AWS Security Reference Architecture (AWS SRA) – AI security

AWS Prescriptive Guidance

AWS Prescriptive Guidance: AWS Security Reference Architecture (AWS SRA) – AI security

Table of Contents

AWS Security Reference Architecture (AWS SRA) – AI security

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Influence the future of the AWS Security Reference Architecture (AWS SRA) by taking a short survey.

AI solutions span multiple use cases, each with distinct security requirements. The Generative AI Security Scoping Matrix defines security scope and disciplines for different use cases, and the Agentic AI Security Scoping Matrix defines the autonomy and agency given to an agent.

Depending on your use case, you can use a managed service where the provider handles operations, or build your own. AWS offers a wide range of services to help you build, run, and integrate artificial intelligence and machine learning (AI/ML) solutions of any size, complexity, or use case. These services operate at all three layers of the generative AI stack: infrastructure, large language models (LLMs), and applications.

This guide focuses on the middle layer, which provides access to all the models and tools you need to build and scale generative AI applications and applications on AWS. Although AI (machine learning and LLMs) can be used for security purposes, this guide focuses on the foundational security controls to protect AI workloads deployed on AWS.

Intended audience

The intended audience for this guidance is security professionals, architects, and developers who are responsible for securely integrating generative AI capabilities into their organizations and applications using AWS services.

In this guide:

About the AWS SRA library

Influence the future of the AWS Security Reference Architecture (AWS SRA) by taking a short survey.

This guide is part of a library that provides architectural blueprints and technical guidance for designing and building security architectures on AWS. The library consists of implementation code (AWS SRA code library), a validation tool (SRA Verify), and two complementary categories of guides that cover the core architecture and deep dive architectures.

AWS SRA – core architecture guide

The AWS SRA – core architecture guide represents a foundation for the recommended AWS security architecture. It is the starting point that applies to all organizations, regardless of their industry, application type, or any other considerations. This foundation helps you build a strong and scalable architecture on AWS and helps create a strong AWS multi-account security baseline that scales securely as your business grows.

AWS SRA – deep dive architectures

The *AWS SRA – core architecture* guide is complemented by additional publications that provide architectural patterns aligned to specific security capabilities, application types, and compliance or regulatory requirements. These patterns extend the core architecture and should be used with the *AWS SRA – core architecture* guide.

The following guides provide architectural patterns aligned to specific security capabilities:

- AWS SRA – identity management provides guidance on how to implement a scalable, robust, and centralized identity and access management solution on AWS.
- AWS SRA – perimeter security discusses architecture patterns and AWS services for implementing edge security in a central account or in individual accounts.
- AWS SRA – cyber forensics describes how to configure an AWS Forensics account as a starting point to develop your organization's forensic capabilities and to help improve your security incident response (IR) preparedness.

The following guides provide architectural patterns for specific application types. You might want to focus on these guides after you build your baseline security architecture:

- *AWS SRA – AI security* (this guide) provides security architectural recommendations to protect AI workloads deployed on AWS.
- AWS SRA – IoT provides security architectural recommendations for designing and building IoT applications on AWS.

In addition, the following guide describes architectural patterns that are aligned with specific compliance or regulatory frameworks:

- AWS Privacy Reference Architecture (AWS PRA) provides a security architecture for applications that process personal data and must support broad privacy compliance requirements such as the General Data Protection Regulation (GDPR), the California Consumer Privacy Act (CCPA), or the Brazilian General Data Protection Law (LGPD). The AWS PRA provides a set of guidelines that are specific to the design and configuration of privacy controls in AWS services.

We recommend that you start with the *AWS SRA – core architecture* guide to understand the foundational architecture. Then consult the complementary guides to take advantage of advanced functionality and implementations. For more information about this content set, see AWS Security Reference Architecture.

To customize the reference architecture diagrams in the AWS SRA library based on your business needs, you can download the following .zip file and extract its contents.

Tip

To customize the reference architecture diagrams in the AWS SRA library based on your business needs, you can download the following .zip file and extract its contents.

Download the diagram source file (Microsoft PowerPoint format)

AWS SRA for AI

Influence the future of the AWS Security Reference Architecture (AWS SRA) by taking a short survey.

This section provides recommendations for securing AI workloads within the AWS SRA multi-account framework. It covers AWS Identity and Access Management (IAM) permissions, data protection, input/output validation, network isolation, logging, and monitoring for generative AI capabilities. This section also covers integrating these capabilities into traditional AWS workloads.

This guidance covers security for the following capabilities:

- Capability 1. Providing developers and data scientists with secure access to generative AI FMs (model inference)
- Capability 2. Providing secure access, usage, and implementation for generative AI model customization
- Capability 3. Providing secure access to data and systems for generative AI
- Capability 4. Providing secure access, usage, and implementation of tools
- Capability 5. Providing secure access, usage, and implementation of generative AI agents
- Capability 6. Providing secure access, usage, and implementation for AI applications

Most capability sections include the following information:

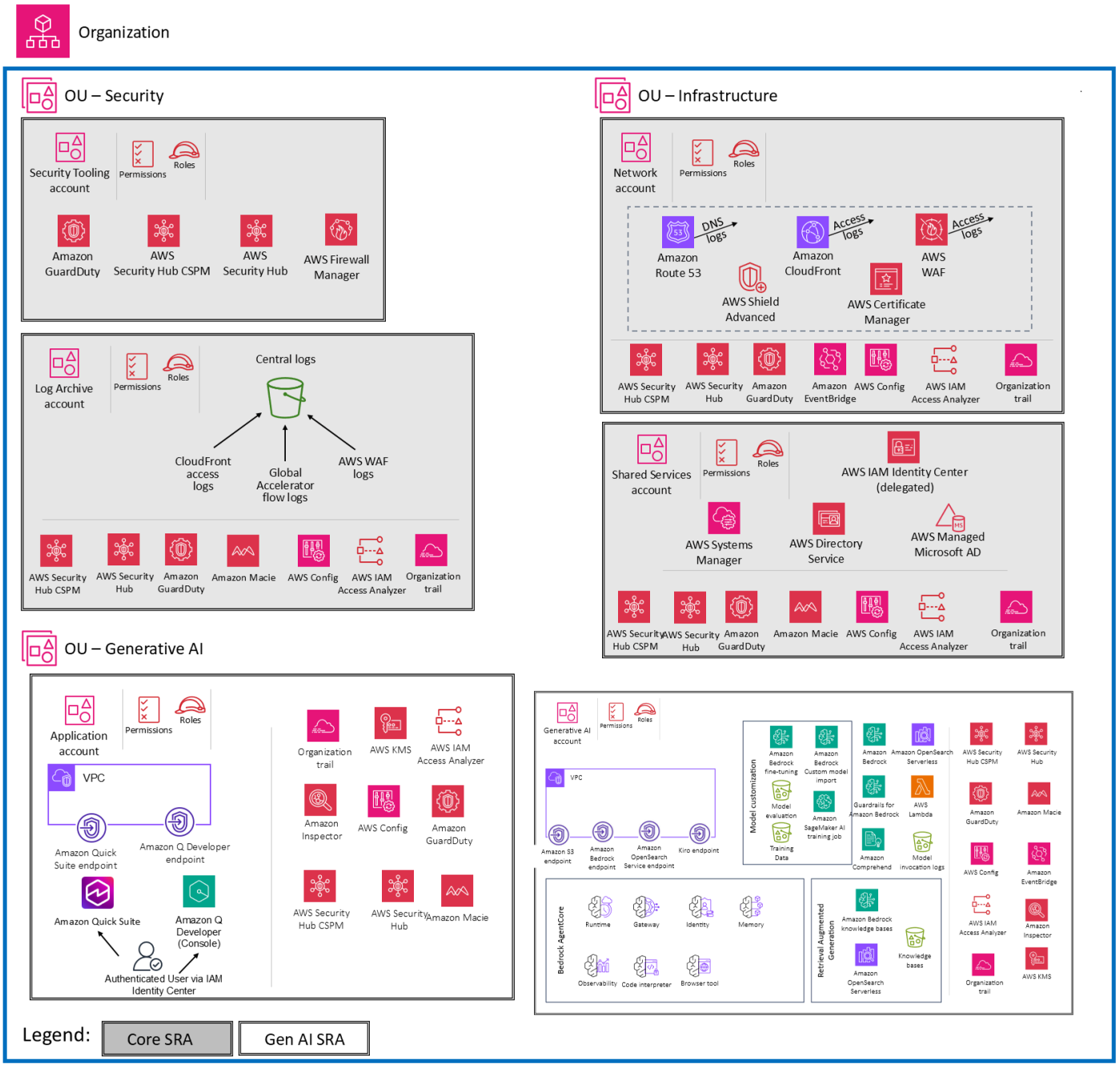
- **Rationale** explains what the capability does and when to use it.
- **Security considerations** describes risks that are specific to the capability.
- **Remediations** reviews the AWS services and features that address the risks.
- **Recommended AWS services** describes the services to build the capability securely.

All capabilities build on Capability 1 (foundation model inference) because they all invoke models. When you combine capabilities, apply security controls from each relevant section. For example, a customized model with Retrieval Augmented Generation (RAG) requires controls from capabilities 1, 2, and 3.

The following diagram shows the extension of the AWS SRA Workloads organizational unit (OU) architecture with a dedicated Generative AI OU. The Generative AI OU contains two accounts that separate concerns:

- The *Application account* hosts your traditional AWS application, which provides specific business functionality.
- The *Generative AI account* hosts Amazon Bedrock and associated AWS services. Your application in the Application account calls Amazon Bedrock capabilities in the Generative AI account through APIs.

This account separation provides two key benefits. First, it enforces security controls through OU-specific and account-specific service control policies. Second, it simplifies implementing least-privilege access by grouping services based on application type. The reference architecture also includes foundational accounts that apply to all application types: Org Management, Security Tooling, Log Archive, Network, and Shared Services. For more information about these accounts, see AWS Security Reference Architecture in the *AWS SRA – core architecture* guide.



Design considerations

- Merge the Application and Generative AI accounts if your architecture requires consolidating both services in one account, or if your generative AI usage spans your entire organization.

- Separate Generative AI accounts by software development lifecycle (SDLC) environment (development, test, and production) or by model and user community:
  - Use separate OUs for each SDLC environment. This approach controls team access, isolates resources, tracks costs separately, and prevents development issues from affecting production.
  - Use AWS Identity and Access Management (IAM) roles in a single account for pre-trained models. Use separate accounts when user communities have different risk levels, or when customized models contain sensitive training data.
- Use multiple accounts when different user communities have distinct risk profiles, when customized models contain sensitive training data, or when regulatory requirements mandate data isolation.
- Use a single account when you only use pre-trained foundation models, when users have a consistent risk profile, or when IAM roles provide sufficient access control.

Note

This guide assumes a single generative AI account strategy with IAM roles.

Amazon Bedrock

Amazon Bedrock helps you build and scale generative AI applications with foundation models (FMs). As a fully managed service, it provides access to FMs from companies such as AI21 Labs, Anthropic, Cohere, Meta, Stability AI, and Amazon through a single API. You can experiment with pre-trained models, customize them with your data, and deploy them into your applications without training models from scratch or managing specialized infrastructure.

Amazon Bedrock protects your data through the following security capabilities:

- **Data protection** – Amazon Bedrock isolates your content by user, encrypts it at rest in your AWS Region, and encrypts it in transit using TLS 1.2 or higher.
  - **Data privacy** – Amazon Bedrock doesn't store or log your prompts and completions. AWS doesn't use your content to train models or share it with third parties.
  - **Model customization** – When you customize a foundation model, your changes use a private copy. Your data isn't shared with model providers or used to improve base models.

- **Abuse detection** – Amazon Bedrock uses automated detection to identify potential violations of the AWS Responsible AI Policy.
- **Compliance** – Amazon Bedrock meets these standards: International Organization for Standardization (ISO), System and Organization Controls (SOC), Federal Risk and Authorization Management Program (FedRAMP) Moderate, and Cloud Security Alliance (CSA) Security Trust Assurance and Risk (STAR) Level 2. Amazon Bedrock is Health Insurance Portability and Accountability Act (HIPAA) eligible and in compliance with the General Data Protection Regulation (GDPR).

For more information, see the AWS secure approach to generative AI.

Amazon Bedrock Guardrails

Amazon Bedrock Guardrails help you implement safeguards that align with your use cases and responsible AI policies. You configure filters to block harmful content, define restricted topics, and customize messages that users see when content is blocked.

Guardrails evaluate both user inputs and model outputs across multiple harmful categories (hate, insults, sexual, violence, misconduct, and prompt attacks). The system classifies each input and output into one of four confidence levels: none, low, medium, or high. You set filter strength for each category based on your risk tolerance. When you deploy a guardrail to production, you create a versioned instance and invoke it in your application through the Amazon Bedrock API. For more information about implementation steps, see the Guardrails section in the Amazon Bedrock documentation.

Security

By default, Amazon Bedrock encrypts guardrails with an AWS managed key in AWS Key Management Service (AWS KMS). We recommend that you use a customer managed key to encrypt your guardrails and prevent unauthorized modifications. Combine encryption with least-privilege IAM permissions to restrict who can view or modify guardrail configurations.

Amazon Bedrock model evaluation

Model evaluation helps you compare FM outputs and select the model that best fits your application requirements. Amazon Bedrock supports both automatic evaluation using prompt datasets and human evaluation with subject matter experts.

Automatic evaluation jobs assess model performance using either custom prompt datasets or built-in datasets. This approach provides quantitative metrics for comparing models at scale. For more information, see Creating an automatic model evaluation job and Use prompt datasets for model evaluation in the Amazon Bedrock documentation.

Human evaluation jobs incorporate input from employees or subject matter experts to assess model quality, relevance, and safety. You organize evaluators into work teams managed through Amazon SageMaker Ground Truth. Create and manage work teams during job setup in Amazon Bedrock, or use the Amazon Cognito or Amazon SageMaker Ground Truth consoles for ongoing management.

Security

We recommend that you run model evaluation in development environments, not production. For information about multi-account strategies, see the Organizing your AWS environment using multiple accounts whitepaper. Both evaluation types require IAM service roles with the following specific permissions:

- Automatic evaluation jobs require permissions to access Amazon Simple Storage Service (Amazon S3) datasets and write results.
- Human evaluation jobs require additional permissions for Amazon SageMaker Ground Truth integration.
- Custom prompt datasets require cross-origin resource sharing (CORS) configuration on Amazon S3 buckets.

For more information, see Service role requirements for automatic model evaluation jobs and Service role requirements for human-based model evaluation jobs in the Amazon Bedrock documentation.

Amazon Bedrock creates a temporary copy of your evaluation data during the job and deletes it after completion. By default, Amazon Bedrock encrypts this data with an AWS managed key. We recommend that you use a customer managed key in AWS KMS for enhanced control over data access. For more information, see Data management and encryption in Amazon Bedrock evaluation job in the Amazon Bedrock documentation.

Amazon Bedrock AgentCore

Amazon Bedrock AgentCore provides infrastructure and controls for deploying AI agents securely at scale. AgentCore consists of the following modular services that work together or independently:

- **AgentCore Runtime** – Serverless execution environment with session isolation
- **AgentCore Identity** – Authentication and credential management for agents and tools
- **AgentCore Memory** – Persistent storage for conversation history and context
- **AgentCore Gateway** – Centralized API integration and tool access
- **AgentCore Policy** – Policy-based governance for agent actions
- **AgentCore tools** – Built-in sandboxed tools (Code Interpreter, Browser)
- **AgentCore Observability** – Trace, debug, and monitor agent performance
- **AgentCore Evaluations** – Assess agent quality through online and on-demand testing

AgentCore works with any agent framework (for example, CrewAI, LangGraph, LlamaIndex, and Strands Agents) and any foundation model (FM). AgentCore provides security capabilities including session isolation through dedicated micro virtual machines (microVMs), encrypted credential storage, namespace-based memory isolation, and comprehensive audit logging.

For detailed security guidance, see Capability 5.

Generative AI capabilities

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This section discusses secure access, usage, and implementation recommendations for the following generative AI capabilities:

- Capability 1. Providing developers and data scientists with secure access to generative AI FMs (model inference)
- Capability 2. Providing secure access, usage, and implementation for generative AI model customization
- Capability 3. Providing secure access to data and systems for generative AI
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Most capability sections include the following information:

- **Rationale** explains what the capability does and when to use it.
- **Security considerations** describes risks that are specific to the capability.
- **Remediations** reviews the AWS services and features that address the risks.
- **Recommended AWS services** to build the capability securely.

All capabilities build on Capability 1 (foundation model inference) because they all invoke models. When you combine capabilities, apply security controls from each relevant section. For example, a customized model with Retrieval Augmented Generation (RAG) requires controls from Capabilities 1, 2, and 3.

