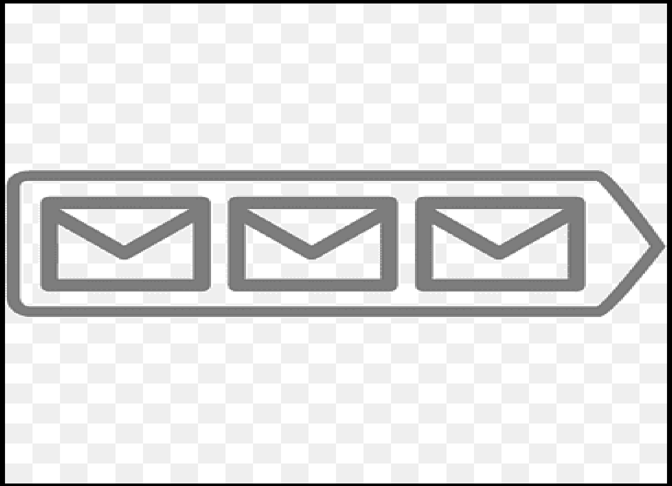
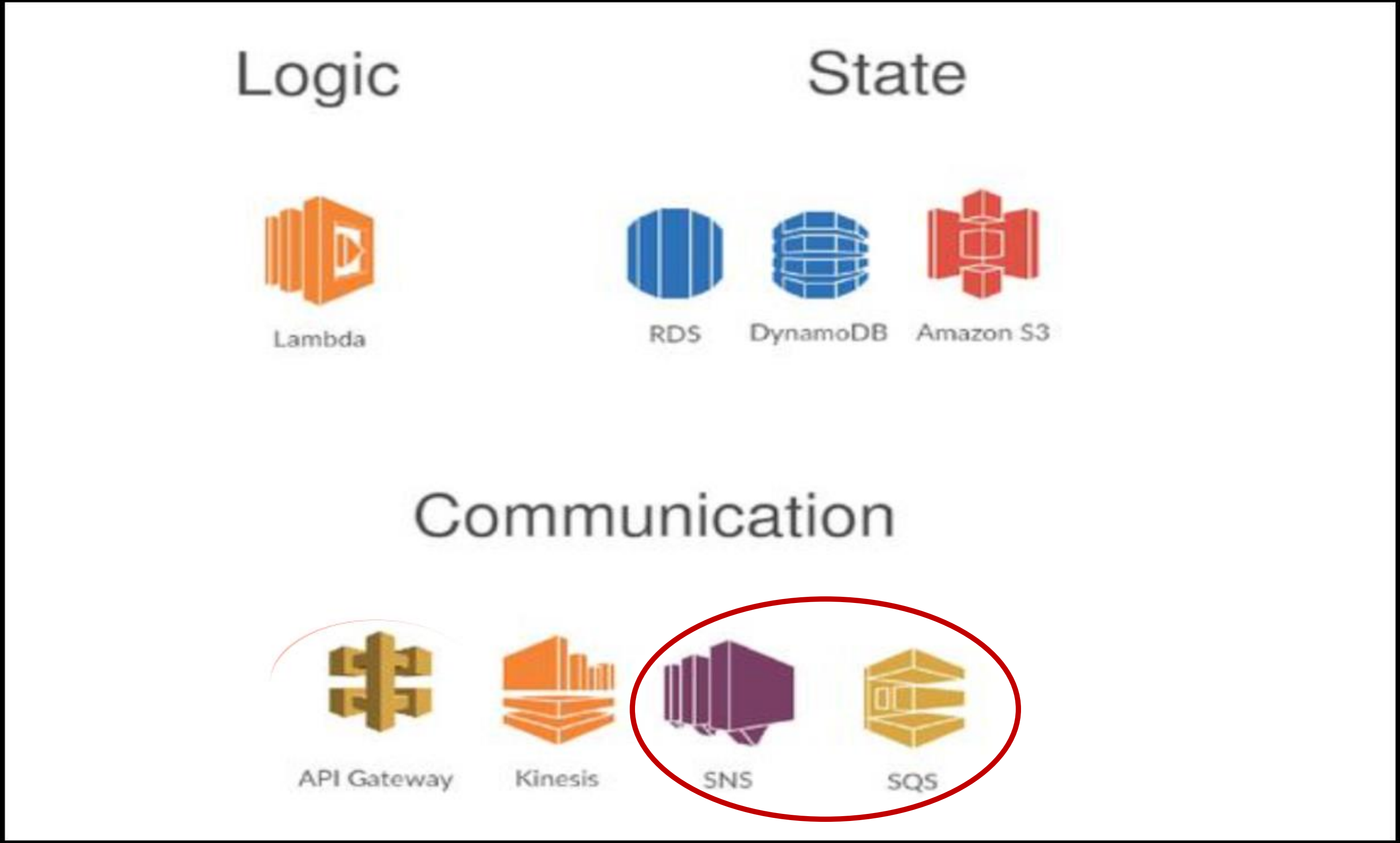
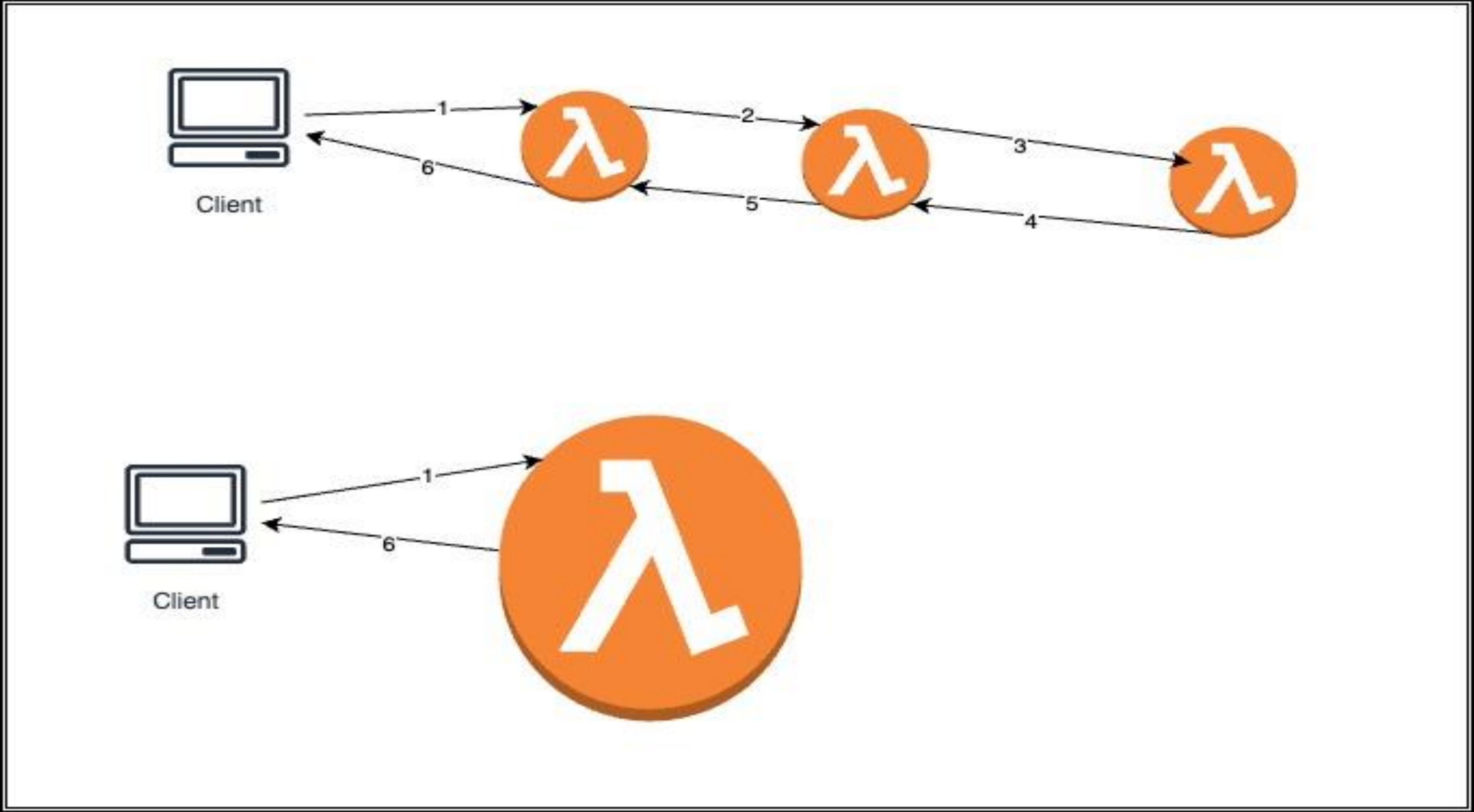


AWS Integration and Messaging Services.

Components of a Serverless, Message-Driven application
(aka Event Driven Architecture - EDA)



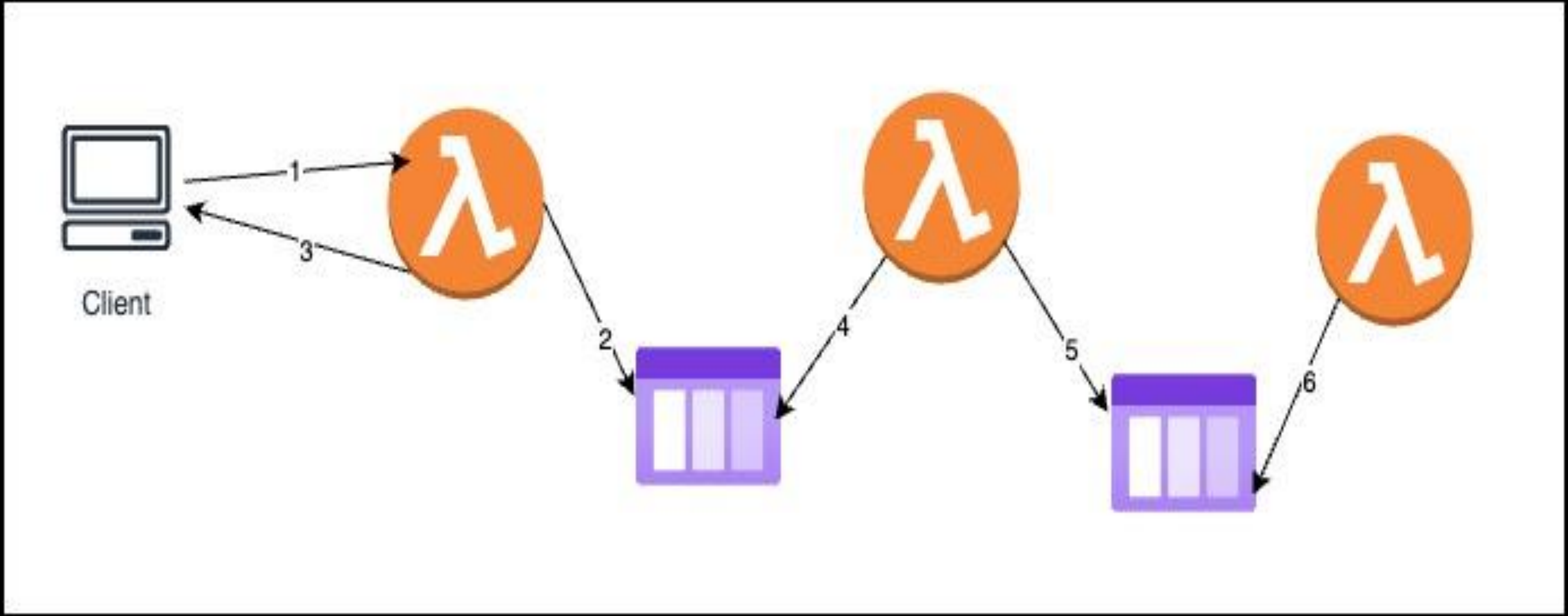
Why do we need Messaging Services?



Why do we need Messaging Services?

- Synchronous communication between compute components (Lambdas, EC2 instance) can be problematic if there are sudden spikes in demand or gaps in availability.
  - E.g. 1000 parallel requests to encode video uploads, when usually the workload is a much smaller scale (10s).
- It's better to decouple compute components using messaging intermediaries.
- AWS messaging services/techniques:
  - SQS: queueing model.
  - SNS: publisher-subscribe model.
  - Data streams.
- These techniques result in:
  - Reduced latency; Increased availability; Reduced complexity (by decreasing dependency).

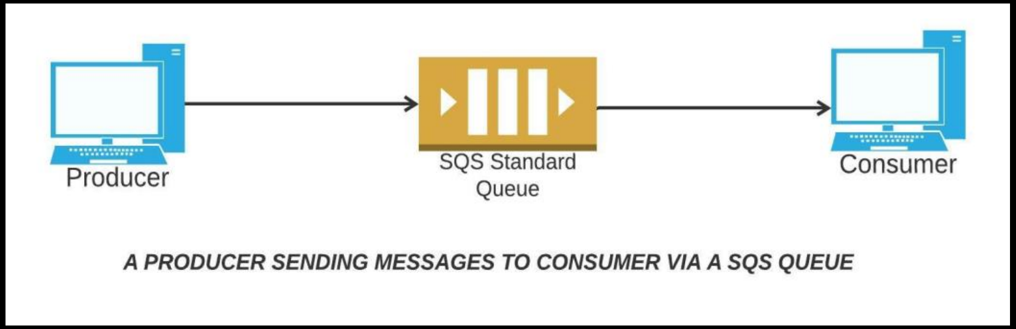
How to use Messaging Services.



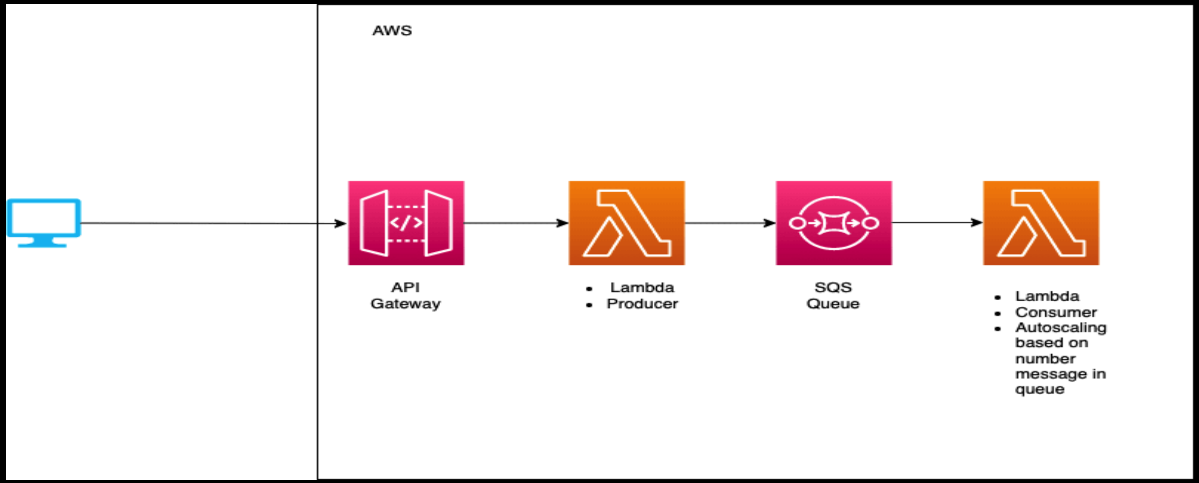
Simple Queue Service (SQS)

SQS - Overview

- Oldest AWS offering (2006).
- Fully managed, distributed queueing service, used to decouple applications/components.
- Compute component roles:
  - Producers.
  - Consumers.



