AWS Monitoring, Audit and Performance

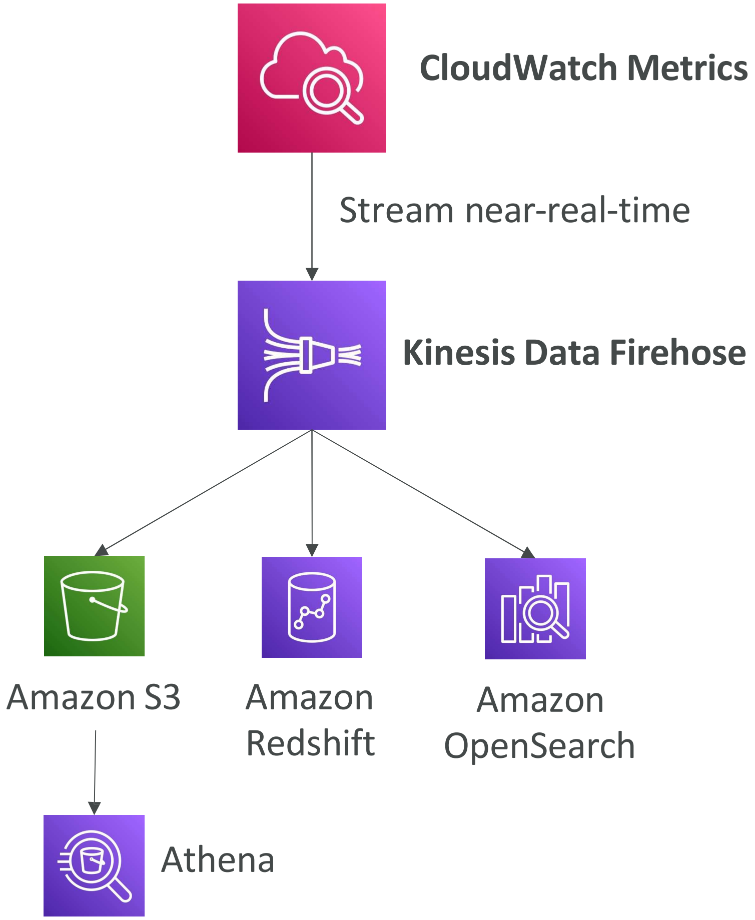
CloudWatch, CloudTrail & AWS Config

Amazon CloudWatch Metrics

- CloudWatch provides metrics for *every* services in AWS
- Metric is a variable to monitor (CPUUtilization, NetworkIn…)
- Metrics belong to namespaces
- Dimension is an attribute of a metric (instance id, environment, etc…).
- Up to 30 dimensions per metric
- Metrics have timestamps
- Can create CloudWatch dashboards of metrics
- Can create CloudWatch Custom Metrics (for the RAM for example)

CloudWatch Metric Streams

- Continually stream CloudWatch metrics to a destination of your choice, with near-real-time delivery and low latency.
  - Amazon Kinesis Data Firehose (and then its destinations)
  - 3rd party service provider: Datadog, Dynatrace, New Relic, Splunk, Sumo Logic…
- Option to filter metrics to only stream a subset of them



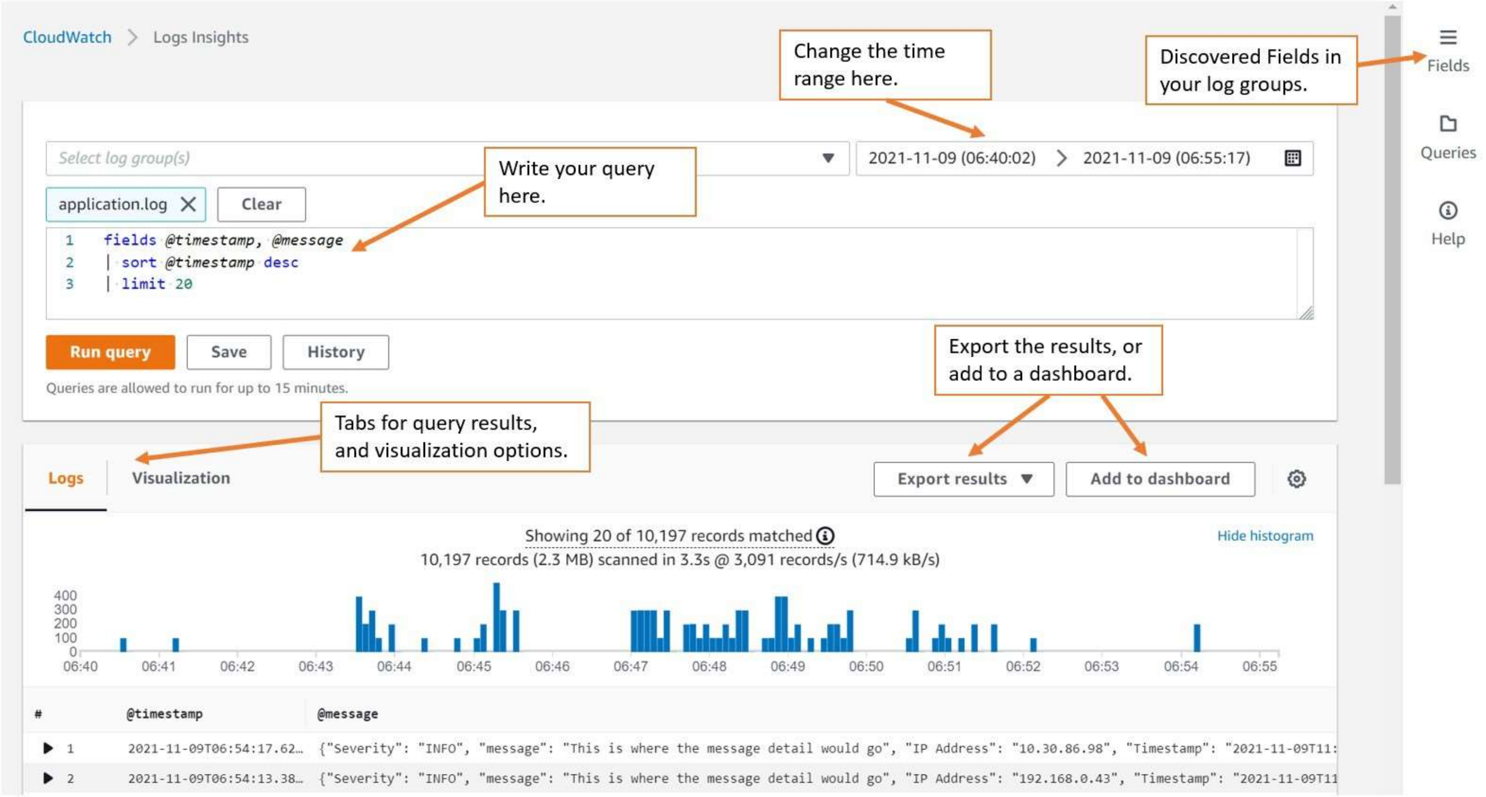
CloudWatch Logs

- Log groups: arbitrary name, usually representing an application
- Log stream: instances within application / log files / containers
- Can define log expiration policies (never expire, 1 day to 10 years...)
- CloudWatch Logs can send logs to:
  - Amazon S3 (exports)
  - Kinesis Data Streams
  - Kinesis Data Firehose
  - AWS Lambda
  - OpenSearch
- Logs are encrypted by default
- Can setup KMS-based encryption with your own keys

CloudWatch Logs - Sources

- SDK, CloudWatch Logs Agent, CloudWatch Unified Agent
- Elastic Beanstalk: collection of logs from application
- ECS: collection from containers
- AWS Lambda: collection from function logs
- VPC Flow Logs: VPC specific logs
- API Gateway
- CloudTrail based on filter
- Route53: Log DNS queries

CloudWatch Logs Insights



Change the time range here.

Discovered Fields in your log groups.

2021-11-09 (06:40:02) > 2021-11-09 (06:55:17)

Write your query here.

```
fields @timestamp, @message
| sort @timestamp desc
| limit 20
```

Queries are allowed to run for up to 15 minutes.

Export the results, or add to a dashboard.

Tabs for query results, and visualization options.