Capability 1. Providing developers and data scientists secure access to generative AI FMs (model inference)

Organizations building AI-powered applications must understand the fundamental differences between traditional AI systems and generative AI foundation models (FMs). Traditional AI systems perform classification, prediction, or optimization tasks with consistent outputs. Generative AI creates new content (text, images, code, or other media) based on learned patterns from training data. FMs are large-scale neural networks trained on vast datasets that generate probabilistic outputs, meaning identical inputs can produce different responses across invocations. This non-deterministic behavior requires security architectures that account for output variability while maintaining consistent protection.

Building applications that integrate generative AI FMs and agent capabilities enables advanced functionality, including natural language processing (NLP), image generation, automated reasoning, and intelligent decision support. This integration drives organizational innovation by allowing developers to build solutions that improve productivity and competitive positioning. However, the probabilistic nature of AI outputs demands security controls that function effectively regardless of model response variability.

Rationale

This use case corresponds to Scope 3 of the Generative AI Security Scoping Matrix. In Scope 3, your organization builds an application or feature that integrates generative AI by using pre-trained FMs, such as those offered on Amazon Bedrock. You control your application and any customer data used by your application, whereas the FM provider controls the pre-trained model and its training data. For data flows pertaining to various application scopes and information about the shared responsibility between you and the FM provider, see Securing generative AI: Applying relevant security controls (AWS blog post).

Organizations can also implement custom AI solutions using Amazon SageMaker AI for model development, training, and deployment. This approach introduces additional security considerations including secure model development environments, protection of training data and model artifacts, and governance of the entire machine learning lifecycle.

Custom models require enhanced monitoring for model drift, bias detection, and performance degradation that could indicate security issues or model compromise. When you customize FMs with your own training data (Scope 4) or train models from scratch (Scope 5), training data security becomes critical. Malicious or poisoned training data can compromise model behavior, introduce

bias, or cause models to leak sensitive information during inference. For detailed guidance on securing model customization and training data, see Capability 2.

The security architecture must address both the non-deterministic nature of AI systems and the autonomous capabilities of AI agents. The security architecture must implement layered defenses that maintain effectiveness across the spectrum of possible AI behaviors and outputs.

Security considerations

AI workloads introduce unique attack vectors and operational risks that traditional security controls don't address. Unlike conventional applications with predictable input-output relationships, AI systems process natural language and generate probabilistic responses that attackers can influence through carefully crafted inputs.

Model-specific risk

These risks target the AI model itself, exploiting the probabilistic nature of neural networks and their training methodologies. Attackers can manipulate model behavior without traditional code injection, instead using carefully crafted natural language inputs to achieve malicious outcomes. Risks include the following:

- Resource exhaustion through crafted prompts that trigger excessive token generation
- Data exfiltration through prompt engineering techniques that extract training data or fine-tuning information
- Model behavior manipulation through adversarial inputs designed to bypass safety mechanisms

Application layer risks

AI applications face unique challenges in validating and securing the interface between human users, AI models, and downstream systems. Traditional application security assumes deterministic behavior with predictable input-output relationships, but AI outputs require dynamic validation strategies that can assess content quality, safety, and appropriateness in real-time. Applications must handle scenarios where models generate syntactically valid but semantically problematic outputs. Examples of such outputs include hallucinated information presented as fact, biased responses that reflect training data patterns, or outputs that inadvertently reveal system architecture details.

The integration of AI into existing application workflows introduces risks when downstream systems consume model outputs without proper validation. This situation can potentially lead to

automated execution of flawed recommendations or propagation of incorrect information through business processes. Additionally, conversational AI applications maintain complex session state across multiple interactions, creating opportunities for session manipulation, context poisoning, and unauthorized access to conversation history containing sensitive information.

A systems-thinking approach reveals deeper interdependencies where AI application risks cascade across system boundaries. Model outputs influence not just immediate application behavior but also training data for future models, decision-making processes, and user trust relationships. Security failures at the application layer can create feedback loops where compromised outputs become trusted inputs, gradually degrading system integrity over time.

The temporal nature of AI interactions means that security decisions must account for both immediate threats and long-term systemic impacts. These impacts include how model behaviors evolve through user interactions and how application-level vulnerabilities might be exploited across multiple sessions or user contexts, such as:

- Unvalidated model outputs being passed to downstream systems
- Context injection where malicious content in Retrieval Augmented Generation (RAG) sources influences model behavior
- Session hijacking in conversational AI applications with inadequate state management
- Missing rate limiting enabling resource exhaustion and denial of service attacks
- Inadequate authentication and authorization for model access endpoints
- Insecure storage of conversation history and user interaction data
- Cascading failures when AI-generated content triggers errors in downstream business logic
- Model output caching creating stale or contextually inappropriate responses
- Feedback loop contamination where AI outputs become training data without validation
- Compound security issues where multiple minor issues combine to create potential security issues

Data governance risks

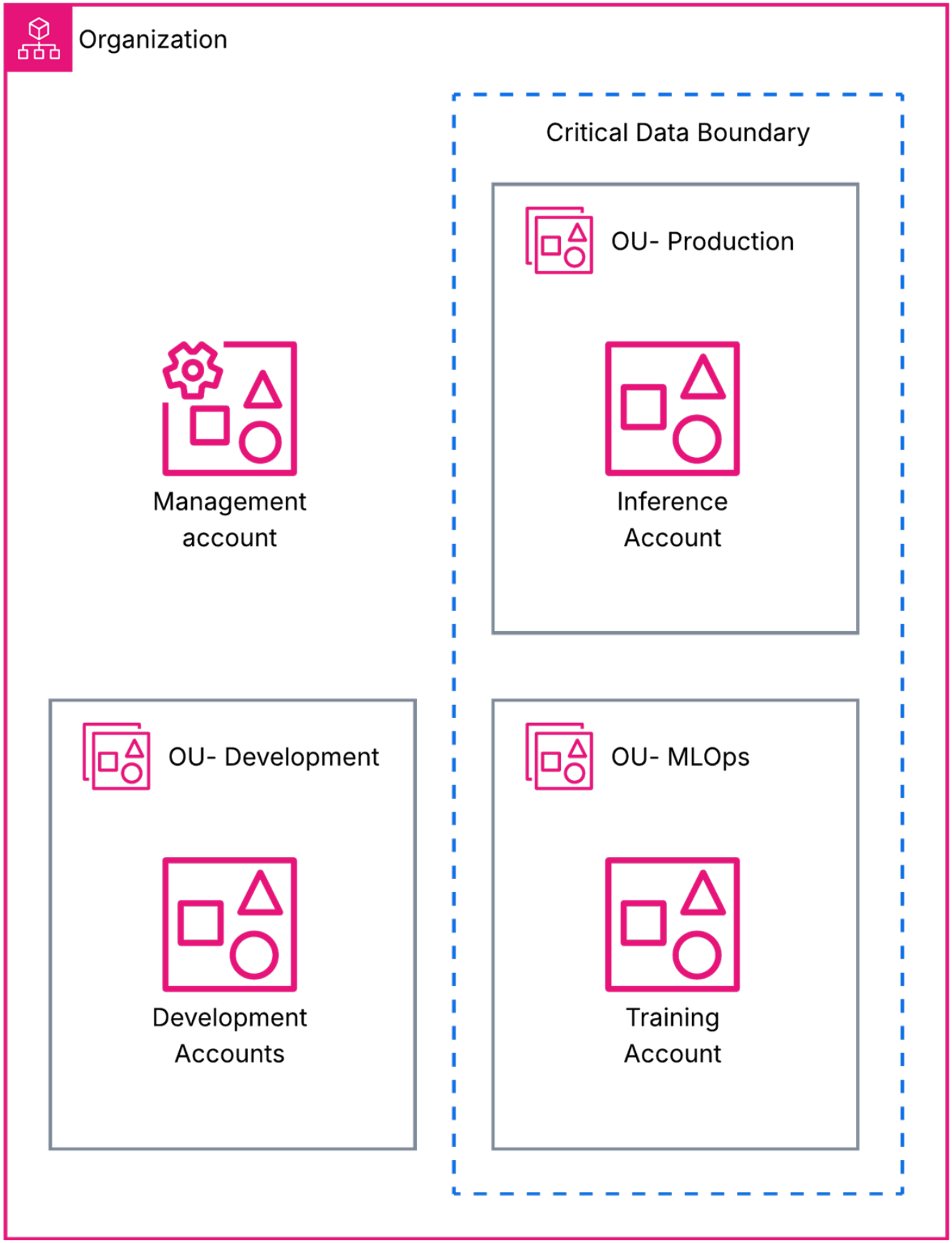
AI systems process and generate data in ways that challenge traditional data classification and protection mechanisms. Models can inadvertently memorize and reproduce sensitive information from training data, while their outputs may contain synthetic but realistic personal information. Risks include the following:

- Sensitive data leakage through model memorization and regurgitation from custom foundation models
- Compliance violations when personal data is processed without proper controls such as overly permissive agents
- Data poisoning in fine-tuning scenarios where malicious training data affects model behavior
- Cross-tenant data exposure in multi-tenant AI applications

Multi-account architecture for AI workloads

Organizations implementing AI at scale should adopt a multi-account strategy that provides clear separation of concerns, enhanced security boundaries, and simplified governance across different AI lifecycle phases. As shown in the following diagram, this architectural approach isolates inference workloads from training activities while maintaining centralized security oversight and cross-account collaboration capabilities:

- **AI development account** – Sandbox for experimentation and prototyping with non-sensitive data
- **AI inference account** – Production environment for AI model consumption and application hosting
- **AI training account** – Secured environment for handling sensitive training data and production model development


Organization
Critical Data Boundary
OU- Production
Management account
Inference Account
OU- Development
OU- MLOps
Development Accounts
Training Account

AI development account

The development account provides a sandbox environment for AI experimentation, prototyping, and initial model development using non-sensitive data. This account enables data scientists and developers to explore AI capabilities, test new approaches, and develop proof-of-concept solutions without access to production or sensitive training datasets.

Deploy Amazon Macie automated data discovery to help security and data science teams identify and classify data in development environments. Configure Macie to scan Amazon Simple Storage Service (Amazon S3) buckets regularly and alert when sensitive data appears in the development account. This approach enables teams to remediate data classification issues before they reach production.

Structure this account with permissive development policies that encourage experimentation while maintaining clear boundaries that prevent access to sensitive data or production systems. Implement cost controls and resource limits to manage experimental workloads and use AWS Budgets to monitor spending on development activities.

Deploy Amazon SageMaker Studio for collaborative development environments, with shared notebooks and experiment tracking capabilities. Configure automated cleanup policies that remove unused resources and temporary datasets, maintaining a clean development environment while controlling costs.

AI inference account

The inference accounts serve as production environments for AI model consumption and application hosting. Organizations typically deploy multiple inference accounts to maintain workload isolation, for example, separate accounts for different business units, applications, or security boundaries. Each inference account contains Amazon Bedrock endpoints, agent orchestration services, and user-facing applications that consume foundation models or custom models deployed from the training account. Security controls in these accounts focus on runtime protection, user access management, and real-time monitoring of AI interactions.

Configure each inference account with restrictive IAM policies that prevent model training activities, while enabling comprehensive inference capabilities. Implement Amazon Cognito or AWS IAM Identity Center for user authentication, and with fine-grained permissions that control access to specific models. Deploy Amazon Bedrock Guardrails and AWS WAF to filter inputs and outputs, ensuring that AI interactions meet organizational security standards.

Establish cross-account trust relationships that allow inference accounts to access approved model artifacts from the training account through secure, audited mechanisms. Use AWS PrivateLink endpoints to maintain private connectivity to AI services while implementing comprehensive logging through AWS CloudTrail and Amazon CloudWatch to monitor all inference activities.

Use Amazon GuardDuty Malware Protection for S3 to scan untrusted files that users submit for processing, such as document uploads, images, or data files that AI workloads analyze. This protection is particularly important for applications that process user-submitted content like mortgage documents, resumes, or customer support attachments.

AI training account

The training account serves as a highly secured staging environment specifically designed for handling sensitive training data and production model development. This account implements the strictest security controls because of the potential presence of personally identifiable information (PII), proprietary datasets, and other sensitive information used in model training processes. Models developed in the development account are promoted to the training account for production-grade training with real datasets before deployment to inference accounts.

Establish secure model promotion workflows that move models from development through training to inference environments with appropriate security validations at each stage. Implement automated security scanning of model artifacts and comprehensive approval processes before any model deployment to production inference systems.

Implement enhanced data protection measures including mandatory encryption at rest and in transit. Use AWS Key Management Service (AWS KMS) customer managed keys that provide granular access control over sensitive training datasets. Deploy Amazon Macie with continuous monitoring to identify and classify sensitive data, to help make sure that all training materials are properly protected and access is appropriately restricted. If possible, redact sensitive data before using it for training to minimize exposure risk.

Configure Amazon SageMaker with private VPC deployments that eliminate internet access for training jobs, using VPC endpoints for necessary AWS service communication. Implement strict IAM policies that limit access to authorized personnel only, with multi-factor authentication requirements and session-based access controls for all training activities.

Establish secure data ingestion pipelines that validate and sanitize incoming training data while maintaining comprehensive audit trails of all data access and processing activities. Use Amazon S3 with Object Lock and versioning to help ensure training data integrity and provide immutable audit records of all training dataset modifications.

Implement temporary elevated access management for access to training data when feasible, granting time-limited permissions that automatically expire after use. Log all user activity through CloudTrail and configure CloudWatch alarms to detect anomalous access patterns to sensitive training datasets.

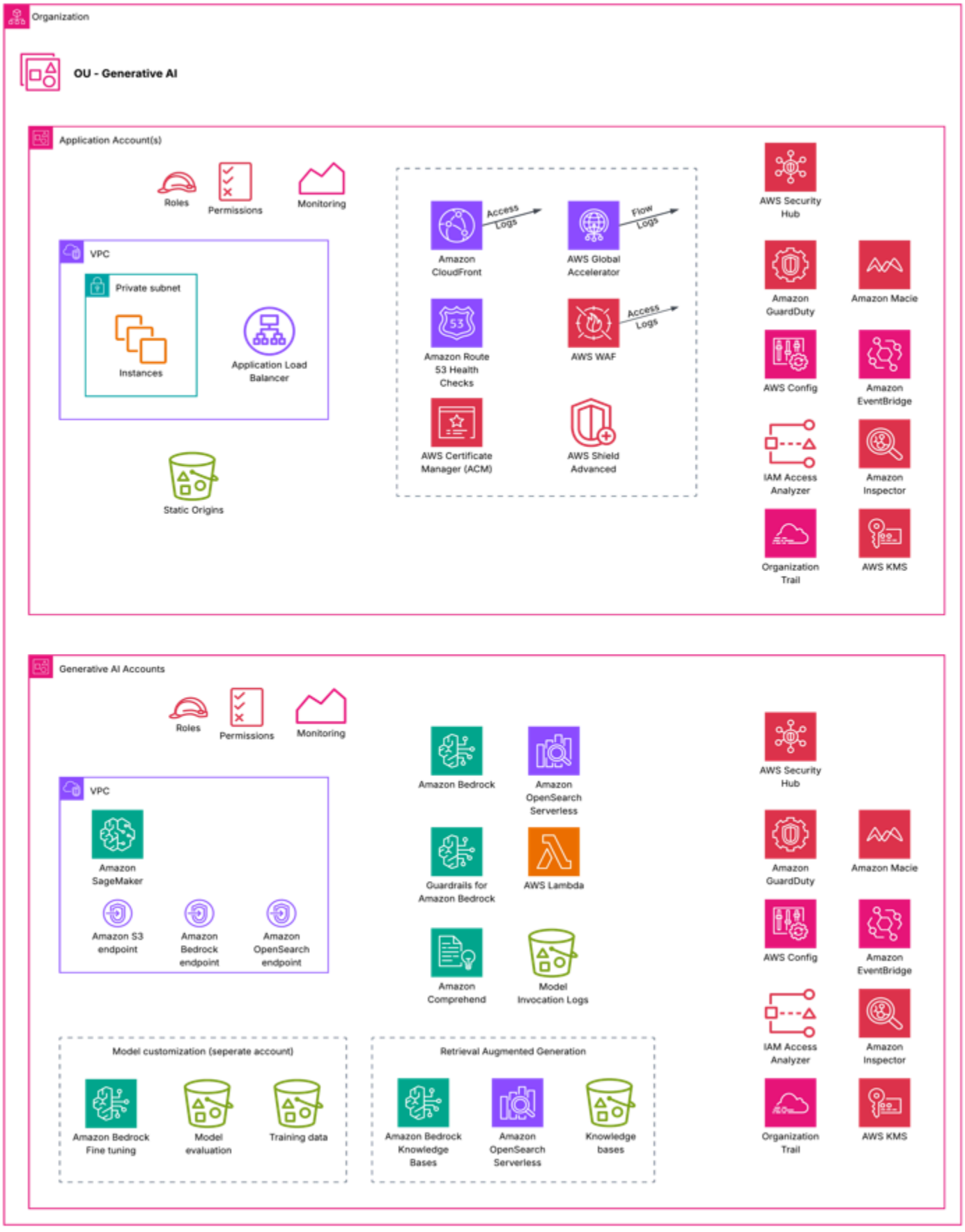
Cross-account security and governance

Implement centralized security monitoring through AWS Security Hub and Amazon GuardDuty deployed across all three account types, with findings aggregated in a dedicated security account. Use AWS Config to enforce consistent security baselines while allowing account-specific security enhancements, particularly for the training account's heightened security requirements.

