
AWS
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SVS312

Building Serverlesspresso: Creating event-driven architectures

James Beswick

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AWS

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About me



- James Beswick
  - Email: jbeswick@amazon.com
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- Manager of AWS Serverless Developer Advocacy
- Serverless geek
- Previously
  - Software Engineer and Product Manager
  - Multiple startup tech guy and Fortune 500s
  - AWS customer since 2012

Agenda

1. Intro to Serverlesspresso
2. Design decisions
3. Lessons learned
4. Useful patterns

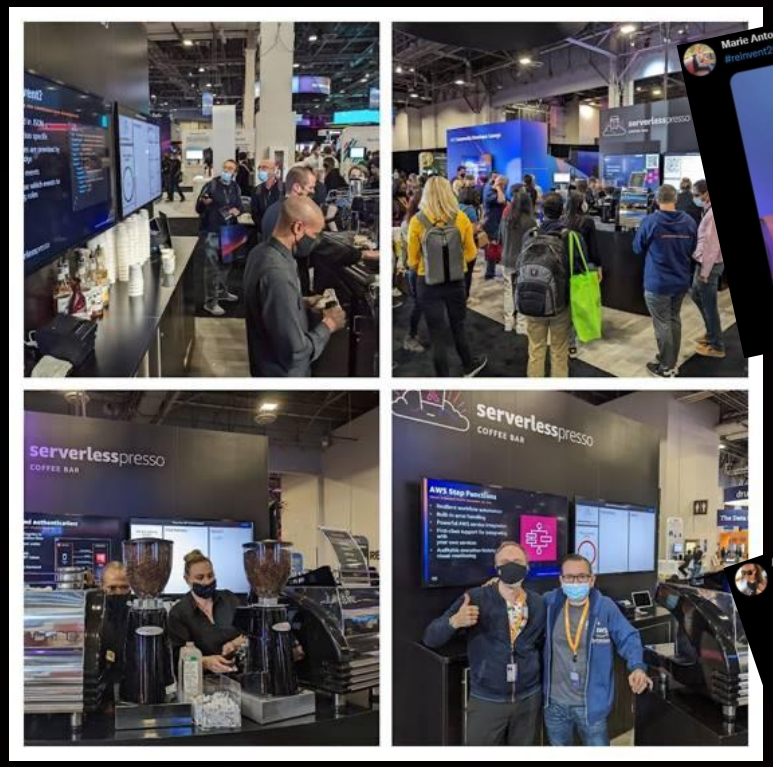
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serverlesspresso

An event-driven coffee ordering app
built with serverless architecture

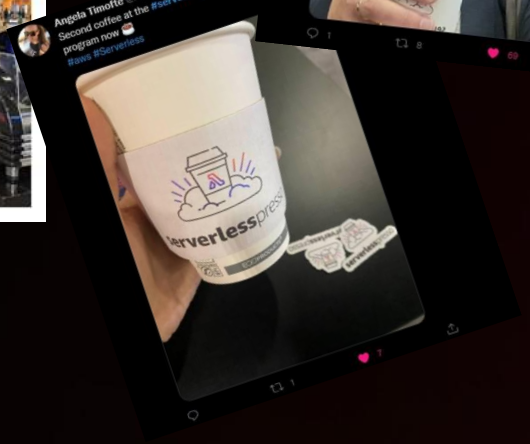
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- 1,920 drinks at re:Invent 2021
- 71 drinks per hour
- Appeared at AWS Summits, EDA Day, GOTO, and others
- Averages 1,000 drinks per day

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What is Serverlesspresso?



The workflow

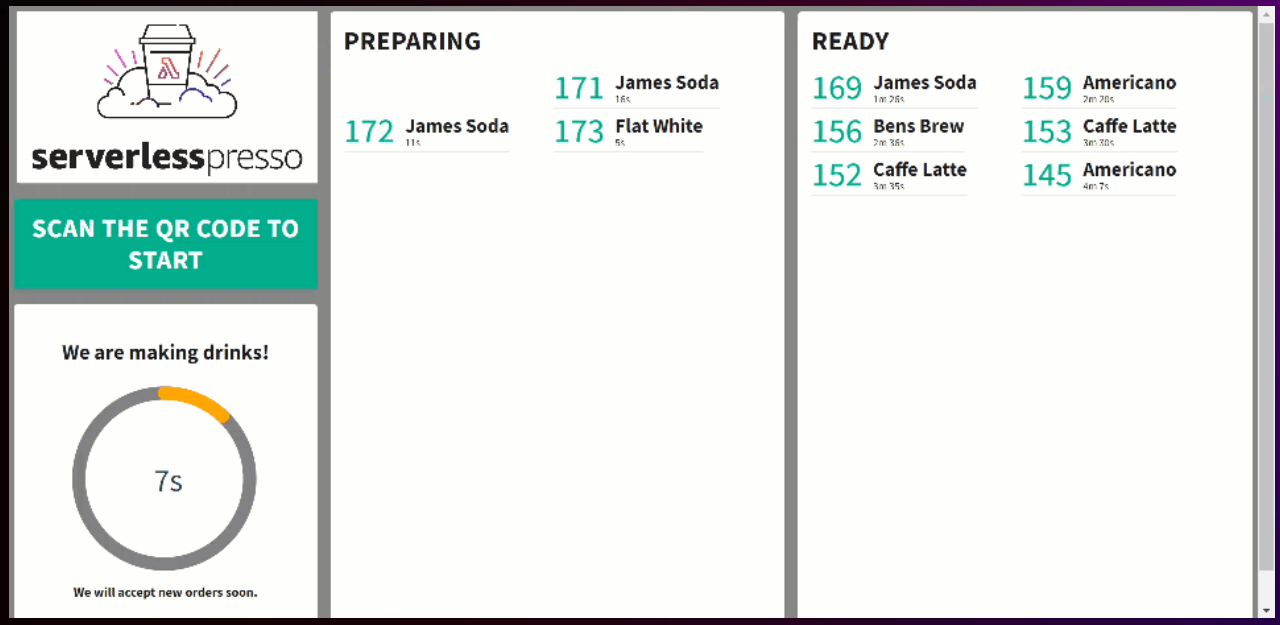
1. Scan a dynamic QR code
2. Place an order with your mobile device
3. The order appears on the monitor and the barista's tablet app
4. You get a notification when the drink is ready

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The Display Web App

VUE.JS APPS HOSTED WITH AWS AMPLIFY CONSOLE

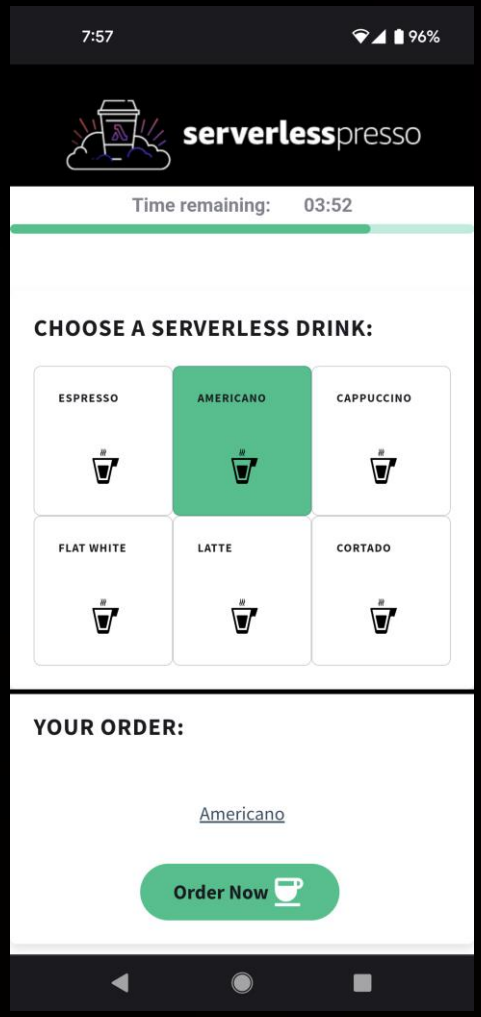
- Shows new barcode every 5 mins
- Receives order status updates
- Listens for store open/close events



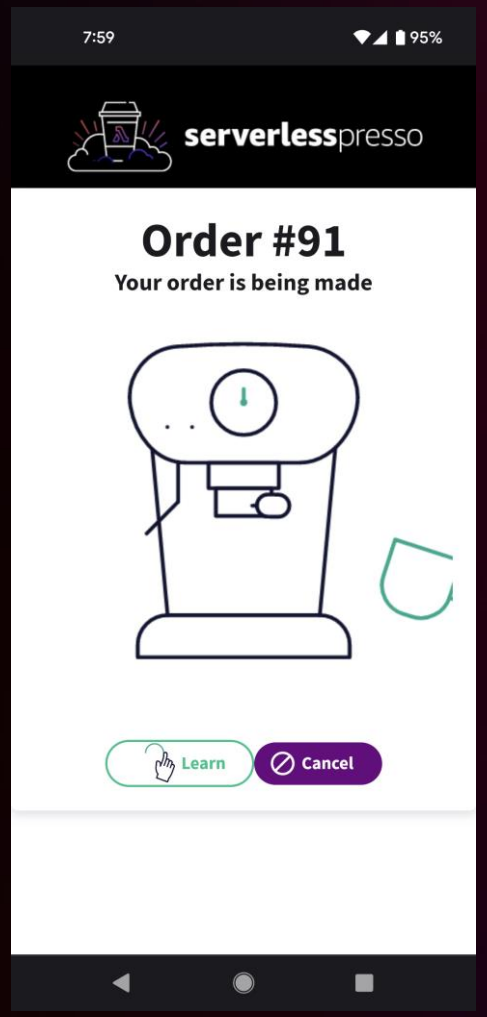
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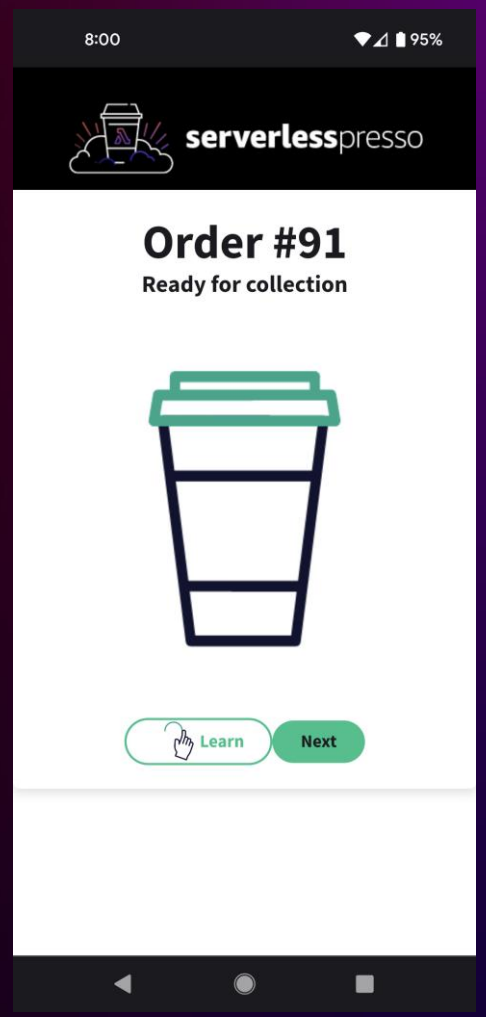
The Ordering Web App

VUE.JS APPS HOSTED WITH AWS AMPLIFY CONSOLE







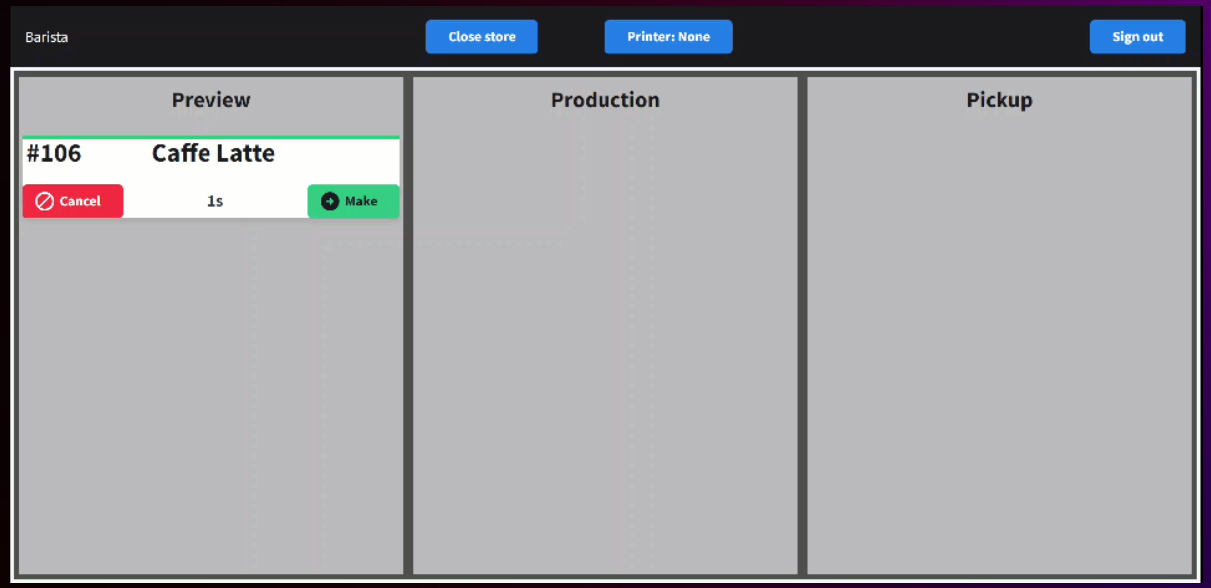


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The Barista Web App

VUE.JS APPS HOSTED WITH AWS AMPLIFY CONSOLE

- Shows incoming orders
- Allows baristas to pick up incoming orders
- Enables order completion or cancellation
- Enables store open/close events
- Prints tickets

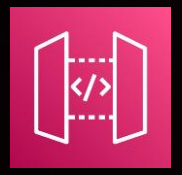


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AWS services used



AWS Amplify console



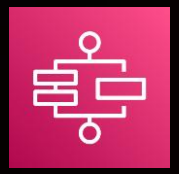
Amazon API Gateway



Amazon DynamoDB



Amazon EventBridge



AWS Step Functions



AWS IoT Core



AWS Lambda

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Design decisions

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Guidelines we used

Architecture goals

- Minimal code
- Extensibility
- Scalability
- Cost efficiency

Tenets

- Each team member responsible for one component
- No implementation sharing
- Each microservice has API/events – no data sharing

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Defining the workflow

The process for making a drink

1) Customer scans the barcode
2) Check the store is open
3) Get barista capacity
4) Wait for the customer order – cancel if > 5 mins
5) Generate an order number
6) Wait for barista to make the drink – cancel if > 15 mins
7) Handle cancelation by the customer or barista



Write it all in (pseudo)code?

```
// Order acceptance

if (isStoreOpen) {
  if (isBaristaBusy) {
    saveOrderToDynamoDB(timeStamp)
  } else {
    rejectOrder('Barista busy')
  }
} else {
  rejectOrder('Store not open')
}
```

```
// Check for timeouts every minute

const orders = getAllOpenOrdersFromDDB
const now = currentTime

for (order in orders) {
  // Did customer time out?
  if (order.waitingForCustomer &&
     (now - order.timeStamp) > 5 mins)
  {
    rejectOrder('Customer timed out')
    updateDynamoDB
  }

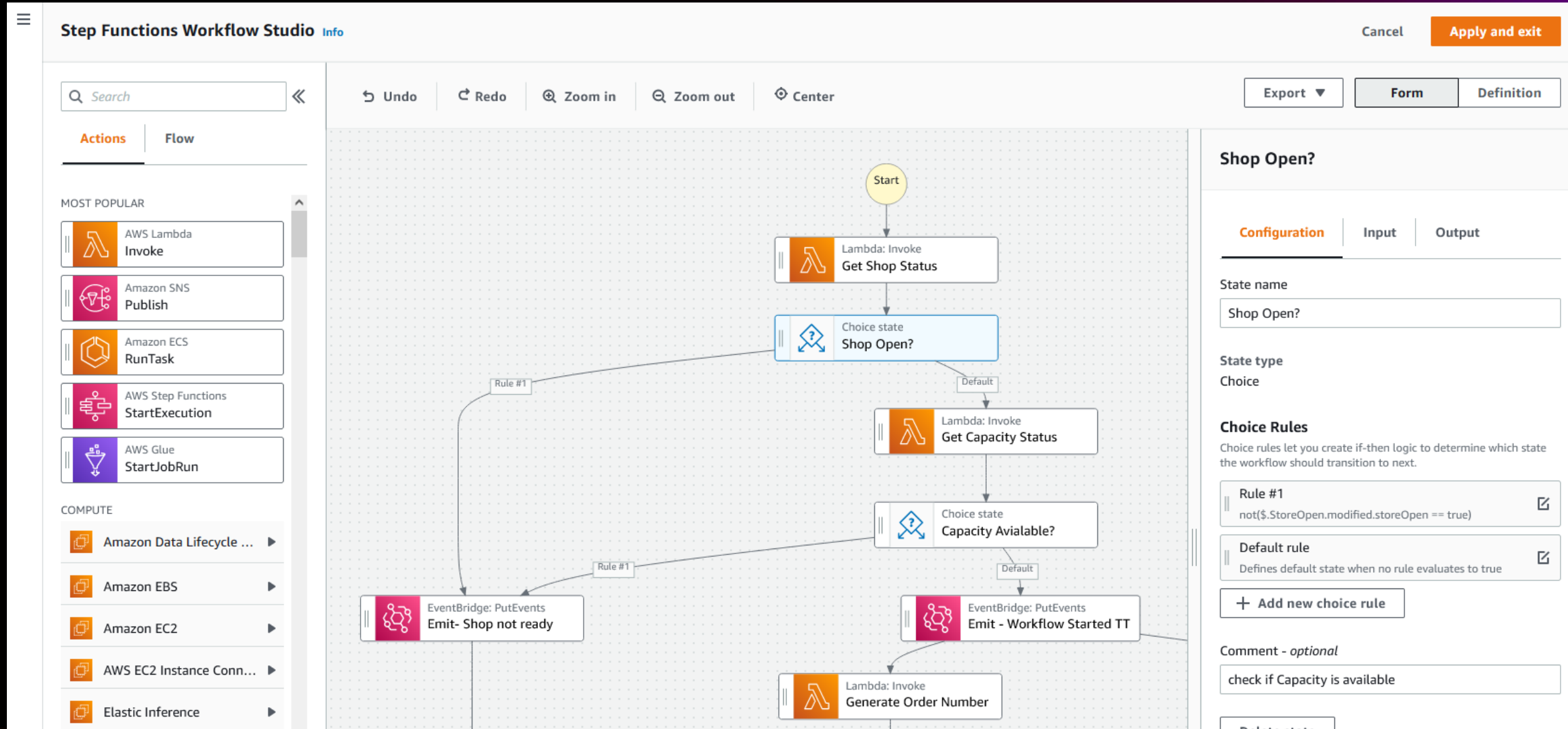
  // Then check for barista time out
  ...
}
```

