AWS re:Inforce

JUNE 10 – 12, 2024 | PHILADELPHIA, PA

DAP301

Building resilient event-driven architectures, feat. United Airlines

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Where are we going today?

1 Why event-driven architectures?

2 Best practices for governance & resiliency

3 Data protection mechanisms

4 Customer story – United Airlines mainframe modernization

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Application modernization

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Business requirements

Go faster

Be more stable

Increase quality

Be cheaper

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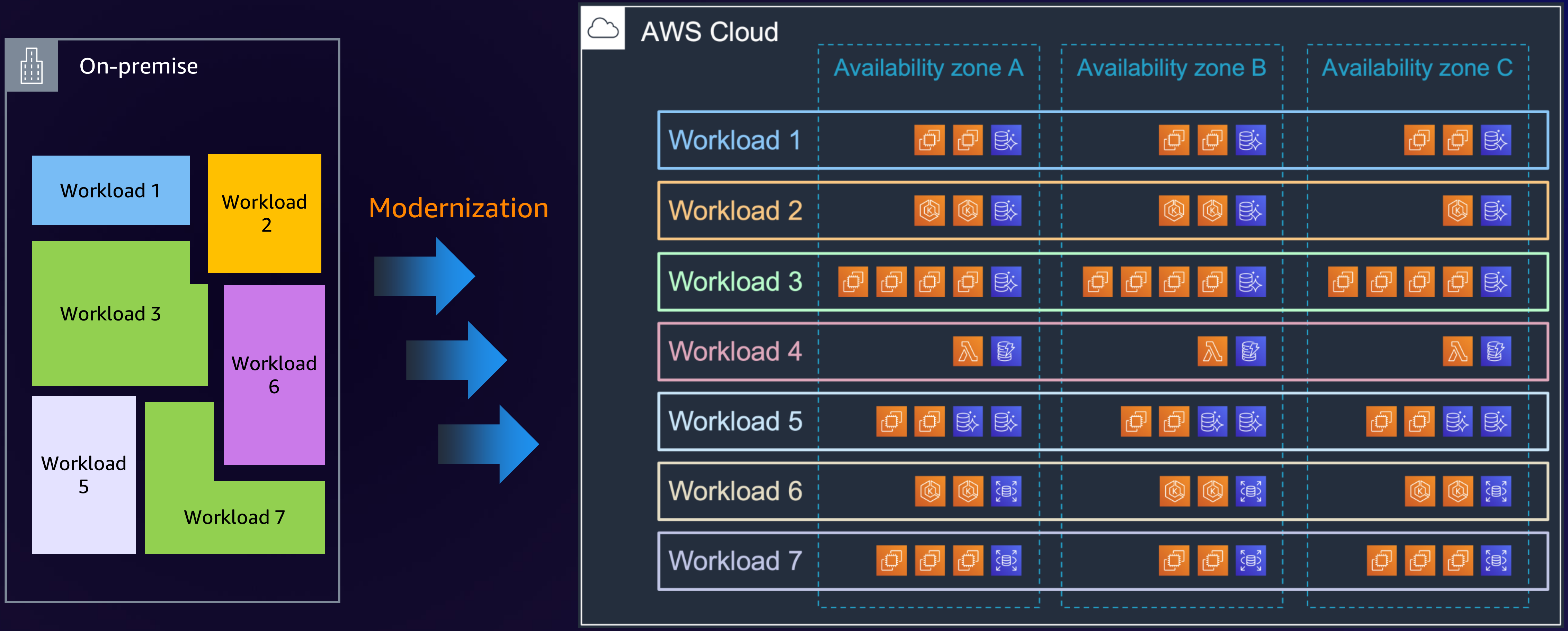
Strangling workload by workload



Guidance:
https://docs.aws.amazon.com/prescriptive-guidance/latest/modernization-decomposing-monoliths/welcome.html

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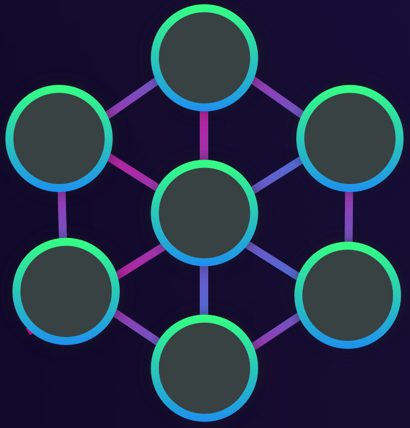
Architecture review

Monolith
Does everything



Microservices
Does one thing

Scales to millions of users

Has global availability

Responds in milliseconds

Handles petabytes of data

Microservices approach advocates creating a system from a collection of small, isolated services, each of which owns their data and is independently isolated, scalable, and resilient to failure

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Why event-driven architecture

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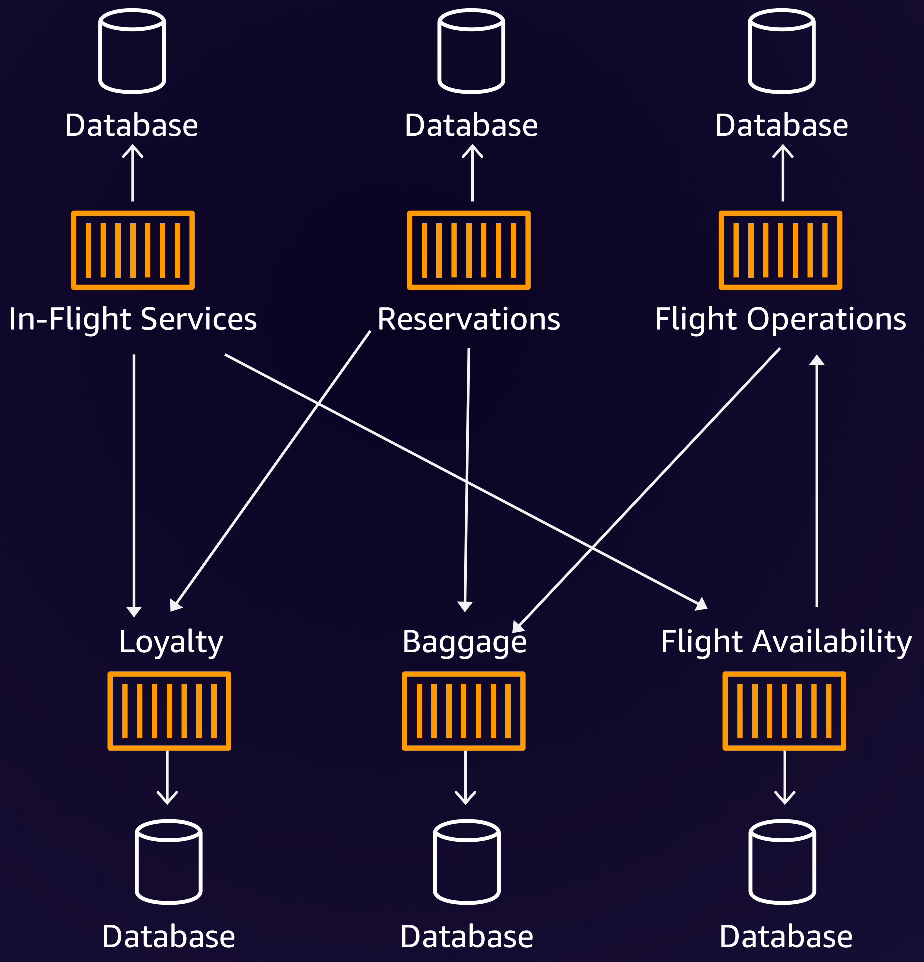
Loosely couple microservices

REQUEST/RESPONSE



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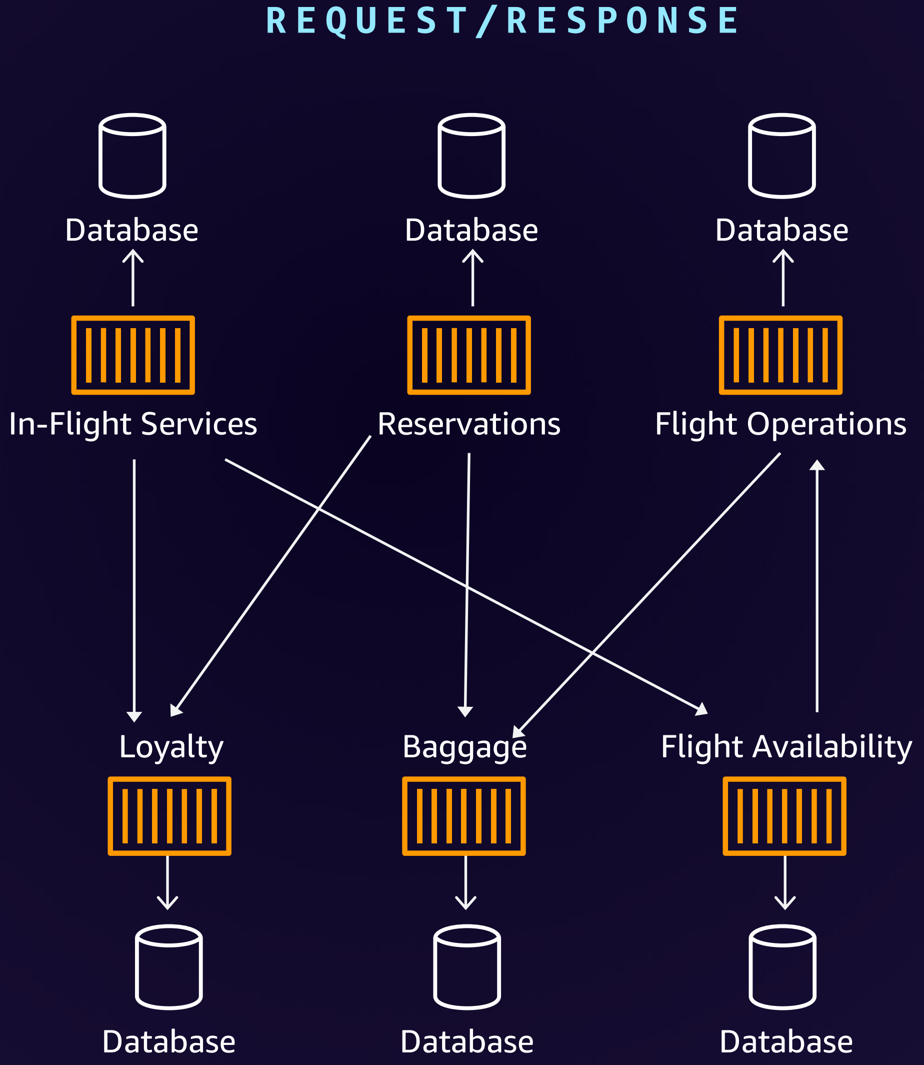
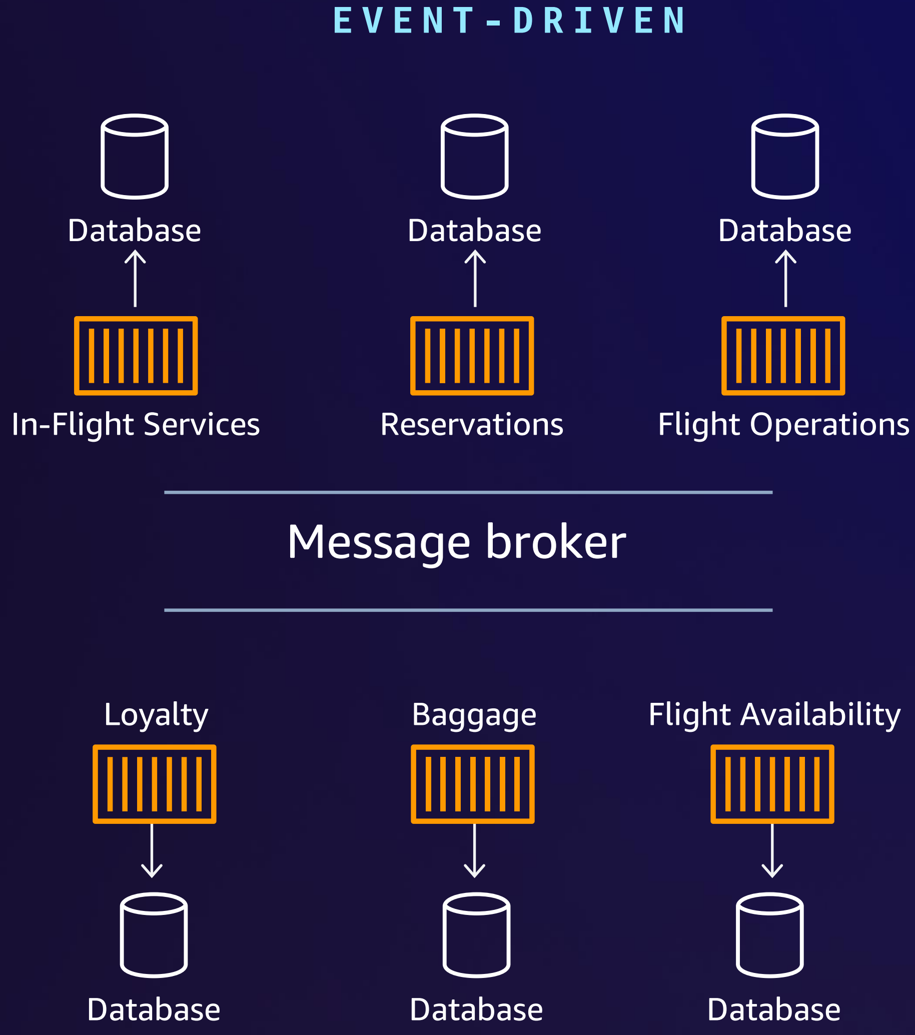
Loosely couple microservices





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Event-driven architectures

An architectural style of building loosely-coupled software systems that work together by emitting and responding to events

“If your application is cloud-native, or large-scale, or distributed, and doesn’t include a messaging component, that’s probably a bug.”

Source:
https://aws.amazon.com/blogs/compute/understanding-asynchronous-messaging-for-microservices/

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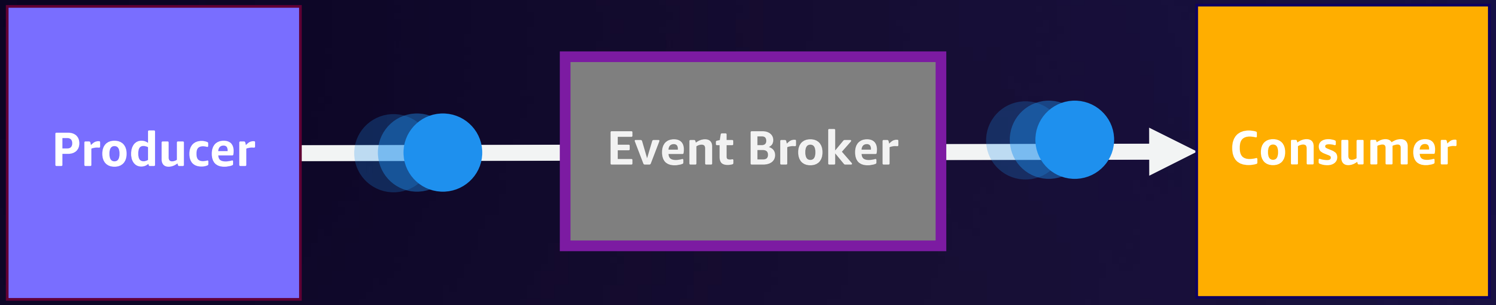
At the core of event-driven architecture



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AWS messaging & event services

