Scalable, Automated Anomaly Detection with Amazon GuardDuty and SageMaker

(Machine Learning for Security)

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What you will do

- Download sample AWS CloudTrail logs and Amazon GuardDuty findings
- Walk through Amazon GuardDuty findings to understand key data elements
- Use Amazon SageMaker to identify users of AWS accounts coming from anomalous IP addresses.
- Fuse those findings with those coming from Amazon GuardDuty to create an aggregated list of suspicious activity.

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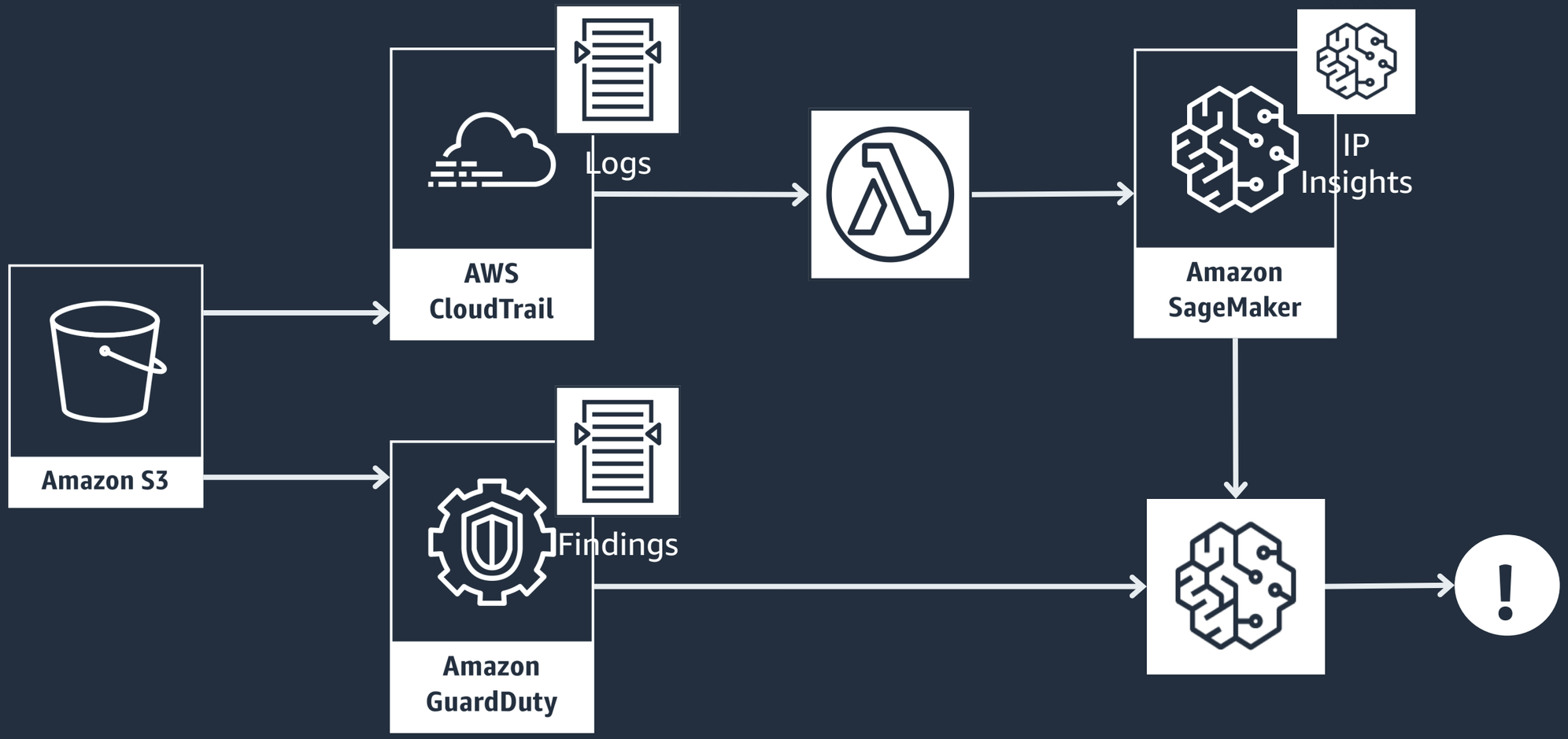
What you will do



