Integrating microservices by using AWS serverless services

AWS Prescriptive Guidance

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An important aspect of modernizing your organization's software is to select the right architectural patterns that enable agility and responsiveness to changing business needs. In some applications, a monolithic architecture is a common choice. However, for many organizations, refactoring monoliths into microservices can be an effective modernization strategy when the use case aligns with the benefits of microservices.

Microservices and monoliths aren't mutually exclusive—many successful organizations employ both patterns together, where modular monoliths serve some domains and microservices handle others.

When microservices are part of your architecture, several services might be called to fetch data for one business transaction. Implementing these integrations requires careful design to address potential challenges such as data consistency, latency, and operational complexity. When microservices are properly integrated, they can provide benefits such as independent scaling, improved development velocity, and potential cost optimizations.

The guide is part of a content series that covers the application modernization approach recommended by AWS. The series also includes:

- Strategy for modernizing applications in the AWS Cloud
- Phased approach to modernizing applications in the AWS Cloud
- Evaluating modernization readiness for applications in the AWS Cloud
- Decomposing monoliths into microservices

Intended audience

This guide is for application owners, business owners, architects, technical leads, and project managers who have determined that microservices are appropriate for their specific use case. The guide introduces several patterns for synchronous and asynchronous communication between

microservices by using serverless AWS services such as AWS Lambda and Amazon API Gateway for autonomy and scalability.

Objectives

By using this guide to integrate your new microservices, you can efficiently transform your organization's architecture into a microservices architecture. This helps provide rapid adjustment to fluctuating business needs through high scalability, improved resiliency, continuous delivery, and failure isolation. A microservices architecture also speeds up innovation, because each microservice can be individually deployed and tested.

A microservices architecture can also help provide a shorter time to market for your products or services, because each microservice has an independent code base that makes it easier and faster to add new features and iterate on them.

Security

You must secure your microservices properly to protect the integrity of your services and data, but ensure that security does not negatively impact the performance of your application.

In a microservices environment, you must consider how each service will authenticate and authorize requests it receives from an external client or another microservice. Also consider how each service will securely access other AWS services.

Access to AWS services should be granted through narrowly scoped AWS Identity and Access Management (IAM) roles. Assuming an IAM role provides the microservice with short-term IAM credentials in the form of an access key, an access secret, and a session token. These are used by the various software development kits (SDKs) to sign requests to AWS services by using AWS Signature Version 4 (SigV4).

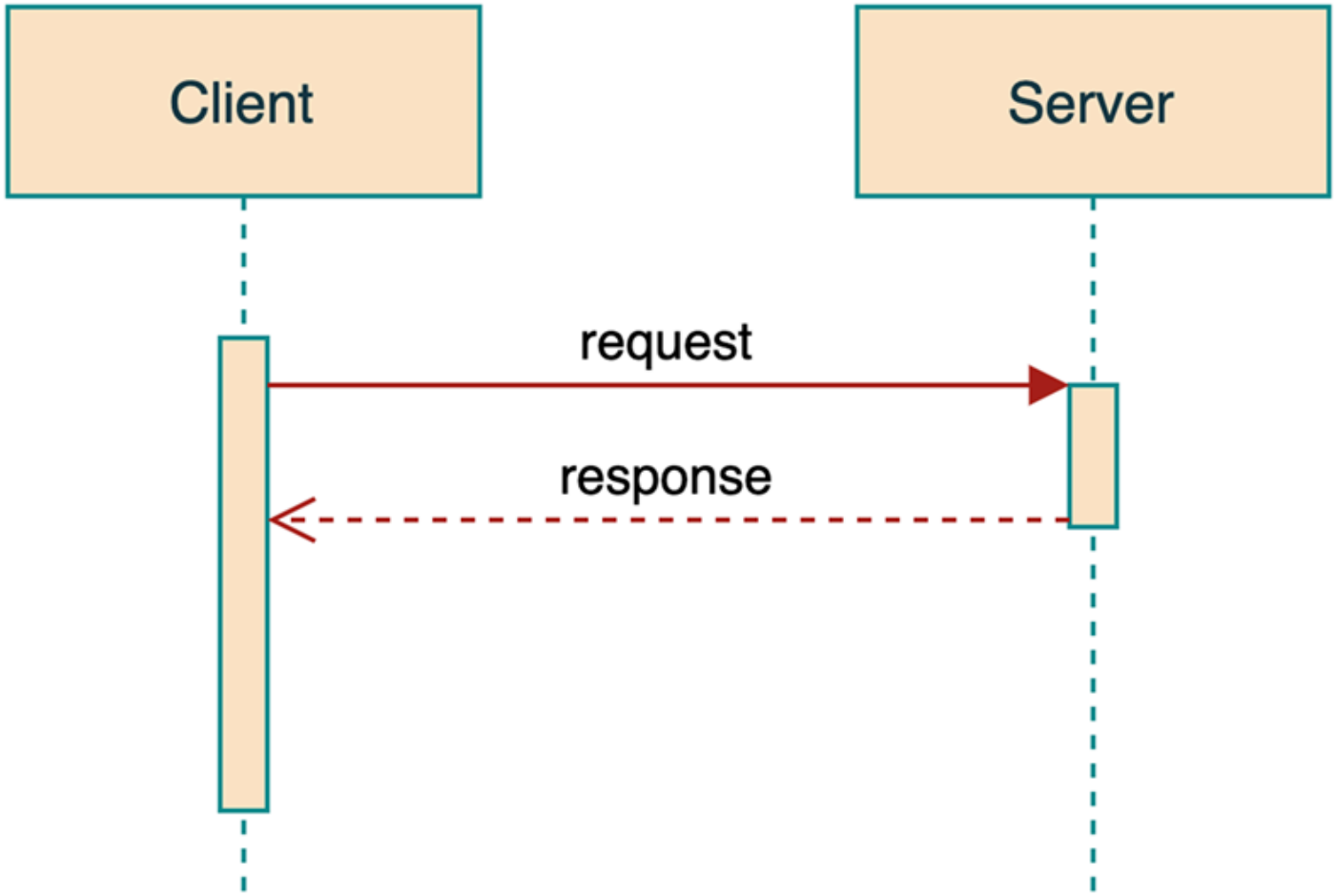
Communication patterns

In a microservices architecture, communication occurs in two main patterns: *synchronous* and *asynchronous*. In synchronous communication, the caller waits for a response before proceeding, similar to a real-time HTTP REST API call. Asynchronous communication follows a message-based pattern where the caller continues processing without waiting for a response, such as when using message queues. The following sections examine each pattern's implementation, benefits, and use cases in detail.

Topics

Synchronous communication

In synchronous communication, a client initiates a request to a service, as the following diagram illustrates. Examples include a request to fetch information, such as an `HTTP GET` request, or a request to mutate data, such as an `HTTP PUT` request. In either case, the client waits for the server to respond before it proceeds. Synchronous calls are familiar to most developers, are easy to implement and troubleshoot, and, in many cases, are the widely accepted standard for communication.



Benefits of synchronous communication include:

- **Predictable flow control** – Deterministic execution and clear request-response cycles that are easier to understand compared with asynchronous communication.
- **Strong consistency** – Immediate confirmation of data changes and state updates.
- **Simple error handling** – Direct propagation of errors and exceptions.
- **Easy debugging** – Straightforward request tracing and monitoring.
- **Protocol support** – Well-established protocols such as HTTP and REST, which make implementation straightforward.

Synchronous communication has some drawbacks:

- **Tight coupling** – Direct dependency of services on each other's availability.
- **Network impact** – Increased network load because of constant open connections.

- **Resource utilization** – Higher memory usage from maintaining connection states.
- **Cascading failures** – Ability for issues in one service to quickly propagate through the system.

Asynchronous communication

Conversely, in asynchronous communication, the client issues a request to a service but doesn't receive an immediate response. In this case, the client usually receives only an acknowledgement that the request was accepted.

Benefits of asynchronous communication include:

- **Event-driven architecture support** – Natural fit for event-sourcing and command query responsibility segregation (CQRS) patterns.
- **Better resource management** – Ability of services to process requests based on their capacity.
- **Improved fault isolation** – Decoupling of services, which prevents cascade failures.
- **Peak load handling** – Better handling of traffic spikes through message queuing.

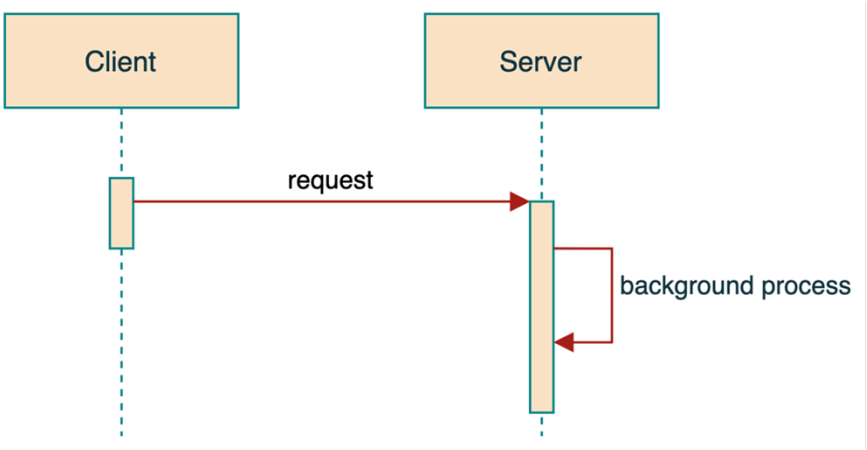
Drawbacks include complexity. For example:

- If the client requires the result of the asynchronous operation, implementing a mechanism to fetch or receive that result requires more effort.
- It can be more difficult to troubleshoot asynchronous operations, because troubleshooting requires examining logs across multiple systems.
- It can be more difficult to test asynchronous operations, because testing requires coordination among multiple systems and services.

Approaches to asynchronous communication include fire and forget, claim check, callback, and bidirectional communication.

Fire and forget

In the fire and forget pattern, a client issues a request to the server and synchronously receives an acknowledgement indicating that the server has received the message and will process it. However, the actual processing has not yet occurred, and the client has no visibility into when or how it will be done. The following diagram illustrates this pattern.



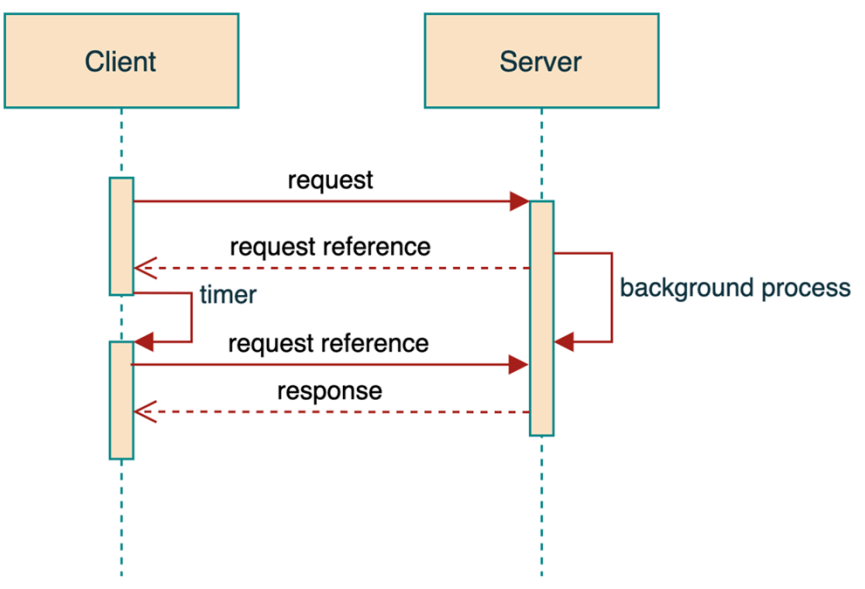
In this case, the service **should not** send the acknowledgement until the object is durably persisted. This persistence could be implemented as a database write operation or by putting an item in a queue.

Additional considerations:

- Implement idempotency to handle duplicate messages. That is, each message should be processed only once.
- Consider dead-letter queues for failed processing.
- Monitor message processing success rates.

Claim check

If a client needs the result of a service call, you can build the service to issue a *claim check* when it receives a request. The following diagram illustrates this pattern. The claim check is implemented as an identifier that the service returns in its acknowledgement. The client can use this identifier later to check on the status of the request and to retrieve the result when the request is complete.