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Instead design visually with Workflow Studio

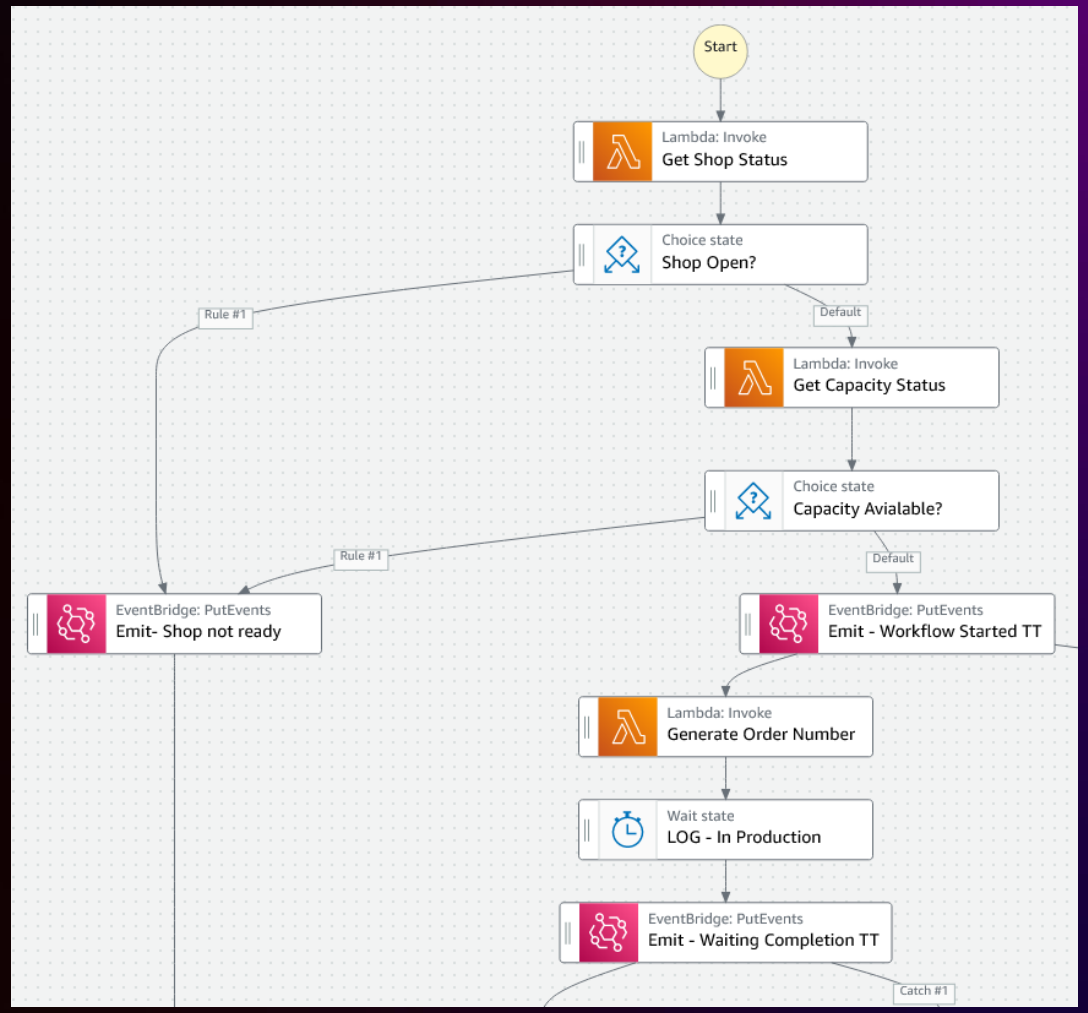
REPLACE SPAGHETTI CODE WITH STATE MACHINES



Managing each coffee's journey

USING AWS STEP FUNCTIONS TO MANAGE EACH WORKFLOW EXECUTION

- Ensure store is open and baristas have capacity
- Allow customer 5 minutes to order before timing out/cancelling
- Allow barista 15 minutes to make before timing out/cancelling
- Uses Lambda functions for custom logic



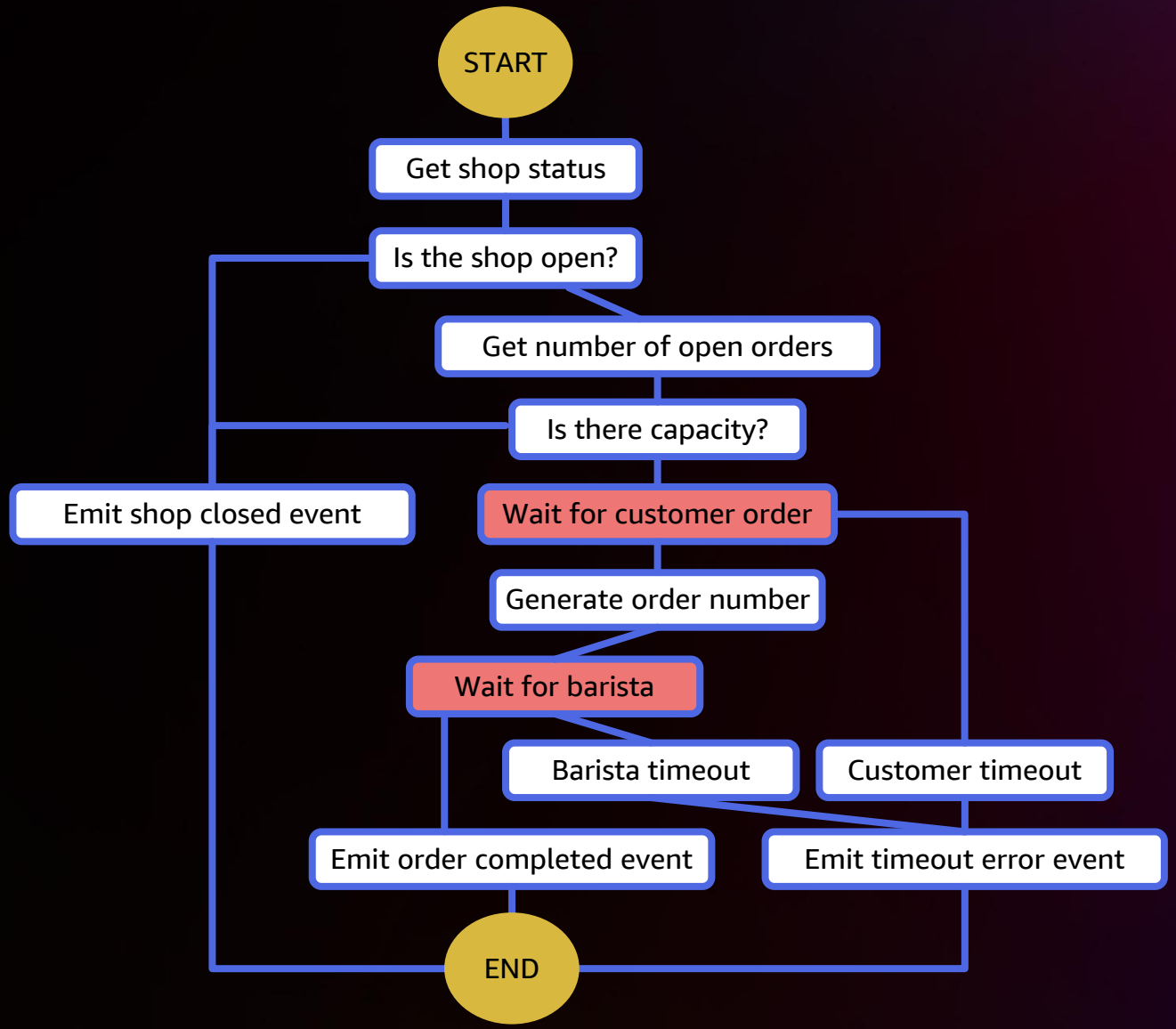


serverlesspresso

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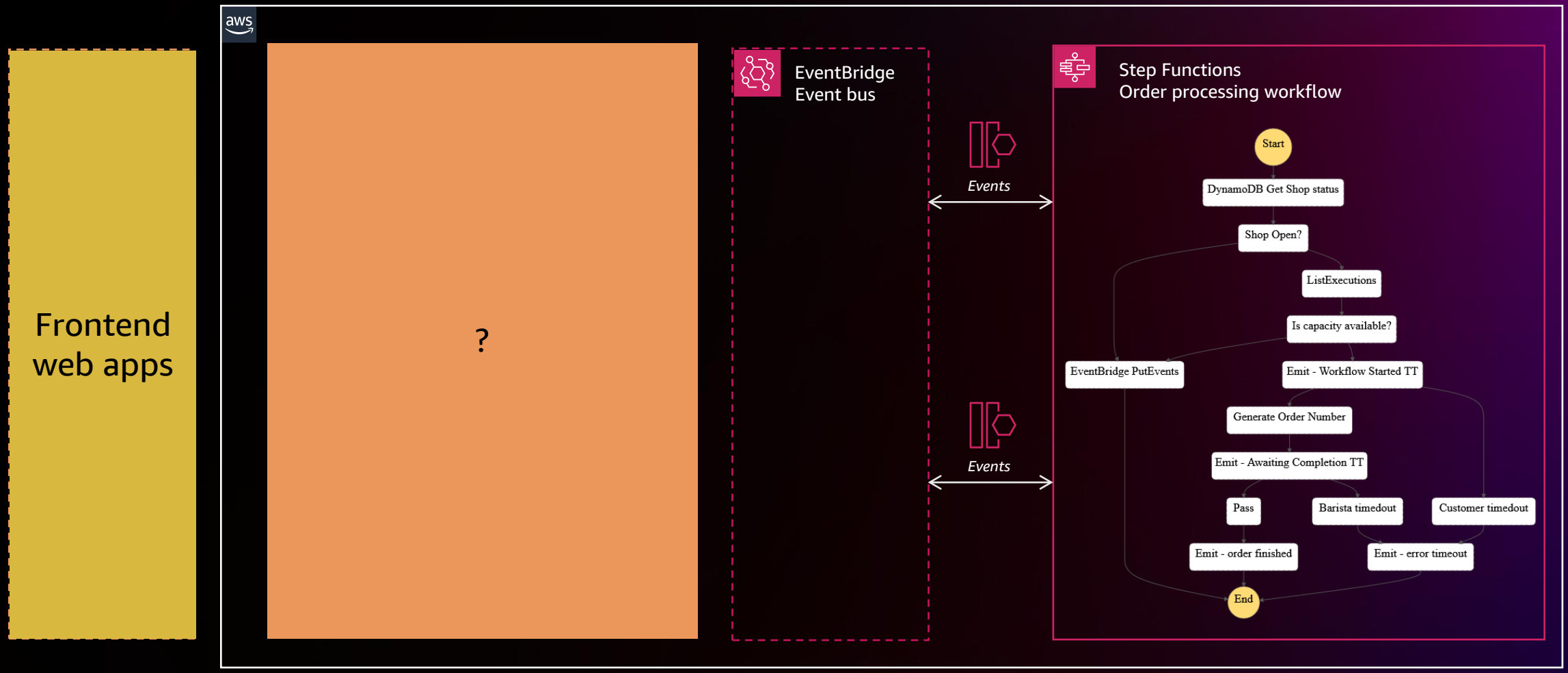
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The version 1 workflow



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Architecture so far



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Starting the order

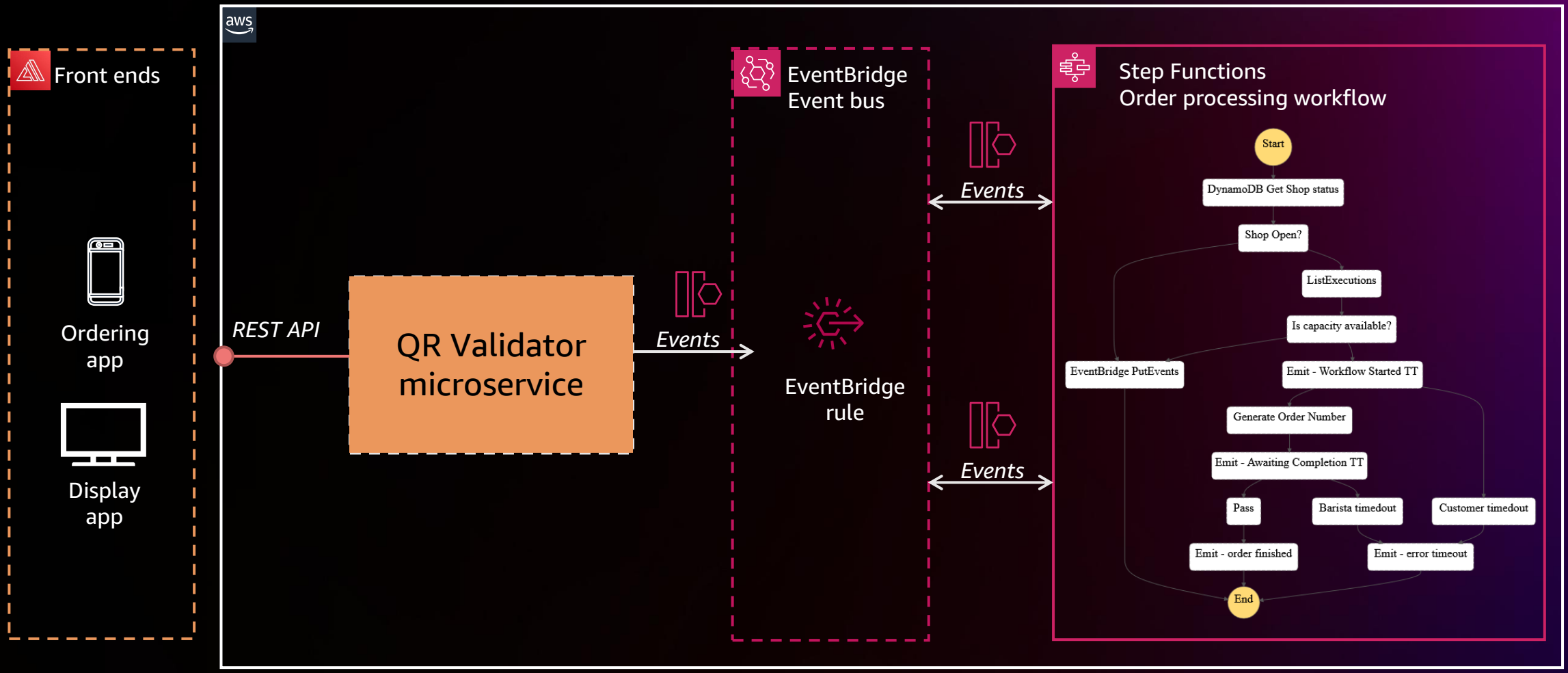
The QR validator microservice

- Throttles the queue to 10 drinks per interval
- Interval is 5 minutes by default
- Generates new QR codes
- QR disappears once all scans "used”
- Successful scan starts the order



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Introducing the QR validator microservice



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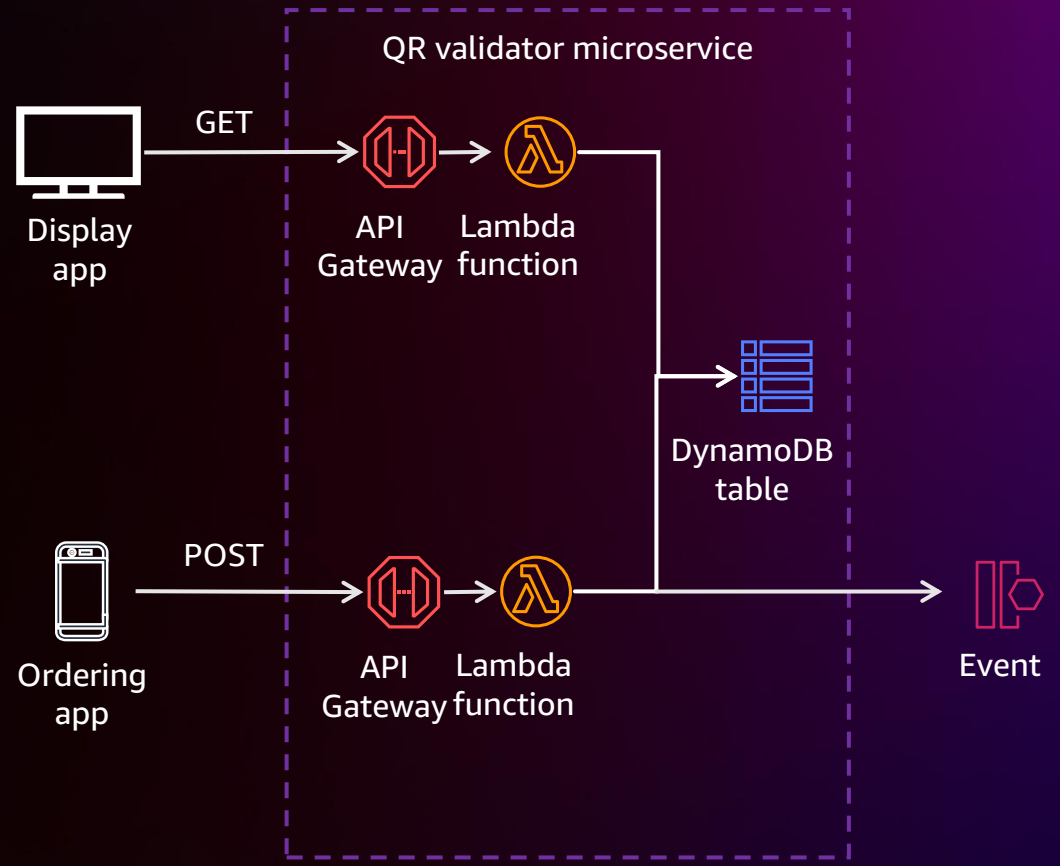
Inside the QR validator service

Generate

- Display app requests new QR code
- Random ID stored in DynamoDB

Validate

- Phone scans the QR code
- ID is passed as a parameter
- Returns success or failure
- Emits an event if successful



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The QR validator DynamoDB table

PK	Available tokens	End_ts	Last_code	Last_id	Start_ts
1234423	10	1645200599999	41g_-KJHGT	1234423	1645200300000
1234123	8	1645628399999	6KJH_-FJ5Lh	1234123	1645628100000
5412322	1	1645449599999	91HHFFJHF	5412322	1645449300000
3435657	2	1645435199999	OCZomT756	3435657	1645434900000

When a valid QR is scanned, it decrements **Available tokens**

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Managing orders

Need to

- Update and cancel orders
- Store and use TaskTokens
- Get list of open or completed orders

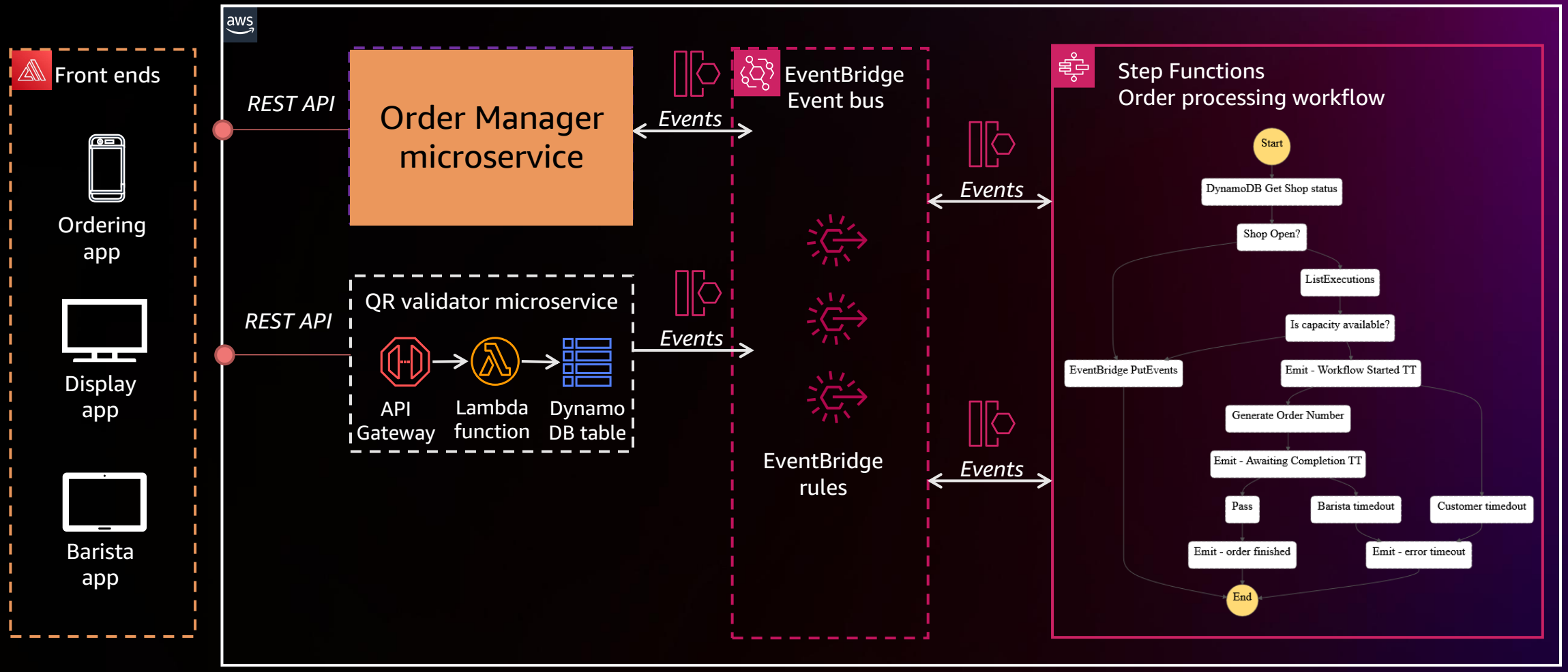
Should we

- Build a monolithic workflow?
- Keep the TaskTokens at the client?
- Query all open workflows?