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What we will cover

AWS CloudTrail logging

- Review CloudTrail data feeds for format and content
- Load test CloudTrail data of good and bad activities

Amazon GuardDuty findings

- Review GuardDuty, finding types, formats
- Hands-on lab - Use GuardDuty findings to create an aggregated list of suspicious activity

Amazon SageMaker

- High-level architecture review - building and deploying a model
- Hands-on lab – Use IP Insights algorithm to detect anomalous IP usage for GuardDuty findings, using CloudTrail log data for model training

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AWS CloudTrail

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AWS CloudTrail

Track user activity and API usage

What can you do?

- Simplify compliance audits and incident response by automatically recording and storing activity logs for your AWS account
- Logs API calls made to AWS services
  - 90-day event history on by default
- Can create log “trails” stored to S3
  - Optional KMS encryption
  - Optional log file integrity validation
- Optional data-level event logging for S3 object calls and Lambda invokes
- Can route events to CloudWatch Events

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Intro to AWS CloudTrail

AWS CloudTrail logs activity for supported services to an AWS account

Example API events that are logged:

- iam:CreateUser
- s3:ListBucket

CloudTrail is enabled by default on all AWS accounts (as of August 2017)

- Event history of create, modify, and delete operations for last 90 days
- Viewable, searchable, and downloadable
- To access CloudTrail log files directly or for a longer time period, create a trail
- You can also use Athena to query the logs directly in S3 buckets

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AWS CloudTrail log files

Gzipped JSON files created in the trail's Amazon S3 bucket

Each file contains API event records covering ~5 minute time window

Log files encrypted by default (SSE with S3 or KMS managed key)

Optional log file integrity validation using signed digest file containing log-file hashes

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AWS CloudTrail events

Each record in a CloudTrail log file represents a single event

All records contain some common fields:

- Timestamp
- Region
- Event name (i.e., the API call)
- Event source (i.e., the service)
- **Source IP address**
- **User identity**

Event-specific request and response parameters may also be included for some events

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What do CloudTrail logs look like?


```
{"Records": [{
    "eventVersion": "1.0",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "EX_PRINCIPAL_ID",
        "arn": "arn:aws:iam::123456789012:user/Alice",
        "accountId": "123456789012",
        "accessKeyId": "EXAMPLE_KEY_ID",
        "userName": "Alice”
    },
    "eventTime": "2017-11-29T11:29:42Z",
    "eventSource": "iam.amazonaws.com",
    "eventName": "CreateUser",
    "awsRegion": "us-east-1",
    "sourceIPAddress": ”192.168.0.1",
    "userAgent": "aws-cli/1.3.2 Python/2.7.5 Windows/7",
    "requestParameters": {"userName": "Bob”},
    "responseElements": {"user": {"createDate": ”Nov 29, 2017 11:29:42 AM", "userName": "Bob",
        "arn": "arn:aws:iam::123456789012:user/Bob", "path": "/", "userId": "EXAMPLEUSERID"}
    }
}]}
```


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What do CloudTrail logs look like?


```
{"Records": [{
    "eventVersion": "1.0",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "EX_PRINCIPAL_ID",
        "arn": "arn:aws:iam::123456789012:user/Alice",
        "accountId": "123456789012",
        "accessKeyId": "EXAMPLE_KEY_ID",
        "userName": "Alice”
    },
    "eventTime": "2017-11-29T11:29:42Z",
    "eventSource": "iam.amazonaws.com",
    "eventName": "CreateUser",
    "awsRegion": "us-east-1",
    "sourceIPAddress": ”192.168.0.1",
    "userAgent": "aws-cli/1.3.2 Python/2.7.5 Windows/7",
    "requestParameters": {"userName": "Bob”},
    "responseElements": {"user": {"createDate": ”Nov 29, 2017 11:29:42 AM", "userName": "Bob",
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    }
}]}
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What do CloudTrail logs look like?


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{"Records": [{
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        "principalId": "EX_PRINCIPAL_ID",
        "arn": "arn:aws:iam::123456789012:user/Alice",
        "accountId": "123456789012",
        "accessKeyId": "EXAMPLE_KEY_ID",
        "userName": "Alice”
    },
    "eventTime": "2017-11-29T11:29:42Z",
    "eventSource": "iam.amazonaws.com",
    "eventName": "CreateUser",
    "awsRegion": "us-east-1",
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        "arn": "arn:aws:iam::123456789012:user/Bob", "path": "/", "userId": "EXAMPLEUSERID"}
    }
}]}
```