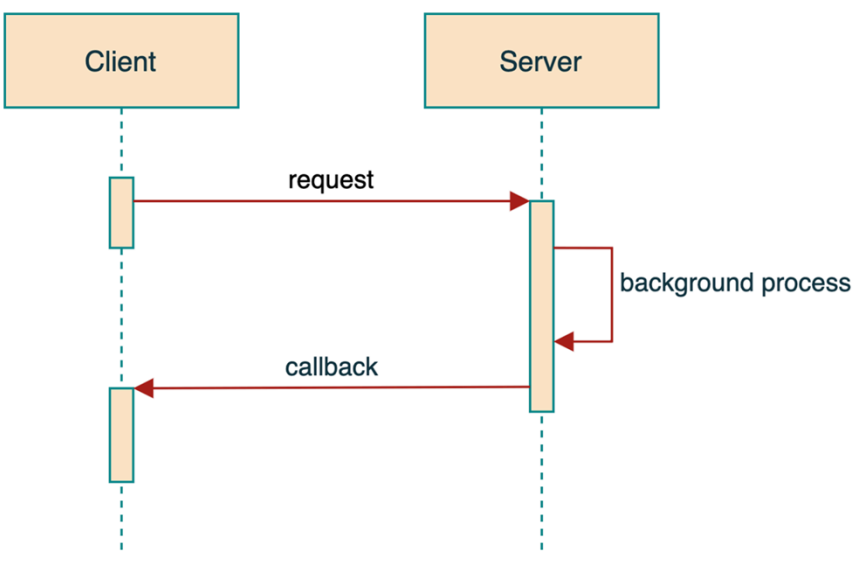
Clients must implement a mechanism to poll for results. This could be automated (for example, a check can be performed every *n* minutes) or implemented manually, where the check is performed in response to another event or user action. Services that implement the claim check pattern should be explicit about the length of time a claim check is valid.

Best practices:

- Implement exponential backoff for polling.
- Set an appropriate time to live (TTL) for claim checks.
- Provide status endpoints for progress tracking.

Callback

In the callback pattern, a client issues a request to a service and provides a location for the service to contact when the processing is complete. The client does not wait for a result, and processing continues. The service is responsible for contacting the location when processing is complete and providing the outcome. Common types of locations for responses are REST APIs or queues. The following diagram illustrates the callback pattern.

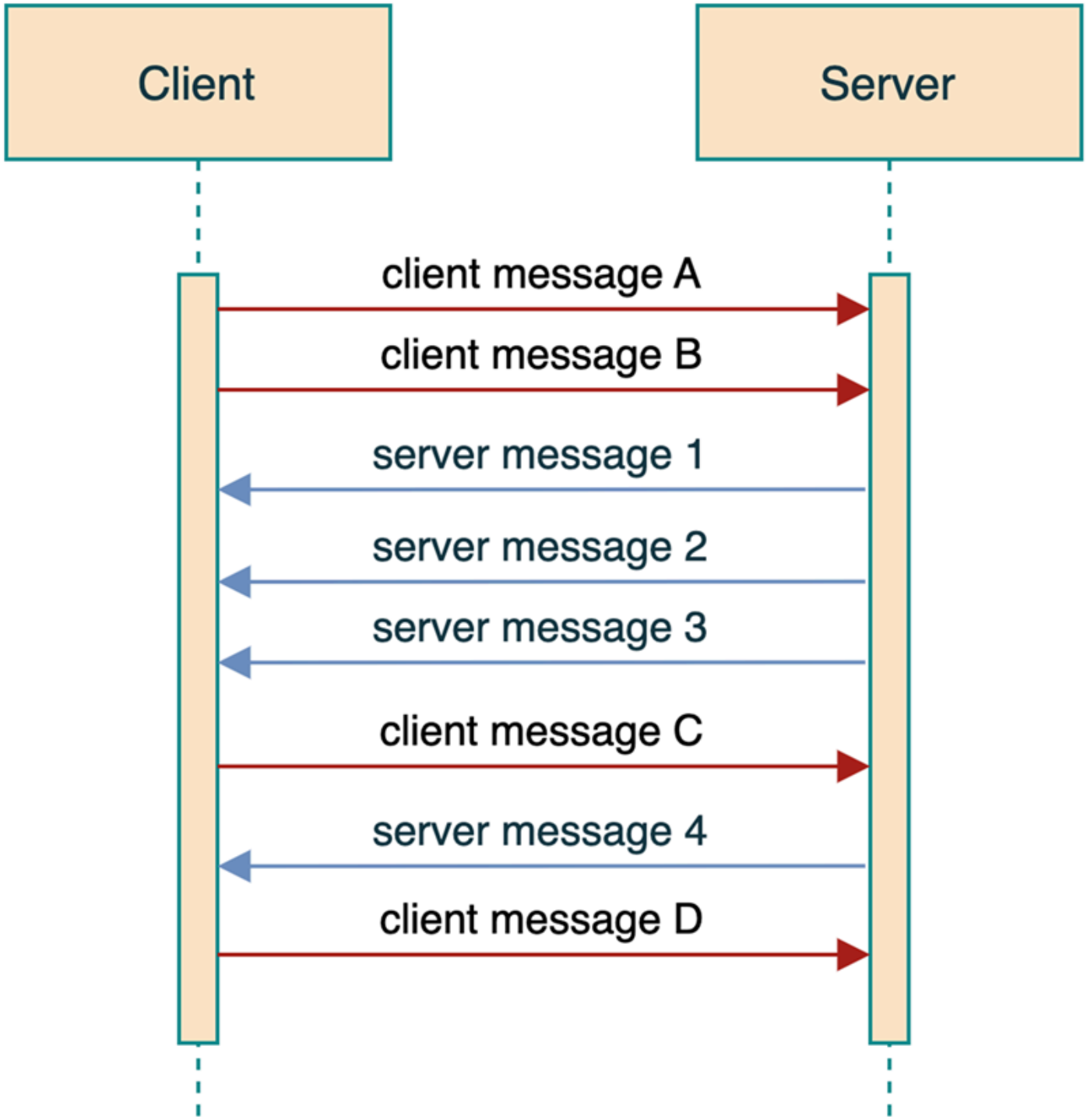


Implementation:

- Implement retry mechanisms for failed callbacks.
- Secure the callback location as you would other services.
- Handle callback timeouts.

Bidirectional communication

To implement bidirectional communication, you must create a stateful connection between a client and a service, which enables both the client and the service to send and process messages. This is illustrated in the following diagram. Although the communication is asynchronous, the service must be able to support an open connection for each client.



Implementation considerations:

- Message ordering
  - Sequence numbers

    - Partition strategies
    - Message ordering
- State management
    - Event sourcing patterns
    - State reconciliation
    - Consistency models
- Error handling
    - Dead letter queues
    - Retry policies
    - Circuit breakers
    - Fallback strategies
- Monitoring and observability
    - Correlation IDs
    - Message tracking
    - Performance metrics
    - System health indicators

Coordination options

Synchronous and asynchronous communication work well for a client that calls a single service or a small number of services. However, in a real-world environment, this communication can quickly become complicated and hard to scale. Accomplishing a unit of work might require several microservices, which might have interdependencies. Often, these interactions are modeled as a workflow. There are two approaches for designing these workflows: orchestration and choreography.

Topics

Orchestration

In this approach, a single orchestrator is responsible for calling each microservice, determining whether to issue calls in sequence or in parallel, manipulating individual service responses along the way, and compiling the end result. An orchestrator can mix synchronous and asynchronous invocations.

AWS Step Functions and Amazon Managed Workflows for Apache Airflow (Amazon MWAA) are great choices for workflow orchestrators.

Orchestration is a good choice when there are logical branches in your process and you need a single place to encapsulate that logic. It is also useful when you want to implement the asynchronous claim check pattern. For example, standard workflows in Step Functions can pause a workflow and wait for a callback from another service. Using an orchestrator also improves monitoring and observability of a process.

Example: Step Functions

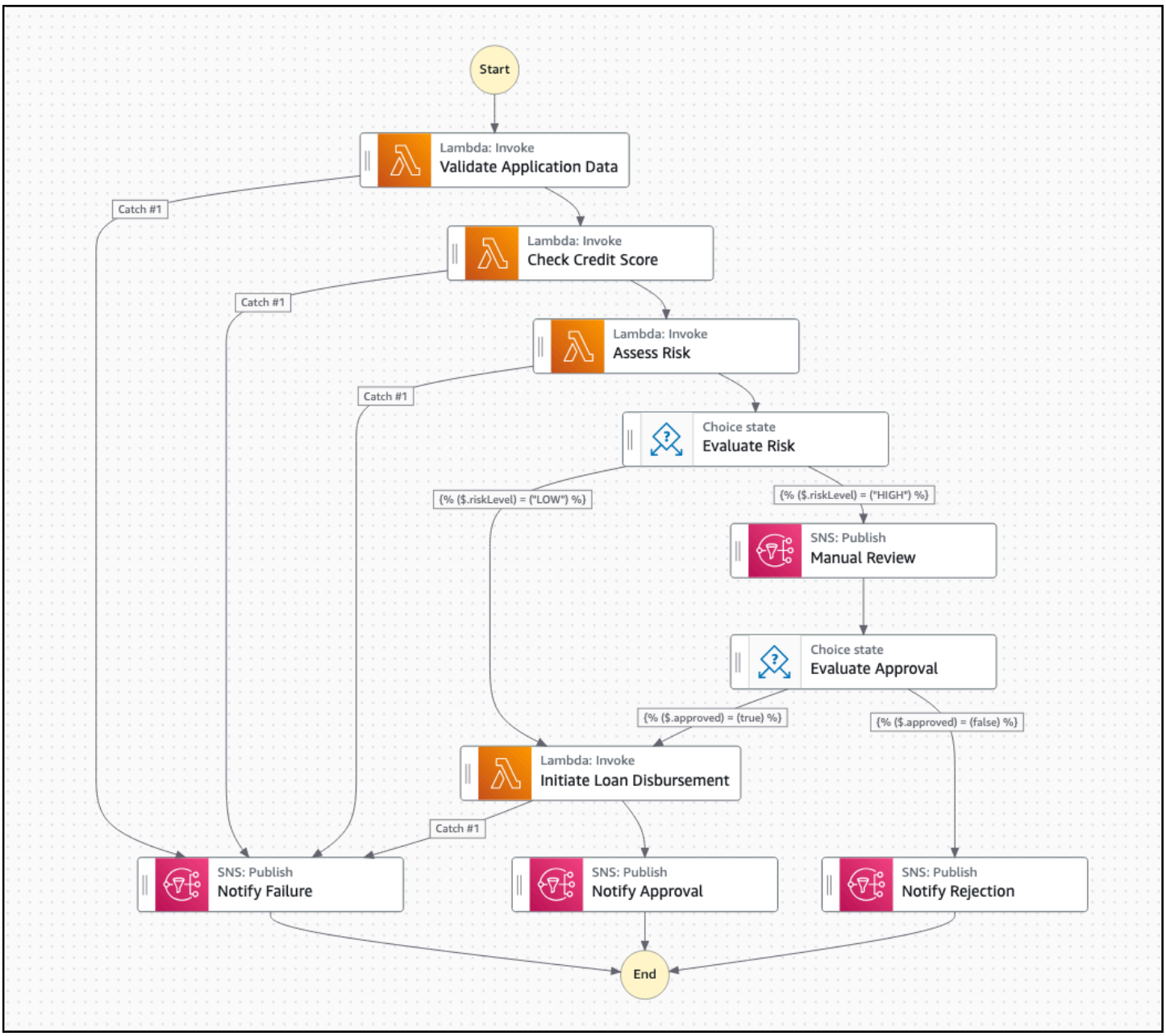
You can use Step Functions to coordinate multiple Lambda functions and other AWS services, to build complex workflows for microservice integration. This option is particularly useful for long-running, multi-step processes that involve several microservices.

You should consider using Step Functions if:

- Your microservice integration involves complex, multi-step processes.
- You need to maintain state across long-running operations.
- You want to implement error handling and retry logic at the workflow level.
- You need to coordinate both synchronous and asynchronous operations.

Step Functions offers a visual editor for designing complex workflows, which simplifies the process of creating and managing state machines. It provides built-in error handling mechanisms, including retry logic and error state management, which enhance the reliability and robustness of your applications. Standard workflows support long-running processes for up to one year, which is suitable for workflows that span extended periods. This option separates orchestration logic from application code, so it significantly reduces code complexity. This means that developers can focus on core business logic while Step Functions handles the flow control and coordination of distributed components.

For example, consider a loan approval process in a financial services application, which is illustrated in the following diagram. The process starts when a loan application is submitted.



In the state machine that's illustrated in the previous diagram, Step Functions orchestrates the following steps:

- Validate application data (Lambda function)
- Check credit score (Lambda function that calls an external API)
- Assess risk (Lambda function)
- If high risk, route to manual review (human approval task)
- If approved, initiate loan disbursement (Lambda function)

- Send notification to applicant (Amazon SNS)

You can use this approach to manage a complex, potentially long-running process reliably, with built-in error handling and the ability to include both automated and manual steps.