Showing 20 of 10,197 records matched

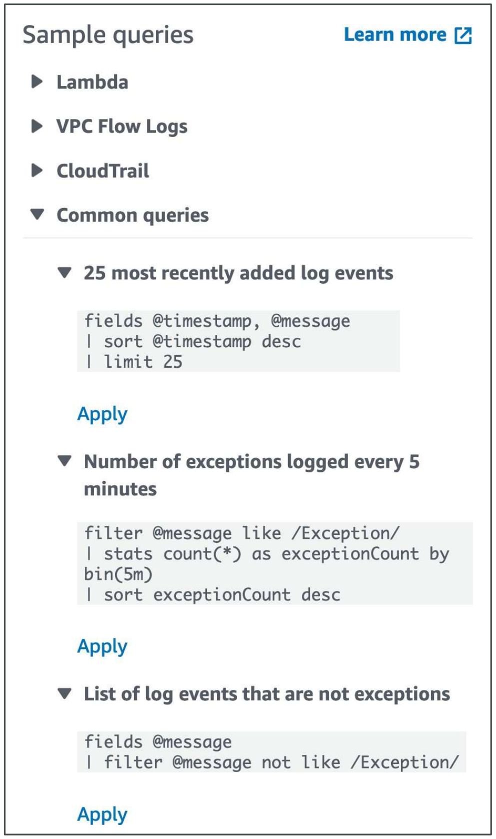
10,197 records (2.3 MB) scanned in 3.3s @ 3,091 records/s (714.9 kB/s)

#	@timestamp	@message
▶ 1	2021-11-09T06:54:17.62…	{"Severity": "INFO", "message": "This is where the message detail would go", "IP Address": "10.30.86.98", "Timestamp": "2021-11-09T11:
▶ 2	2021-11-09T06:54:13.38…	{"Severity": "INFO", "message": "This is where the message detail would go", "IP Address": "192.168.0.43", "Timestamp": "2021-11-09T11

https://mng.workshop.aws/operations-2022/detect/cwlogs.html

CloudWatch Logs Insights

- Search and analyze log data stored in CloudWatch Logs
- Example: find a specific IP inside a log, count occurrences of "ERROR" in your logs…
- Provides a purpose-built query language
  - Automatically discovers fields from AWS services and JSON log events
  - Fetch desired event fields, filter based on conditions, calculate aggregate statistics, sort events, limit number of events…
  - Can save queries and add them to CloudWatch Dashboards
- Can query multiple Log Groups in different AWS accounts
- It's a query engine, not a real-time engine



25 most recently added log events

```
fields @timestamp, @message
| sort @timestamp desc
| limit 25
```

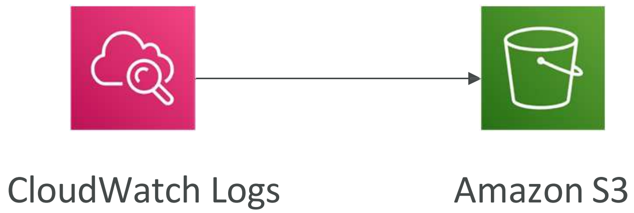
Number of exceptions logged every 5 minutes

```
filter @message like /Exception/
| stats count(*) as exceptionCount by
bin(5m)
| sort exceptionCount desc
```

List of log events that are not exceptions

```
fields @message
| filter @message not like /Exception/
```

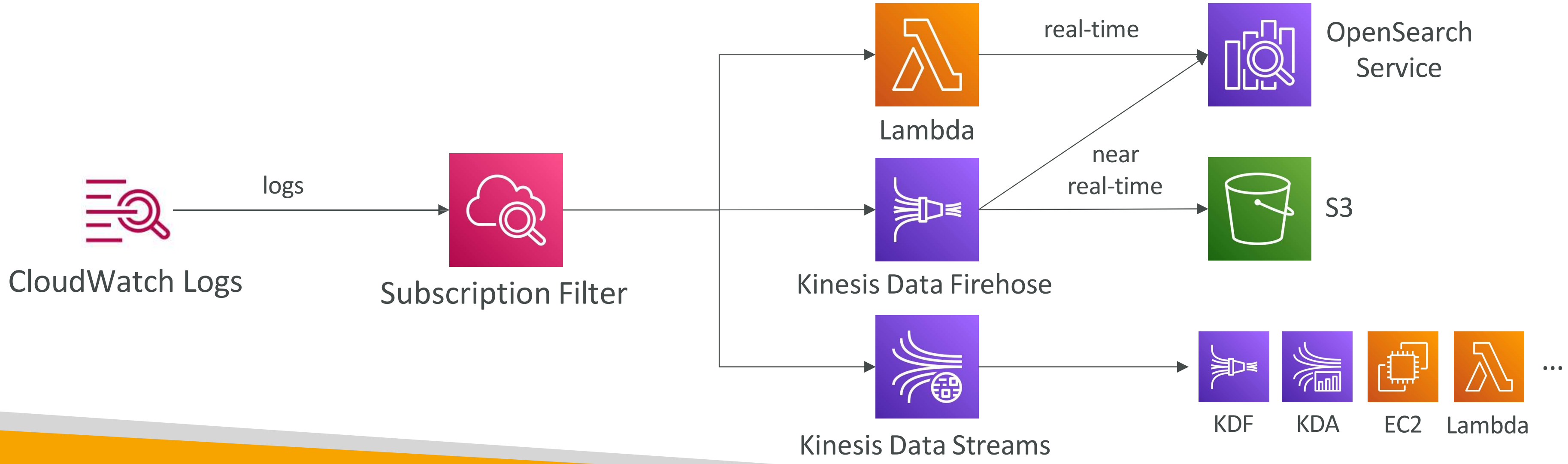
CloudWatch Logs - S3 Export



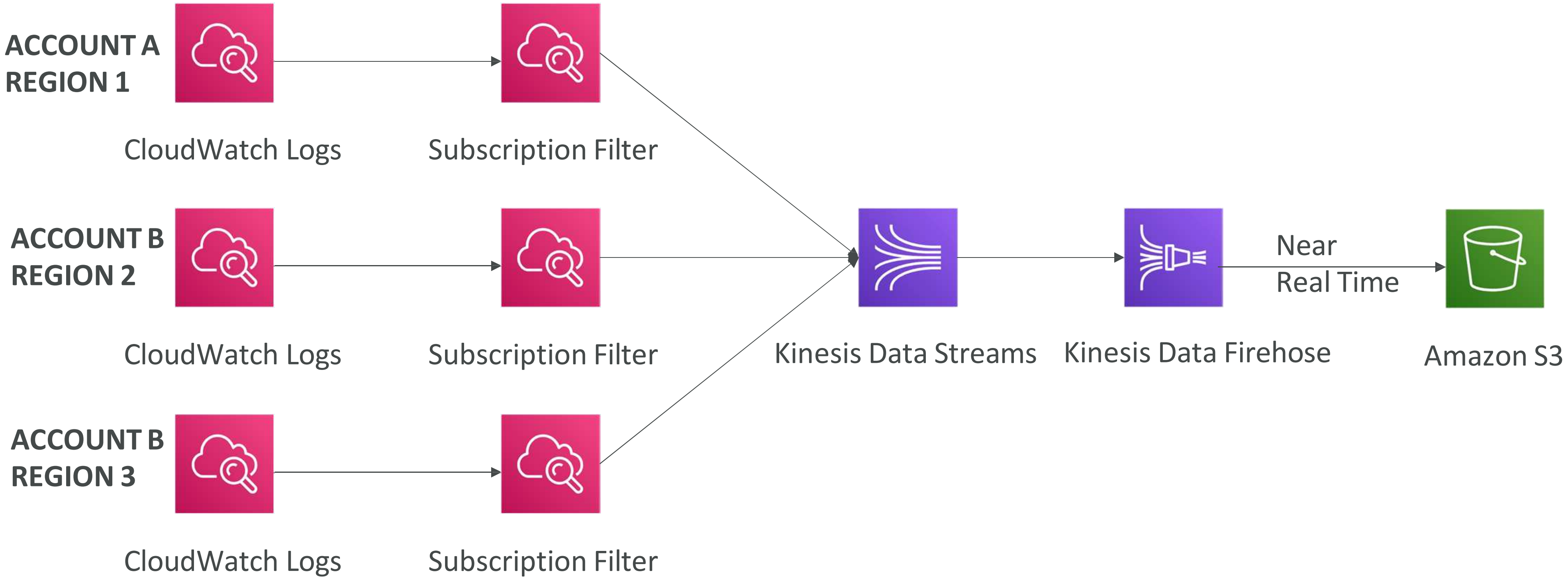
- Log data can take up to 12 hours to become available for export
- The API call is CreateExportTask
- Not near-real time or real-time… use Logs Subscriptions instead

CloudWatch Logs Subscriptions

- Get a real-time log events from CloudWatch Logs for processing and analysis
- Send to Kinesis Data Streams, Kinesis Data Firehose, or Lambda
- Subscription Filter - filter which logs are events delivered to your destination

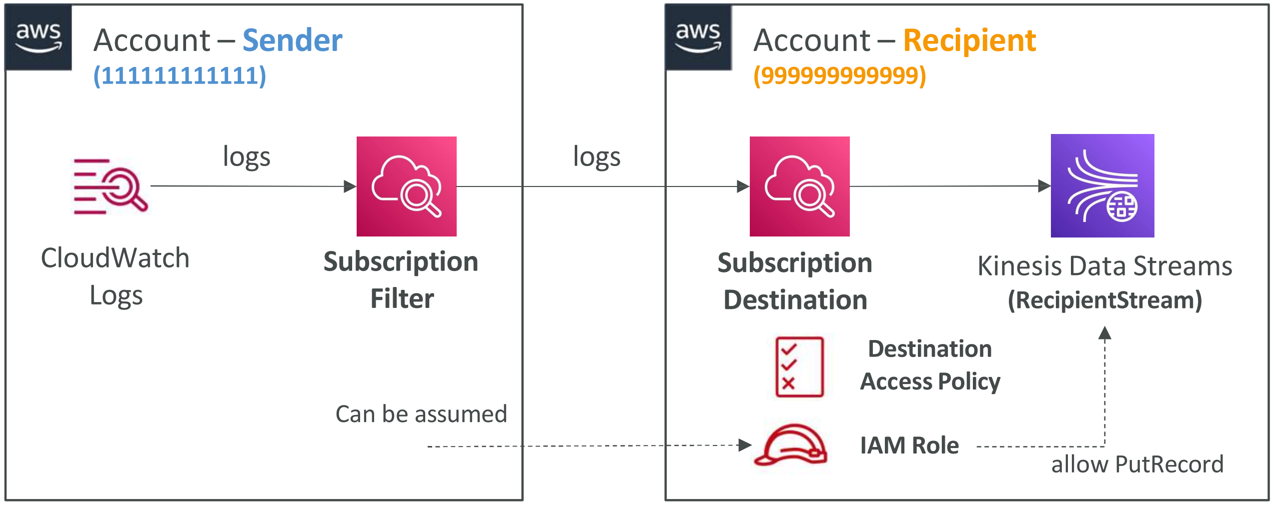


CloudWatch Logs Aggregation Multi-Account & Multi Region

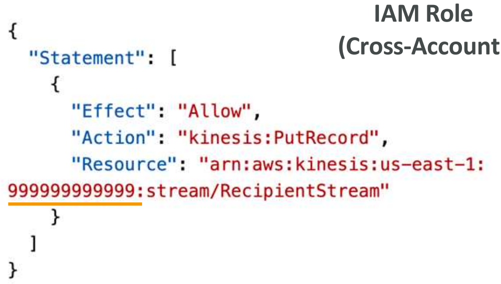


CloudWatch Logs Subscriptions

- Cross-Account Subscription - send log events to resources in a different AWS account (KDS, KDF)

