Jun 18, 2018*	78:6A:74:AC:76:AB:14:7F:9C:6A:30:50:BA:9E:A8:7E:FE:9A:
verisignclass3publicprimarycertificationauthorityg4	*Jun 18, 2018*	22:D5:D8:DF:8F:02:31:D1:8D:F7:9D:B7:CF:8A:2D:64:C9:3F:
verisignclass3publicprimarycertificationauthorityg3	*Jun 18, 2018*	13:2D:0D:45:53:4B:69:97:CD:B2:D5:C3:39:E2:55:76:60:9B:
thawtepersonalfreemailca	*Apr 21, 2018*	E6:18:83:AE:84:CA:C1:C1:CD:52:AD:E8:E9:25:2B:45:A6:4F:
verisignc1g2.pem	*Jun 18, 2018*	27:3E:E1:24:57:FD:C4:F9:0C:55:E8:2B:56:16:7F:62:F5:32:
gtecybertrustglobalca	*Apr 21, 2018*	97:81:79:50:D8:1C:96:70:CC:34:D8:09:CF:79:44:31:36:7E:
trustcenteruniversalcai	*Apr 21, 2018*	6B:2F:34:AD:89:58:BE:62:FD:B0:6B:5C:CE:BB:9D:D9:4F:4E:
camerfirmachamberscommerceca	*Apr 21, 2018*	6E:3A:55:A4:19:0C:19:5C:93:84:3C:C0:DB:72:2E:31:30:61:
verisignclass1ca	*Apr 21, 2018*	CE:6A:64:A3:09:E4:2F:BB:D9:85:1C:45:3E:64:09:EA:E8:7D:

Resolver mapping template changelog

Resolver and function mapping templates are versioned. The mapping template version, such as `2018-05-29`) dictates the following: * The expected shape of the data source request configuration provided by the request template * The execution behavior of the request mapping template and the response mapping template

Versions are represented using the YYYY-MM-DD format, a later date corresponds to a more recent version. This page lists the differences between the mapping template versions currently supported in AWS AppSync.

Topics

Datasource Operation Availability Per Version Matrix

Operation/Version Supported	2017-02-28	2018-05-29
AWS Lambda Invoke	Yes	Yes

Operation/Version Supported	2017-02-28	2018-05-29
AWS Lambda BatchInvoke	Yes	Yes
None Datasource	Yes	Yes
Amazon Elasticsearch GET	Yes	Yes
Amazon Elasticsearch POST	Yes	Yes
Amazon Elasticsearch PUT	Yes	Yes
Amazon Elasticsearch DELETE	Yes	Yes
Amazon Elasticsearch GET	Yes	Yes
DynamoDB GetItem	Yes	Yes
DynamoDB Scan	Yes	Yes
DynamoDB Query	Yes	Yes
DynamoDB DeleteItem	Yes	Yes
DynamoDB PutItem	Yes	Yes
DynamoDB BatchGetItem	No	Yes
DynamoDB BatchPutItem	No	Yes
DynamoDB BatchDeleteItem	No	Yes
HTTP	No	Yes
Amazon RDS	No	Yes

Note: Only **2018-05-29** version is currently supported in functions.

Changing the Version on a Unit Resolver Mapping Template

For Unit resolvers, the version is specified as part of the body of the request mapping template. To update the version, simply update the `version` field to the new version.

For example, to update the version on the AWS Lambda template:

```
{
    "version": "2017-02-28",
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "arguments": $utils.toJson($context.arguments)
    }
}
```

You need to update the version field from `2017-02-28` to `2018-05-29` as follows:

```
{
    "version": "2018-05-29", ## Note the version
```

```
    "operation": "Invoke",
    "payload": {
        "field": "getPost",
        "arguments": $utils.toJson($context.arguments)
    }
}
```

Changing the Version on a Function

For functions, the version is specified as the `functionVersion` field on the function object. To update the version, simply update the `functionVersion`. *Note:* Currently, only `2018-05-29` is supported for function.

The following is an example of a CLI command to update an existing function version:

```
aws appsync update-function \
--api-id REPLACE_WITH_API_ID \
--function-id REPLACE_WITH_FUNCTION_ID \
--data-source-name "PostTable" \
--function-version "2018-05-29" \
--request-mapping-template "{...}" \
--response-mapping-template "\$util.toJson(\$ctx.result)"
```

Note: It is recommended to omit the version field from the function request mapping template as it will not be honored. If you do specify a version inside a function request mapping template, the version value will be overridden by the value of the `functionVersion` field.

2018-05-29

Behavior Change

- If the datasource invocation result is `null`, the response mapping template is executed.
- If the datasource invocation yields an error, it is now up to you to handle the error, the response mapping template evaluated result will **always** be placed inside the GraphQL response `data` block.