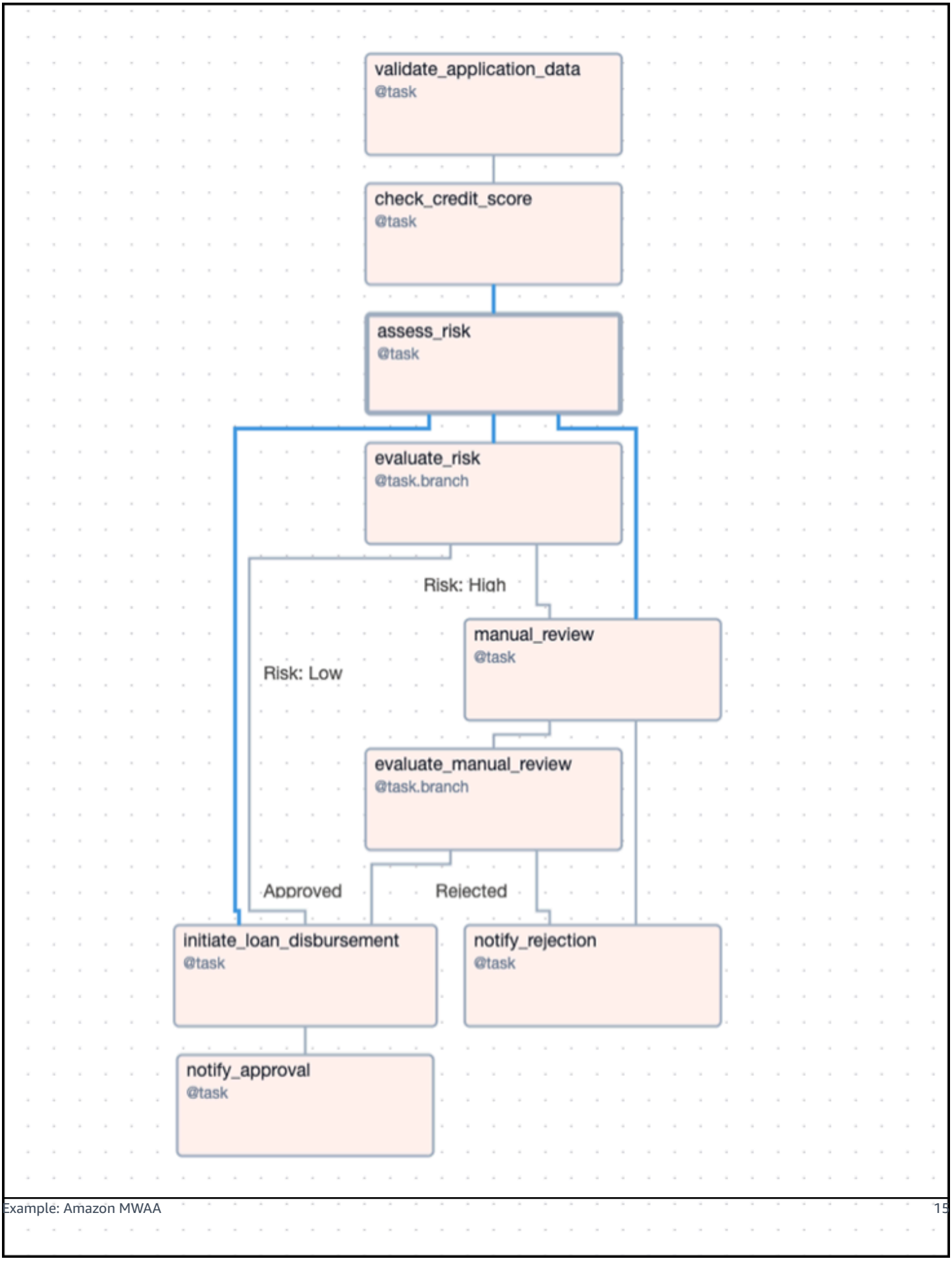
Considerations:

- Design your state machine carefully to handle all possible scenarios.
- Perform steps in parallel where possible.
- Use the built-in error handling and retry mechanisms in Step Functions for both permanent and temporary failures.
- Consider using standard or express workflows based on your use case. Express workflows might be preferable for short-duration or high-volume workflows.
- Monitor execution metrics to optimize your workflow.
- Use nested workflows to encapsulate and reuse functionality across multiple state machines.
- For complex workflows, consider using Amazon Bedrock Agents as an alternative to Step Functions.

For more information, see the Step Functions documentation.

Example: Amazon MWAA

If your organization already uses Apache Airflow, Amazon MWAA is a natural choice as a workflow orchestrator. In Apache Airflow, you build your workflows as directed acyclic graphs (DAGs) by using Python. The DAG representation of the state machine that's illustrated in the Step Functions section might look like this:


validate_application_data
@task
check_credit_score
@task
assess_risk
@task
evaluate_risk
@task.branch
Risk: High
Risk: Low
manual_review
@task
evaluate_manual_review
@task.branch
Approved
Rejected
initiate_loan_disbursement
@task
notify_rejection
@task
notify_approval
@task

For information about working with DAGs, see the Amazon MWAA documentation.

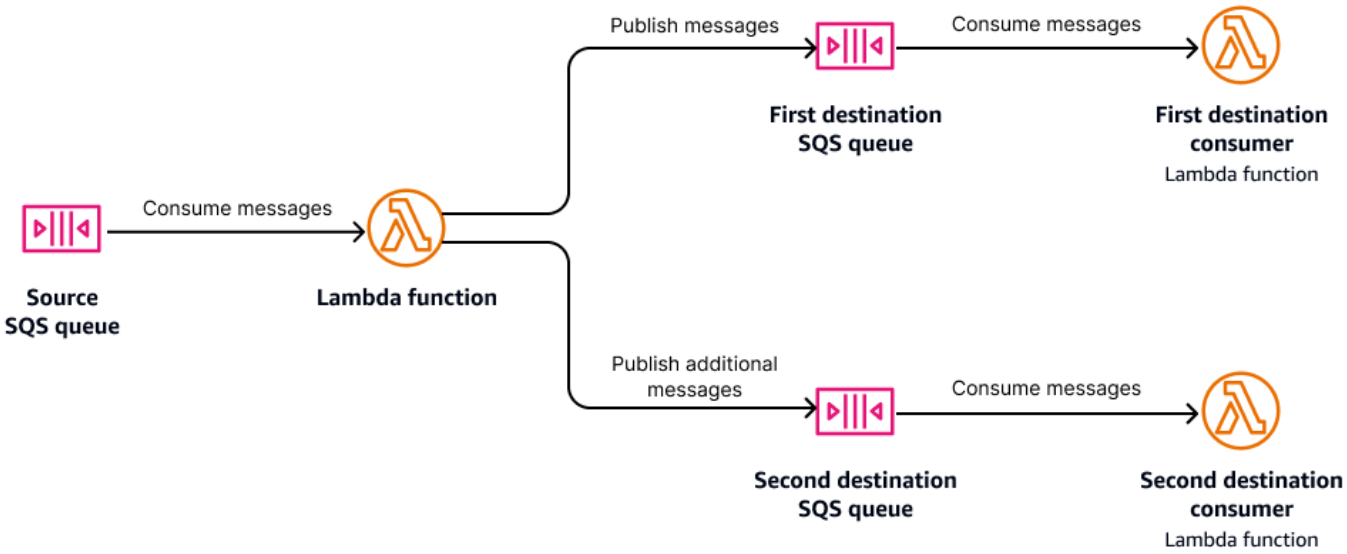
Key differences between Step Functions and Amazon MWAA

- Step Functions is a fully-managed serverless service, so there is no infrastructure to pre-provision and no need to schedule a maintenance window. Amazon MWAA must be deployed ahead of time, and you choose the size and number of nodes in your cluster.
- In Step Functions, you can author state machines in a variety of ways, including Workflow Studio, directly as JSON, or using the AWS Cloud Development Kit (AWS CDK). Apache Airflow DAGs are written in Python.
- With Step Functions, you incur no cost when there are no workflows running. With Amazon MWAA, you will incur costs even when no DAGs are running.

Choreography

In a choreographed system, individual components receive a task, perform some work, and possibly emit a task for subsequent work to be performed. There is no central orchestration mechanism. Choreography makes it easy to scale services independently, because each service operates in relative isolation. It performs work when it receives work, at whatever throughput the service is capable of. Choreography is often a central part of an event-driven architecture (EDA).

In the following diagram, there is no coordination between the Lambda functions. Each function only processes messages in the subscribed queue. Each function is responsible for its own error handling and can control concurrency—for example, if a downstream dependency has a requests per second (RPS) limit.



An EDA provides a number of benefits, such as loose coupling of services and extensibility. A full discussion of EDA principles is beyond the scope of this guide. For more information, see:

- AWS Well-Architected Framework – Serverless Application Lens
- Introduction to Event Driven Architecture (*Serverless Land*)
- Transitioning to event-driven architecture (*Serverless Developer Guide*)

Choosing your coordination approach

Choreography and orchestration both have their uses when integrating microservices. Choose choreography within the boundary of a single microservice, where you have full control over dependencies. Choose orchestration when you work across microservice boundaries. For example, multiple microservices that participate in a distributed transaction will benefit from orchestration to account for rollback from failures. Microservices that handle events that might be of interest to other microservices will benefit from choreography and an event-driven architecture.

A common pattern for implementing rollback when multiple systems are involved in a single transaction is the saga pattern. For more information, see Saga pattern in the guide *Enabling data persistence in microservices*.

Managing APIs

Proper API management makes your microservices accessible to both internal and external consumers. AWS offers a variety of services that you can use together to securely expose your microservice APIs. These services enable you to enforce security for your APIs and implement monitoring and observability from a central location. You can also use Amazon CloudFront to improve performance if the users of your APIs are geographically distant from the AWS Region that the services are hosted in.

Amazon API Gateway

Amazon API Gateway is a fully managed service that enables developers to create, publish, maintain, monitor, and secure REST and WebSocket APIs at any scale. You can use API Gateway to implement many of the patterns described in the Communication patterns section of this guide.

There are two main types of REST APIs: REST and HTTP. Both types support RESTful APIs but offer different features. To determine which best fits your needs, see Choose between REST APIs and HTTP APIs in the API Gateway documentation. This section of the guide focuses on API Gateway REST APIs.

Using API Gateway as the entry point for your APIs provides a single place to implement common concerns, such as request validation and security. API Gateway REST APIs offer request validation, which allows you to define the format of your requests by using JSON Schema. API Gateway validates incoming requests against your defined schema and rejects malformed requests.

Authentication and authorization

API Gateway REST APIs support the following authentication (authN) and authorization (authZ) mechanisms:

- **IAM** – If you use IAM, the requests to your API must be signed by using AWS Signature Version 4 (SigV4).
- **Amazon Cognito** – API Gateway will validate a presented bearer token as having been issued by an Amazon Cognito user pool. You can also configure your Amazon Cognito user pool to integrate with a third-party identity provider (IdP), if you're already using one. You can also use an Amazon Cognito user pool for machine-to-machine (M2M) authentication.

- **AWS Lambda authorizer** – API Gateway will invoke a Lambda function that you specify to perform any checks you would like, to determine whether a request should be authorized.

For more information, see Control and manage access to REST APIs in the API Gateway documentation.

API keys and rate limits

You can control who is allowed to call your APIs and at what rate by using API keys and usage plans. API keys should not be used for authentication but can be used in conjunction with the schemes mentioned earlier. Users don't always need to provide their own API key—for example, Lambda authorizers can return an API key for a user. The usage plan allows you to specify the throughput, burst limit, and monthly quota. For more information, see Usage plans and API keys for REST APIs in the API Gateway documentation.

Public and private APIs

API Gateway REST APIs that are accessible through the internet support two endpoint types:

- Edge-optimized, which means that callers' requests are routed to a nearby CloudFront point of presence (POP). This can result in improved performance for geographically disparate clients.
- Regional, which means that requests route to a resource within a specific AWS Region. This is a good choice when all your clients are near the Region where your API is deployed.

API Gateway REST APIs also support private API endpoints, which are accessible from a virtual private cloud (VPC) by using an interface VPC endpoint. You can also securely share private REST APIs by creating interface VPC endpoints in other VPCs and even other AWS accounts. For more information, see API endpoint types for REST APIs in the API Gateway documentation.

When to use API Gateway

API Gateway is a good choice for RESTful web services and real-time WebSocket connections. When you use WebSocket APIs in API Gateway, you can add behavior for connect and disconnect events, such as storing connection IDs in an external data store that's associated with client attributes. You can also route requests to custom behaviors by using message attributes.

Both REST and WebSocket APIs can directly integrate with many AWS services without requiring separate compute resources such as Lambda functions. This can improve performance and reduce cost.

REST APIs support both path-based and header-based routing, and you can use them separately or together. A common pattern is to provide a REST API as a front door for a number of APIs, to implement shared concerns as discussed earlier, and then behave like a reverse proxy and route authorized requests to the correct API endpoint.

Messaging

As discussed in the Communication patterns section, you can use messaging to communicate either synchronously or asynchronously between services. There are many AWS serverless services to choose from, and your choice should be based on your integration needs. For example, if you require an ordered delivery of messages, you should choose a service such as Amazon Simple Queue Service (Amazon SQS) or Amazon Simple Notification Service (Amazon SNS). Both services support first in first out (FIFO) delivery, as opposed to Amazon EventBridge, which does not.

The following sections discuss these services in more detail.

Topics

Amazon SQS

Amazon SQS supports standard queues, which do not guarantee ordering, and FIFO queues, which do guarantee ordering within a given *message group*.