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Amazon GuardDuty

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Amazon GuardDuty

Intelligent threat detection and continuous monitoring to protect your AWS accounts and workloads

What can you do?

- Continuous monitoring to rapidly detect threats (needle) to your environments in the sea of log data (haystack)
- Processes AWS CloudTrail logs, Amazon VPC flow logs, and DNS logs
- Analyzes billions of events across your AWS accounts for signs of risk
- Identifies unexpected and suspicious activity, such as privilege escalation, exposed creds, and communication with malicious IPs
- Can send findings to CloudWatch Events

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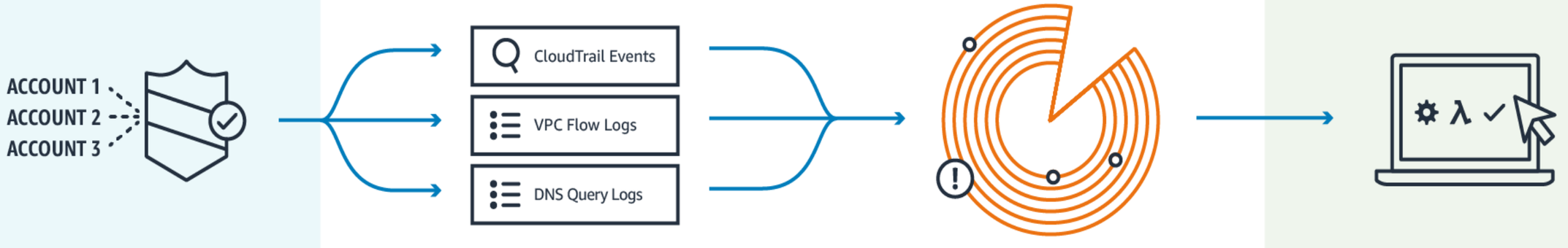
GuardDuty Threat Detection and Notification



Enable GuardDuty

With a few clicks in the console, monitor your AWS accounts without additional security software or infrastructure to deploy or manage

Continuously analyze

Automatically analyze network and account activity at scale providing broad, continuous monitoring of your AWS accounts and workloads

Intelligently detect threats

Utilize managed rule-sets, integrated threat intelligence, anomaly detection, and machine learning to intelligently detect malicious or unauthorized behavior

Leverage actionable alerts

Review detailed findings in the console, integrate into event management or workflow systems, or trigger AWS Lambda for automated remediation or prevention

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GuardDuty Data Sources

VPC Flow Logs

- Flow Logs for VPCs do *not* need to Be Turned on to generate findings Data is consumed through independent duplicate stream.
- Suggested turning on VPC Flow Logs to augment data analysis (charges apply).

DNS Logs

- DNS Logs are based on queries made from EC2 instances to known questionable domains.
- DNS Logs are in addition to Route 53 query logs. Route 53 is not required for GuardDuty to generate DNS based findings.

CloudTrail Logs

- CloudTrail history of AWS API calls used to access the Management Console, SDKs , CLI, etc. presented by GuardDuty.
- Identification of user and account activity including source IP address used to make the calls.

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Trusted IP and Threat IP Lists

GuardDuty uses AWS developed threat intelligence and threat intelligence feeds from: CrowdStrike & Proofpoint

Expand Findings with Custom Trusted IP Lists and Known Threat Lists

- Trusted IP lists whitelisted for secure communication with infrastructure and applications
- No Findings will be presented for IP Addresses on trusted lists (no false positives!)
- Threat lists consist of known malicious IP addresses.
- GuardDuty generates findings based on threat lists.