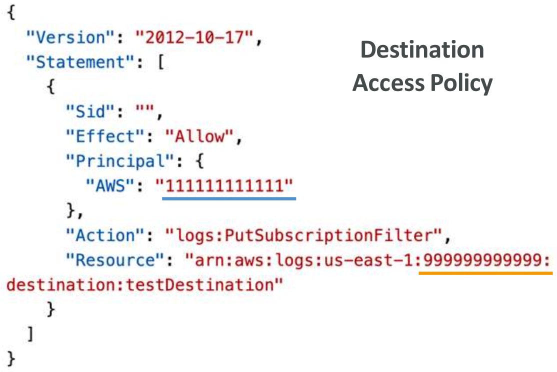


IAM Role (Cross-Account)



```
{
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "kinesis:PutRecord",
      "Resource": "arn:aws:kinesis:us-east-1:
999999999999:stream/RecipientStream"
    }
  ]
}
```

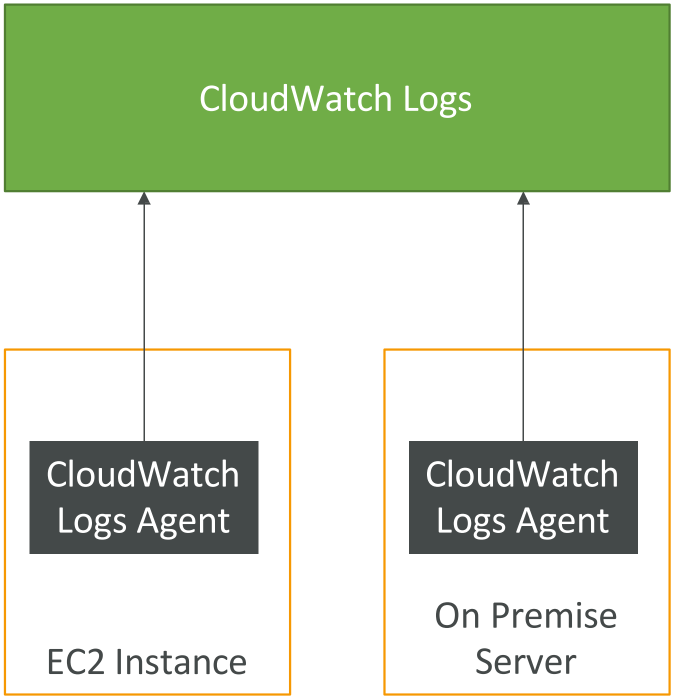
Destination Access Policy



```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "AWS": "111111111111"
      },
      "Action": "logs:PutSubscriptionFilter",
      "Resource": "arn:aws:logs:us-east-1:999999999999:
destination:testDestination"
    }
  ]
}
```

CloudWatch Logs for EC2

- By default, no logs from your EC2 machine will go to CloudWatch
- You need to run a CloudWatch agent on EC2 to push the log files you want
- Make sure IAM permissions are correct
- The CloudWatch log agent can be setup on-premises too



CloudWatch Logs Agent & Unified Agent

- For virtual servers (EC2 instances, on-premises servers…)
- CloudWatch Logs Agent
  - Old version of the agent
  - Can only send to CloudWatch Logs
- CloudWatch Unified Agent
  - Collect additional system-level metrics such as RAM, processes, etc…
  - Collect logs to send to CloudWatch Logs
  - Centralized configuration using SSM Parameter Store

CloudWatch Unified Agent - Metrics

- Collected directly on your Linux server / EC2 instance

- CPU (active, guest, idle, system, user, steal)
- Disk metrics (free, used, total), Disk IO (writes, reads, bytes, iops)
- RAM (free, inactive, used, total, cached)
- Netstat (number of TCP and UDP connections, net packets, bytes)
- Processes (total, dead, bloqued, idle, running, sleep)
- Swap Space (free, used, used %)

- Reminder: out-of-the box metrics for EC2 - disk, CPU, network (high level)

CloudWatch Alarms

- Alarms are used to trigger notifications for any metric
- Various options (sampling, %, max, min, etc…)
- Alarm States:
  - OK
  - INSUFFICIENT_DATA
  - ALARM
- Period:
  - Length of time in seconds to evaluate the metric
  - High resolution custom metrics: 10 sec, 30 sec or multiples of 60 sec

CloudWatch Alarm Targets

- Stop, Terminate, Reboot, or Recover an EC2 Instance
- Trigger Auto Scaling Action
- Send notification to SNS (from which you can do pretty much anything)

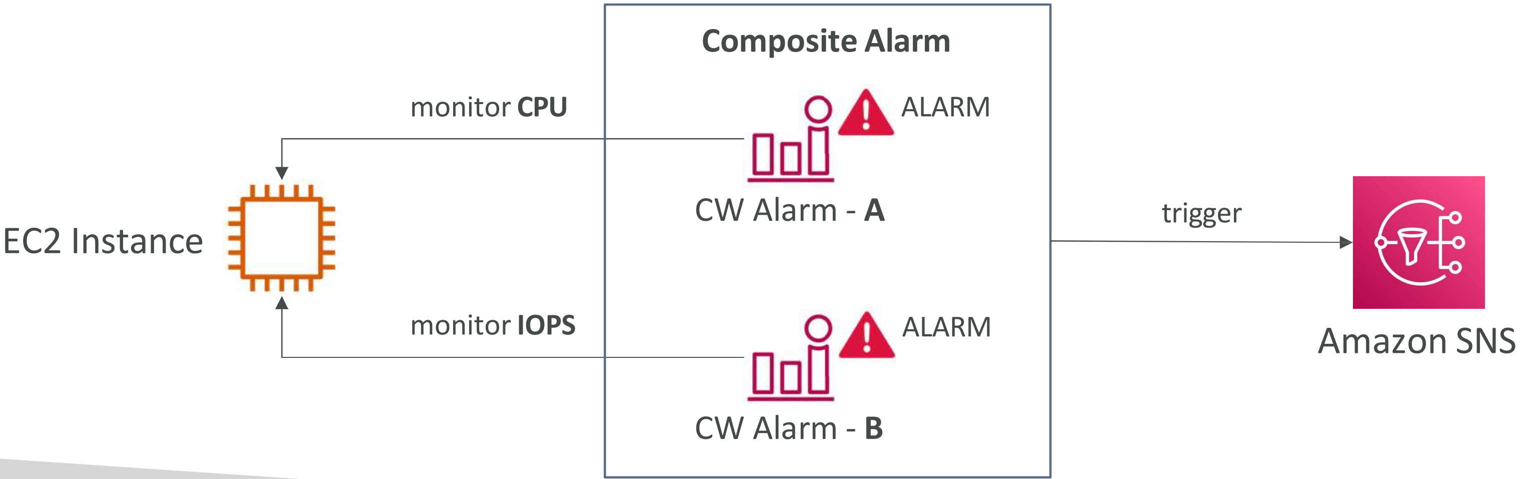
Amazon EC2

EC2 Auto Scaling

Amazon SNS

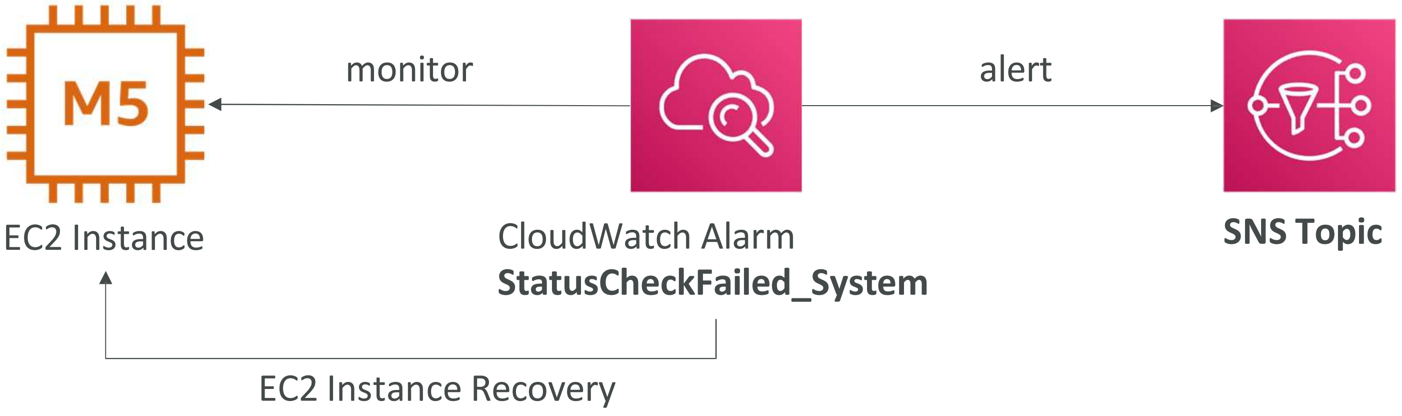
CloudWatch Alarms - Composite Alarms

- CloudWatch Alarms are on a single metric
- Composite Alarms are monitoring the states of multiple other alarms
- AND and OR conditions
- Helpful to reduce "alarm noise" by creating complex composite alarms