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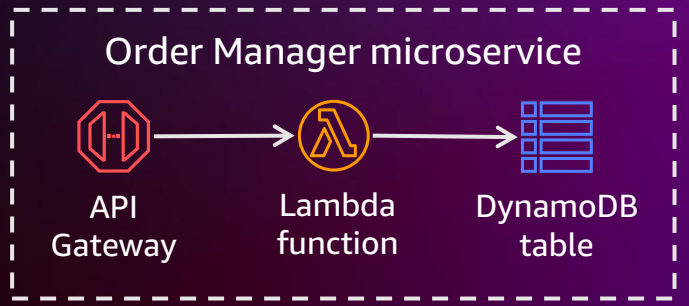
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Introducing the Order Manager microservice



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Updating orders



- Persists each order to a DynamoDB table
- Item updated at various stages of the order lifecycle
- Responsible for managing task tokens
- GSI on OrderState attribute for querying open/completed orders

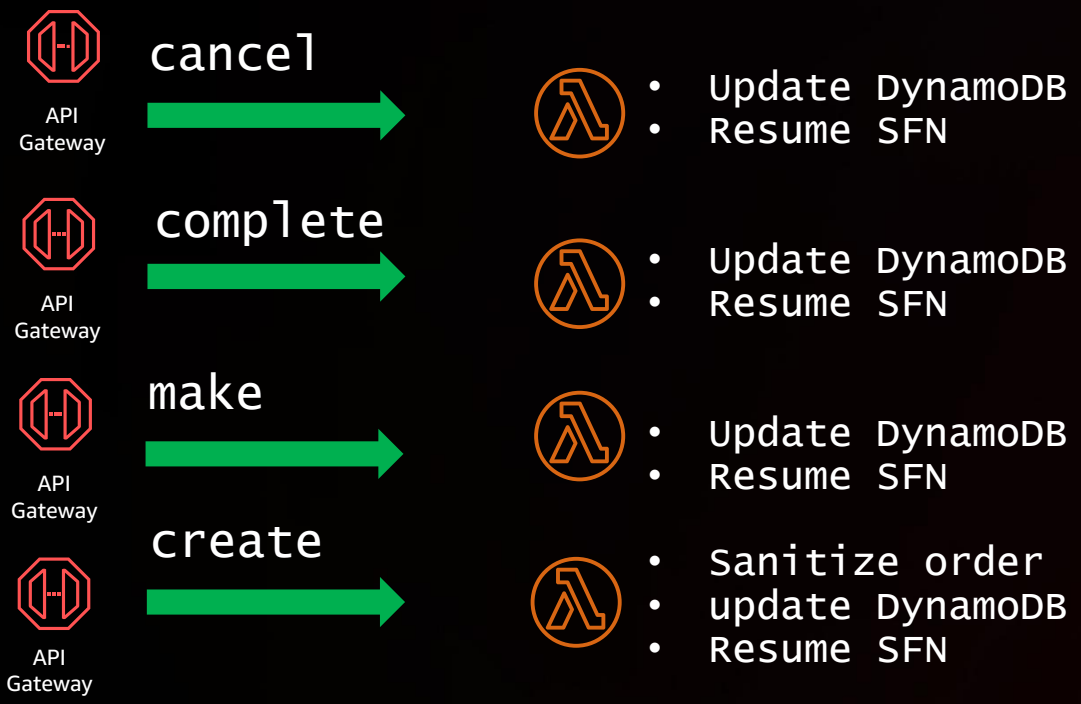
PK	SK	TS	UID	OrderNo	TaskToken	OrderState	DrinkOrder
Orders	2	1645726346199	1	10	AAAAKgAAAAIAAAAAAAAAAAlp4um0gPw/FO3rqpCDvlEAL+l/h+	COMPLETED	{"userId":"1","drink":"Cappuccino","modifiers":[],"icon":"barista-icons_cappuccino-alternative"}

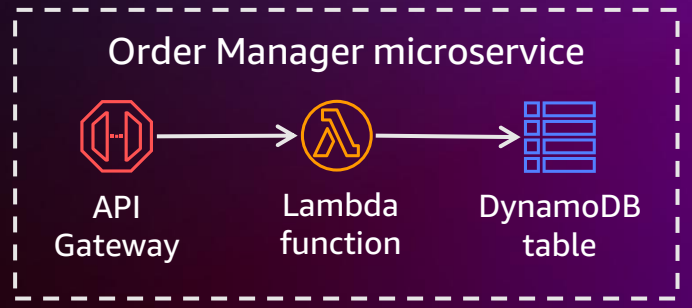
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Order Manager service

Version 1

Each operation invokes a Lambda Function





Application grew more complex over time, performing multiple tasks to handle increasingly complex business logic

Led to

- Tightly coupled code base
- Slower release cadence
- Poor discoverability
- Additional complexity

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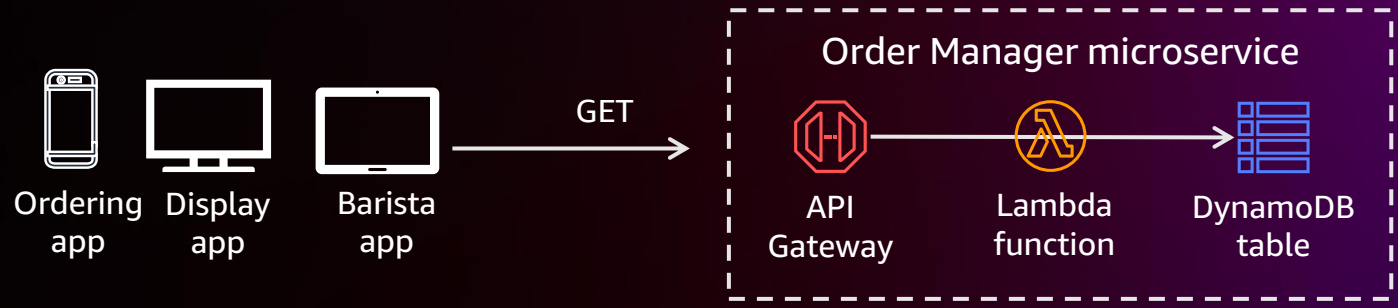
Order Manager service: Direct integration

Version 1.5

/myOrders - GET
/orders - GET
/orders/{id} - GET

Front ends query *Order* table directly from API Gateway

Velocity mapping templates modify the incoming request




```
#set($subFromJWT = $context.authorizer.claims.sub)

{
    "TableName": "serverlesspresso-order-table",
    "IndexName": "GSI-userId",
    "KeyConditionExpression": "#USERID = :USERID",
    "ExpressionAttributeNames": {
    "#USERID": "USERID"
    },
    "ExpressionAttributeValues": {
    ":USERID": {
      "S": "$subFromJWT"
    }
    },
    "ScanIndexForward": true,
    "ProjectionExpression": "PK, SK, orderNumber, robot, drinkOrder,
ORDERSTATE, TS"
}
```

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Order Manager service: CRUD operations

Version 1.5

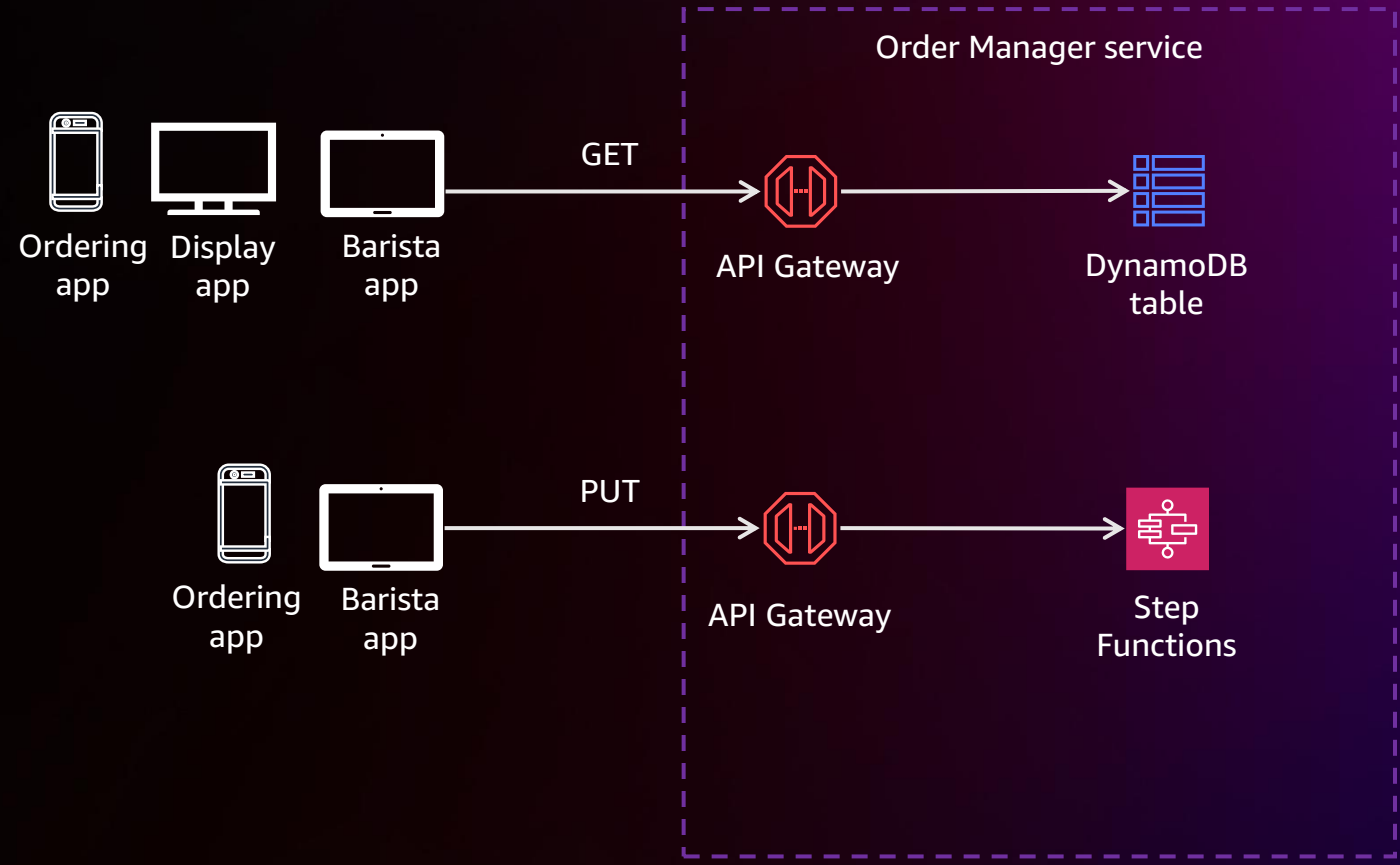
/myOrders - GET

/orders - GET

/orders/{id} - GET

/orders/{id} - PUT

Updates made to *Order* table via a PUT request

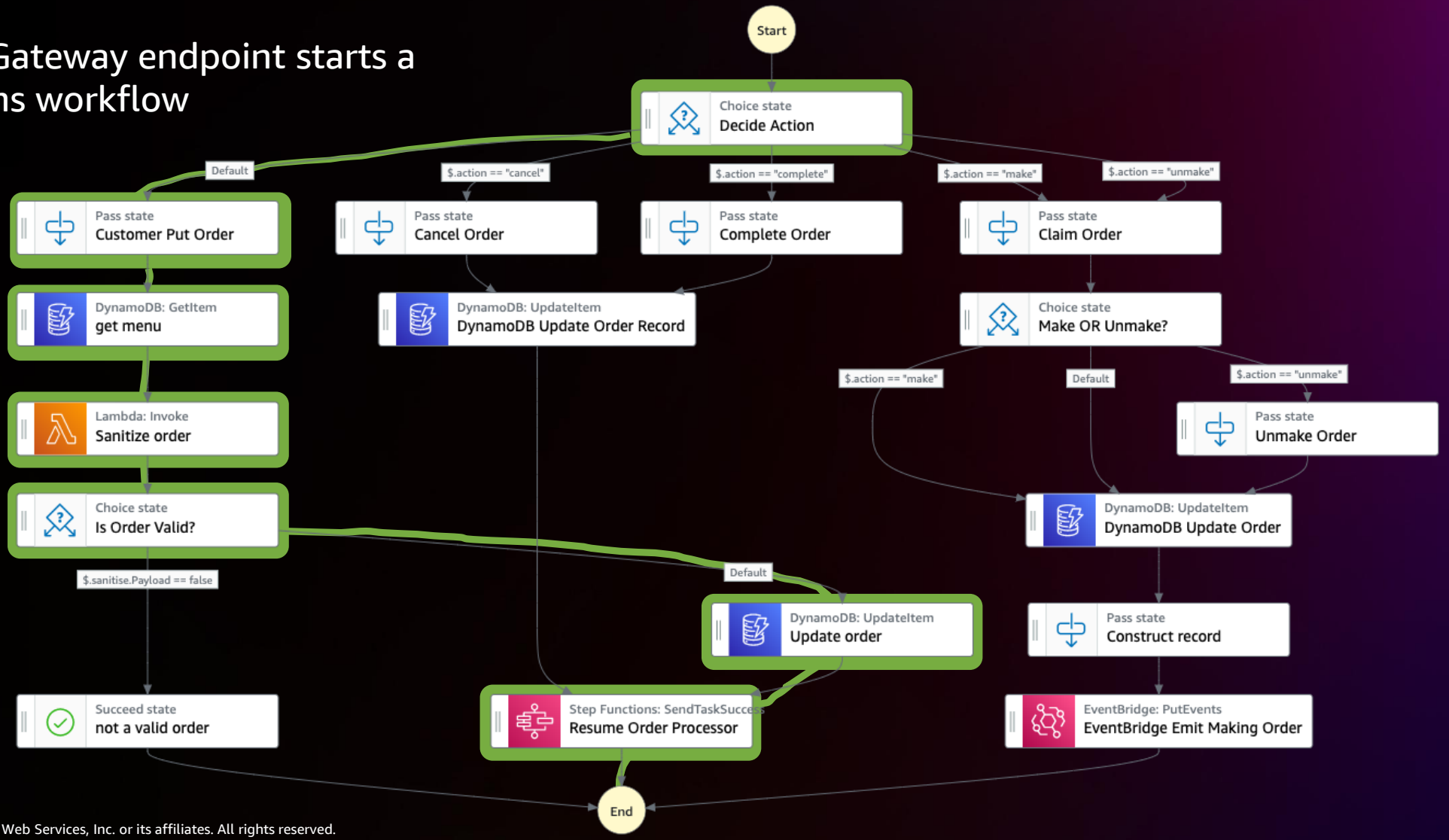


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Order Manager service as a workflow

Version 2

A single API Gateway endpoint starts a Step Functions workflow



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Notifying the web apps

Need to

- Keep web apps in sync with order state
- Respond to global events, such as store open/close
- Approximate real-time without refreshing
- Be resilient, given mobile network dropout

Should we

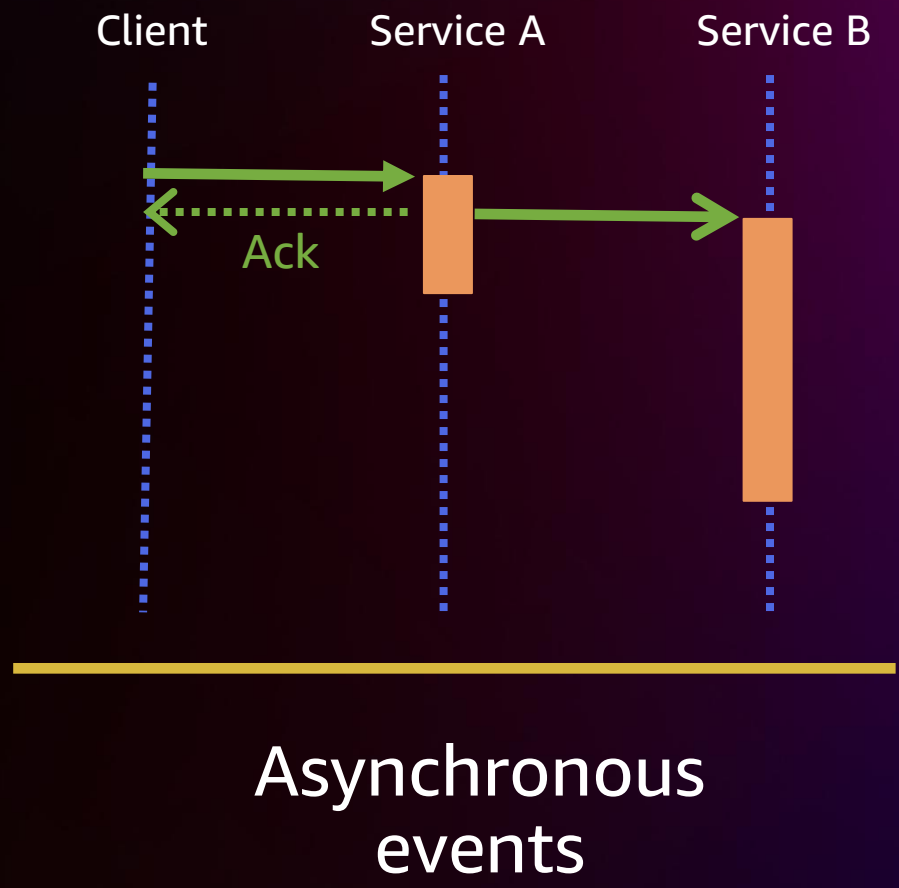
- Create polling APIs?
- Use mechanisms like SMS?
- Use API Gateway WebSockets?

