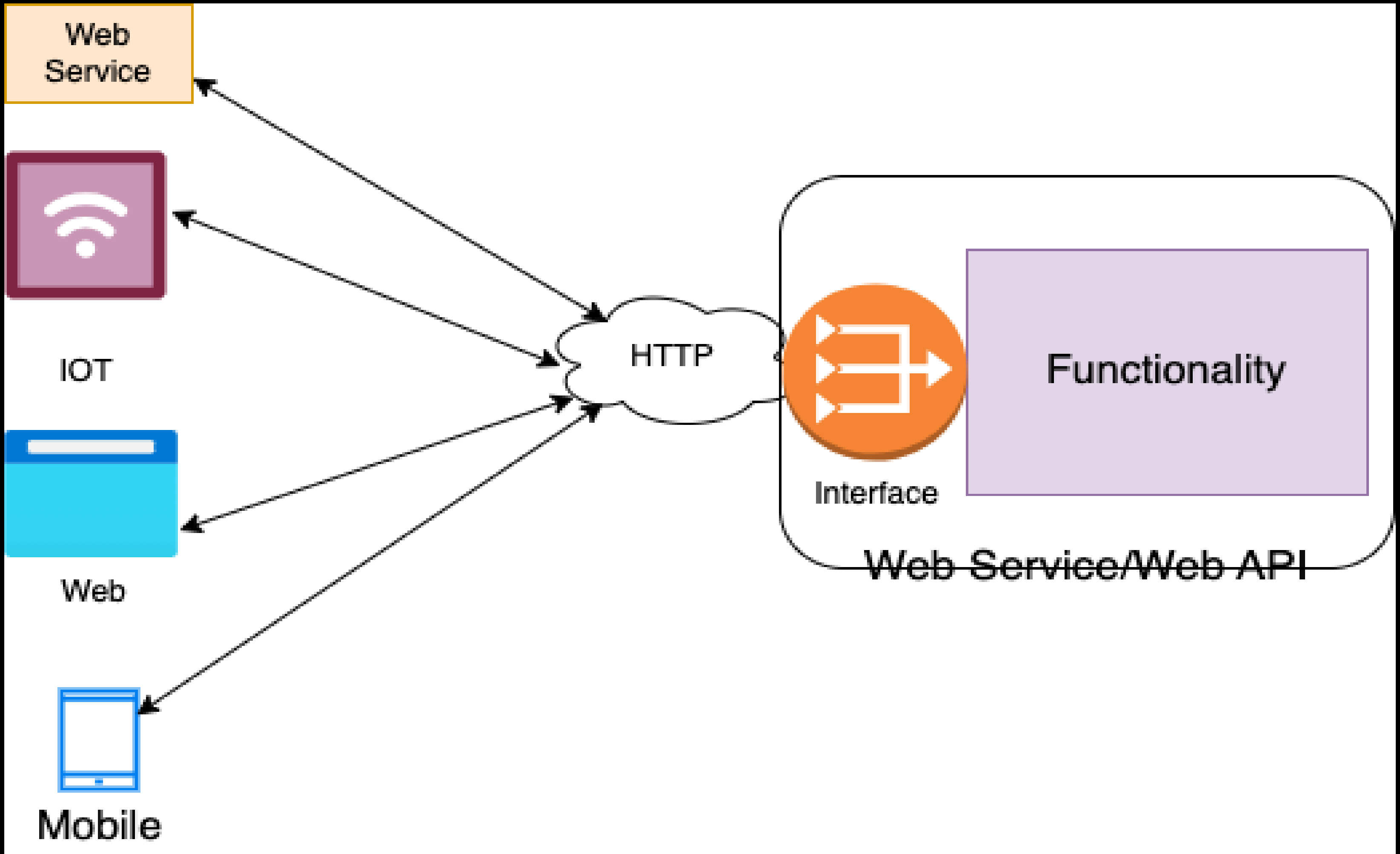
Serverless Web APIs

The AWS-related services

Serverless?

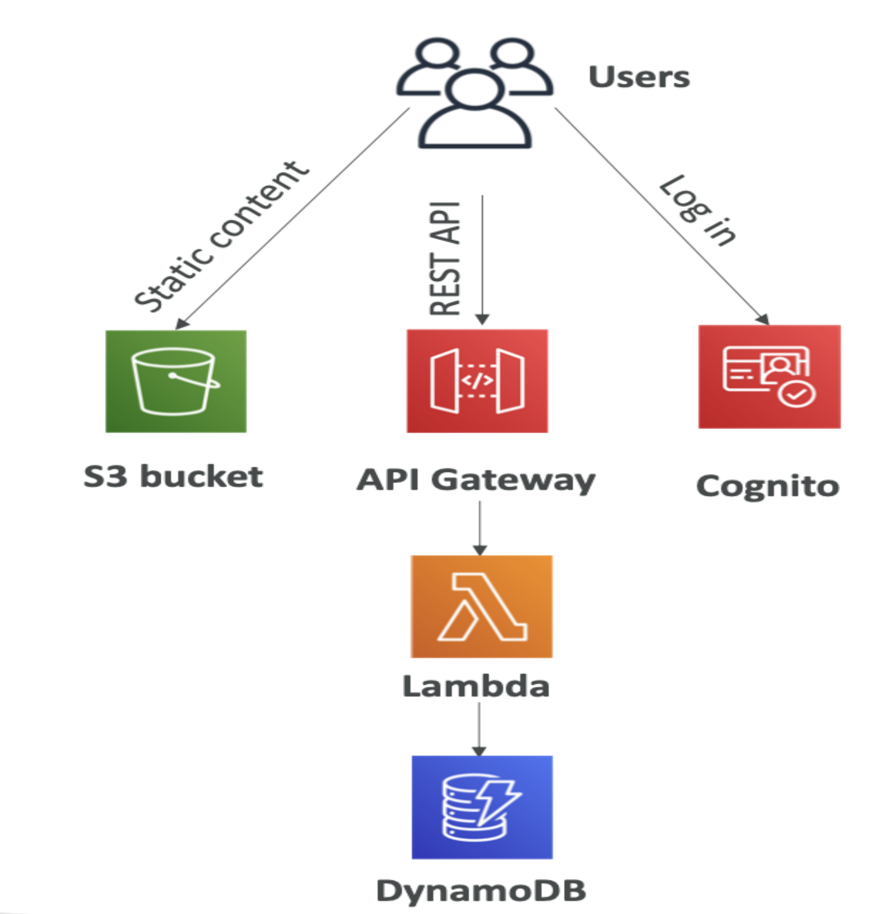
- Serverless relieves the developer of responsibilities:
    1. No servers to provision or manage.
    2. Auto-Scales with usage.
    3. No Up-front cost.
    4. Availability and fault tolerance built-in.

Web APIs?


Web Service
IOT
Web
Mobile
HTTP
Interface
Functionality
Web Service/Web API

Serverless Services on AWS

- AWS Lambda. (Compute)
- DynamoDB. (NoSQL?)
- AWS Cognito. (User Accounts Mgt.)
- API Gateway (HTTP/REST endpoints)
- S3 (Storage)
- SNS & SQS. (Messaging)
- Aurora Serverless (RDB)
- Step Functions (Orchestration)
- Fargate (Containers)
- And more …



AWS Lambda Service

Serverless Compute

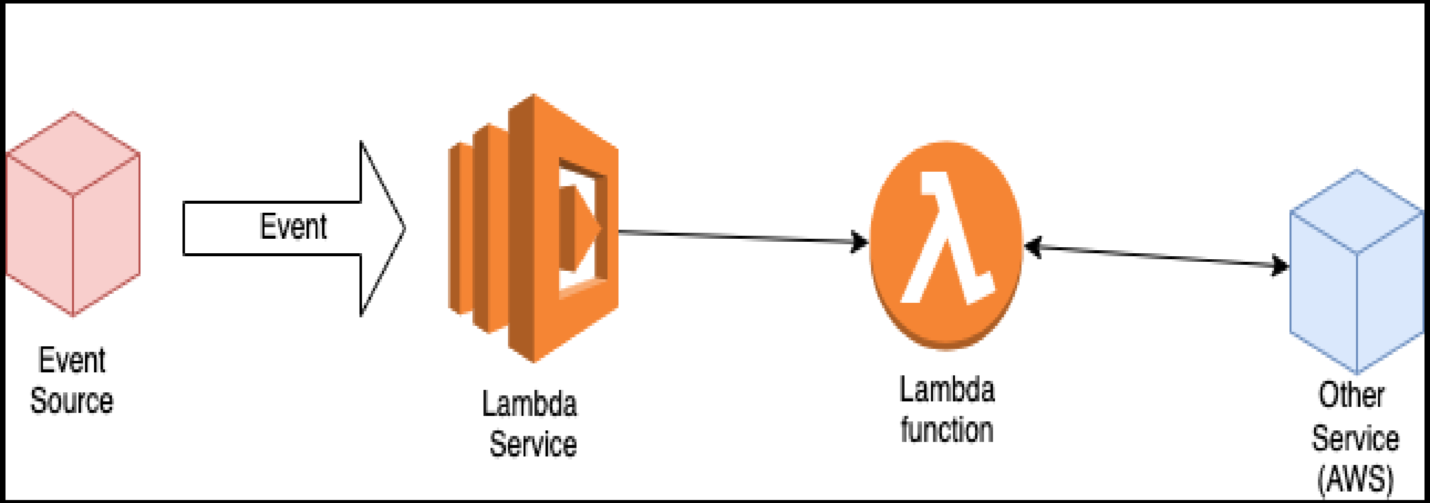
AWS Lambda

- The Lambda Service is an event-driven, serverless computing platform.
- It runs code (a function) in response to events.
- It manages the computing resources (CPU, memory, networking) required by that code.