Configure cross-account logging aggregation that forwards all AI-related logs to a centralized log archive account, with enhanced retention and protection for training account logs due to their potential sensitivity. Use Amazon EventBridge rules to orchestrate security responses across all accounts while maintaining appropriate isolation between environments.

Defense in depth

As shown in the following diagram, a defense-in-depth strategy implements security controls at different layers within each account to protect AI workloads. This section details security controls in the Application, Data, and Network layers.


Organization
OU - Generative AI
Application Account(s)
Roles
Permissions
Monitoring
VPC
Private subnet
Instances
Application Load Balancer
Static Origins
Amazon CloudFront
Access Logs
AWS Global Accelerator
Flow Logs
Amazon Route 53 Health Checks
AWS WAF
Access Logs
AWS Certificate Manager (ACM)
AWS Shield Advanced
AWS Security Hub
Amazon GuardDuty
Amazon Macie
AWS Config
Amazon EventBridge
IAM Access Analyzer
Amazon Inspector
Organization Trail
AWS KMS
Generative AI Accounts
Roles
Permissions
Monitoring
VPC
Amazon SageMaker
Amazon S3 endpoint
Amazon Bedrock endpoint
Amazon OpenSearch endpoint
Amazon Bedrock
Amazon OpenSearch Serverless
Guardrails for Amazon Bedrock
AWS Lambda
Amazon Comprehend
Model Invocation Logs
Model customization (seperate account)
Amazon Bedrock Fine tuning
Model evaluation
Training data
Retrieval Augmented Generation
Amazon Bedrock Knowledge Bases
Amazon OpenSearch Serverless
Knowledge bases
AWS Security Hub
Amazon GuardDuty
Amazon Macie
AWS Config
Amazon EventBridge
IAM Access Analyzer
Amazon Inspector
Organization Trail
AWS KMS

Application security layer

Deploy AWS WAF as the first line of defense against malicious requests targeting your AI applications. Configure rate limiting to prevent resource exhaustion attacks and implement AWS Managed Rules for the Core rule set and Known bad inputs managed rule groups. Create custom AWS WAF rules to detect common prompt injection patterns such as instruction override attempts, delimiter manipulation, and context escape sequences. For applications handling critical business functions or experiencing high request volumes, enhance this protection with AWS Shield Advanced to guard against DDoS attacks.

Implement comprehensive input validation through Amazon API Gateway request validators. Configure validators to enforce JSON schema requirements and establish appropriate character limits for prompts and metadata fields. This validation prevents malformed requests from reaching your AI models and helps mitigate prompt injection attacks.

Strengthen authentication and authorization by deploying AWS Lambda authorizers that validate user context and session state. Alternatively, implement Amazon Verified Permissions for policy-based authorization that evaluates fine-grained permissions dynamically based on user attributes, resource context, and request parameters before model invocation. This approach enables centralized policy management and consistent authorization decisions across your AI applications.

Configure response transformation to strip sensitive metadata from model outputs, helping to ensure that internal system information never reaches end users. This approach includes removing debug information, internal identifiers, and system prompts that could reveal application architecture or security controls.

Monitor the effectiveness of these controls through CloudWatch custom metrics that track prompt characteristics, response times, and error rates. Create CloudWatch alarms to identify anomalous patterns that potentially indicate attacks or system degradation, enabling rapid response to emerging threats.

Data security

Deploy Amazon Macie automated data discovery to identify and classify sensitive data in your AI inference workloads. Configure Macie to scan Amazon S3 buckets that contain the following:

- User prompts and conversation logs
- Model responses and generated content
- RAG knowledge base documents

- Agent memory and session data
- Application configuration and prompt templates

Enhance detection capabilities with custom data identifiers that recognize your organization's specific sensitive data patterns. Review Macie findings regularly and establish automated remediation workflows using EventBridge to alert security teams when sensitive data appears in unexpected locations.

Implement encryption using AWS KMS with customer managed keys for all inference-related data at rest. Organize your encryption strategy by using separate keys for the following:

- Conversation history and session data
- RAG knowledge base documents
- Agent memory and context storage
- Application logs and audit trails
- Cached model responses, if applicable

Establish key rotation policies that balance security requirements with operational efficiency. Implement cross-region key replication to support disaster recovery scenarios without compromising data protection.

Extend your data protection to real-time processing by deploying Amazon Comprehend PII detection or Amazon Bedrock Guardrails on both model inputs and outputs. Configure automatic redaction capabilities that operate in real time for interactive applications or in batch mode for stored conversations.

Amazon Comprehend detects common PII types including names, addresses, credit card numbers, and Social Security numbers. Amazon Bedrock Guardrails provides additional capabilities including custom regex patterns for organization-specific sensitive data and contextual filtering based on conversation flow.

Monitor PII detection rates through CloudWatch metrics to identify potential data handling issues and help ensure compliance with privacy regulations. Create CloudWatch alarms when PII detection rates exceed expected baselines, which may indicate users attempting to share sensitive information or applications inadvertently processing restricted data.

Configure Amazon S3 bucket policies that enforce encryption requirements, restrict access appropriately, and require multi-factor authentication for critical operations such as bucket deletion or policy modification. Implement Amazon S3 access points with VPC endpoints to provide role-based access control for different workload types. For example, create separate access points for application workloads accessing RAG knowledge bases, security teams reviewing conversation logs, and compliance auditors accessing audit trails.

Enable S3 Versioning for conversation logs and knowledge base documents to support audit requirements and incident investigation. Enable Amazon S3 data event logging through CloudTrail to maintain comprehensive access records, capturing who accessed what data, when, and from which source. For applications with data retention requirements, configure Amazon S3 Lifecycle policies to archive or delete conversation logs automatically after appropriate retention periods. This approach balances compliance needs with data minimization principles.

Network security enhancement

Design your network security architecture around the principle of defense in depth. Begin with restrictive virtual private cloud (VPC) security groups that allow only necessary traffic between application tiers. Structure these security groups to create clear boundaries between web, application, and data tiers, with controlled inter-tier communication flowing only through designated ports and protocols. This segmented approach limits the potential impact of any security breach while maintaining operational functionality.

Architect your network topology using dedicated subnets for AI workloads. Design routing carefully so that traffic is directed through NAT gateways for secure outbound internet access and VPC endpoints for efficient AWS service communication. Implement network ACLs as an additional defensive layer, using explicit allow rules for required traffic while maintaining a default-deny posture for all other communications.

Enhance your network defenses by deploying AWS Network Firewall. Use its intrusion detection and prevention capabilities for east-west traffic between application tiers, north-south traffic for ingress and egress, and lateral movement detection within your VPC. Configure rules that identify unusual request characteristics, detect high-frequency automated attacks, and recognize other indicators of malicious activity targeting AI systems. This deep packet inspection capability provides visibility into threats that might bypass application-layer controls.

Deploy Resolver DNS Firewall, a feature of Amazon Route 53 Resolver, to block malicious domain queries and enforce DNS-level security policies for your AI infrastructure. Configure DNS Firewall

to block known malicious domains, prevent data exfiltration through DNS tunneling, and alert on suspicious DNS patterns that may indicate compromised systems or command-and-control communications.

Maintain comprehensive network visibility through VPC Flow Logs configured with custom formats that capture relevant metadata for security analysis. Enable VPC Flow Logs for all subnets hosting AI workloads. Configure VPC Flow Logs to capture accepted traffic, rejected traffic, and all traffic to provide complete visibility into network communications.

Integrate VPC Flow Logs with your security information and event management (SIEM) solution for automated pattern analysis and threat detection. You can use Amazon OpenSearch Service for log aggregation and analysis, or integrate with third-party SIEM platforms that support AWS log ingestion. Configure your SIEM to detect anomalous patterns including unusual traffic volumes, connections to unexpected destinations, or communication patterns that deviate from established baselines.

Connect your threat detection system to EventBridge for orchestrated incident response. Configure EventBridge rules to trigger automated responses when security events are detected such as the following:

- Invoke AWS Lambda functions to isolate compromised resources.
- Execute AWS Systems Manager Automation runbooks to remediate common security issues.
- Send notifications to security teams through Amazon Simple Notification Service (Amazon SNS) for manual investigation.

This approach creates a closed-loop security monitoring and response system that reduces time to detection and response.

Model evaluation and validation

Model evaluation represents a critical security checkpoint in AI implementations, requiring comprehensive assessment of model behavior, output quality, and adherence to organizational policies before deployment. Evaluate foundation models (FMs) in the context of your specific use cases to ensure they meet security and quality requirements.

Before deploying an FM to production, establish evaluation frameworks that test model behavior against your security requirements. Use Amazon Bedrock model evaluation to compare different FMs and select the one that best meets your needs. Create standardized evaluation datasets that

include adversarial examples to test model robustness against prompt injection, jailbreak attempts, and other manipulation techniques.

Test models against your organization's responsible AI policies by evaluating outputs for bias, toxicity, and alignment with ethical guidelines. Use Amazon SageMaker Clarify to analyze model outputs for potential bias across different demographic groups or use cases. Document evaluation results and obtain appropriate approvals before deploying models to production environments.

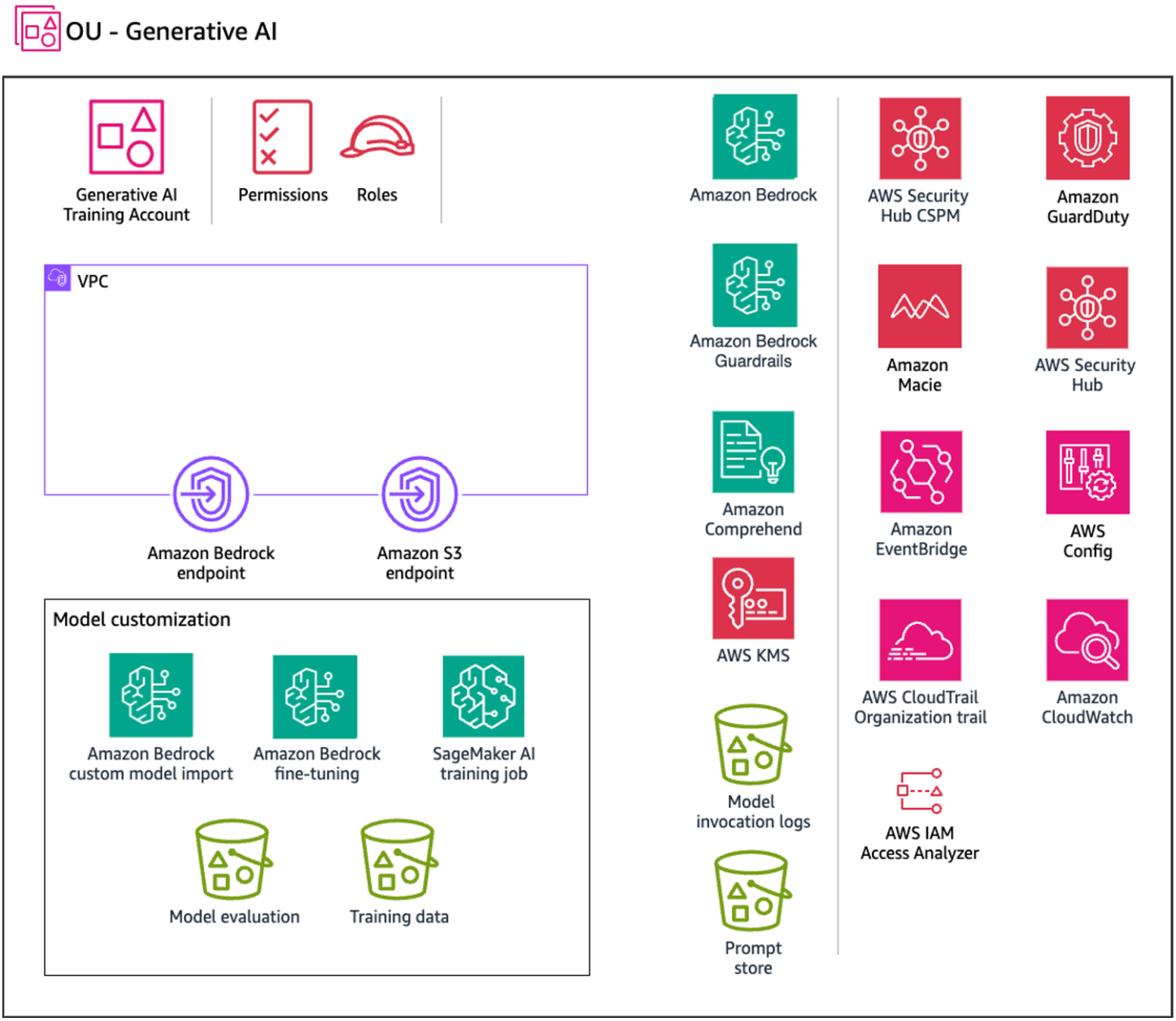
Implement continuous monitoring through CloudWatch to identify performance degradation or unusual output patterns in production environments. Configure CloudWatch metrics to track model invocation rates, response latencies, error rates, and token usage patterns. Create CloudWatch alarms that trigger when metrics deviate from established baselines, which may indicate security issues, service degradation, or unexpected usage patterns.

Monitor Amazon Bedrock Guardrails metrics to track how frequently content is filtered or blocked, providing visibility into potential security threats or policy violations. Analyze trends in guardrail activations to identify emerging attack patterns or areas where additional security controls may be needed.

Use AWS Step Functions to establish automated pipelines that orchestrate regular security assessments, performance benchmarks, and compliance validation. Configure these pipelines to run on a schedule or trigger based on specific events such as significant changes in usage patterns or the availability of new model versions.

Capability 2. Providing secure access, usage, and implementation for generative AI model customization

The scope of this scenario is to secure model customization. This use case focuses on securing the resources and training environment for a model customization job as well as securing the invocation of a custom model. The following diagram illustrates the AWS services recommended for the Generative AI account for this capability.



The Generative AI account includes services required for customizing a model along with a suite of required security services to implement security guardrails and centralized security governance. To allow for private model customization, you should create Amazon S3 gateway endpoints for the training data and evaluation Amazon S3 buckets that a private VPC environment is configured to access.

Rationale

Model customization improves foundation model (FM) performance for specific use cases by providing training data. Amazon Bedrock offers two customization methods:

- Continued pre-training with unlabeled data to enhance domain knowledge
- Fine-tuning with labeled data to optimize task-specific performance

Customized models require Provisioned Throughput for inference.

This capability addresses the following scenarios from the Generative AI Security Scoping Matrix:

- **Scope 4 - Model customization** – You customize an FM (from Amazon Bedrock or Amazon SageMaker Jumpstart) with your data to improve performance for specific tasks or domains. You control the application, customer data, training data, and customized model. The FM provider controls the pre-trained model and its training data.
- **Scope 5 - Model training from scratch** – You train a model from scratch using datasets you provide. You control the training data, model algorithm, training infrastructure, application, customer data, and related infrastructure.

Beyond customizing models within Amazon Bedrock, you can use the Custom Model Import feature to import models customized in other environments, such as Amazon SageMaker AI. Use Safetensors for the imported model serialization format. Unlike `pickle`, Safetensors stores only tensor data, not arbitrary Python objects. This approach eliminates vulnerabilities from unpickling untrusted data because Safetensors can't execute code.

To detect potential training data leakage, introduce canaries into your training data. Canaries are unique, identifiable strings that should never appear in model outputs. Configure prompt logging to alert when these canaries are detected, indicating the model may be memorizing and reproducing training data inappropriately.

Amazon Bedrock model customization

You can privately and securely customize FMs with your own data in Amazon Bedrock to build applications specific to your domain, organization, and use case. Fine-tuning increases model accuracy by providing your own task-specific, labeled training dataset to further specialize FMs. Continued pre-training trains models using your own unlabeled data in a secure and managed environment with customer managed keys. For more information, see Customize your model to improve its performance for your use case in the Amazon Bedrock documentation.

Model training or fine-tuning with SageMaker AI

You can train new models or fine-tune existing models by using Amazon SageMaker AI training jobs. This solution creates models customized for your business needs while maintaining control of all resources, including Amazon Elastic Compute Cloud (Amazon EC2) instances, training code, and training infrastructure.

Security considerations

Model customization creates artifacts, including the model and its weights, that are used in production workloads. This stage faces the following threats:

- **Data and model poisoning** – A threat actor injects malicious data to alter model behavior, introducing bias and causing unintended outputs.
- **Sensitive information disclosure** – A model trained on datasets containing personally identifiable information (PII) leaks sensitive information during inference.

SageMaker AI and Amazon Bedrock provide features that mitigate these risks, including data protection, access control, network security, logging, and monitoring.

Remediations

This section reviews the AWS services and features that address the risks that are specific to this capability.