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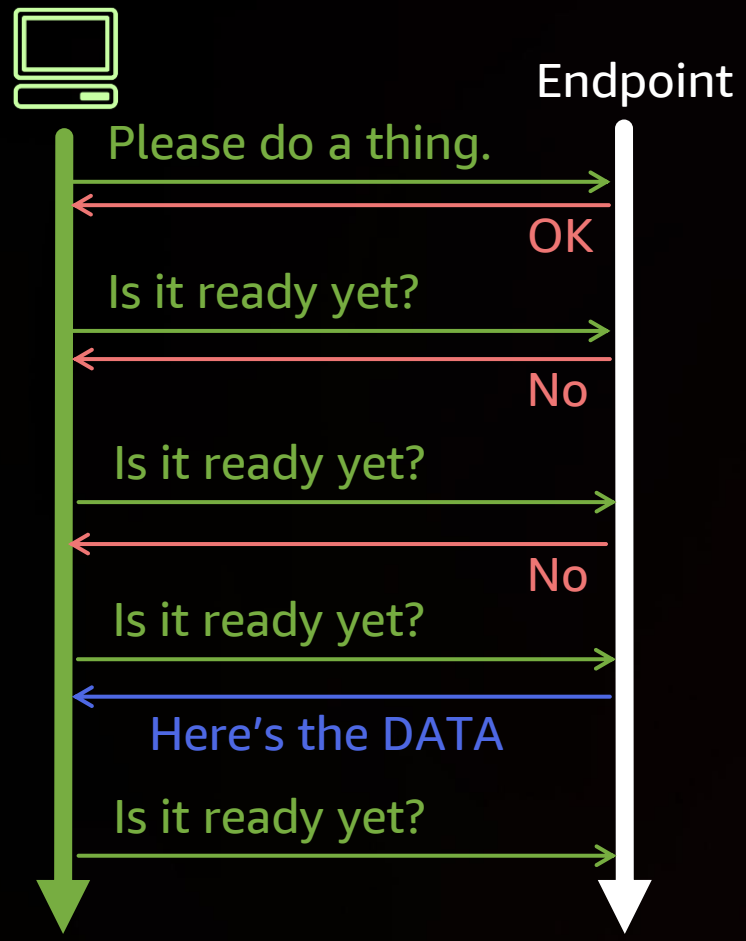
Handling response values and state for asynchronous requests

No return path to provide further information beyond the initial acknowledgement



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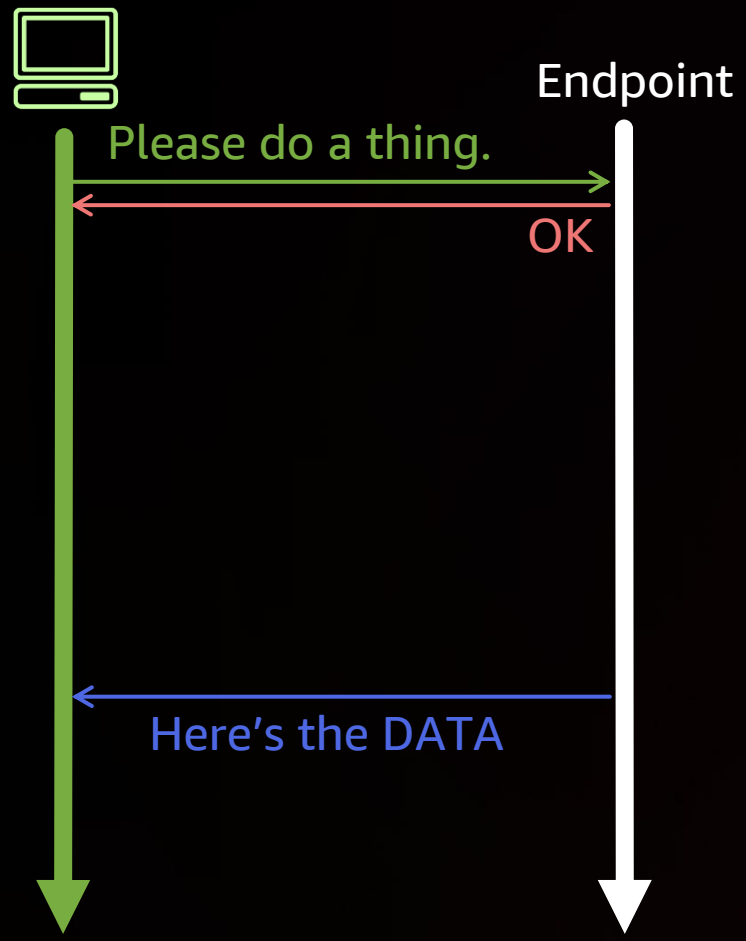
Tracking an inflight request: Polling



- Initial request returns a tracking identifier
- Create a second API endpoint for the front end to check the request status, referencing the tracking ID
- Use DynamoDB to track the state of the request
- Simple mechanism to implement
- Can create many empty calls
- Delay between availability and front-end notification

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Tracking an inflight request: WebSocket



- A bidirectional connection between the front end client and the backend service
- Your backend services can continue to send data back to the client by using a WebSocket connection
- Closer to real time
- Reduces the number of messages between the client and backend system
- Often more complex to implement

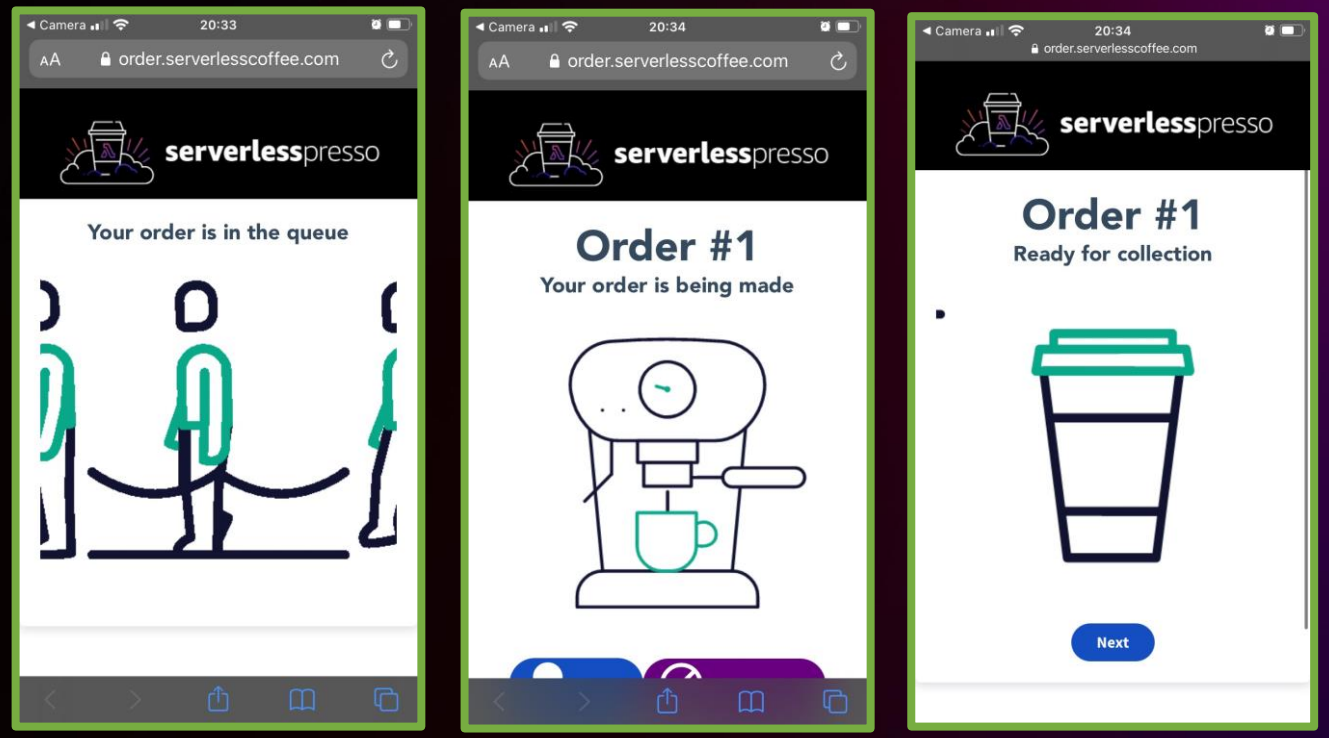
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Using AWS IoT Core for real-time messaging

WEB APPLICATIONS OFTEN REQUIRE PARTIAL INFORMATION



Completion percentages

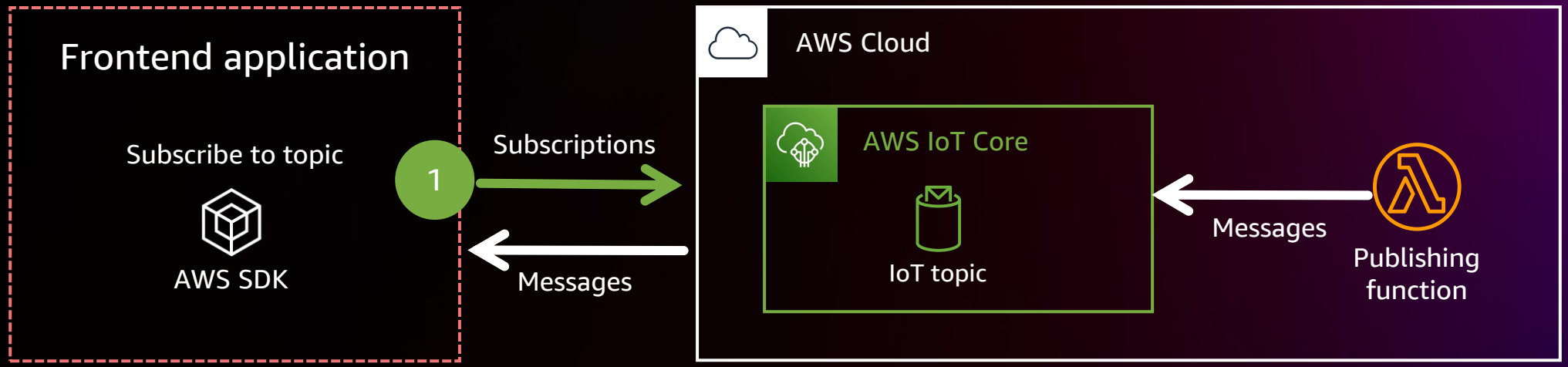


Continuous data changes

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Using AWS IoT Core for real-time messaging

Frontend application uses pub-sub to “listen” for event updates

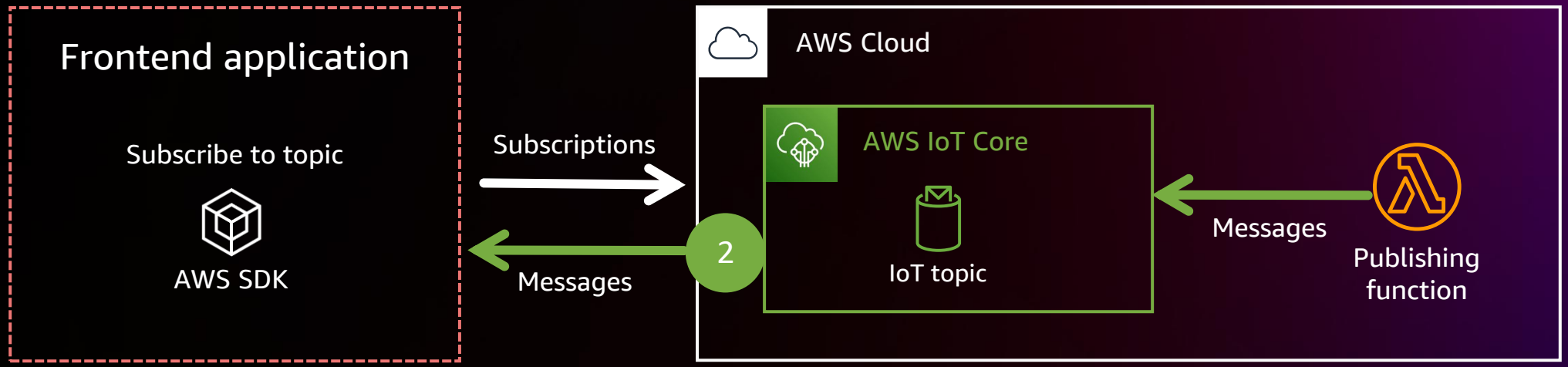


Frontend uses AWS SDK to subscribe to a topic based on user’s unique user ID

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Using AWS IoT Core for real-time messaging

Frontend application uses pub-sub to “listen” for event updates

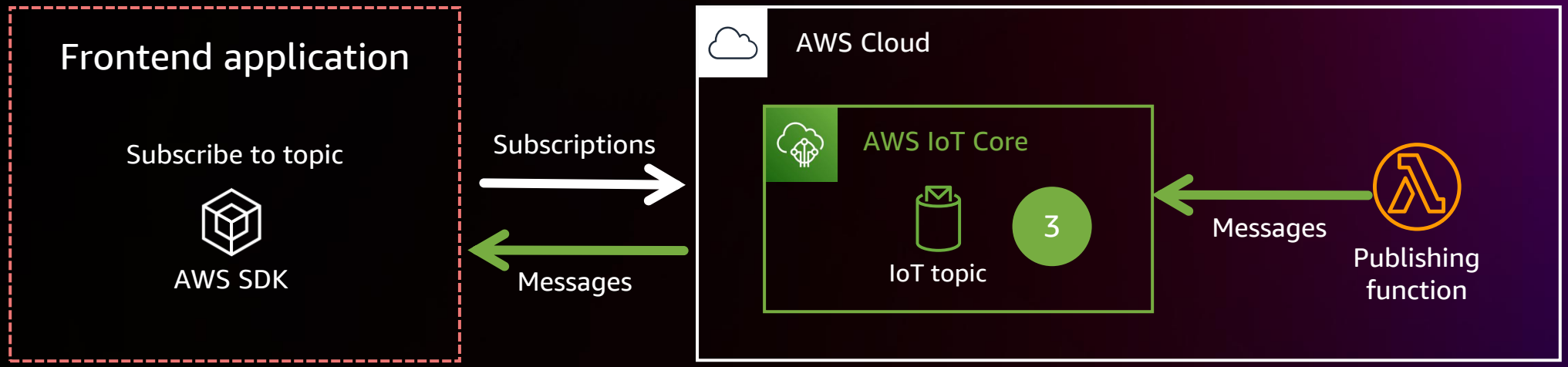


Receives messages published by the backend to this topic

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Using AWS IoT Core for real-time messaging

Frontend application uses pub-sub to “listen” for event updates

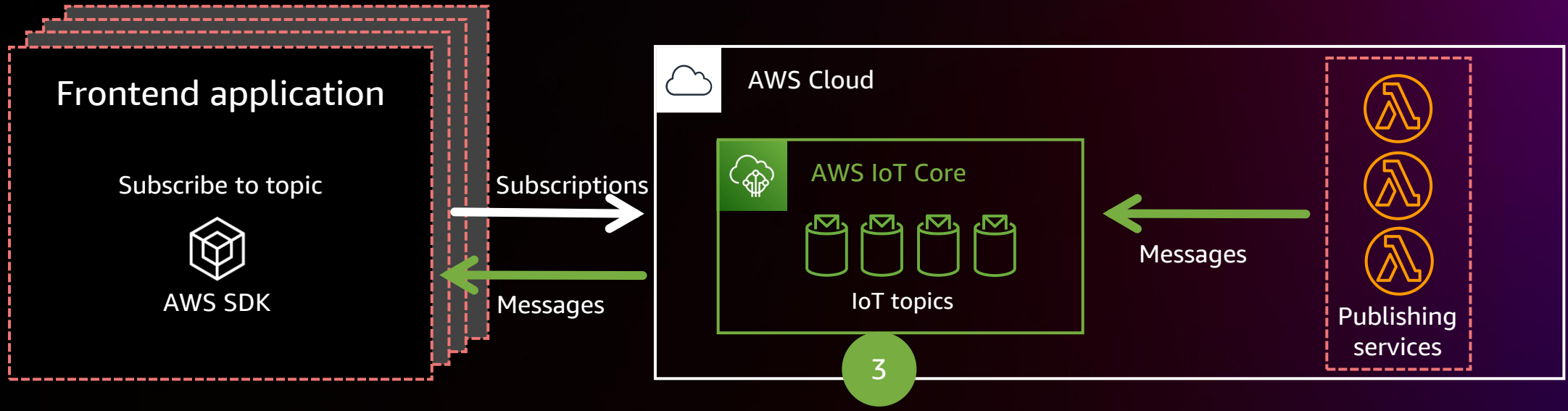


Messages are categorized using topics

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Using AWS IoT Core for real-time messaging

Frontend application uses pub-sub to “listen” for event updates



The AWS IoT Core service manages the WebSocket connection between publishers and subscribers

This enables fanout functionality to thousands frontend devices

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Using AWS IoT Core for real-time messaging