EC2 Instance Recovery

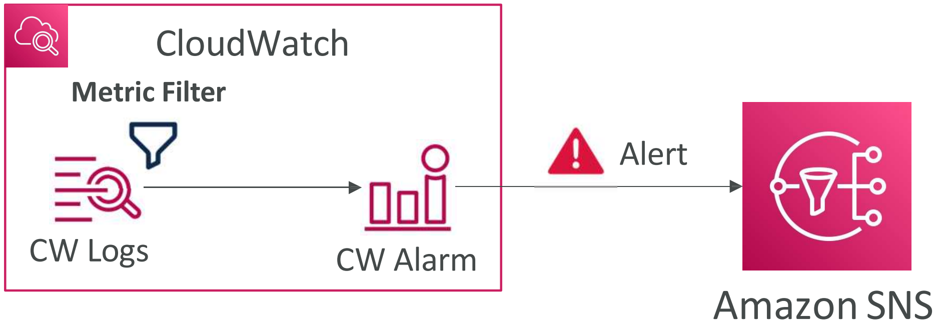
- Status Check:
  - Instance status = check the EC2 VM
  - System status = check the underlying hardware



- Recovery: Same Private, Public, Elastic IP, metadata, placement group

CloudWatch Alarm: good to know

- Alarms can be created based on CloudWatch Logs Metrics Filters

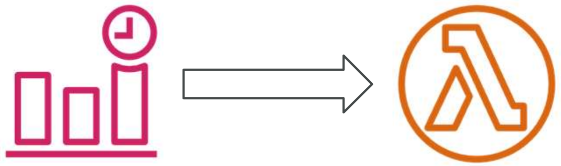


- To test alarms and notifications, set the alarm state to Alarm using CLI

```
aws cloudwatch set-alarm-state --alarm-name "myalarm" --state-value
ALARM --state-reason "testing purposes"
```

Amazon EventBridge
(formerly CloudWatch Events)

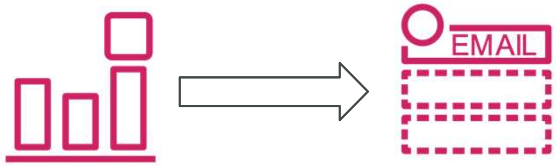
- Schedule: Cron jobs (scheduled scripts)



Schedule Every hour

Trigger script on Lambda function

- Event Pattern: Event rules to react to a service doing something

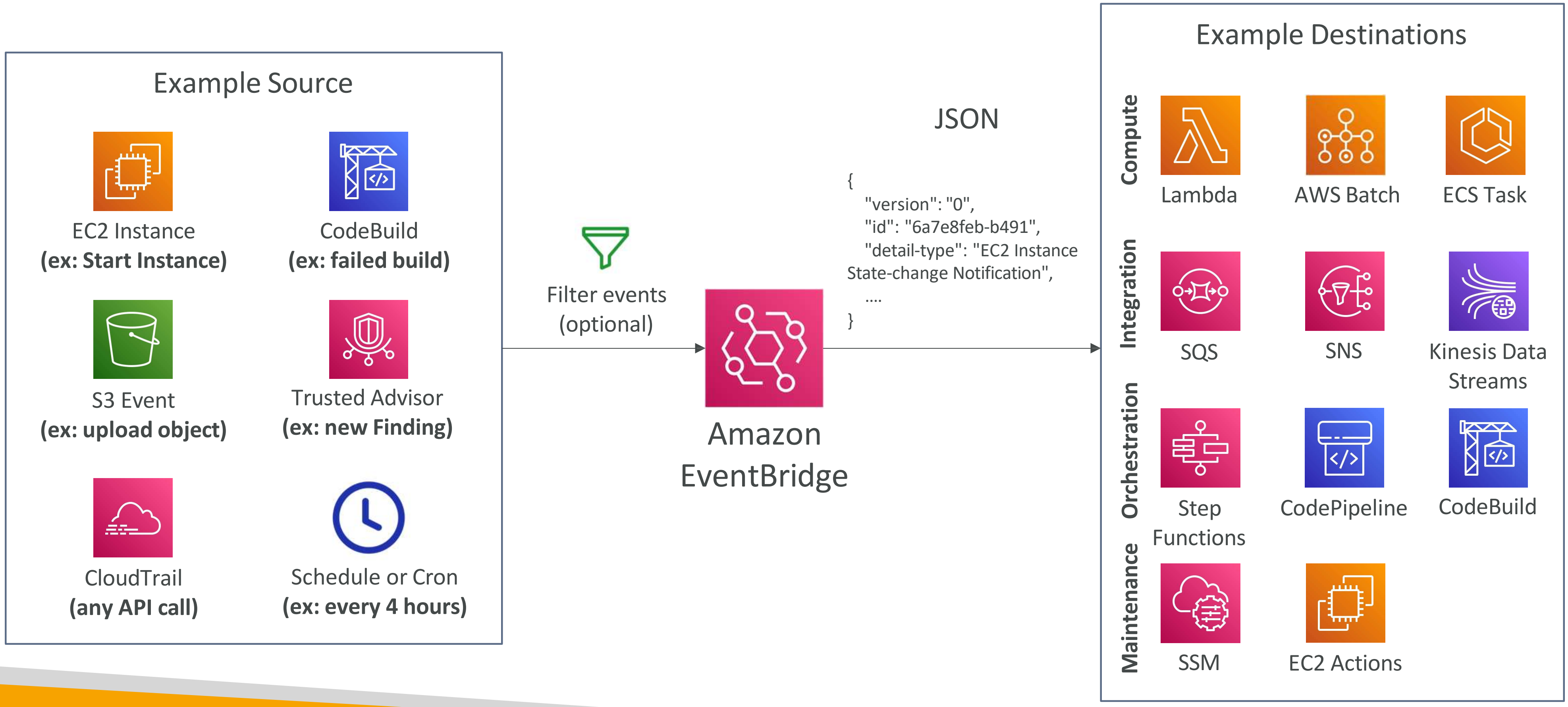


IAM Root User Sign in Event

SNS Topic with Email Notification

- Trigger Lambda functions, send SQS/SNS messages…

Amazon EventBridge Rules



Example Source

EC2 Instance
(ex: Start Instance)

CodeBuild
(ex: failed build)

S3 Event
(ex: upload object)

Trusted Advisor
(ex: new Finding)

CloudTrail
(any API call)

Schedule or Cron
(ex: every 4 hours)

Filter events
(optional)

Amazon
EventBridge

JSON

```
{
   "version": "0",
   "id": "6a7e8feb-b491",
   "detail-type": "EC2 Instance
State-change Notification",
   ....
}
```

Example Destinations

Compute

Lambda

AWS Batch

ECS Task

Integration

SQS

SNS

Kinesis Data
Streams

Orchestration

Step
Functions

CodePipeline

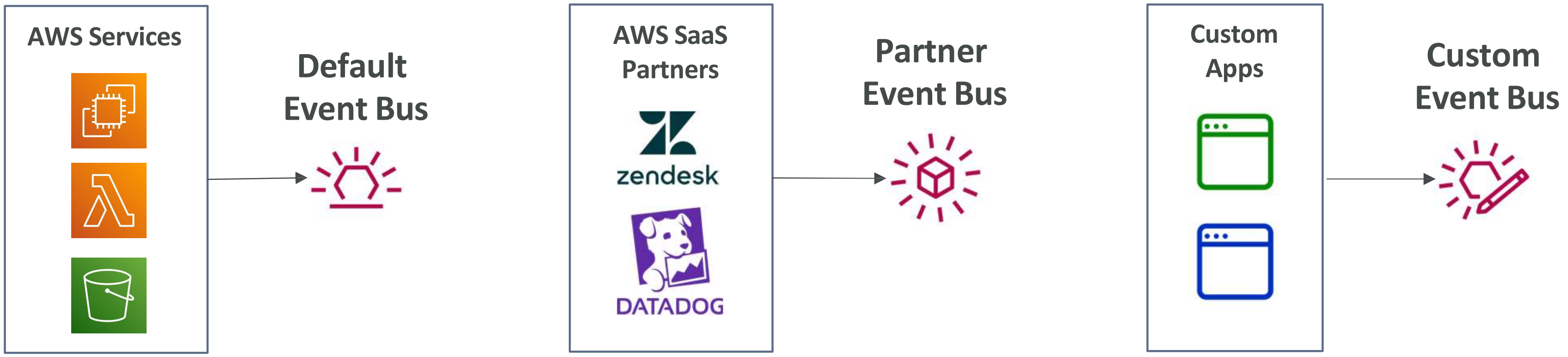
CodeBuild

Maintenance

SSM

EC2 Actions

Amazon EventBridge



- Event buses can be accessed by other AWS accounts using Resource-based Policies