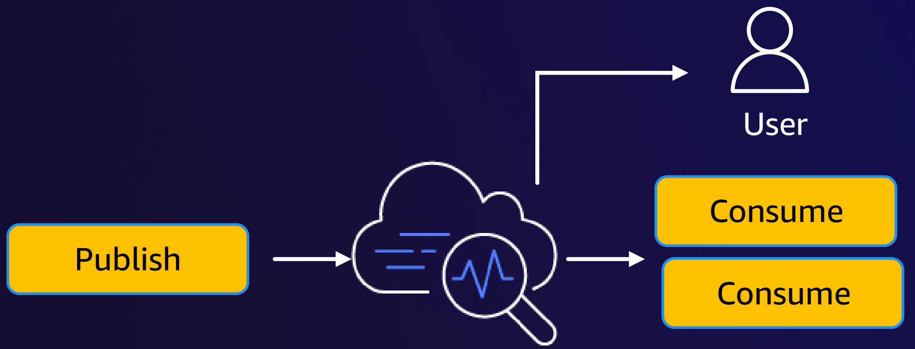
Born in the Cloud | Micro Services

Amazon SQS

Amazon SNS

Amazon EventBridge

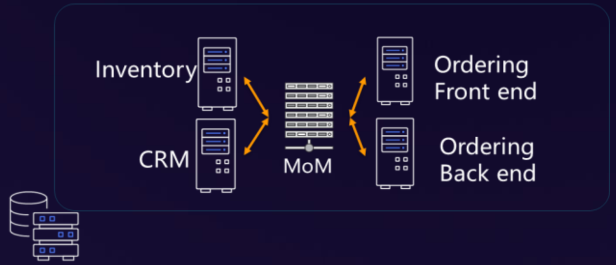
Event Bus & SaaS



Amazon EventBridge

Amazon Pinpoint

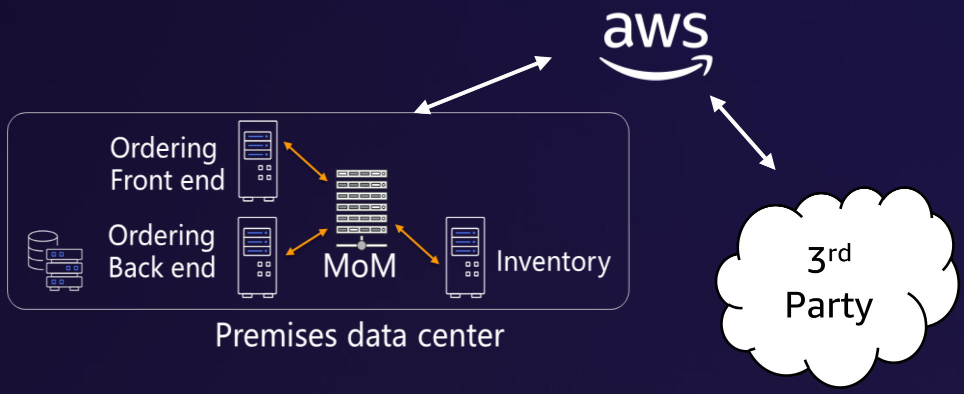
Cloud Migration & Modernization



Amazon MQ

Amazon MSK

Hybrid & Multicloud



Amazon MQ

Amazon MSK

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Governance architecture

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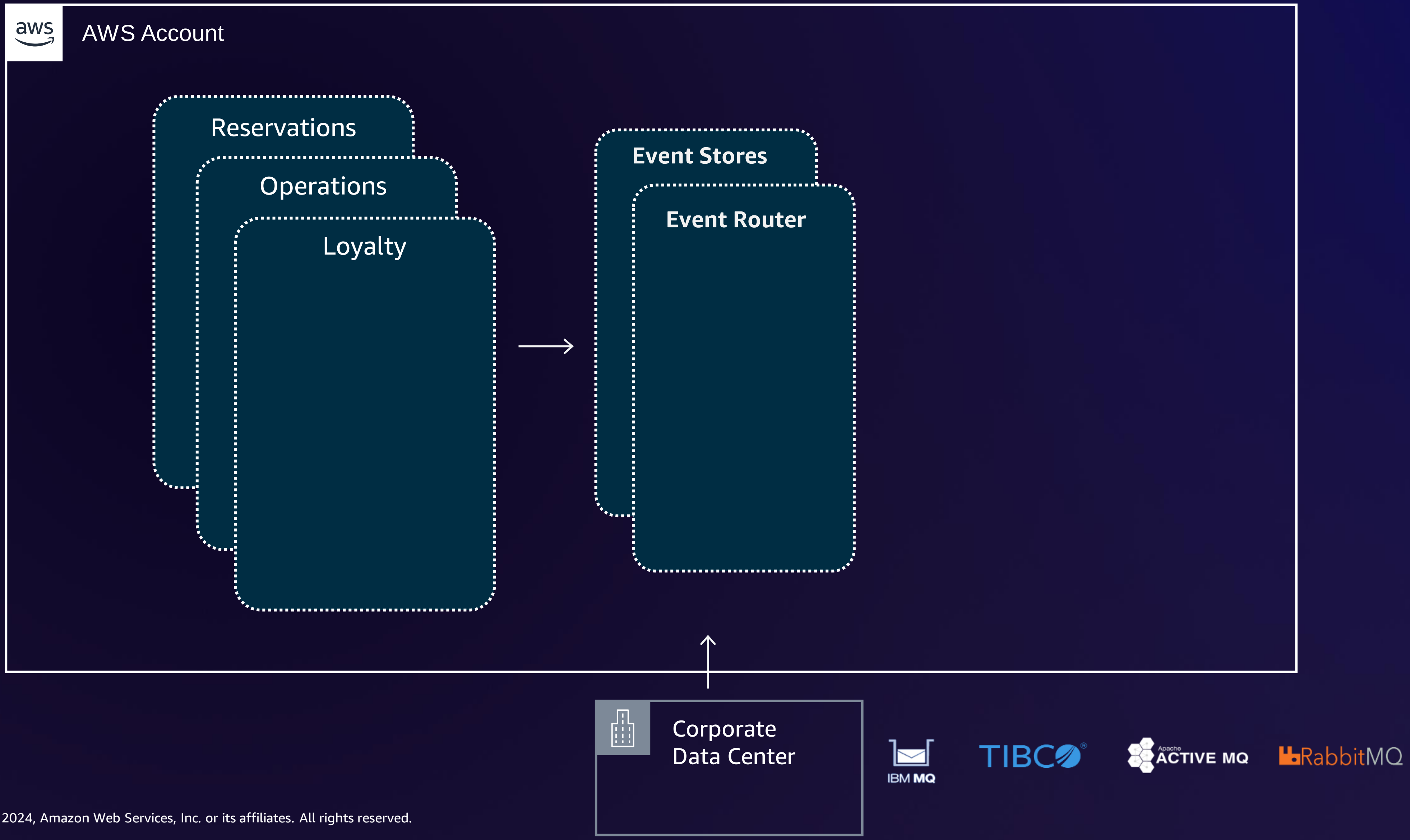
Event-driven architecture implementation



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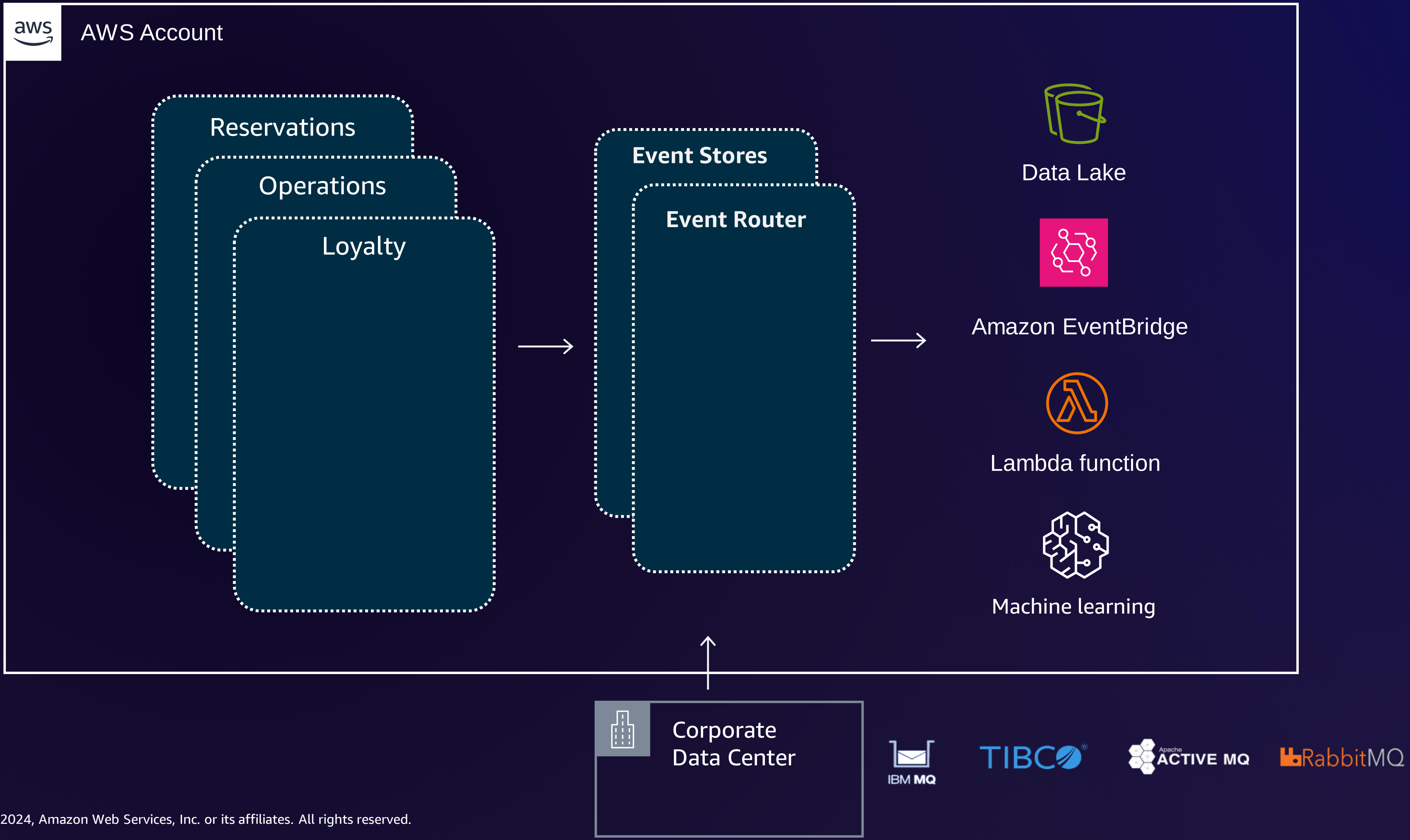
Event-driven architecture implementation



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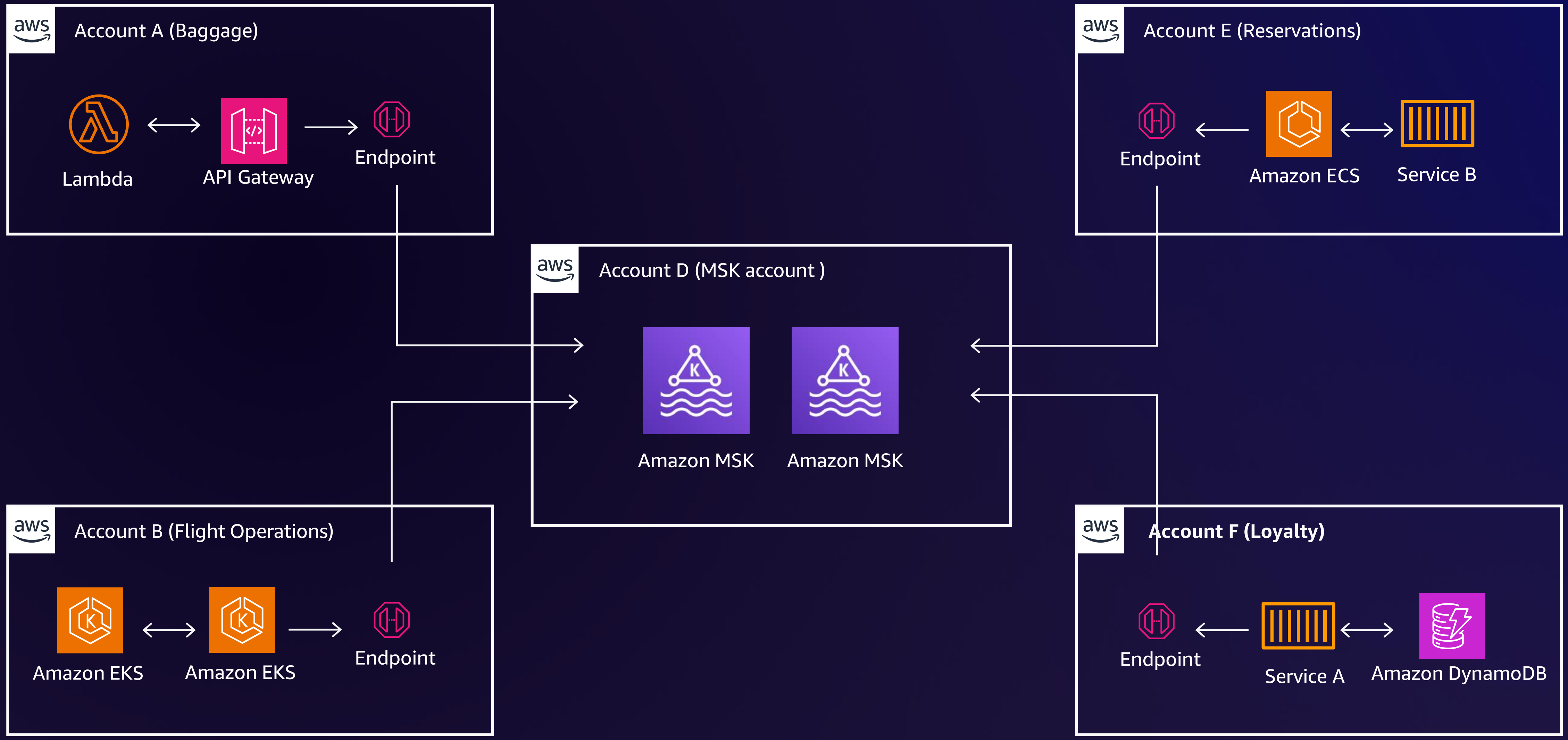
Micro account architectures



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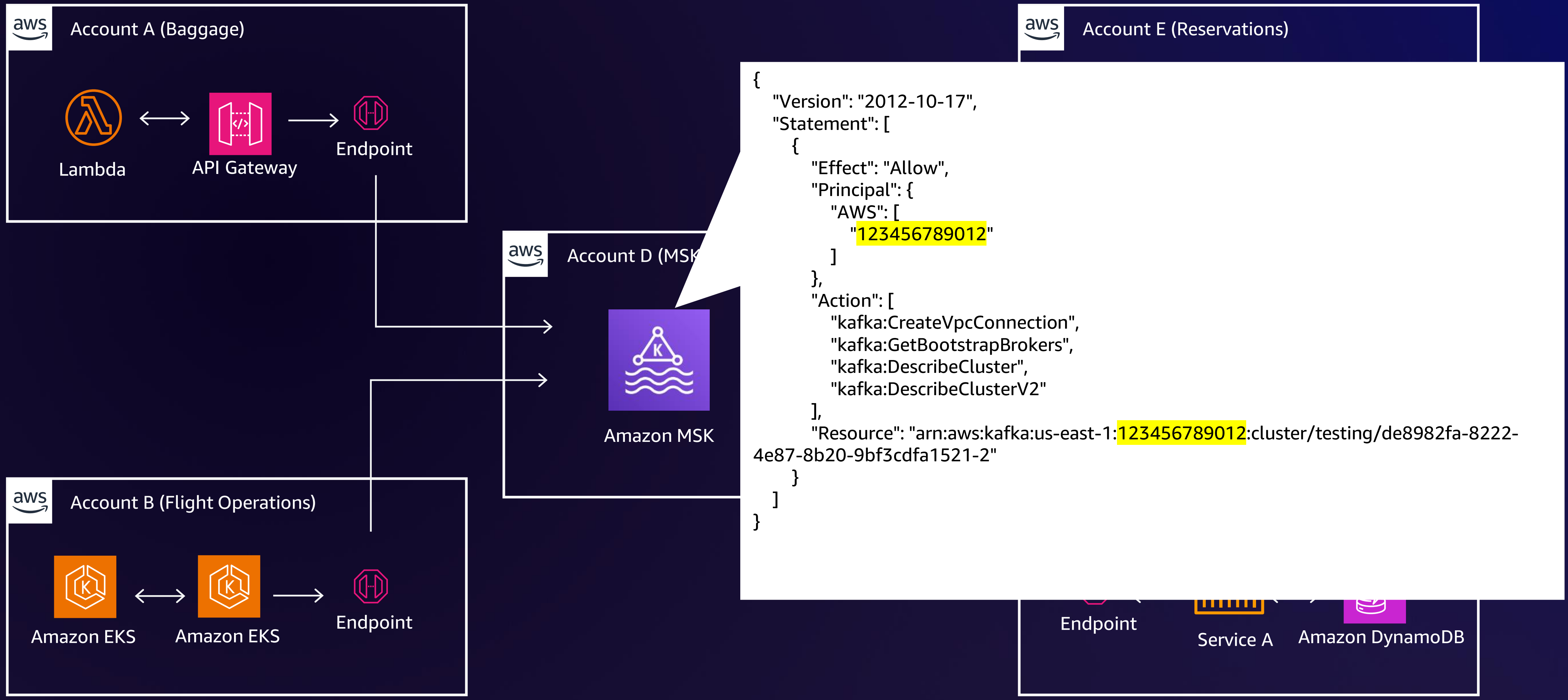
Micro account architectures



```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Principal": {
            "AWS": [
               "123456789012"
            ]
         },
         "Action": [
            "kafka:CreateVpcConnection",
            "kafka:GetBootstrapBrokers",
            "kafka:DescribeCluster",
            "kafka:DescribeClusterV2"
         ],
         "Resource": "arn:aws:kafka:us-east-1:123456789012:cluster/testing/de8982fa-8222-
4e87-8b20-9bf3cdfa1521-2"
      }
   ]
}
```

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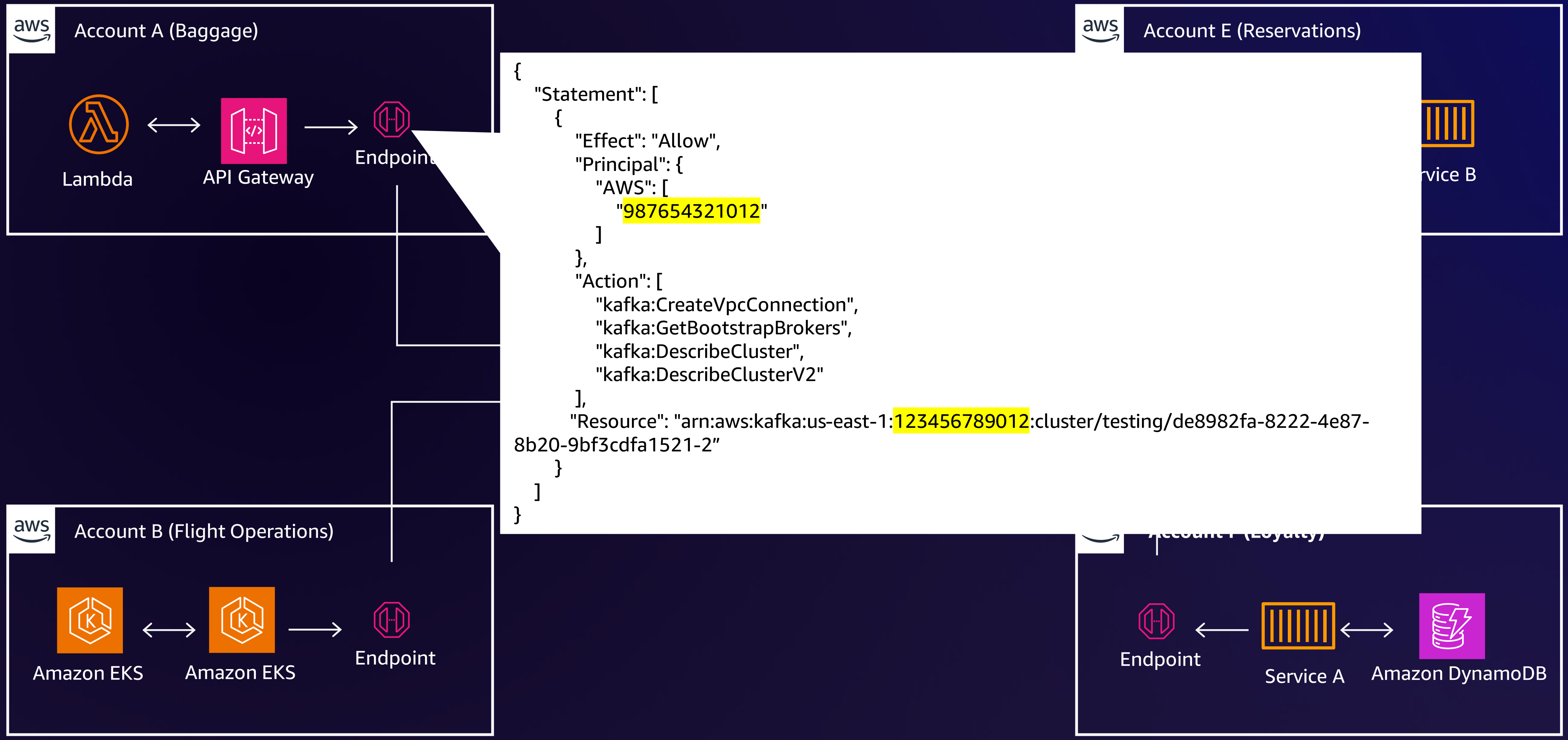
Micro account architectures



```
{
   "Statement": [
      {
         "Effect": "Allow",
         "Principal": {
            "AWS": [
               "987654321012"
            ]
         },
         "Action": [
            "kafka:CreateVpcConnection",
            "kafka:GetBootstrapBrokers",
            "kafka:DescribeCluster",
            "kafka:DescribeClusterV2"
         ],
        "Resource": "arn:aws:kafka:us-east-1:123456789012:cluster/testing/de8982fa-8222-4e87-
8b20-9bf3cdfa1521-2”
      }
   ]
}
```