The *IotData* class in the AWS SDK returns a client that uses the MQTT protocol. Example handlers in the frontend:

```
mqttClient.on('connect', function () {
     console.log('mqttClient connected’)
})

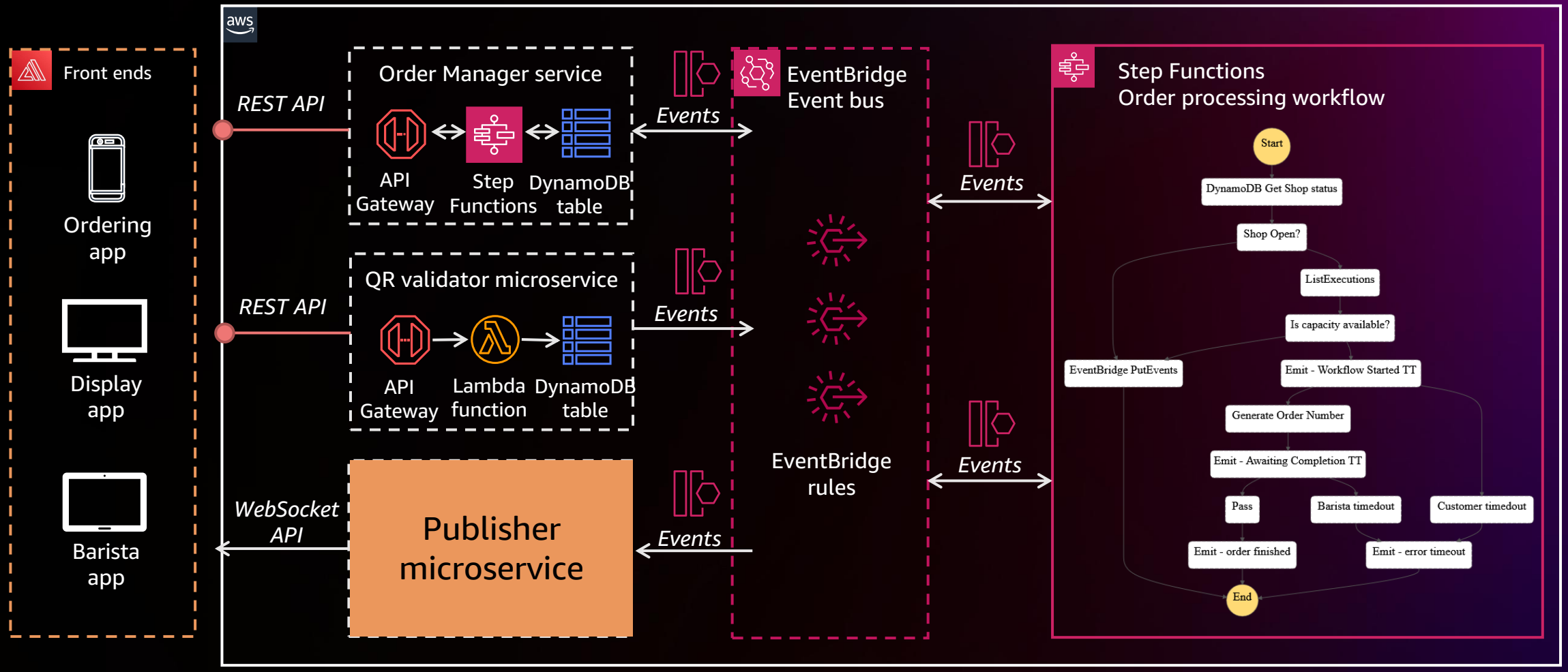
mqttClient.on('error', function (err) {
     console.log('mqttClient error: ', err)
})

mqttClient.on('message', function (topic, payload) {
     const msg = JSON.parse(payload.toString())
     console.log('IoT msg: ', topic, msg)
})
```

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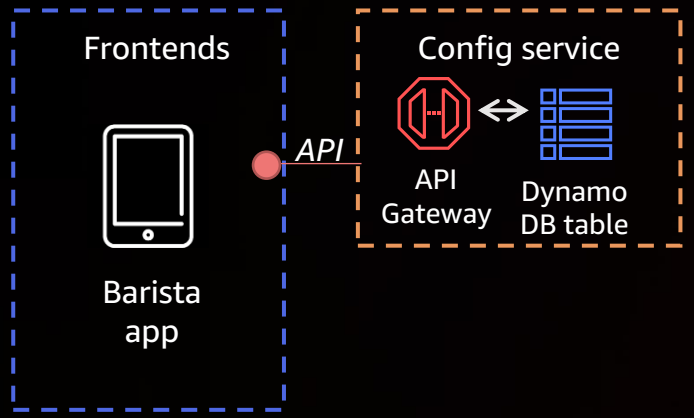
Introducing the Publisher microservice



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Combining multiple approaches for your frontend application

Many frontend applications can combine synchronous and asynchronous response models

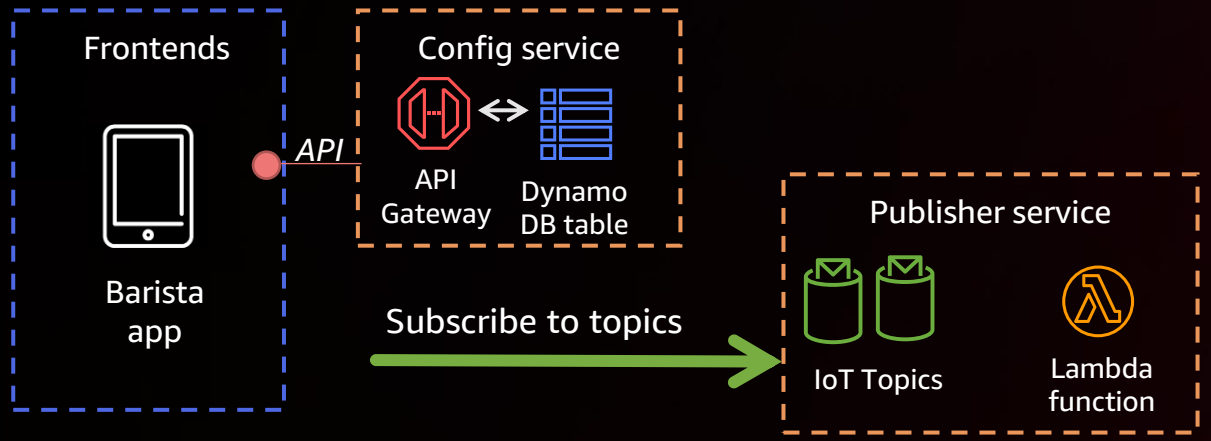


Serverlesspresso sends an initial synchronous request to retrieve the current “state of things”

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Combining multiple approaches for your frontend application

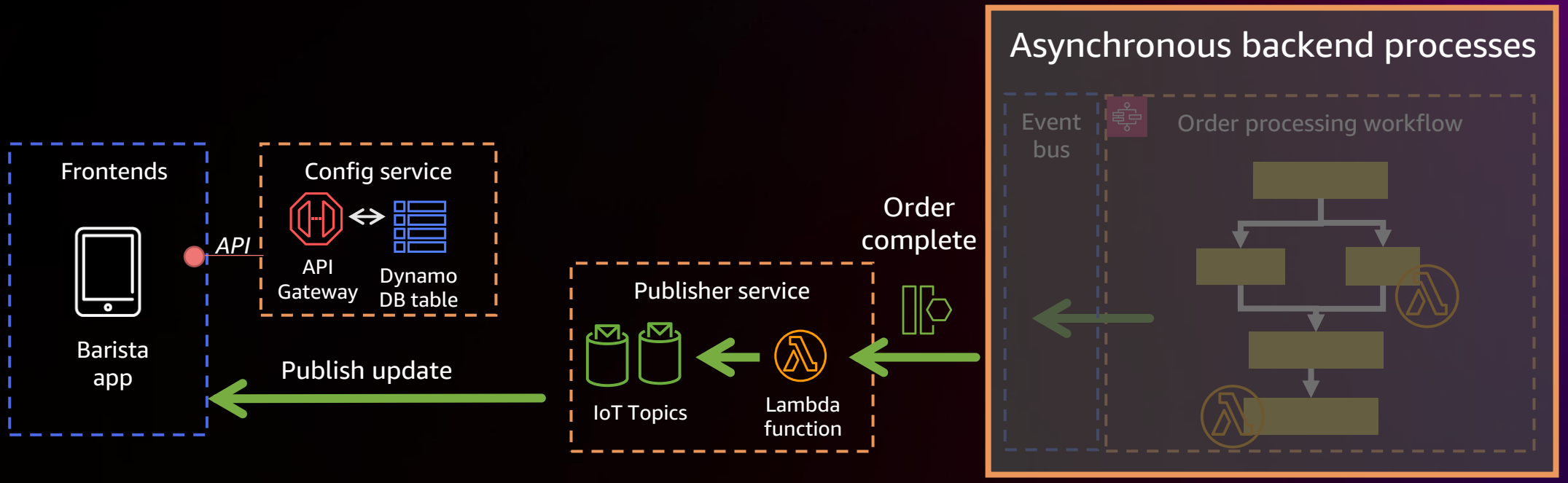
Many frontend applications can combine synchronous and asynchronous response models



Simultaneously the frontend subscribes to global and user-based IoT topics

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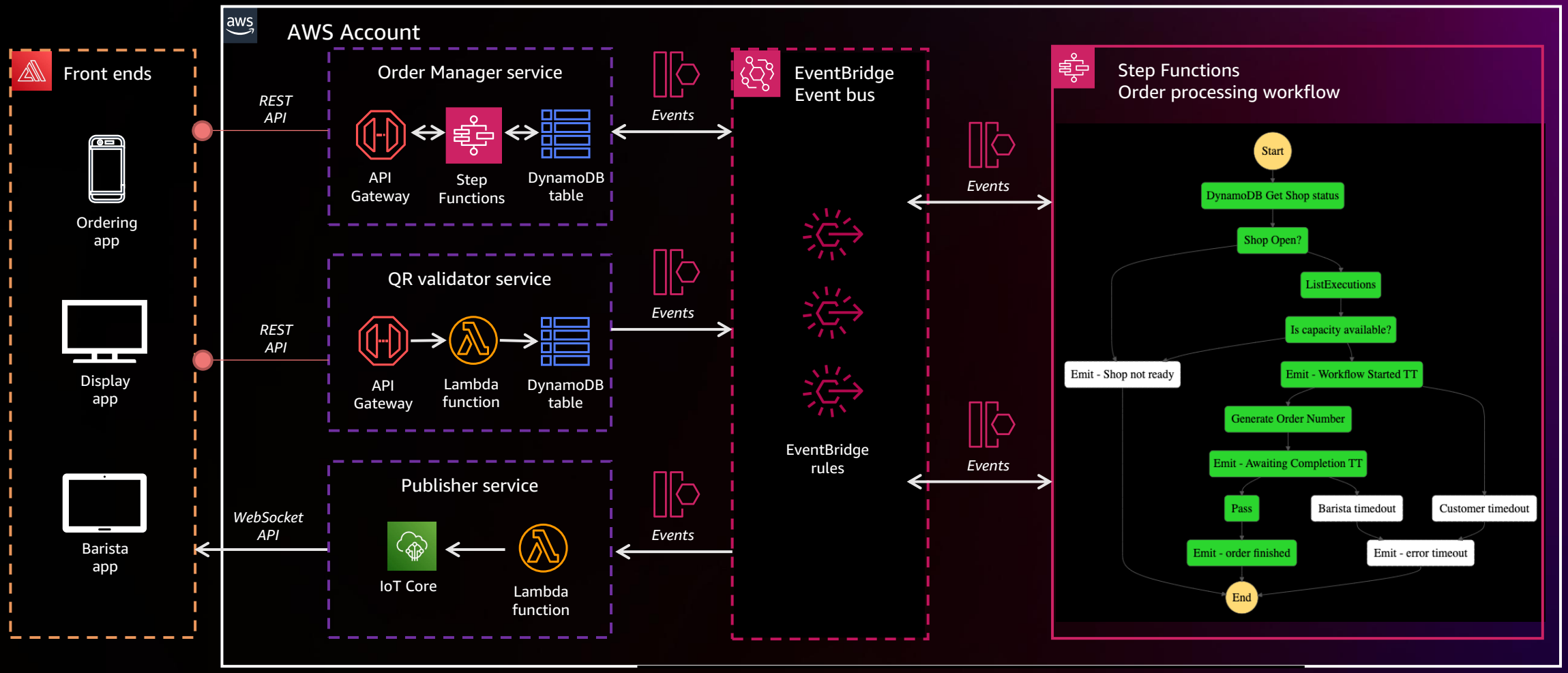
Combining multiple approaches for your frontend application



New orders are posted to the application, processed asynchronously, with updates published to the frontend via the IoT topic

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Final architecture



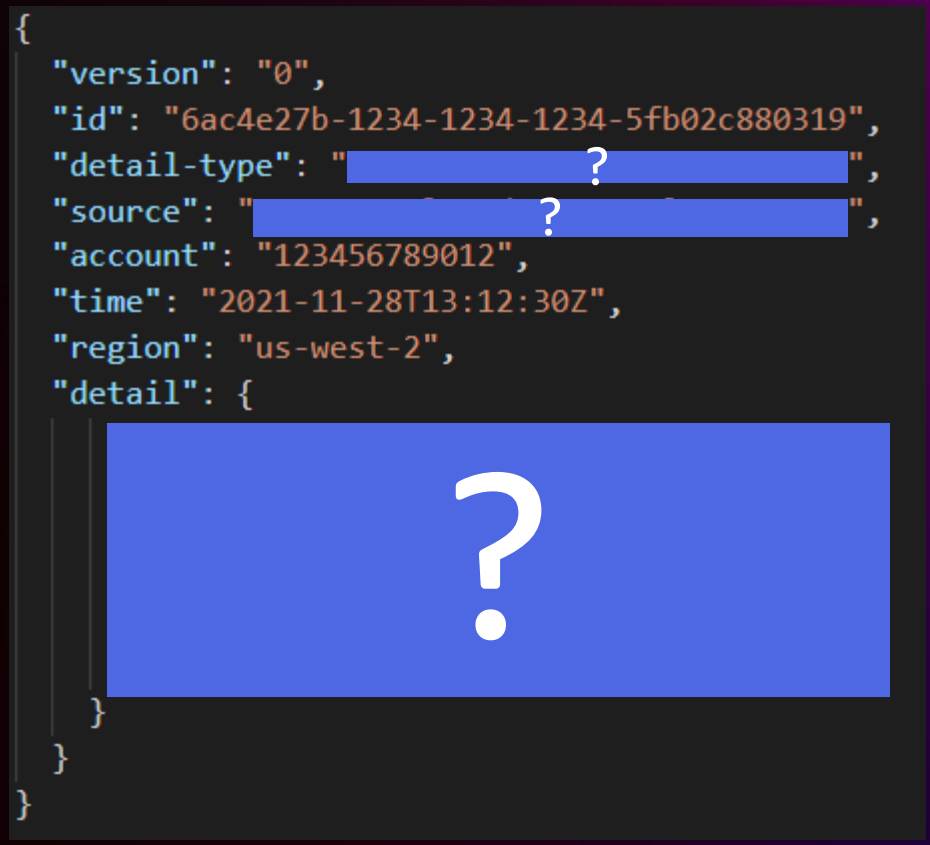
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Lessons learned

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What should events contain?

- Producers create events
- An event is defined in JSON
- Envelope attributes are provided by Amazon EventBridge
- `detail`, `detail-type`, and `source` are entirely your choice
- Fat events or thin events?
- Include metadata like versioning



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What events should you generate?

- Publishing more events than you currently use helps with extensibility
- Step Functions generates some events automatically; can also manually emit events
- Naming conventions: `Microservice.ThingThatHappened`

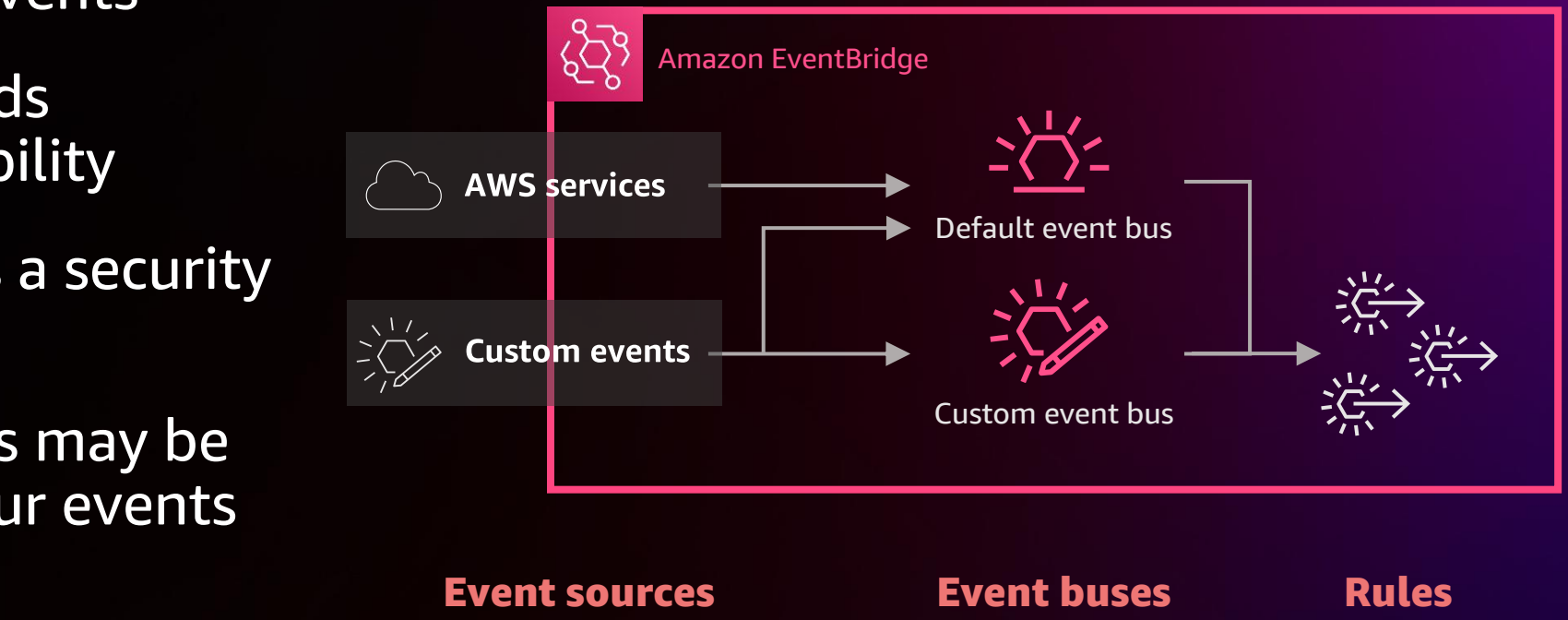
```
ConfigService.ConfigChanged
OrderJourney.AllEventsStored
OrderManager.MakeOrder
OrderManager.OrderCancelled
OrderManager.OrderCompleted
OrderManager.WaitingCompletion
OrderProcessor.OrderTimeOut
OrderProcessor.ShopNotready
OrderProcessor.WaitingCompletion
OrderProcessor.WaitingProduction
OrderProcessor.WorkflowStarted
QueueService.OrderCancelled
QueueService.OrderCompleted
QueueService.OrderStarted
Validator.NewOrder
```

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Amazon EventBridge: One bus or two?