Queues are a common method for choreographing microservices and provide durable storage for messages for up to 14 days. Queues are populated by producers and drained by consumers. When you use AWS Lambda as a consumer, you can configure an SQS queue as an event source. In this case, the Lambda service event source mapping (ESM) polls the queue for you and delivers messages to your Lambda function when they become available. Microservices that run on other types of compute services, such as Amazon Elastic Container Service (Amazon ECS) or Amazon Elastic Compute Cloud (Amazon EC2), have to implement their own polling mechanism to fetch new messages from the queue, when they become available.

Lambda ESM for Amazon SQS also supports message filtering, which enables you to process only a subset of messages in a queue based on the contents of the message body.

Polling

Amazon SQS supports short polling and long polling of messages. Short polling queries a subset of servers to find available messages and returns them immediately. However, it might not return all available messages. This is useful when your application needs to consume messages as quickly as possible or cannot tolerate waiting for a longer period of time.

Long polling waits until a configurable amount of time has passed or a configurable number of messages have been received before returning the messages. This might reduce the number of *empty polls*, that is, the number of polls where no messages are returned, especially for queues that do not receive many messages. Reducing the number of empty polls can reduce your Amazon SQS costs, because this service charges for each request, and each polling operation is a request.

Guidance

Queues are a good choice when:

- You want to decouple components and do not need synchronous communication between them.
- You are communicating between components that have different availability service-level agreements (SLAs) or service-level objectives (SLOs).
- You generally have a single consumer for a set of messages.

Consider an alternate option if:

- You need synchronous communication.
- You need complicated routing logic to send messages to the correct consumer.

Amazon SNS

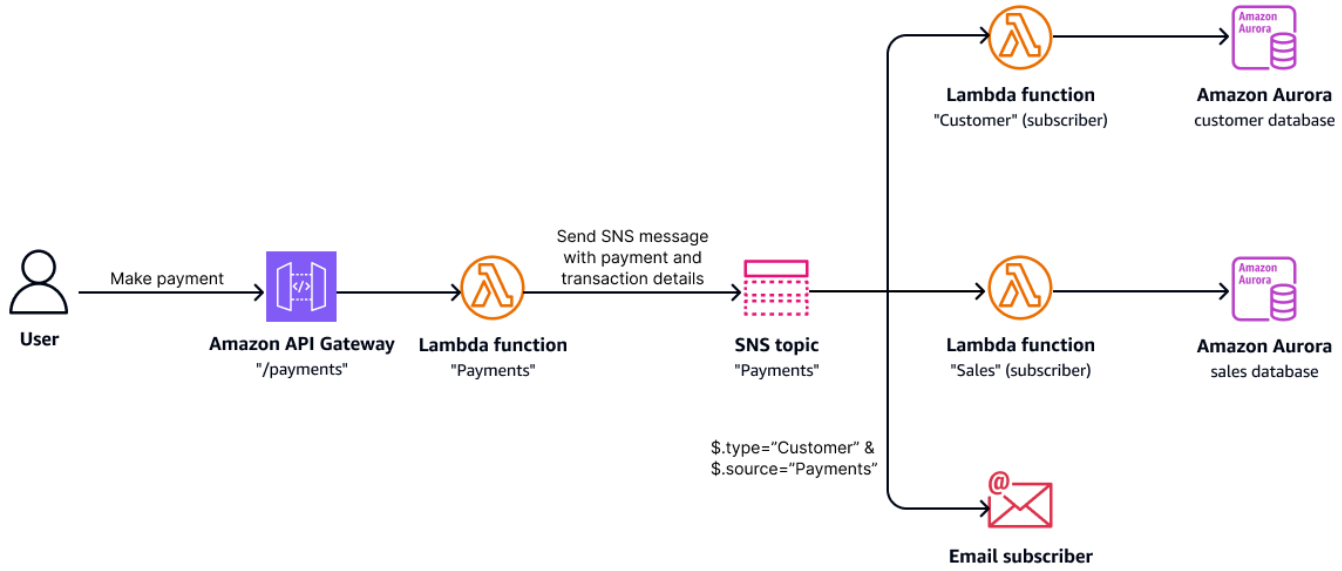
Amazon SNS allows you to create both standard and FIFO topics. Topics are used to implement a publish/subscribe (pub/sub) architecture. Amazon SNS supports a variety of subscription types, including email, SMS (assuming that you've configured an origination identity, such as a toll-free number or 10-digit long code), HTTP(S) endpoints, and SQS queues. End-user subscriptions, such as email messages and SMS messages, to an SNS topic **must be confirmed by the subscriber**. Amazon SNS enables services to *fan out* widely, which means that a single message can be delivered to a potentially large number of subscribers. An SNS standard topic has a default limit of 12.5 million subscriptions.

In a microservices environment, an SNS topic is useful for decoupling message routing and delivery logic from a publisher. This can be implemented by using topic filters. Conceptually, topic filters are somewhat similar to Amazon EventBridge rules, but they are configured for each subscriber instead of being available from a centralized location. For example, let's say you have:

- An Order service, which processes orders.
- A Fulfillment service, which handles order fulfillment.
- A Loyalty service, which awards members loyalty points for orders.

When an order is ready to be fulfilled, it publishes a message to a topic. The Fulfillment service subscribes to the topic but doesn't apply a filter, because it wants to know about all orders. Imagine that you have a Loyalty service, which is responsible for awarding points to members when they place an order. However, not all orders are placed by members. The Loyalty service would subscribe to the topic but would implement a subscription filter to check an attribute that indicates whether the order was for a member or a guest.

Consider the case where a system receives a request from an end user to make a payment, as illustrated in the following diagram. In this case, multiple downstream systems need to know that the request was made so that various actions can be taken. When you use Amazon SNS, payments are published to an SNS topic, and Lambda functions subscribe to the topic to update the customer and sales databases. Additionally, an email subscription (which must be confirmed by the customer) sends an email confirmation to the customer by using a subscription filter.



Guidance

Some of the functionality described in this section for Amazon SNS overlaps with the functionality offered by an event bus, such as EventBridge. Consider using Amazon SNS when:

- You will have a large number of subscribers to a topic.
- You want to use subscription types (such as email or SMS), which are not natively supported by EventBridge.
- Subscribers should be able to determine their subscription filter.
- You require ordered delivery to subscribers (per message group).

If you have many topics, and subscriptions and filters are being used to route messages between microservices, EventBridge is likely the better choice.

Amazon EventBridge

Amazon EventBridge is a serverless event bus service and often acts as the foundation for an event-driven architecture (EDA). You can also use it to route and deliver messages asynchronously between microservices. Using EventBridge, producers publish events to a bus. You configure rules that match events based on their content and choose one or more targets that events matching that rule will be delivered to. EventBridge supports a wide range of rule targets. Using an event bus enables you to decouple producers from consumers and consolidate your routing and delivery logic.

In EventBridge, you can also create scheduled rules, so you can take actions at specific times. You can define events by using cron-based and rate-based expressions.

EventBridge Pipes gives you the ability to pipe messages from a source to a target without using a compute service such as AWS Lambda. For example, let's say you have an SQS queue that receives messages, which should trigger an AWS Step Functions state machine. Instead of creating a Lambda function that has an event source mapping to consume messages from the queue, and writing code by using an AWS SDK to invoke the state machine, you can use EventBridge Pipes to do this for you without writing any custom code.

EventBridge is commonly used with other messaging services such as Amazon SQS and Amazon SNS. For example, delivering events to an SQS queue gives a receiving service the flexibility to consume messages when it's able, at a rate that is independent of the rate at which events

are produced. Likewise, you can deliver events that should be fanned out to a large number of subscribers to an SNS topic.

Guidance

Use EventBridge when:

- You do not require synchronous communication between services.
- You want to decouple message routing logic from your microservices. The microservices only produce events and publish them to the event bus, and interested services create rules to match and deliver those events.
- You need to deliver messages from one supported service to another.

Consider other services in situations where:

- You require strict ordering of events. In these cases, consider Amazon SQS FIFO queues or Amazon SNS FIFO topics. Alternatively, consider event stream services such as Amazon Kinesis Data Streams or Amazon Managed Streaming for Apache Kafka (Amazon MSK).

AWS AppSync Events and API Gateway

AWS AppSync Events and Amazon API Gateway both provide a managed WebSocket experience for your microservices.

AWS AppSync Events offers a simplified experience for real-time messaging by using a WebSocket. AWS AppSync Events supports unicast and multicast messaging and a flexible grouping of channels into namespaces, with support for wildcards. Microservices can communicate with one another in a variety of ways by using AWS AppSync Events. For example, a service that receives real-time data can transform and publish the data to the appropriate channel, where subscribers will receive it in real time.

API Gateway also supports WebSocket APIs. You can define integrations with AWS services, such as AWS Lambda and Amazon DynamoDB, and configure route selection expressions that are mapped to those integrations. API Gateway has special routes that you can use to authorize and manage your WebSocket connections. Depending on your needs, you can store WebSocket connection information in a data store such as DynamoDB. Using this information, messages can be published to specific WebSocket connections through a REST API, given a specific connection ID.

Guidance

Use AWS AppSync Events when:

- You have multiple messaging channels that are grouped into namespaces and want to publish and subscribe to groups of channels by using wildcards.
- Your communications are primarily between different systems instead of being between AWS services.

Use API Gateway WebSocket APIs when:

- You want to enable clients to have real-time persistent connections to AWS service integrations.
- You want to manage WebSocket connections yourself. For example, you might want to allow other systems to send messages to a particular client after looking up their connection ID.
- You want to use API Gateway features such as stage deployments or proxy integrations, or you want to configure your own subprotocols.

FAQ

How can I combine different integration patterns?

In most situations you will want to combine integration patterns. For example, you can use AWS Step Functions to orchestrate a process that calls a remote service by using the claim check pattern. Or, you might have an orchestrated process that puts messages into queues, which, in turn, trigger choreographed services.

What is the primary benefit of using a microservices architecture?

The main advantages include independent scaling of services, improved fault isolation, enhanced development speed through parallel team work, and the ability for continuous delivery and deployment (CI/CD).

How can I implement error handling in these patterns?

You can implement error handling by using built-in mechanisms in AWS services. For example, AWS Lambda functions can be configured with retry logic, and Amazon SQS supports dead-letter queues for handling persistent failures. Additionally, Step Functions provides error handling and retry mechanisms at the workflow level.

What are the benefits of using the claim check pattern in asynchronous communication?

The claim check pattern allows clients to receive an identifier upon request submission. This identifier can be used later to check the status and retrieve the result. This pattern benefits clients by providing a mechanism to poll for results without waiting synchronously. For more information, see the Claim check section earlier in this guide.

How does the callback pattern improve asynchronous communication in microservices?

The callback pattern improves asynchronous communication by allowing the client to provide a location for the service to contact upon completion of processing. This decouples the client from waiting for a response, and enables it to continue with other tasks. For more information, see the Callback section earlier in this guide.

Can I implement bidirectional communication in microservices by using the patterns described?

You can implement bidirectional communication by creating a stateful connection between a client and a service, so they can both send and process messages asynchronously. This requires the service to support an open connection for each client. For more information, see the Bidirectional communication section earlier in this guide.

How can I optimize the use of Lambda functions in asynchronous communication patterns?

You can optimize Lambda functions by ensuring they are idempotent to handle potential message duplications, by using Amazon SQS features such as message groups for ordering, and by implementing long polling to reduce costs. Additionally, you can monitor execution metrics to identify optimization opportunities.

What are the key differences between using Amazon SNS and EventBridge for the pub/sub pattern?

Amazon SNS sends a single message to all subscribers, which may include unnecessary data for some subscribers. Amazon EventBridge allows for more granular control by allowing you to have several rules that match a single event, with each rule triggering a different downstream service or action. For more information, see the Amazon SNS and EventBridge sections earlier in this guide.

Resources

AWS service documentation

- Amazon API Gateway
- AWS AppSync Events
- Amazon EventBridge
- Amazon MWAA
- Amazon SNS
- Amazon SQS
- AWS Step Functions

Additional reading

- Strategy for modernizing applications in the AWS Cloud
- Phased approach to modernizing applications in the AWS Cloud
- Evaluating modernization readiness for applications in the AWS Cloud
- Decomposing monoliths into microservices
- Implementing enterprise integration patterns with AWS messaging services: point-to-point channels
- Pub/sub messaging: Asynchronous event notifications

Document history

The following table describes significant changes to this guide. If you want to be notified about future updates, you can subscribe to an RSS feed.

Change	Description	Date
Major updates	Expanded, reorganized, and updated guide to reflect AWS service updates.	September 10, 2025
Initial publication	—	January 11, 2021

AWS Prescriptive Guidance glossary

The following are commonly used terms in strategies, guides, and patterns provided by AWS Prescriptive Guidance. To suggest entries, please use the **Provide feedback** link at the end of the glossary.