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Cross-Region architecture

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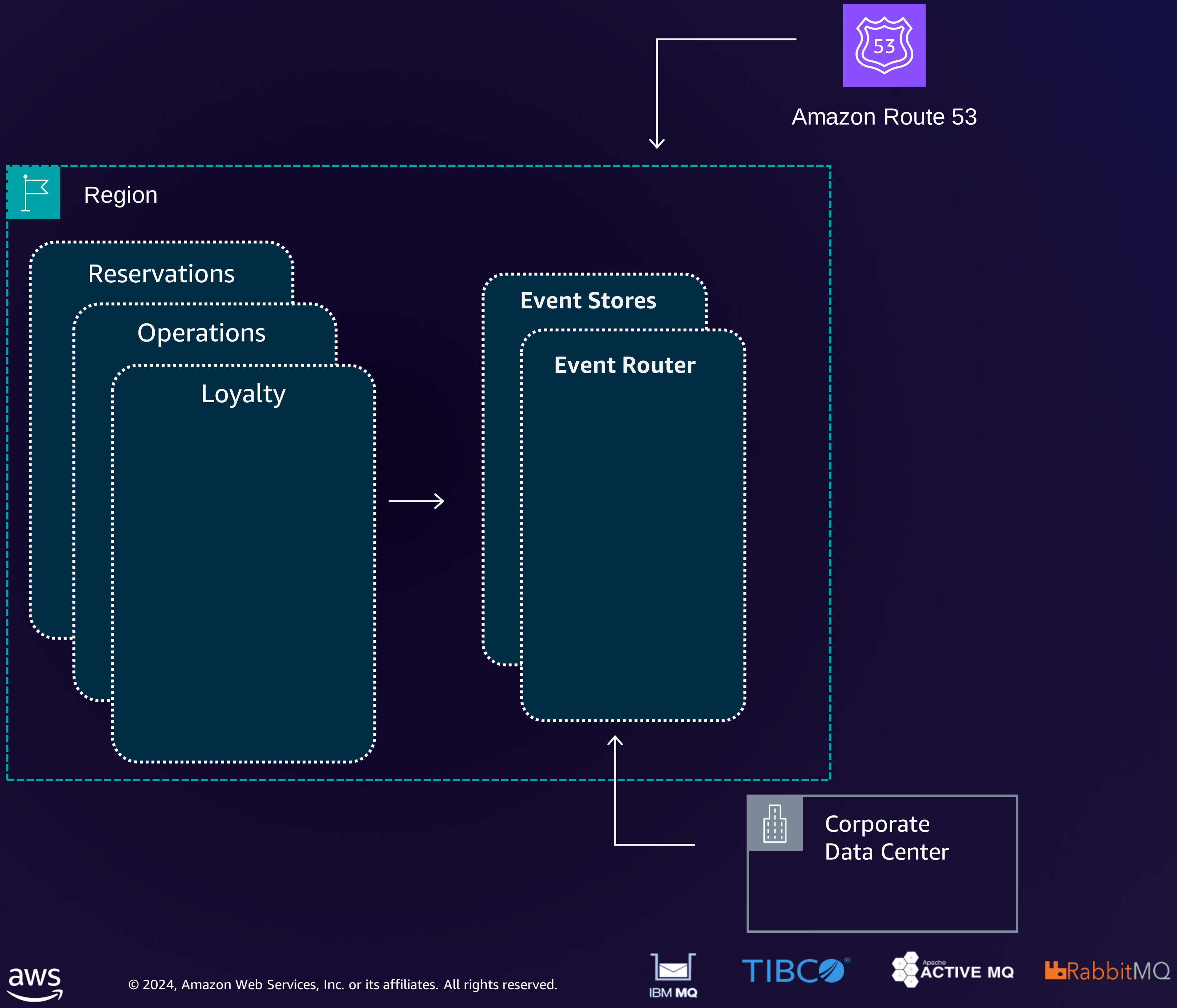

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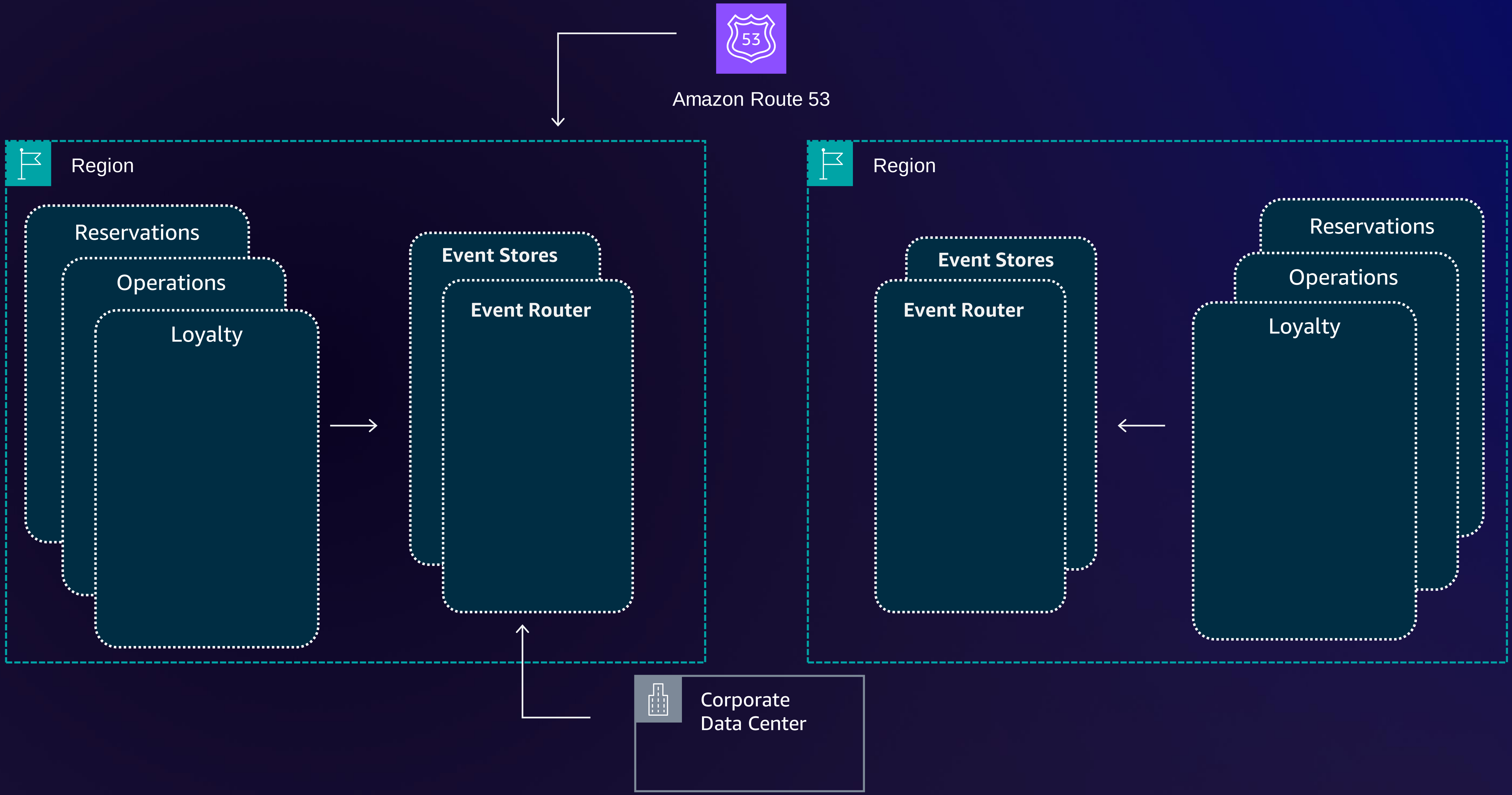

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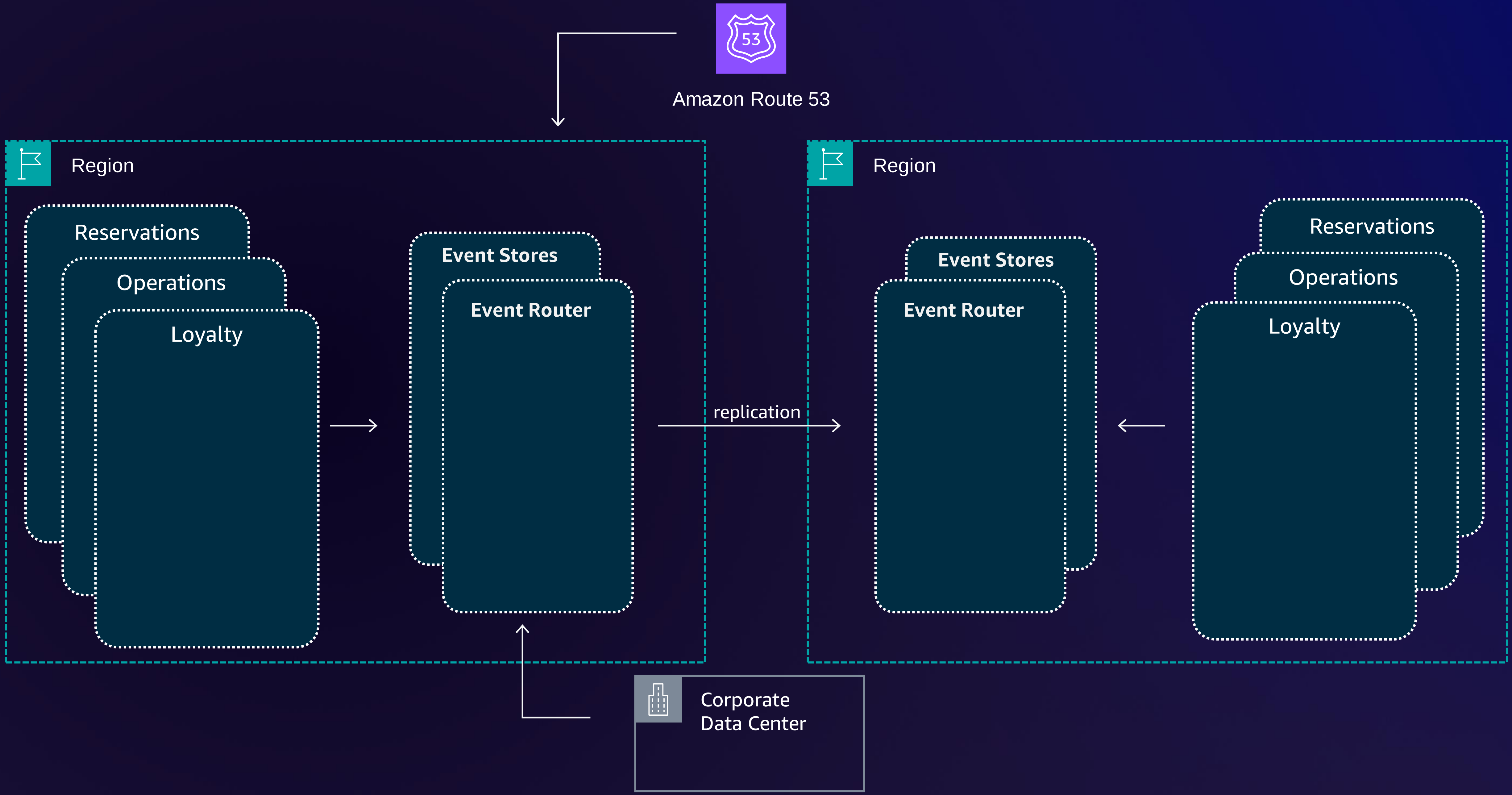

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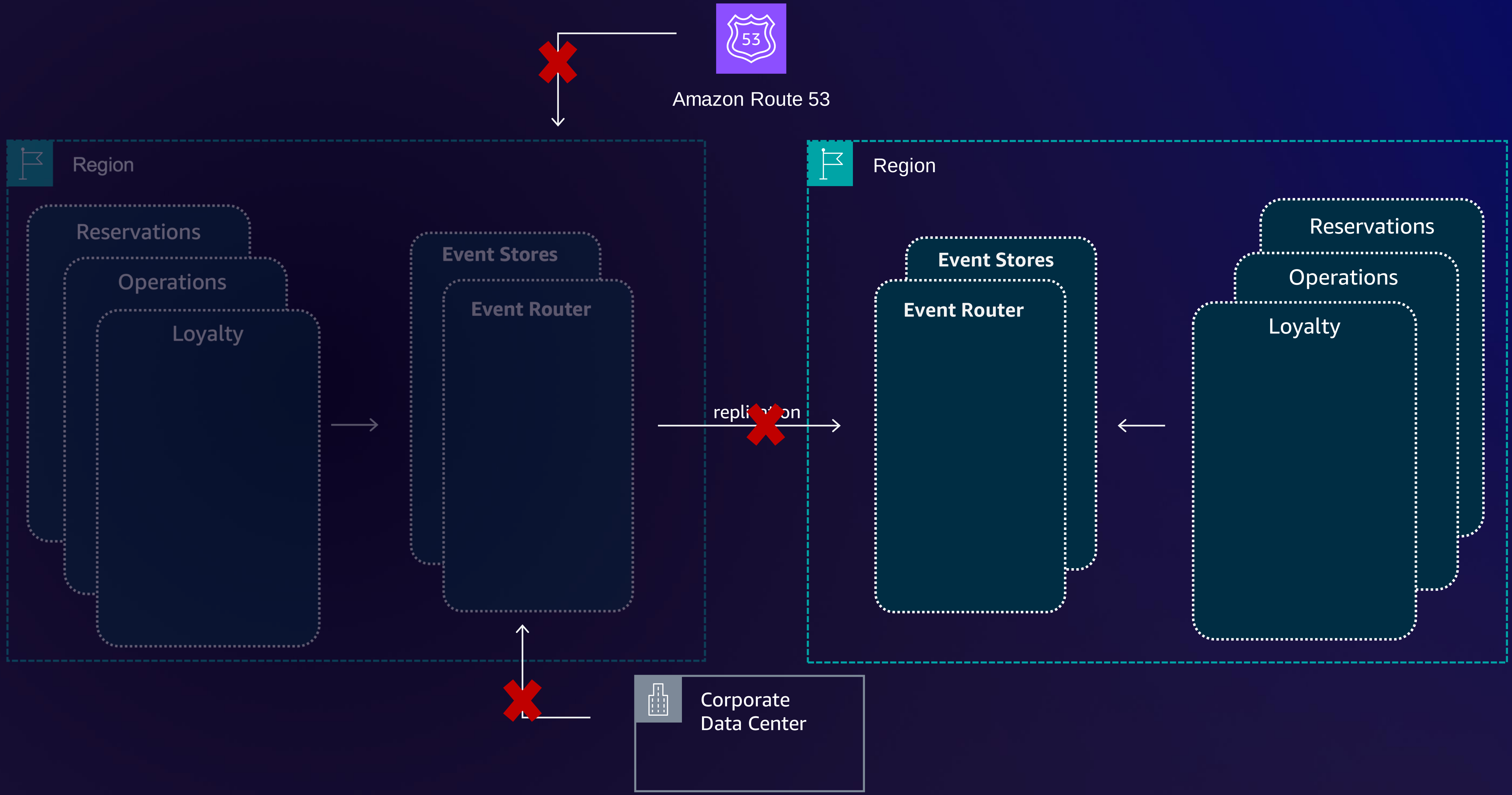

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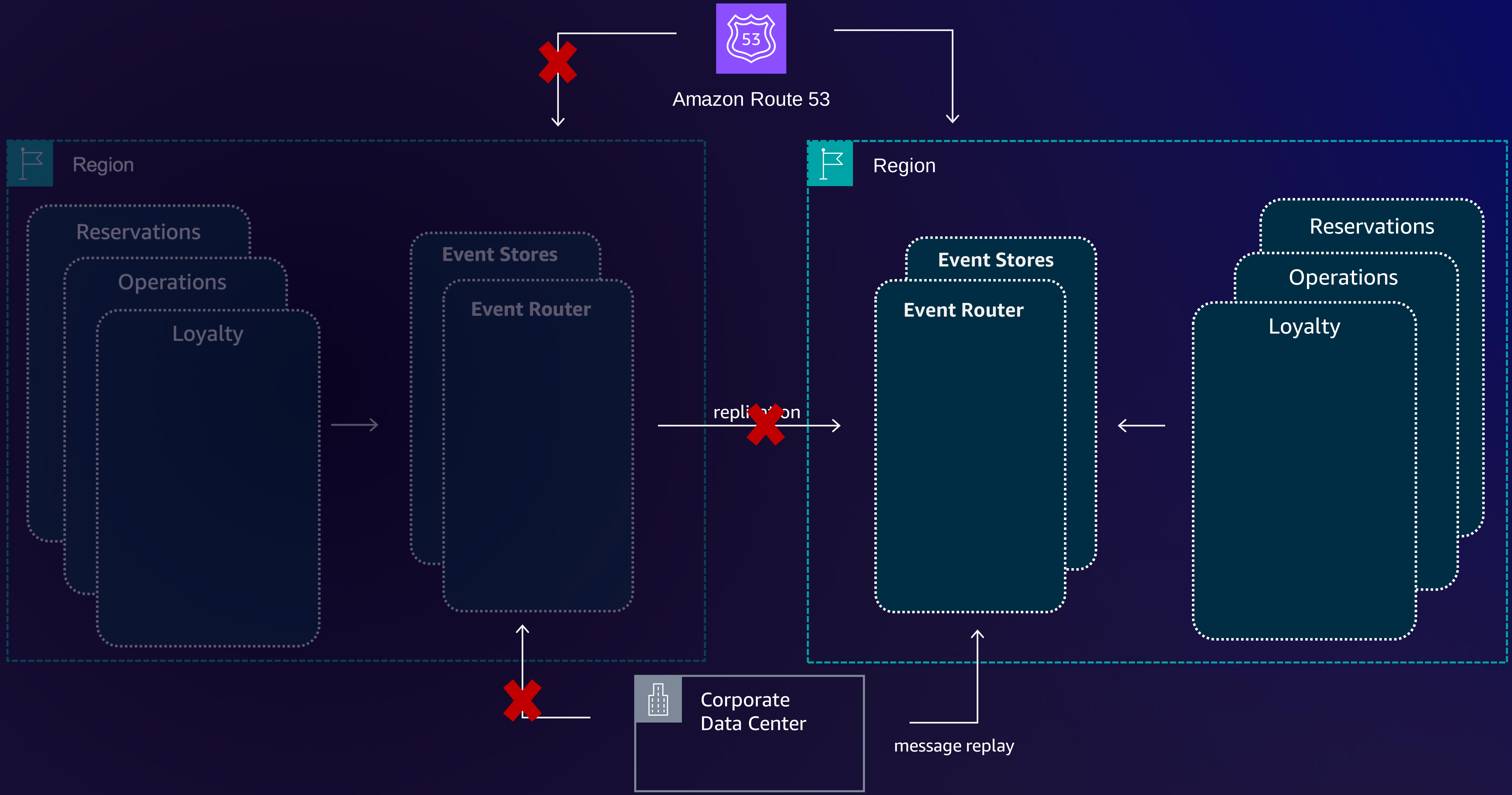