- “Custom code that runs in an ephemeral container” Mike Robins

- FaaS (Functions as a Service)
  - Preceded by IaaS, PaaS, SaaS.

Lambda runtime model.



- Event Source (Trigger), e.g. HTTP request; Data state change, e.g. database, S3; Resource state change, e.g. EC2 instance.

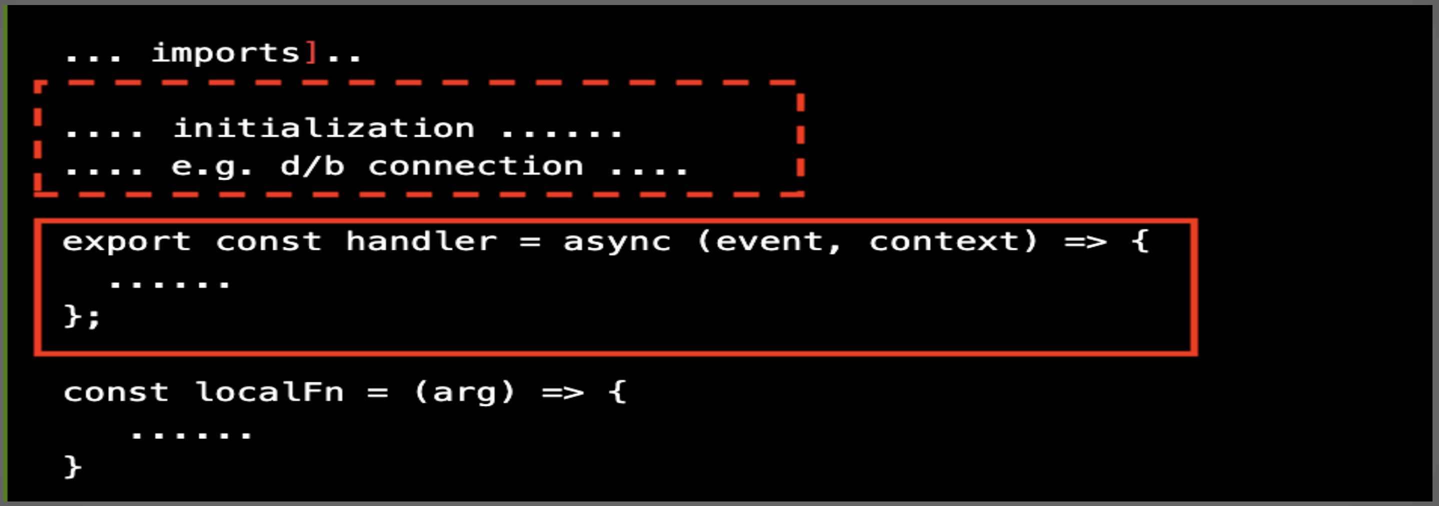
- Lambda function: Python, Node, Java, Go, C#, etc.

AWS Lambda service

- The Lambda service manages:
  1. Auto scaling (horizontal)
  2. Load balancing.
  3. OS maintenance.
  4. Security isolation.
  5. Utilization (Memory, CPU, Networking)

- Characteristics:
  1. Function as a unit of scale.
  2. Function as a unit of deployment.
  3. Stateless nature.
  4. Limited by time - short executions.
  5. Run on-demand.
  6. Pay per execution and compute time – generous free tier.
  7. Do not pay for idle time.

Anatomy of a Lambda function



```
... imports]..

.... initialization ......
.... e.g. d/b connection ....

export const handler = async (event, context) => {
  ......
};

const localFn = (arg) => {
   ......
}
```

- handler() – function to be executed upon invocation.
- Event object – the payload and metadata provided by the event source.
- Context object – access to runtime information.
- Initialization code executes before the handler for Cold starts only.

Lambda function configuration

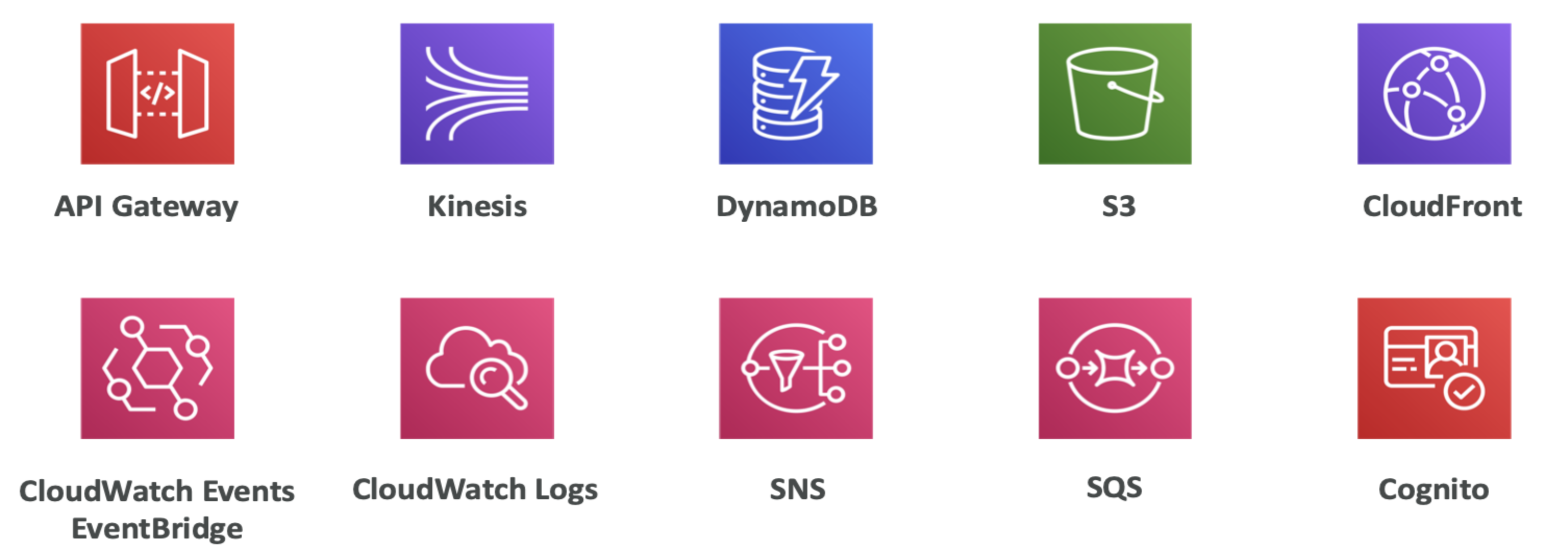
- Lambda service provides a memory control to configure a function’s compute power requirements.
  - The % of CPU core and network capacity are computed in proportion to its RAM.
- RAM:
  - From 128MB to 3,008 MB in 64 MB increments
  - The more RAM you add, the more vCPU credits you get.
    - 1,792 MB RAM allocation → one full vCPU reserved.
    - After 1,792 MB → more than one CPU assigned → should use multi-threading to fully utilize.
- For CPU-bound processing, increase the RAM allocation.
- Timeout setting: Max. runtime allowed.
  - Default 3 seconds; maximum 900 seconds (15 minutes).

Demo

- Objective:
    - Use the CDK to provision a ‘Hello World’ (Typescript/Node) lambda function.
    - Invok it (trigger it) using the AWS CLI.
    - Check console.log() statement output in the CloudWatch Logs.

Lambda integration

- What services can trigger a lambda function?

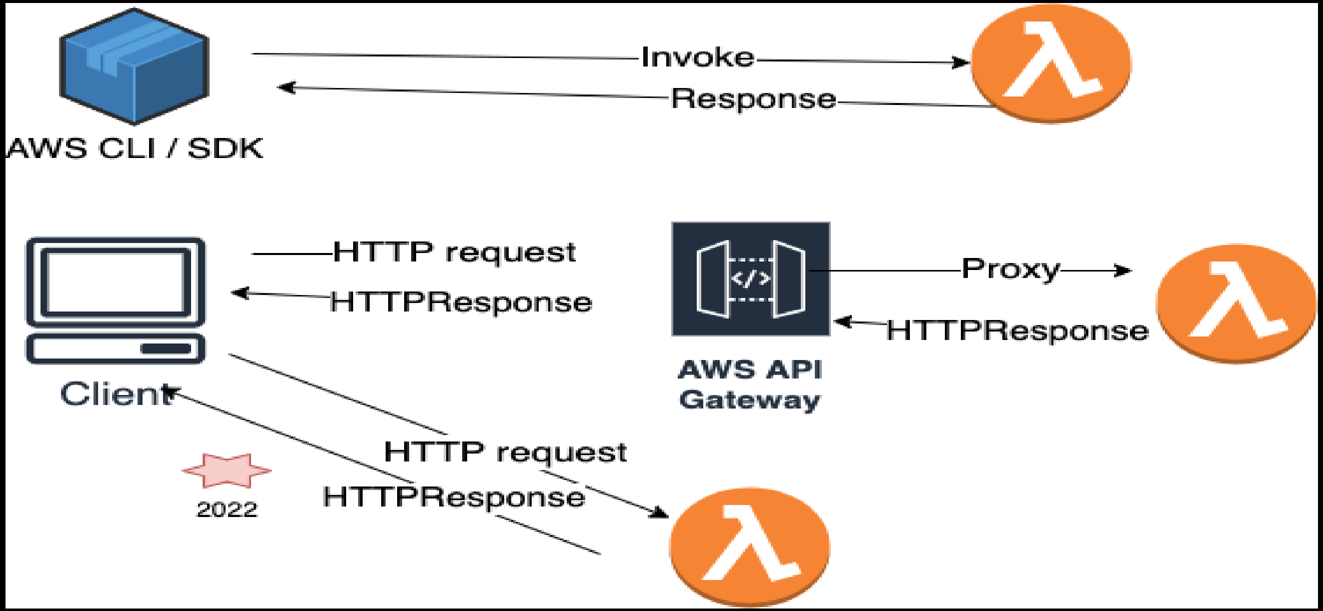


- Integration models:

  1. Synchronous. 2. Asynchronous. 3. Poll-based

Synchronous Integration

- Client (Event source) waits for the response, i.e. synchronous.
- Trigger (Event Source) options: CLI, SDK, API Gateway, Load Balancers, Function URLs.
- Client should handle error responses (retries, exponential backoff, etc.)