A PRODUCER SENDING MESSAGES TO CONSUMER VIA A SQS QUEUE



SQS - Overview

- SQS Attributes:
  - Scalability - Unlimited throughput, unlimited number of messages in a queue.
  - Message Retention: 4 days (default), maximum of 14 days.
  - Low latency (< 10 msgs on publish and receive).
  - Limitation of 256KB per message.

- Caveats:
  - Duplicate messages may occur, occasionally.
    - So, consumer processing must be idempotent.
  - Message order is not guaranteed (best-effort ordering).

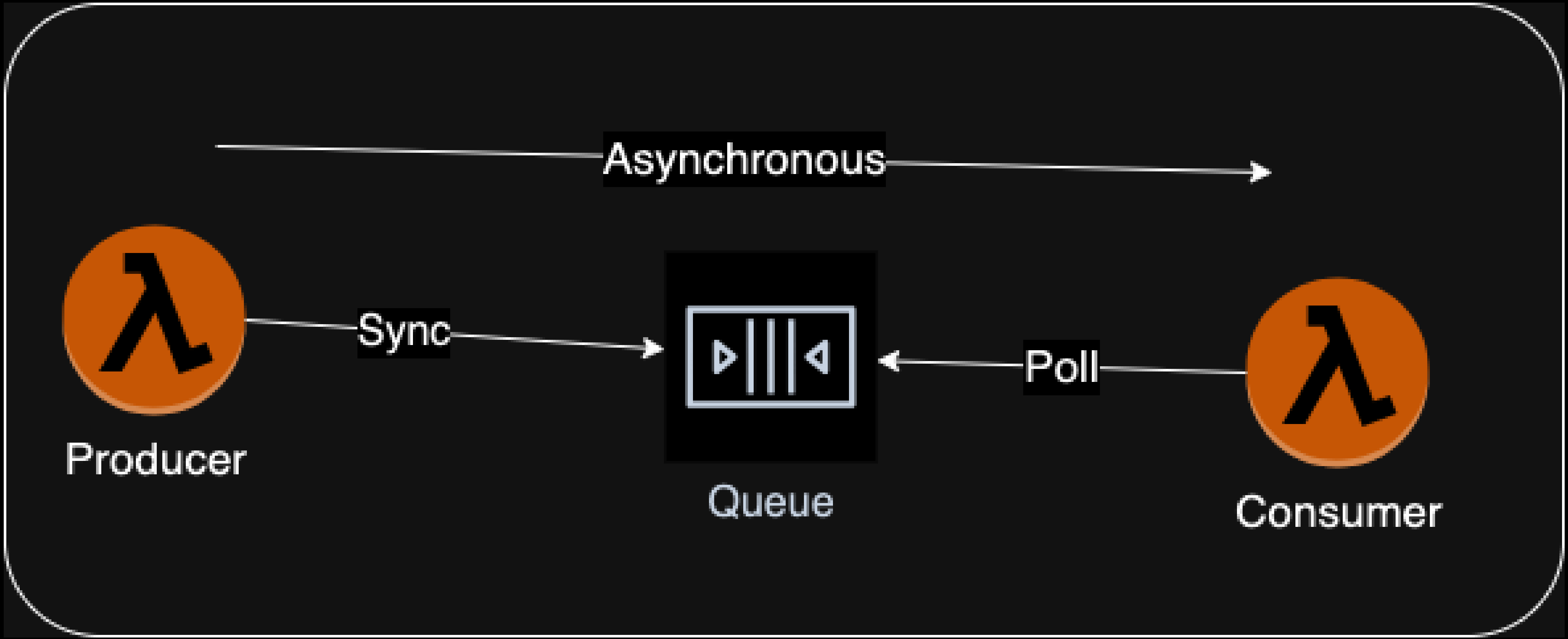
Basic Operations.

- Producer:
  - Publish/Write message to a queue using SQS SDK.
    - SQS persists messages until (a) a consumer processes AND deletes it, or (b) its TTL expires (default 4 days).
    - e.g. Publish a goods order to a queue for processing.

      Message = Order id + Customer id + Order details

- Consumer:
  1. Polls SQS service for messages.
  2. Receives a batch response (<= 10 messages).
  3. Processes the message batch, e.g. validate & insert order into a d/b.
  4. Deletes the message batch in the SQS queue.

Communication styles.



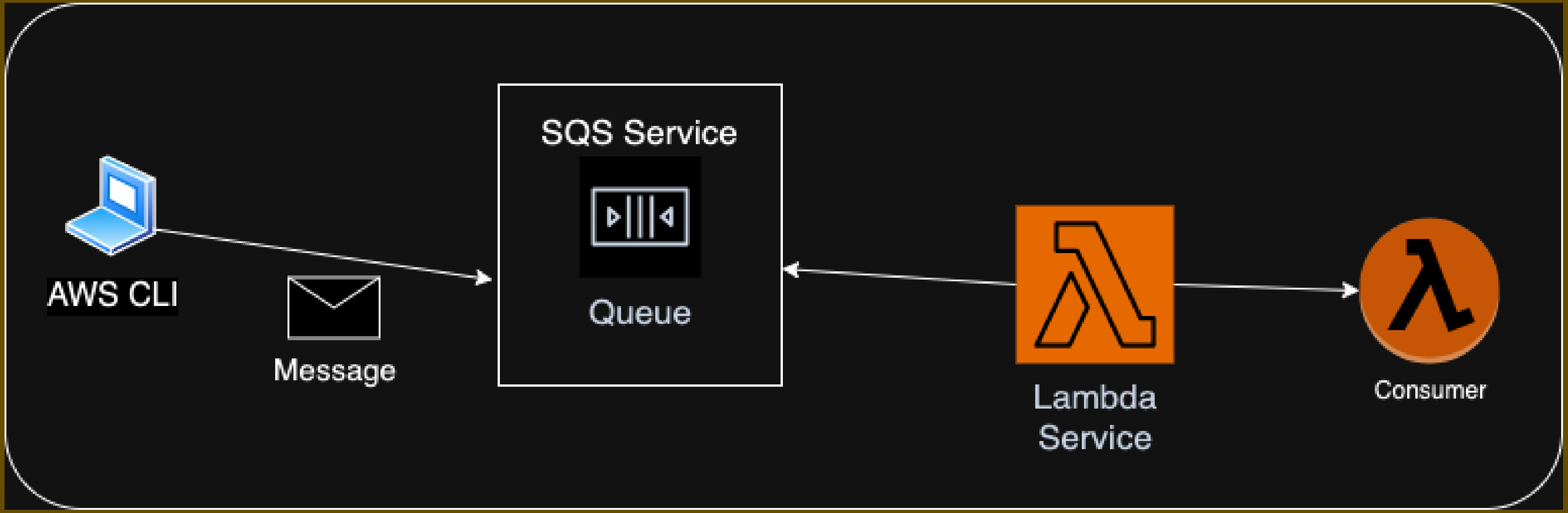
Security

- Encryption.
  - In-flight encryption using HTTPS.
  - At-rest encryption using KMS keys.

- Access Controls: IAM policies to regulate access to the SQS API.

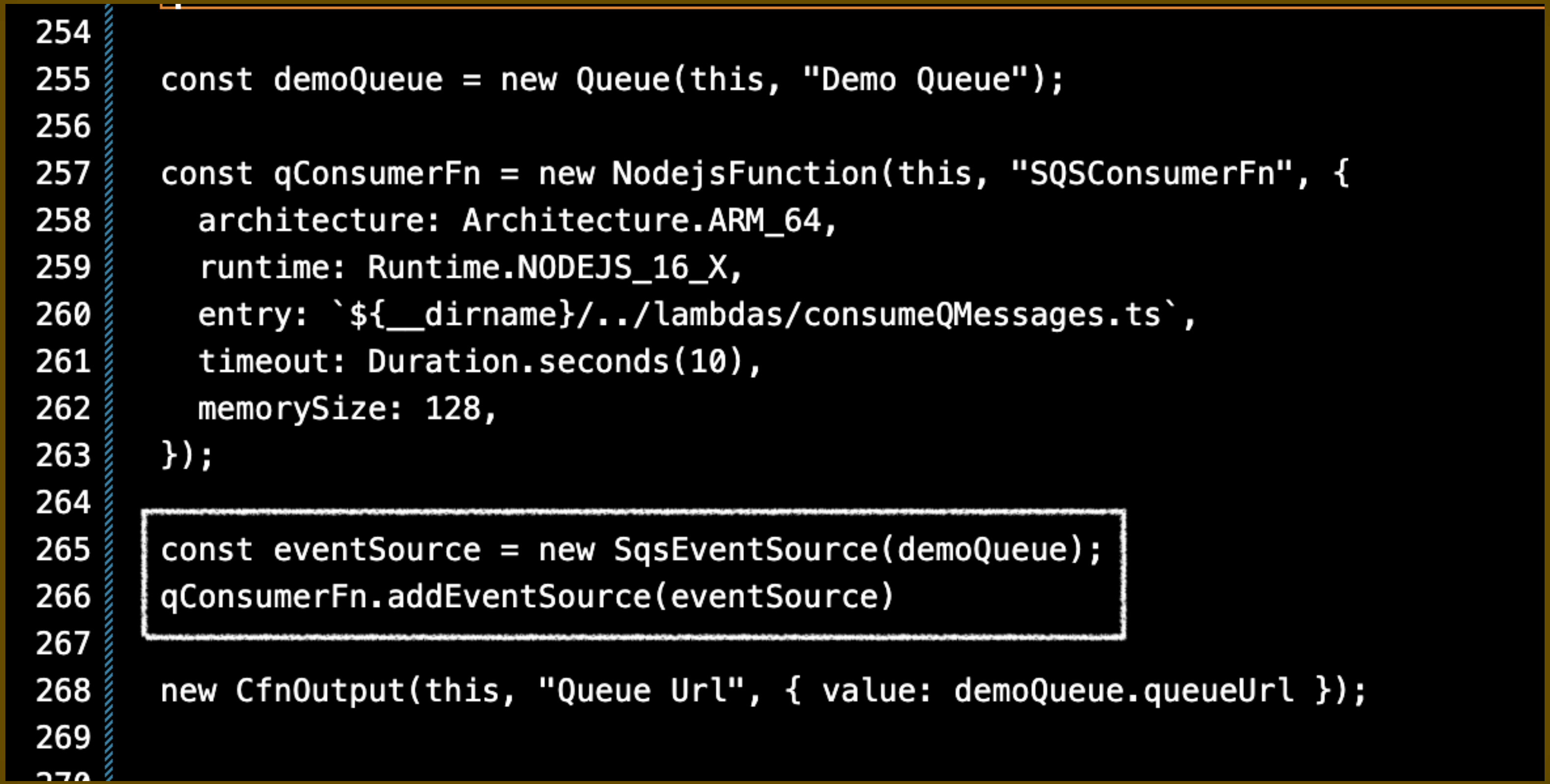
- SQS Access Policies (similar to S3 bucket policies).
  - Useful for cross-account access to SQS queues.
  - Useful for allowing other services (SNS, S3…) write to a queue.

Demo.



- The Lambda service polls the SQS service for messages and calls the lambda function synchronously with a batch.
- If the function processes the batch without a failure/exception, the the Lambda service deletes the batch from the queue.
    - Otherwise, the entire batch remains in the queue for reprocessing by the function/consumer.

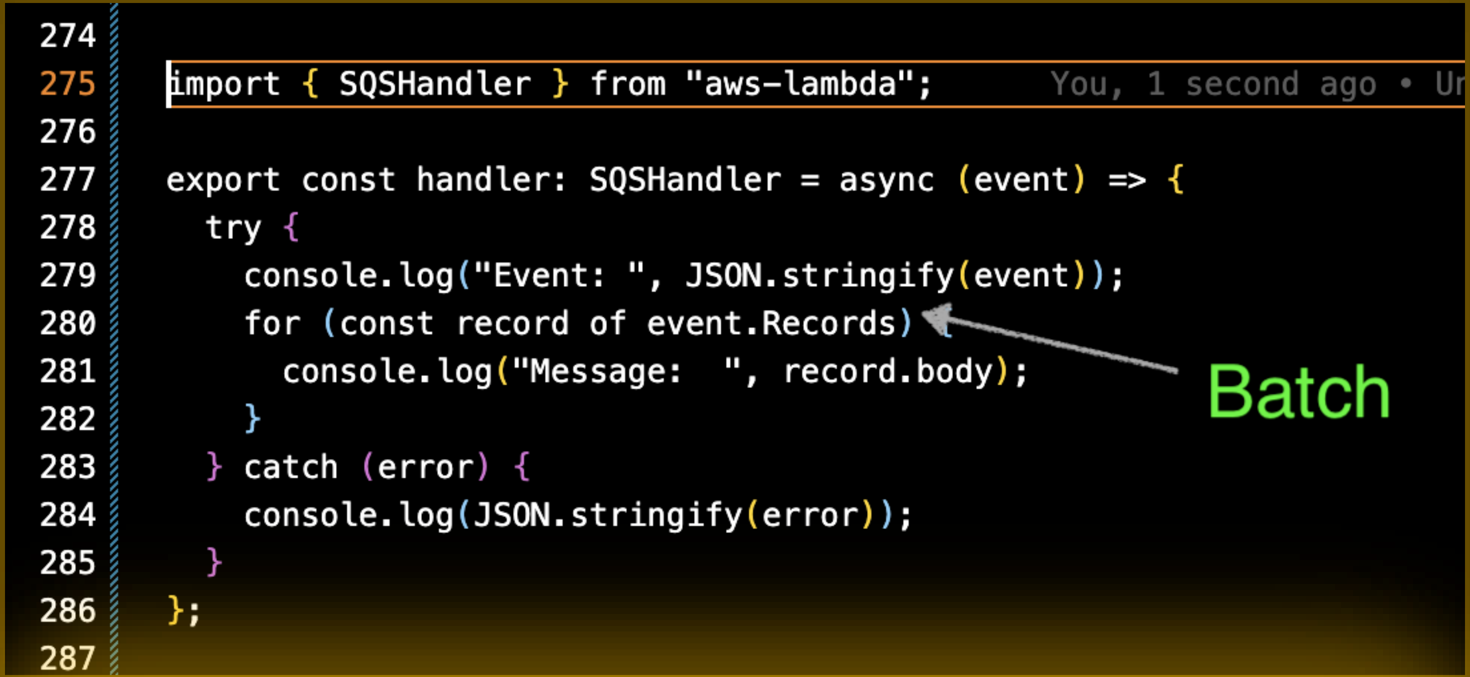
Demo - CDK Infrastructure.