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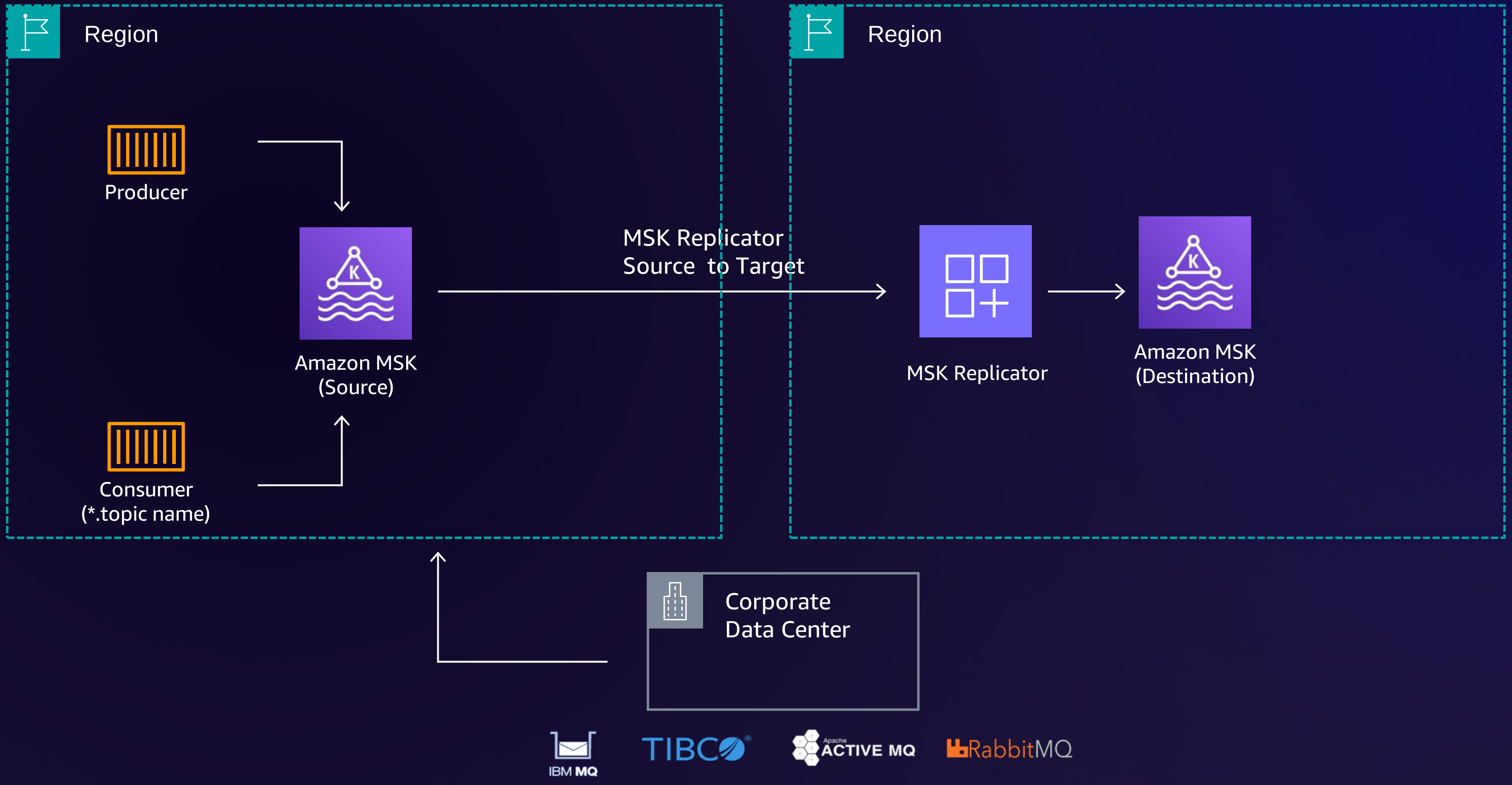
Amazon MSK Replicator



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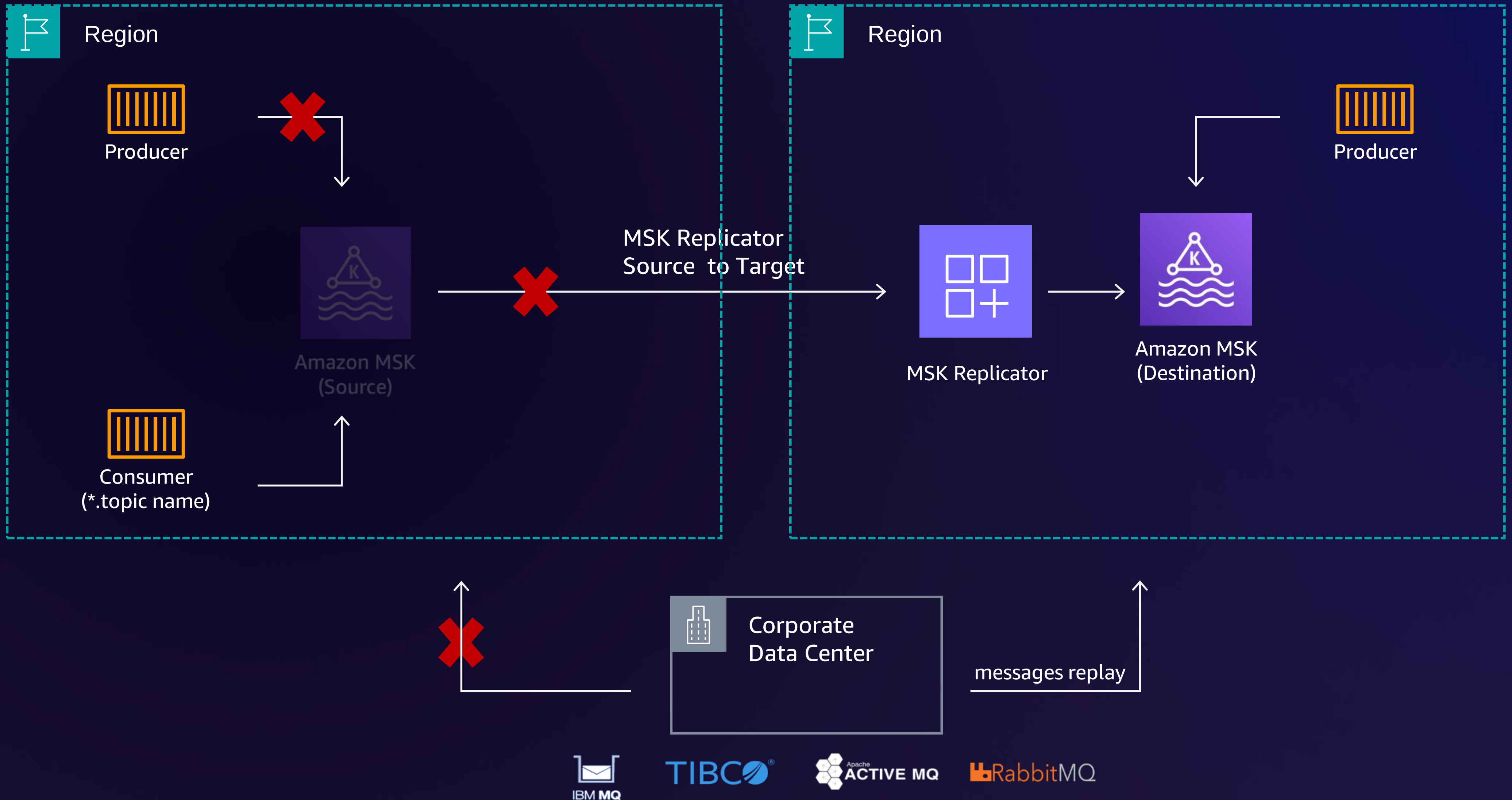
Amazon MSK Replicator



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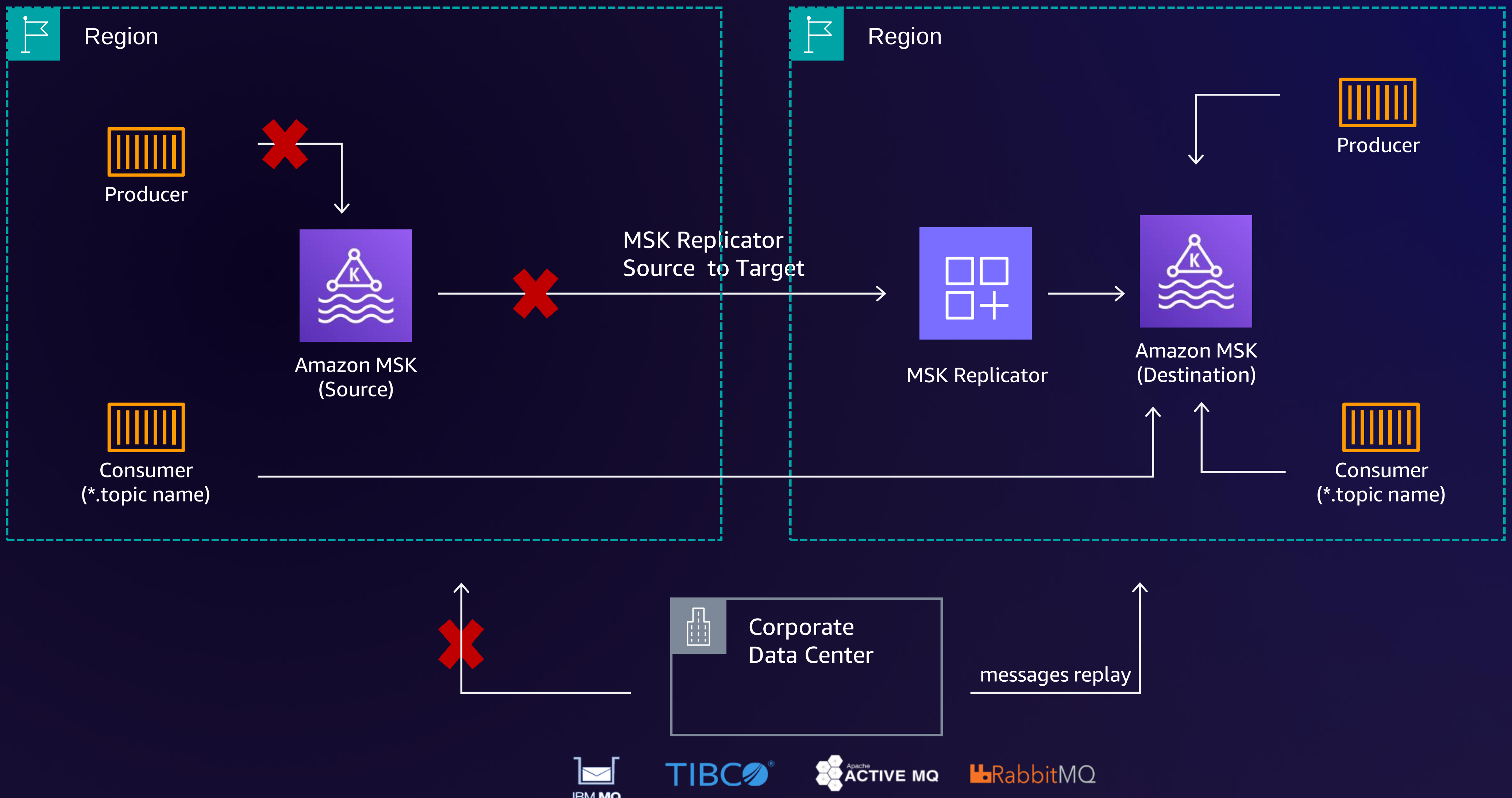
Amazon MSK Replicator



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Other considerations

1. Failover process automation
2. Asynchronous replication
3. Strong observability practice & health checks
4. Latency across Regions
5. Fine-grained access to secrets

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Data protection for event-driven architecture

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Characteristics of EDA

In event-driven architecture (EDA) focuses on the production, detection, and reaction to events

Events can **propagate across a network**, updating data stores as they go, and can be initiated anywhere

It consists of **event emitters** (or agents), **event consumers** (or sinks), and **event channels**, with a focus on **decoupling producers and consumers** of events to allow for independent operation and scalability

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Characteristics of EDA

Data in movement

Across locations
on-premises <-> AWS <-> Regions & AZs

Across system components
producers, channels, consumers & storages

On top of a network layer

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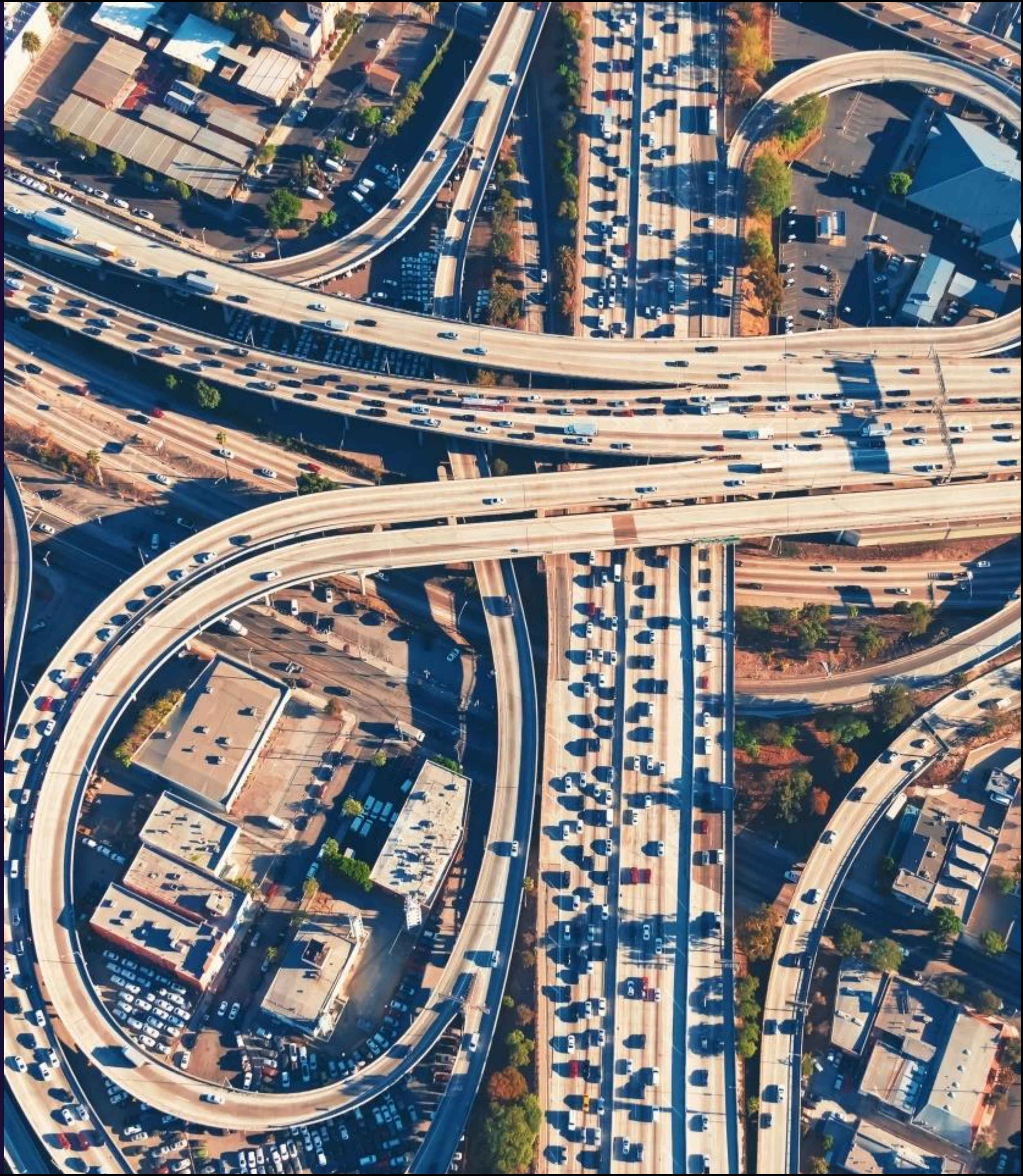
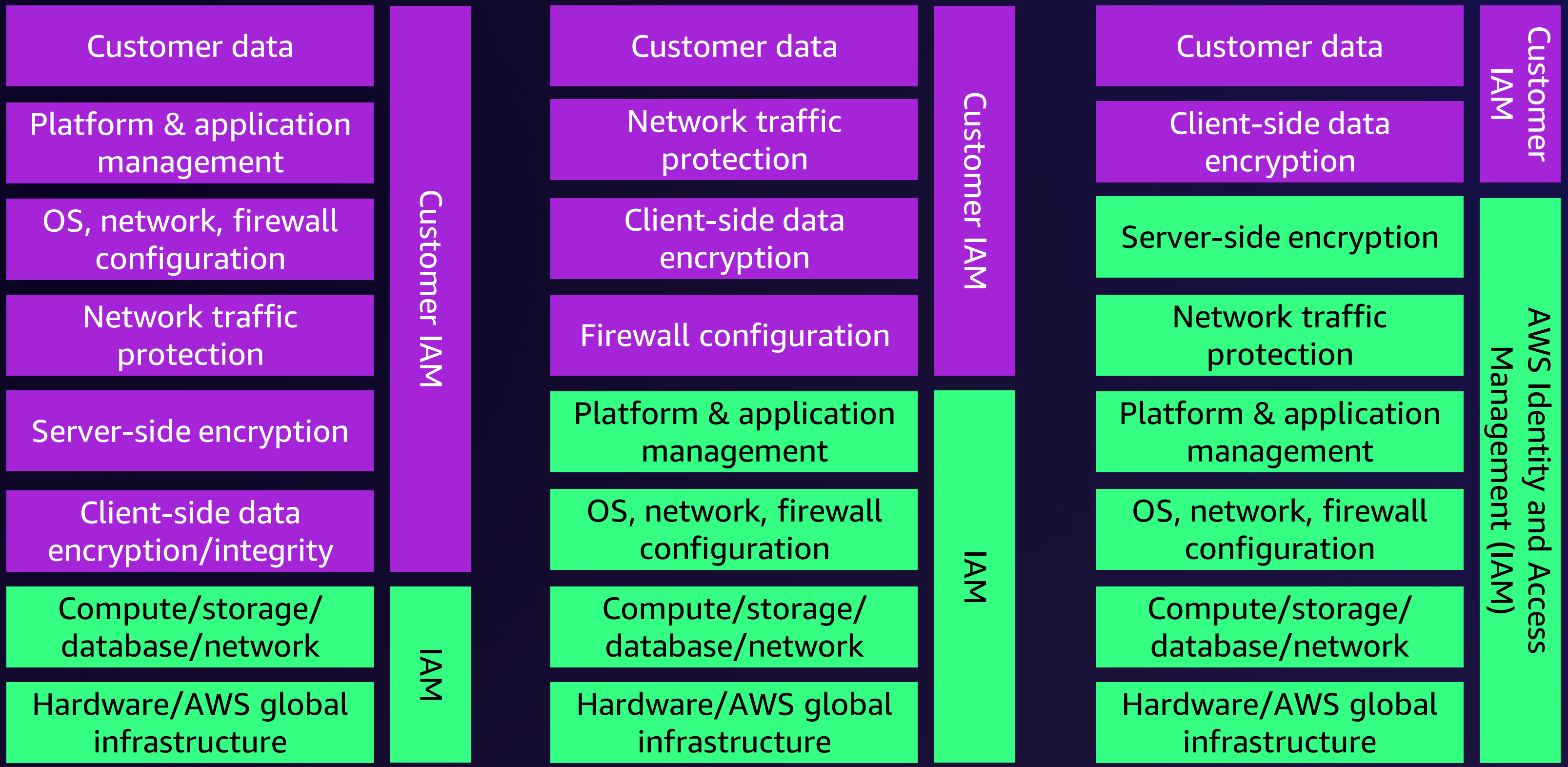


Shared responsibility

Amazon EC2 | AWS Fargate | Amazon RDS | Amazon S3 | AWS KMS | Amazon DynamoDB

More customizable
+
More customer
Responsibility


Customer data
Platform & application management
OS, network, firewall configuration
Network traffic protection
Server-side encryption
Client-side data encryption/integrity
Customer IAM
Compute/storage/ database/network
Hardware/AWS global infrastructure
IAM
Customer data
Network traffic protection
Client-side data encryption
Firewall configuration
Customer IAM
Platform & application management
OS, network, firewall configuration
Compute/storage/ database/network
Hardware/AWS global infrastructure
IAM
Customer data
Client-side data encryption
Customer IAM
Server-side encryption
Network traffic protection
Platform & application management
OS, network, firewall configuration
Compute/storage/ database/network
Hardware/AWS global infrastructure
AWS Identity and Access Management (IAM)