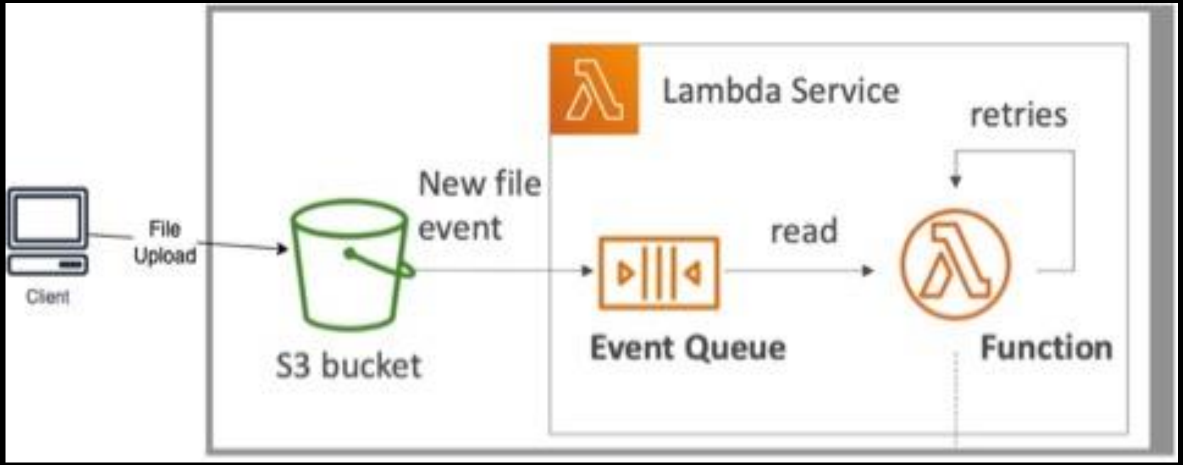


Demo

- Objective:
    - Use the CDK to:
        1. Provision a lambda function.
        2. Get the Lambda service to generate a URL endpoint.
    - Test the URL with the Postman HTTP client.
    - Configure the endpoint as private.

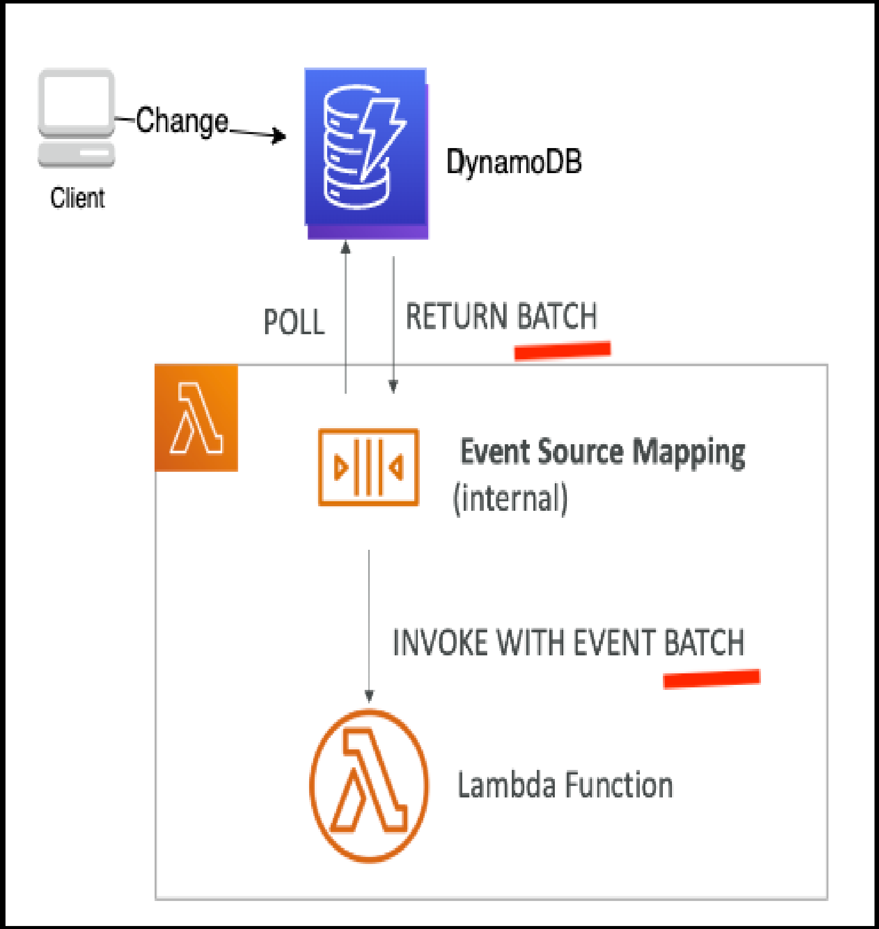
Asynchronous Integration.

- Trigger (Event Source): S3, SNS, CloudWatch.
- Lambda service places the events in an internal queue.
- Lambda service retries on errors – 3 retries, using exponential backoff algorithm.
- Function's processing should be idempotent (due to retries)
- Suitable when the client does not require the function result immediately.



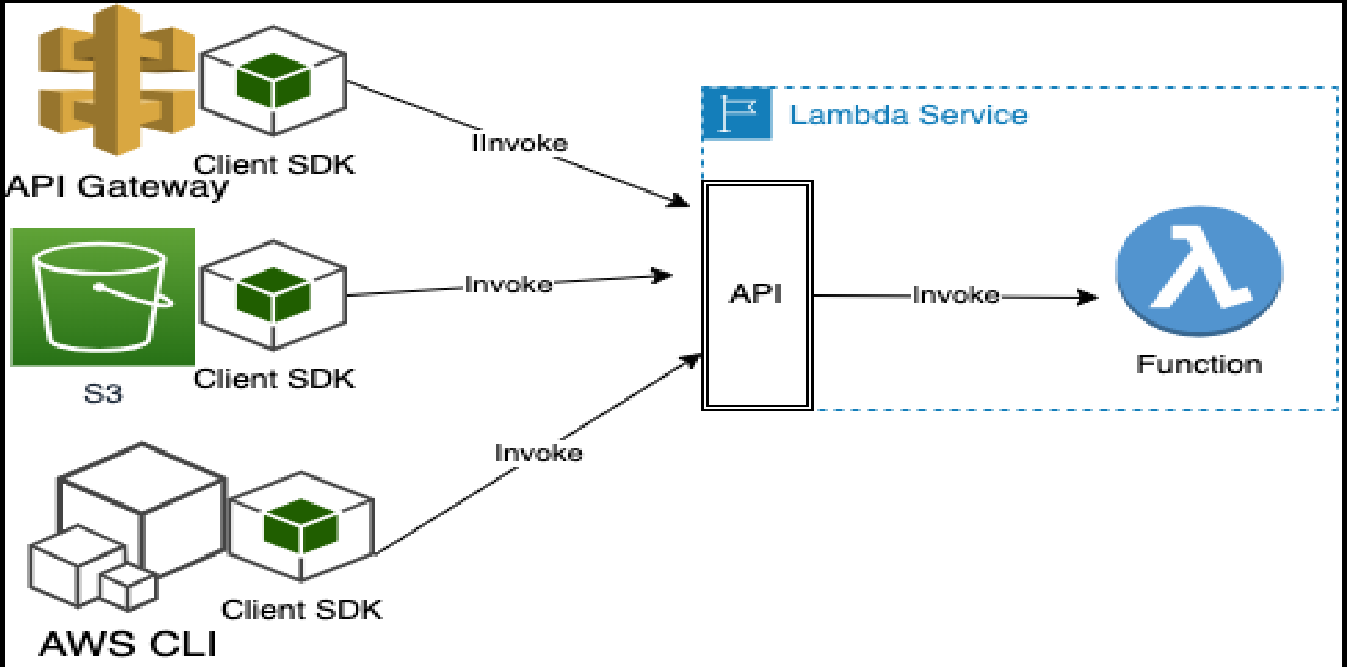
Event source mapping. (Poll-based Integration)

- Event Sources/Trigger: DynamoDB streams, SQS, Kinesis streams.
- Lambda service <u>polls</u> the source for event records.
- Lambda service invokes the function synchronously.



Lambda service API & SDK

- Lambda Service provides an API.
- Used by all other services that trigger Lambda functions across all integration models.
- Can pass any event payload structure you want.



Execution Role (IAM Role)

- Grants the lambda function permissions to access specified AWS services / resources.
- Many predefined / Managed policies, e.g.
  - AWSLambdaBasicExecutionRole – Upload logs to CloudWatch.
  - AWSLambdaDynamoDBExecutionRole – Read from DynamoDB Streams.
  - AWSLambdaSQSQueueExecutionRole – Read from SQS queue
  - AWSLambdaVPCAccessExecutionRole – Deploy function in VPC.

- Best practice: Create one Execution Role per function.