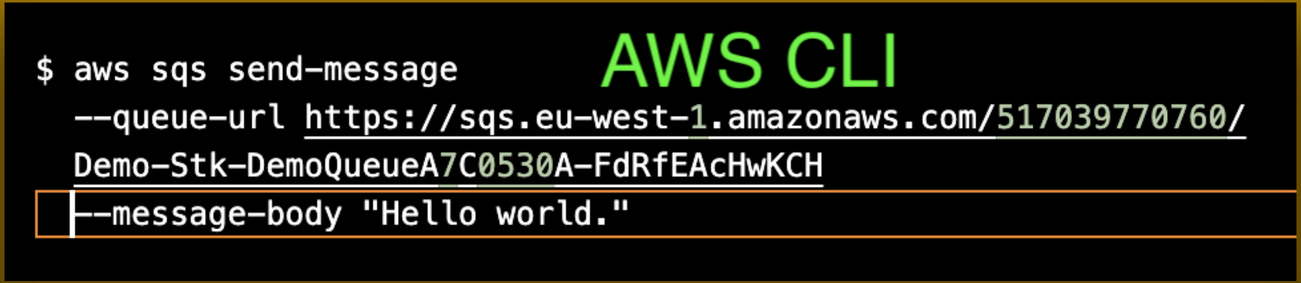
```
const demoQueue = new Queue(this, "Demo Queue");

const qConsumerFn = new NodejsFunction(this, "SQSConsumerFn", {
  architecture: Architecture.ARM_64,
  runtime: Runtime.NODEJS_16_X,
  entry: `${__dirname}/../lambdas/consumeQMessages.ts`,
  timeout: Duration.seconds(10),
  memorySize: 128,
});

const eventSource = new SqsEventSource(demoQueue);
qConsumerFn.addEventSource(eventSource)

new CfnOutput(this, "Queue Url", { value: demoQueue.queueUrl });
```

- Recall, lambda functions are triggered by an event.
- Here, the event source is a message queue polled by the Lambda service.

Demo - Producer & Consumer.

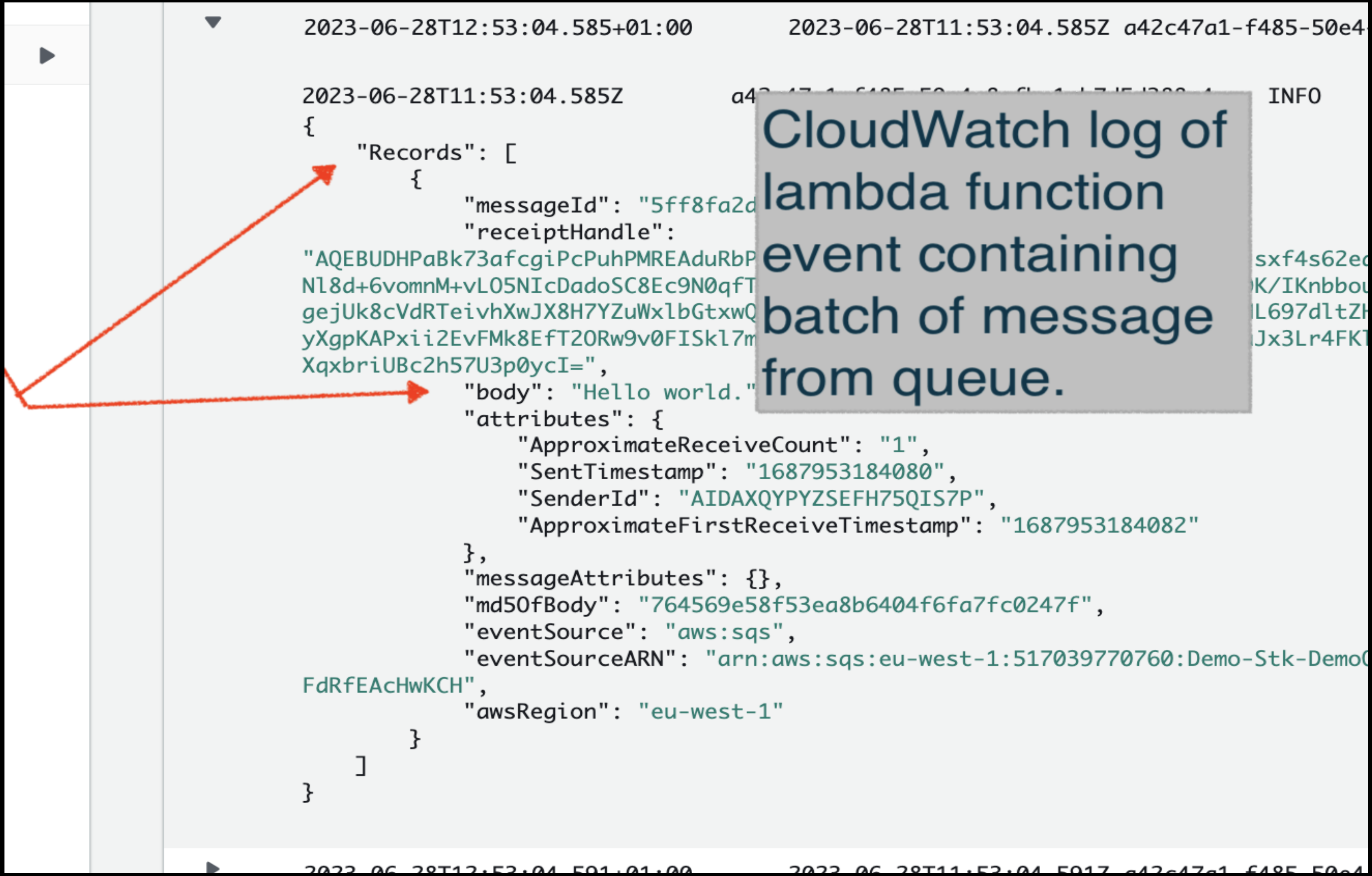


```
import { SQSHandler } from "aws-lambda";        You, 1 second ago • Ur

export const handler: SQSHandler = async (event) => {
  try {
    console.log("Event: ", JSON.stringify(event));
    for (const record of event.Records)
      console.log("Message:  ", record.body);
    }
  } catch (error) {
    console.log(JSON.stringify(error));
  }
};
```



```
$ aws sqs send-message
  --queue-url https://sqs.eu-west-1.amazonaws.com/517039770760/
  Demo-Stk-DemoQueueA7C0530A-FdRfEAcHwKCH
  --message-body "Hello world."
```

Demo – Lambda Consumer event structure.

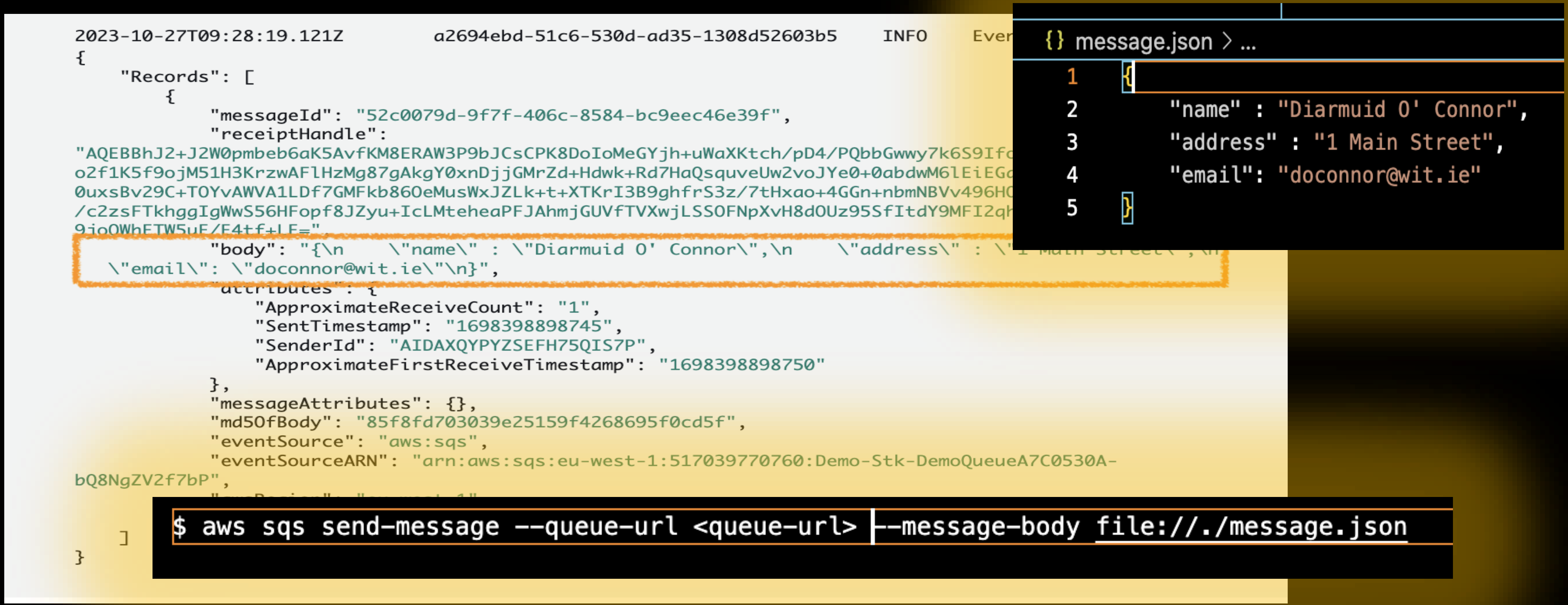


```
2023-06-28T12:53:04.585+01:00       2023-06-28T11:53:04.585Z a42c47a1-f485-50e4

2023-06-28T11:53:04.585Z       a4                                   INFO
{
    "Records": [
        {
            "messageId": "5ff8fa2d
            "receiptHandle":
"AQEBUDHPaBk73afcgiPcPuhPMREAduRbP                                sxf4s62ed
Nl8d+6vomnM+vLO5NIcDadoSC8Ec9N0qfT                                K/IKnbbou
gejUk8cVdRTeivhXwJX8H7YZuWxlbGtxwQ                                L697dltZH
yXgpKAPxii2EvFMk8EfT2ORw9v0FISkl7m                                Jx3Lr4FKT
XqxbriUBc2h57U3p0ycI=",
            "body": "Hello world."
            "attributes": {
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1687953184080",
                "SenderId": "AIDAXQYPYZSEFH75QIS7P",
                "ApproximateFirstReceiveTimestamp": "1687953184082"
            },
            "messageAttributes": {},
            "md5OfBody": "764569e58f53ea8b6404f6fa7fc0247f",
            "eventSource": "aws:sqs",
            "eventSourceARN": "arn:aws:sqs:eu-west-1:517039770760:Demo-Stk-Demo
FdRfEAcHwKCH",
            "awsRegion": "eu-west-1"
        }
    ]
}

2023-06-28T12:53:04.591+01:00       2023-06-28T11:53:04.591Z a42c47a1-f485-50e4
```

CloudWatch log of lambda function event containing batch of message from queue.

Demo - JSON messages.

- SQS serialize JSON messages → Handler must parse it before processing.



```
2023-10-27T09:28:19.121Z        a2694ebd-51c6-530d-ad35-1308d52603b5    INFO    Ever
{
    "Records": [
        {
            "messageId": "52c0079d-9f7f-406c-8584-bc9eec46e39f",
            "receiptHandle":
"AQEBBhJ2+J2W0pmbeb6aK5AvfKM8ERAW3P9bJCsCPK8DoIoMeGYjh+uWaXKtch/pD4/PQbbGwwy7k6S9Ifc
o2f1K5f9ojM51H3KrzwAFlHzMg87gAkgY0xnDjjGMrZd+Hdwk+Rd7HaQsquveUw2voJYe0+0abdwM6lEiEGa
0uxsBv29C+TOYvAWVA1LDf7GMFkb86OeMusWxJZLk+t+XTKrI3B9ghfrS3z/7tHxao+4GGn+nbmNBVv496HC
/c2zsFTkhggIgWwS56HFopf8JZyu+IcLMteheaPFJAhmjGUVfTVXwjLSSOFNpXvH8dOUz95SfItdY9MFI2qh
9joQWhFTW5uF/F4tf+LF=",
            "body": "{\n    \"name\" : \"Diarmuid O' Connor\",\n    \"address\" : \"1 Main Street\",\n
  \"email\": \"doconnor@wit.ie\"\n}",
            "attributes": {
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1698398898745",
                "SenderId": "AIDAXQYPYZSEFH75QIS7P",
                "ApproximateFirstReceiveTimestamp": "1698398898750"
            },
            "messageAttributes": {},
            "md5OfBody": "85f8fd703039e25159f4268695f0cd5f",
            "eventSource": "aws:sqs",
            "eventSourceARN": "arn:aws:sqs:eu-west-1:517039770760:Demo-Stk-DemoQueueA7C0530A-
bQ8NgZV2f7bP",
    ]
}
```

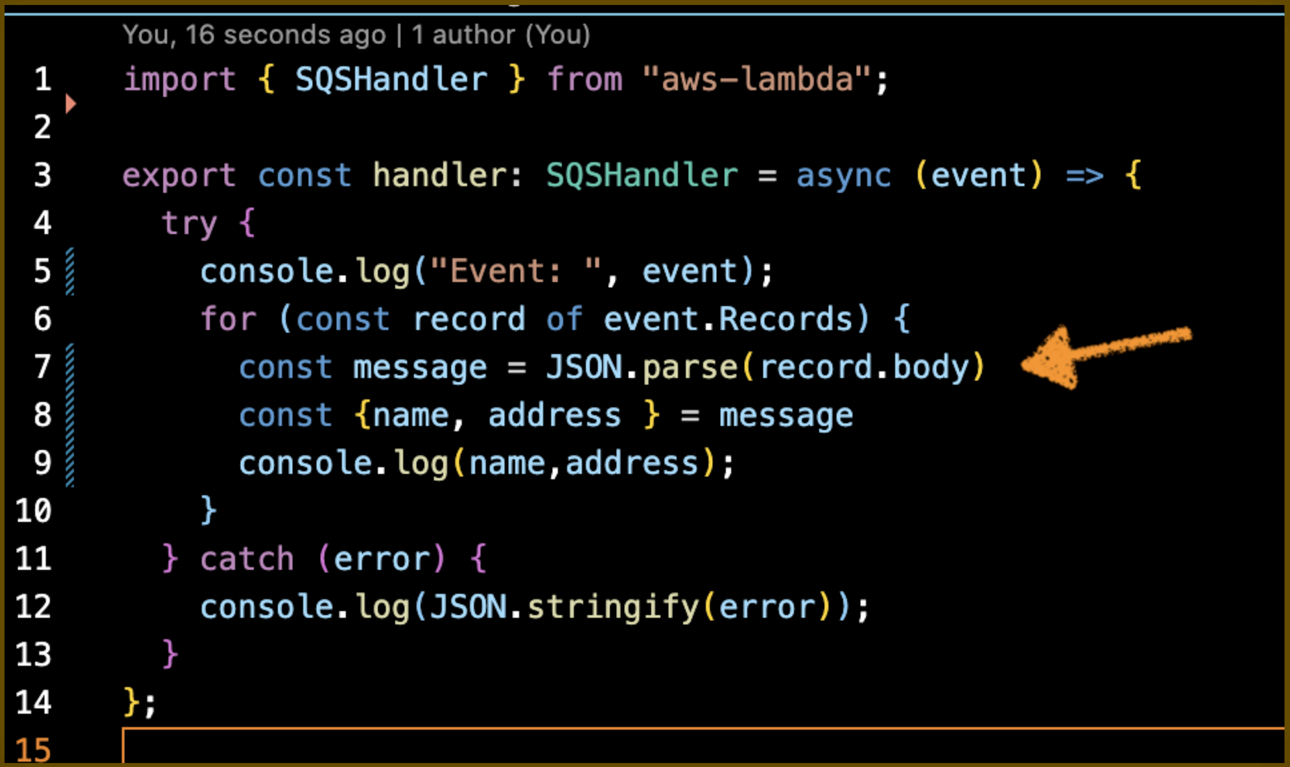
message.json > ...

```json
{
    "name" : "Diarmuid O' Connor",
    "address" : "1 Main Street",
    "email": "doconnor@wit.ie"
}
```

```
$ aws sqs send-message --queue-url <queue-url> --message-body file://./message.json
```

Demo - JSON messages.