Limits: 1 Trusted and 6 Threat Lists per Account

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GuardDuty Findings

Describes threats by their primary purpose:
ThreatPurpose:ResourceTypeAffected/ThreatFamilyName.ThreatFamilyVariant!Artifact

Backdoor: resource compromised and capable of contacting source home

Behavior: activity that differs from established baseline

Crypto Currency: detected software associated with Crypto currencies

Pentest: activity detected similar to that generated by known pen testing tools

Recon: attack scoping vulnerabilities by probing ports, listening, database tables, etc.

Stealth: attack trying to hide actions / tracks

Trojan: program detected carrying out suspicious activity

Unauthorized Access: suspicious activity / pattern by unauthorized user

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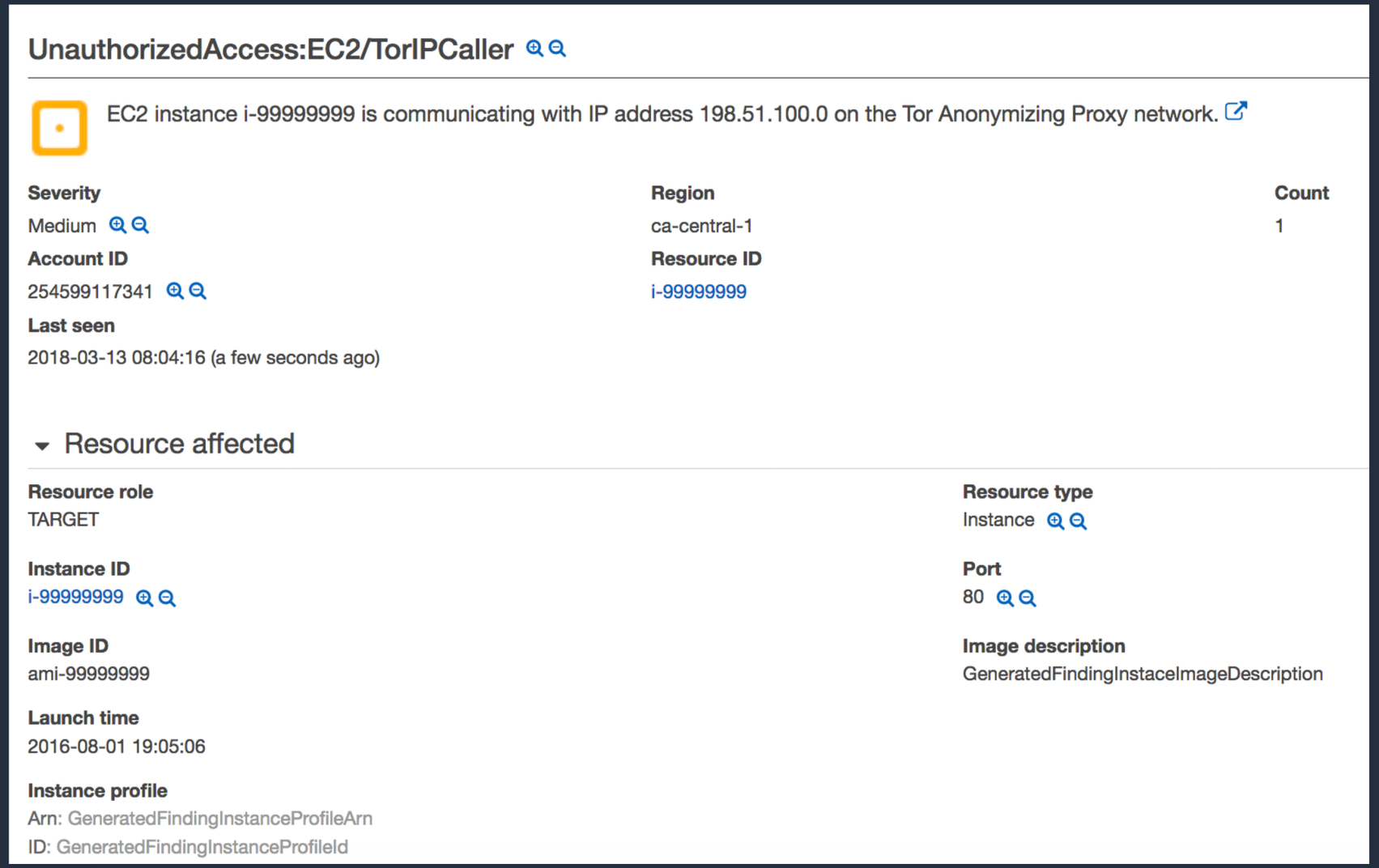
GuardDuty Findings in Console