Data protection

Encrypt the model customization job, output files (training and validation metrics), and resulting custom model. For this encryption, use an AWS Key Management Service (AWS KMS) customer managed key that you create, own, and manage.

When you use Amazon Bedrock to run a model customization job, you store the input files (training and validation data) in your Amazon S3 bucket. When the job is completed, Amazon Bedrock stores the output metrics files in the S3 bucket that you specified when you created the job. Amazon Bedrock stores the resulting custom model artifacts in an S3 bucket controlled by AWS. By default, input and output files are encrypted with Amazon S3 SSE-S3 server-side encryption using an AWS managed key. You can choose to encrypt these files with a customer managed key.

Identity and access management

Create a custom AWS Identity and Access Management (IAM) service role for model customization or model import that follows the principle of least privilege.

To create a service role for model customization, follow the instructions in the Amazon Bedrock documentation.

To create a service role for importing pre-trained models, follow the instructions in the Amazon Bedrock documentation.

Network security

Use a VPC with Amazon Virtual Private Cloud (Amazon VPC) to control access to your data. When you create your VPC, use the default DNS settings for your endpoint route table so that standard Amazon S3 URLs resolve.

If you configure your VPC with no internet access, create an Amazon S3 VPC endpoint. Use this VPC endpoint to allow your model customization jobs to access the S3 buckets that store your training and validation data and model artifacts.

For SageMaker AI, configure the training job with a VPC configuration, including private subnets and security groups that restrict both inbound and outbound traffic. This approach helps to ensure that Amazon EC2 instances can only access the resources that you define. Combined with Amazon S3 VPC endpoints, this approach helps to ensure that EC2 instances only access specified S3 buckets.

After you set up your VPC and endpoint, attach permissions to your model customization IAM role. After you configure the VPC and required roles and permissions, you can create a model customization job that uses this VPC. By creating a VPC with no internet access and an associated Amazon S3 VPC endpoint for training data, you can run your model customization job with private connectivity without internet exposure.

Recommended AWS services

This section discusses the AWS services that are recommended to build this capability securely. In addition to the services in this section, use Amazon OpenSearch Service and Amazon Comprehend as discussed in Capability 3.

Amazon S3

When you run a model customization job, the job accesses your Amazon S3 bucket to download input data and upload job metrics. You can choose fine-tuning or continued pre-training as the model type when you submit your model customization job on the Amazon Bedrock console or API. After a model customization job completes, analyze the training process results. To do this, you can view the files in the output S3 bucket that you specified when you submitted the job or view details about the model.

Encrypt both buckets with a customer managed key. Use Amazon S3 Object Lock or versioning to ensure data integrity. For additional network security hardening, create a gateway endpoint for the S3 buckets that the VPC environment accesses. Log and monitor all access. Use resource-based policies to control access to your Amazon S3 files.

Amazon Macie

Amazon Macie is a fully managed data security and data privacy service that uses machine learning and pattern matching to discover and help protect your sensitive data in AWS. You need to identify the type and classification of data that your workload is processing to ensure that appropriate controls are enforced. Macie can help identify sensitive data in your prompt store and model invocation logs stored in S3 buckets.

You can use Macie to automate discovery, logging, and reporting of sensitive data in Amazon S3. You can do this in two ways: Configure Macie to perform automated sensitive data discovery, or create and run sensitive data discovery jobs. For more information, see Discovering sensitive data with Amazon Macie in the Macie documentation.

Amazon EventBridge

Use EventBridge to configure SageMaker to respond automatically to model customization job status changes in Amazon Bedrock. Events from Amazon Bedrock are delivered to EventBridge in near real time. You can write simple rules to automate actions when an event matches a rule.

AWS KMS

Use a customer managed key to encrypt the model customization job, output files (training and validation metrics), resulting custom model, and Amazon S3 buckets that host the training, validation, and output data. For more information, see Encryption of custom models in the Amazon Bedrock documentation.

A key policy is a resource policy for an AWS KMS key. Key policies are the primary way to control access to KMS keys. You can also use IAM policies and grants to control access to KMS keys, but every KMS key must have a key policy. Use a key policy to provide permissions to a role to access the custom model encrypted with the customer managed key. This approach allows specified roles to use a custom model for inference.

Amazon CloudWatch

Use CloudWatch to monitor training job metrics in SageMaker and fine-tuning metrics in Amazon Bedrock. Create alarms to receive notifications when a job fails or when a metric deviates from baseline.

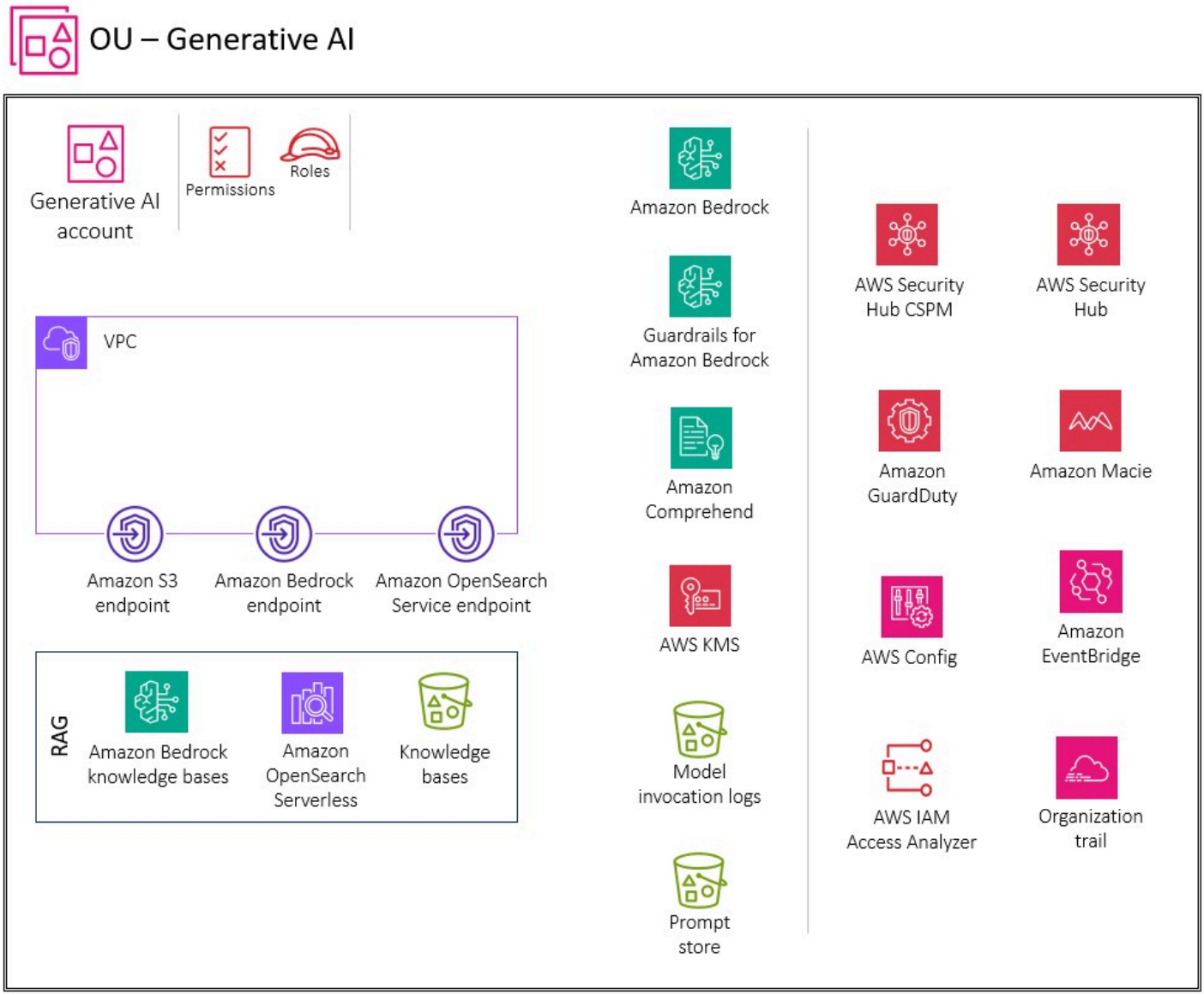
AWS CloudTrail

Use CloudTrail to log all events on your AWS resources. Create a trail filtered on your training resources, including datasets on Amazon S3. This trail enables you to act on suspicious activity surrounding your resources.

Capability 3. Providing secure access to data and systems for generative AI

Retrieval Augmented Generation (RAG) is a foundational pattern that enhances large language model (LLM) responses by retrieving information from external knowledge bases before generating answers. This approach addresses a core limitation of foundation models (FMs): They are trained on data with a fixed knowledge cutoff and lack access to current enterprise data such as customer records, product catalogs, internal documentation, and business systems.

RAG enables the LLM to provide up-to-date, context-specific responses by dynamically pulling relevant information from enterprise data sources. However, this integration introduces critical security challenges. Securing RAG implementations requires extending defense-in-depth principles from Capability 1 and Capability 2 to address how LLMs securely use data from external sources. The following diagram illustrates recommended AWS services for the Generative AI account RAG capability.



The Generative AI account includes services for storing embeddings in a vector database, storing conversations for users, and maintaining a prompt store. The account includes security services to implement security guardrails and centralized security governance. Create Amazon Simple Storage Service (Amazon S3) gateway endpoints for the model invocation logs, prompt store, and knowledge base data source buckets in Amazon S3 that the VPC environment accesses. Create an Amazon CloudWatch Logs gateway endpoint for the CloudWatch logs that the VPC environment accesses.

Rationale

RAG enhances FM responses by retrieving information from external, authoritative knowledge bases before generating answers. This approach overcomes FM limitations by providing access to up-to-date, context-specific data, improving the accuracy and relevance of generated responses.

RAG can be implemented across Scopes 2-5 of the Generative AI Security Scoping Matrix. Scope 2 applications represent scenarios where organizations use third-party AI services (like Salesforce Einstein or ChatGPT) where the service provider controls both the FM and the application layer. You control only the prompts and customer data you provide to the service. You can enhance responses from third-party enterprise applications by implementing RAG to extract information from internal data, which augments queries processed by the third-party application. In Scope 2, you implement RAG either by connecting to your organization's data sources or by uploading and referencing custom documents.

In Scope 3, you build a generative AI application using a pre-trained FM such as those offered on Amazon Bedrock. You control your application and any customer data your application uses. The FM provider controls the pre-trained model and its training data.

RAG systems face the following unique security risks:

- Data exfiltration of RAG data sources by threat actors
- Poisoning of RAG data sources with prompt injections or malware
- Unauthorized access to sensitive information through inadequate access controls
- Sensitive information disclosure through uncontrolled model outputs
- Lack of data provenance leading to compliance and auditability challenges

Design considerations

Avoid customizing an FM with sensitive data (for more information, see Capability 2). Instead, use the RAG technique to interact with sensitive information. RAG provides the following advantages:

- **Tighter control and visibility** – Keep sensitive data separate from the model. You can edit, update, or remove data without retraining the model, ensuring data governance and compliance with regulatory requirements.

- **Reduced sensitive information disclosure** – RAG controls interactions with sensitive data during model invocation. This reduces the risk of unintended disclosure that occurs when you incorporate data directly into the model's parameters.
- **Flexibility and adaptability** – Update or modify sensitive information as data requirements or regulations change without retraining or rebuilding the language model.
- **Enhanced security posture** – Implement multiple security layers including metadata filtering, access controls, and data redaction at different stages of the RAG pipeline.

Multi-layered security strategy

Implement a defense-in-depth approach with security controls at the following stages:

- **Ingestion time** – Filter and validate data before it enters the knowledge base.
- **Storage level** – Encrypt data at rest and implement access controls.
- **Retrieval time** – Apply metadata filtering and role-based access controls.
- **Inference time** – Use guardrails to filter model outputs and detect sensitive information.

Amazon Bedrock Knowledge Bases

Amazon Bedrock Knowledge Bases provides a fully managed solution for building RAG applications by securely connecting FMs to your organization's data. This service uses vector stores (such as Amazon OpenSearch Serverless) to retrieve relevant information efficiently. The FM uses this information to generate responses. Amazon Bedrock synchronizes your data from Amazon S3 to the knowledge base and generates embeddings for efficient retrieval.

Key features of Amazon Bedrock Knowledge Bases include the following:

- **Source attribution** – Knowledge bases include source attribution for all retrieved information to improve transparency and minimize hallucinations. This provenance tracking enables you to:
  - Verify the accuracy of generated responses.
  - Maintain audit trails for compliance.
  - Build user trust in AI-generated content.
  - Support troubleshooting and investigations during security events.

- **Automated vector store management** – Amazon Bedrock automatically creates and manages vector stores in OpenSearch Serverless, synchronizing data from Amazon S3 and generating embeddings for efficient retrieval.
- **Metadata filtering** – Knowledge bases support metadata filtering capabilities that enable access control by pre-filtering the vector store based on document metadata before searching for relevant documents. This filtering reduces noise, improves retrieval accuracy, and enforces data access policies.
- **Multimodal support** – Knowledge bases process documents with visual resources, extracting and retrieving images in responses to queries, which supports comprehensive document understanding.

For each vector database option, configure the following:

- Field mappings for vector embeddings, text chunks, and metadata
- Customer managed AWS KMS keys for encrypting secrets and data
- AWS Secrets Manager secrets for authentication credentials
- Network connectivity through AWS PrivateLink where supported

Security considerations

Generative AI RAG workloads face unique risks, including data exfiltration of RAG data sources. Another risk is indirect prompt injection attacks where threat actors insert malicious documents into the knowledge base to manipulate model outputs.

Amazon Bedrock knowledge bases provide security controls for data protection, access control, network security, logging and monitoring, and metadata filtering for secure retrieval. These controls address data exfiltration and unauthorized access risks. To mitigate indirect prompt injection attacks, implement input validation and content filtering on documents before ingestion.

Remediations

This section reviews the AWS services and features that address the risks that are specific to this capability.

Data protection

Encrypt your knowledge base data in transit and at rest using an AWS Key Management Service (AWS KMS) customer managed key. When you configure a data ingestion job for your knowledge base, encrypt the job with a customer managed key. If you let Amazon Bedrock create a vector store in Amazon OpenSearch Service for your knowledge base, Amazon Bedrock passes an AWS KMS key of your choice to OpenSearch Service for encryption.

You can encrypt sessions in which you generate responses from querying a knowledge base with an AWS KMS key. You store the data sources for your knowledge base in your Amazon S3 bucket. If you encrypt your data sources in Amazon S3 with a customer managed key, attach the required policies to your knowledge base service role.

If you configure vector stores with AWS Secrets Manager secrets, encrypt the secrets with customer managed keys and attach decryption permissions to the knowledge base service role. Ensure all data in transit uses TLS 1.2 or higher with secure cipher suites.

For more information and the policies to use, see Encryption of knowledge base resources in the Amazon Bedrock documentation.

Data classification and handling

Implement data classification schemes to categorize data based on sensitivity and criticality. Establish clear classification tiers (for example, Public, Internal, Confidential, and Restricted) with specific handling requirements for each level.

Classify data at the point of ingestion. Use automated tools like Amazon Macie to detect and classify sensitive data in Amazon S3 buckets that contain knowledge base data sources.

Use AWS resource tags to categorize sensitive data and monitor compliance with protection requirements. AWS Organizations tag policies enforce tagging standards across accounts.

Maintain a data catalog that maps data in your organization, its location, sensitivity level, and the controls in place to protect it. AWS Glue Data Catalog supports metadata storage and management.

Data lineage and provenance tracking

Implement comprehensive data provenance tracking to record the history of data as it progresses through your RAG workload.

Data lineage provides the following benefits:

- **Regulatory compliance** – Demonstrates data handling practices for audits and certifications
- **Troubleshooting** – Enables root cause analysis when data quality issues arise
- **Security investigations** – Provides audit trails during security incidents
- **Data quality** – Ensures confidence in data origin, transformations, and ownership
- **Impact analysis** – Identifies downstream effects of data changes

Implementation approaches for data provenance tracking include the following:

- **AWS Glue Data Catalog** – Store metadata and track lineage across data processing pipelines.
- **Amazon SageMaker ML Lineage Tracking** – Track model training data, hyperparameters, and deployment artifacts.
- **AWS CloudTrail** – Capture API activities across AI services for audit trails.
- **Amazon CloudWatch** – Monitor data quality, usage, and model drift with generative AI-driven debugging and root cause analysis.
- **Third-party integration** – Support open telemetry with integration to third-party observability tools.

Identity and access management

Create a custom service role for knowledge bases for Amazon Bedrock following the principle of least privilege. Create a trust relationship that allows Amazon Bedrock to assume this role, and create and manage knowledge bases.

Attach identity policies to the custom knowledge base service role that grant permissions to access Amazon Bedrock models, data sources in Amazon S3, vector databases, and encryption keys. For the complete list of required permissions, see Create a service role for Amazon Bedrock Knowledge Bases in the Amazon Bedrock documentation.