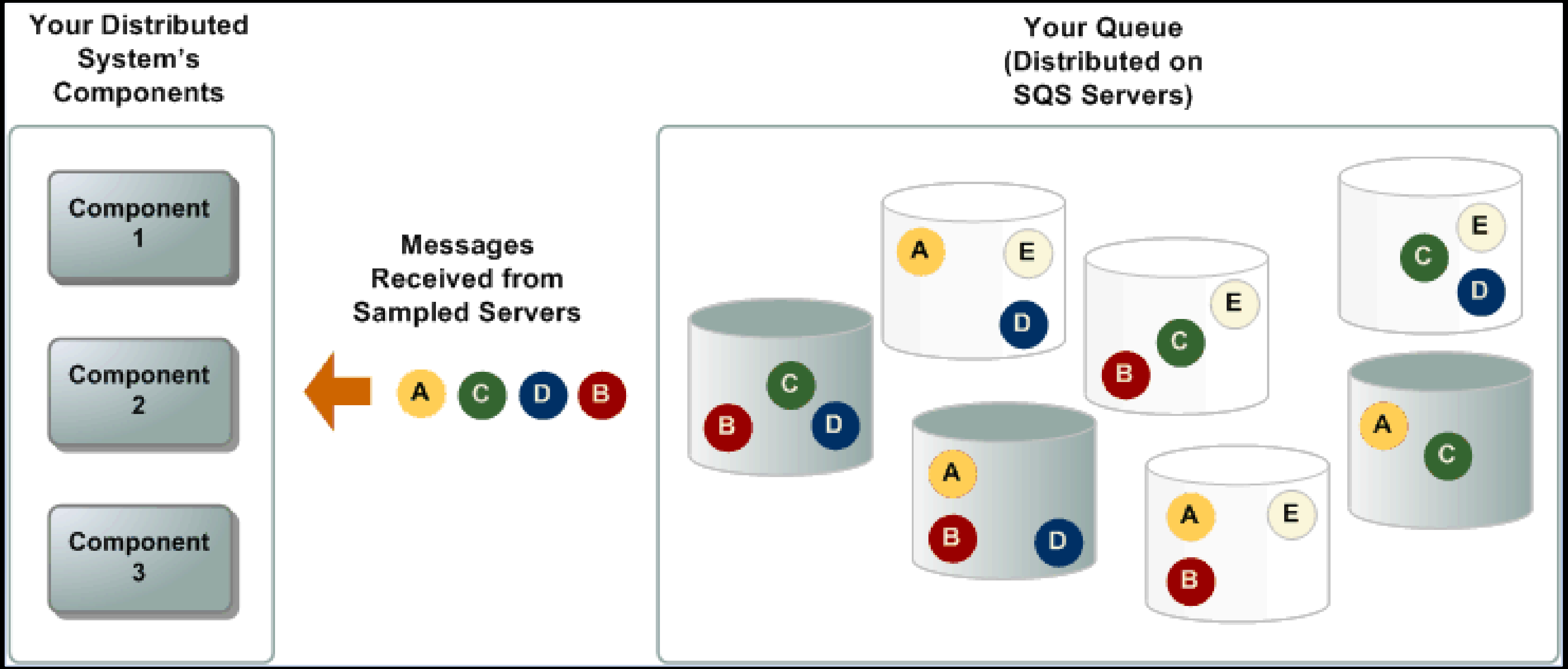
- The lambda handler (Consumer)



You, 16 seconds ago | 1 author (You)

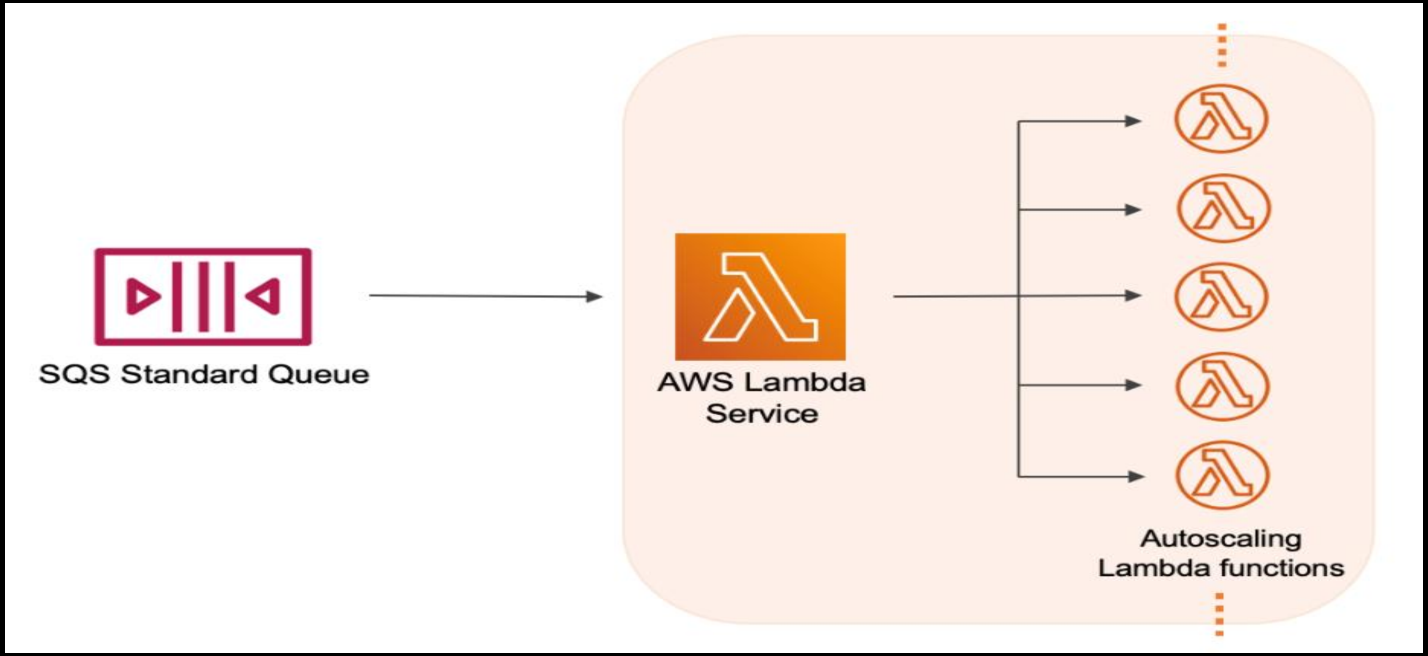
```
import { SQSHandler } from "aws-lambda";

export const handler: SQSHandler = async (event) => {
  try {
    console.log("Event: ", event);
    for (const record of event.Records) {
      const message = JSON.parse(record.body)
      const {name, address } = message
      console.log(name,address);
    }
  } catch (error) {
    console.log(JSON.stringify(error));
  }
};

```

SQS is Highly Available


Your Distributed System's Components
Component 1
Component 2
Component 3
Messages Received from Sampled Servers
A C D B
Your Queue (Distributed on SQS Servers)
B C D
A E D
B C E
C E D
A B D
A B E
A C

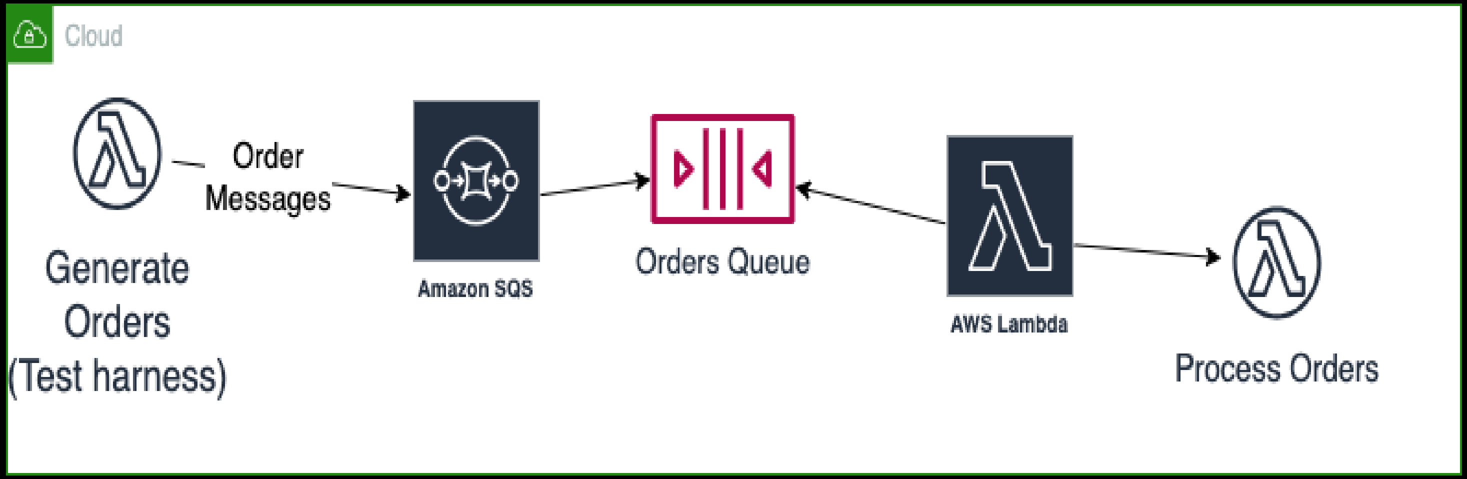
- When a consumer polls a queue for messages, the SQS service samples a subset of its servers (based on a weighted random distribution) and returns messages from the chosen servers.

Lambda Consumer scaling



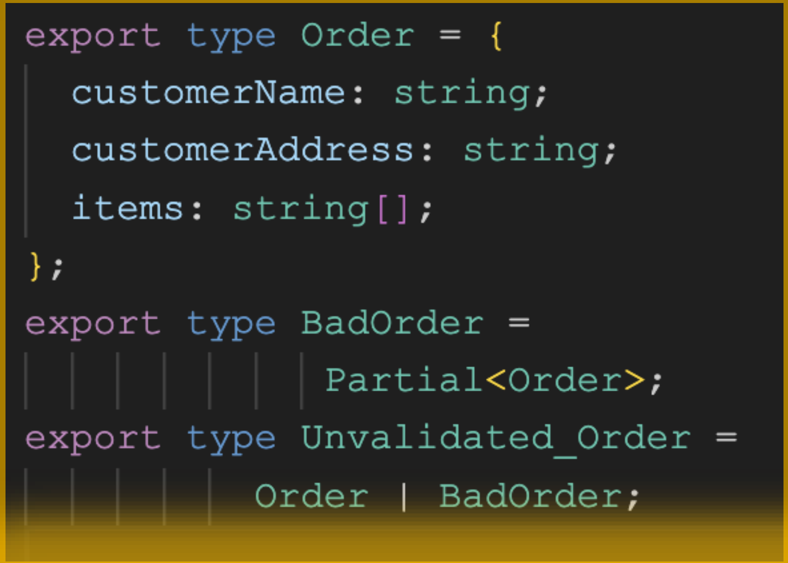
- Lambda service:
    1. Polls SQS and waits for a message batch response.
    2. Arbitrarily splits the batch into smaller sub-batches
    3. Instantiates a micro VM (function) for each sub-batch
- It adds up to 60 functions per minute, up to max. of 1,000, to consume large message volumes.