Less customizable
+
Less customer
responsibility
+
More best practices
built-in

Infrastructure services | **Container services** | **Abstracted services**

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EDA data protection best practices

- Move only needed data, attributes, or metadata (avoid verbose events/messages)
- Filter and remove unneeded sensitive data (at source or at the edge)
- Always use encryption

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Encryption

In Transit

Protects data being transferred (network) using a secure protocols

At Rest

Protects data stored (includes short-term storage like cached data)

Client-Side

Protects data at the client or event producer, before it is transmitted

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AWS KMS 101

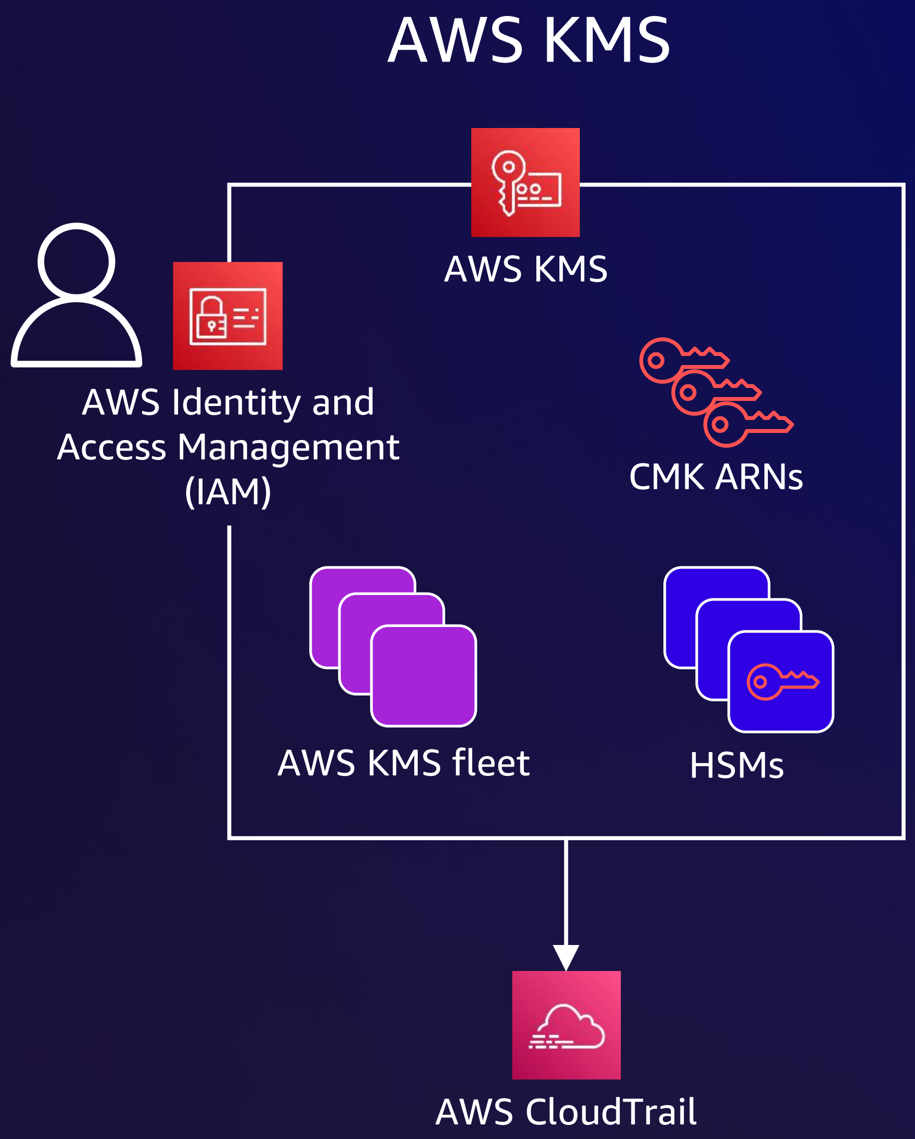
AWS managed **web service** with console, REST API, and CLI access

Database of encrypted keys leveraging role- and attribute-based access controls

Backed by a fleet of **hardware security modules (HSMs)**

All requests authorized with **IAM**

All activity tracked with **AWS CloudTrail**



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EDA services encryption

	AWS Native				Managed Open Source	
	Queue	Stream	Topic	Bus	Stream	Broker
	Amazon SQS	Amazon Kinesis Data Streams	Amazon SNS	Amazon EventBridge	Amazon MSK	Amazon MQ *(ActiveMQ/RabbitMQ)*
In Transit	TLS 1.2+	TLS 1.2+	TLS 1.2+ (optional but recommended for subscription)	TLS 1.2+	TLS 1.2 (default between brokers of a cluster)	TLS 1.2+ *see RabbitMQ inter-node encryption
At Rest SSE server-side encryption	Supported SSE-SQS or KMS	Supported KMS	Supported KMS	Default | AWS owned key KMS	Always encrypted KMS	Always encrypted KMS

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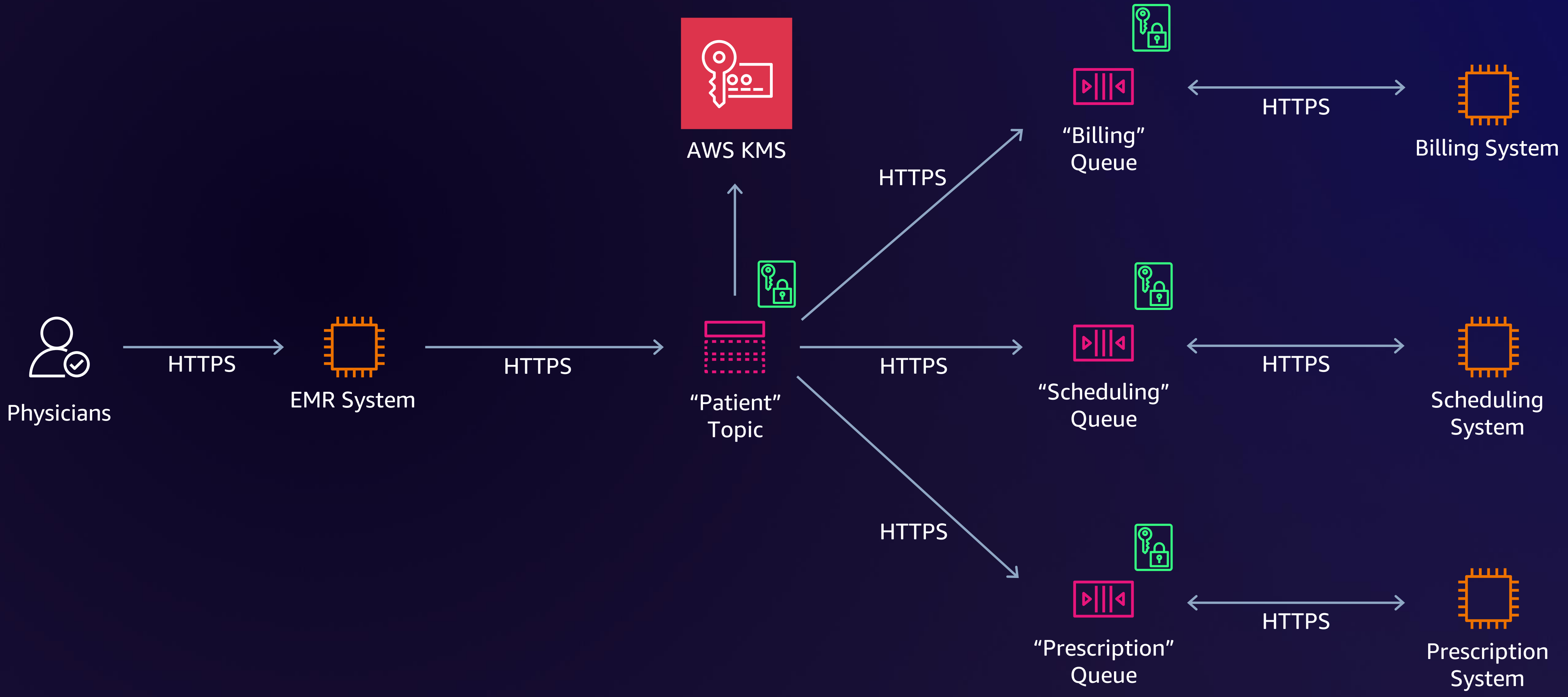
Electronic medical record (EMR) example



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Client-side encryption

Plaintext:

```
{
  “title” : { S : “Encryption Is Fun” },
  “year” : { N : “2023” },
  “keywords” : { SS : [ “B”, “A”, “C” ] }
}
```

Encrypted form:

```
{
 “title” : { B : “FkdT1jwRcRb0MvONY=” },
 “year” : { B : “Jc9o1w==” },
 “keywords” : { B : “FYAHd8jenWb8Zf1a” }
}
```

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Client-side encryption and event-based systems

- Consider payload-level VS field-level encryption (overhead VS accessible fields)
- Your bus/broker/topic may need plaintext access to specific fields (filter rules, routing)
- Avoid adding sensitive information in metadata, context, or bus/topic names

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Selective field-level client-side encryption

```
Plaintext:
{
  "name" : { S : "My Name" },
  "SSN" : { N : "111-11-1111" },
  "keywords" : { SS : [ "B", "A", "C" ] }
}
```

```
Encrypted selective form:
{
 "name" : { B : "FkdT1jwRcRb0MvONY=" },
 "SSN" : { B : "Jc9o1w==" },
 "keywords" : { SS : [ "B", "A", "C" ] }
}
```

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Client-side encryption – The easy way

AWS Encryption SDK

Making client-side encryption safer and easier to use

- Open source
- C/.NET/Java/JavaScript/Python/CLI
- Supports Keyrings and multi-Region KMS keys
- Simplifies the development process
- Envelope encryption
- **Data protection** (encryption) and **data integrity** (signature) in a single tool

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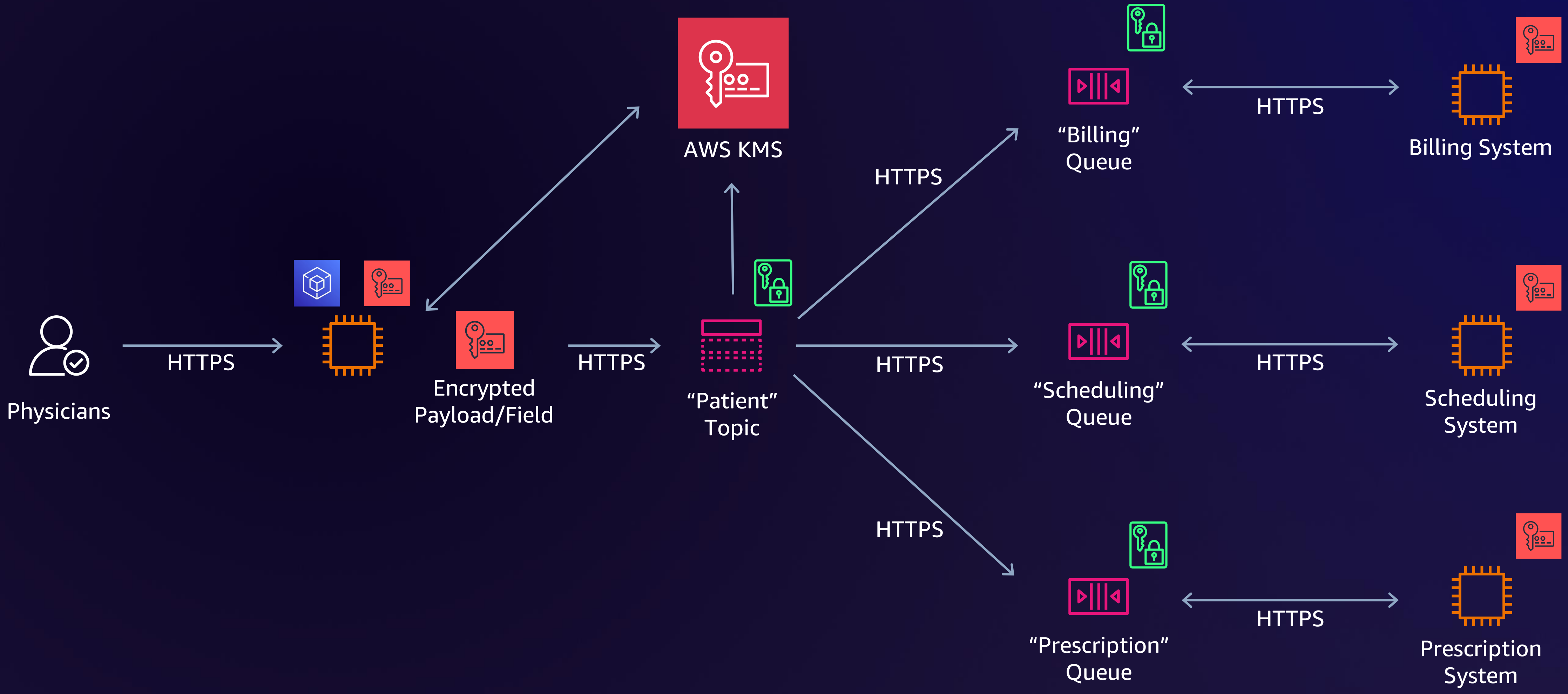
Electronic medical record (EMR) example 2



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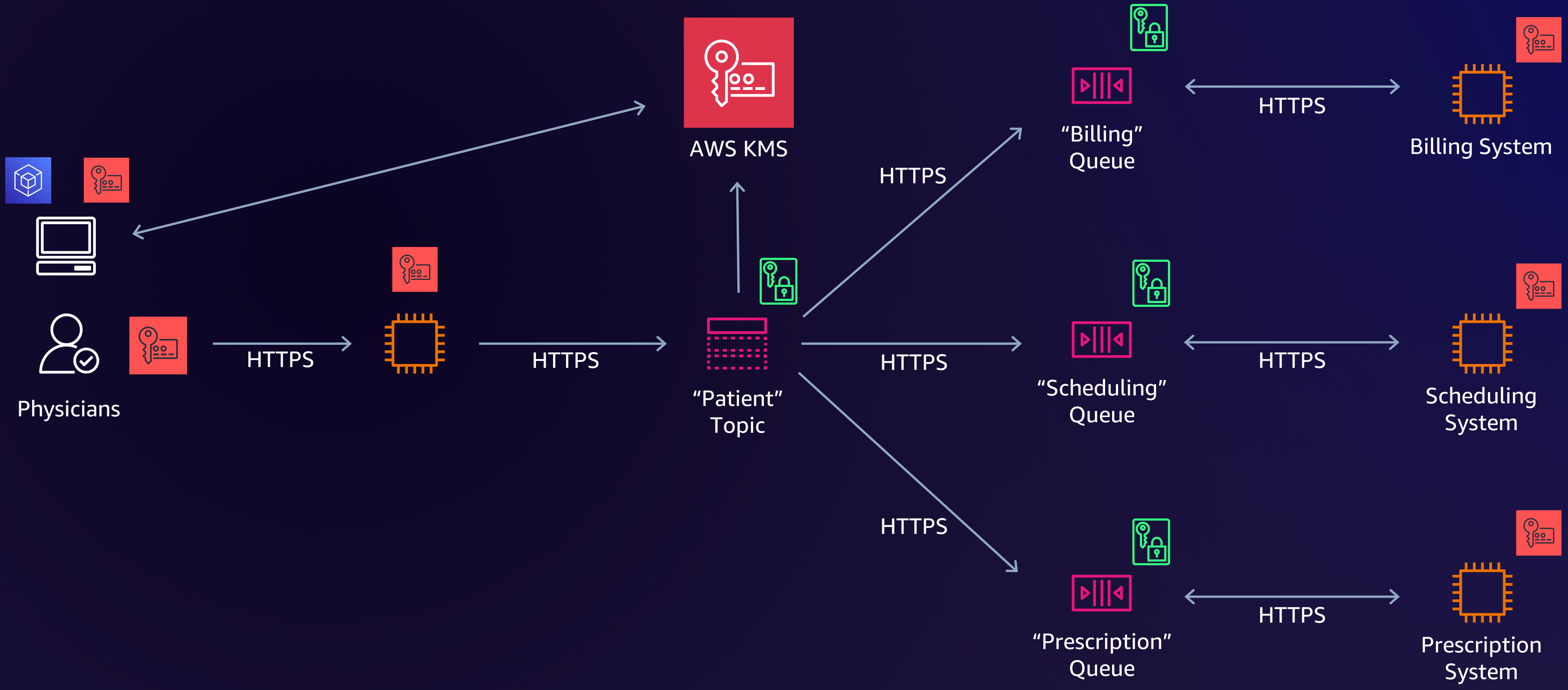
Electronic medical record (EMR) example 3



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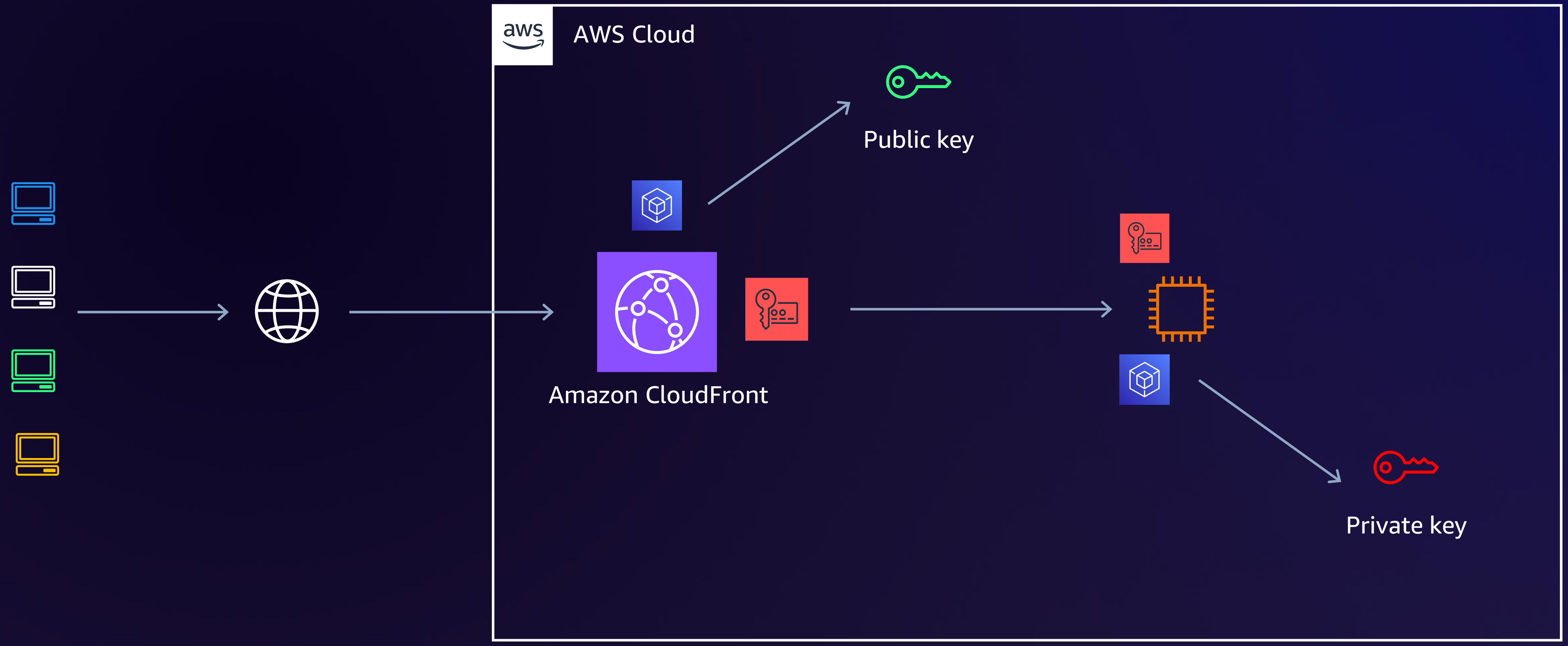
What if I don't control external clients?