Knowledge bases support security configurations to set up data access policies for your knowledge base and network access policies for your private Amazon OpenSearch Serverless knowledge base. For more information, see Create a knowledge base by connecting to a data source in Amazon Bedrock Knowledge Bases in the Amazon Bedrock documentation.

Metadata filtering for secure retrieval

Amazon Bedrock Knowledge Bases supports metadata filtering to refine and secure contextual retrieval from vector stores. For every document added, you can supply metadata files (up to 10KB each) with attributes such as tags, dates, project IDs, and business units.

Metadata filtering enables fine-grained access control for RAG systems. By attaching metadata as key-value pairs to each vector during ingestion, you can do the following:

- **Filter queries** – Filter queries based on user attributes such as department, role, or clearance level. For example, metadata can include `{"department": "finance", "classification": "confidential"}` to restrict access to financial data.
- **Enforce data classification policies** – Tag vectors with sensitivity levels (public, internal, confidential, and restricted) and filter based on user permissions.
- **Support multi-tenant architectures** – Use metadata to isolate data between different tenants or business units, ensuring data segregation in shared infrastructure.
- **Enable temporal access controls** – Include timestamp metadata to implement time-based access restrictions or data retention policies.

It's up to the application or agent to add the correct metadata to each API call with Amazon Bedrock to filter results based on required key-value pairs.

Input and output validation

Input validation protects Amazon Bedrock knowledge bases from malicious content. Use malware protection in Amazon S3 to scan files for malicious content before uploading them to a data source. For an example implementation, see Integrating Malware Scanning into Your Data Ingestion Pipeline with Antivirus for Amazon S3 (AWS Blog post).

Use Amazon Comprehend to detect and redact sensitive information in documents before indexing them in your RAG knowledge base. For an example implementation, see Protect sensitive data in RAG applications with Amazon Bedrock (AWS blog post). For more information, see Detecting PII entities in the Amazon Comprehend documentation.

Use Amazon Macie to detect and generate alerts on potential sensitive data in Amazon S3 data sources to enhance security and compliance.

Recommended AWS services

This section discusses the AWS services that are recommended to build this capability securely. In addition to the services in this section, use Amazon CloudWatch and AWS CloudTrail as explained in Capability 2.

Amazon OpenSearch Serverless

Amazon OpenSearch Serverless is an on-demand, auto-scaling configuration for Amazon OpenSearch Service. An OpenSearch Serverless collection is an OpenSearch cluster that scales compute capacity based on your application's needs. Amazon Bedrock knowledge bases use OpenSearchServerless for embeddings and Amazon S3 for the data sources that sync with the OpenSearch Serverless vector index.

Implement authentication and authorization for your OpenSearch Serverless vector store following the principle of least privilege. With data access control in OpenSearch Serverless, you can allow users to access collections and indexes regardless of their access mechanisms or network sources. Access permissions are done at the generative AI application layer.

OpenSearch Serverless supports server-side encryption with AWS KMS to protect data at rest. Use a customer managed key to encrypt that data. To allow the creation of an AWS KMS key for transient data storage during data ingestion, attach a policy to your knowledge bases for the Amazon Bedrock service role.

Private access can apply to OpenSearch Serverless-managed VPC endpoints, supported AWS services such as Amazon Bedrock, or both. Use AWS PrivateLink to create a private connection between your VPC and OpenSearch Serverless endpoint services. Use network policy rules to specify Amazon Bedrock access.

Monitor OpenSearch Serverless using Amazon CloudWatch, which collects raw data and processes it into readable, near real-time metrics. OpenSearch Serverless integrates with AWS CloudTrail, which captures API calls for OpenSearch Serverless as events. OpenSearch Service integrates with Amazon EventBridge to notify you of events that affect your domains.

Amazon S3

Store your data sources for your knowledge base in an Amazon S3 bucket. If you encrypted your data sources in Amazon S3 using a custom AWS KMS key (recommended), attach a policy to your knowledge base service role.

Use malware protection in Amazon S3 to scan files for malicious content before uploading them to a data source. Host your model invocation logs and commonly used prompts as a prompt store in Amazon S3. Encrypt all buckets with a customer managed key.

For additional network security hardening, create a gateway endpoint for the S3 buckets that the VPC environment accesses. Log and monitor all access. Enable versioning if you have a business need to retain the history of Amazon S3 objects. Apply object-level immutability with Amazon S3 Object Lock. Use resource-based policies to control access to your Amazon S3 files.

Amazon Comprehend

Amazon Comprehend uses natural language processing (NLP) to extract insights from document content. You can use Amazon Comprehend to detect and redact PII entities in English or Spanish text documents.

Integrate Amazon Comprehend into your data ingestion pipeline to automatically detect and redact PII entities from documents before you index them in your RAG knowledge base. This approach helps to ensure compliance and protects user privacy. Depending on the document types, you can use Amazon Textract to extract and send text to Amazon Comprehend for analysis and redaction.

With Amazon S3, you can encrypt your input documents when creating a text analysis, topic modeling, or custom Amazon Comprehend job. Amazon Comprehend integrates with AWS KMS to encrypt the data in the storage volume for `Start*` and `Create*` jobs. Amazon Comprehend encrypts the output results of `Start*` jobs by using a customer managed key.

Use the `aws:SourceArn` and `aws:SourceAccount` global condition context keys in resource policies to limit the permissions that Amazon Comprehend gives another service to the resource. Use AWS PrivateLink to create a private connection between your virtual private cloud (VPC) and Amazon Comprehend endpoint services. Implement identity-based policies for Amazon Comprehend with the principle of least privilege.

Amazon Comprehend integrates with AWS CloudTrail, which captures API calls for Amazon Comprehend as events.

Amazon Macie

Macie identifies sensitive data in your knowledge bases that is stored as data sources, model invocation logs, and prompt stores in Amazon S3 buckets. For Macie security best practices, see the *Amazon Macie* section in Capability 2.

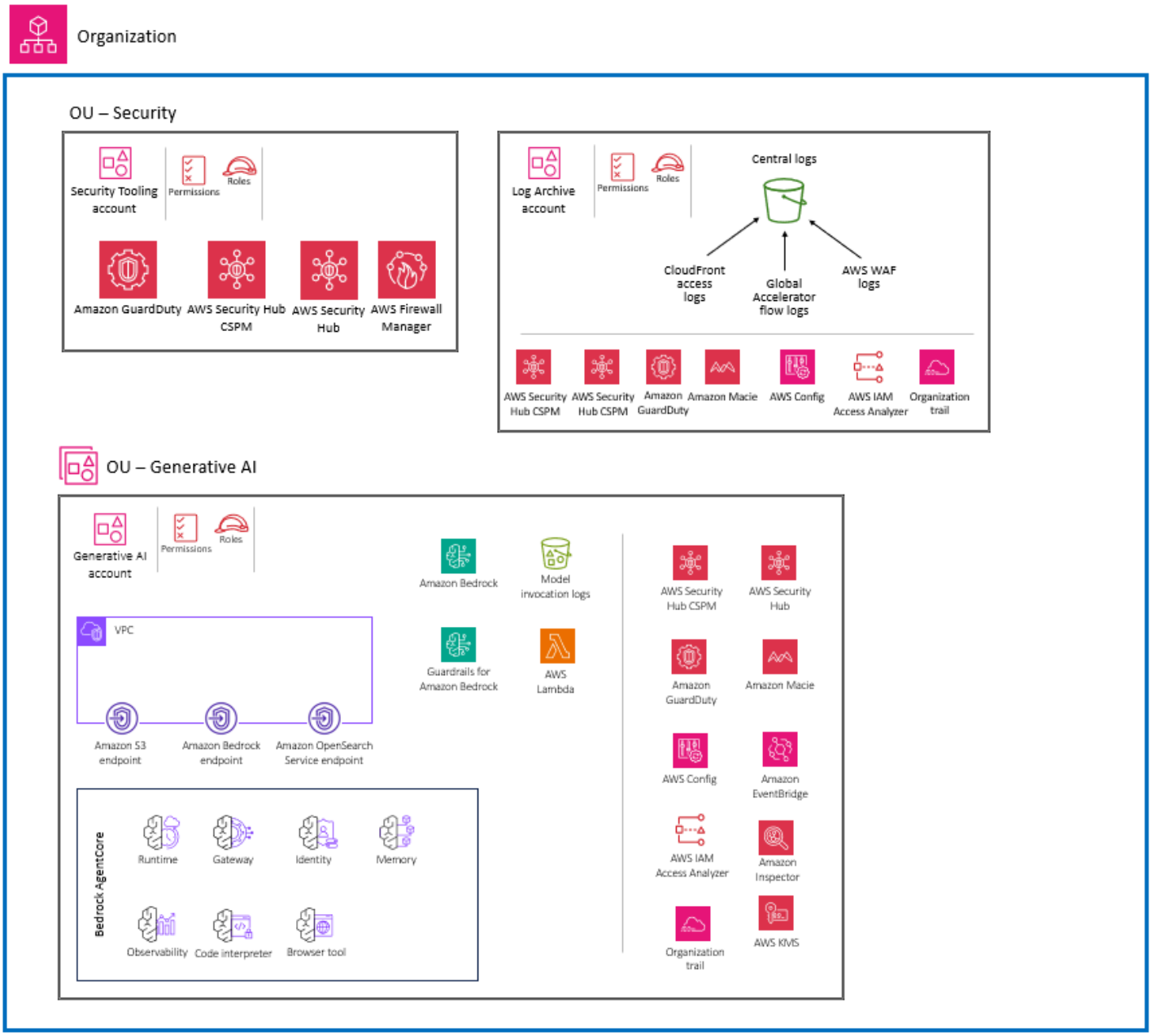
AWS KMS

Use AWS Key Management Service (AWS KMS) customer managed keys to encrypt the following:

- Data ingestion jobs for your knowledge base
- Amazon OpenSearch Service vector database
- Sessions in which you generate responses from querying a knowledge base
- Model invocation logs in Amazon S3
- Amazon S3 bucket that hosts the data sources

Capability 4. Providing secure access, usage, and implementation of tools

The scope of this capability is to secure tool access and authentication for AI applications. The following diagram illustrates the AWS services recommended for the Generative AI account for this capability.



Rationale

Tool integration extends AI capabilities by connecting foundation models (FMs) to external functions and services. AI applications integrate tools through the following patterns:

- AWS Lambda functions for serverless business logic
- Model Context Protocol (MCP) servers for standardized tool interfaces
- External APIs for real-time data access

- Operating system tools for system-level operations
- Agent-to-agent (A2A) communication protocols for multi-agent workflows

This capability addresses Scope 3 of the Generative AI Security Scoping Matrix. In Scope 3, your organization builds a generative AI application using a pre-trained FM such as those offered in Amazon Bedrock while integrating external tools and services. You control your application, the tools it accesses, customer data, and permissions granted to the AI application. The FM provider controls the pre-trained model and its training data.

> **Note**
>
> Although this guidance focuses on application-level tool integration with Amazon Bedrock FMs (Scope 3), similar principles apply to fine-tuned and self-trained models (Scopes 4 and 5).

For user-facing AI applications that provide tool access to end users, see Capability 6.

Security considerations

AI applications with tool access face unique security risks that extend beyond traditional application vulnerabilities. When you grant AI applications the ability to invoke external functions and services, you create new attack surfaces. Adversaries can exploit these surfaces through both technical vulnerabilities and manipulation of the AI's reasoning process:

- Tool access introduces authentication and authorization challenges across multiple integration points. Unauthorized tool access can occur when authentication mechanisms fail to properly validate AI application identities, or when authentication credentials are exposed during tool invocation chains. Adversaries who gain unauthorized access can execute privileged operations, access sensitive data, or manipulate business logic.
- Prompt injection attacks represent a threat vector specific to AI applications with tool access. Attackers craft malicious inputs designed to manipulate the AI's reasoning process, causing it to misuse tools or generate malicious parameters for tool invocations. The AI application may interpret attacker-controlled prompts as legitimate instructions, leading to unintended tool executions that compromise security controls.
- Privilege escalation risks emerge when AI applications chain multiple tools with varying permission levels. An attacker who compromises a low-privilege tool can potentially leverage the

AI's orchestration capabilities to access higher-privilege tools through unintended combinations. This risk intensifies in autonomous agent scenarios where the AI makes independent decisions about which tools to invoke and in what sequence.

- Resource exhaustion and API abuse pose operational and security risks when AI applications make excessive tool calls. AI-driven workloads can generate high volumes of tool invocations through reasoning loops or self-perpetuating execution patterns. Adversaries can exploit this behavior to launch denial-of-service attacks by crafting prompts that trigger resource-intensive tool chains, exhausting API limits and consuming compute resources.
- Supply chain vulnerabilities affect both upstream and downstream components in tool integration architectures. Upstream risks include compromised tool dependencies, malicious MCP servers, or vulnerable third-party APIs. Downstream risks involve insecure network routes between AI applications and external tools, man-in-the-middle attacks on tool communication channels, and exposure of sensitive data in transit.

Remediations

This section reviews the AWS services and features that address the risks that are specific to this capability.

Data protection

Encrypt tool inputs, outputs, and execution contexts in transit and at rest using AWS Key Management Service (AWS KMS) customer managed keys. Amazon Bedrock AgentCore encrypts all data at rest and in transit by default. Use TLS 1.2 or higher with AES-256 encryption for all tool communications.

Implement session isolation to prevent data leakage between tool executions. Amazon Bedrock AgentCore Runtime provides dedicated microVM architecture that isolates each session with separate CPU, memory, and file system resources. Sessions terminate automatically and purge all state data to prevent cross-contamination.

Store authentication credentials for external tool access in AWS Secrets Manager encrypted with customer managed keys. Configure Amazon Bedrock AgentCore Identity as a secure credential broker that retrieves credentials at runtime without exposing them to AI applications.

Apply Amazon Bedrock Guardrails to validate and filter tool inputs and outputs across all integration patterns. Configure guardrails to detect and block malicious parameters, sensitive data exposure, and policy violations before tools execute.

Identity and access management

Create custom service roles for AI application tool integration following the principle of least privilege. Grant permissions only for specific tools and AWS services that are required for your use case. Implement permission boundaries to prevent privilege escalation through unintended tool combinations.

Configure AgentCore Identity as a secure credential broker supporting Signature Version 4 (SigV4) signing for AWS services and OAuth 2.0 authentication for external APIs. Store credentials in AWS Secrets Manager with automatic rotation where supported by external services.

Implement fine-grained access controls through Amazon Bedrock AgentCore Gateway centralized tool management. Register tools explicitly and configure which AI applications can invoke each tool. Apply rate limiting and resource quotas at the identity level to prevent resource exhaustion from excessive tool calls.

Apply guardrails with identity context for persona-based content filtering. Configure your orchestration and agent layers to require identity invocation and creation for each scoped task rather than using default settings.

Network security

Use AWS PrivateLink to establish private connectivity to Amazon Bedrock AgentCore services. Create VPC endpoints for AgentCore Gateway and AgentCore Runtime to help ensure tool integration occurs through private network paths without internet exposure.

Deploy AI applications and AWS Lambda function tools within private subnets using restrictive security groups. Configure security group rules to allow only necessary communication between AgentCore Gateway and registered tools. Use AgentCore Gateway native VPC support for secure, isolated tool access.

Configure VPC endpoint policies to restrict service access to authorized AI applications only. Implement network-level rate limiting and traffic controls to prevent resource exhaustion. Use AWS Network Firewall to inspect traffic between AI applications and external tools for malicious patterns.

Logging and monitoring

Enable AWS CloudTrail to log tool invocation activities with user context attribution. Configure organization trails to capture cross-account tool access and maintain comprehensive audit trails. Forward all logs to the Log Archive account for centralized security analysis.

Configure Amazon CloudWatch to monitor tool executions and detect anomalous behavior. Create metrics for tool invocation rates, execution duration, failure patterns, and resource consumption across different integration types. Set CloudWatch alarms to alert when metrics deviate from established baselines.

Implement Amazon Bedrock AgentCore Observability for MCP servers integrated with AgentCore Gateway. Monitor agent behavior, multi-agent workflows, and tool chain executions. Use trace data to identify security issues, performance bottlenecks, and unusual access patterns.

For operating system (OS) tools, use AWS Systems Manager Session Manager to log session activity to Amazon CloudWatch Logs or Amazon S3. Deploy CloudWatch agents to collect OS-level metrics and logs. Use AWS Systems Manager Run Command to maintain history of commands and outputs for audit purposes.

Recommended AWS services

This section reviews the AWS services that are recommended to build this capability securely.

Amazon Bedrock AgentCore Runtime

AgentCore Runtime provides secure, serverless hosting environments for AI agents with complete session isolation using dedicated microVMs. Each user session runs with isolated CPU, memory, and file system resources, ensuring separation between users regardless of tool type.

Configure customer managed KMS keys for enhanced encryption control over session data. AgentCore Runtime automatically terminates sessions and sanitizes memory after completion. The service supports both real-time interactions and long-running workloads up to 8 hours while maintaining security isolation throughout execution.