Demo

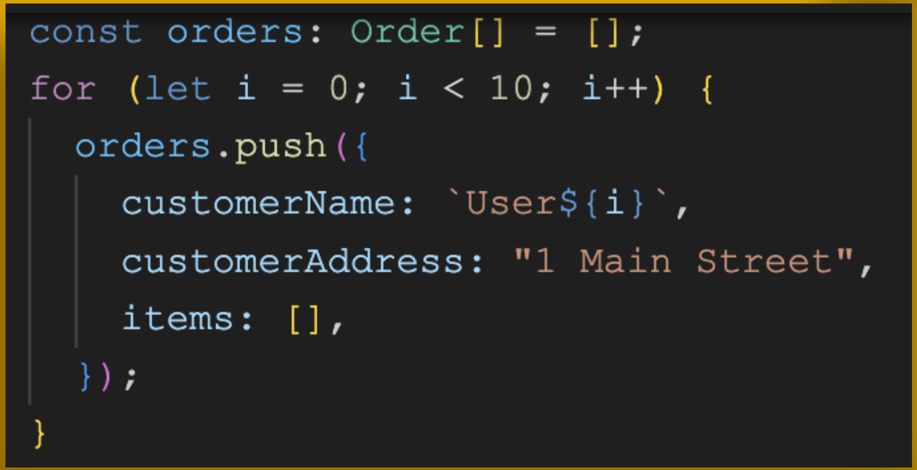


- The Generate_Orders lambda function needs permission to send messages to a queue, i.e.
  ordersQueue.grantSendMessages(generateOrdersFn)

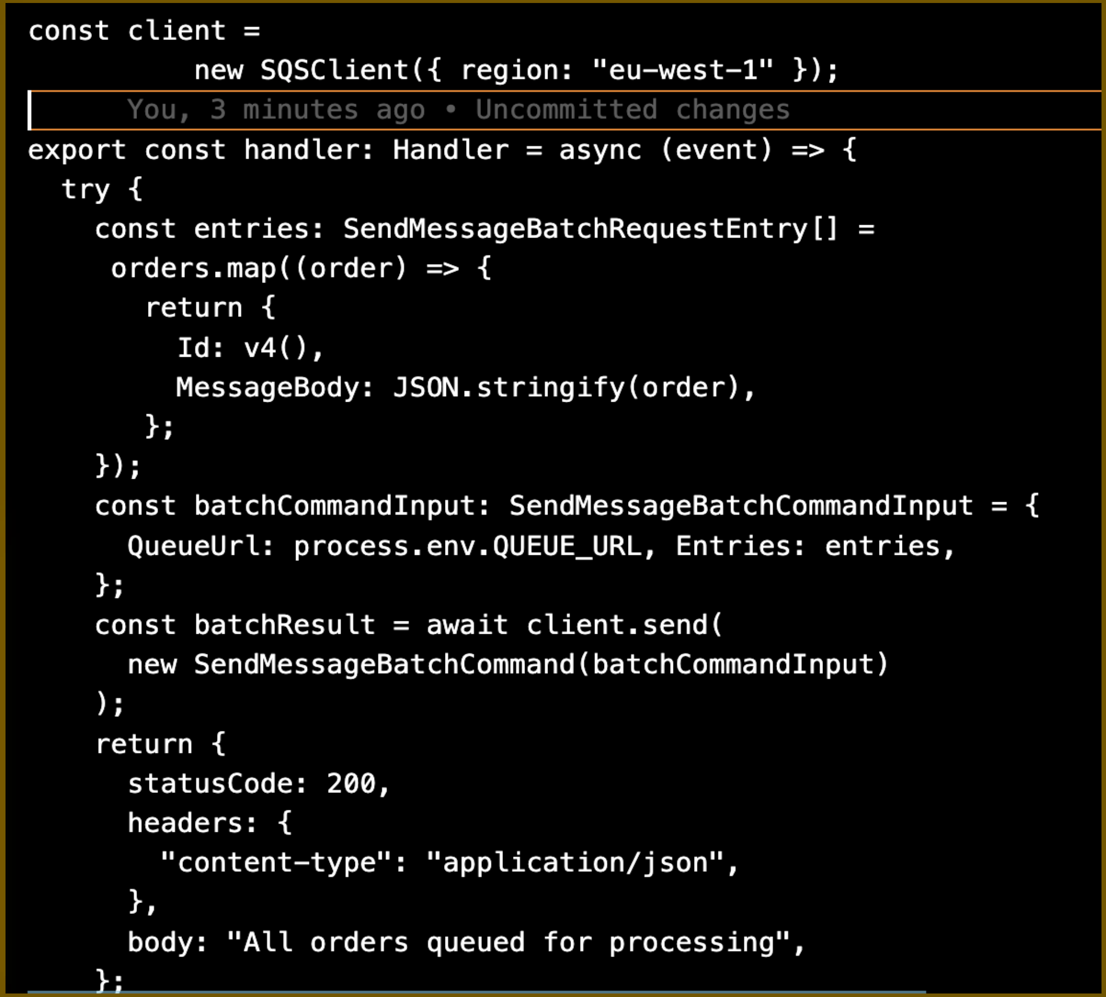
Demo - Generate Orders (Producer)



```typescript
export type Order = {
  customerName: string;
  customerAddress: string;
  items: string[];
};
export type BadOrder =
              Partial<Order>;
export type Unvalidated_Order =
          Order | BadOrder;
```

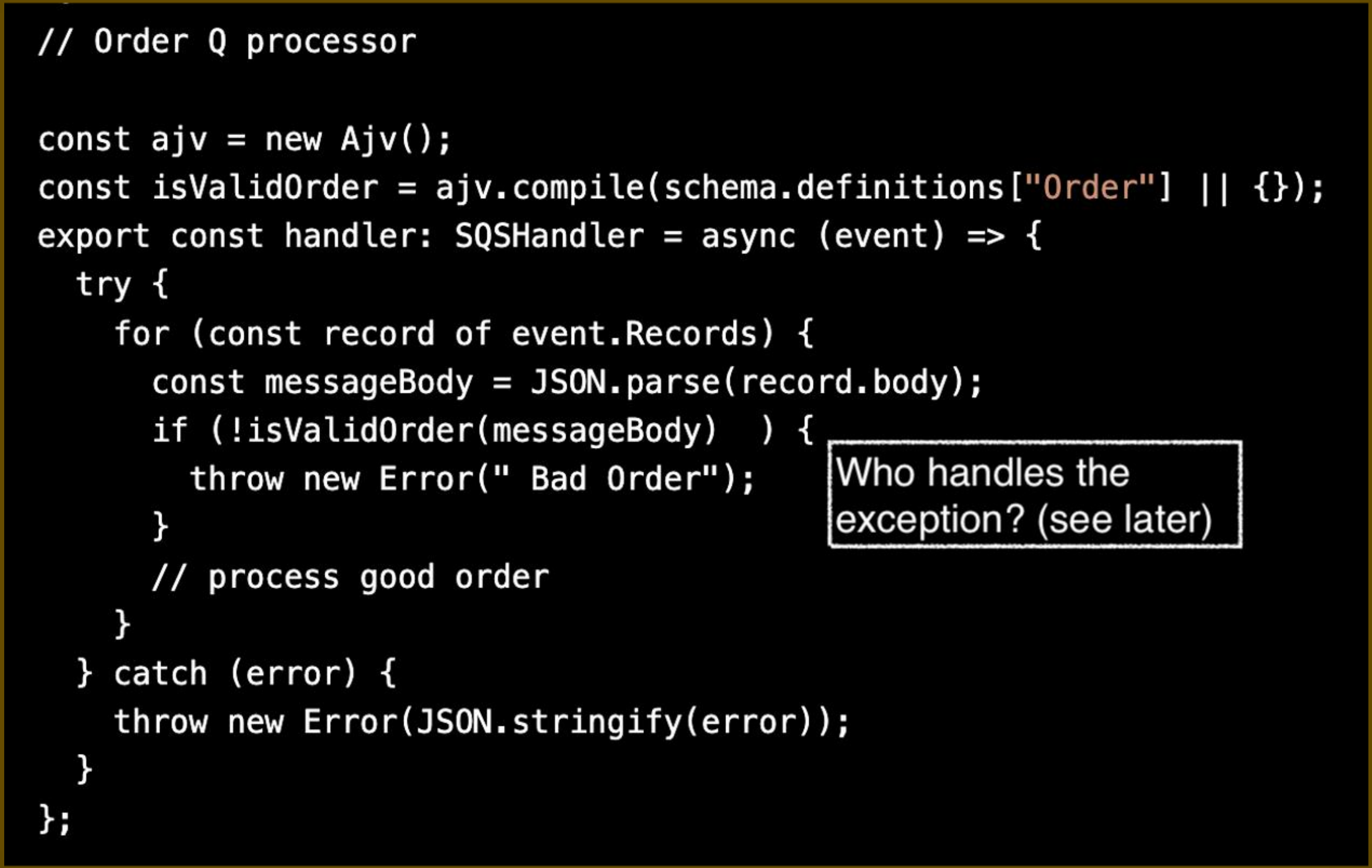


```typescript
const orders: Order[] = [];
for (let i = 0; i < 10; i++) {
  orders.push({
    customerName: `User${i}`,
    customerAddress: "1 Main Street",
    items: [],
  });
}
```



```typescript
const client =
          new SQSClient({ region: "eu-west-1" });
      You, 3 minutes ago • Uncommitted changes
export const handler: Handler = async (event) => {
  try {
    const entries: SendMessageBatchRequestEntry[] =
     orders.map((order) => {
       return {
         Id: v4(),
         MessageBody: JSON.stringify(order),
       };
    });
    const batchCommandInput: SendMessageBatchCommandInput = {
      QueueUrl: process.env.QUEUE_URL, Entries: entries,
    };
    const batchResult = await client.send(
      new SendMessageBatchCommand(batchCommandInput)
    );
    return {
      statusCode: 200,
      headers: {
        "content-type": "application/json",
      },
      body: "All orders queued for processing",
    };
```

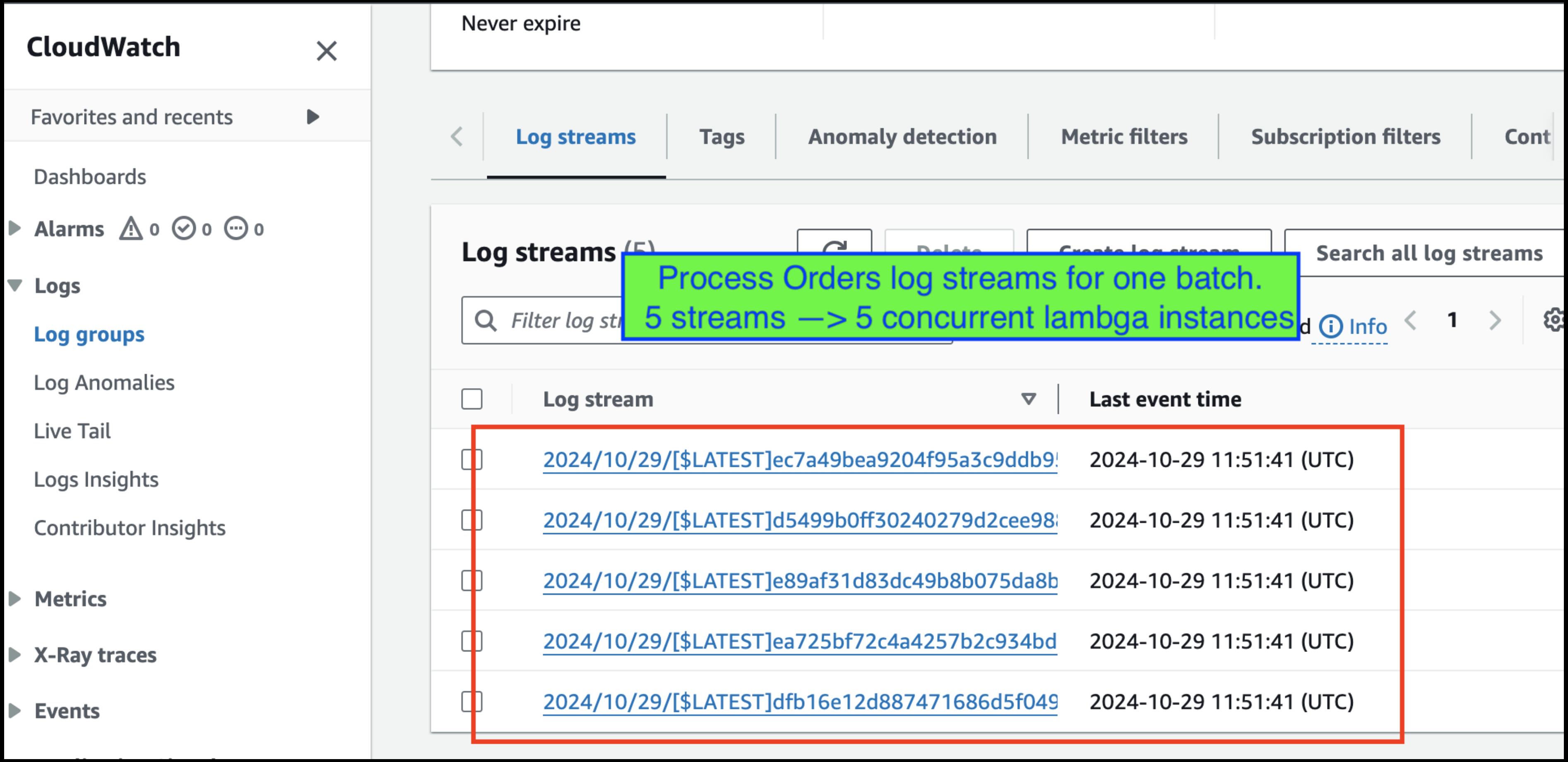
Demo – Process Orders (Consumer)



```
// Order Q processor

const ajv = new Ajv();
const isValidOrder = ajv.compile(schema.definitions["Order"] || {});
export const handler: SQSHandler = async (event) => {
  try {
    for (const record of event.Records) {
      const messageBody = JSON.parse(record.body);
      if (!isValidOrder(messageBody)  ) {
        throw new Error(" Bad Order");
      }
      // process good order
    }
  } catch (error) {
    throw new Error(JSON.stringify(error));
  }
};
```

Who handles the exception? (see later)

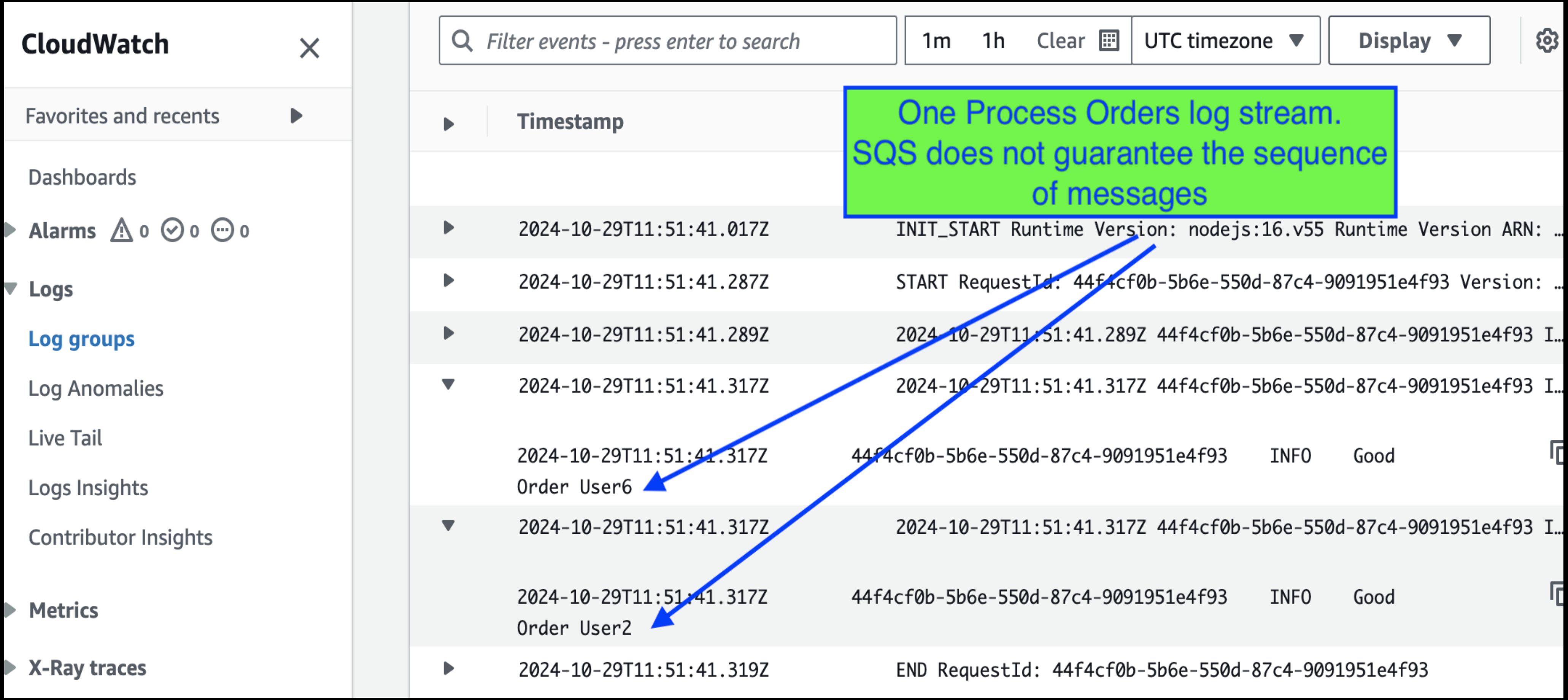
Demo – Lambda consumer scaling



Process Orders log streams for one batch.
5 streams —> 5 concurrent lambga instances