Field-level encryption at the edge with Amazon CloudFront



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UNITED

United Airlines

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Agenda

Passenger **S**ervice **S**ystem

Transformation experience using event-driven architecture

Setting up for success

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UNITED NEXT

700+

New Aircrafts

50,000

Jobs

LARGEST WIDEBODY ORDER BY A U.S. CARRIER IN COMMERCIAL AVIATION HISTORY.
Up to 200 new 787 Dreamliners.
UNITED
DREAMLINER
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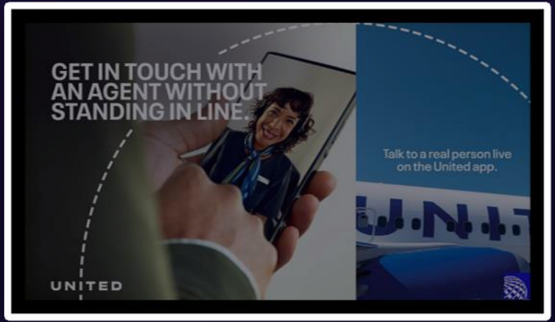
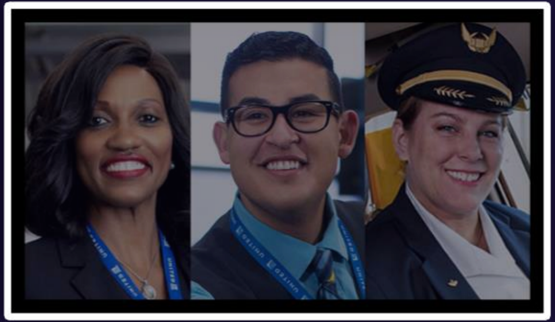


Success so far built upon decades old technology



Bag drop shortcut
Already checked in and paid for your bags?
Use these kiosks to skip the lines.
UNITED

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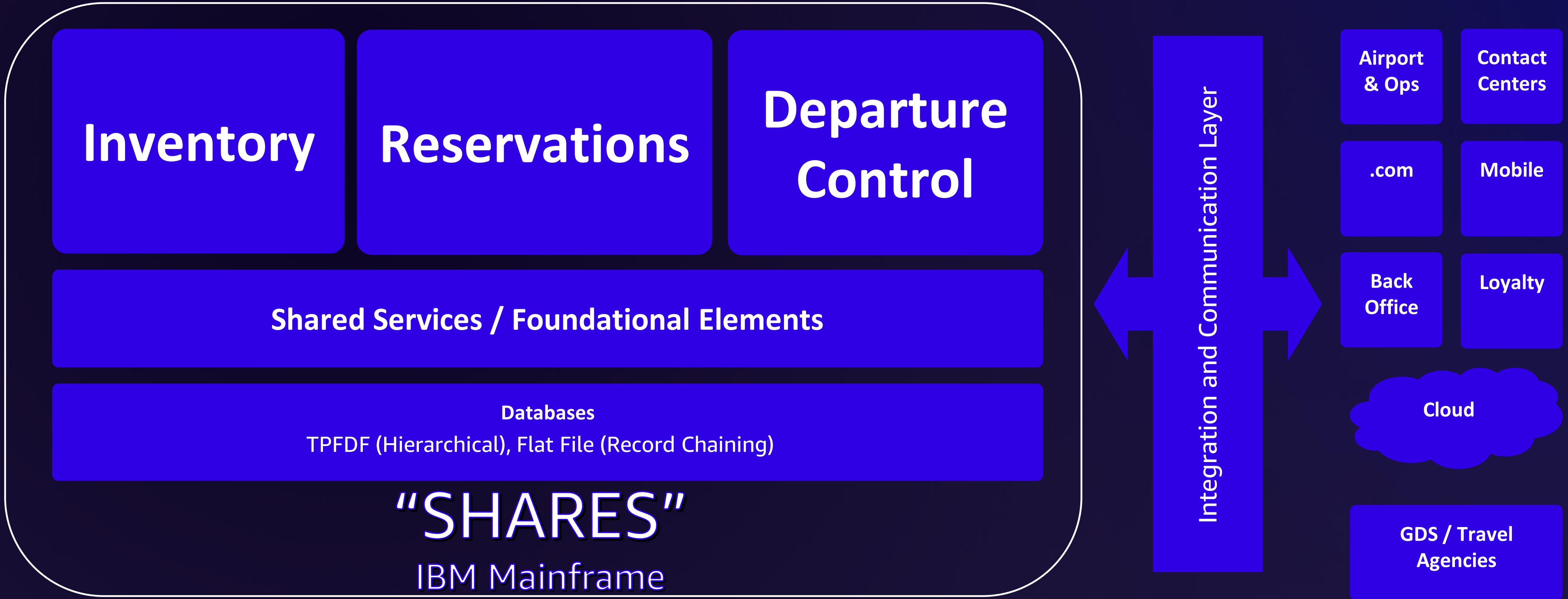
What is a Passenger Service System (PSS)?

A passenger service system (PSS) is a series of critical systems used by airlines. The PSS usually comprises an airline reservations system, an airline inventory system and a departure control system (DCS).



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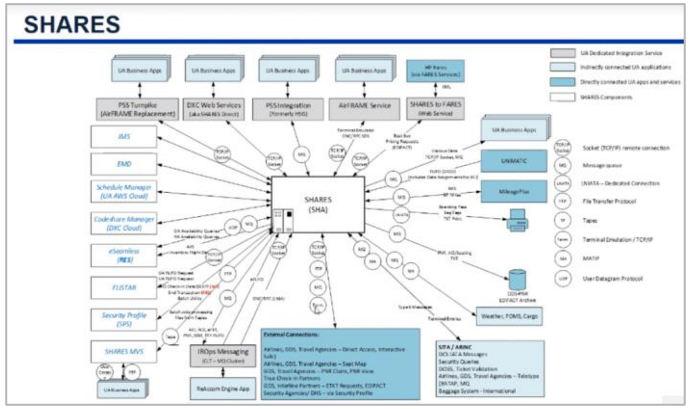
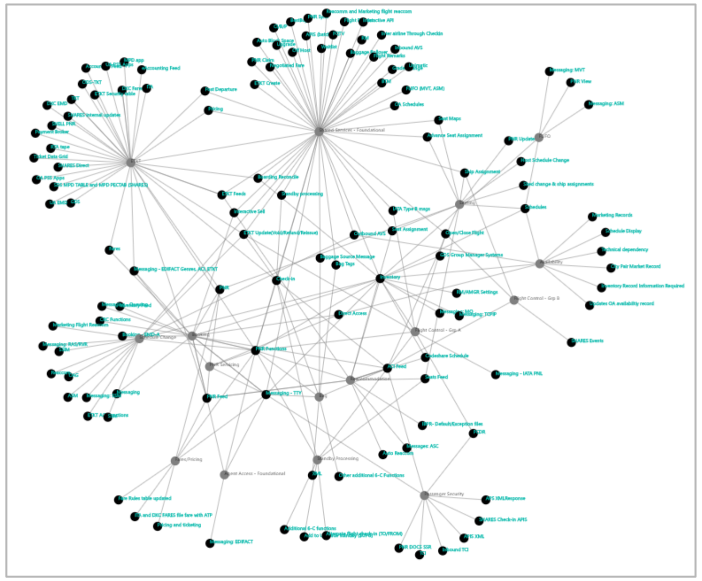
Transformation requires careful examination of dependencies and customer priorities

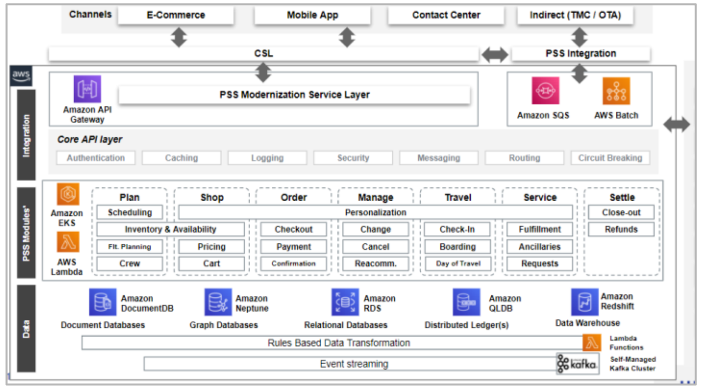
1 Document Current-State PSS Components and Dependencies

2 Examine **Component Dependencies**

3 Implement Future-State PSS with Mitigation of Dependencies







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Pivot PSS Design to Order Management System

- Customer centricity
- Alignment to domain-driven architecture*
- Lead industry transformation
- Technology transformation

*Redefine and remain compliant

Source: https://twitter.com/united/status/542688661083807746

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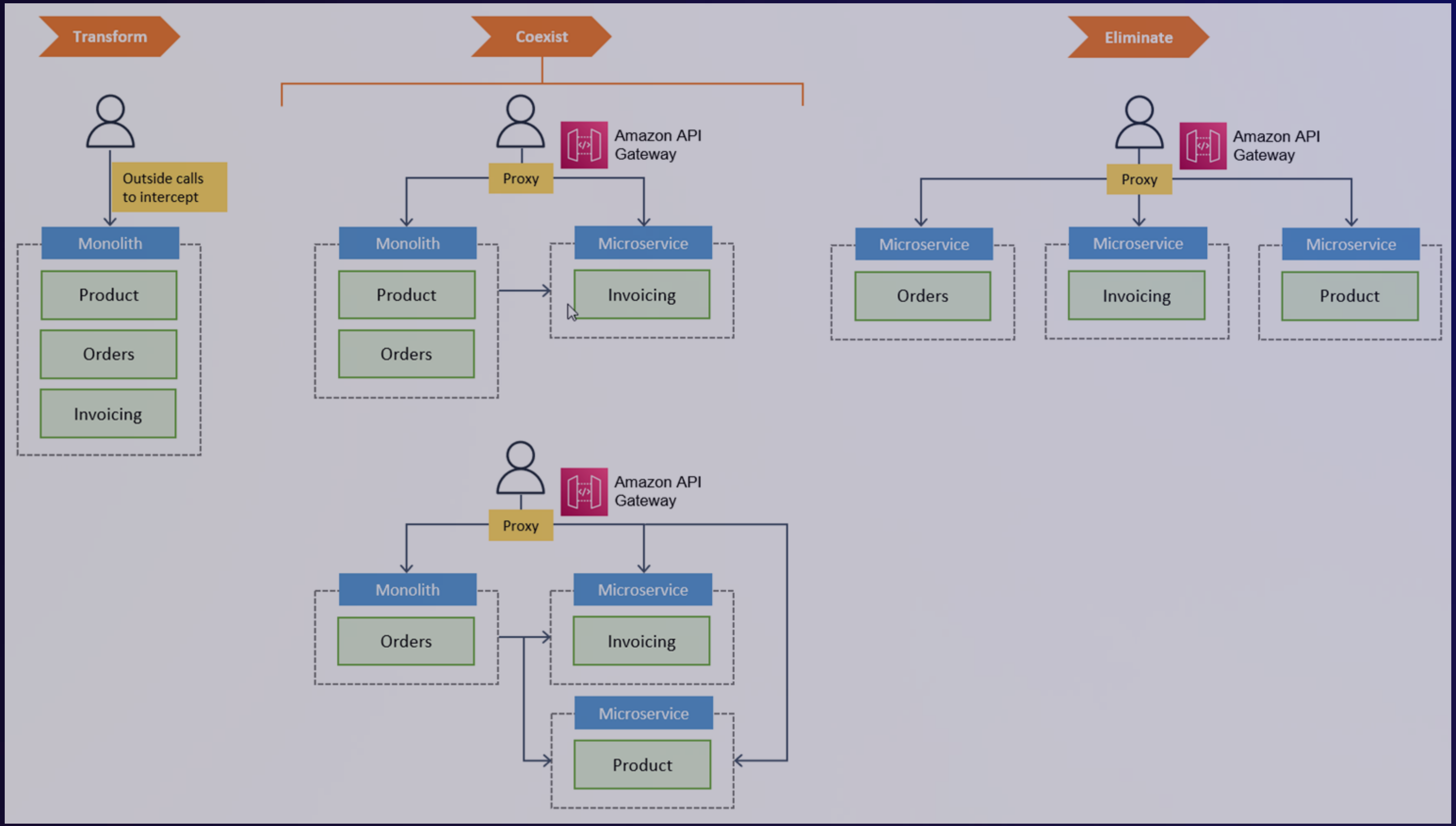
Transformation stages of strangler fig pattern

Complexity of **mainframe**

Coexist: Dependencies on other airlines and external systems

Eliminate: Green screen commands

Natural progression to event-driven architecture



Source: Strangler fig pattern - AWS Prescriptive Guidance (amazon.com)

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Key business requirements

15M+ daily transactions

1.7M+ flights

8.5M+ daily seat map view

500k+ daily passengers

Resilience & High Availability

Ensuring recovery from failures or disruptions and minimize downtime; ability to handle increased demand

Monitoring & Observability

End-to-end transaction tracing and proactive issue detection

Data Management

Maintain data integrity between legacy and modern system as well data storage, retrieval, processing, and analysis

Cost-Effectiveness

Variablize cost-structure, serverless where applicable

Interoperability

Interoperability between on premises and cloud; ability to support current business needs while modernizing for future

Agility & DevOps

Iterative approach to deliver business benefits; enable faster time to market, frequent updates, and improved quality

Security

Incorporate robust security measures, such as encryption, authentication, authorization, and audit logging

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Reference architecture

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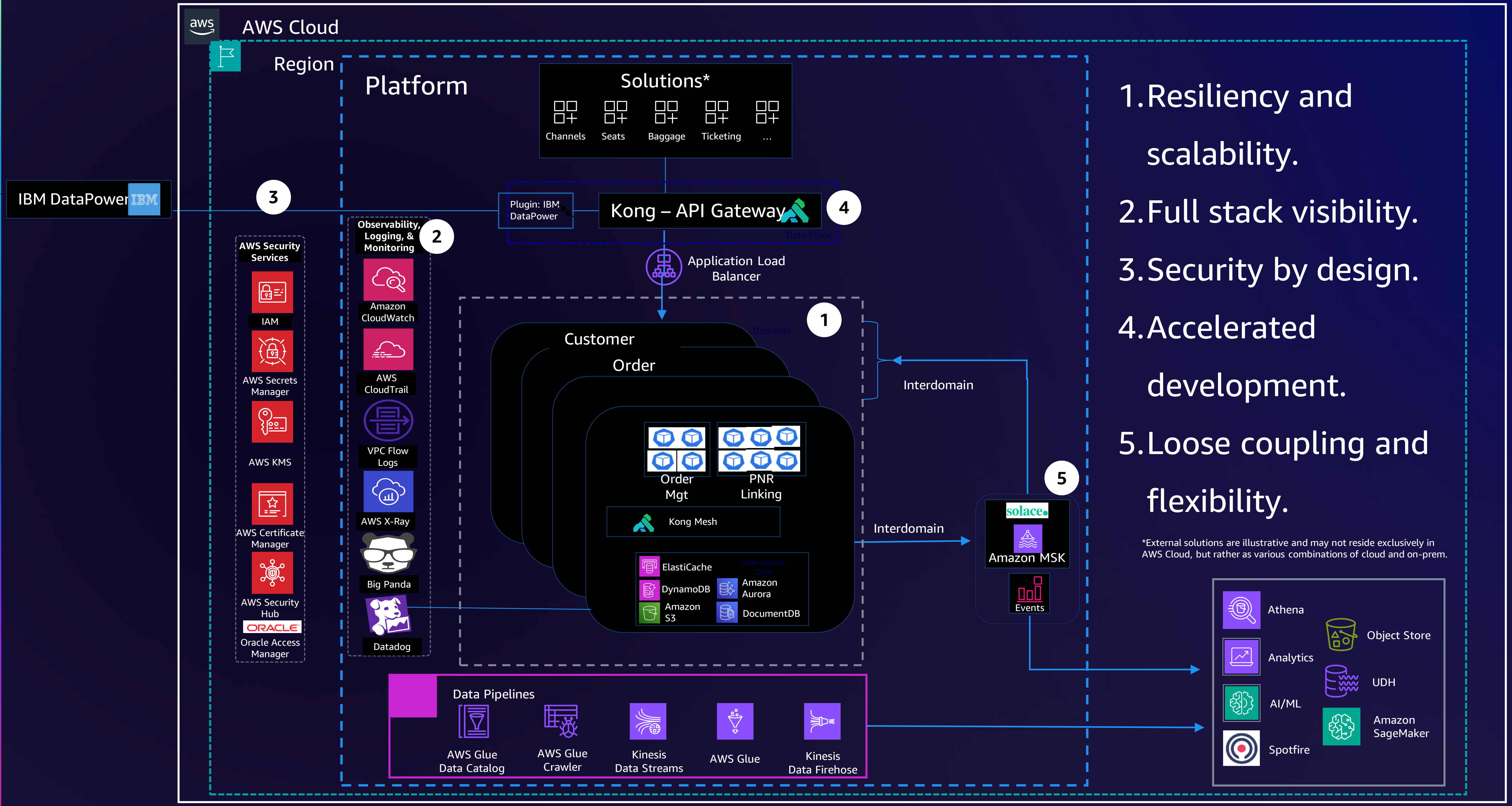

1. Resiliency and scalability.
2. Full stack visibility.
3. Security by design.
4. Accelerated development.
5. Loose coupling and flexibility.

*External solutions are illustrative and may not reside exclusively in AWS Cloud, but rather as various combinations of cloud and on-prem.