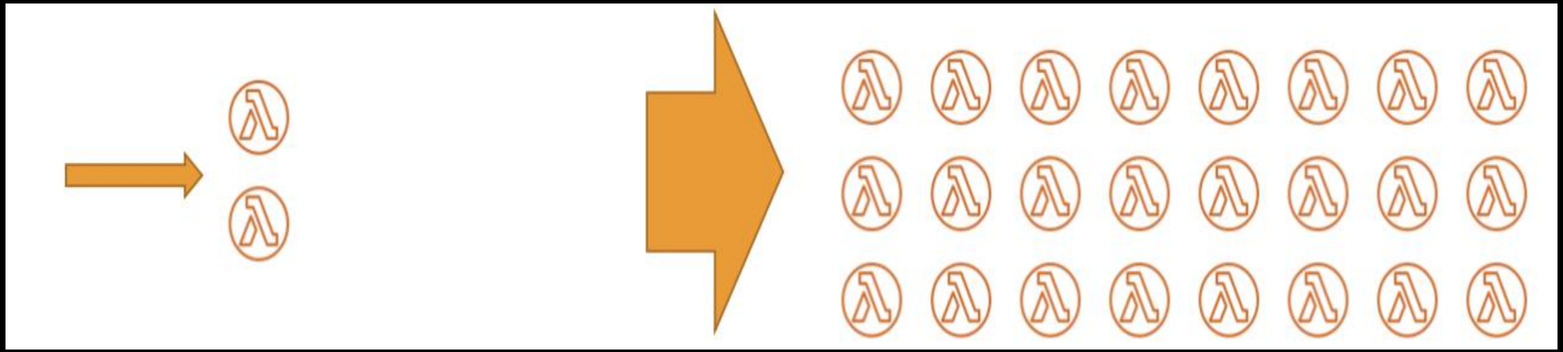
Resource based Policies.

- Use resource-based policies to give other AWS services (and accounts) permission to use your Lambda resource/function.

- An IAM principal (e.g. user, service) can access a Lambda resource if:
  - The IAM policy attached to the principal authorizes it, or
  - The function’s resource-based policy authorizes it.

- Ex. An AWS S3 service can trigger a Lambda function if the function’s resource-based policy permits it.

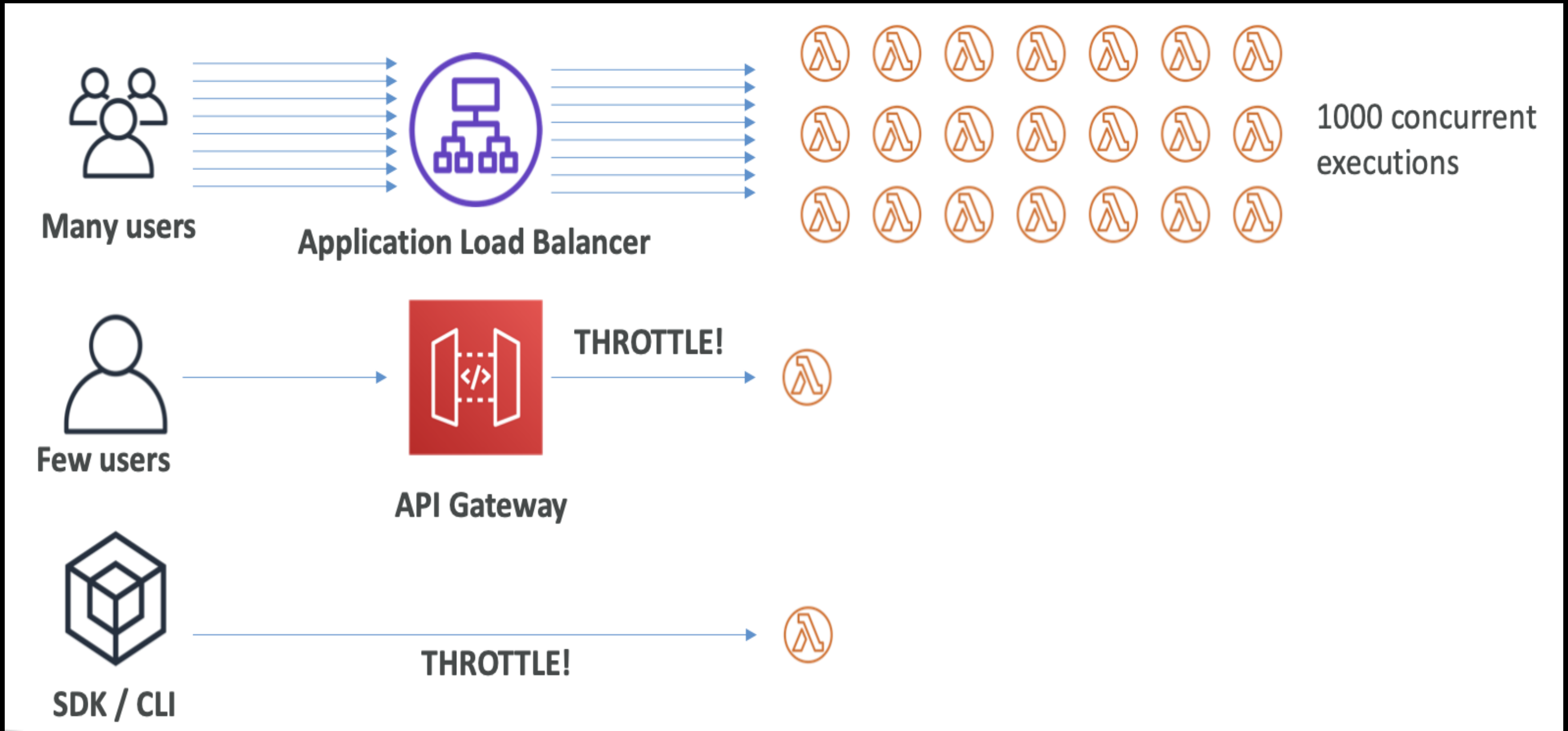
Concurrency and Throttling



- AWS account lambda concurrency limit is set to 1000 executions.
- Can set a reserved concurrency at the function level (= limit).
  - “Throttle” error response when limit is exceeded.
- Throttle behavior:
  - Synchronous invocation: Return ThrottleError (HTTP status 429)
  - Asynchronous invocation: retry automatically and then go to a DLQ (Dead Letter Queue).

Concurrency issues

- Use reserved concurrency to avoid the following:



Cold Starts & Provisioned Concurrency.

- Cold Start:
  - Source Event → New micro VM instance created → function's initialization code executes → handler code executes
- Warm start: Micro VM reused; Init code not executed.
- Problem: Lengthy init code (LoC, dependencies, SDK) effects overall event processing time.
  - Greater latency with cold start executions.
- Solution – Use Provisioned Concurrency:
  - Micro VMs are pre-allocated in advance; Init code executed during pre-allocation.
  - Cold starts avoided (or minimized)
  - Lower latency on average.

AWS DynamoDB Service

Serverless NoSQL Database

Features

- NoSQL database - not a relational database.
- Fully Managed (Serverless), Highly available with replication across 3 AZ.
- Schema-less.
    - Records in the same table can have different attributes.
- No support for joins.
    - Consider denormalization instead.
- Integrated with IAM for security, authorization and administration.
- Supports event driven application architecture via DynamoDB Streams

DynamoDB Basics

- A DynamoDB database is made up of tables.
- Each table has a primary key (must be decided at creation time).
- A table’s entries are termed items (= rows/records).
- Each item has attributes.
  - Schema-less - can be added over time; can be null.
  - Primary key attribute(s) declared at creation-time.
  - Maximum size of an item is 400 KB.

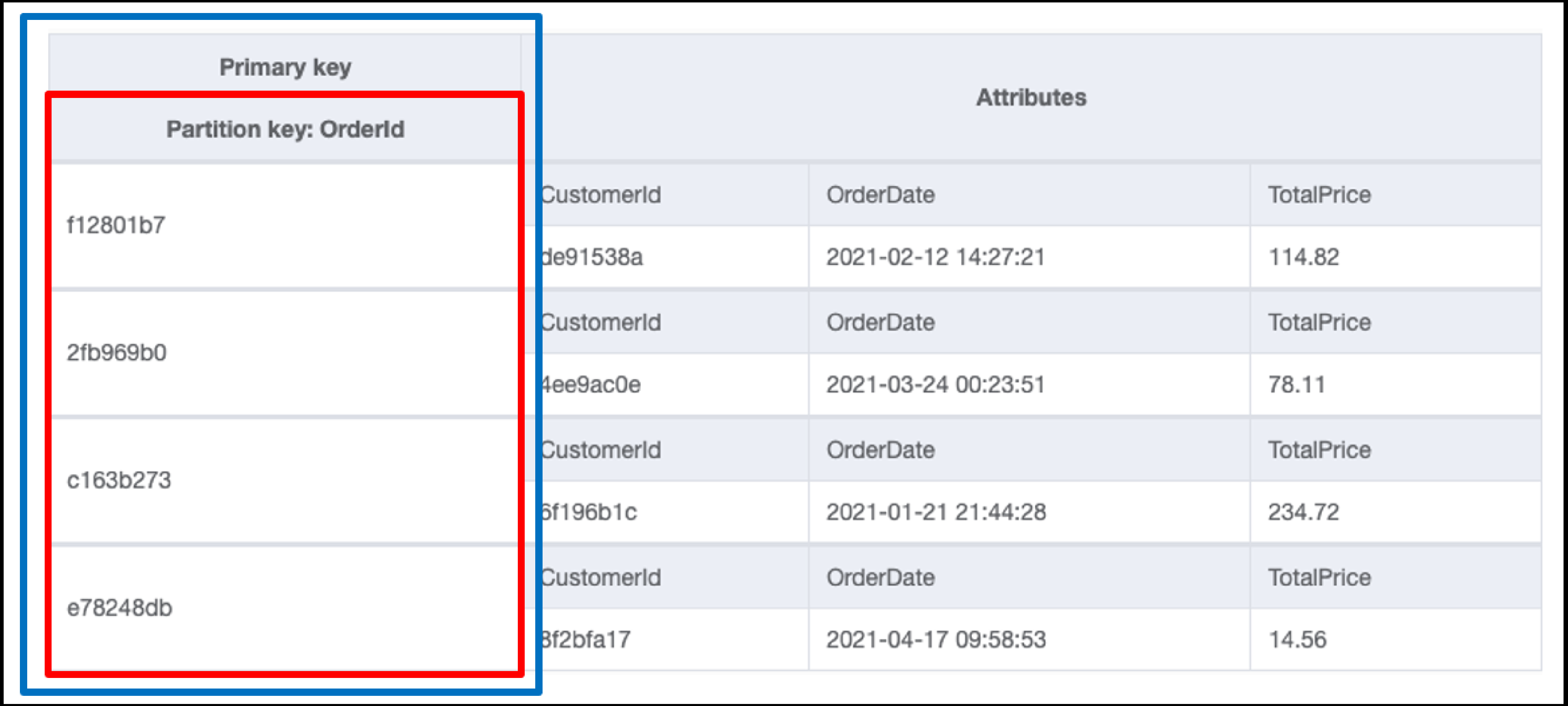
- Data types supported are:
  - Scalar Types: String, Number, Binary, Boolean, Null.
  - Document Types: List, Map.
  - Set Types: String Set, Number Set, Binary Set.