Log stream	Last event time
2024/10/29/[$LATEST]ec7a49bea9204f95a3c9ddb9	2024-10-29 11:51:41 (UTC)
2024/10/29/[$LATEST]d5499b0ff30240279d2cee98	2024-10-29 11:51:41 (UTC)
2024/10/29/[$LATEST]e89af31d83dc49b8b075da8b	2024-10-29 11:51:41 (UTC)
2024/10/29/[$LATEST]ea725bf72c4a4257b2c934bd	2024-10-29 11:51:41 (UTC)
2024/10/29/[$LATEST]dfb16e12d887471686d5f049	2024-10-29 11:51:41 (UTC)

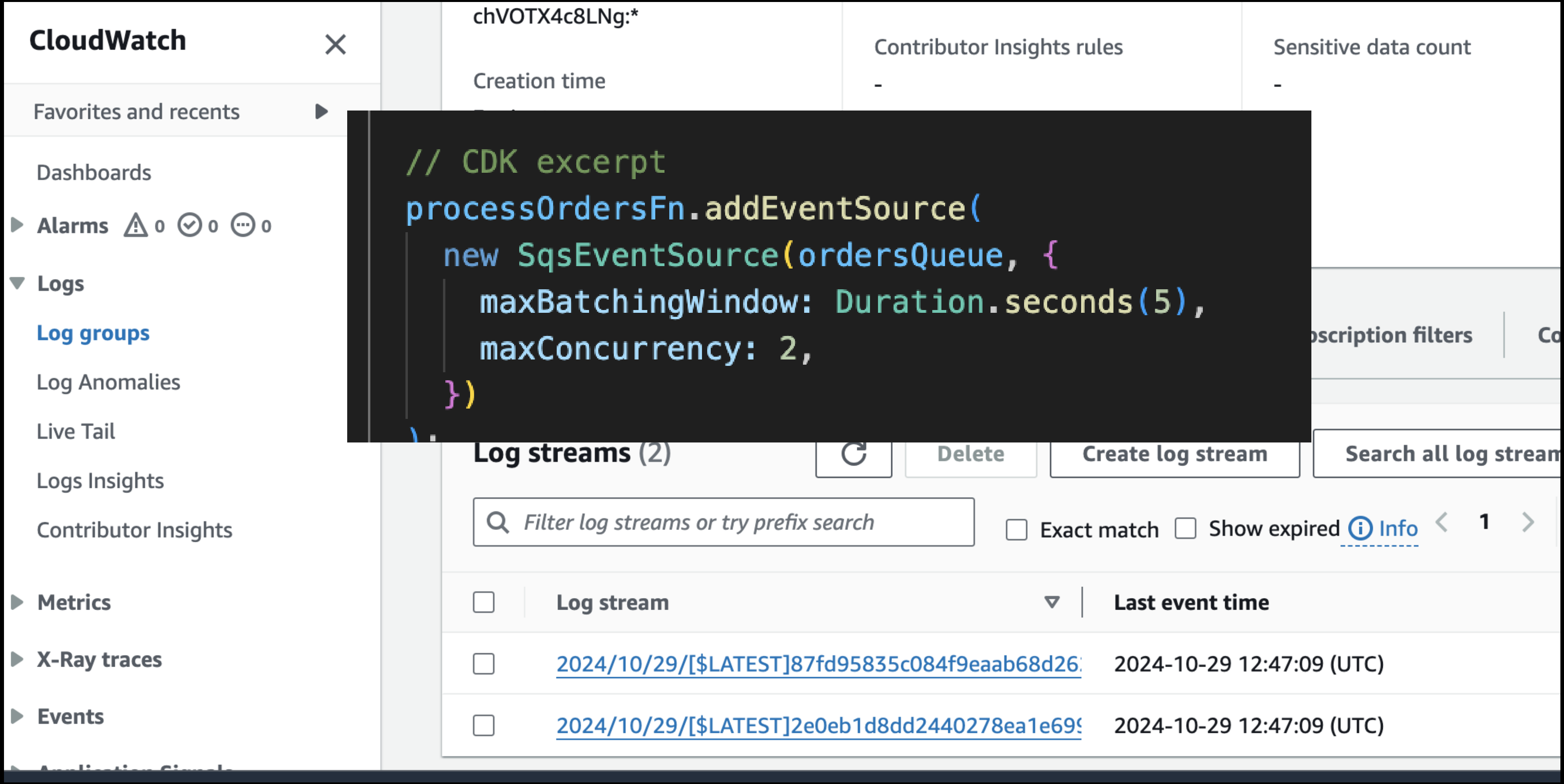
Demo – No guarantee of message order



One Process Orders log stream. SQS does not guarantee the sequence of messages

```
2024-10-29T11:51:41.017Z    INIT_START Runtime Version: nodejs:16.v55 Runtime Version ARN: …
2024-10-29T11:51:41.287Z    START RequestId: 44f4cf0b-5b6e-550d-87c4-9091951e4f93 Version: …
2024-10-29T11:51:41.289Z    2024-10-29T11:51:41.289Z 44f4cf0b-5b6e-550d-87c4-9091951e4f93 I…
2024-10-29T11:51:41.317Z    2024-10-29T11:51:41.317Z 44f4cf0b-5b6e-550d-87c4-9091951e4f93 I…

    2024-10-29T11:51:41.317Z    44f4cf0b-5b6e-550d-87c4-9091951e4f93    INFO    Good
    Order User6
2024-10-29T11:51:41.317Z    2024-10-29T11:51:41.317Z 44f4cf0b-5b6e-550d-87c4-9091951e4f93 I…

    2024-10-29T11:51:41.317Z    44f4cf0b-5b6e-550d-87c4-9091951e4f93    INFO    Good
    Order User2
2024-10-29T11:51:41.319Z    END RequestId: 44f4cf0b-5b6e-550d-87c4-9091951e4f93
```

Demo – Controlling consumer concurrency.



chVOTX4c8LNg:*

```
// CDK excerpt
processOrdersFn.addEventSource(
  new SqsEventSource(ordersQueue, {
    maxBatchingWindow: Duration.seconds(5),
    maxConcurrency: 2,
  })
);
```

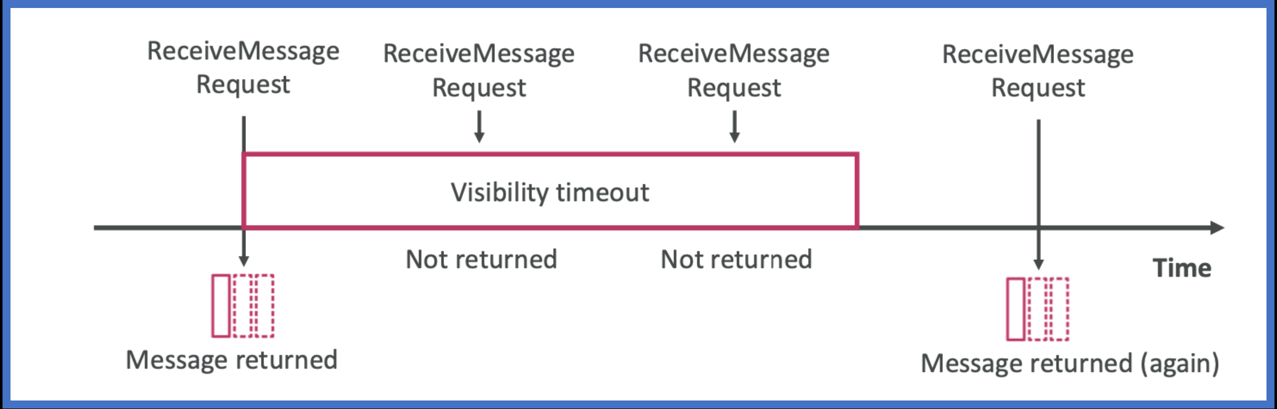
Log streams (2)

Filter log streams or try prefix search

Log stream	Last event time
2024/10/29/[$LATEST]87fd95835c084f9eaab68d26	2024-10-29 12:47:09 (UTC)
2024/10/29/[$LATEST]2e0eb1d8dd2440278ea1e69	2024-10-29 12:47:09 (UTC)

Message Visibility.

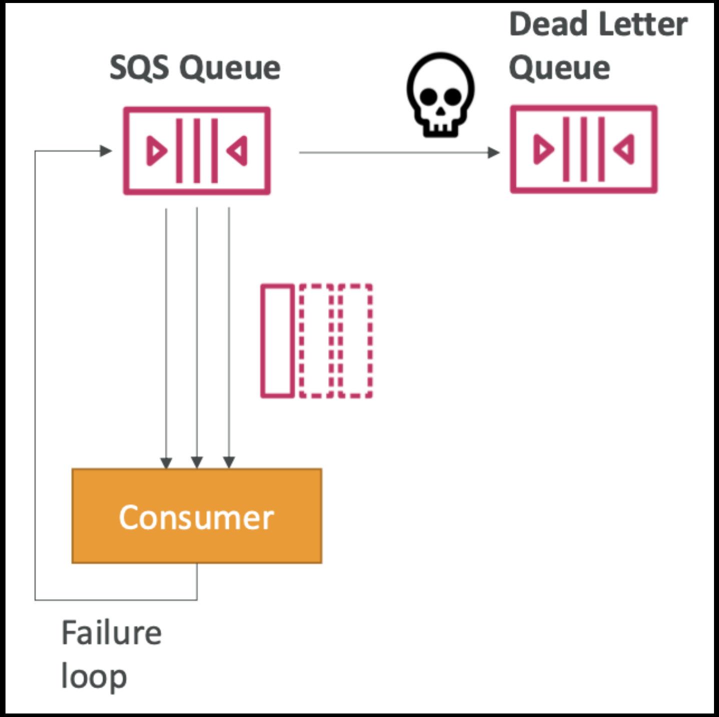
- When a message is polled by a consumer, it remains in the queue but is invisible to other consumers.
  - The default "message visibility timeout" is 30 seconds.
- Consumer must process (and delete) a message within the timeout period. Otherwise, the message is "visible" again.



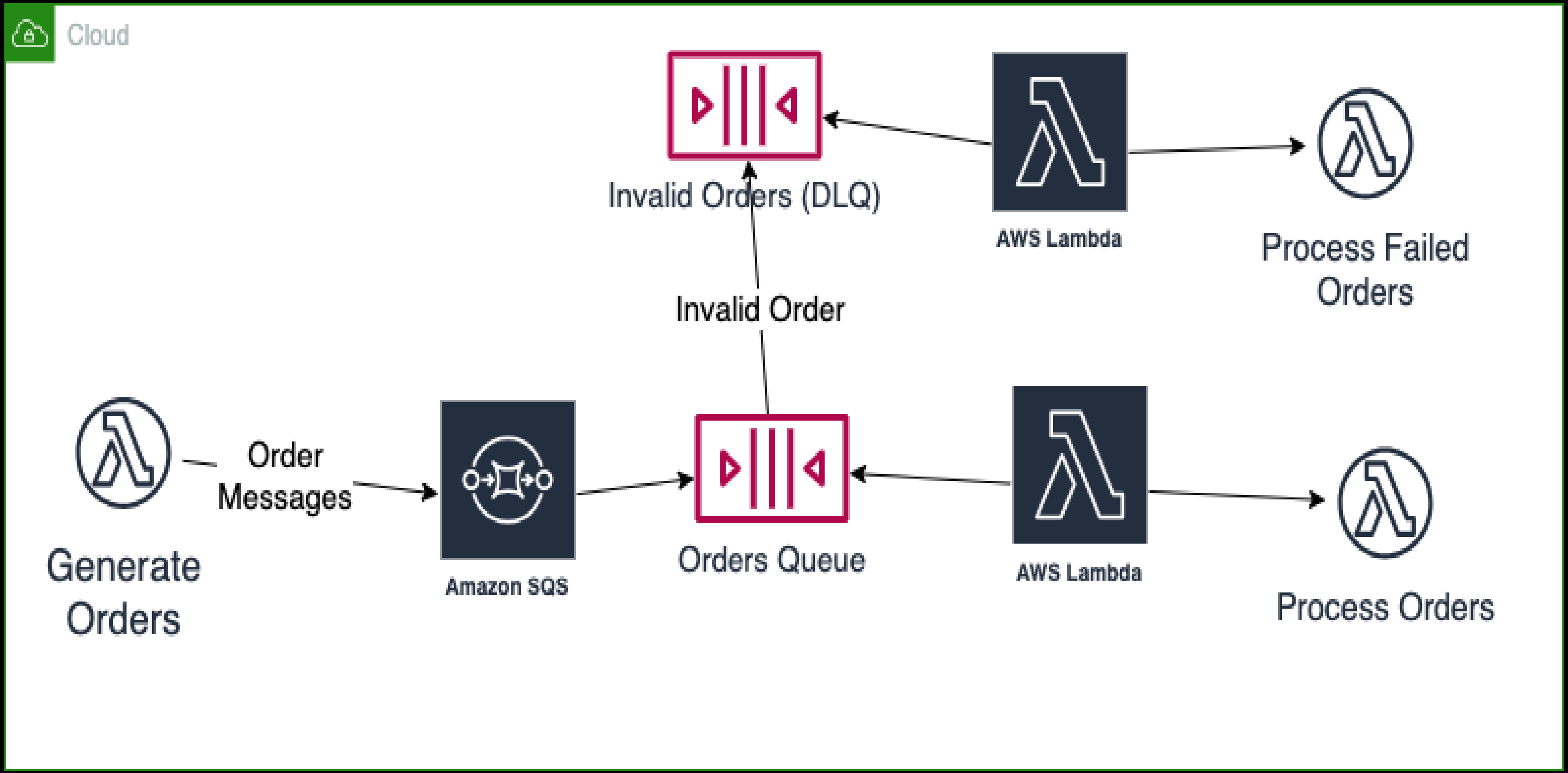
- Timeout too high (minutes/hours) => Re-processing delayed when consumer fails.
- Timeout too low => message may be processed by multiple consumer.