Amazon Bedrock AgentCore Gateway

AgentCore Gateway provides centralized tool discovery and invocation using the Model Context Protocol (MCP). It supports multiple tool types including AWS Lambda functions, OpenAPI specifications, Smithy models, and MCP servers through a standardized interface.

Configure OAuth authorizers for gateway access and manage authentication credentials securely with AgentCore Identity. Create VPC endpoints for private connectivity and apply endpoint policies to restrict access to authorized AI applications. The gateway enforces mandatory TLS 1.2+ encryption for all communications by default.

Register tools explicitly through the gateway console or API. Configure tool-specific access controls, rate limits, and timeout values. Monitor tool usage through integrated CloudWatch metrics and CloudTrail logging.

Amazon Bedrock AgentCore Identity

AgentCore Identity serves as a secure credential broker supporting multiple authentication methods. These methods include AWS Signature Version 4 (SigV4) signing for native AWS services and OAuth 2.0 with JWT bearer tokens for external APIs. AgentCore Identity maintains a protected token vault using AWS KMS encryption for credential storage.

Configure integration with enterprise identity providers including Amazon Cognito, Okta, and Microsoft Entra ID. AgentCore Identity ensures complete separation between ingress authentication (verifying user identity) and egress authorization (accessing tools), preventing customer credentials from being forwarded to target services.

AWS Lambda

Lambda functions serve as custom tools for AI applications, providing serverless compute for business logic execution. Create AWS Identity and Access Management (IAM) execution roles with permissions scoped to invoke only registered tools and access required AWS services.

Configure Lambda functions within virtual private clouds (VPCs) for network isolation and apply resource-based policies to control which principals can invoke functions. Use environment variable encryption with customer managed KMS keys for sensitive configuration data. Set appropriate timeout values and memory limits to prevent resource exhaustion.

AWS Secrets Manager

Secrets Manager provides secure storage and automatic rotation of authentication credentials for external tool access. Store API keys, OAuth tokens, and database credentials with encryption using customer managed KMS keys.

Configure automatic credential rotation where supported by external services. Use fine-grained IAM policies to control which AI applications can retrieve specific credentials. Enable CloudTrail logging for all secret access operations to maintain audit trails.

Amazon Bedrock Guardrails

Amazon Bedrock Guardrails enables content filtering and validation for tool inputs and outputs. Configure content filters to block harmful content across multiple categories: hate, insults, sexual,

violence, misconduct, and prompt attacks. Set filter strength for each category based on your risk tolerance.

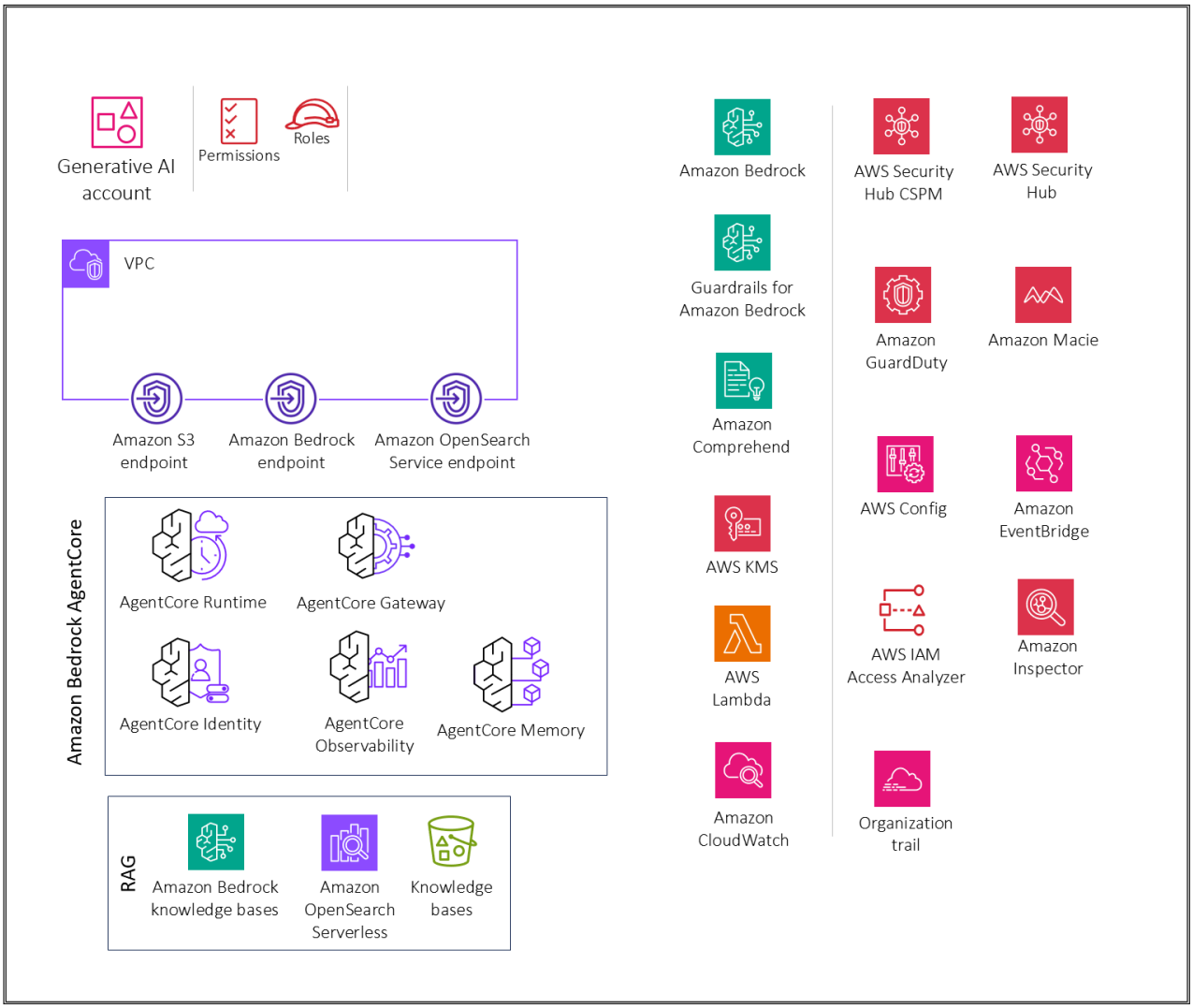
Define restricted topics to prevent AI applications from discussing sensitive subjects or internal systems. Create custom word filters tailored to your organization's sensitive terminology. Configure custom response messages that users see when content is blocked.

Apply guardrails consistently across all tool integration patterns by invoking them through the `InvokeModel` API with the `guardrailConfig` parameter. For AgentCore Gateway integrations, configure guardrails directly within gateway settings to filter both tool inputs and outputs before execution.

Use guardrail metrics in CloudWatch to monitor filtering effectiveness and identify potential security threats. Create alarms when guardrail activation rates exceed expected thresholds, which may indicate attack attempts or policy violations.

Capability 5. Providing secure access, usage, and implementation of generative AI agents

The scope of this capability is to secure autonomous agent functionality for generative AI applications. The following diagram illustrates the AWS services recommended for the Generative AI account for this capability.



Rationale

AI agents extend foundation model (FM) capabilities by orchestrating chains of reasoning steps, tool invocations, and decision-making processes to accomplish complex tasks autonomously. Unlike simple model inference, agents maintain conversation context, make independent decisions

about which tools to invoke, and execute multi-step workflows based on user goals rather than explicit instructions.

Agents solve problems that require multiple interactions with external systems. For example, a customer service agent might retrieve order information from a database, check inventory through an API, process a refund through a payment system, and update a CRM. These actions are all based on a single customer request. The agent determines which tools to use, in what sequence, and how to handle errors or unexpected responses.

This capability addresses Scope 3 of the Generative AI Security Scoping Matrix. In Scope 3, your organization builds an agentic AI application using a pre-trained FM such as those models offered in Amazon Bedrock. You control your application, the tools agents can access, and customer data. The FM provider controls the pre-trained model and its training data.

Amazon Bedrock AgentCore provides a comprehensive platform for deploying and managing AI agents securely. AgentCore Runtime hosts agents with session isolation, AgentCore Gateway centralizes tool access, AgentCore Memory stores conversation history, AgentCore Identity manages authentication, and AgentCore Observability monitors agent behavior. Combined with Amazon Bedrock Guardrails, these services address the unique security challenges of autonomous agent systems.

Security considerations

Agentic AI applications face security risks that extend beyond those of traditional generative AI applications because of their autonomous decision-making capabilities and persistent state management. The combination of autonomy, tool access, and memory creates attack surfaces that require specialized security controls.

- Session isolation becomes critical when agents serve multiple users concurrently. Without proper isolation, one user's sensitive data could leak into another user's session through shared memory, cached context, or persistent state. Agents that maintain conversation history across sessions require secure memory stores. These memory stores prevent unauthorized access to historical interactions and protect against memory poisoning attacks where adversaries inject false information to manipulate future agent behavior.
- Excessive autonomy introduces risks when agents make independent decisions about tool invocations without sufficient constraints. An agent with broad tool access and minimal oversight can do the following:
  - Execute unintended operations.

  - Chain tools in ways that developers did not anticipate.
  - Escalate privileges by combining low-privilege tools to achieve high-privilege outcomes.

  The autonomous nature of agents makes it difficult to predict all possible execution paths, requiring defense-in-depth controls that limit scope when agents behave unexpectedly.
- Identity and access management complexity increases as agents authenticate with multiple systems on behalf of users. Improper credential management can expose user credentials to the agent runtime, fail to properly scope agent permissions, or allow agents to access resources beyond their intended authorization. Multi-agent architectures compound this complexity when orchestrator agents invoke subordinate agents, each requiring appropriate authentication and authorization at every step in the chain.
- Secure execution environments become necessary when agents run code or interact with websites. Code execution capabilities enable powerful agent functionality but create risks of arbitrary code execution, resource exhaustion, or access to the underlying host system. Browser automation allows agents to interact with web applications but introduces risks of credential exposure, cross-site scripting, or unintended actions on behalf of users.

Remediations

This section reviews the AWS services and features that address the risks that are specific to this capability.

Data protection

Implement session isolation through Amazon Bedrock AgentCore Runtime, which runs each user session in a dedicated microVM with isolated CPU, memory, and file system resources. This architecture provides complete separation between user sessions, preventing cross-session data contamination even when agents process requests concurrently. After session completion, AgentCore Runtime terminates the microVM and sanitizes memory, ensuring no data persists between sessions.

Secure agent memory through the Amazon Bedrock AgentCore Memory namespace structure for logical data isolation. Memory is organized by session ID, actor ID, and strategy ID, preventing users from accessing data belonging to other users. Configure short-term memory retention periods to the minimum required for your use case (up to 365 days). For long-term memory, which lacks built-in retention, implement automated deletion workflows using the AgentCore Memory API to comply with data retention policies.

Prevent memory poisoning by ensuring that users can't modify their session ID or actor ID. Don't include `ActorID` or `SessionID` values in system prompts where users could manipulate them. Implement input validation that rejects attempts to inject false information designed to corrupt the agent's memory and influence future behavior.

Encrypt agent data at rest by using AWS Key Management Service (AWS KMS) customer managed keys for AgentCore Memory resources, AgentCore Identity token vaults, AgentCoreGateway configuration, and Amazon CloudWatch log groups containing agent logs. This approach provides enhanced control over encryption key management and enables detailed audit trails of key usage.

Identity and access management

Design authentication architecture that addresses the following distinct authentication points:

- User authentication to invoke the agent
- Agent authentication to access tools and resources
- Tool authentication to access downstream systems

Each authentication point requires appropriate identity providers and credential management strategies.

Configure inbound authentication using AgentCore Identity, which supports both AWS credentials and OAuth 2.0. For AWS credentials, limit AWS Identity and Access Management (IAM) principals who can invoke agents by controlling access to the `InvokeAgentRuntime` API. Add IAM conditions to policies that specify the ARN of agents that are hosted by AgentCore, preventing unauthorized invocations. For OAuth 2.0, federate with your corporate identity provider for internal applications or select an identity provider that meets your requirements for external applications. Amazon Cognito integrates natively with AgentCore Runtime to facilitate OAuth authentication.

Assign IAM roles to agents running on AgentCore Runtime that provide minimum permissions required for agent functions. Follow the principle of least privilege by granting access only to specific tools, AWS resources, and secrets that the agent needs. Avoid broad permissions that enable privilege escalation through unintended tool combinations.

Centralize tool access through AgentCore Gateway, which manages both inbound authentication (verifying agent identity) and outbound authorization (connecting to tools). Configure the gateway with a separate identity store from the one used for user authentication. This identity store authenticates agents making calls to gateway targets using the OAuth Client Credentials flow.

Store client IDs and client secrets in AWS Secrets Manager rather than in code or environment variables and configure agents to retrieve credentials at runtime.

Implement outbound authorization using authentication based in IAM with AWS Signature Version 4 (SigV4) for AWS services, OAuth 2.0 for external APIs, or, if needed, API keys for third-party services. When using IAM-based authorization, scope the gateway service role to invoke only registered AWS Lambda functions and access only required secrets. When using API keys, store them securely in AgentCore Identity instead of in application code. Add granularity to tool access using OAuth scopes that limit which tools specific agents can invoke.

Configure tool authentication by assigning IAM policies to Lambda functions that interact with AWS resources. Scope policies to only the permissions that each tool needs, preventing tools from accessing resources beyond their intended function.

Network security

Deploy VPC endpoints for AgentCore Runtime and AgentCore tools to enable private connectivity without internet exposure. This architecture allows agents to access private resources, maintain secure communications within your network boundaries, and connect to enterprise data stores while preserving security isolation.

Configure AWS WAF to protect public-facing agent applications from common web exploits. Create custom AWS WAF rules that detect prompt injection patterns, rate limit requests to prevent abuse, and block malicious traffic before it reaches your agents.

Implement network-level monitoring through VPC Flow Logs to track traffic patterns between agents and tools. Configure flow logs to capture accepted and rejected traffic, providing visibility into network communications for security analysis and threat detection.

Application security

Evaluate tool architecture by assessing which capabilities agents require and whether those capabilities justify the associated risks. Limit agent access to mutative or destructive operations, implementing additional security controls for high-impact actions. Controls include instruction hardening that makes agent prompts resistant to manipulation, human-in-the-loop approval for sensitive operations, and least-privilege IAM roles that reduces access risks.

Deploy Amazon Bedrock Guardrails to protect agents from prompt attacks, prevent unwanted behavior, and limit hallucinations. Configure guardrails with content filters appropriate for your use case, define denied topics that agents should not discuss, and create custom word filters for

organization-specific sensitive terms. Deploy guardrail versions to production and configure agents to invoke the versioned guardrail as part of their response generation.

Implement pre-processing validation through Lambda functions that sanitize and validate input before passing it to agents. This additional layer of defense detects malicious prompts that attempt to bypass guardrails or manipulate agent behavior. Regularly test applications for prompt attacks using adversarial testing techniques.

Use AWS Security Agent to accelerate security reviews by analyzing architecture documents against AWS best practices and organizational requirements during the planning phase. It scales secure code analysis by automatically reviewing pull requests for common vulnerabilities and providing immediate remediation guidance within developer workflows. Additionally, the agent enables on-demand penetration testing to discover and report validated security vulnerabilities through tailored, multi-step attack scenarios.

Logging and monitoring

Enable AgentCore Observability to trace, debug, and monitor agent activity. Configure Transaction Search in CloudWatch and enable observability for agents hosted by AgentCoreRuntime. This approach provides visibility into agent behavior, including input and output prompts, reasoning traces, and tool invocations.

Monitor tool usage through AWS CloudTrail and CloudWatch to detect anomalous patterns. Create CloudWatch metrics that track tool invocation rates, execution duration, and error rates. Set alarms that trigger when metrics deviate from established baselines, indicating potential security issues or agent misbehavior.

Configure AgentCore Memory to emit logs to CloudWatch, providing visibility into data plane events such as `CreateEvent`, `DeleteEvent`, and `RetrieveMemoryRecords`. Use these logs to audit memory access patterns and detect unauthorized attempts to access or manipulate agent memory.

Implement centralized log aggregation by forwarding all agent-related logs to the Log Archive account. This approach enables security teams to correlate events across multiple agents and detect attack patterns that span multiple sessions or users.

Recommended AWS services

This section discusses the AWS services and features that address the security risks that are specific to this capability. In addition to the services in this section, use Amazon CloudWatch, AWS

CloudTrail, Amazon OpenSearch Serverless, Amazon S3, and Amazon Comprehend as explained in Capability 1 (model inference) and Capability 3 (RAG).

Amazon Bedrock AgentCore Runtime

AgentCore Runtime provides secure, serverless hosting for AI agents with complete session isolation using dedicated microVMs. Each user session runs with isolated CPU, memory, and file system resources, ensuring separation between users and preventing cross-session data contamination.

Configure customer managed AWS KMS keys for enhanced encryption control over session data. AgentCore Runtime automatically terminates sessions and sanitizes memory after completion, providing deterministic security even with non-deterministic AI processes. The service supports both real-time interactions and long-running workloads up to 8 hours while maintaining security isolation.