Numbers

7 Rs

Seven common migration strategies for moving applications to the cloud. These strategies build upon the 5 Rs that Gartner identified in 2011 and consist of the following:

- Refactor/re-architect – Move an application and modify its architecture by taking full advantage of cloud-native features to improve agility, performance, and scalability. This typically involves porting the operating system and database. Example: Migrate your on-premises Oracle database to the Amazon Aurora PostgreSQL-Compatible Edition.
- Replatform (lift and reshape) – Move an application to the cloud, and introduce some level of optimization to take advantage of cloud capabilities. Example: Migrate your on-premises Oracle database to Amazon Relational Database Service (Amazon RDS) for Oracle in the AWS Cloud.
- Repurchase (drop and shop) – Switch to a different product, typically by moving from a traditional license to a SaaS model. Example: Migrate your customer relationship management (CRM) system to Salesforce.com.
- Rehost (lift and shift) – Move an application to the cloud without making any changes to take advantage of cloud capabilities. Example: Migrate your on-premises Oracle database to Oracle on an EC2 instance in the AWS Cloud.
- Relocate (hypervisor-level lift and shift) – Move infrastructure to the cloud without purchasing new hardware, rewriting applications, or modifying your existing operations. You migrate servers from an on-premises platform to a cloud service for the same platform. Example: Migrate a Microsoft Hyper-V application to AWS.
- Retain (revisit) – Keep applications in your source environment. These might include applications that require major refactoring, and you want to postpone that work until a later time, and legacy applications that you want to retain, because there's no business justification for migrating them.

- Retire – Decommission or remove applications that are no longer needed in your source environment.

A

ABAC

See attribute-based access control.

abstracted services

See managed services.

ACID

See atomicity, consistency, isolation, durability.

active-active migration

A database migration method in which the source and target databases are kept in sync (by using a bidirectional replication tool or dual write operations), and both databases handle transactions from connecting applications during migration. This method supports migration in small, controlled batches instead of requiring a one-time cutover. It's more flexible but requires more work than active-passive migration.

active-passive migration

A database migration method in which the source and target databases are kept in sync, but only the source database handles transactions from connecting applications while data is replicated to the target database. The target database doesn't accept any transactions during migration.

aggregate function

A SQL function that operates on a group of rows and calculates a single return value for the group. Examples of aggregate functions include `SUM` and `MAX`.

AI

See artificial intelligence.

AIOps

See artificial intelligence operations.

anonymization

The process of permanently deleting personal information in a dataset. Anonymization can help protect personal privacy. Anonymized data is no longer considered to be personal data.

anti-pattern

A frequently used solution for a recurring issue where the solution is counter-productive, ineffective, or less effective than an alternative.

application control

A security approach that allows the use of only approved applications in order to help protect a system from malware.

application portfolio

A collection of detailed information about each application used by an organization, including the cost to build and maintain the application, and its business value. This information is key to the portfolio discovery and analysis process and helps identify and prioritize the applications to be migrated, modernized, and optimized.

artificial intelligence (AI)

The field of computer science that is dedicated to using computing technologies to perform cognitive functions that are typically associated with humans, such as learning, solving problems, and recognizing patterns. For more information, see What is Artificial Intelligence?

artificial intelligence operations (AIOps)

The process of using machine learning techniques to solve operational problems, reduce operational incidents and human intervention, and increase service quality. For more information about how AIOps is used in the AWS migration strategy, see the operations integration guide.

asymmetric encryption

An encryption algorithm that uses a pair of keys, a public key for encryption and a private key for decryption. You can share the public key because it isn't used for decryption, but access to the private key should be highly restricted.

atomicity, consistency, isolation, durability (ACID)

A set of software properties that guarantee the data validity and operational reliability of a database, even in the case of errors, power failures, or other problems.

attribute-based access control (ABAC)

The practice of creating fine-grained permissions based on user attributes, such as department, job role, and team name. For more information, see ABAC for AWS in the AWS Identity and Access Management (IAM) documentation.

authoritative data source

A location where you store the primary version of data, which is considered to be the most reliable source of information. You can copy data from the authoritative data source to other locations for the purposes of processing or modifying the data, such as anonymizing, redacting, or pseudonymizing it.

Availability Zone

A distinct location within an AWS Region that is insulated from failures in other Availability Zones and provides inexpensive, low-latency network connectivity to other Availability Zones in the same Region.

AWS Cloud Adoption Framework (AWS CAF)

A framework of guidelines and best practices from AWS to help organizations develop an efficient and effective plan to move successfully to the cloud. AWS CAF organizes guidance into six focus areas called perspectives: business, people, governance, platform, security, and operations. The business, people, and governance perspectives focus on business skills and processes; the platform, security, and operations perspectives focus on technical skills and processes. For example, the people perspective targets stakeholders who handle human resources (HR), staffing functions, and people management. For this perspective, AWS CAF provides guidance for people development, training, and communications to help ready the organization for successful cloud adoption. For more information, see the AWS CAF website and the AWS CAF whitepaper.

AWS Workload Qualification Framework (AWS WQF)

A tool that evaluates database migration workloads, recommends migration strategies, and provides work estimates. AWS WQF is included with AWS Schema Conversion Tool (AWS SCT). It analyzes database schemas and code objects, application code, dependencies, and performance characteristics, and provides assessment reports.

B

bad bot

A bot that is intended to disrupt or cause harm to individuals or organizations.

BCP

See business continuity planning.

behavior graph

A unified, interactive view of resource behavior and interactions over time. You can use a behavior graph with Amazon Detective to examine failed logon attempts, suspicious API calls, and similar actions. For more information, see Data in a behavior graph in the Detective documentation.

big-endian system

A system that stores the most significant byte first. See also endianness.

binary classification

A process that predicts a binary outcome (one of two possible classes). For example, your ML model might need to predict problems such as “Is this email spam or not spam?" or "Is this product a book or a car?"

bloom filter

A probabilistic, memory-efficient data structure that is used to test whether an element is a member of a set.

blue/green deployment

A deployment strategy where you create two separate but identical environments. You run the current application version in one environment (blue) and the new application version in the other environment (green). This strategy helps you quickly roll back with minimal impact.

bot

A software application that runs automated tasks over the internet and simulates human activity or interaction. Some bots are useful or beneficial, such as web crawlers that index information on the internet. Some other bots, known as *bad bots*, are intended to disrupt or cause harm to individuals or organizations.

botnet

Networks of bots that are infected by malware and are under the control of a single party, known as a *bot herder* or *bot operator*. Botnets are the best-known mechanism to scale bots and their impact.

branch

A contained area of a code repository. The first branch created in a repository is the *main branch*. You can create a new branch from an existing branch, and you can then develop features or fix bugs in the new branch. A branch you create to build a feature is commonly referred to as a *feature branch*. When the feature is ready for release, you merge the feature branch back into the main branch. For more information, see About branches (GitHub documentation).

break-glass access

In exceptional circumstances and through an approved process, a quick means for a user to gain access to an AWS account that they don't typically have permissions to access. For more information, see the Implement break-glass procedures indicator in the AWS Well-Architected guidance.

brownfield strategy

The existing infrastructure in your environment. When adopting a brownfield strategy for a system architecture, you design the architecture around the constraints of the current systems and infrastructure. If you are expanding the existing infrastructure, you might blend brownfield and greenfield strategies.

buffer cache

The memory area where the most frequently accessed data is stored.

business capability

What a business does to generate value (for example, sales, customer service, or marketing). Microservices architectures and development decisions can be driven by business capabilities. For more information, see the Organized around business capabilities section of the Running containerized microservices on AWS whitepaper.

business continuity planning (BCP)

A plan that addresses the potential impact of a disruptive event, such as a large-scale migration, on operations and enables a business to resume operations quickly.

C

CAF

See AWS Cloud Adoption Framework.

canary deployment

The slow and incremental release of a version to end users. When you are confident, you deploy the new version and replace the current version in its entirety.

CCoE

See Cloud Center of Excellence.

CDC

See change data capture.

change data capture (CDC)

The process of tracking changes to a data source, such as a database table, and recording metadata about the change. You can use CDC for various purposes, such as auditing or replicating changes in a target system to maintain synchronization.

chaos engineering

Intentionally introducing failures or disruptive events to test a system's resilience. You can use AWS Fault Injection Service (AWS FIS) to perform experiments that stress your AWS workloads and evaluate their response.

CI/CD

See continuous integration and continuous delivery.

classification

A categorization process that helps generate predictions. ML models for classification problems predict a discrete value. Discrete values are always distinct from one another. For example, a model might need to evaluate whether or not there is a car in an image.

client-side encryption

Encryption of data locally, before the target AWS service receives it.

Cloud Center of Excellence (CCoE)

A multi-disciplinary team that drives cloud adoption efforts across an organization, including developing cloud best practices, mobilizing resources, establishing migration timelines, and leading the organization through large-scale transformations. For more information, see the CCoE posts on the AWS Cloud Enterprise Strategy Blog.

cloud computing

The cloud technology that is typically used for remote data storage and IoT device management. Cloud computing is commonly connected to edge computing technology.

cloud operating model

In an IT organization, the operating model that is used to build, mature, and optimize one or more cloud environments. For more information, see Building your Cloud Operating Model.

cloud stages of adoption

The four phases that organizations typically go through when they migrate to the AWS Cloud:

- Project – Running a few cloud-related projects for proof of concept and learning purposes
- Foundation – Making foundational investments to scale your cloud adoption (e.g., creating a landing zone, defining a CCoE, establishing an operations model)
- Migration – Migrating individual applications
- Re-invention – Optimizing products and services, and innovating in the cloud

These stages were defined by Stephen Orban in the blog post The Journey Toward Cloud-First & the Stages of Adoption on the AWS Cloud Enterprise Strategy blog. For information about how they relate to the AWS migration strategy, see the migration readiness guide.

CMDB

See configuration management database.

code repository

A location where source code and other assets, such as documentation, samples, and scripts, are stored and updated through version control processes. Common cloud repositories include GitHub or Bitbucket Cloud. Each version of the code is called a *branch*. In a microservice structure, each repository is devoted to a single piece of functionality. A single CI/CD pipeline can use multiple repositories.

cold cache

A buffer cache that is empty, not well populated, or contains stale or irrelevant data. This affects performance because the database instance must read from the main memory or disk, which is slower than reading from the buffer cache.

cold data

Data that is rarely accessed and is typically historical. When querying this kind of data, slow queries are typically acceptable. Moving this data to lower-performing and less expensive storage tiers or classes can reduce costs.

computer vision (CV)

A field of AI that uses machine learning to analyze and extract information from visual formats such as digital images and videos. For example, Amazon SageMaker AI provides image processing algorithms for CV.

configuration drift

For a workload, a configuration change from the expected state. It might cause the workload to become noncompliant, and it's typically gradual and unintentional.

configuration management database (CMDB)

A repository that stores and manages information about a database and its IT environment, including both hardware and software components and their configurations. You typically use data from a CMDB in the portfolio discovery and analysis stage of migration.

conformance pack

A collection of AWS Config rules and remediation actions that you can assemble to customize your compliance and security checks. You can deploy a conformance pack as a single entity in an AWS account and Region, or across an organization, by using a YAML template. For more information, see Conformance packs in the AWS Config documentation.

continuous integration and continuous delivery (CI/CD)

The process of automating the source, build, test, staging, and production stages of the software release process. CI/CD is commonly described as a pipeline. CI/CD can help you automate processes, improve productivity, improve code quality, and deliver faster. For more information, see Benefits of continuous delivery. CD can also stand for *continuous deployment*. For more information, see Continuous Delivery vs. Continuous Deployment.

CV

See computer vision.

D

data at rest

Data that is stationary in your network, such as data that is in storage.

data classification

A process for identifying and categorizing the data in your network based on its criticality and sensitivity. It is a critical component of any cybersecurity risk management strategy because it helps you determine the appropriate protection and retention controls for the data. Data classification is a component of the security pillar in the AWS Well-Architected Framework. For more information, see Data classification.

data drift

A meaningful variation between the production data and the data that was used to train an ML model, or a meaningful change in the input data over time. Data drift can reduce the overall quality, accuracy, and fairness in ML model predictions.

data in transit

Data that is actively moving through your network, such as between network resources.

data mesh

An architectural framework that provides distributed, decentralized data ownership with centralized management and governance.

data minimization

The principle of collecting and processing only the data that is strictly necessary. Practicing data minimization in the AWS Cloud can reduce privacy risks, costs, and your analytics carbon footprint.

data perimeter

A set of preventive guardrails in your AWS environment that help make sure that only trusted identities are accessing trusted resources from expected networks. For more information, see Building a data perimeter on AWS.

data preprocessing

To transform raw data into a format that is easily parsed by your ML model. Preprocessing data can mean removing certain columns or rows and addressing missing, inconsistent, or duplicate values.

data provenance

The process of tracking the origin and history of data throughout its lifecycle, such as how the data was generated, transmitted, and stored.

data subject

An individual whose data is being collected and processed.

data warehouse

A data management system that supports business intelligence, such as analytics. Data warehouses commonly contain large amounts of historical data, and they are typically used for queries and analysis.

database definition language (DDL)

Statements or commands for creating or modifying the structure of tables and objects in a database.

database manipulation language (DML)

Statements or commands for modifying (inserting, updating, and deleting) information in a database.