The Primary Key

- Option 1: Simple - Partition key (Hash key) only.
  - Partition key must be unique for each item.
  - Partition key value range must be “diverse” to ensure data is distributed evenly.
  - Example: user_id for a users table.

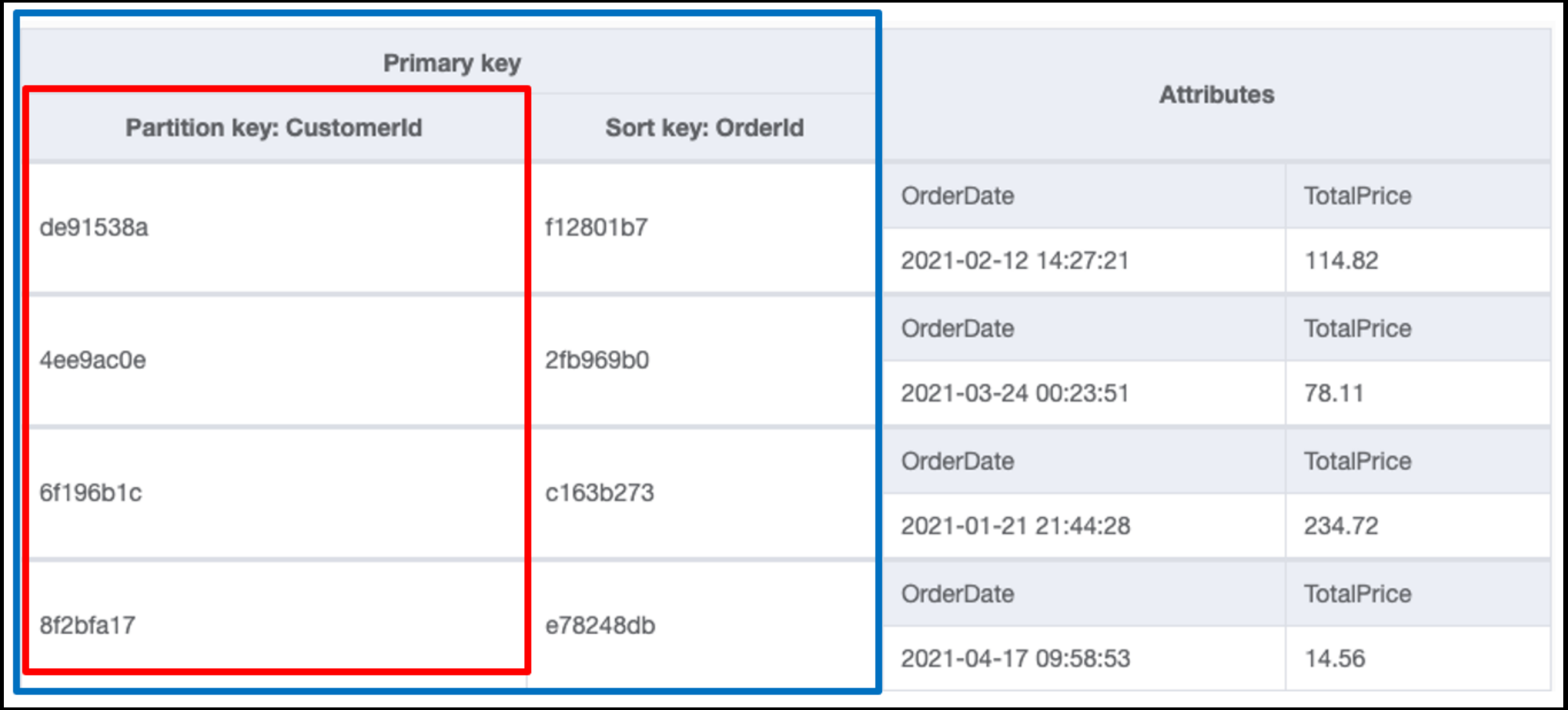
- Option 2: Composite - Partition key + Sort Key (Range key).
  - The combination must be unique.
  - Results in item collections within a table:
    - grouped by partition key. and
    - ordered by the sort key.
  - Example: users-games table (Games played by users)
    - user_id (Partition key) + game_id (Sort key).

Simple Primary key example



Primary key	Attributes		
Partition key: OrderId			
f12801b7	CustomerId	OrderDate	TotalPrice
	de91538a	2021-02-12 14:27:21	114.82
2fb969b0	CustomerId	OrderDate	TotalPrice
	4ee9ac0e	2021-03-24 00:23:51	78.11
c163b273	CustomerId	OrderDate	TotalPrice
	6f196b1c	2021-01-21 21:44:28	234.72
e78248db	CustomerId	OrderDate	TotalPrice
	8f2bfa17	2021-04-17 09:58:53	14.56