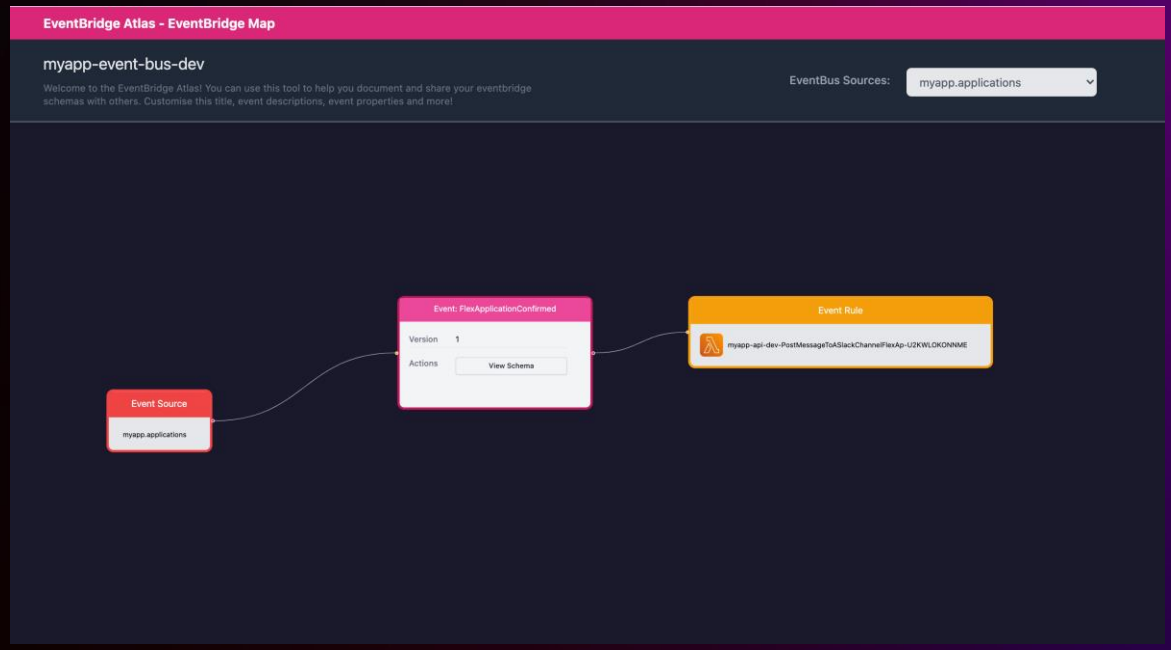
- Default bus already exists – only destination for AWS events
- Adding events here aids discovery and extensibility
- Custom bus can act as a security boundary
- Trade-off: other teams may be unable to build off your events



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Aiding discovery of events

- Events will change in development. Use versioning to implement contracts.
- Use EventBridge Schema Registry to keep track of all your events
- Use open-source tools like EventBridge Atlas to visualize and document flows
- Start documenting events from the beginning

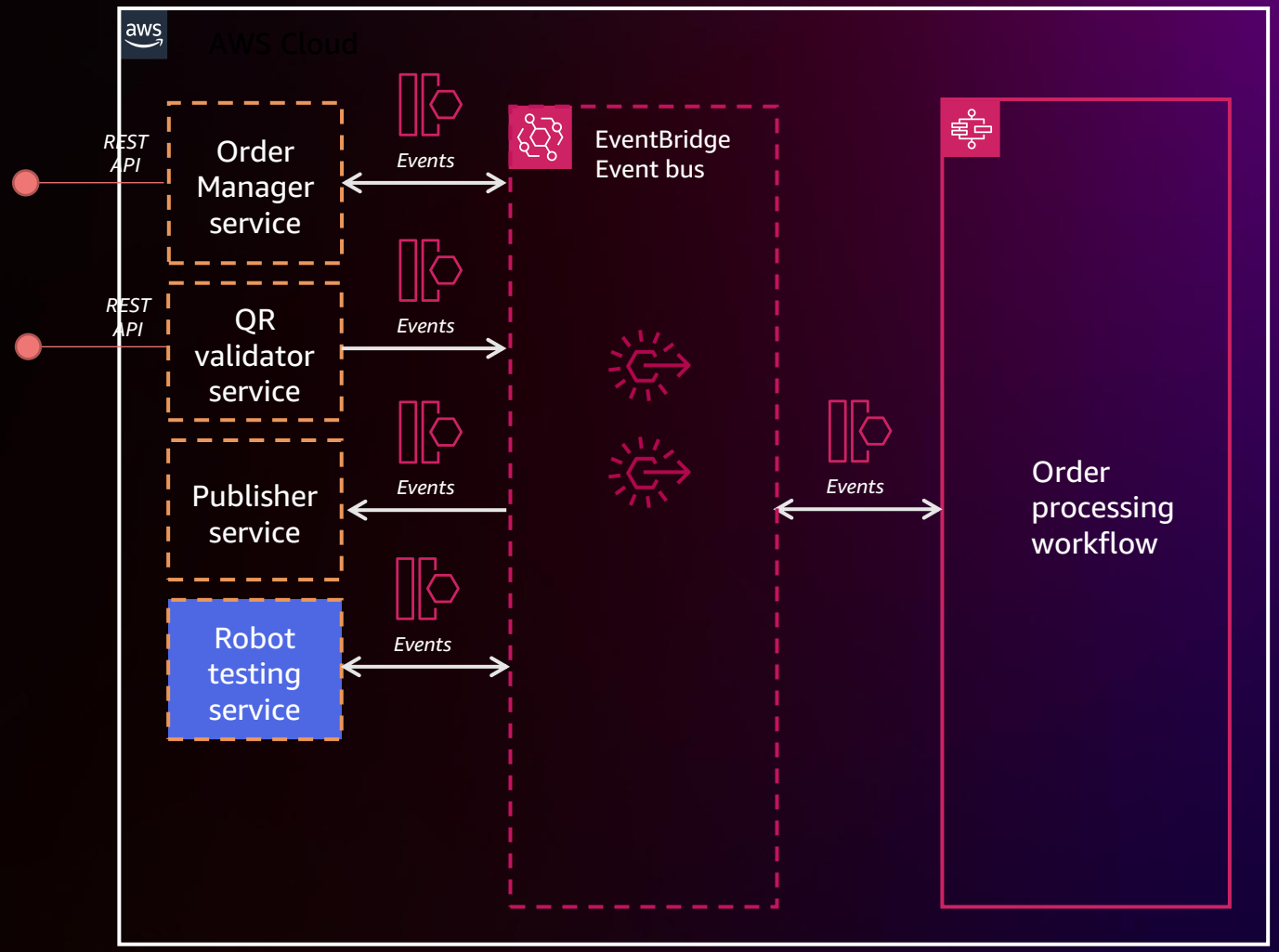


EventBridge Atlas: https://eventbridge-atlas.netlify.app/

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Testing by event injection

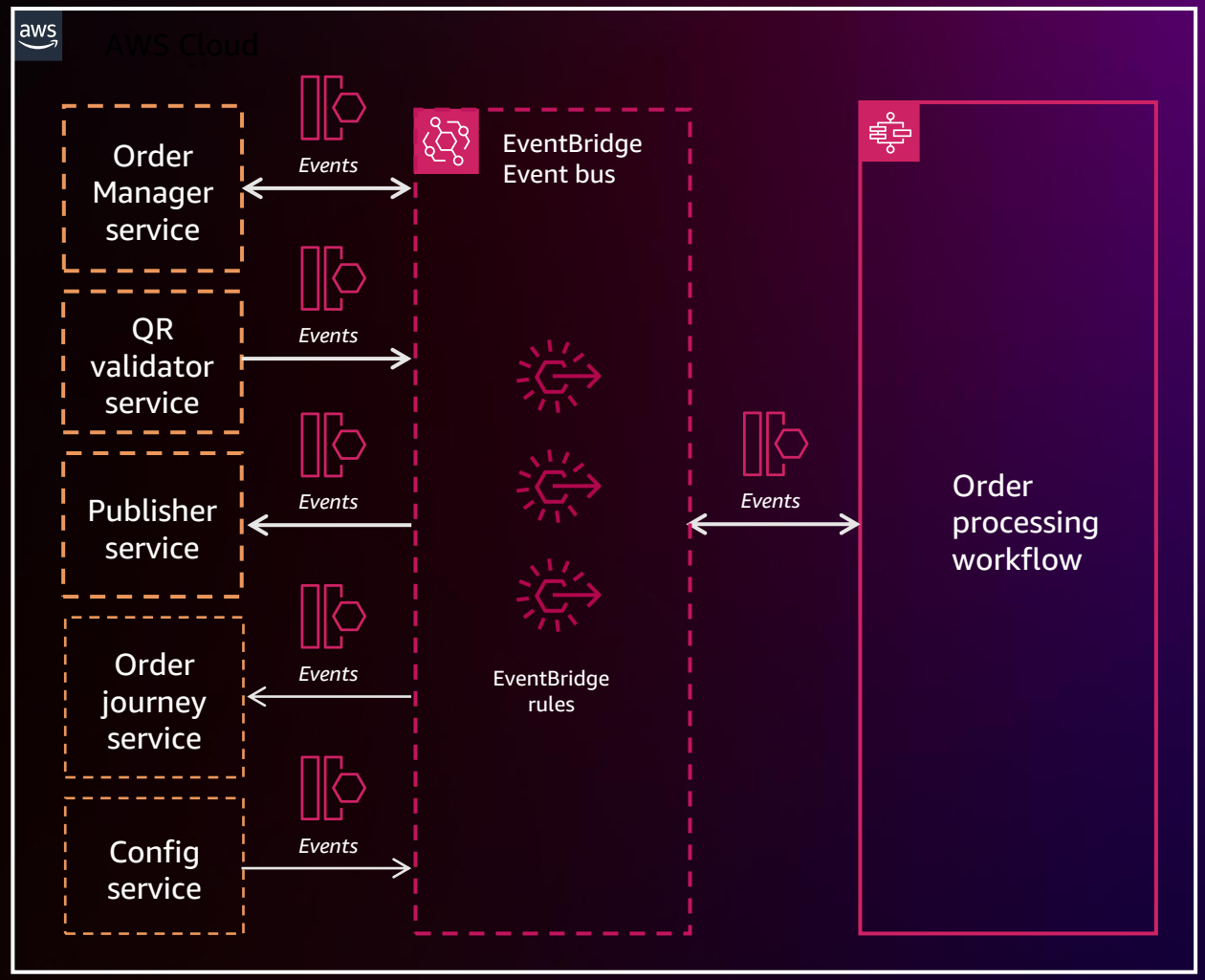
- Instead of calling APIs, put events on the bus
- Our Robot Tester is another microservice – it generates and completes orders at scale
- Use archive/replay to test services in dev with real data
- Create one rule to send all events to CloudWatch Logs (in dev/test). Tail the logs with the CLI.



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Communicating between microservices

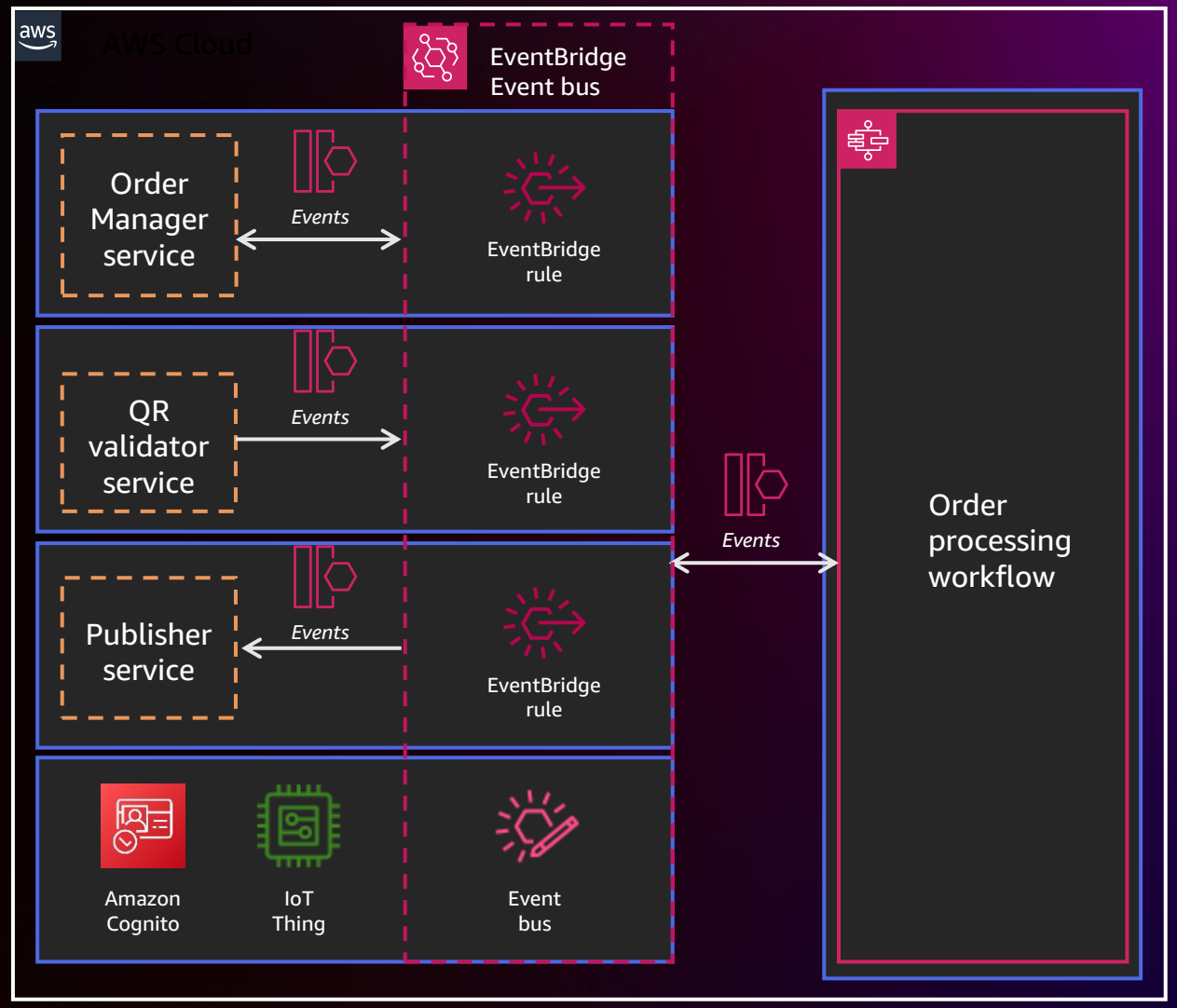
- Event flow drives the application
- Events choreograph the services, while Step Functions orchestrates the transactions
- Replace private APIs with event where possible
- Add new microservices without changing existing code
- Microservices emit events independently of consumers



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Breaking up monolithic deployments

- Originally one large AWS SAM template
- Use a core template for common resources
- Each microservice is an AWS SAM template including a rule
- Each workflow is an AWS SAM template
- Faster and safer to deploy

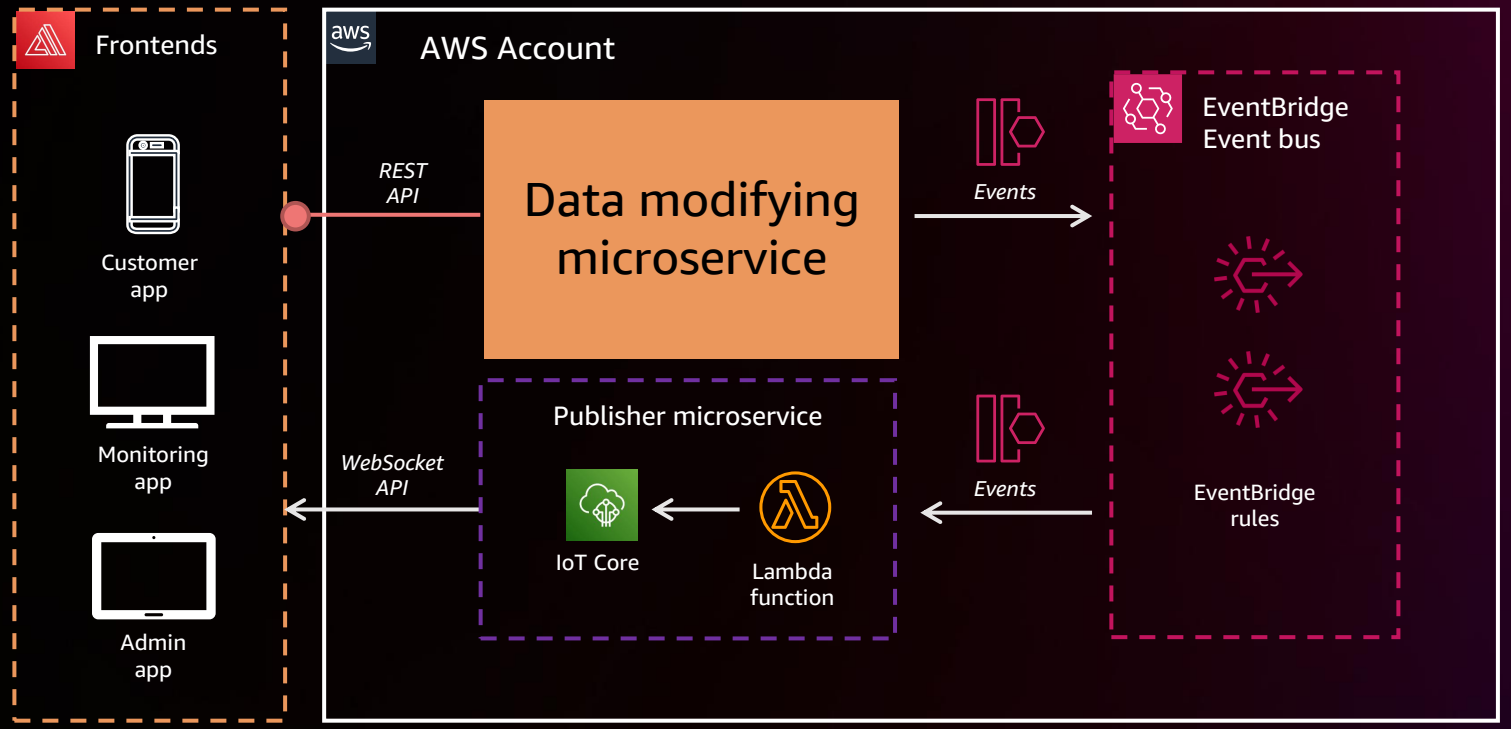


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Useful patterns

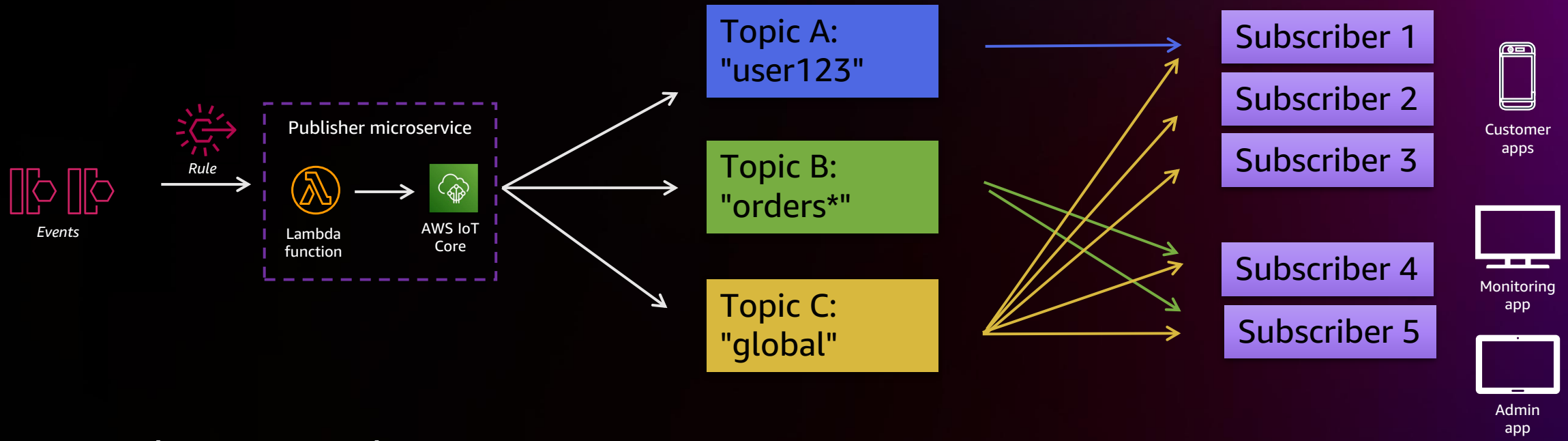
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Command Query Responsibility Separation (CQRS) ... with WebSockets