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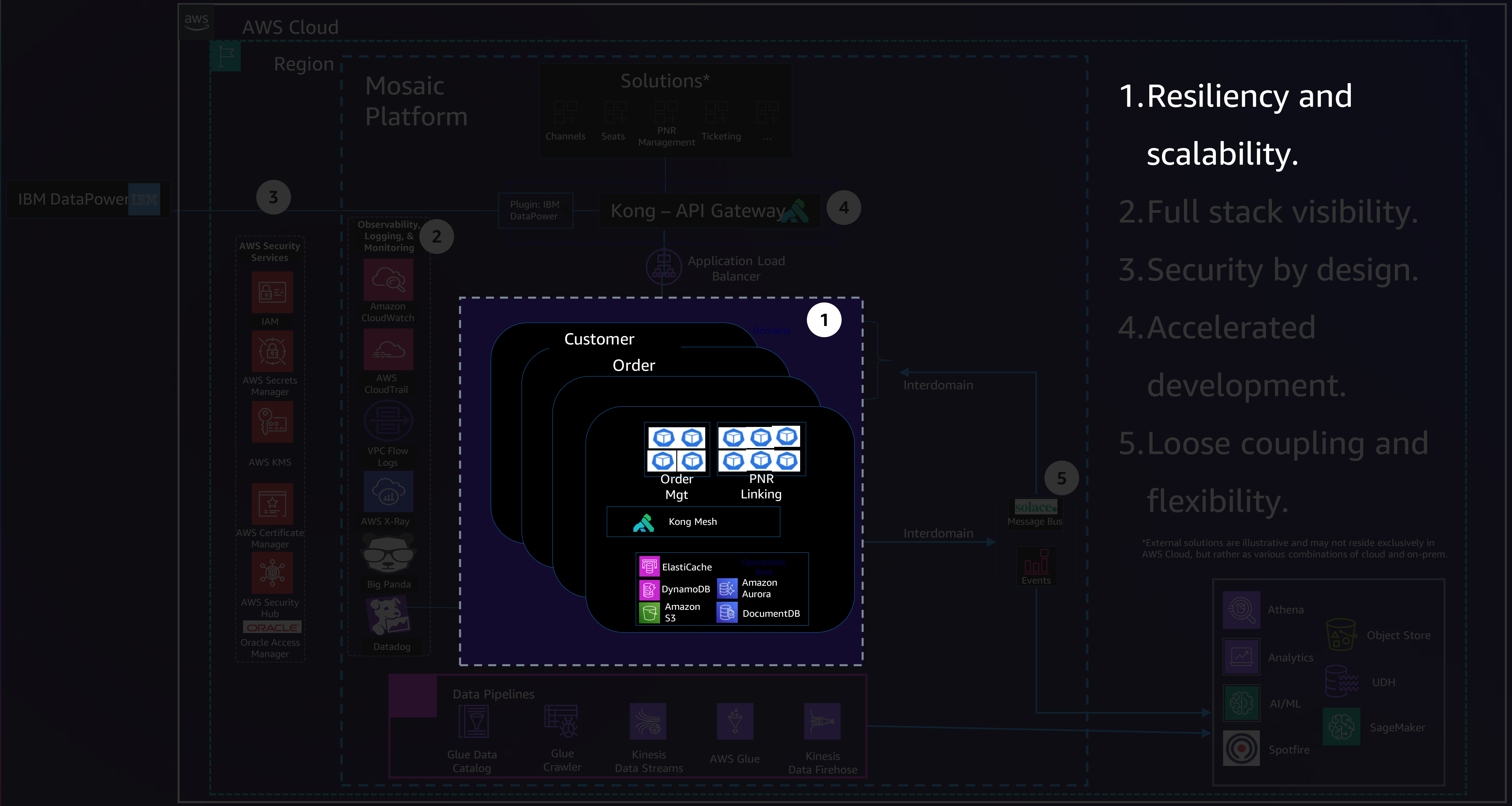

1. Resiliency and scalability.
2. Full stack visibility.
3. Security by design.
4. Accelerated development.
5. Loose coupling and flexibility.

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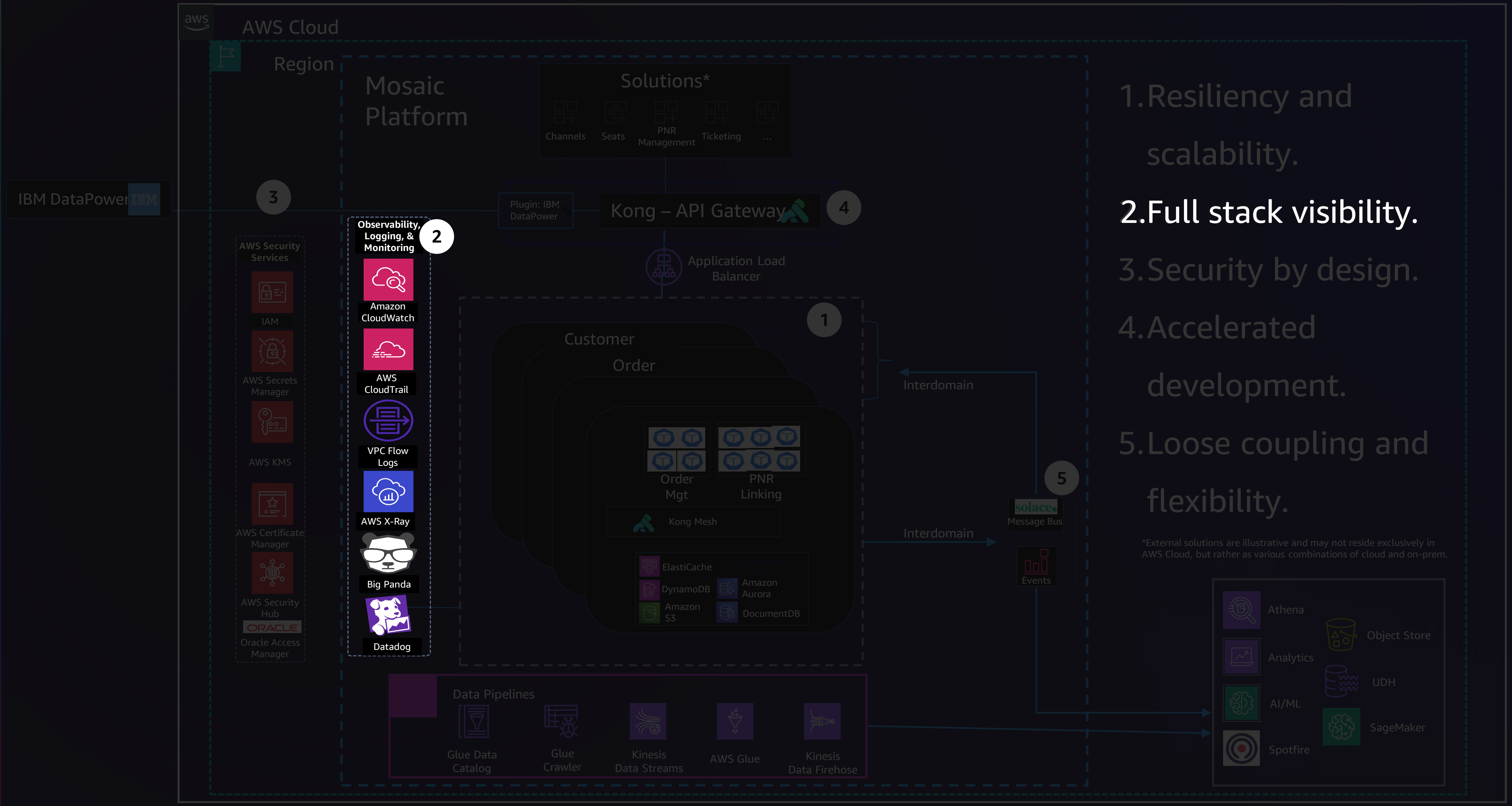

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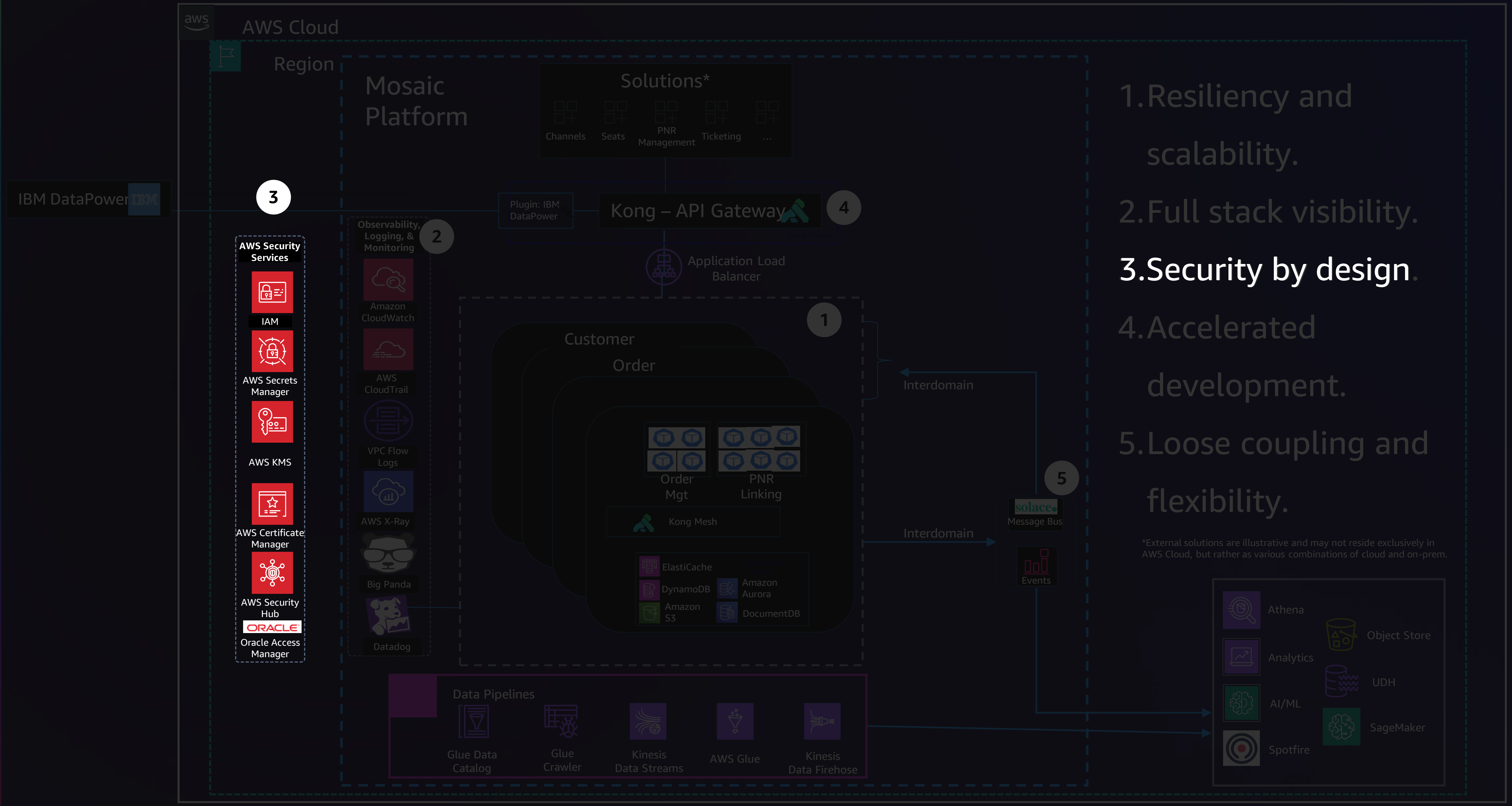

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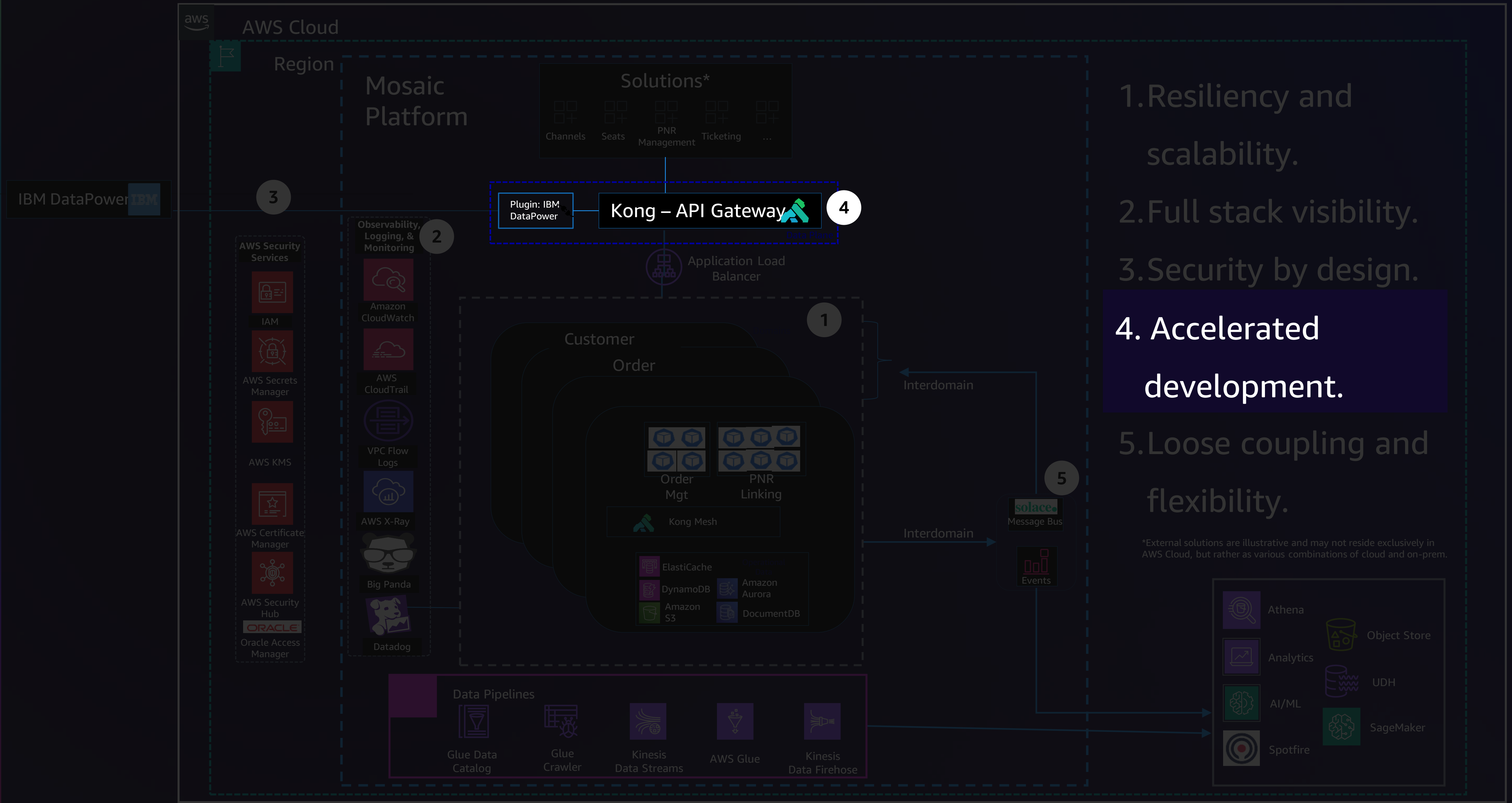

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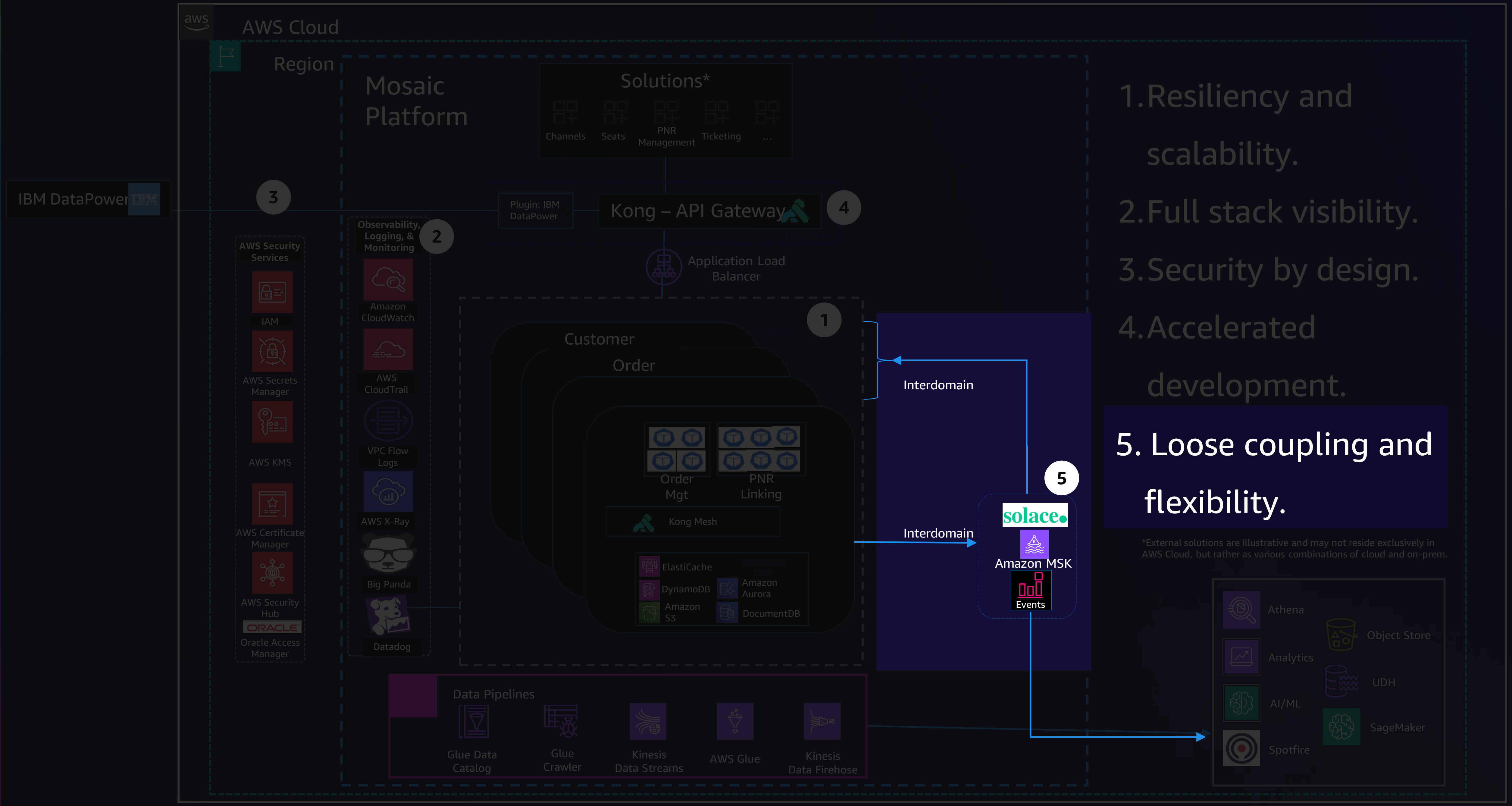