DDL

See database definition language.

deep ensemble

To combine multiple deep learning models for prediction. You can use deep ensembles to obtain a more accurate prediction or for estimating uncertainty in predictions.

deep learning

An ML subfield that uses multiple layers of artificial neural networks to identify mapping between input data and target variables of interest.

defense-in-depth

An information security approach in which a series of security mechanisms and controls are thoughtfully layered throughout a computer network to protect the confidentiality, integrity, and availability of the network and the data within. When you adopt this strategy on AWS, you add multiple controls at different layers of the AWS Organizations structure to help secure resources. For example, a defense-in-depth approach might combine multi-factor authentication, network segmentation, and encryption.

delegated administrator

In AWS Organizations, a compatible service can register an AWS member account to administer the organization's accounts and manage permissions for that service. This account is called the *delegated administrator* for that service. For more information and a list of compatible services, see Services that work with AWS Organizations in the AWS Organizations documentation.

deployment

The process of making an application, new features, or code fixes available in the target environment. Deployment involves implementing changes in a code base and then building and running that code base in the application's environments.

development environment

See environment.

detective control

A security control that is designed to detect, log, and alert after an event has occurred. These controls are a second line of defense, alerting you to security events that bypassed the preventative controls in place. For more information, see Detective controls in *Implementing security controls on AWS*.

development value stream mapping (DVSM)

A process used to identify and prioritize constraints that adversely affect speed and quality in a software development lifecycle. DVSM extends the value stream mapping process originally designed for lean manufacturing practices. It focuses on the steps and teams required to create and move value through the software development process.

digital twin

A virtual representation of a real-world system, such as a building, factory, industrial equipment, or production line. Digital twins support predictive maintenance, remote monitoring, and production optimization.

dimension table

In a star schema, a smaller table that contains data attributes about quantitative data in a fact table. Dimension table attributes are typically text fields or discrete numbers that behave like text. These attributes are commonly used for query constraining, filtering, and result set labeling.

disaster

An event that prevents a workload or system from fulfilling its business objectives in its primary deployed location. These events can be natural disasters, technical failures, or the result of human actions, such as unintentional misconfiguration or a malware attack.

disaster recovery (DR)

The strategy and process you use to minimize downtime and data loss caused by a disaster. For more information, see Disaster Recovery of Workloads on AWS: Recovery in the Cloud in the AWS Well-Architected Framework.

DML

See database manipulation language.

domain-driven design

An approach to developing a complex software system by connecting its components to evolving domains, or core business goals, that each component serves. This concept was introduced by Eric Evans in his book, *Domain-Driven Design: Tackling Complexity in the Heart of Software* (Boston: Addison-Wesley Professional, 2003). For information about how you can use domain-driven design with the strangler fig pattern, see Modernizing legacy Microsoft ASP.NET (ASMX) web services incrementally by using containers and Amazon API Gateway.

DR

See disaster recovery.

drift detection

Tracking deviations from a baselined configuration. For example, you can use AWS CloudFormation to detect drift in system resources, or you can use AWS Control Tower to detect changes in your landing zone that might affect compliance with governance requirements.

DVSM

See development value stream mapping.

E

EDA

See exploratory data analysis.

EDI

See electronic data interchange.

edge computing

The technology that increases the computing power for smart devices at the edges of an IoT network. When compared with cloud computing, edge computing can reduce communication latency and improve response time.

electronic data interchange (EDI)

The automated exchange of business documents between organizations. For more information, see What is Electronic Data Interchange.

encryption

A computing process that transforms plaintext data, which is human-readable, into ciphertext.

encryption key

A cryptographic string of randomized bits that is generated by an encryption algorithm. Keys can vary in length, and each key is designed to be unpredictable and unique.

endianness

The order in which bytes are stored in computer memory. Big-endian systems store the most significant byte first. Little-endian systems store the least significant byte first.

endpoint

See service endpoint.

endpoint service

A service that you can host in a virtual private cloud (VPC) to share with other users. You can create an endpoint service with AWS PrivateLink and grant permissions to other AWS accounts or to AWS Identity and Access Management (IAM) principals. These accounts or principals can connect to your endpoint service privately by creating interface VPC endpoints. For more

information, see Create an endpoint service in the Amazon Virtual Private Cloud (Amazon VPC) documentation.

enterprise resource planning (ERP)

A system that automates and manages key business processes (such as accounting, MES, and project management) for an enterprise.

envelope encryption

The process of encrypting an encryption key with another encryption key. For more information, see Envelope encryption in the AWS Key Management Service (AWS KMS) documentation.

environment

An instance of a running application. The following are common types of environments in cloud computing:

- development environment – An instance of a running application that is available only to the core team responsible for maintaining the application. Development environments are used to test changes before promoting them to upper environments. This type of environment is sometimes referred to as a *test environment*.
- lower environments – All development environments for an application, such as those used for initial builds and tests.
- production environment – An instance of a running application that end users can access. In a CI/CD pipeline, the production environment is the last deployment environment.
- upper environments – All environments that can be accessed by users other than the core development team. This can include a production environment, preproduction environments, and environments for user acceptance testing.

epic

In agile methodologies, functional categories that help organize and prioritize your work. Epics provide a high-level description of requirements and implementation tasks. For example, AWS CAF security epics include identity and access management, detective controls, infrastructure security, data protection, and incident response. For more information about epics in the AWS migration strategy, see the program implementation guide.

ERP

See enterprise resource planning.

exploratory data analysis (EDA)

The process of analyzing a dataset to understand its main characteristics. You collect or aggregate data and then perform initial investigations to find patterns, detect anomalies, and check assumptions. EDA is performed by calculating summary statistics and creating data visualizations.

F

fact table

The central table in a star schema. It stores quantitative data about business operations. Typically, a fact table contains two types of columns: those that contain measures and those that contain a foreign key to a dimension table.

fail fast

A philosophy that uses frequent and incremental testing to reduce the development lifecycle. It is a critical part of an agile approach.

fault isolation boundary

In the AWS Cloud, a boundary such as an Availability Zone, AWS Region, control plane, or data plane that limits the effect of a failure and helps improve the resilience of workloads. For more information, see AWS Fault Isolation Boundaries.

feature branch

See branch.

features

The input data that you use to make a prediction. For example, in a manufacturing context, features could be images that are periodically captured from the manufacturing line.

feature importance

How significant a feature is for a model's predictions. This is usually expressed as a numerical score that can be calculated through various techniques, such as Shapley Additive Explanations (SHAP) and integrated gradients. For more information, see Machine learning model interpretability with AWS.

feature transformation

To optimize data for the ML process, including enriching data with additional sources, scaling values, or extracting multiple sets of information from a single data field. This enables the ML model to benefit from the data. For example, if you break down the “2021-05-27 00:15:37” date into “2021”, “May”, “Thu”, and “15”, you can help the learning algorithm learn nuanced patterns associated with different data components.

few-shot prompting

Providing an LLM with a small number of examples that demonstrate the task and desired output before asking it to perform a similar task. This technique is an application of in-context learning, where models learn from examples (*shots*) that are embedded in prompts. Few-shot prompting can be effective for tasks that require specific formatting, reasoning, or domain knowledge. See also zero-shot prompting.

FGAC

See fine-grained access control.

fine-grained access control (FGAC)

The use of multiple conditions to allow or deny an access request.

flash-cut migration

A database migration method that uses continuous data replication through change data capture to migrate data in the shortest time possible, instead of using a phased approach. The objective is to keep downtime to a minimum.

FM

See foundation model.

foundation model (FM)

A large deep-learning neural network that has been training on massive datasets of generalized and unlabeled data. FMs are capable of performing a wide variety of general tasks, such as understanding language, generating text and images, and conversing in natural language. For more information, see What are Foundation Models.

G

generative AI

A subset of AI models that have been trained on large amounts of data and that can use a simple text prompt to create new content and artifacts, such as images, videos, text, and audio. For more information, see What is Generative AI.

geo blocking

See geographic restrictions.

geographic restrictions (geo blocking)

In Amazon CloudFront, an option to prevent users in specific countries from accessing content distributions. You can use an allow list or block list to specify approved and banned countries. For more information, see Restricting the geographic distribution of your content in the CloudFront documentation.

Gitflow workflow

An approach in which lower and upper environments use different branches in a source code repository. The Gitflow workflow is considered legacy, and the trunk-based workflow is the modern, preferred approach.

golden image

A snapshot of a system or software that is used as a template to deploy new instances of that system or software. For example, in manufacturing, a golden image can be used to provision software on multiple devices and helps improve speed, scalability, and productivity in device manufacturing operations.

greenfield strategy

The absence of existing infrastructure in a new environment. When adopting a greenfield strategy for a system architecture, you can select all new technologies without the restriction of compatibility with existing infrastructure, also known as brownfield. If you are expanding the existing infrastructure, you might blend brownfield and greenfield strategies.

guardrail

A high-level rule that helps govern resources, policies, and compliance across organizational units (OUs). *Preventive guardrails* enforce policies to ensure alignment to compliance standards. They are implemented by using service control policies and IAM permissions boundaries.

Detective guardrails detect policy violations and compliance issues, and generate alerts for remediation. They are implemented by using AWS Config, AWS Security Hub CSPM, Amazon GuardDuty, AWS Trusted Advisor, Amazon Inspector, and custom AWS Lambda checks.

H

HA

See high availability.

heterogeneous database migration

Migrating your source database to a target database that uses a different database engine (for example, Oracle to Amazon Aurora). Heterogeneous migration is typically part of a re-architecting effort, and converting the schema can be a complex task. AWS provides AWS SCT that helps with schema conversions.

high availability (HA)

The ability of a workload to operate continuously, without intervention, in the event of challenges or disasters. HA systems are designed to automatically fail over, consistently deliver high-quality performance, and handle different loads and failures with minimal performance impact.

historian modernization

An approach used to modernize and upgrade operational technology (OT) systems to better serve the needs of the manufacturing industry. A *historian* is a type of database that is used to collect and store data from various sources in a factory.

holdout data

A portion of historical, labeled data that is withheld from a dataset that is used to train a machine learning model. You can use holdout data to evaluate the model performance by comparing the model predictions against the holdout data.

homogeneous database migration

Migrating your source database to a target database that shares the same database engine (for example, Microsoft SQL Server to Amazon RDS for SQL Server). Homogeneous migration is typically part of a rehosting or replatforming effort. You can use native database utilities to migrate the schema.

hot data

Data that is frequently accessed, such as real-time data or recent translational data. This data typically requires a high-performance storage tier or class to provide fast query responses.

hotfix

An urgent fix for a critical issue in a production environment. Due to its urgency, a hotfix is usually made outside of the typical DevOps release workflow.

hypercare period

Immediately following cutover, the period of time when a migration team manages and monitors the migrated applications in the cloud in order to address any issues. Typically, this period is 1–4 days in length. At the end of the hypercare period, the migration team typically transfers responsibility for the applications to the cloud operations team.

I

IaC

See infrastructure as code.

identity-based policy

A policy attached to one or more IAM principals that defines their permissions within the AWS Cloud environment.

idle application

An application that has an average CPU and memory usage between 5 and 20 percent over a period of 90 days. In a migration project, it is common to retire these applications or retain them on premises.

IIoT

See industrial Internet of Things.

immutable infrastructure

A model that deploys new infrastructure for production workloads instead of updating, patching, or modifying the existing infrastructure. Immutable infrastructures are inherently more consistent, reliable, and predictable than mutable infrastructure. For more information, see the Deploy using immutable infrastructure best practice in the AWS Well-Architected Framework.

inbound (ingress) VPC

In an AWS multi-account architecture, a VPC that accepts, inspects, and routes network connections from outside an application. The AWS Security Reference Architecture recommends setting up your Network account with inbound, outbound, and inspection VPCs to protect the two-way interface between your application and the broader internet.

incremental migration

A cutover strategy in which you migrate your application in small parts instead of performing a single, full cutover. For example, you might move only a few microservices or users to the new system initially. After you verify that everything is working properly, you can incrementally move additional microservices or users until you can decommission your legacy system. This strategy reduces the risks associated with large migrations.

Industry 4.0

A term that was introduced by Klaus Schwab in 2016 to refer to the modernization of manufacturing processes through advances in connectivity, real-time data, automation, analytics, and AI/ML.

infrastructure

All of the resources and assets contained within an application's environment.

infrastructure as code (IaC)

The process of provisioning and managing an application's infrastructure through a set of configuration files. IaC is designed to help you centralize infrastructure management, standardize resources, and scale quickly so that new environments are repeatable, reliable, and consistent.

industrial Internet of Things (IIoT)

The use of internet-connected sensors and devices in the industrial sectors, such as manufacturing, energy, automotive, healthcare, life sciences, and agriculture. For more information, see Building an industrial Internet of Things (IIoT) digital transformation strategy.

inspection VPC

In an AWS multi-account architecture, a centralized VPC that manages inspections of network traffic between VPCs (in the same or different AWS Regions), the internet, and on-premises networks. The AWS Security Reference Architecture recommends setting up your Network account with inbound, outbound, and inspection VPCs to protect the two-way interface between your application and the broader internet.