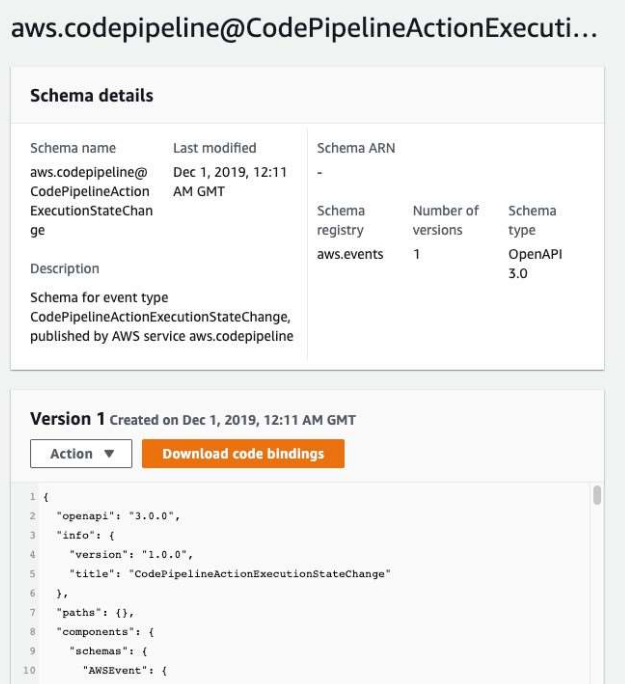
- You can archive events (all/filter) sent to an event bus (indefinitely or set period)
- Ability to replay archived events

Amazon EventBridge - Schema Registry

- EventBridge can analyze the events in your bus and infer the schema

- The Schema Registry allows you to generate code for your application, that will know in advance how data is structured in the event bus

- Schema can be versioned



aws.codepipeline@CodePipelineActionExecuti…

Schema details

Schema name: aws.codepipeline@CodePipelineActionExecutionStateChange

Last modified: Dec 1, 2019, 12:11 AM GMT

Description: Schema for event type CodePipelineActionExecutionStateChange, published by AWS service aws.codepipeline

Schema ARN: -

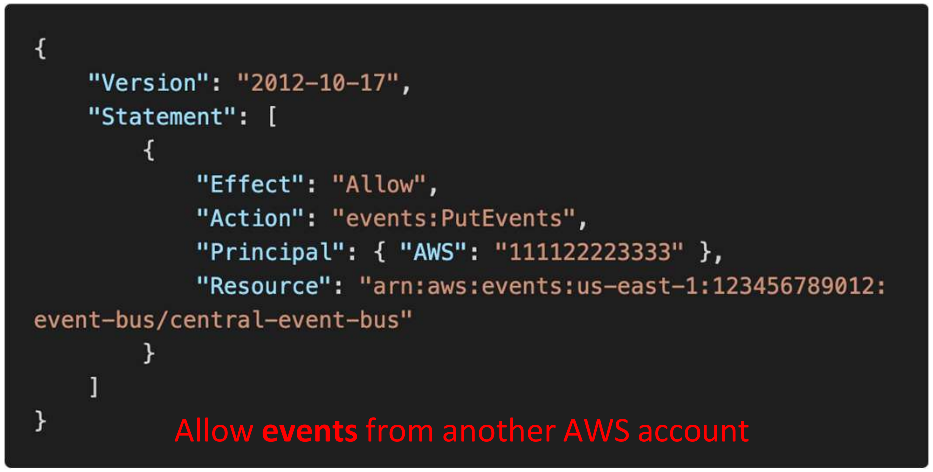
Schema registry	Number of versions	Schema type
aws.events	1	OpenAPI 3.0

Version 1 Created on Dec 1, 2019, 12:11 AM GMT

```
{
  "openapi": "3.0.0",
  "info": {
    "version": "1.0.0",
    "title": "CodePipelineActionExecutionStateChange"
  },
  "paths": {},
  "components": {
    "schemas": {
      "AWSEvent": {
```

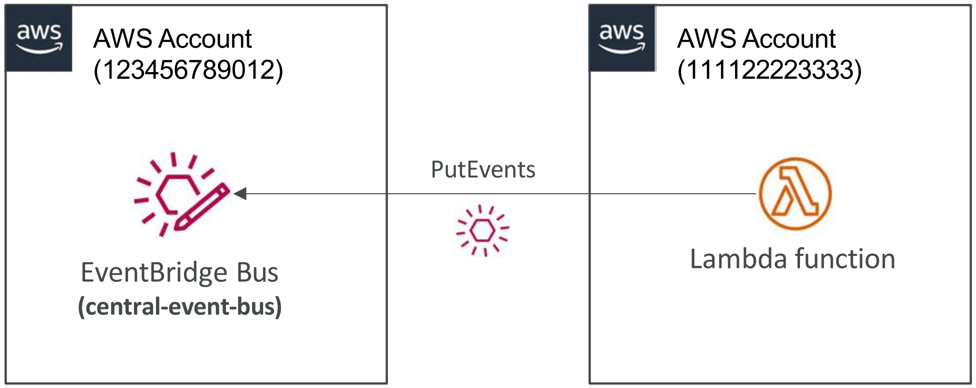
Amazon EventBridge - Resource-based Policy

- Manage permissions for a specific Event Bus
- Example: allow/deny events from another AWS account or AWS region
- Use case: aggregate all events from your AWS Organization in a single AWS account or AWS region



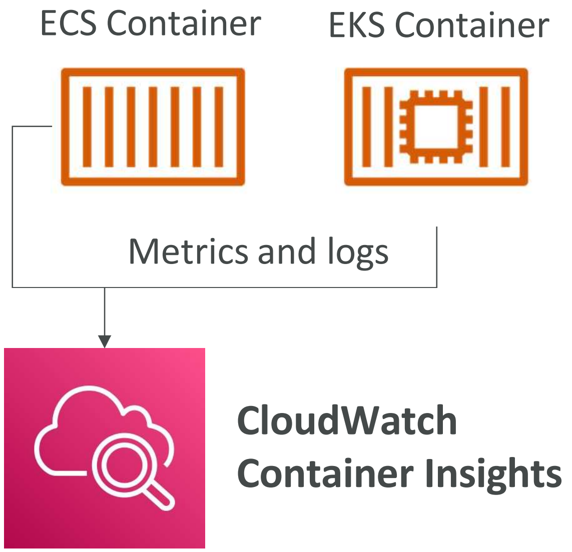
```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "events:PutEvents",
            "Principal": { "AWS": "111122223333" },
            "Resource": "arn:aws:events:us-east-1:123456789012:
event-bus/central-event-bus"
        }
    ]
}
```

Allow **events** from another AWS account



CloudWatch Container Insights

- Collect, aggregate, summarize metrics and logs from containers
- Available for containers o n…
    - Amazon Elastic Container Service (Amazon ECS)
    - Amazon Elastic Kubernetes Services (Amazon EKS)
    - Kubernetes platforms on EC2
    - Fargate (both for ECS and EKS)
- In Amazon EKS and Kubernetes, CloudWatch Insights is using a containerized version of the CloudWatch Agent to discover containers

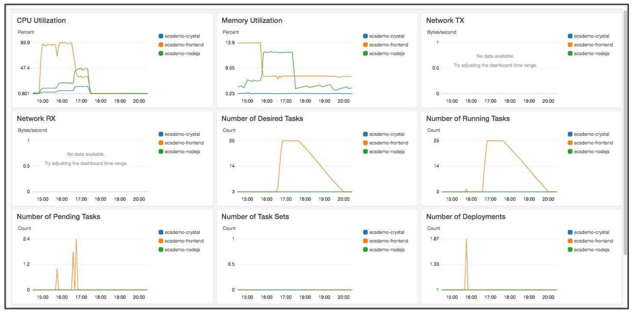


ECS Container

EKS Container

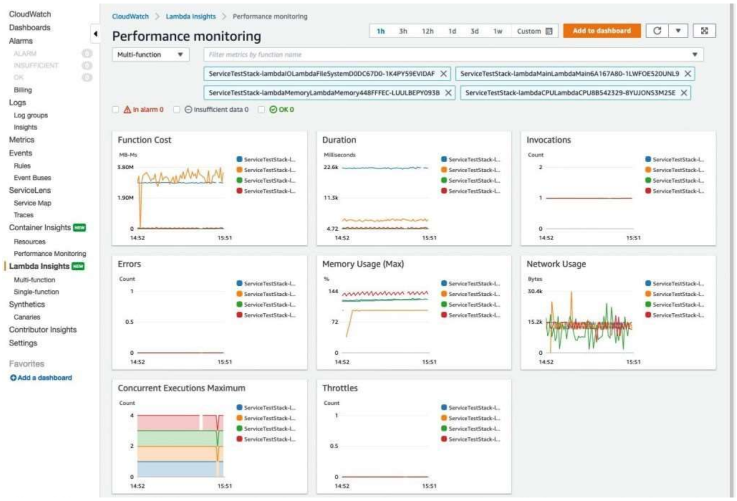
Metrics and logs

CloudWatch Container Insights



CloudWatch Lambda Insights

- Monitoring and troubleshooting solution for serverless applications running on AWS Lambda
- Collects, aggregates, and summarizes system-level metrics including CPU time, memory, disk, and network
- Collects, aggregates, and summarizes diagnostic information such as cold starts and Lambda worker shutdowns
- Lambda Insights is provided as a Lambda Layer