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EDA patterns

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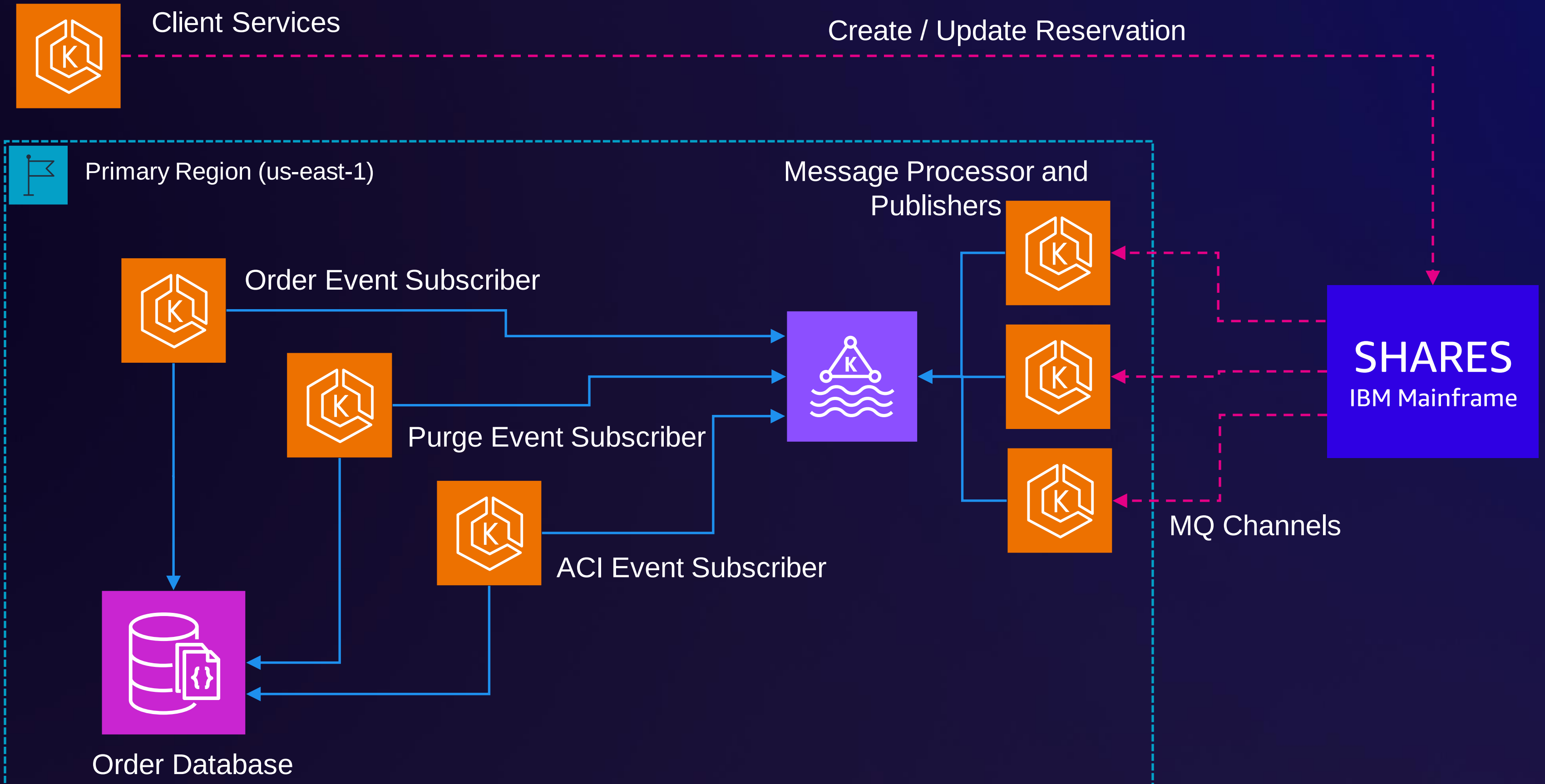
Pattern 1 – Coexist with mainframe

Transformed application in passive state

Order Event

Purge Lifecycle Event

Automated Check In Event



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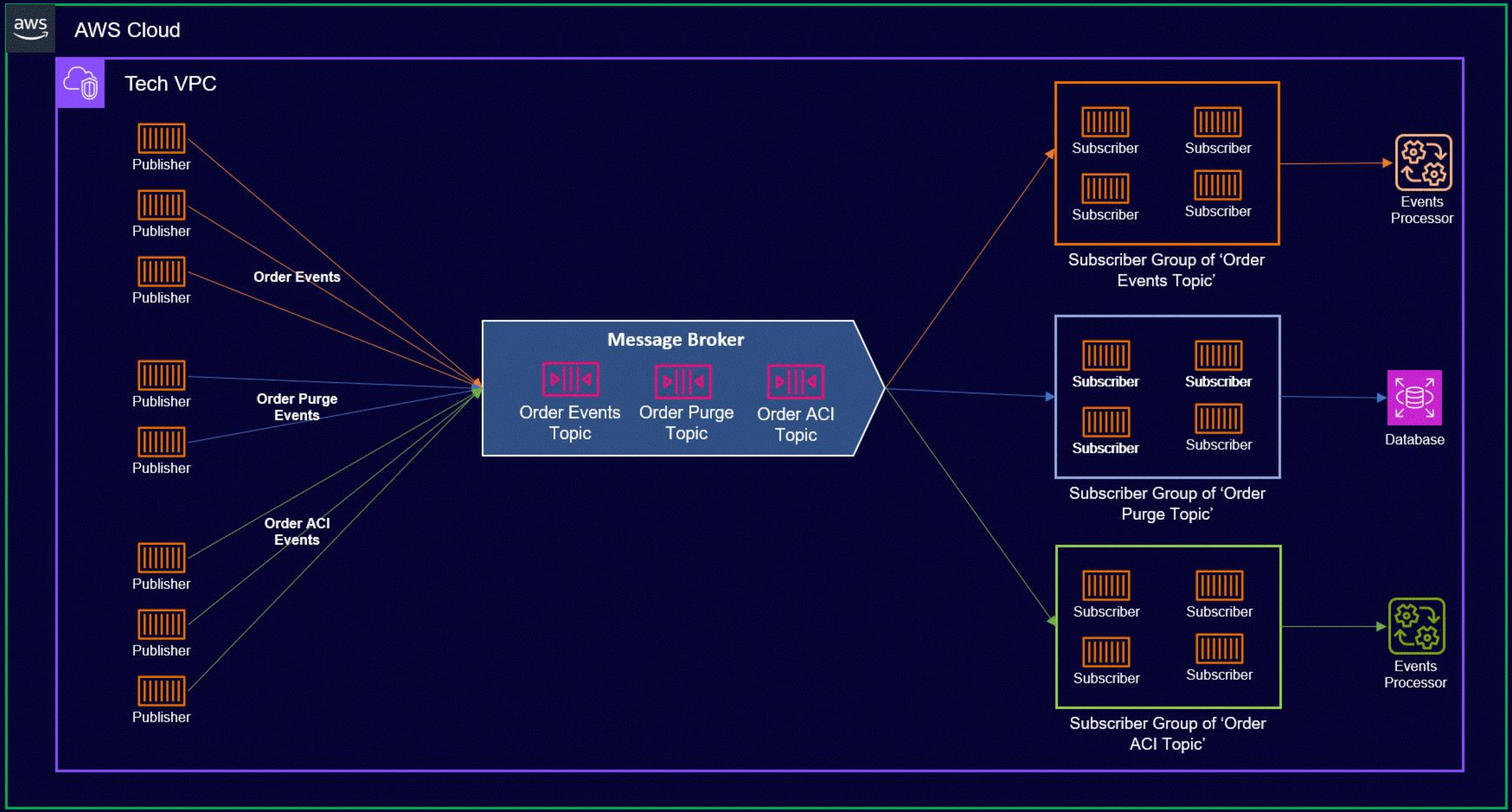
Pattern 2 - Event streaming

Order events for Baggage

Order events to serve customers

Guaranteed sequence for events during IRROPS



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Pattern 3 - Data integrity check

Multiple System Of Record

Maintain Seat Assignment Sequence

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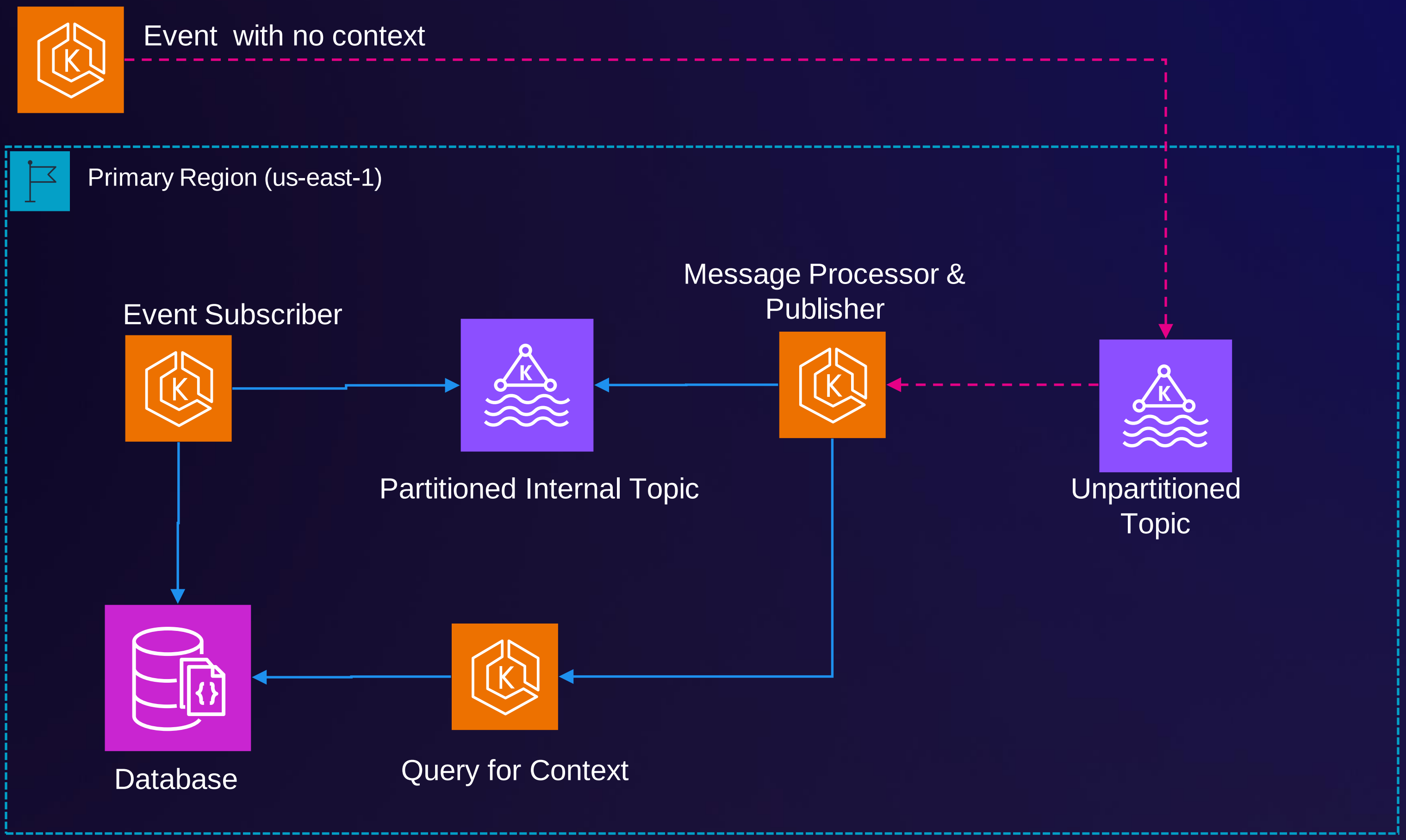
Pattern 4 - Context injection

Augment context to process event sequentially

Provides scalability during IRROPS events

Enable low latency updates for downstream systems


Event with no context
Primary Region (us-east-1)
Message Processor & Publisher
Event Subscriber
Partitioned Internal Topic
Unpartitioned Topic
Database
Query for Context

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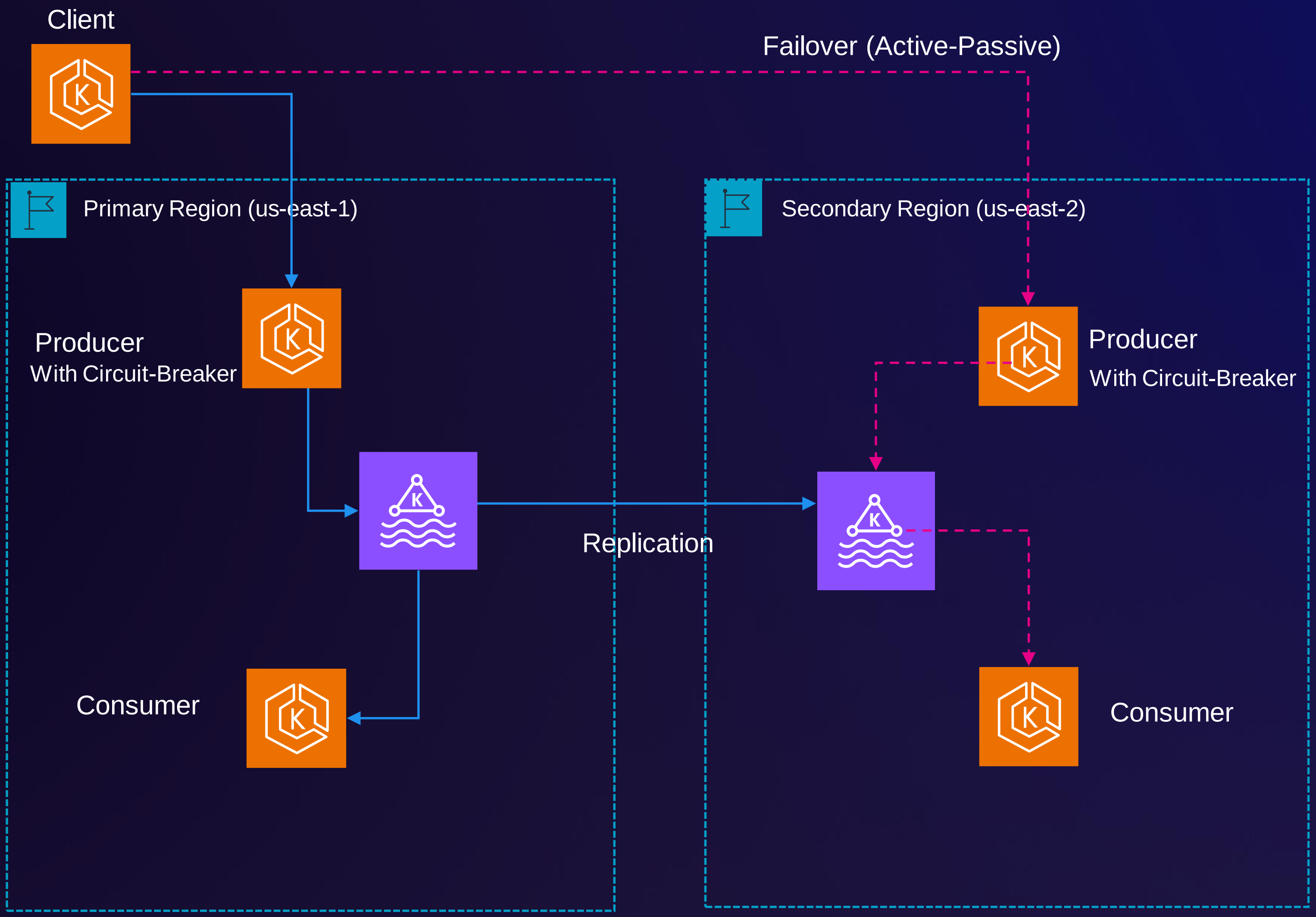
Pattern 5 – Circuit breaker

- **Scenario with Active-Passive setup**
  Messaging or Database failure

- **MSK Broker Failure**
  Circuit Breaker setup to initiate cross region failover



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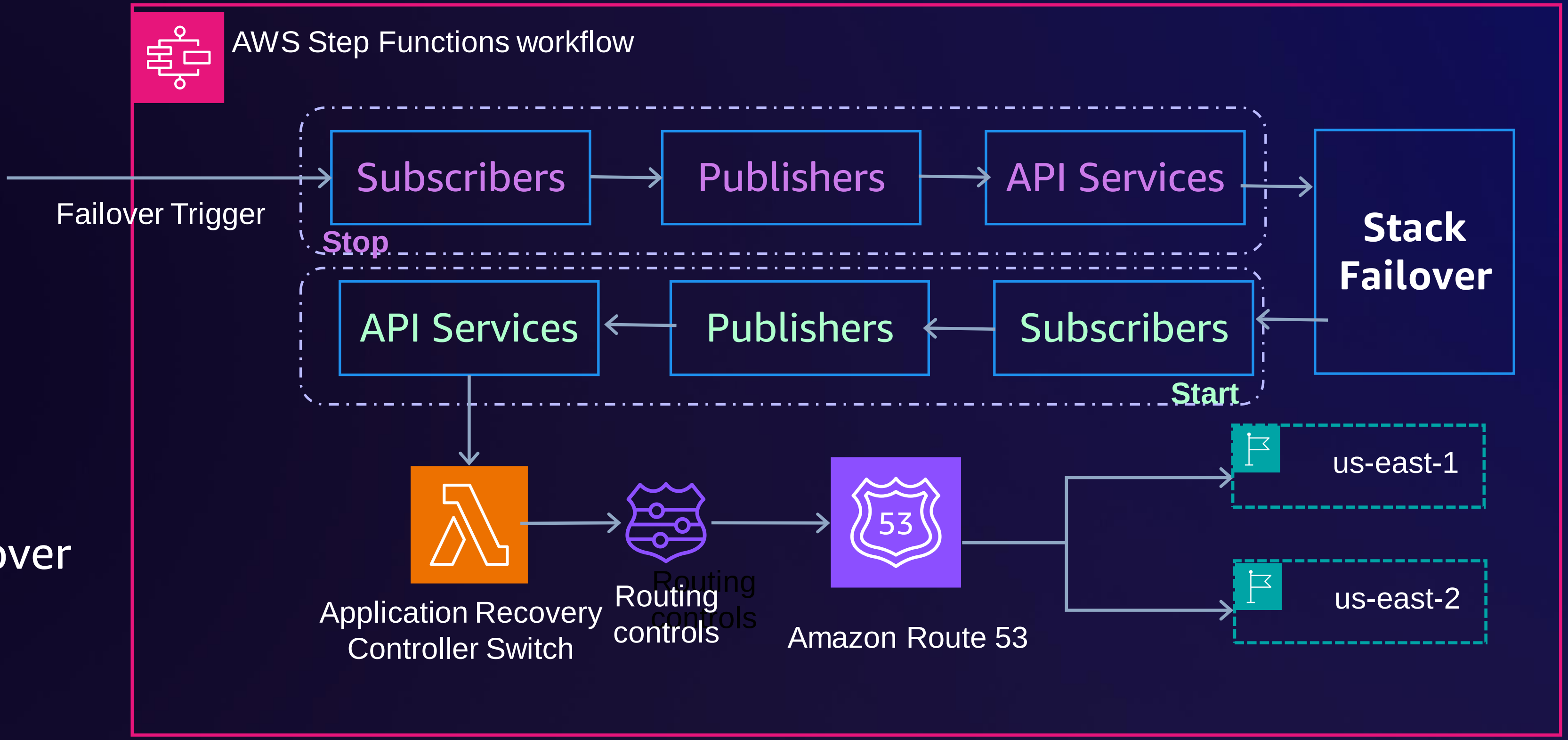
Failover automation process

- **AWS Step function**
  Minimize data loss by restart services in sequence

- **Application Recovery Controller**
  Re-route API traffic post failover



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Guiding principles for resilient architecture

- Microservices design
- Event-driven architecture
- Leverage platform capabilities
- Data-driven integrations
- Design flexible interfaces
- Use cloud-native technologies
- Loose coupling of components
- Transition away from batch processing
- Establish systems of record with SOC
- Build for today, design for the future
- Comply with UAL security standards
- Iterate and continuously improve

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Summary

Event-driven architecture is key enabler for resilient PSS system

Data generated from PSS system is fueling Innovative capabilities enhancing your travel experience

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