Internet of Things (IoT)

The network of connected physical objects with embedded sensors or processors that communicate with other devices and systems through the internet or over a local communication network. For more information, see What is IoT?

interpretability

A characteristic of a machine learning model that describes the degree to which a human can understand how the model's predictions depend on its inputs. For more information, see Machine learning model interpretability with AWS.

IoT

See Internet of Things.

IT information library (ITIL)

A set of best practices for delivering IT services and aligning these services with business requirements. ITIL provides the foundation for ITSM.

IT service management (ITSM)

Activities associated with designing, implementing, managing, and supporting IT services for an organization. For information about integrating cloud operations with ITSM tools, see the operations integration guide.

ITIL

See IT information library.

ITSM

See IT service management.

L

label-based access control (LBAC)

An implementation of mandatory access control (MAC) where the users and the data itself are each explicitly assigned a security label value. The intersection between the user security label and data security label determines which rows and columns can be seen by the user.

landing zone

A landing zone is a well-architected, multi-account AWS environment that is scalable and secure. This is a starting point from which your organizations can quickly launch and deploy workloads and applications with confidence in their security and infrastructure environment. For more information about landing zones, see Setting up a secure and scalable multi-account AWS environment.

large language model (LLM)

A deep learning AI model that is pretrained on a vast amount of data. An LLM can perform multiple tasks, such as answering questions, summarizing documents, translating text into other languages, and completing sentences. For more information, see What are LLMs.

large migration

A migration of 300 or more servers.

LBAC

See label-based access control.

least privilege

The security best practice of granting the minimum permissions required to perform a task. For more information, see Apply least-privilege permissions in the IAM documentation.

lift and shift

See 7 Rs.

little-endian system

A system that stores the least significant byte first. See also endianness.

LLM

See large language model.

lower environments

See environment.

M

machine learning (ML)

A type of artificial intelligence that uses algorithms and techniques for pattern recognition and learning. ML analyzes and learns from recorded data, such as Internet of Things (IoT) data, to generate a statistical model based on patterns. For more information, see Machine Learning.

main branch

See branch.

malware

Software that is designed to compromise computer security or privacy. Malware might disrupt computer systems, leak sensitive information, or gain unauthorized access. Examples of malware include viruses, worms, ransomware, Trojan horses, spyware, and keyloggers.

managed services

AWS services for which AWS operates the infrastructure layer, the operating system, and platforms, and you access the endpoints to store and retrieve data. Amazon Simple Storage Service (Amazon S3) and Amazon DynamoDB are examples of managed services. These are also known as *abstracted services*.

manufacturing execution system (MES)

A software system for tracking, monitoring, documenting, and controlling production processes that convert raw materials to finished products on the shop floor.

MAP

See Migration Acceleration Program.

mechanism

A complete process in which you create a tool, drive adoption of the tool, and then inspect the results in order to make adjustments. A mechanism is a cycle that reinforces and improves itself as it operates. For more information, see Building mechanisms in the AWS Well-Architected Framework.

member account

All AWS accounts other than the management account that are part of an organization in AWS Organizations. An account can be a member of only one organization at a time.

MES

See manufacturing execution system.

Message Queuing Telemetry Transport (MQTT)

A lightweight, machine-to-machine (M2M) communication protocol, based on the publish/subscribe pattern, for resource-constrained IoT devices.

microservice

A small, independent service that communicates over well-defined APIs and is typically owned by small, self-contained teams. For example, an insurance system might include microservices that map to business capabilities, such as sales or marketing, or subdomains, such as purchasing, claims, or analytics. The benefits of microservices include agility, flexible scaling, easy deployment, reusable code, and resilience. For more information, see Integrating microservices by using AWS serverless services.

microservices architecture

An approach to building an application with independent components that run each application process as a microservice. These microservices communicate through a well-defined interface by using lightweight APIs. Each microservice in this architecture can be updated, deployed, and scaled to meet demand for specific functions of an application. For more information, see Implementing microservices on AWS.

Migration Acceleration Program (MAP)

An AWS program that provides consulting support, training, and services to help organizations build a strong operational foundation for moving to the cloud, and to help offset the initial cost of migrations. MAP includes a migration methodology for executing legacy migrations in a methodical way and a set of tools to automate and accelerate common migration scenarios.

migration at scale

The process of moving the majority of the application portfolio to the cloud in waves, with more applications moved at a faster rate in each wave. This phase uses the best practices and lessons learned from the earlier phases to implement a *migration factory* of teams, tools, and processes to streamline the migration of workloads through automation and agile delivery. This is the third phase of the AWS migration strategy.

migration factory

Cross-functional teams that streamline the migration of workloads through automated, agile approaches. Migration factory teams typically include operations, business analysts and owners,

migration engineers, developers, and DevOps professionals working in sprints. Between 20 and 50 percent of an enterprise application portfolio consists of repeated patterns that can be optimized by a factory approach. For more information, see the discussion of migration factories and the Cloud Migration Factory guide in this content set.

migration metadata

The information about the application and server that is needed to complete the migration. Each migration pattern requires a different set of migration metadata. Examples of migration metadata include the target subnet, security group, and AWS account.

migration pattern

A repeatable migration task that details the migration strategy, the migration destination, and the migration application or service used. Example: Rehost migration to Amazon EC2 with AWS Application Migration Service.

Migration Portfolio Assessment (MPA)

An online tool that provides information for validating the business case for migrating to the AWS Cloud. MPA provides detailed portfolio assessment (server right-sizing, pricing, TCO comparisons, migration cost analysis) as well as migration planning (application data analysis and data collection, application grouping, migration prioritization, and wave planning). The MPA tool (requires login) is available free of charge to all AWS consultants and APN Partner consultants.

Migration Readiness Assessment (MRA)

The process of gaining insights about an organization's cloud readiness status, identifying strengths and weaknesses, and building an action plan to close identified gaps, using the AWS CAF. For more information, see the migration readiness guide. MRA is the first phase of the AWS migration strategy.

migration strategy

The approach used to migrate a workload to the AWS Cloud. For more information, see the 7 Rs entry in this glossary and see Mobilize your organization to accelerate large-scale migrations.

ML

See machine learning.

modernization

Transforming an outdated (legacy or monolithic) application and its infrastructure into an agile, elastic, and highly available system in the cloud to reduce costs, gain efficiencies, and take advantage of innovations. For more information, see Strategy for modernizing applications in the AWS Cloud.

modernization readiness assessment

An evaluation that helps determine the modernization readiness of an organization's applications; identifies benefits, risks, and dependencies; and determines how well the organization can support the future state of those applications. The outcome of the assessment is a blueprint of the target architecture, a roadmap that details development phases and milestones for the modernization process, and an action plan for addressing identified gaps. For more information, see Evaluating modernization readiness for applications in the AWS Cloud.

monolithic applications (monoliths)

Applications that run as a single service with tightly coupled processes. Monolithic applications have several drawbacks. If one application feature experiences a spike in demand, the entire architecture must be scaled. Adding or improving a monolithic application's features also becomes more complex when the code base grows. To address these issues, you can use a microservices architecture. For more information, see Decomposing monoliths into microservices.

MPA

See Migration Portfolio Assessment.

MQTT

See Message Queuing Telemetry Transport.

multiclass classification

A process that helps generate predictions for multiple classes (predicting one of more than two outcomes). For example, an ML model might ask "Is this product a book, car, or phone?" or "Which product category is most interesting to this customer?"

mutable infrastructure

A model that updates and modifies the existing infrastructure for production workloads. For improved consistency, reliability, and predictability, the AWS Well-Architected Framework recommends the use of immutable infrastructure as a best practice.

O

OAC

See origin access control.

OAI

See origin access identity.

OCM

See organizational change management.

offline migration

A migration method in which the source workload is taken down during the migration process. This method involves extended downtime and is typically used for small, non-critical workloads.

OI

See operations integration.

OLA

See operational-level agreement.

online migration

A migration method in which the source workload is copied to the target system without being taken offline. Applications that are connected to the workload can continue to function during the migration. This method involves zero to minimal downtime and is typically used for critical production workloads.

OPC-UA

See Open Process Communications - Unified Architecture.

Open Process Communications - Unified Architecture (OPC-UA)

A machine-to-machine (M2M) communication protocol for industrial automation. OPC-UA provides an interoperability standard with data encryption, authentication, and authorization schemes.

operational-level agreement (OLA)

An agreement that clarifies what functional IT groups promise to deliver to each other, to support a service-level agreement (SLA).

operational readiness review (ORR)

A checklist of questions and associated best practices that help you understand, evaluate, prevent, or reduce the scope of incidents and possible failures. For more information, see Operational Readiness Reviews (ORR) in the AWS Well-Architected Framework.

operational technology (OT)

Hardware and software systems that work with the physical environment to control industrial operations, equipment, and infrastructure. In manufacturing, the integration of OT and information technology (IT) systems is a key focus for Industry 4.0 transformations.

operations integration (OI)

The process of modernizing operations in the cloud, which involves readiness planning, automation, and integration. For more information, see the operations integration guide.

organization trail

A trail that's created by AWS CloudTrail that logs all events for all AWS accounts in an organization in AWS Organizations. This trail is created in each AWS account that's part of the organization and tracks the activity in each account. For more information, see Creating a trail for an organization in the CloudTrail documentation.

organizational change management (OCM)

A framework for managing major, disruptive business transformations from a people, culture, and leadership perspective. OCM helps organizations prepare for, and transition to, new systems and strategies by accelerating change adoption, addressing transitional issues, and driving cultural and organizational changes. In the AWS migration strategy, this framework is called *people acceleration*, because of the speed of change required in cloud adoption projects. For more information, see the OCM guide.

origin access control (OAC)

In CloudFront, an enhanced option for restricting access to secure your Amazon Simple Storage Service (Amazon S3) content. OAC supports all S3 buckets in all AWS Regions, server-side encryption with AWS KMS (SSE-KMS), and dynamic PUT and DELETE requests to the S3 bucket.

origin access identity (OAI)

In CloudFront, an option for restricting access to secure your Amazon S3 content. When you use OAI, CloudFront creates a principal that Amazon S3 can authenticate with. Authenticated principals can access content in an S3 bucket only through a specific CloudFront distribution. See also OAC, which provides more granular and enhanced access control.

ORR

See operational readiness review.

OT

See operational technology.

outbound (egress) VPC

In an AWS multi-account architecture, a VPC that handles network connections that are initiated from within an application. The AWS Security Reference Architecture recommends setting up your Network account with inbound, outbound, and inspection VPCs to protect the two-way interface between your application and the broader internet.

P

permissions boundary

An IAM management policy that is attached to IAM principals to set the maximum permissions that the user or role can have. For more information, see Permissions boundaries in the IAM documentation.

personally identifiable information (PII)

Information that, when viewed directly or paired with other related data, can be used to reasonably infer the identity of an individual. Examples of PII include names, addresses, and contact information.

PII

See personally identifiable information.

playbook

A set of predefined steps that capture the work associated with migrations, such as delivering core operations functions in the cloud. A playbook can take the form of scripts, automated runbooks, or a summary of processes or steps required to operate your modernized environment.

PLC

See programmable logic controller.

PLM

See product lifecycle management.

policy

An object that can define permissions (see identity-based policy), specify access conditions (see resource-based policy), or define the maximum permissions for all accounts in an organization in AWS Organizations (see service control policy).

polyglot persistence

Independently choosing a microservice's data storage technology based on data access patterns and other requirements. If your microservices have the same data storage technology, they can encounter implementation challenges or experience poor performance. Microservices are more easily implemented and achieve better performance and scalability if they use the data store best adapted to their requirements. For more information, see Enabling data persistence in microservices.

portfolio assessment

A process of discovering, analyzing, and prioritizing the application portfolio in order to plan the migration. For more information, see Evaluating migration readiness.

predicate

A query condition that returns `true` or `false`, commonly located in a `WHERE` clause.

predicate pushdown

A database query optimization technique that filters the data in the query before transfer. This reduces the amount of data that must be retrieved and processed from the relational database, and it improves query performance.

preventative control

A security control that is designed to prevent an event from occurring. These controls are a first line of defense to help prevent unauthorized access or unwanted changes to your network. For more information, see Preventative controls in *Implementing security controls on AWS*.

principal

An entity in AWS that can perform actions and access resources. This entity is typically a root user for an AWS account, an IAM role, or a user. For more information, see *Principal* in Roles terms and concepts in the IAM documentation.

privacy by design

A system engineering approach that takes privacy into account through the whole development process.

private hosted zones

A container that holds information about how you want Amazon Route 53 to respond to DNS queries for a domain and its subdomains within one or more VPCs. For more information, see Working with private hosted zones in the Route 53 documentation.

proactive control

A security control designed to prevent the deployment of noncompliant resources. These controls scan resources before they are provisioned. If the resource is not compliant with the control, then it isn't provisioned. For more information, see the Controls reference guide in the AWS Control Tower documentation and see Proactive controls in *Implementing security controls on AWS*.

product lifecycle management (PLM)

The management of data and processes for a product throughout its entire lifecycle, from design, development, and launch, through growth and maturity, to decline and removal.

production environment

See environment.

programmable logic controller (PLC)

In manufacturing, a highly reliable, adaptable computer that monitors machines and automates manufacturing processes.

prompt chaining

Using the output of one LLM prompt as the input for the next prompt to generate better responses. This technique is used to break down a complex task into subtasks, or to iteratively refine or expand a preliminary response. It helps improve the accuracy and relevance of a model's responses and allows for more granular, personalized results.

pseudonymization

The process of replacing personal identifiers in a dataset with placeholder values. Pseudonymization can help protect personal privacy. Pseudonymized data is still considered to be personal data.

publish/subscribe (pub/sub)

A pattern that enables asynchronous communications among microservices to improve scalability and responsiveness. For example, in a microservices-based MES, a microservice can publish event messages to a channel that other microservices can subscribe to. The system can add new microservices without changing the publishing service.