CloudWatch > Lambda Insights > Performance monitoring

Performance monitoring

Multi-function

ServiceTestStack-lambdaIOLambdaFileSystemD0DC67D0-1K4PY59EVIDAF

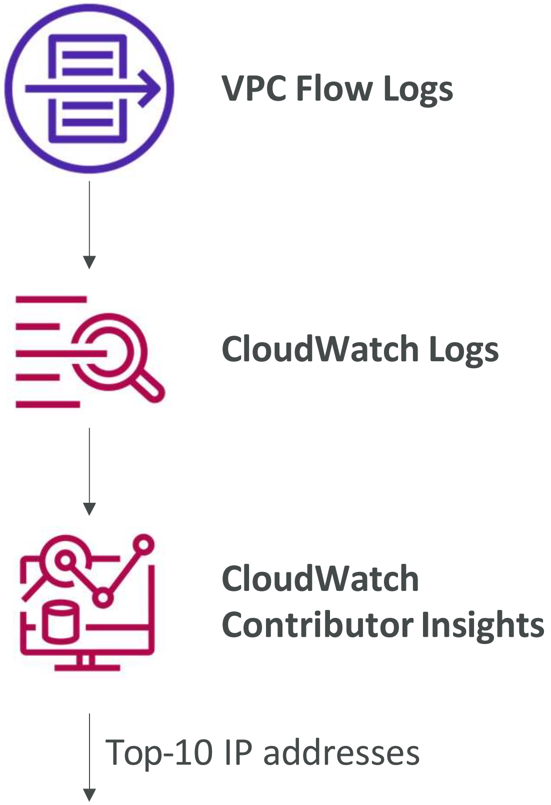
ServiceTestStack-lambdaMainLambdaMain6A167A80-1LWFOE520UNL9

ServiceTestStack-lambdaMemoryLambdaMemory448FFFEC-LUULBEPY093B

ServiceTestStack-lambdaCPULambdaCPU8B542329-8YUJONS3M2SE

CloudWatch Contributor Insights

- Analyze log data and create time series that display contributor data.
  - See metrics about the top-N contributors
  - The total number of unique contributors, and their usage.
- This helps you find top talkers and understand who or what is impacting system performance.
- Works for any AWS-generated logs (VPC, DNS, etc..)
- For example, you can find bad hosts, identify the heaviest network users, or find the URLs that generate the most errors.
- You can build your rules from scratch, or you can also use sample rules that AWS has created - leverages your CloudWatch Logs
- CloudWatch also provides built-in rules that you can use to analyze metrics from other AWS services.



CloudWatch Application Insights

- Provides automated dashboards that show potential problems with monitored applications, to help isolate ongoing issues
- Your applications run on Amazon EC2 Instances with select technologies only (Java, .NET, Microsoft IIS Web Server, databases…)
- And you can use other AWS resources such as Amazon EBS, RDS, ELB, ASG, Lambda, SQS, DynamoDB, S3 bucket, ECS, EKS, SNS, API Gateway…

- Powered by SageMaker
- Enhanced visibility into your application health to reduce the time it will take you to troubleshoot and repair your applications
- Findings and alerts are sent to Amazon EventBridge and SSM OpsCenter

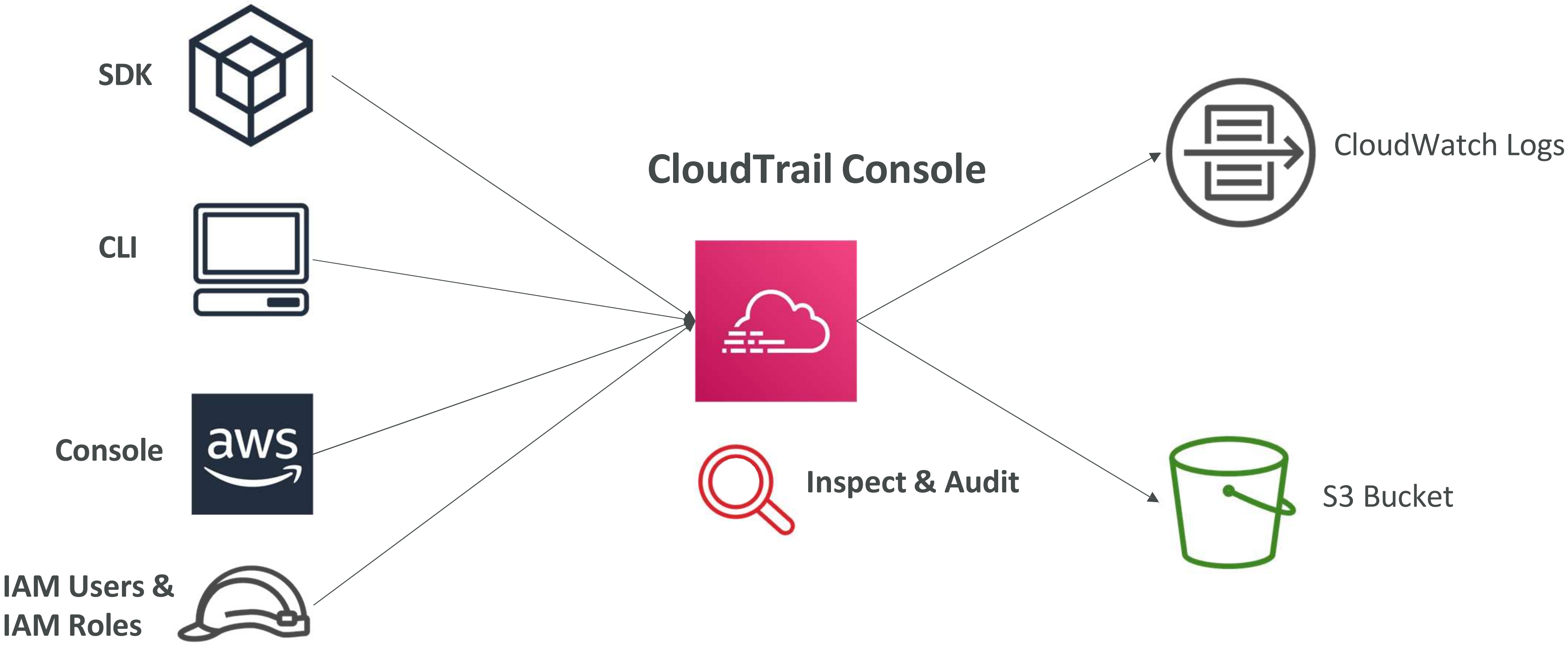
CloudWatch Insights and Operational Visibility

- CloudWatch Container Insights
  - ECS, EKS, Kubernetes on EC2, Fargate, needs agent for Kubernetes
  - Metrics and logs
- CloudWatch Lambda Insights
  - Detailed metrics to troubleshoot serverless applications
- CloudWatch Contributors Insights
  - Find "Top-N" Contributors through CloudWatch Logs
- CloudWatch Application Insights
  - Automatic dashboard to troubleshoot your application and related AWS services

AWS CloudTrail

- Provides governance, compliance and audit for your AWS Account
- CloudTrail is enabled by default!
- Get an history of events / API calls made within your AWS Account by:
    - Console
    - SDK
    - CLI
    - AWS Services
- Can put logs from CloudTrail into CloudWatch Logs or S3
- A trail can be applied to All Regions (default) or a single Region.
- If a resource is deleted in AWS, investigate CloudTrail first!

CloudTrail Diagram



CloudTrail Events

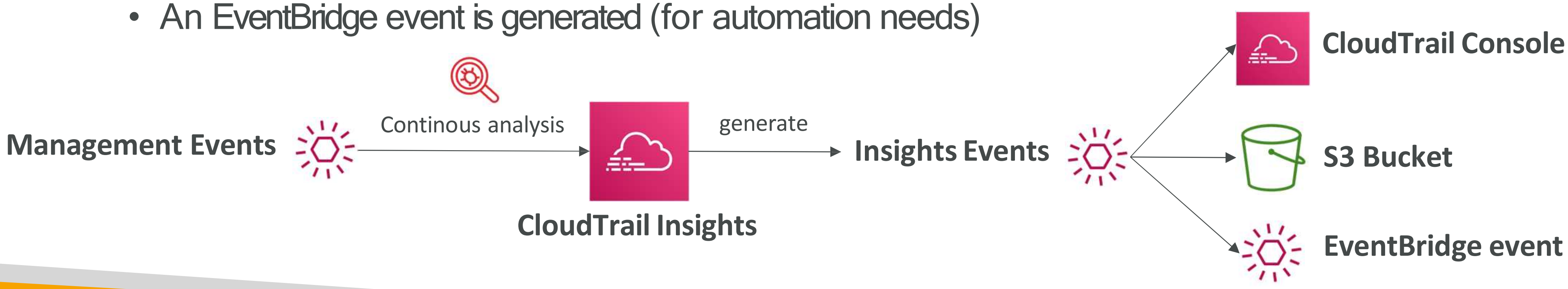
- Management Events:
  - Operations that are performed on resources in your AWS account
  - Examples:
    - Configuring security (IAM `AttachRolePolicy`)
    - Configuring rules for routing data (Amazon EC2 `CreateSubnet`)
    - Setting up logging (AWS CloudTrail `CreateTrail`)
  - By default, trails are configured to log management events.
  - Can separate Read Events (that don't modify resources) from Write Events (that may modify resources)