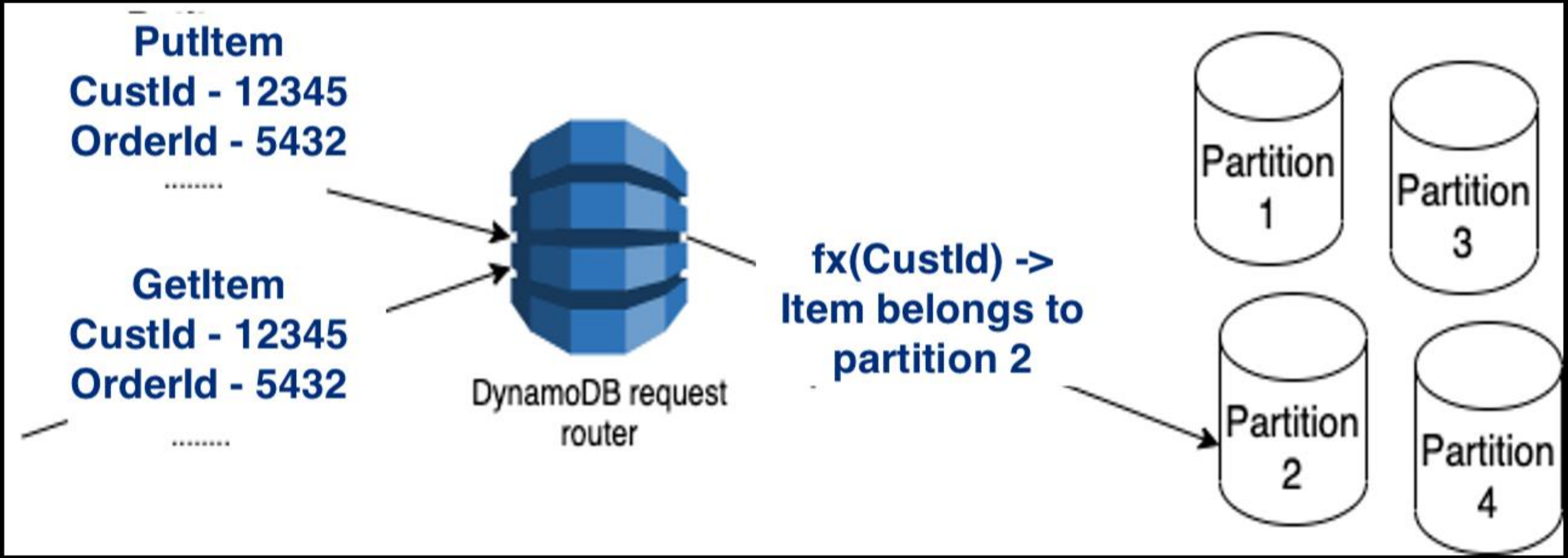
Composite Primary key example



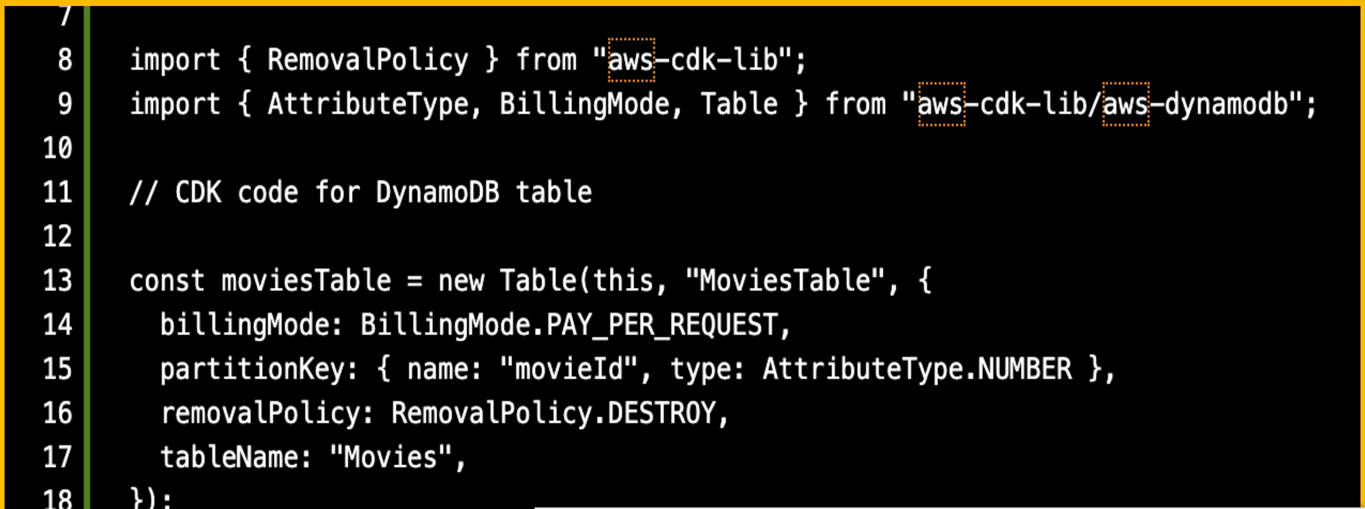
Primary key		Attributes	
Partition key: CustomerId	Sort key: OrderId		
de91538a	f12801b7	OrderDate	TotalPrice
		2021-02-12 14:27:21	114.82
4ee9ac0e	2fb969b0	OrderDate	TotalPrice
		2021-03-24 00:23:51	78.11
6f196b1c	c163b273	OrderDate	TotalPrice
		2021-01-21 21:44:28	234.72
8f2bfa17	e78248db	OrderDate	TotalPrice
		2021-04-17 09:58:53	14.56

Horizontal Scaling

- Data is distributed across a fleet of computers, where a single node holds a subset of a table's data, called 'partitions’ (max. 10GB).
- Adv – Scalability; Consistent performance.



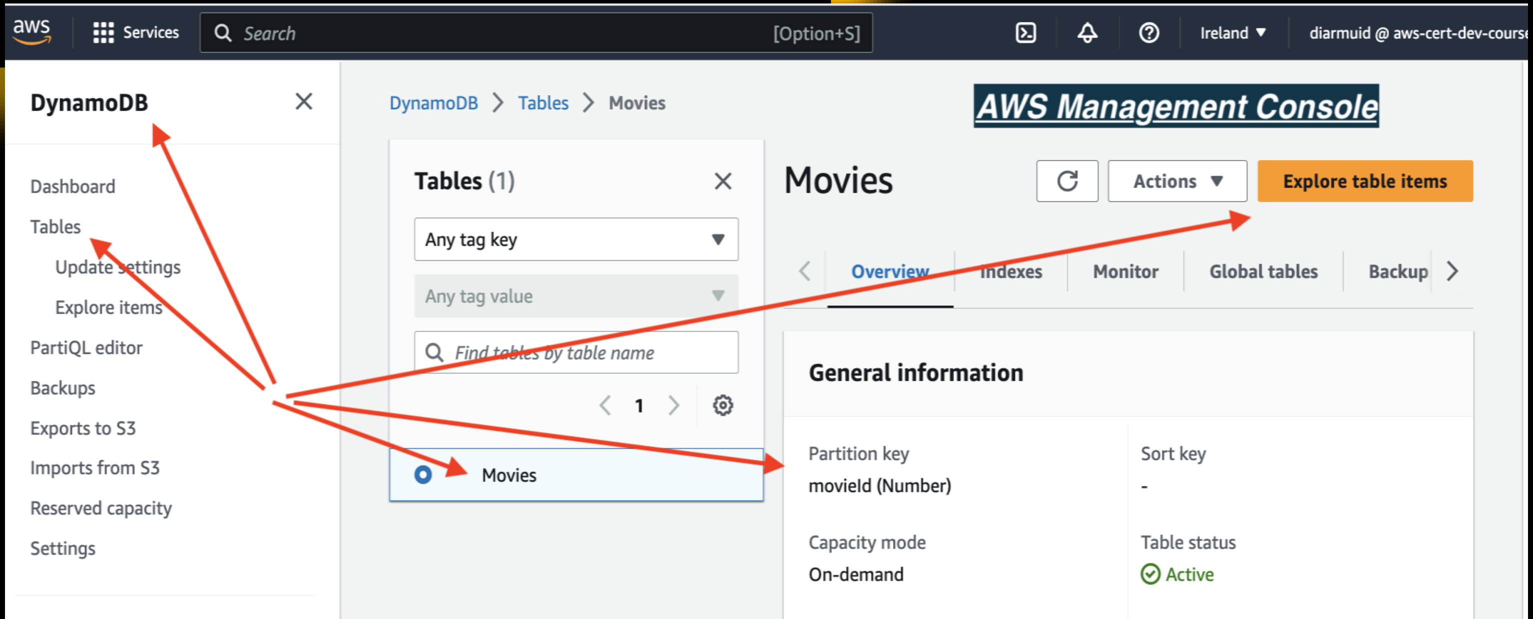
CDK Table Declaration



```
import { RemovalPolicy } from "aws-cdk-lib";
import { AttributeType, BillingMode, Table } from "aws-cdk-lib/aws-dynamodb";

// CDK code for DynamoDB table

const moviesTable = new Table(this, "MoviesTable", {
  billingMode: BillingMode.PAY_PER_REQUEST,
  partitionKey: { name: "movieId", type: AttributeType.NUMBER },
  removalPolicy: RemovalPolicy.DESTROY,
  tableName: "Movies",
});
```



AWS Management Console

Movies

General information

Partition key: movieId (Number)

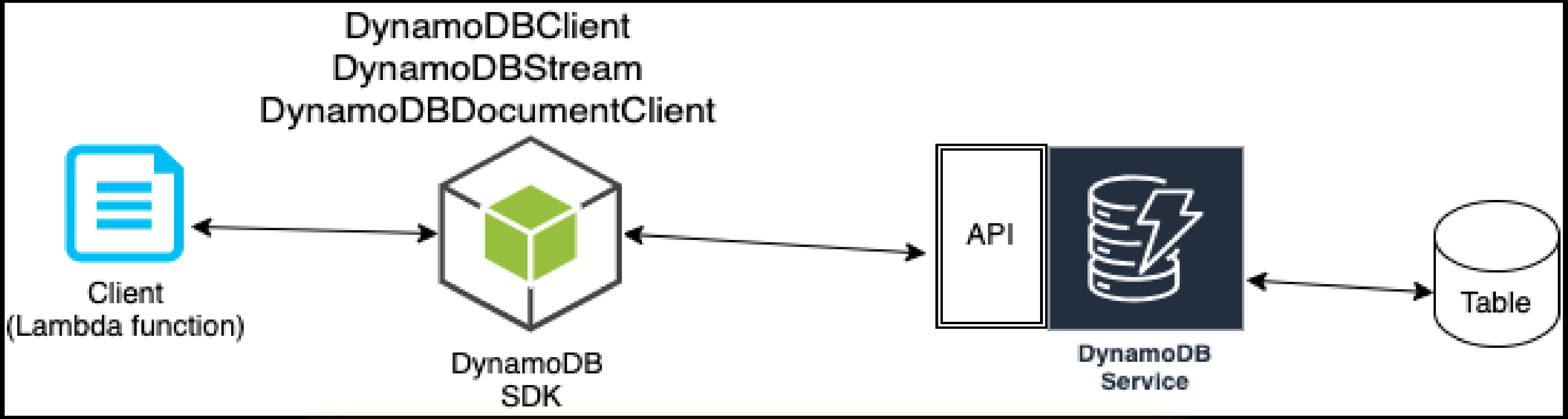
Sort key: -

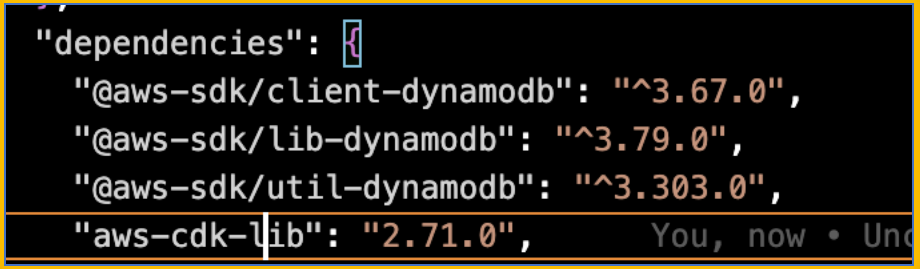
Capacity mode: On-demand

Table status: ✓ Active

DynamoDB API & SDK

- The SDK provides three classes for client interaction:
  - DynamoDBClient, DynamoDBStreams, and DynamoDBDocumentClient.