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CQRS with WebSockets



- Use rules to map between event attributes and topics
- Use content filtering rules to match multiple values (e.g., wildcards)

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Orchestration and choreography

Orchestration with AWS Step Functions

- One system controls the flow between components
- Easier end-to-end monitoring
- Robust timeouts, retries, error handling
- Centralized business logic

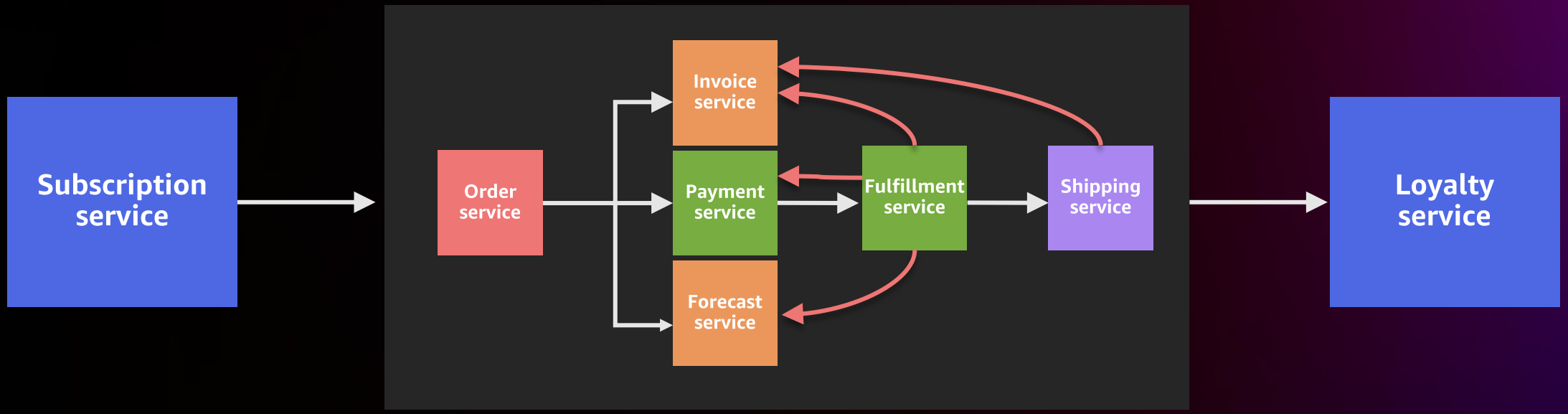
Choreography with Amazon EventBridge

- Pass messages between bounded context of services
- The flow is an emergent property of events being sent
- Easier to extend, modify, and build upon the messages being passed

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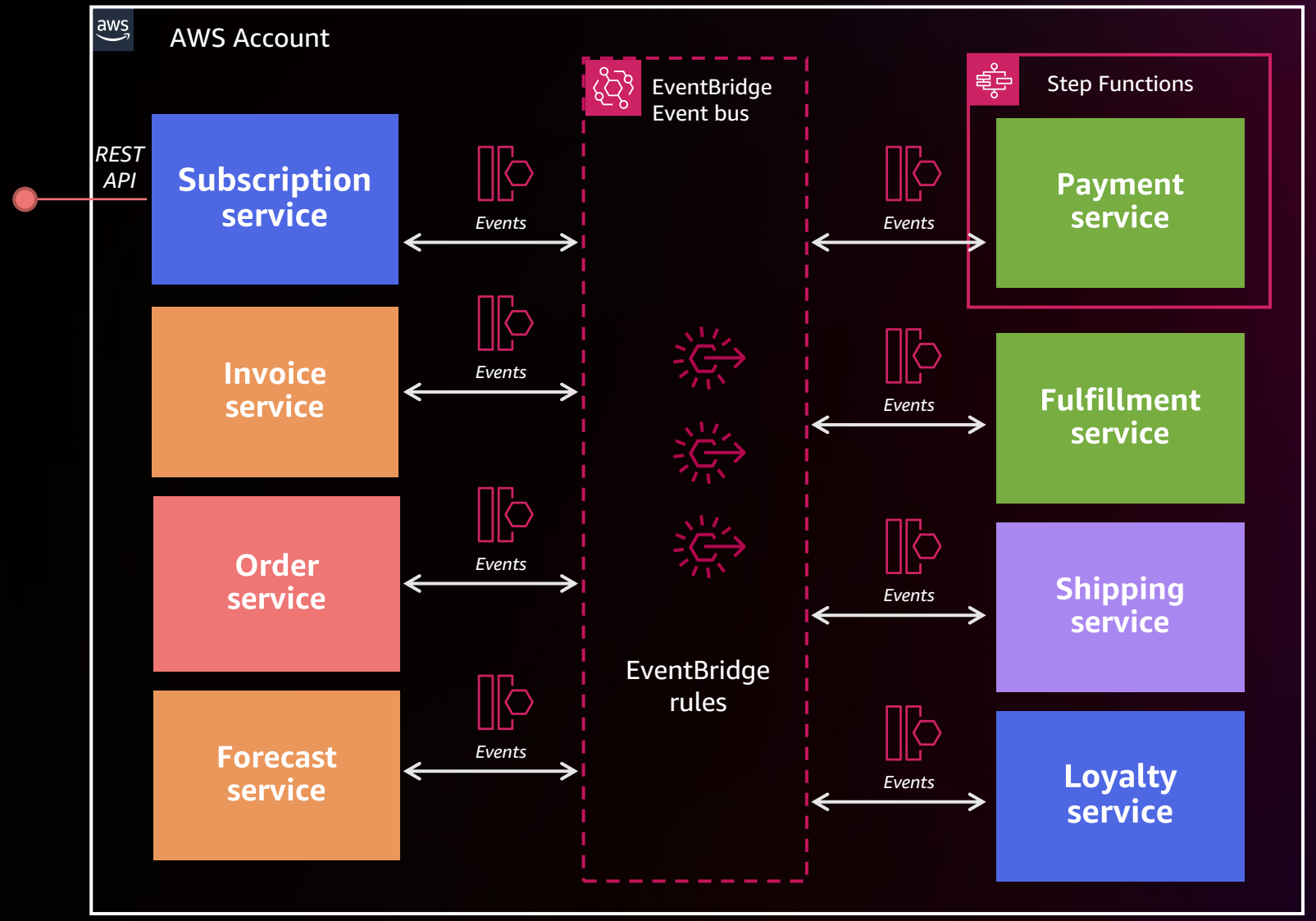
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Moving from API driven...



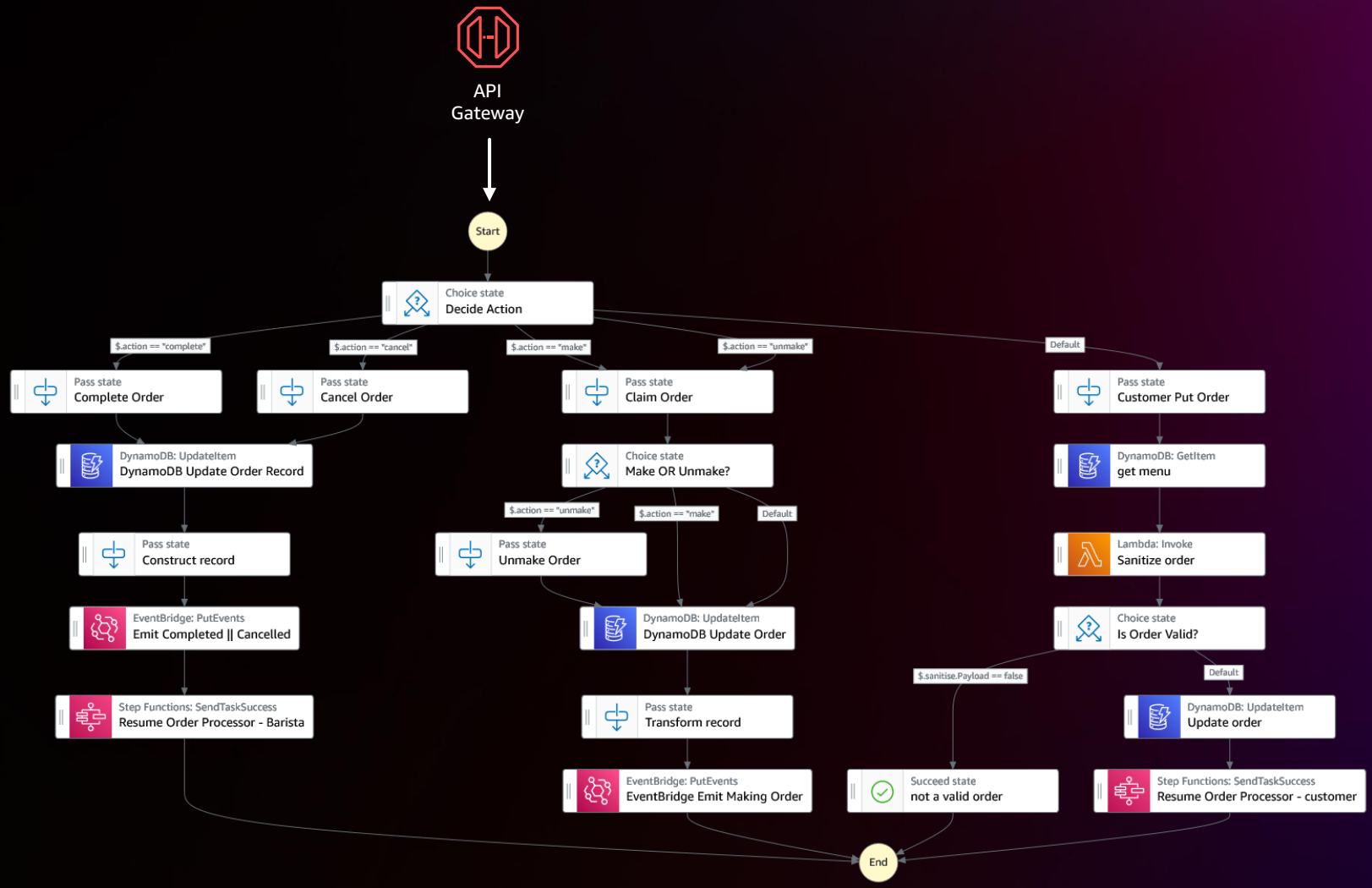
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… to event-driven architecture



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The Step Functions CRUD workflow



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The Step Functions CRUD workflow

How?

- One API Gateway endpoint starts the workflow
- First transition routes CRUD action
- Uses service integrations wherever possible to reduce compute
- Uses Lambda for custom logic
- Can also use Express workflows if return value needed

Benefits

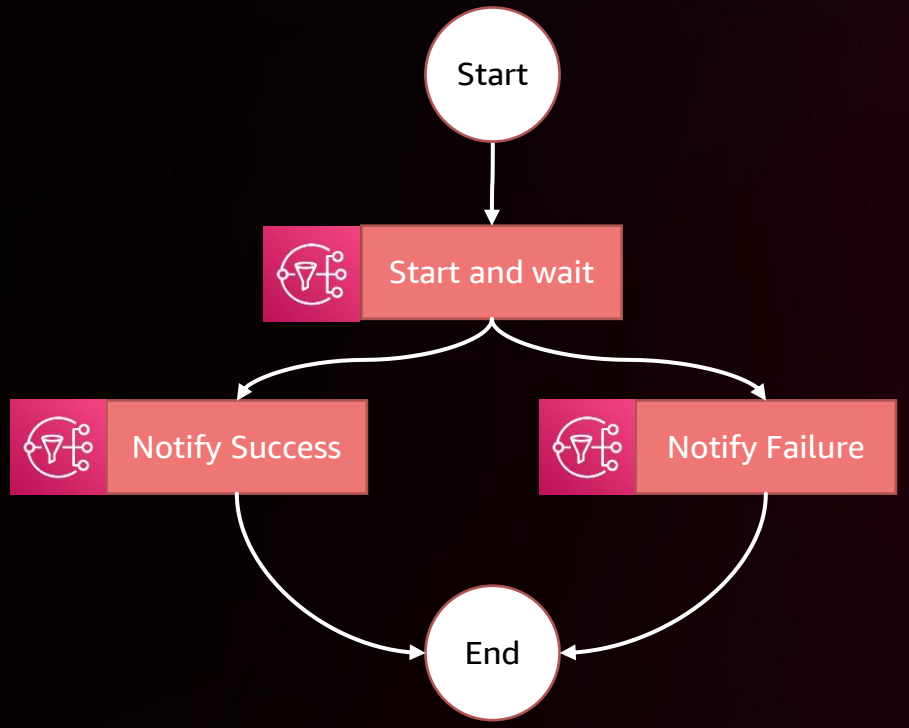
- Reduced complexity (single ASL file)
- Easier monitoring and debugging
- Simpler to implement retries and error handling
- May be more cost effective
- May reduce latency
- Allows versioning of workflows

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Using workflows to manage waiting

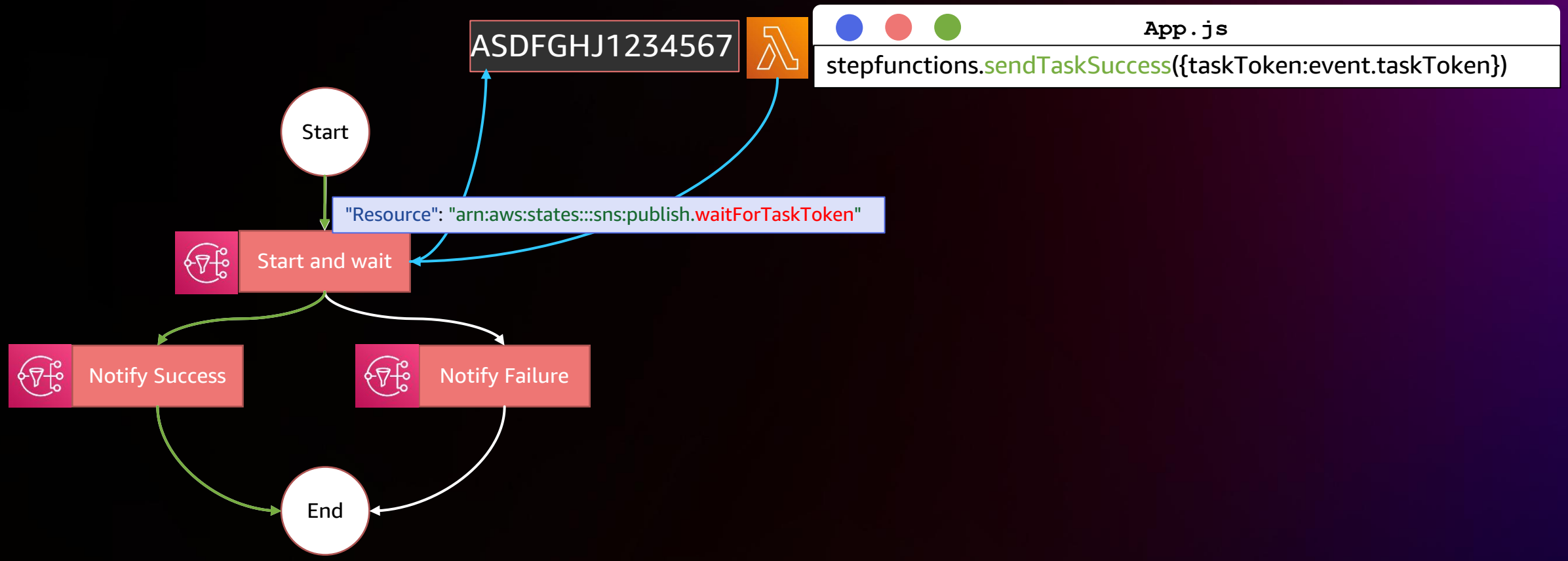
PAUSE A WORKFLOW FOR UP TO 1 YEAR UNTIL A TASK TOKEN IS RETURNED



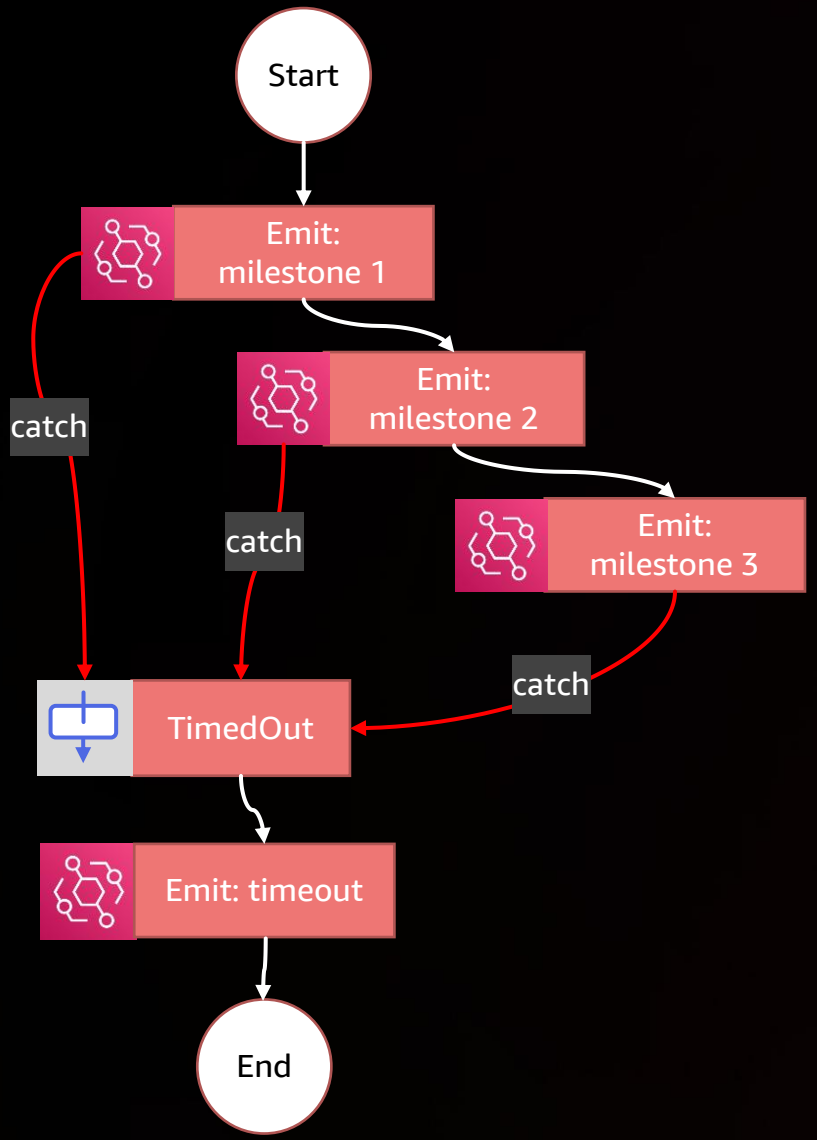
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Using workflows to manage waiting