Amazon Bedrock AgentCore Memory

AgentCore Memory provides secure storage for agent conversation history and context across sessions. The service offers two memory types:

- *Short-term memory* for turn-by-turn interactions within a single session
- *Long-term memory* for persistent knowledge retention across multiple sessions

Configure short-term memory retention periods to the minimum required for your use case. Implement automated deletion workflows for long-term memory to comply with data retention policies. Use the namespace structure (session ID, actor ID, and strategy ID) to enforce logical data isolation between users. Encrypt memory resources with customer managed KMS keys and restrict IAM access to memory APIs (such as `ListMemoryRecords`, `GetMemoryRecord`, `CreateMemoryRecord`, and `DeleteMemoryRecord`) to authorized services only.

Amazon Bedrock AgentCore Gateway

AgentCore Gateway centralizes tool access and management, providing a single point of control for agent-tool interactions. The gateway manages both inbound authentication (verifying agent identity) and outbound authorization (connecting to tools), simplifying security architecture.

Configure the gateway with a separate identity store for agent authentication using OAuth Client Credentials flow. Implement outbound authorization using IAM-based authentication for AWS

services, OAuth 2.0 for external APIs, or API keys for third-party services. Create VPC endpoints for private connectivity and apply endpoint policies to restrict access to authorized agents. Encrypt gateway configuration with customer managed KMS keys.

Amazon Bedrock AgentCore Identity

AgentCore Identity serves as a secure credential broker for agents, supporting AWS Signature Version 4 (SigV4) signing, OAuth 2.0 with JWT bearer tokens, and API key authentication. The service maintains a protected token vault using AWS Key Management Service (AWS KMS) encryption for credential storage.

Configure integration with enterprise identity providers including Amazon Cognito, Okta, and Microsoft Entra ID. Implement credential rotation policies through integration with AWS Secrets Manager. AgentCore Identity ensures complete separation between ingress authentication (verifying user identity) and egress authorization (accessing tools), preventing credential exposure.

Amazon Bedrock AgentCore Observability

AgentCore Observability provides comprehensive monitoring, tracing, and debugging capabilities for agent behavior. Enable Transaction Search in CloudWatch to track agent execution paths, tool invocations, and reasoning traces.

Configure observability to capture input and output prompts, tool call parameters, and error conditions. Use trace data to identify security issues, performance bottlenecks, and unusual access patterns. Integrate with CloudWatch alarms to trigger automated responses when agents exhibit anomalous behavior.

Amazon Bedrock Guardrails

Amazon Bedrock Guardrails provides configurable safeguards that detect and filter harmful content, prevent prompt attacks, and reduce hallucinations. Configure content filters across multiple categories (hate, insults, sexual, violence, misconduct, and prompt attacks) with filter strength appropriate for your risk tolerance.

Define denied topics to prevent agents from discussing sensitive subjects or internal systems. Create custom word filters for organization-specific sensitive terminology. Implement contextual grounding checks to detect hallucinations and verify response accuracy against source documents. Deploy guardrail versions to production and configure agents to invoke versioned guardrails for consistent protection.

AWS Security Agent

AWS Security Agent is an autonomous agent that provides continuous application security validation across the software development lifecycle (SDLC). It functions as a virtual security engineer by conducting automated architectural reviews against organizational standards and performing on-demand penetration testing to identify exploitable vulnerabilities.

Configure the agent to analyze code bases and design documents for early vulnerability detection. It leverages context-aware reasoning to execute multi-step attack chains, discovering complex risks that traditional scanners miss. The agent integrates developer workflows to provide actionable remediation guidance and automated pull requests. The agent helps scale security validation with development velocity without using customer data for underlying model training.

Amazon GuardDuty

GuardDuty provides threat detection for agentic applications by monitoring AWS CloudTrail management events for suspicious and malicious activity. The service detects unauthorized access attempts, unusual API call patterns, and potential compromises of agent infrastructure.

Enable GuardDuty in the Security Tooling account as the delegated administrator for centralized management across the organization. Configure automated responses to GuardDuty findings using Amazon EventBridge rules that trigger remediation workflows when threats are detected.

Amazon Inspector

Amazon Inspector scans agent code for known software vulnerabilities, identifying security issues in Lambda functions, container images, and Amazon EC2 instances hosting agent components. The service provides continuous vulnerability assessment and prioritized findings based on risk.

Enable Amazon Inspector in the Security Tooling account as the delegated administrator for centralized vulnerability management. Configure automated scanning for all agent-related resources and integrate findings with your security information and event management (SIEM) system for comprehensive security monitoring.

AWS KMS

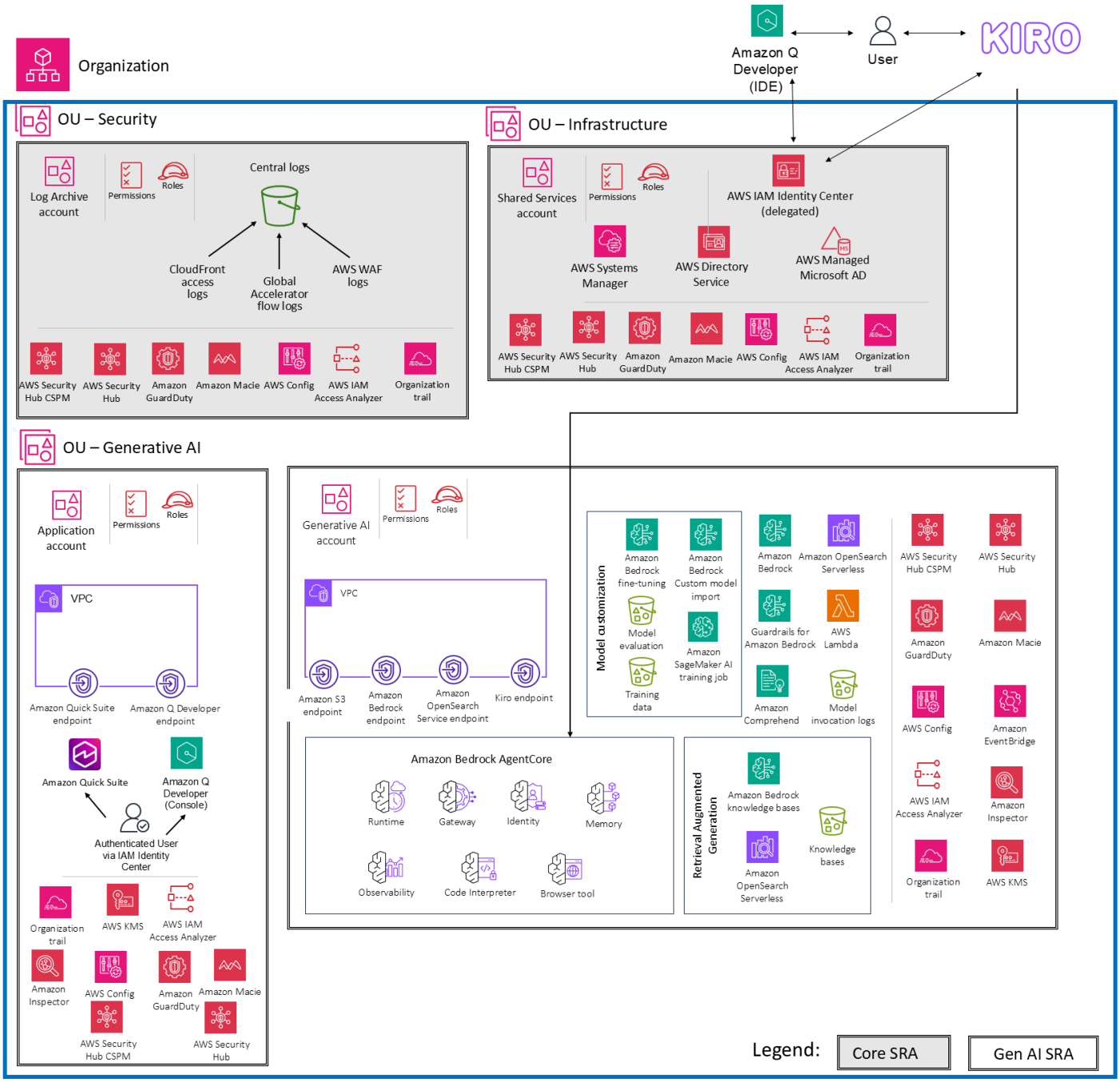
AWS Key Management Service (AWS KMS) helps you create and control cryptographic keys to help protect your data. Use customer managed AWS KMS keys to encrypt AgentCore Memory resources, AgentCore Identity token vaults, AgentCore Gateway configuration, and CloudWatch log groups

that contain agent logs. Customer managed KMS keys provide enhanced control over encryption key management, enable detailed audit trails of key usage, and support key rotation policies.

Configure key policies that grant encryption and decryption permissions only to authorized services and IAM roles. Enable CloudTrail logging for all KMS key usage to maintain comprehensive audit trails of data access.

Capability 6. Providing secure access, usage, and implementation for AI applications

The scope of this capability is to secure user-facing AI applications that provide direct access to AI capabilities. The following diagram illustrates the AWS services recommended for the Generative AI account for this capability.



Rationale

User-facing AI applications enable organizations to deliver generative AI capabilities directly to end users through web interfaces, mobile applications, and integrated workflows. These applications include Amazon Q Developer for AI-assisted software development, Amazon Quick for enterprise productivity and business intelligence, and Kiro for agentic development environments. Each

application provides distinct capabilities while requiring consistent security controls to protect user data, prevent misuse, and maintain organizational governance.

This use case refers to Scope 3 of the Generative AI Security Scoping Matrix, where your organization deploys user-facing AI applications using pre-trained foundation models. In this scope, you control the application interface, user authentication, data access permissions, and usage policies, whereas the AI service provider controls the underlying models and infrastructure.

> **Note**
>
> Although this guidance focuses on AI applications managed by AWS, similar principles apply to custom-built AI applications and third-party AI services integrated into your environment.

Security considerations

When you provide users with direct access to AI applications, you should address these key security considerations:

- User authentication and authorization across multiple AI application types with varying sensitivity levels
- Data protection for user inputs, conversation history, and AI-generated outputs that might contain sensitive organizational information
- Content filtering and guardrails to prevent inappropriate use, prompt injection attacks, and generation of harmful content
- Usage monitoring and governance to track AI application adoption, detect anomalous behavior, and maintain compliance with organizational policies and controls

Remediations

This section reviews the AWS services and features that address the risks that are specific to this capability.

Data protection

Encrypt user inputs, conversation history, and AI-generated outputs in transit and at rest using AWS Key Management Service (AWS KMS) customer managed keys and TLS 1.2. Amazon Q

Developer, Quick, and Kiro provide comprehensive encryption by default, with options for customer managed keys to maintain enhanced control over encryption.

Implement session isolation to prevent data leakage between user sessions and maintain separation of user contexts across different AI applications. Configure data retention and memory policies that align with organizational requirements and regulatory obligations for AI-generated content and user interaction history. For more information about user-level context separation and conversation history isolation, see Enabling identity-enhanced console sessions in the AWS IAM Identity Center documentation.

Store application credentials and API keys in AWS Secrets Manager with customer managed key encryption. Configure automatic credential rotation where supported and implement fine-grained access controls to limit which users and applications can retrieve specific credentials.

Apply content filtering and validation for user inputs and AI-generated outputs across all application types.

Identity and access management

Use AWS IAM Identity Center for centralized identity management across all AI applications. Integrate with enterprise identity providers including Amazon Cognito, Okta, and Microsoft Entra ID to provide consistent authentication and single sign-on capabilities. For information about Amazon Q Developer integration, see Getting started with IAM Identity Center in the Amazon Q Developer documentation. For information about integrating Quick with IAM Identity Center, see Granting Quick access through IAM Identity Center integration in the *Choosing the right access approach for Amazon Quick* AWS Prescriptive Guidance guide. For information about Kiro, see its onboarding quickstart documentation. For more information, see Configure access to your applications in the IAM Identity Center documentation.

Create custom IAM policies that implement least-privilege access for AI application usage. Define granular permissions that control which users can access specific AI features, applications, and data sources based on their organizational roles and responsibilities. Implement permission data boundaries and service control policies to prevent privilege escalation through AI application features.

Configure access controls that limit AI applications to accessing only the data sources and AWS services necessary for their intended functionality. For more information, see How Amazon Q Developer works with IAM in the Amazon Q Developer documentation. For information about Quick, see Using IAM in the Quick documentation. For information relevant to Kiro, see How Kiro

works with IAM in the Kiro documentation. For more information about implementing least-privilege access with IAM for both human and workload users, see Security best practices in IAM in the IAM documentation.

Apply rate limiting and usage quotas at the user and application level to prevent resource exhaustion and control costs. Monitor usage patterns to detect anomalous behavior that might indicate compromised credentials or policy violations. For information about monitoring of API quota usage against service limits for Quick, see Monitoring and maintenance in the Quick documentation.

Network security

Deploy AI applications within private subnets using AWS PrivateLink for private connectivity to AWS services. Create VPC endpoints for Amazon Bedrock, Amazon Q Developer, and other AI services to help ensure that all traffic remains within the AWS network. For more information about VPC endpoints, see the following resources:

- Amazon Q Developer and interface endpoints (AWS PrivateLink) in the Amazon Q Developer documentation
- Quick and interface VPC endpoints (AWS PrivateLink) in the Quick documentation
- Kiro and interface endpoints (AWS PrivateLink) in the Kiro documentation
- Access an AWS service using an interface VPC endpoint in the Amazon Virtual Private Cloud documentation

Configure security groups and network access control lists that restrict traffic to only necessary communication paths. Implement network segmentation to isolate AI application infrastructure from other organizational workloads, based on data sensitivity and compliance requirements.

Use AWS WAF to protect web-based AI application interfaces from common attacks including SQL injection, cross-site scripting, and bot traffic. Configure custom rules to detect and block potential prompt injection patterns and implement rate limiting at the network edge. For information about an example pattern that integrates AWS WAF with a web-based AI application, see Securing Amazon Q Business Web Experiences with AWS Amplify and AWS WAF (AWS Blog post).

Enforce TLS 1.2 or higher for all user connections to AI applications. Use AWS Certificate Manager for certificate issuance and automatic rotation to maintain secure encrypted communications between users and AI services.

Logging and monitoring

Enable AWS CloudTrail to log all AI application access and usage activities with user context attribution. Configure organization trails to capture cross-account access and maintain comprehensive audit trails for compliance and security investigations.

Configure Amazon CloudWatch to monitor AI application usage patterns, error rates, and performance metrics. Create custom metrics for tracking user adoption, feature usage, and potential security events across different AI applications.

Implement application-specific observability features including Amazon Q Developer usage analytics, Quick audit logging, and the telemetry collection available in Kiro. Use these specialized monitoring capabilities to gain visibility into AI-specific behaviors and usage patterns.

Configure Amazon EventBridge rules to automate responses to security events including unauthorized access attempts, policy violations, and anomalous usage patterns. Forward all logs to the Security Tooling account for centralized analysis and long-term retention. For more information, see AWS service events.

Recommended AWS services

This section reviews the AWS services and features that address the security risks that are specific to this capability:

Amazon Q Developer

Amazon Q Developer is an AI-powered productivity tool for software development teams that integrates directly into integrated development environments (IDEs) and command line interfaces (CLIs). It provides context-aware code suggestions, automated code reviews, security scanning, and documentation generation while maintaining enterprise security controls.

Configure Amazon Q Developer with IAM Identity Center for centralized authentication and access control. Enable customer managed AWS KMS keys for conversation history encryption and code analysis data. Implement resource-based policies to control which code repositories Amazon Q Developer can access. Configure code scanning sensitivity levels and customize security scanning policies to align with organizational security requirements.

Amazon Quick

Quick combines conversational business intelligence with generative AI capabilities to transform enterprise data into actionable insights. The suite includes Amazon Quick Sight for data analysis

and visualization, enabling users to interact with business data using plain language questions while maintaining comprehensive security controls.

Implement row-level security (RLS) in Quick Sight to ensure users can only access authorized data based on their role and permissions. Configure column-level security to mask sensitive fields from unauthorized users. Use private virtual private cloud (VPC) connectivity to establish secure connections to data sources. Enable embedded analytics with identity federation to maintain consistent access controls when integrating Quick capabilities into custom applications.

Kiro

Kiro provides an agentic development environment that accelerates software delivery through AI-assisted workflows and automated implementation planning. Kiro transforms high-level specifications into detailed implementation plans with automated code generation while maintaining security through comprehensive isolation and encryption.

Configure Kiro with customer managed AWS KMS keys for session data encryption and persistent storage. Implement fine-grained access controls to limit which users can initiate agentic workflows and access generated code. Enable VPC connectivity to establish private network paths between Kiro and internal code repositories. Configure audit logging to track all code generation activities and link them to originating user requests for comprehensive traceability.

AWS IAM Identity Center

IAM Identity Center provides centralized identity management for all AI applications with consistent authentication and authorization. It enables single sign-on across multiple AWS accounts and business applications including Amazon Q Developer, Quick, and Kiro.