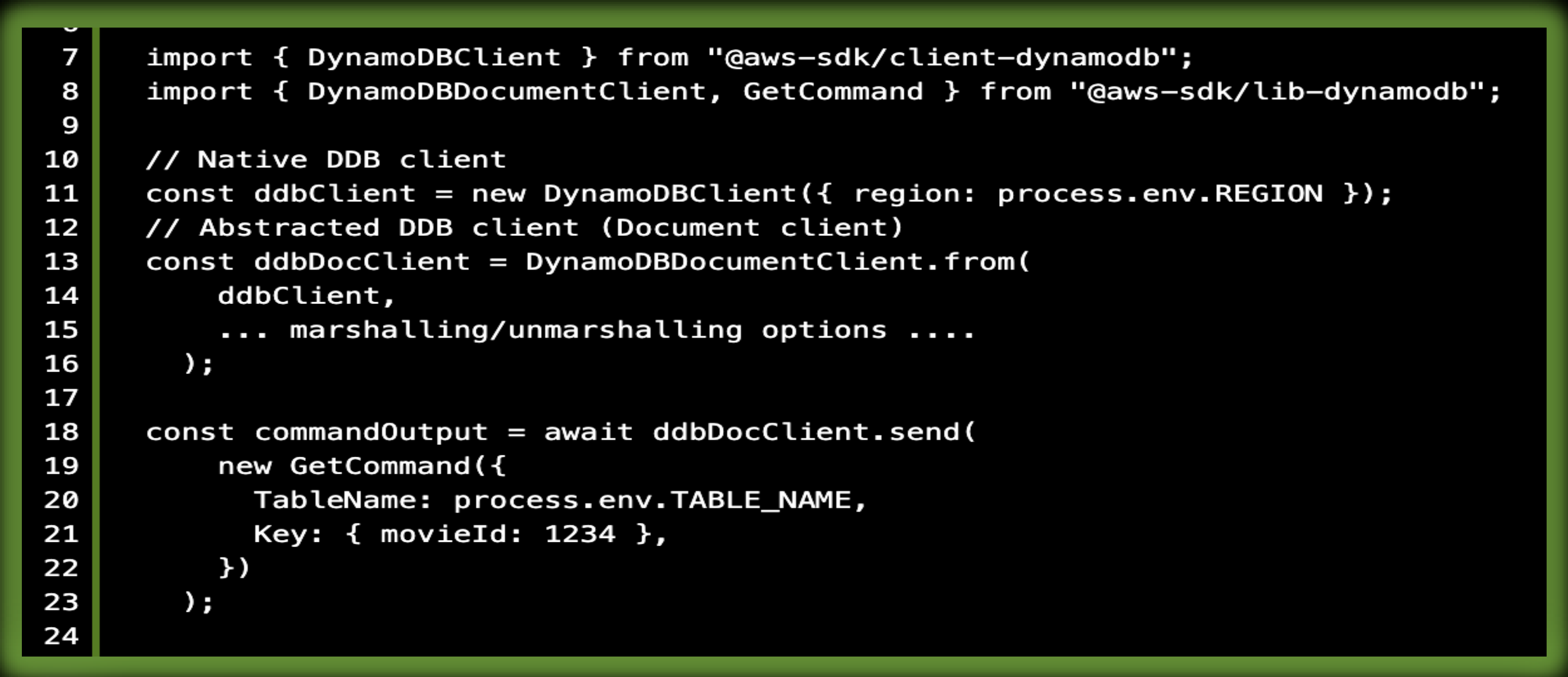
```
"dependencies": {
  "@aws-sdk/client-dynamodb": "^3.67.0",
  "@aws-sdk/lib-dynamodb": "^3.79.0",
  "@aws-sdk/util-dynamodb": "^3.303.0",
  "aws-cdk-lib": "2.71.0",       You, now • Unc
```

DynamoDB API

- Three types of DB read actions:

1. Single-item requests - acts on a single, specific table item and requires the full primary key.
   - PutItem, GetItem, UpdateItem, DeleteItem.
2. Query - reads a range/collection of item, all with the same partition key.
   - Only suitable for tables with composite primary key. ***
   - Query result are always from the same partition (item collection).
3. Scan - reads a set of items, but searches across the entire table; an inefficient operation.

Sample Lambda Code



```
import { DynamoDBClient } from "@aws-sdk/client-dynamodb";
import { DynamoDBDocumentClient, GetCommand } from "@aws-sdk/lib-dynamodb";

// Native DDB client
const ddbClient = new DynamoDBClient({ region: process.env.REGION });
// Abstracted DDB client (Document client)
const ddbDocClient = DynamoDBDocumentClient.from(
    ddbClient,
    ... marshalling/unmarshalling options ....
  );

const commandOutput = await ddbDocClient.send(
    new GetCommand({
      TableName: process.env.TABLE_NAME,
      Key: { movieId: 1234 },
    })
  );
```

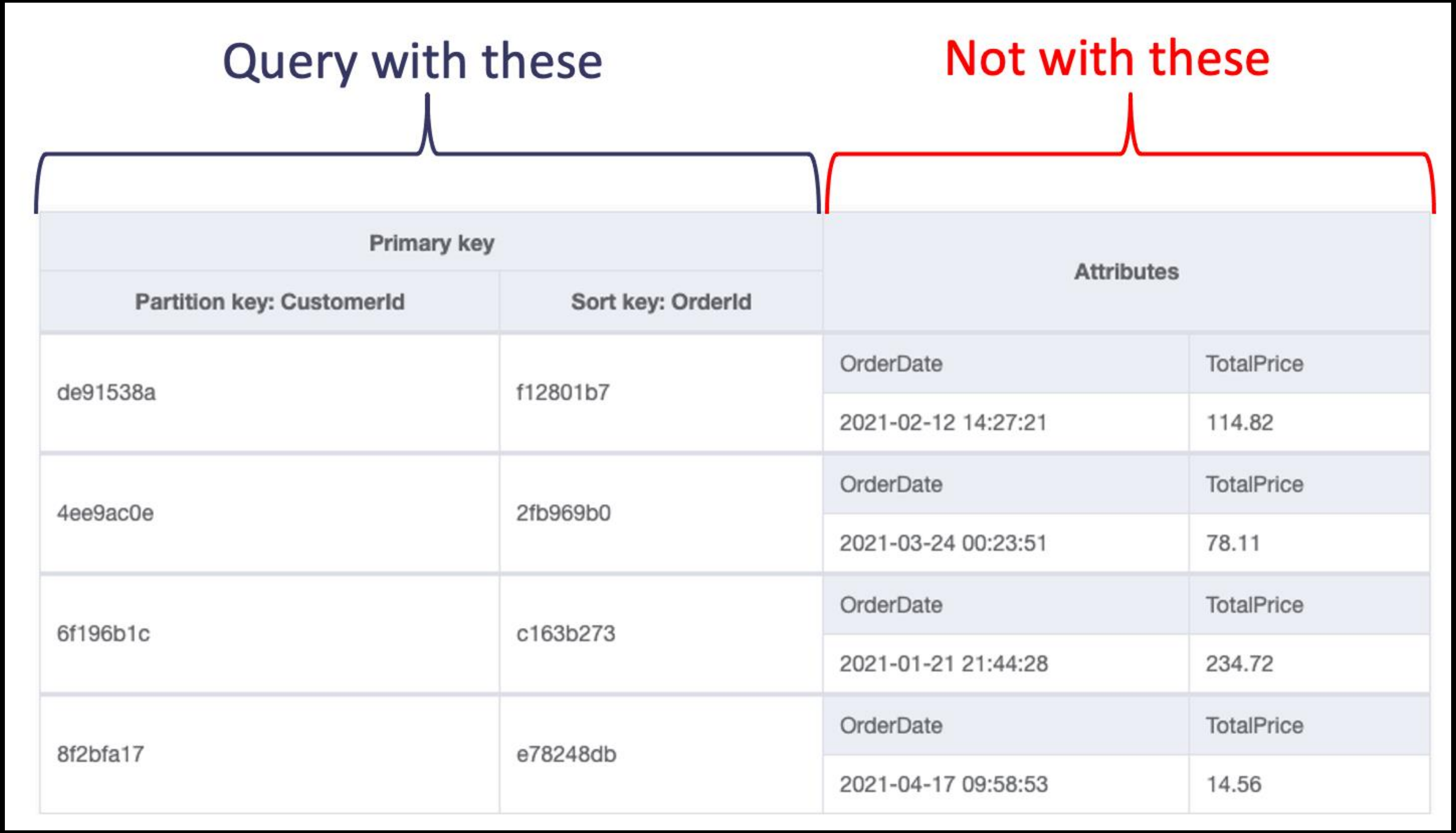
- Marshalling and Unmarshalling Data – Our code uses JS/TS types instead of DynamoDB's native AttributeValue types.
  - JS objects are marshalled into AttributeValue shapes for DB write operations.
  - Responses from DDB are unmarshalled into plain JS objects.

Query actions

- Query requests return items based on:
  - Partition Key (equals (=) operator only)

    + Sort Key (=, <, <=, >, >=, Between, BeginsWith) – optional.
- Can include a <u>Filter Expression</u> for further filtering (performed on the client side!!).
- Query response:
  - Up to 1MB of data, or
  - Use a Limit parameter to reduce response size.
- Supports Pagination response.