- Data Events:
  - By default, data events are not logged (because high volume operations)
  - Amazon S3 object-level activity (ex: `GetObject`, `DeleteObject`, `PutObject`): can separate Read and Write Events
  - AWS Lambda function execution activity (the `Invoke` API)

- CloudTrail Insights Events:
  - See next slide ©

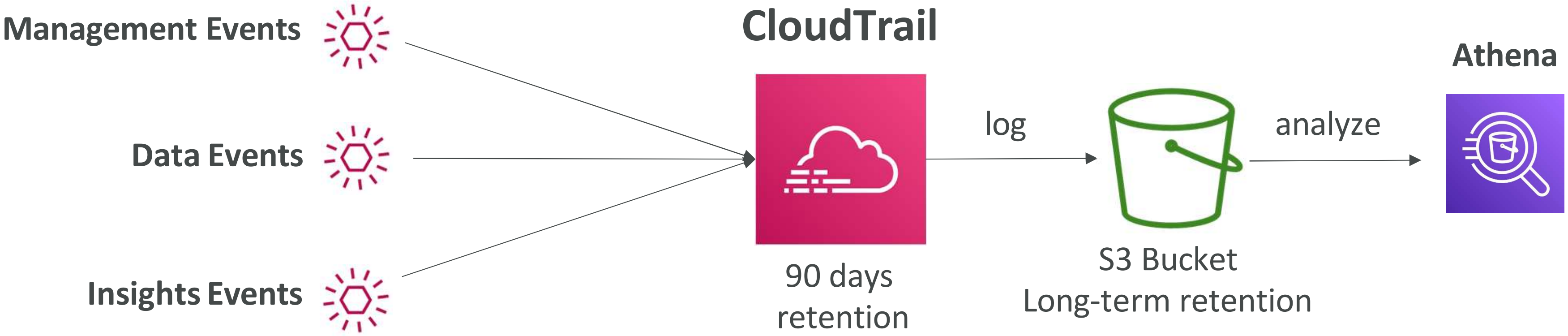
CloudTrail Insights

- Enable CloudTrail Insights to detect unusual activity in your account:
  - inaccurate resource provisioning
  - hitting service limits
  - Bursts of AWS IAM actions
  - Gaps in periodic maintenance activity
- CloudTrail Insights analyzes normal management events to create a baseline
- And then continuously analyzes write events to detect unusual patterns
  - Anomalies appear in the CloudTrail console
  - Event is sent to Amazon S3
  - An EventBridge event is generated (for automation needs)

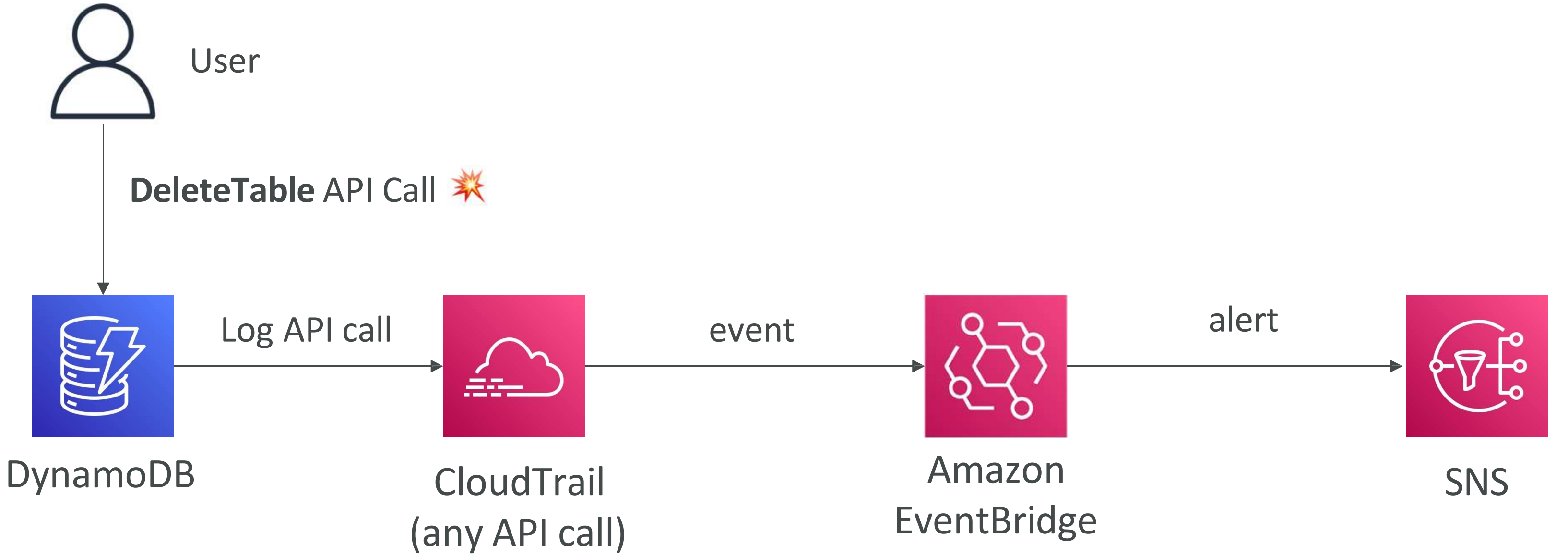


CloudTrail Events Retention

- Events are stored for 90 days in CloudTrail
- To keep events beyond this period, log them to S3 and use Athena



Amazon EventBridge - Intercept API Calls



User

DeleteTable API Call 💥

DynamoDB

Log API call

CloudTrail
(any API call)

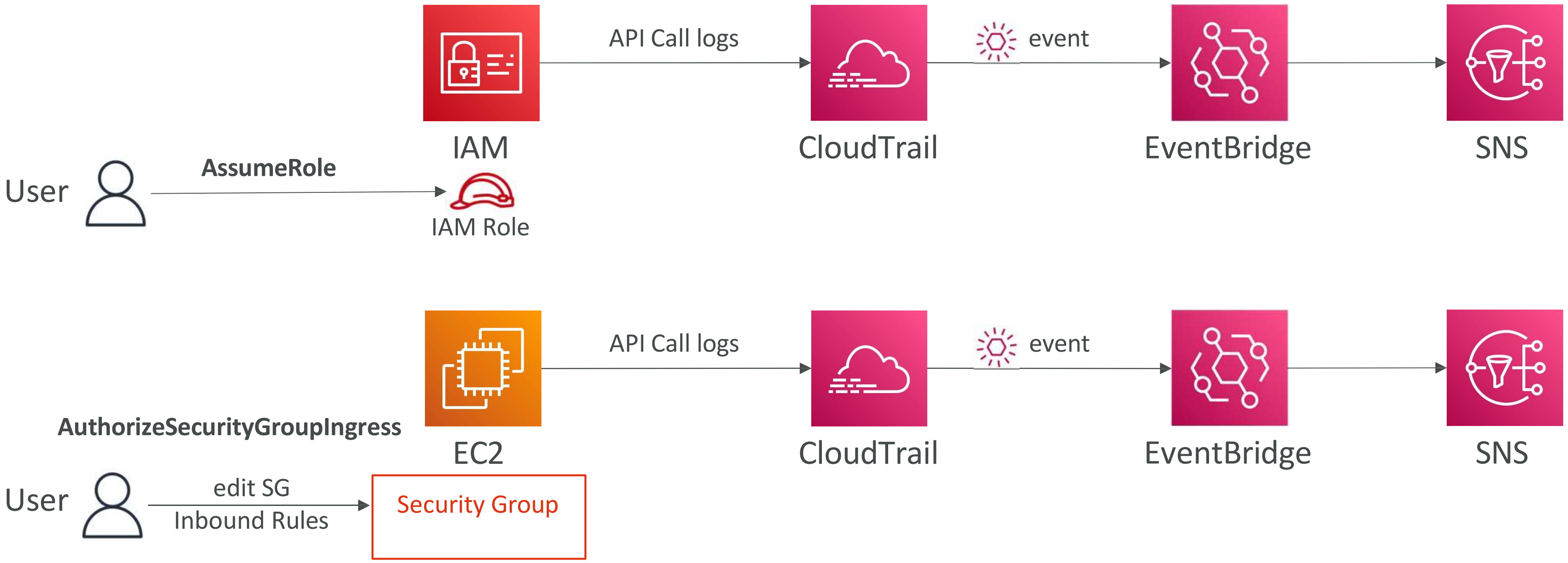
event

Amazon
EventBridge

alert

SNS

Amazon EventBridge + CloudTrail



AWS Config

- Helps with auditing and recording compliance of your AWS resources
- Helps record configurations and changes over time
- Questions that can be solved by AWS Config:
  - Is there unrestricted SSH access to my security groups?
  - Do my buckets have any public access?
  - How has my ALB configuration changed over time?
- You can receive alerts (SNS notifications) for any changes
- AWS Config is a per-region service
- Can be aggregated across regions and accounts
- Possibility of storing the configuration data into S3 (analyzed by Athena)