PAUSE A WORKFLOW FOR UP TO 1 YEAR UNTIL A TASK TOKEN IS RETURNED



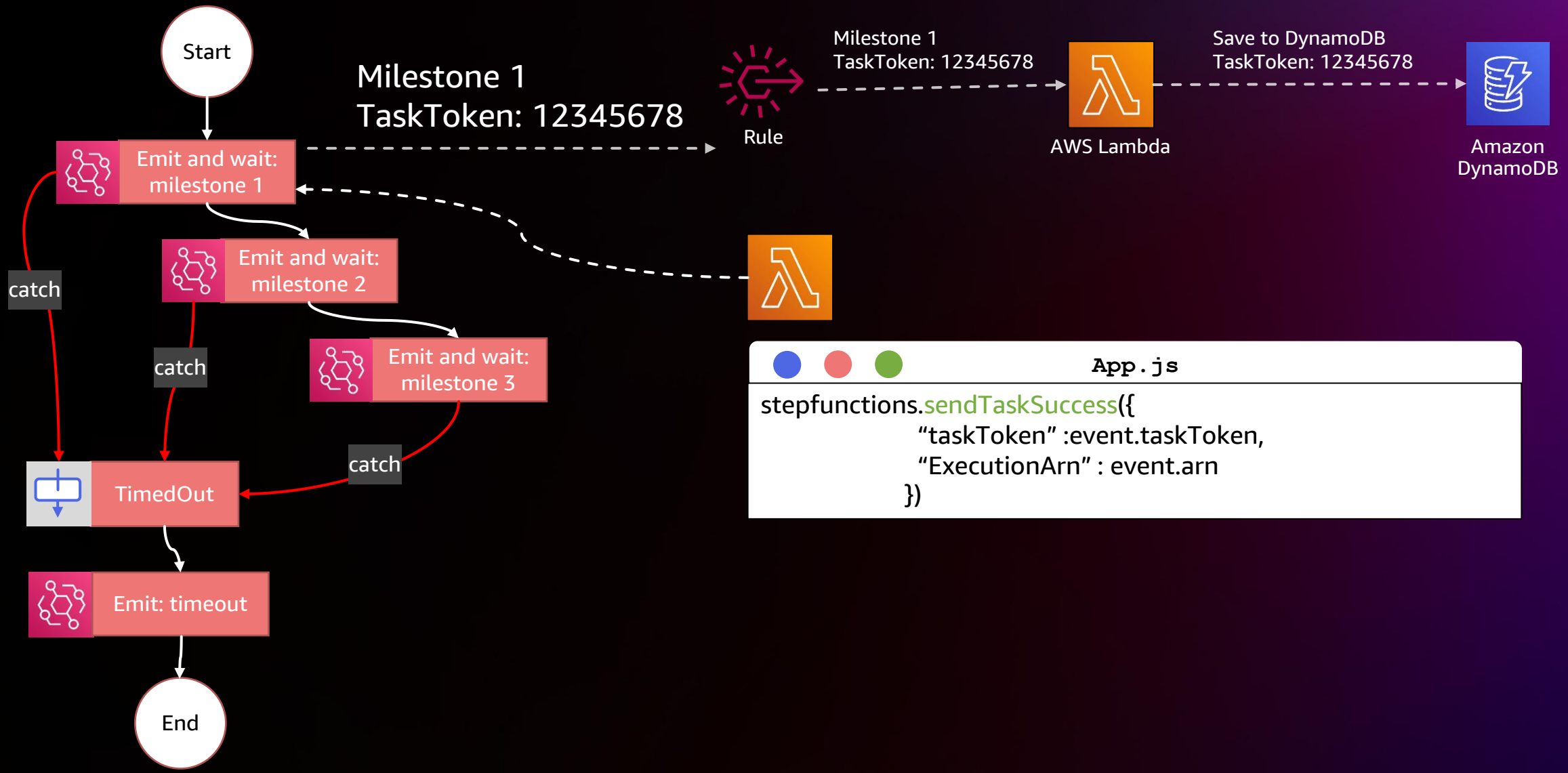
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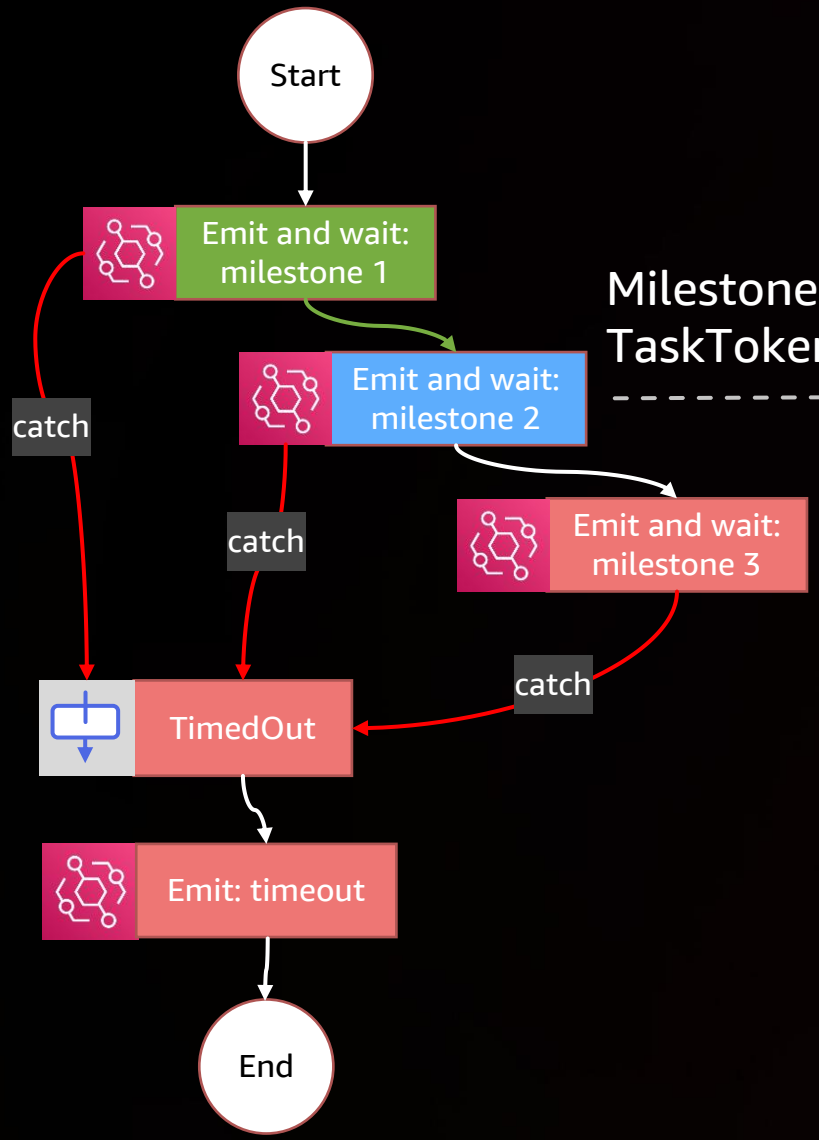
The “emit and wait” pattern

Emit milestone events that invoke external decoupled microservices. Emit error events if they don’t respond in time

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Milestone 2
TaskToken: 12345678

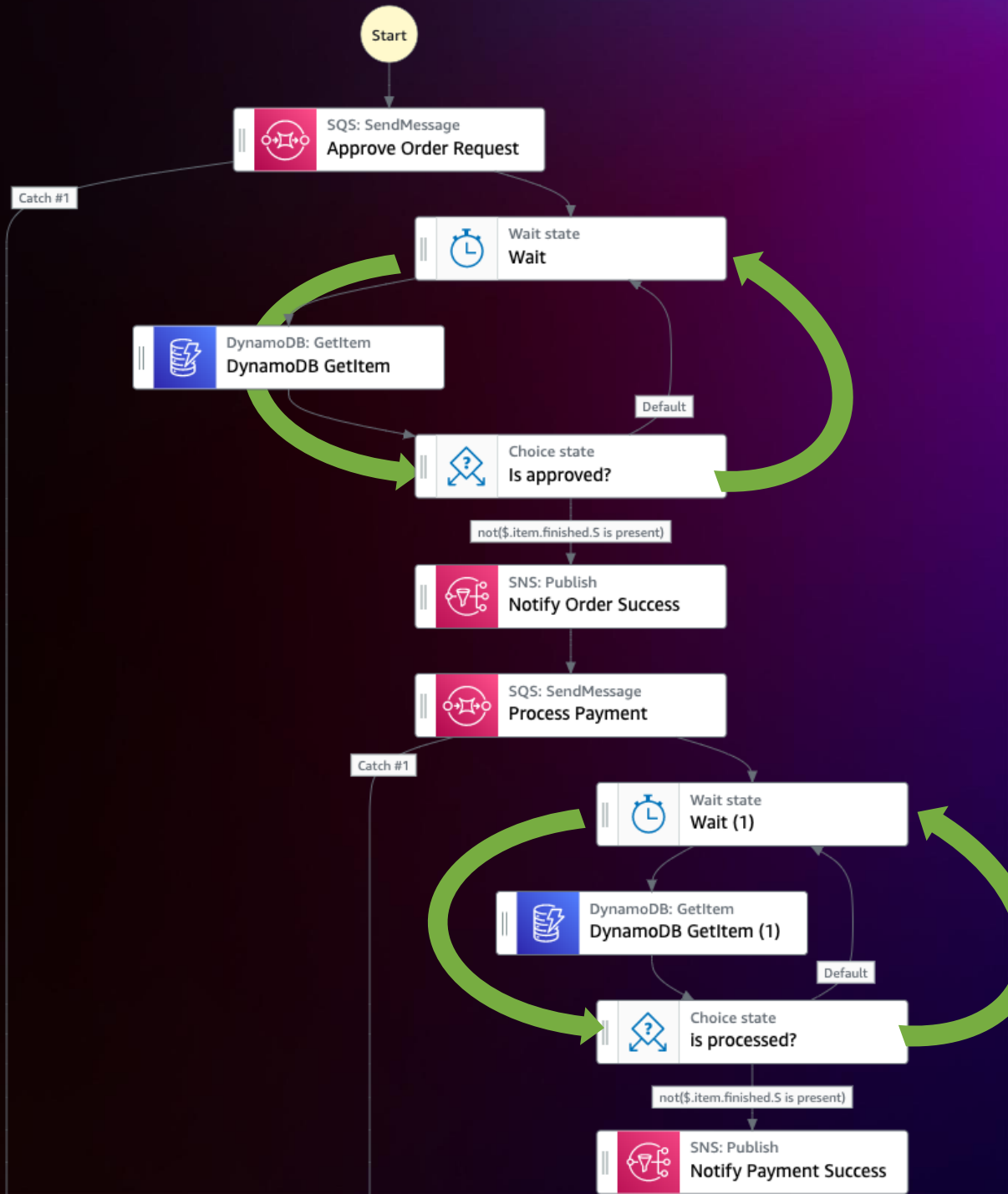


Set a time limit to wait for task token

"HeartbeatSeconds": 20

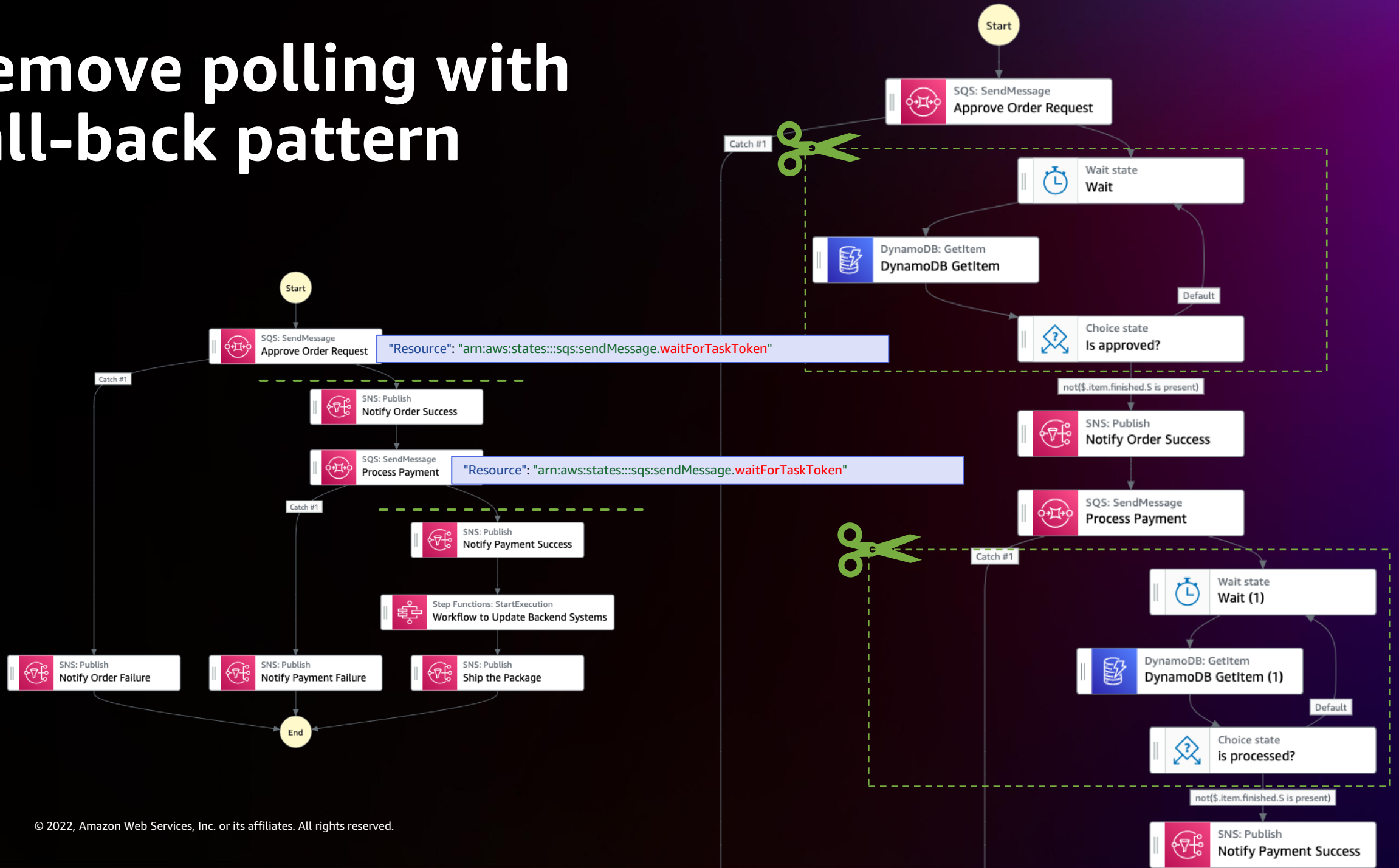
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Remove polling with call-back pattern



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Remove polling with call-back pattern



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What does it cost to run this workload?

We can serve up to 960 drinks to 960 customers every day

Service	Daily cost	With Free Tier
AWS Amplify console	$0.28	Free
Amazon API Gateway	$0.01	Free
Amazon Cognito	$0.00	Free
Amazon DynamoDB	$0.01	Free
Amazon EventBridge	$0.01	Free
AWS IoT Core	$0.01	Free
AWS Lambda	$0.01	Free
Amazon SNS (SMS messaging)	$7.98	$7.98
AWS Step Functions	$0.29	Free



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Learn about the AWS Free Tier:
https://aws.amazon.com/free

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Summary

- Design: start with the workflow; attach microservices; add frontends
- Microservices: communicate with events; use APIs if outward facing
- Real-time frontends: using AWS IoT Core for serverless WebSockets
- Use Step Functions to orchestrate within microservice boundaries. Use EventBridge to communicate across those boundaries.
- Combining orchestration with choreography can create highly extensible, low-code, cost-effective workloads



Resources from this talk at
https://s12d.com/svs312

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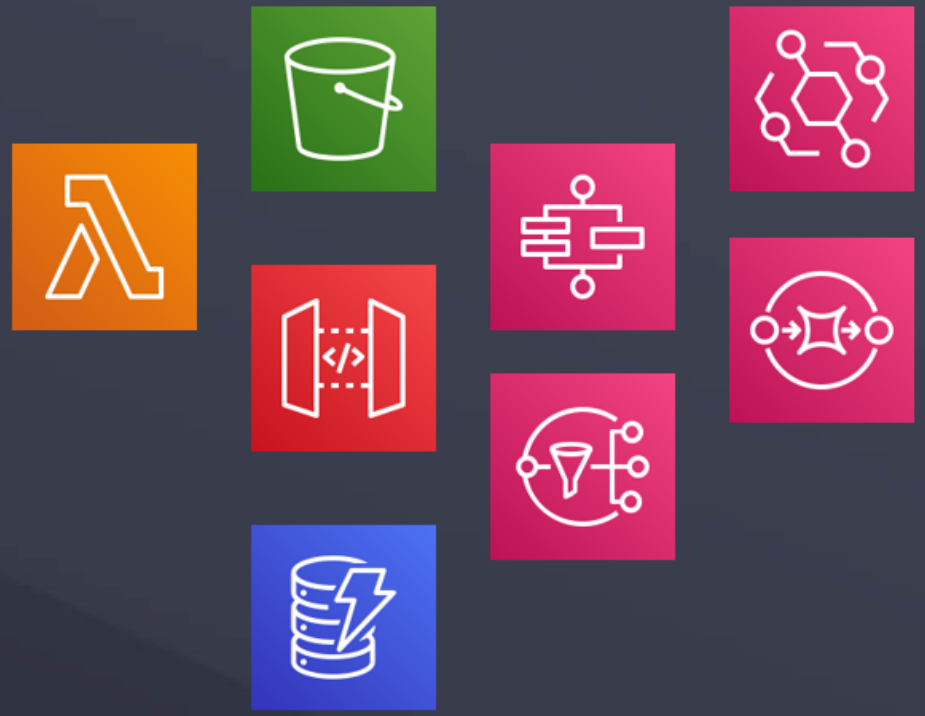
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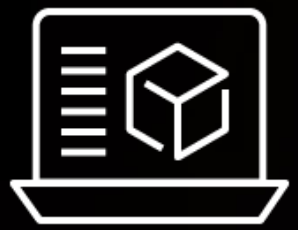
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Thank you!

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