Reasoning

- A `null` invocation result has meaning, and in some application use cases we might want to handle `null` results in a custom way. For example, an application might check if a record exists in an Amazon DynamoDB table to perform some authorization check. In this case, a `null` invocation result would mean the user might not be authorized. Executing the response mapping template now provides the ability to raise an unauthorized error. This behavior provides greater control to the API designer.

Given the following response mapping template:

```
$util.toJson($ctx.result)
```

Previously with `2017-02-28`, if `$ctx.result` came back null, the response mapping template was not executed. With `2018-05-29`, we can now handle this scenario. For example, we can choose to raise an authorization error as follows:

```
# throw an unauthorized error if the result is null
#if ( $util.isNull($ctx.result) )
    $util.unauthorized()
```

```
#end
$util.toJson($ctx.result)
```

Note: Errors coming back from a data source are sometimes not fatal or even expected, that is why the response mapping template should be given the flexibility to handle the invocation error and decide whether to ignore it, re-raise it, or throw a different error.

Given the following response mapping template:

```
$util.toJson($ctx.result)
```

Previously, with `2017-02-28`, in case of an invocation error, the response mapping template was evaluated and the result was placed automatically in the `errors` block of the GraphQL response. With `2018-05-29`, we can now choose what to do with the error, re-raise it, raise a different error, or append the error while return data.

Re-raise an Invocation Error

In the following response template, we raise the same error that came back from the data source.

```
#if ( $ctx.error )
    $util.error($ctx.error.message, $ctx.error.type)
#end
$util.toJson($ctx.result)
```

In case of an invocation error (for example, `$ctx.error` is present) the response looks like the following:

```
{
    "data": {
        "getPost": null
    },
    "errors": [
        {
            "path": [
                "getPost"
            ],
            "errorType": "DynamoDB:ConditionalCheckFailedException",
            "message": "Conditional check failed exception...",
            "locations": [
                {
                    "line": 5,
                    "column": 5
                }
            ]
        }
    ]
}
```

Raise a Different Error

In the following response template, we raise our own custom error after processing the error that came back from the data source.

```
#if ( $ctx.error )
    #if ( $ctx.error.type.equals("ConditionalCheckFailedException") )
        ## we choose here to change the type and message of the error for
 ConditionalCheckFailedExceptions
```

```
        $util.error("Error while updating the post, try again. Error: $ctx.error.message",
 "UpdateError")
    #else
        $util.error($ctx.error.message, $ctx.error.type)
    #end
#end
$util.toJson($ctx.result)
```

In case of an invocation error (for example, `$ctx.error` is present) the response looks like the following:

```
{
    "data": {
        "getPost": null
    },
    "errors": [
        {
            "path": [
                "getPost"
            ],
            "errorType": "UpdateError",
            "message": "Error while updating the post, try again. Error: Conditional check
 failed exception...",
            "locations": [
                {
                    "line": 5,
                    "column": 5
                }
            ]
        }
    ]
}
```

Append an Error to Return Data

In the following response template, we append the same error that came back from the data source while returning data back inside the response. This is also known as a partial response.

```
#if ( $ctx.error )
    $util.appendError($ctx.error.message, $ctx.error.type)
    #set($defaultPost = {id: "1", title: 'default post'})
    $util.toJson($defaultPost)
#else
    $util.toJson($ctx.result)
#end
```

In case of an invocation error (for example, `$ctx.error` is present) the response looks like the following:

```
{
    "data": {
        "getPost": {
            "id": "1",
            "title: "A post"
        }
    },
    "errors": [
        {
            "path": [
                "getPost"
            ],
```

```
            "errorType": "ConditionalCheckFailedException",
            "message": "Conditional check failed exception...",
            "locations": [
                {
                    "line": 5,
                    "column": 5
                }
            ]
        }
    ]
}
```

Migrating from *2017-02-28* to *2018-05-29*

Migrating from **2017-02-28** to **2018-05-29** is straightforward. Change the version field on the resolver request mapping template or on the function version object. However, note that **2018-05-29** execution behaves differently from **2017-02-28**, changes are outlined here (p. 360).

Preserving the same execution behavior from *2017-02-28* to *2018-05-29*

In some cases, it is possible to retain the same execution behavior as the **2017-02-28** version while executing a **2018-05-29** versioned template.