Dead Letter Queue (DLQ)

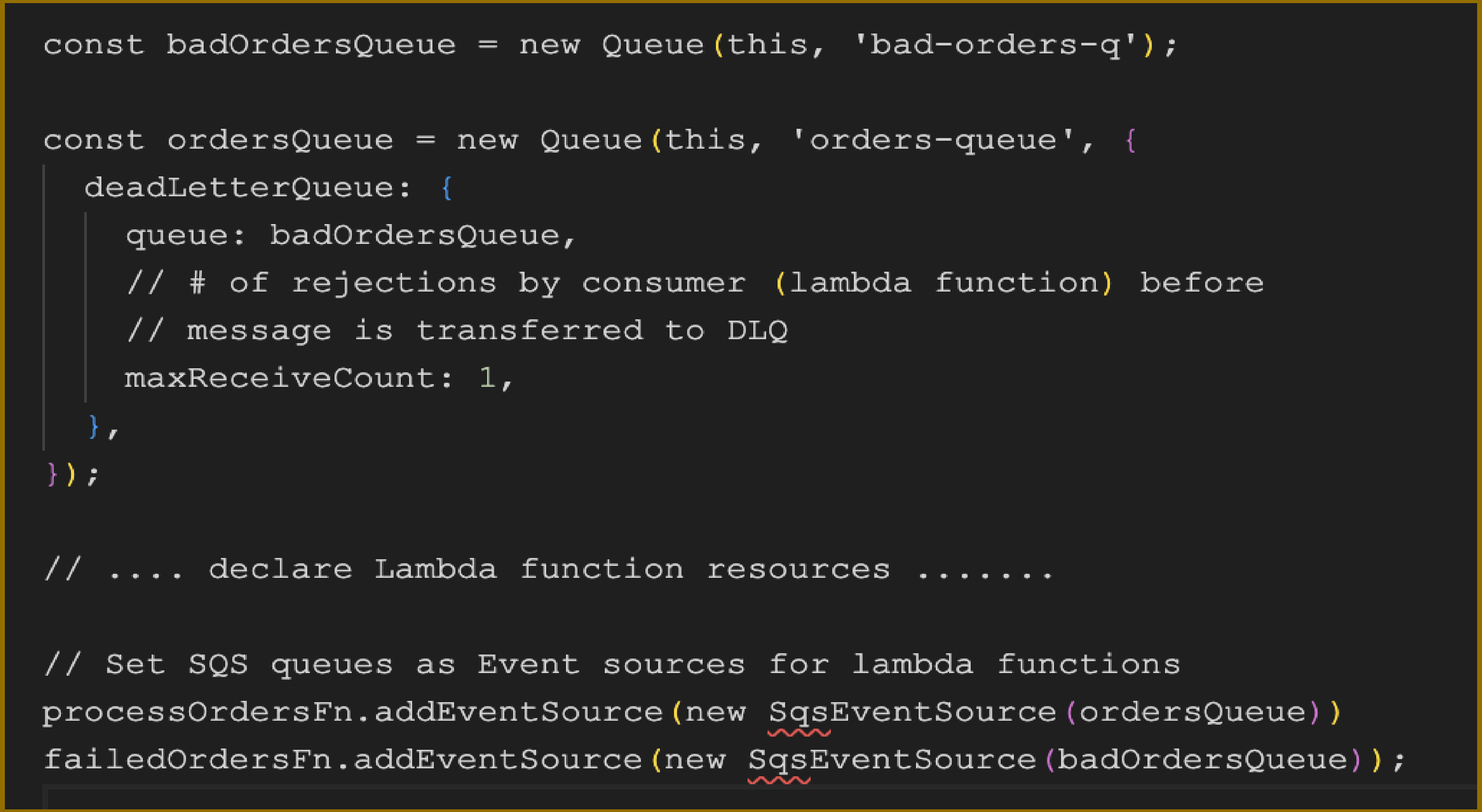
- If a consumer does not process a message batch within the visibility period (due to timeout or an exception), the batch is ‘returns to the queue’.
- Maximum Receives threshold – the number of times a message is returned to the queue.
- After the threshold is exceeded, the batch goes into a DLQ, if defined.
    - Useful for debugging!
    - DLQ may have a separate consumer.



Demo – DLQ.

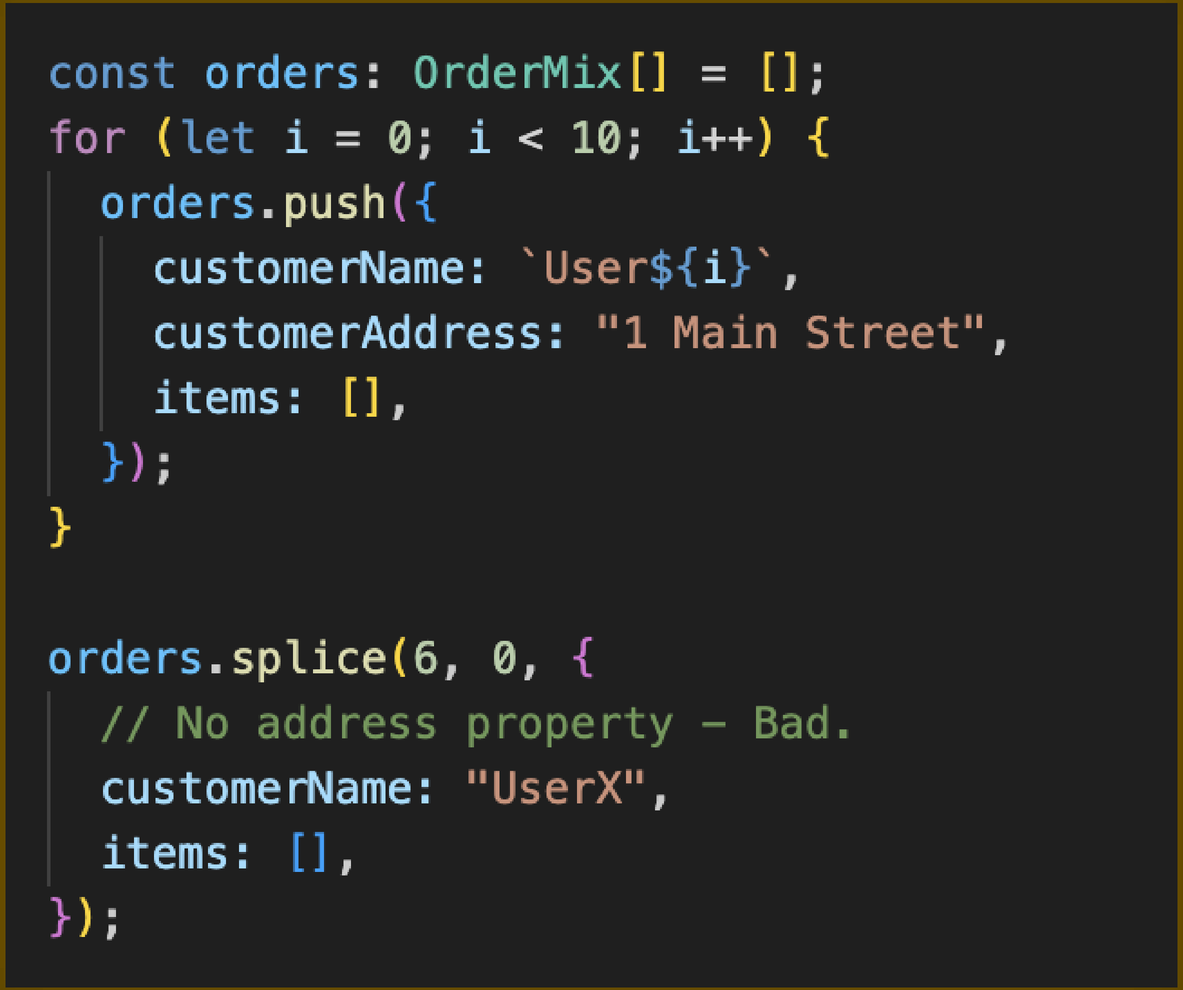

Cloud
Invalid Orders (DLQ)
AWS Lambda
Process Failed Orders
Invalid Order
Order Messages
Generate Orders
Amazon SQS
Orders Queue
AWS Lambda
Process Orders

Demo – Provision the DLQ .



```
const badOrdersQueue = new Queue(this, 'bad-orders-q');

const ordersQueue = new Queue(this, 'orders-queue', {
  deadLetterQueue: {
    queue: badOrdersQueue,
    // # of rejections by consumer (lambda function) before
    // message is transferred to DLQ
    maxReceiveCount: 1,
  },
});

// .... declare Lambda function resources .......

// Set SQS queues as Event sources for lambda functions
processOrdersFn.addEventSource(new SqsEventSource(ordersQueue))
failedOrdersFn.addEventSource(new SqsEventSource(badOrdersQueue));
```

Demo – Generate Orders (Producer).



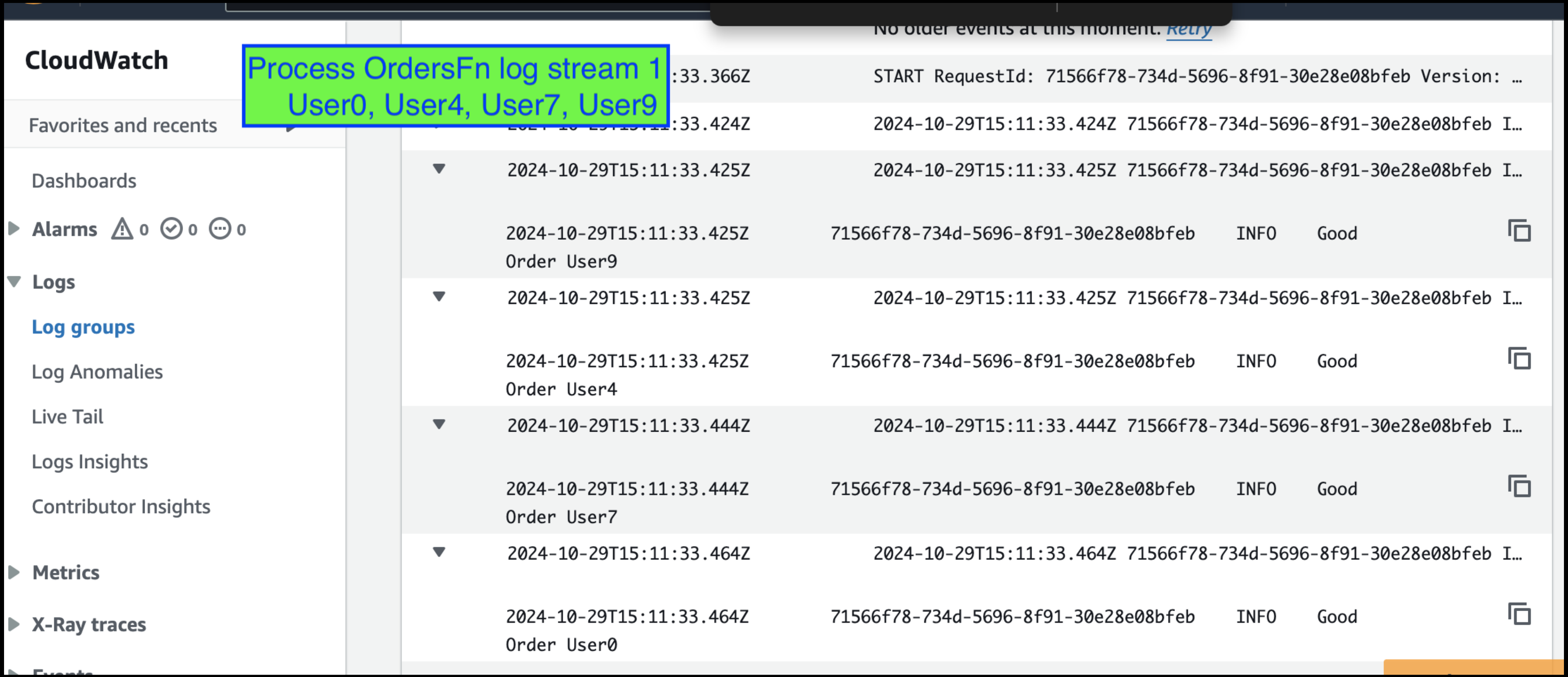
```
const orders: OrderMix[] = [];
for (let i = 0; i < 10; i++) {
  orders.push({
    customerName: `User${i}`,
    customerAddress: "1 Main Street",
    items: [],
  });
}

orders.splice(6, 0, {
  // No address property – Bad.
  customerName: "UserX",
  items: [],
});
```

Demo – Sample Execution

- Scenario:
  - Set the maxConcurrency of the Process Orders handler to 2.
  - Set the maximum receive count of the Orders q to 1 – batches containing a bad order are sent to DLQ after first failed processing attempt.

- Outcome:
  - Process Orders instance 1 → User0, User4, User7, User9.
  - Process Orders instance 2 → User1, User2, User3, User5, UserX, User8.
  - Bad Orders instance 1 → User1, User3, User8.
  - Bad Orders instance 2 → User2, User5, UserX.