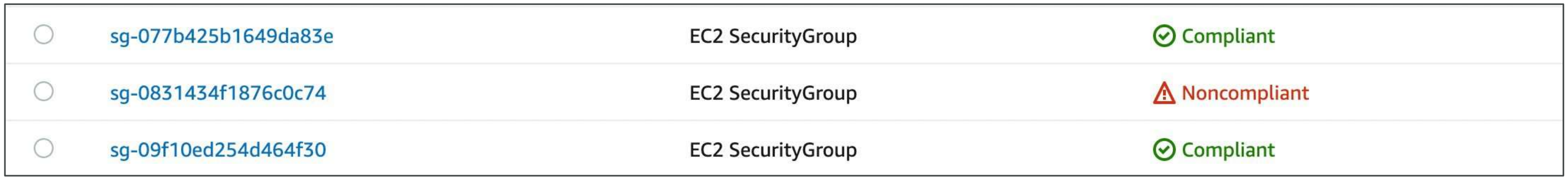
Config Rules

- Can use AWS managed config rules (over 75)
- Can make custom config rules (must be defined in AWS Lambda)
  - Ex: evaluate if each EBS disk is of type gp2
  - Ex: evaluate if each EC2 instance is t2.micro
- Rules can be evaluated / triggered:
  - For each config change
  - And / or: at regular time intervals
- AWS Config Rules does not prevent actions from happening (no deny)

- Pricing: no free tier, $0.003 per configuration item recorded per region, $0.001 per config rule evaluation per region

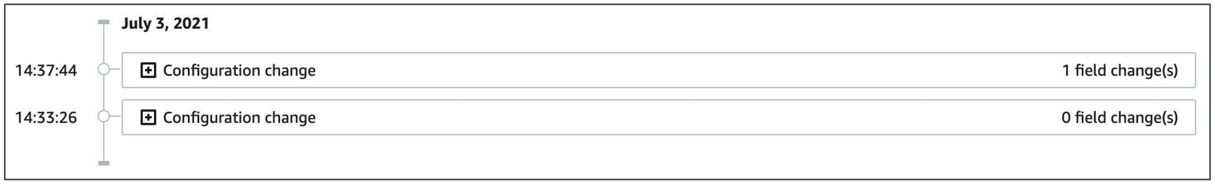
AWS Config Resource

- View compliance of a resource over time



○	sg-077b425b1649da83e	EC2 SecurityGroup	✓ Compliant
○	sg-0831434f1876c0c74	EC2 SecurityGroup	⚠ Noncompliant
○	sg-09f10ed254d464f30	EC2 SecurityGroup	✓ Compliant

- View configuration of a resource over time

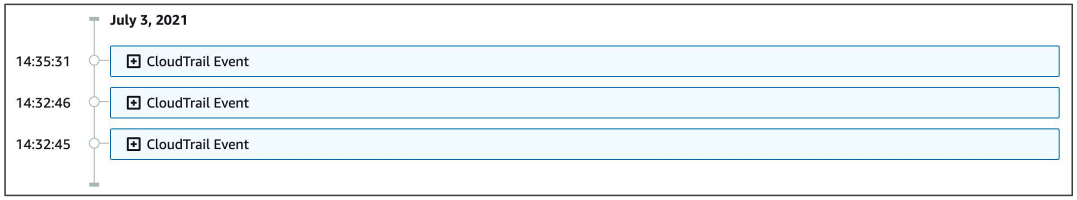


July 3, 2021

14:37:44 ⊞ Configuration change 1 field change(s)

14:33:26 ⊞ Configuration change 0 field change(s)

- View CloudTrail API calls of a resource over time



July 3, 2021

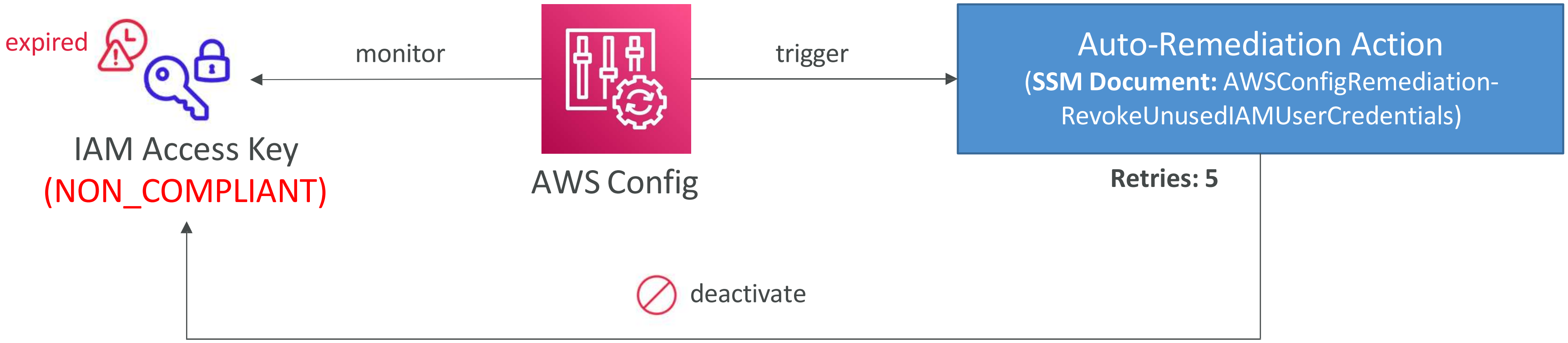
14:35:31 ⊞ CloudTrail Event

14:32:46 ⊞ CloudTrail Event

14:32:45 ⊞ CloudTrail Event

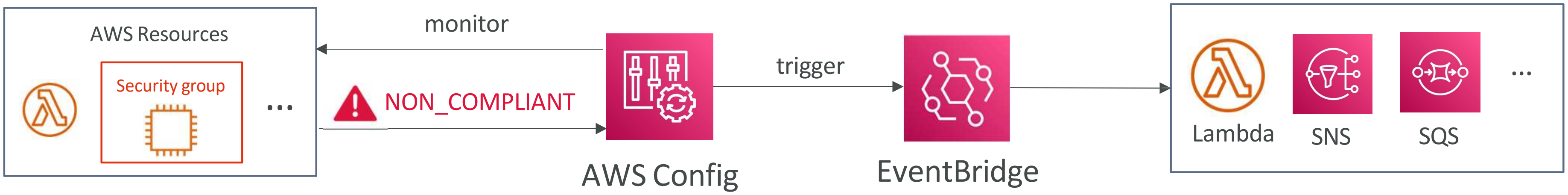
Config Rules - Remediations

- Automate remediation of non-compliant resources using SSM Automation Documents
- Use AWS-Managed Automation Documents or create custom Automation Documents
  - Tip: you can create custom Automation Documents that invokes Lambda function
- You can set Remediation Retries if the resource is still non-compliant after auto-remediation

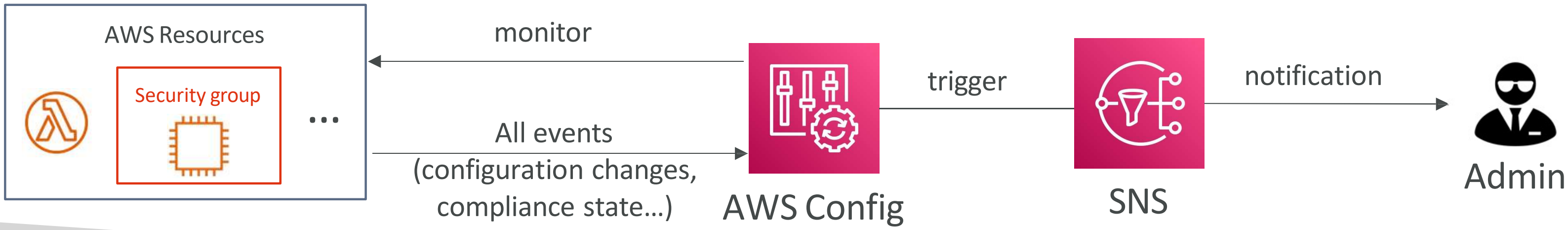


Config Rules - Notifications

- Use EventBridge to trigger notifications when AWS resources are non-compliant



- Ability to send configuration changes and compliance state notifications to SNS (all events - use SNS Filtering or filter at client-side)



CloudWatch vs CloudTrail vs Config

- CloudWatch
  - Performance monitoring (metrics, CPU, network, etc…) & dashboards
  - Events & Alerting
  - Log Aggregation & Analysis
- CloudTrail
  - Record API calls made within your Account by everyone
  - Can define trails for specific resources
  - Global Service
- Config
  - Record configuration changes
  - Evaluate resources against compliance rules
  - Get timeline of changes and compliance

For an Elastic Load Balancer

- CloudWatch:
  - Monitoring Incoming connections metric
  - Visualize error codes as % over time
  - Make a dashboard to get an idea of your load balancer performance
- Config:
  - Track security group rules for the Load Balancer
  - Track configuration changes for the Load Balancer
  - Ensure an SSL certificate is always assigned to the Load Balancer (compliance)
- CloudTrail:
  - Track who made any changes to the Load Balancer with API calls