Example: DynamoDB PutItem

Given the following **2017-02-28** DynamoDB PutItem request template:

```
{
    "version" : "2017-02-28",
    "operation" : "PutItem",
    "key": {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "attributeValues" : {
        "baz" : ... typed value
    },
    "condition" : {
       ...
    }
}
```

And the following response template:

```
$util.toJson($ctx.result)
```

Migrating to **2018-05-29** changes these templates as follows:

```
{
    "version" : "2018-05-29", ## Note the new 2018-05-29 version
    "operation" : "PutItem",
    "key": {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "attributeValues" : {
        "baz" : ... typed value
    },
    "condition" : {
```

```
        ...
    }
}
```

And changes the response template as follows:

```
## If there is a datasource invocation error, we choose to raise the same error
## the field data will be set to null.
#if($ctx.error)
  $util.error($ctx.error.message, $ctx.error.type, $ctx.result)
#end

## If the data source invocation is null, we return null.
#if($util.isNull($ctx.result))
  #return
#end

$util.toJson($ctx.result)
```

Now that it is your responsibility to handle errors, we chose to raise the same error using `$util.error()` that was returned from DynamoDB. You can adapt this snippet to convert your mapping template to **2018-05-29**, note that if your response template is different you will have to take account of the execution behavior changes.

Example: DynamoDB GetItem

Given the following **2017-02-28** DynamoDB GetItem request template:

```
{
    "version" : "2017-02-28",
    "operation" : "GetItem",
    "key" : {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "consistentRead" : true
}
```

And the following response template:

```
## map table attribute postId to field Post.id
$util.qr($ctx.result.put("id", $ctx.result.get("postId")))

$util.toJson($ctx.result)
```

Migrating to **2018-05-29** changes these templates as follows:

```
{
    "version" : "2018-05-29", ## Note the new 2018-05-29 version
    "operation" : "GetItem",
    "key" : {
        "foo" : ... typed value,
        "bar" : ... typed value
    },
    "consistentRead" : true
}
```

And changes the response template as follows:

```
## If there is a datasource invocation error, we choose to raise the same error
#if($ctx.error)
  $util.error($ctx.error.message, $ctx.error.type)
#end

## If the data source invocation is null, we return null.
#if($util.isNull($ctx.result))
  #return
#end

## map table attribute postId to field Post.id
$util.qr($ctx.result.put("id", $ctx.result.get("postId")))

$util.toJson($ctx.result)
```

In the **2017-02-28** version, if the datasource invocation was `null`, meaning there is no item in the DynamoDB table that matches our key, the response mapping template would not execute. It might be fine for most of the cases, but if you expected the `$ctx.result` to not be `null`, you now have to handle that scenario.

2017-02-28

Characteristics

- If the datasource invocation result is `null`, the response mapping template is **not** executed.
- If the datasource invocation yields an error, the response mapping template is executed and the evaluated result is placed inside the GraphQL response `errors.data` block.

Troubleshooting and Common Mistakes

This section discusses some common errors and how to troubleshoot them.

Incorrect DynamoDB Key Mapping

If your GraphQL operation returns the following error message, it may be because your request mapping template structure doesn't match the Amazon DynamoDB key structure:

```
The provided key element does not match the schema (Service: AmazonDynamoDBv2; Status Code:
 400; Error Code
```

For example, if your DynamoDB table has a hash key called `"id"` and your template says `"PostID"`, as in the following example, this results in the preceding error, because `"id"` doesn't match `"PostID"`.

```
{
    "version" : "2017-02-28",
    "operation" : "GetItem",
    "key" : {
        "PostID" : $util.dynamodb.toDynamoDBJson($ctx.args.id)
    }
}
```

Missing Resolver

If you execute a GraphQL operation, such as a query, and get a null response, this may be because you don't have a resolver configured.

For example, if you import a schema that defines a `getCustomer(userId: ID!):` field, and you haven't configured a resolver for this field, then when you execute a query such as `getCustomer(userId:"ID123"){...}`, you'll get a response such as the following:

```
{
    "data": {
    "getCustomer": null
    }
}
```

Mapping Template Errors

If your mapping template isn't properly configured, you'll receive a GraphQL response whose `errorType` is `MappingTemplate`. The `message` field should indicate where the problem is in your mapping template.

For example, if you don't have an `operation` field in your request mapping template, or if the `operation` field name is incorrect, you'll get a response like the following:

```
{
    "data": {
        "searchPosts": null
    },
    "errors": [
        {
        "path": [
            "searchPosts"
        ],
        "errorType": "MappingTemplate",
        "locations": [
            {
            "line": 2,
            "column": 3
            }
        ],
        "message": "Value for field '$[operation]' not found."
        }
    ]
}
```

Incorrect Return Types

The return type from your data source must match the defined type of an object in your schema, otherwise you may see a GraphQL error like:

```
"errors": [
    {
    "path": [
        "posts"
    ],
    "locations": null,
    "message": "Can't resolve value (/posts) : type mismatch error, expected type LIST, got
 OBJECT"
    }
]
```

For example this could occur with the following query definition:

```
type Query {
    posts: [Post]
}
```

Which expects a LIST of `[Posts]` objects. For example if you had a Lambda function in Node.JS with something like the following:

```
const result = { data: data.Items.map(item => { return item ; }) };
callback(err, result);
```

This would throw an error as `result` is an object. You would need to either change the callback to `result.data` or alter your schema to not return a LIST.