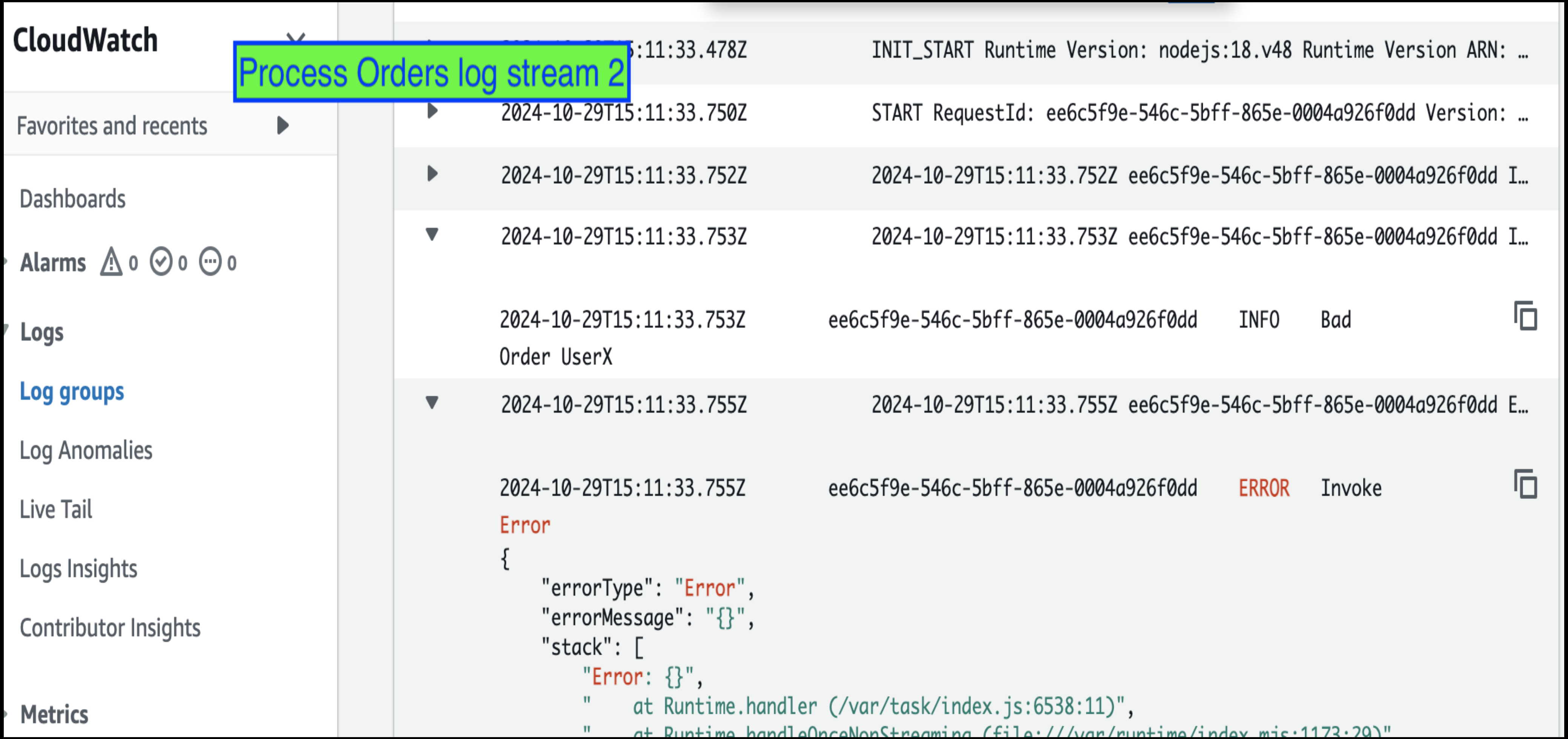
Demo – Sample Execution



Process OrdersFn log stream 1
User0, User4, User7, User9

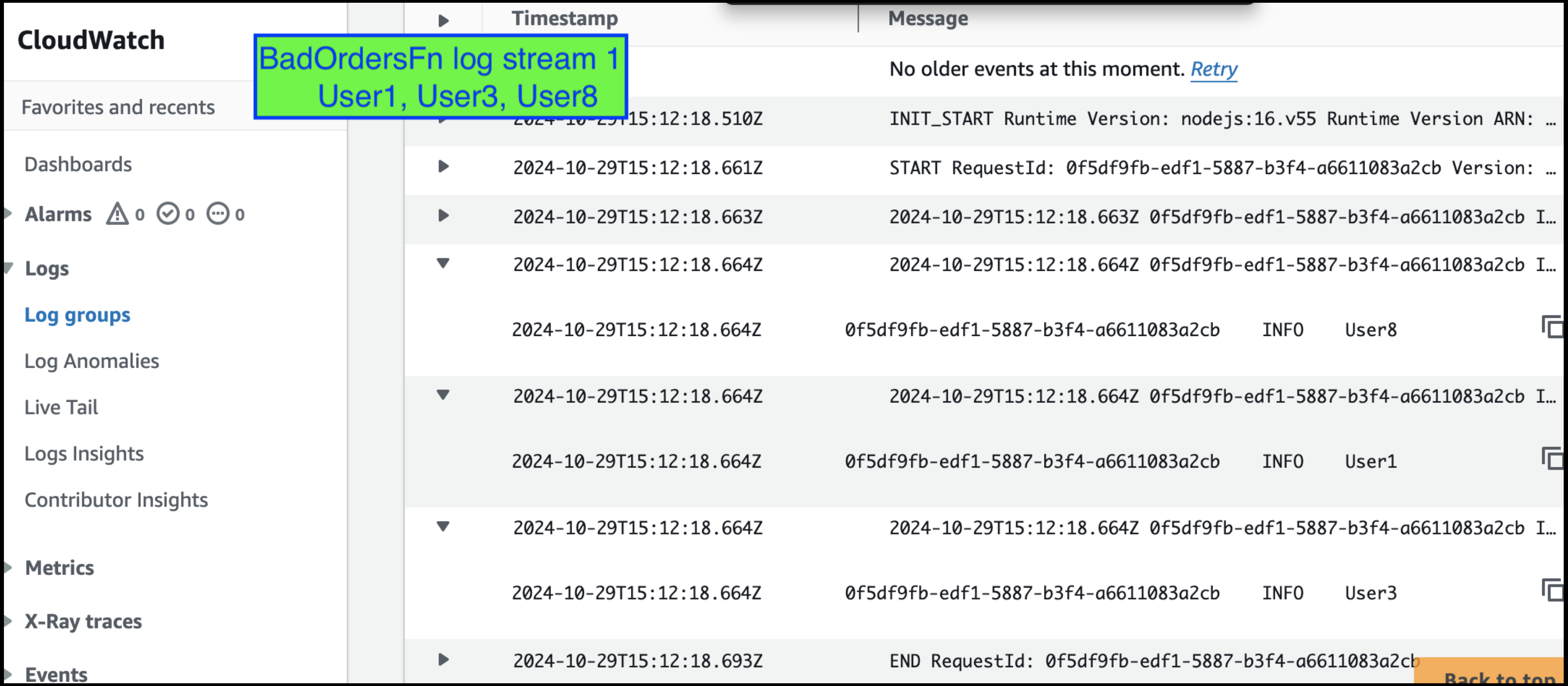
```
No older events at this moment. Retry
:33.366Z                START RequestId: 71566f78-734d-5696-8f91-30e28e08bfeb Version: …
:33.424Z                2024-10-29T15:11:33.424Z 71566f78-734d-5696-8f91-30e28e08bfeb I…
▼ 2024-10-29T15:11:33.425Z    2024-10-29T15:11:33.425Z 71566f78-734d-5696-8f91-30e28e08bfeb I…

  2024-10-29T15:11:33.425Z    71566f78-734d-5696-8f91-30e28e08bfeb    INFO    Good
  Order User9
▼ 2024-10-29T15:11:33.425Z    2024-10-29T15:11:33.425Z 71566f78-734d-5696-8f91-30e28e08bfeb I…

  2024-10-29T15:11:33.425Z    71566f78-734d-5696-8f91-30e28e08bfeb    INFO    Good
  Order User4
▼ 2024-10-29T15:11:33.444Z    2024-10-29T15:11:33.444Z 71566f78-734d-5696-8f91-30e28e08bfeb I…

  2024-10-29T15:11:33.444Z    71566f78-734d-5696-8f91-30e28e08bfeb    INFO    Good
  Order User7
▼ 2024-10-29T15:11:33.464Z    2024-10-29T15:11:33.464Z 71566f78-734d-5696-8f91-30e28e08bfeb I…

  2024-10-29T15:11:33.464Z    71566f78-734d-5696-8f91-30e28e08bfeb    INFO    Good
  Order User0
```

Demo – Sample Execution



```
5:11:33.478Z          INIT_START Runtime Version: nodejs:18.v48 Runtime Version ARN: …
2024-10-29T15:11:33.750Z          START RequestId: ee6c5f9e-546c-5bff-865e-0004a926f0dd Version: …
2024-10-29T15:11:33.752Z          2024-10-29T15:11:33.752Z ee6c5f9e-546c-5bff-865e-0004a926f0dd I…
2024-10-29T15:11:33.753Z          2024-10-29T15:11:33.753Z ee6c5f9e-546c-5bff-865e-0004a926f0dd I…

2024-10-29T15:11:33.753Z     ee6c5f9e-546c-5bff-865e-0004a926f0dd    INFO    Bad
Order UserX
2024-10-29T15:11:33.755Z          2024-10-29T15:11:33.755Z ee6c5f9e-546c-5bff-865e-0004a926f0dd E…

2024-10-29T15:11:33.755Z     ee6c5f9e-546c-5bff-865e-0004a926f0dd    ERROR   Invoke
Error
{
    "errorType": "Error",
    "errorMessage": "{}",
    "stack": [
        "Error: {}",
        "    at Runtime.handler (/var/task/index.js:6538:11)",
```

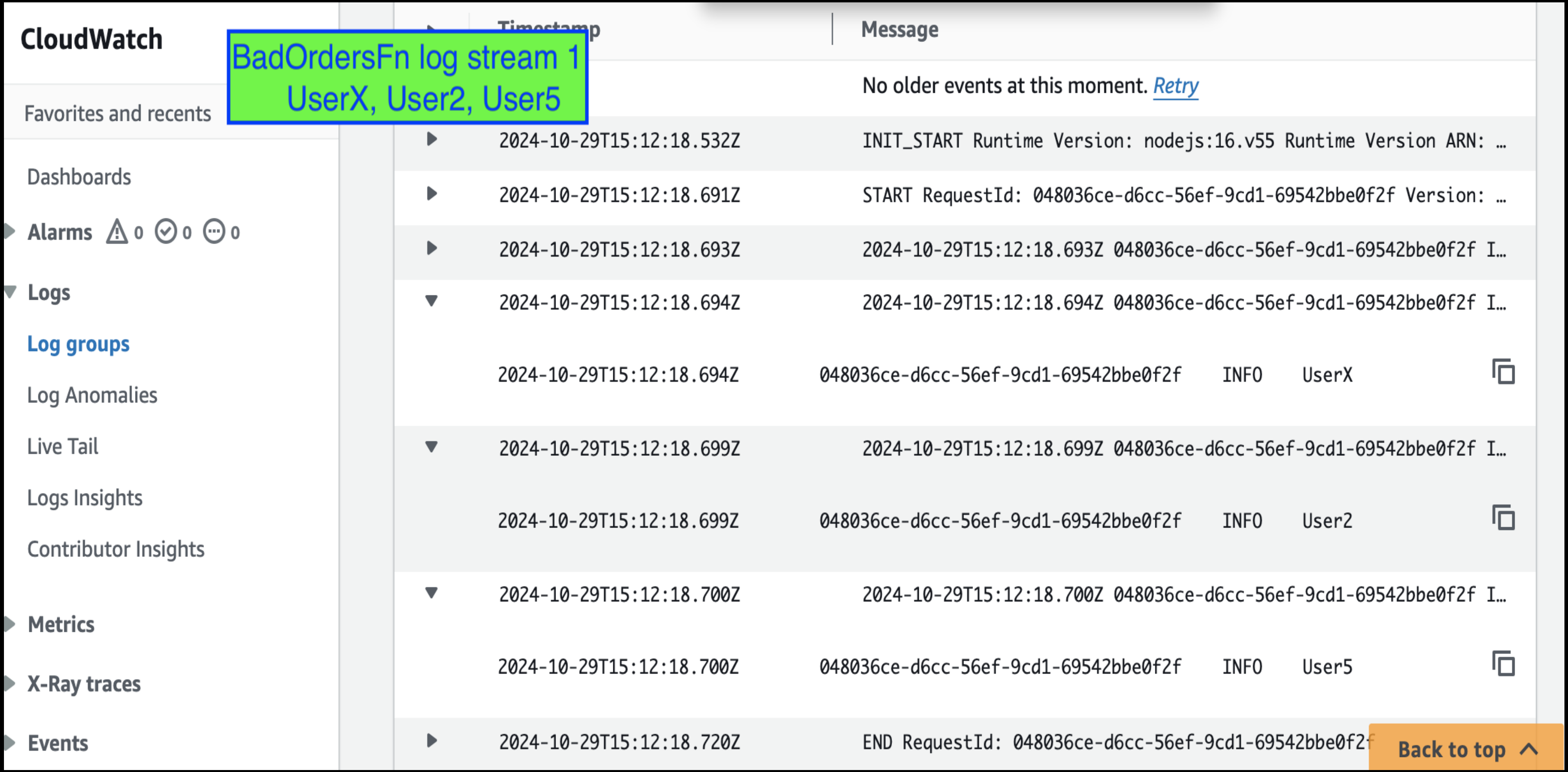
Demo – Sample Execution



BadOrdersFn log stream 1
User1, User3, User8

```
Timestamp                  Message
                           No older events at this moment. Retry
2024-10-29T15:12:18.510Z   INIT_START Runtime Version: nodejs:16.v55 Runtime Version ARN: …
2024-10-29T15:12:18.661Z   START RequestId: 0f5df9fb-edf1-5887-b3f4-a6611083a2cb Version: …
2024-10-29T15:12:18.663Z   2024-10-29T15:12:18.663Z 0f5df9fb-edf1-5887-b3f4-a6611083a2cb I…
2024-10-29T15:12:18.664Z   2024-10-29T15:12:18.664Z 0f5df9fb-edf1-5887-b3f4-a6611083a2cb I…
    2024-10-29T15:12:18.664Z   0f5df9fb-edf1-5887-b3f4-a6611083a2cb   INFO   User8
2024-10-29T15:12:18.664Z   2024-10-29T15:12:18.664Z 0f5df9fb-edf1-5887-b3f4-a6611083a2cb I…
    2024-10-29T15:12:18.664Z   0f5df9fb-edf1-5887-b3f4-a6611083a2cb   INFO   User1
2024-10-29T15:12:18.664Z   2024-10-29T15:12:18.664Z 0f5df9fb-edf1-5887-b3f4-a6611083a2cb I…
    2024-10-29T15:12:18.664Z   0f5df9fb-edf1-5887-b3f4-a6611083a2cb   INFO   User3
2024-10-29T15:12:18.693Z   END RequestId: 0f5df9fb-edf1-5887-b3f4-a6611083a2cb
```

Demo – Sample Execution



BadOrdersFn log stream 1
UserX, User2, User5

```
Timestamp                   Message
                            No older events at this moment. Retry
2024-10-29T15:12:18.532Z    INIT_START Runtime Version: nodejs:16.v55 Runtime Version ARN: …
2024-10-29T15:12:18.691Z    START RequestId: 048036ce-d6cc-56ef-9cd1-69542bbe0f2f Version: …
2024-10-29T15:12:18.693Z    2024-10-29T15:12:18.693Z 048036ce-d6cc-56ef-9cd1-69542bbe0f2f I…
2024-10-29T15:12:18.694Z    2024-10-29T15:12:18.694Z 048036ce-d6cc-56ef-9cd1-69542bbe0f2f I…
    2024-10-29T15:12:18.694Z    048036ce-d6cc-56ef-9cd1-69542bbe0f2f    INFO    UserX
2024-10-29T15:12:18.699Z    2024-10-29T15:12:18.699Z 048036ce-d6cc-56ef-9cd1-69542bbe0f2f I…
    2024-10-29T15:12:18.699Z    048036ce-d6cc-56ef-9cd1-69542bbe0f2f    INFO    User2
2024-10-29T15:12:18.700Z    2024-10-29T15:12:18.700Z 048036ce-d6cc-56ef-9cd1-69542bbe0f2f I…
    2024-10-29T15:12:18.700Z    048036ce-d6cc-56ef-9cd1-69542bbe0f2f    INFO    User5
2024-10-29T15:12:18.720Z    END RequestId: 048036ce-d6cc-56ef-9cd1-69542bbe0f2f
```

SQS - Summary

- What:
  - Messaging service
  - Decoupling app compute components
- Why:
  - Decrease response time to client; Improve scalability.
- Actors: Producer and Consumer.
- Consumer polls the queue.
- Lambda function consumer.
  - Lambda service polls SQS; Scales handler instances
- Dealing with error cases:
  - Retries (Infinite by default)
  - Dead Letter Queue (DLQ)