Query actions



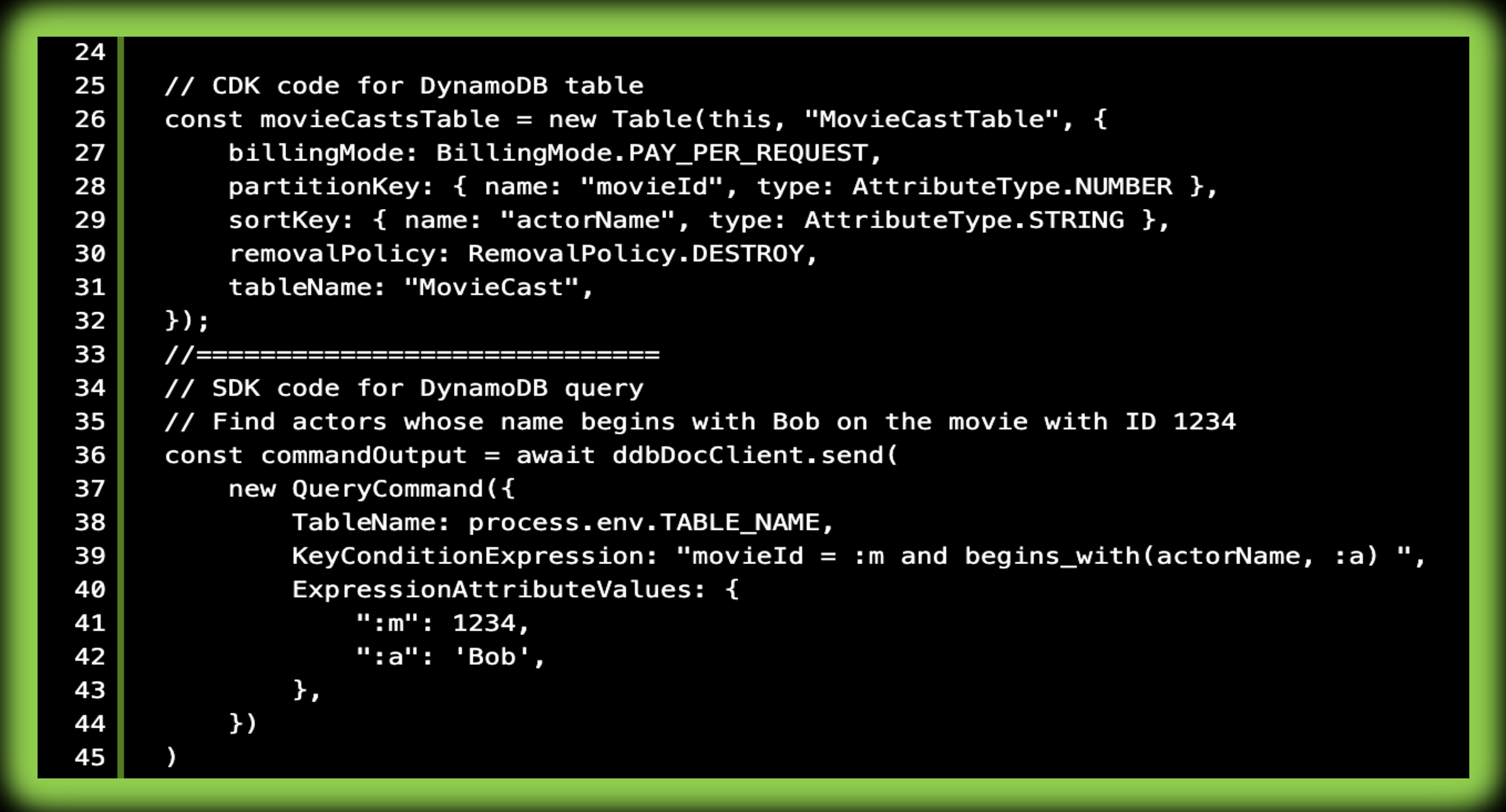
Query with these

Not with these

Primary key		Attributes	
Partition key: CustomerId	Sort key: OrderId		
de91538a	f12801b7	OrderDate	TotalPrice
		2021-02-12 14:27:21	114.82
4ee9ac0e	2fb969b0	OrderDate	TotalPrice
		2021-03-24 00:23:51	78.11
6f196b1c	c163b273	OrderDate	TotalPrice
		2021-01-21 21:44:28	234.72
8f2bfa17	e78248db	OrderDate	TotalPrice
		2021-04-17 09:58:53	14.56

Query Example

- A table stores the movie cast data, with one item per cast member.

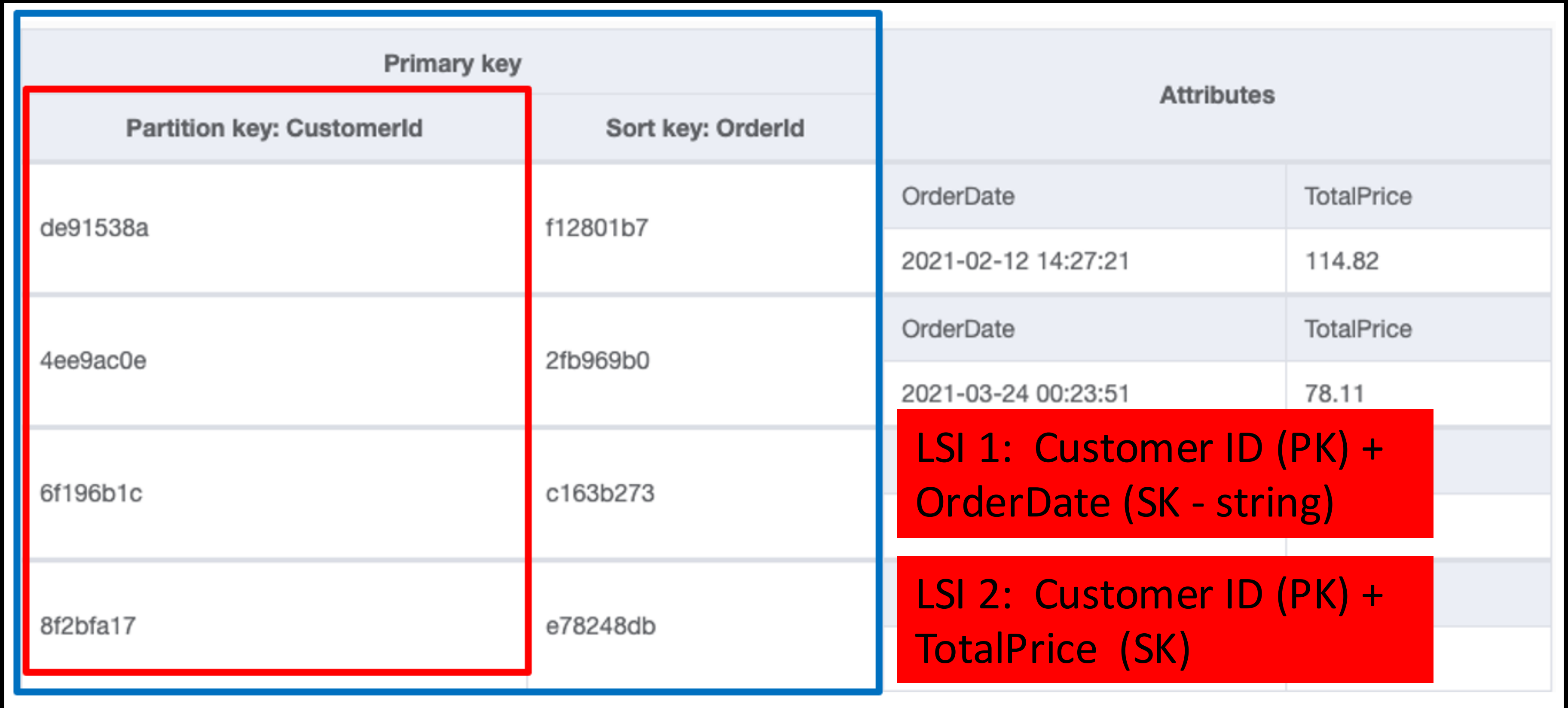


```
// CDK code for DynamoDB table
const movieCastsTable = new Table(this, "MovieCastTable", {
    billingMode: BillingMode.PAY_PER_REQUEST,
    partitionKey: { name: "movieId", type: AttributeType.NUMBER },
    sortKey: { name: "actorName", type: AttributeType.STRING },
    removalPolicy: RemovalPolicy.DESTROY,
    tableName: "MovieCast",
});
//=============================
// SDK code for DynamoDB query
// Find actors whose name begins with Bob on the movie with ID 1234
const commandOutput = await ddbDocClient.send(
    new QueryCommand({
        TableName: process.env.TABLE_NAME,
        KeyConditionExpression: "movieId = :m and begins_with(actorName, :a) ",
        ExpressionAttributeValues: {
            ":m": 1234,
            ":a": 'Bob',
        },
    })
)
```

Local Secondary Index (LSI)

- Only apply to table’s with composite primary key.
- LSIs are based on an alternate sort key attribute.
- LSIs are stored local to the partition key.
- Max of five LSIs per table.
- Used with Query actions.
- The attribute chosen for LSI sort key must be a scalar String, Number, or Binary.
- LSI must be defined at table creation time.
- Each LSI entry is a projection of the table item.
- A table has: (1) A primary/main index (2) (optionl) multiple LSIs + (optional) multiple GSIs (Global secondary indices)

LSI example



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Partition key: CustomerId	Sort key: OrderId		
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4ee9ac0e	2fb969b0	OrderDate 2021-03-24 00:23:51	TotalPrice 78.11
6f196b1c	c163b273		
8f2bfa17	e78248db		

LSI 1: Customer ID (PK) + OrderDate (SK - string)

LSI 2: Customer ID (PK) + TotalPrice (SK)

LSI example

- Sample Query:
- LSI 1
  - Get orders for customer 1234 with a date that begins with 2021.
  - Get orders for customer 1234 with a date that begins with 2021-06.
- LSI 2
  - Get orders for customer 1234 with a total price < 100.
  - Get orders for customer 1234 with a total price >= 200.

Information

- Watch https://www.youtube.com/watch?v=ErPrf74RUDY