Q

query plan

A series of steps, like instructions, that are used to access the data in a SQL relational database system.

query plan regression

When a database service optimizer chooses a less optimal plan than it did before a given change to the database environment. This can be caused by changes to statistics, constraints, environment settings, query parameter bindings, and updates to the database engine.

R

RACI matrix

See responsible, accountable, consulted, informed (RACI).

RAG

See Retrieval Augmented Generation.

ransomware

A malicious software that is designed to block access to a computer system or data until a payment is made.

RASCI matrix

See responsible, accountable, consulted, informed (RACI).

RCAC

See row and column access control.

read replica

A copy of a database that's used for read-only purposes. You can route queries to the read replica to reduce the load on your primary database.

re-architect

See 7 Rs.

recovery point objective (RPO)

The maximum acceptable amount of time since the last data recovery point. This determines what is considered an acceptable loss of data between the last recovery point and the interruption of service.

recovery time objective (RTO)

The maximum acceptable delay between the interruption of service and restoration of service.

refactor

See 7 Rs.

Region

A collection of AWS resources in a geographic area. Each AWS Region is isolated and independent of the others to provide fault tolerance, stability, and resilience. For more information, see Specify which AWS Regions your account can use.

regression

An ML technique that predicts a numeric value. For example, to solve the problem of "What price will this house sell for?" an ML model could use a linear regression model to predict a house's sale price based on known facts about the house (for example, the square footage).

rehost

See 7 Rs.

release

In a deployment process, the act of promoting changes to a production environment.

relocate

See 7 Rs.

replatform

See 7 Rs.

repurchase

See 7 Rs.

resiliency

An application's ability to resist or recover from disruptions. High availability and disaster recovery are common considerations when planning for resiliency in the AWS Cloud. For more information, see AWS Cloud Resilience.

resource-based policy

A policy attached to a resource, such as an Amazon S3 bucket, an endpoint, or an encryption key. This type of policy specifies which principals are allowed access, supported actions, and any other conditions that must be met.

responsible, accountable, consulted, informed (RACI) matrix

A matrix that defines the roles and responsibilities for all parties involved in migration activities and cloud operations. The matrix name is derived from the responsibility types defined in the matrix: responsible (R), accountable (A), consulted (C), and informed (I). The support (S) type is optional. If you include support, the matrix is called a *RASCI matrix*, and if you exclude it, it's called a *RACI matrix*.

responsive control

A security control that is designed to drive remediation of adverse events or deviations from your security baseline. For more information, see Responsive controls in *Implementing security controls on AWS*.

retain

See 7 Rs.

retire

See 7 Rs.

Retrieval Augmented Generation (RAG)

A generative AI technology in which an LLM references an authoritative data source that is outside of its training data sources before generating a response. For example, a RAG model might perform a semantic search of an organization's knowledge base or custom data. For more information, see What is RAG.

rotation

The process of periodically updating a secret to make it more difficult for an attacker to access the credentials.

row and column access control (RCAC)

The use of basic, flexible SQL expressions that have defined access rules. RCAC consists of row permissions and column masks.

RPO

See recovery point objective.

RTO

See recovery time objective.

runbook

A set of manual or automated procedures required to perform a specific task. These are typically built to streamline repetitive operations or procedures with high error rates.

S

SAML 2.0

An open standard that many identity providers (IdPs) use. This feature enables federated single sign-on (SSO), so users can log into the AWS Management Console or call the AWS API operations without you having to create user in IAM for everyone in your organization. For more information about SAML 2.0-based federation, see About SAML 2.0-based federation in the IAM documentation.

SCADA

See supervisory control and data acquisition.

SCP

See service control policy.

secret

In AWS Secrets Manager, confidential or restricted information, such as a password or user credentials, that you store in encrypted form. It consists of the secret value and its metadata.

The secret value can be binary, a single string, or multiple strings. For more information, see What's in a Secrets Manager secret? in the Secrets Manager documentation.

security by design

A system engineering approach that takes security into account through the whole development process.

security control

A technical or administrative guardrail that prevents, detects, or reduces the ability of a threat actor to exploit a security vulnerability. There are four primary types of security controls: preventative, detective, responsive, and proactive.

security hardening

The process of reducing the attack surface to make it more resistant to attacks. This can include actions such as removing resources that are no longer needed, implementing the security best practice of granting least privilege, or deactivating unnecessary features in configuration files.

security information and event management (SIEM) system

Tools and services that combine security information management (SIM) and security event management (SEM) systems. A SIEM system collects, monitors, and analyzes data from servers, networks, devices, and other sources to detect threats and security breaches, and to generate alerts.

security response automation

A predefined and programmed action that is designed to automatically respond to or remediate a security event. These automations serve as detective or responsive security controls that help you implement AWS security best practices. Examples of automated response actions include modifying a VPC security group, patching an Amazon EC2 instance, or rotating credentials.

server-side encryption

Encryption of data at its destination, by the AWS service that receives it.

service control policy (SCP)

A policy that provides centralized control over permissions for all accounts in an organization in AWS Organizations. SCPs define guardrails or set limits on actions that an administrator can delegate to users or roles. You can use SCPs as allow lists or deny lists, to specify which services or actions are permitted or prohibited. For more information, see Service control policies in the AWS Organizations documentation.

service endpoint

The URL of the entry point for an AWS service. You can use the endpoint to connect programmatically to the target service. For more information, see AWS service endpoints in *AWS General Reference*.

service-level agreement (SLA)

An agreement that clarifies what an IT team promises to deliver to their customers, such as service uptime and performance.

service-level indicator (SLI)

A measurement of a performance aspect of a service, such as its error rate, availability, or throughput.

service-level objective (SLO)

A target metric that represents the health of a service, as measured by a service-level indicator.

shared responsibility model

A model describing the responsibility you share with AWS for cloud security and compliance. AWS is responsible for security *of* the cloud, whereas you are responsible for security *in* the cloud. For more information, see Shared responsibility model.

SIEM

See security information and event management system.

single point of failure (SPOF)

A failure in a single, critical component of an application that can disrupt the system.

SLA

See service-level agreement.

SLI

See service-level indicator.

SLO

See service-level objective.

split-and-seed model

A pattern for scaling and accelerating modernization projects. As new features and product releases are defined, the core team splits up to create new product teams. This helps scale your

organization's capabilities and services, improves developer productivity, and supports rapid innovation. For more information, see Phased approach to modernizing applications in the AWS Cloud.

SPOF

See single point of failure.

star schema

A database organizational structure that uses one large fact table to store transactional or measured data and uses one or more smaller dimensional tables to store data attributes. This structure is designed for use in a data warehouse or for business intelligence purposes.

strangler fig pattern

An approach to modernizing monolithic systems by incrementally rewriting and replacing system functionality until the legacy system can be decommissioned. This pattern uses the analogy of a fig vine that grows into an established tree and eventually overcomes and replaces its host. The pattern was introduced by Martin Fowler as a way to manage risk when rewriting monolithic systems. For an example of how to apply this pattern, see Modernizing legacy Microsoft ASP.NET (ASMX) web services incrementally by using containers and Amazon API Gateway.

subnet

A range of IP addresses in your VPC. A subnet must reside in a single Availability Zone.

supervisory control and data acquisition (SCADA)

In manufacturing, a system that uses hardware and software to monitor physical assets and production operations.

symmetric encryption

An encryption algorithm that uses the same key to encrypt and decrypt the data.

synthetic testing

Testing a system in a way that simulates user interactions to detect potential issues or to monitor performance. You can use Amazon CloudWatch Synthetics to create these tests.

system prompt

A technique for providing context, instructions, or guidelines to an LLM to direct its behavior. System prompts help set context and establish rules for interactions with users.

T

tags

Key-value pairs that act as metadata for organizing your AWS resources. Tags can help you manage, identify, organize, search for, and filter resources. For more information, see Tagging your AWS resources.

target variable

The value that you are trying to predict in supervised ML. This is also referred to as an *outcome variable*. For example, in a manufacturing setting the target variable could be a product defect.

task list

A tool that is used to track progress through a runbook. A task list contains an overview of the runbook and a list of general tasks to be completed. For each general task, it includes the estimated amount of time required, the owner, and the progress.

test environment

See environment.

training

To provide data for your ML model to learn from. The training data must contain the correct answer. The learning algorithm finds patterns in the training data that map the input data attributes to the target (the answer that you want to predict). It outputs an ML model that captures these patterns. You can then use the ML model to make predictions on new data for which you don't know the target.

transit gateway

A network transit hub that you can use to interconnect your VPCs and on-premises networks. For more information, see What is a transit gateway in the AWS Transit Gateway documentation.

trunk-based workflow

An approach in which developers build and test features locally in a feature branch and then merge those changes into the main branch. The main branch is then built to the development, preproduction, and production environments, sequentially.

trusted access

Granting permissions to a service that you specify to perform tasks in your organization in AWS Organizations and in its accounts on your behalf. The trusted service creates a service-linked role in each account, when that role is needed, to perform management tasks for you. For more information, see Using AWS Organizations with other AWS services in the AWS Organizations documentation.

tuning

To change aspects of your training process to improve the ML model's accuracy. For example, you can train the ML model by generating a labeling set, adding labels, and then repeating these steps several times under different settings to optimize the model.

two-pizza team

A small DevOps team that you can feed with two pizzas. A two-pizza team size ensures the best possible opportunity for collaboration in software development.

U

uncertainty

A concept that refers to imprecise, incomplete, or unknown information that can undermine the reliability of predictive ML models. There are two types of uncertainty: *Epistemic uncertainty* is caused by limited, incomplete data, whereas *aleatoric uncertainty* is caused by the noise and randomness inherent in the data. For more information, see the Quantifying uncertainty in deep learning systems guide.

undifferentiated tasks

Also known as *heavy lifting*, work that is necessary to create and operate an application but that doesn't provide direct value to the end user or provide competitive advantage. Examples of undifferentiated tasks include procurement, maintenance, and capacity planning.

upper environments

See environment.

V

vacuuming

A database maintenance operation that involves cleaning up after incremental updates to reclaim storage and improve performance.

version control

Processes and tools that track changes, such as changes to source code in a repository.

VPC peering

A connection between two VPCs that allows you to route traffic by using private IP addresses. For more information, see What is VPC peering in the Amazon VPC documentation.

vulnerability

A software or hardware flaw that compromises the security of the system.

W

warm cache

A buffer cache that contains current, relevant data that is frequently accessed. The database instance can read from the buffer cache, which is faster than reading from the main memory or disk.

warm data

Data that is infrequently accessed. When querying this kind of data, moderately slow queries are typically acceptable.

window function

A SQL function that performs a calculation on a group of rows that relate in some way to the current record. Window functions are useful for processing tasks, such as calculating a moving average or accessing the value of rows based on the relative position of the current row.

workload

A collection of resources and code that delivers business value, such as a customer-facing application or backend process.

workstream

Functional groups in a migration project that are responsible for a specific set of tasks. Each workstream is independent but supports the other workstreams in the project. For example, the portfolio workstream is responsible for prioritizing applications, wave planning, and collecting migration metadata. The portfolio workstream delivers these assets to the migration workstream, which then migrates the servers and applications.

WORM

See write once, read many.

WQF

See AWS Workload Qualification Framework.

write once, read many (WORM)

A storage model that writes data a single time and prevents the data from being deleted or modified. Authorized users can read the data as many times as needed, but they cannot change it. This data storage infrastructure is considered immutable.

Z

zero-day exploit

An attack, typically malware, that takes advantage of a zero-day vulnerability.

zero-day vulnerability

An unmitigated flaw or vulnerability in a production system. Threat actors can use this type of vulnerability to attack the system. Developers frequently become aware of the vulnerability as a result of the attack.

zero-shot prompting

Providing an LLM with instructions for performing a task but no examples (*shots*) that can help guide it. The LLM must use its pre-trained knowledge to handle the task. The effectiveness of zero-shot prompting depends on the complexity of the task and the quality of the prompt. See also few-shot prompting.

zombie application

An application that has an average CPU and memory usage below 5 percent. In a migration project, it is common to retire these applications.