Configure IAM Identity Center with your enterprise identity provider to maintain consistent user access controls. Create permission sets that define specific access levels for different user roles. Implement attribute-based access control (ABAC) to dynamically adjust permissions based on user attributes. Enable multi-factor authentication (MFA) for all AI application access to enhance security posture and protect against credential theft.

AWS Secrets Manager

Secrets Manager securely stores and manages API keys, database credentials, and service tokens that are required by AI applications. It automatically rotates credentials according to configured schedules and provides a centralized service for secure credential distribution.

Store all AI application credentials in Secrets Manager with encryption by using customer managed KMS keys. Configure automatic rotation for database credentials, API keys, and OAuth tokens where supported. Implement fine-grained access policies to control which AI services can retrieve specific secrets. Enable CloudTrail logging for all secret access operations to maintain a comprehensive audit trail.

AWS WAF

AWS WAF protects AI application interfaces from common web vulnerabilities and specialized attacks against generative AI systems. It provides customizable security rules to filter malicious traffic and protect against distributed denial-of-service (DDoS) attacks.

Configure AWS WAF with managed rule groups to protect against common vulnerabilities including SQL injection and cross-site scripting. Create custom rules to detect and block prompt injection patterns targeting AI applications. Implement rate-based rules to prevent abuse and resource exhaustion from automated or excessive queries. Enable logging to Amazon Simple Storage Service (Amazon S3) for comprehensive traffic analysis and security investigation.

Amazon CloudWatch

CloudWatch provides comprehensive monitoring and observability for all AI applications through metrics collection, log aggregation, and automated alerting. It enables detection of anomalous usage patterns and security events across your AI application portfolio.

Create custom dashboards to monitor key AI application metrics including usage rates, error frequencies, and performance indicators. Configure metric filters to extract actionable data from application logs. Implement CloudWatch alarms to detect potential security incidents including unusual access patterns or policy violations. Set up composite alarms that correlate multiple metrics to identify complex security scenarios with higher confidence. For more information, see the following resources:

- Monitoring Amazon Q Developer with Amazon CloudWatch in the Amazon Q Developer documentation
- Monitoring Amazon Quick usage using CloudWatch Logs in the Quick documentation
- Monitoring and tracking on the Kiro website

AWS CloudTrail

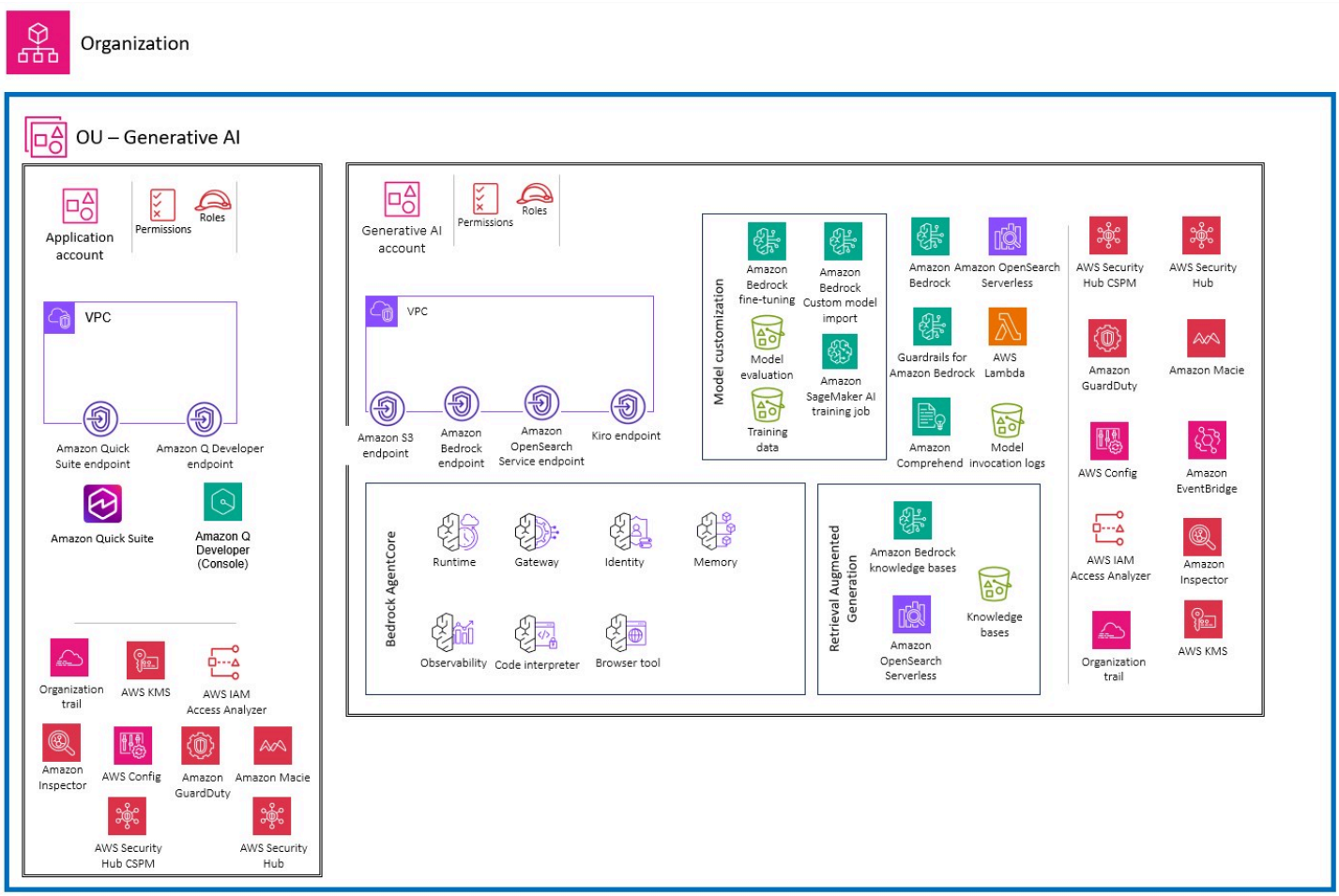
CloudTrail provides comprehensive audit logging for all API calls and user activities across your AI application environment. It captures detailed information about each action including the identity, IP address, timestamp, and parameters used.

Enable organization trails to capture activities across all AWS accounts and forward them to centralized storage in the Log Archive account. Configure log file validation to ensure integrity of audit trails. Implement event selection to capture both management and data events related to AI application usage. Use CloudTrail Lake to create SQL-based queries for security investigations and compliance reporting on AI application activities. For more information, see the AWS CloudTrail section of Security OU - Security Tooling account in the *AWS SRA – core architecture* guide.

Integrating a traditional cloud workload with Amazon Bedrock

Influence the future of the AWS Security Reference Architecture (AWS SRA) by taking a short survey.

The scope of this use case is to demonstrate a traditional cloud workload that is integrated with Amazon Bedrock to take advantage of generative AI capabilities. The following diagram illustrates the Generative AI account in conjunction with an example application account.



The *Generative AI account* provides generative AI functionality by using Amazon Bedrock. The *Application account* hosts an example workload. The AWS services that you use in this account depend on your requirements. Interactions between the Generative AI account and the Application account use the Amazon Bedrock APIs.

The *Application account* is separated from the Generative AI account to help group workloads based on business purposes and ownership. This separation constrains access to sensitive data in the generative AI environment and supports the application of distinct security controls by environment. Keeping the traditional cloud workload in a separate account also helps limit the scope of impact of adverse events.

You can build and scale enterprise generative AI applications around various use cases that are supported by Amazon Bedrock. Common use cases include text generation, virtual assistance, text and image search, text summarization, and image generation. Depending on your use case, your application component interacts with one or more Amazon Bedrock capabilities such as foundation model (FM) inference, knowledge bases, agents, and model customization.

Application account

The Application account hosts the primary infrastructure and services to run and maintain an enterprise application. In this context, the Application account acts as the traditional cloud workload, which interacts with the Amazon Bedrock managed service in the Generative AI account. For general security best practices for securing this account, see Workloads OU - Application account in the *AWS SRA – core architecture guide*.

Identity propagation and access control

Implement identity propagation throughout your generative AI application architecture. When your application uses Retrieval Augmented Generation (RAG), propagate the user's identity from the application in the form of metadata to the knowledge base. The knowledge base enforces controls through metadata filtering, ensuring users only access data they are authorized to view.

For agentic applications, make sure every agent propagates the application user's identity to all systems it interacts with, including data sources, knowledge bases, and external APIs. Each system must understand the user identity, limit its responses to actions the user is authorized to perform, and respond with data the user is authorized to access. Use Amazon Bedrock AgentCore Identity to manage authentication and authorization across the agent workflow, maintaining separation between ingress authentication (verifying user identity) and egress authorization (accessing tools and resources).

Application security

Apply standard application security best practices as you would for other applications. Protect your web application infrastructure using AWS WAF to defend against common web exploits including

SQL injection, cross-site scripting, and request floods. Configure rate limiting to prevent resource exhaustion and control costs, as application invocations trigger model inference API calls that incur charges.

Restrict direct access to foundation model inference endpoints to control costs and monitor activity. Use AWS Identity and Access Management (IAM) policies to control permissions to invoke inference actions on Amazon Bedrock base models. Implement least-privilege access by granting only the minimum permissions required for your application to function.

Prompt injection protection

Traditional web application firewalls don't protect against prompt injection threats because these threats use natural language text rather than code patterns that firewalls detect. Implement Amazon Bedrock Guardrails to protect against prompt injection attacks and ensure model safety. Configure guardrails with prompt attack detection enabled, set appropriate filter strength based on your risk tolerance, and deploy versioned guardrails to production.

Add pre-processing validation through AWS Lambda functions that sanitize and validate input before passing it to foundation models or agents. This additional layer of defense detects malicious prompts that attempt to bypass guardrails or manipulate model behavior. Regularly test your applications for prompt attacks using adversarial testing techniques.

Data protection

Encrypt data in transit between the Application account and Generative AI account by using TLS 1.2 or higher. Encrypt data at rest using AWS Key Management Service (AWS KMS) customer managed keys for application data stores, conversation logs, and any cached model responses.

Implement data classification schemes to categorize data based on sensitivity and criticality. Use Amazon Macie to detect and classify sensitive data in Amazon S3 buckets that contain user prompts, conversation logs, and application data. Deploy Amazon Comprehend personally identifiable information (PII) detection or Amazon Bedrock Guardrails to detect and redact sensitive information in both model inputs and outputs before processing or storage.

Network security

Deploy your application within a virtual private cloud (VPC) by using private subnets for application tiers that don't require direct internet access. Use VPC endpoints to establish private

connectivity to Amazon Bedrock services, to help make sure traffic between your application and Amazon Bedrock doesn't traverse the public internet.

Configure security groups with restrictive rules that allow only necessary traffic between application tiers. Implement network access control lists (network ACLs) as an additional defensive layer with explicit allow rules for required traffic and a default-deny posture. Deploy AWS Network Firewall for deep packet inspection of traffic between application tiers and to detect unusual request patterns that might indicate attacks.

Logging and monitoring

Enable comprehensive logging and monitoring for your generative AI application. Configure AWS CloudTrail to log all API calls to Amazon Bedrock, capturing user identity, request parameters, and response metadata. Forward CloudTrail logs to the Log Archive account for centralized security analysis.

Configure CloudWatch to monitor application metrics including model invocation rates, response latencies, error rates, and token usage patterns. Create CloudWatch alarms that trigger when metrics deviate from established baselines, indicating potential security issues, service degradation, or unexpected usage patterns.

Monitor Amazon Bedrock Guardrails metrics to track how frequently content is filtered or blocked, providing visibility into potential security threats or policy violations. Analyze trends in guardrail activations to identify emerging attack patterns or areas where additional security controls might be needed.

Implement centralized log aggregation using Amazon OpenSearch Service or integrate with third-party security information and event management (SIEM) platforms. Configure automated pattern analysis and threat detection to identify anomalous behavior including unusual traffic volumes, connections to unexpected destinations, or communication patterns that deviate from established baselines.

Generative AI account

Depending on the use case, the Generative AI account hosts all generative AI activities. These include model inference (Capability 1), model customization (Capability 2), Retrieval Augmented Generation (RAG) with knowledge bases (Capability 3), tool integration (Capability 4), autonomous agents (Capability 5), and end-user AI applications (Capability 6). For more information about these capabilities, see Generative AI capabilities.

Foundation model inference

Implement the security controls described in Capability 1 for foundation model (FM) inference. Deploy AWS WAF as the first line of defense against malicious requests targeting your AI applications. Configure rate limiting to prevent resource exhaustion attacks and implement AWS Managed Rules for the Core rule set managed rule group and the Known bad inputs managed rule group.

Use Amazon Bedrock Guardrails to filter inputs and outputs across multiple harmful categories: hate, insults, sexual, violence, misconduct, and prompt attacks. Configure filter strength for each category based on your risk tolerance. Define restricted topics to prevent models from discussing sensitive subjects or internal systems.

Model customization

If your use case requires model customization, implement the security controls described in Capability 2. Encrypt the model customization job, output files, and resulting custom model by using customer managed keys in AWS Key Management Service (AWS KMS). Store training and validation data in Amazon S3 buckets with encryption, versioning, and access logging enabled.

Use a virtual private cloud (VPC) with no internet access for model customization jobs. Create Amazon S3 VPC endpoints to allow customization jobs to access training data buckets without internet exposure. This approach helps to ensure that training data and model artifacts remain private throughout the customization process.

Knowledge bases and RAG

For applications using RAG, implement the security controls described in Capability 3. Encrypt knowledge base data in transit and at rest using customer managed AWS KMS keys. Configure data ingestion jobs with customer managed keys and implement metadata filtering for secure retrieval based on user attributes.

Use Amazon Macie to detect and classify sensitive data in Amazon S3 buckets that contain knowledge base data sources. Implement input validation to protect knowledge bases from malicious content by scanning files for malware before uploading them to data sources. Use Amazon Comprehend to detect and redact sensitive information in documents before indexing them in your knowledge base.

Tool integration

For applications that extend AI capabilities through tool integration, implement the security controls described in Capability 4. Use Amazon Bedrock AgentCore Gateway to centralize tool discovery and invocation through the Model Context Protocol (MCP). Configure OAuth authorizers for gateway access and use Amazon Bedrock AgentCore Identity to manage authentication credentials securely.

Deploy AI applications and AWS Lambda function tools within private subnets by using restrictive security groups. Create VPC endpoints for AgentCore Gateway and Amazon Bedrock AgentCore Runtime to help make sure that tool integration occurs through private network paths. Apply rate limiting and resource quotas at the identity level to prevent resource exhaustion from excessive tool calls.

Autonomous agents

For agentic applications, implement the security controls described in Capability 5. Use Amazon Bedrock AgentCore Runtime to host agents with complete session isolation by using dedicated microVMs. Configure customer managed KMS keys for Amazon Bedrock AgentCore Memory resources, AgentCore Identity token vaults, and AgentCore Gateway configuration.

Implement authentication architecture that addresses user authentication to invoke the agent, agent authentication to access tools and resources, and tool authentication to access downstream systems. Assign IAM roles to agents that provide minimum permissions required for agent functions. Enable Amazon Bedrock AgentCore Observability to trace, debug, and monitor agent activity.

End-user AI applications

For end-user AI applications described in Capability 6, implement appropriate authentication and authorization controls based on your user population. For internal applications, federate with your corporate identity provider. For external applications, use Amazon Cognito or another identity provider that meets your requirements.

Implement user session management that maintains security boundaries between users. Use Amazon Bedrock Guardrails to filter content based on user context and persona. Monitor user interactions for anomalous patterns that might indicate account compromise or malicious activity.

Conclusion

Influence the future of the AWS Security Reference Architecture (AWS SRA) by taking a short survey.

The architectures presented in this guide offer a comprehensive framework for organizations that use AWS services to take advantage of generative AI capabilities securely and efficiently. These architectures combine the fully managed functionality of Amazon Bedrock with security best practices to provide a solid foundation for integrating generative AI into traditional cloud workloads and organizational processes.

The specific capabilities covered—foundation model inference, model customization, retrieval augmented generation, tool integration, autonomous agents, and end-user applications—address a wide range of potential applications and scenarios. This guidance equips organizations with the necessary understanding of Amazon Bedrock services and their inherent and configurable security controls. With this knowledge, organizations can make informed decisions tailored to their unique infrastructure, applications, and security requirements.

By implementing the security controls described across all six capabilities, organizations can build generative AI applications that maintain strong security postures while delivering innovative functionality. The separation of concerns between Application and Generative AI accounts, combined with defense-in-depth security controls at every layer, provides the foundation for secure, scalable generative AI deployments.

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Document history

The following table describes significant changes to this guide.

Change	Description	Date
Reorganization and new content	Reorganized guide and added new content throughout.	February 24, 2026
Initial publication as standalone guide	Converted from a chapter in the AWS SRA – core architecture guide to an individual guide.	December 22, 2025

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.

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.