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GuardDuty Findings in Console


```
{
  "version": "0",
  "id": "c8c4daa7-a20c-2f03-0070-b7393dd542ad",
  "detail-type": "GuardDuty Finding",
  "source": "aws.guardduty",
  "account": "254599117341",
  "time": ”2018-03-13T08:04:33Z",
  "region": ”ca-central-1",
  "resources": [],
  "detail": {
    "schemaVersion": "2.0",
    "accountId": "254599117341",
    "region": ”ca-central-1",
    "partition": "aws",
    "id": "16afba5c5c43e07c9e3e5e2e544e95df",
    "arn": "arn:aws:guardduty:us-east-1:254599117341:detector/254599117341/finding/16afba5c5c43e07c9e3e5e2e544e95df",
    "type": ”UnauthorizedAccess:EC2/TorIPCaller",
    “resource”: { ... },
    “service”: { ... },
    "severity": 3,
    "createdAt": "2018-03-13T08:04:16.000Z",
    "updatedAt": "2018-03-13T08:04:16.000Z",
    "title": ”UnauthorizedAccess:EC2/TorIPCaller",
    "description": ”UnauthorizedAccess:EC2/TorIPCaller"
}}
```


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GuardDuty Findings for this workshop

Unauthorized Access: suspicious activity / pattern by unauthorized user

- UnauthorizedAccess:IAMUser/ConsoleLogin
- UnauthorizedAccess:IAMUser/ConsoleLoginSuccess.B
- UnauthorizedAccess:IAMUser/InstanceCredentialExfiltration
- UnauthorizedAccess:IAMUser/MaliciousIPCaller
- UnauthorizedAccess:IAMUser/UnusualASNCaller

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GuardDuty Findings for this Workshop

Threat UnauthorizedAccess:IAMUser/ConsoleLogin

- This IAM user has no prior history of login activity
- Your IAM user credentials might be compromised

Severity

- Medium
- Unknown confidence

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GuardDuty + Additional Machine Learning

GuardDuty severity scores are assigned by the type of finding

They do not factor in context beyond their finding conditions

We can add context and start to build a more holistic confidence score by using a ML approach we can assign

Let's combine the UnauthorizedAccess GuardDuty finding with an additional estimate of the likelihood of seeing this [User + SourceIP] to further evaluate how unusual the activity is.

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Amazon SageMaker

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Amazon SageMaker

Build, train, and deploy machine learning models at scale

What can you do?

- Rapidly build, train, and deploy ML models
  - Automated model training and tuning
- Supports all algorithms and frameworks
  - Many built-in optimized algorithms
  - Includes MXNet, TensorFlow, and others
- Experiment using hosted interactive notebooks
  - Jupyter notebooks that support multiple languages (e.g., Python, Scala)
- Built-in A/B testing capabilities

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The Amazon Machine Learning Stack

AI SERVICES

Vision


REKOGNITION IMAGE


REKOGNITION VIDEO

Speech


TEXTRACT


POLLY


TRANSCRIBE

Language


TRANSLATE


COMPREHEND

Chatbots


LEX

Forecasting


FORECAST

Recommendations


PERSONALIZE

ML SERVICES


AMAZON SAGEMAKER

BUILD

Pre-built algorithms & notebooks

Data labeling (GROUND TRUTH)

Algorithms & models (AWS MARKETPLACE FOR MACHINE LEARNING)

TRAIN

One-click model training & tuning

Optimization (NEO)

Reinforcement learning

DEPLOY

One-click deployment & hosting

ML FRAMEWORKS & INFRASTRUCTURE

Frameworks

TensorFlow

mxnet

PYTORCH

Interfaces

GLUON

Keras

Infrastructure


EC2 P3 & P3N


EC2 C5


FPGAs


GREENGRASS


ELASTIC INFERENCE

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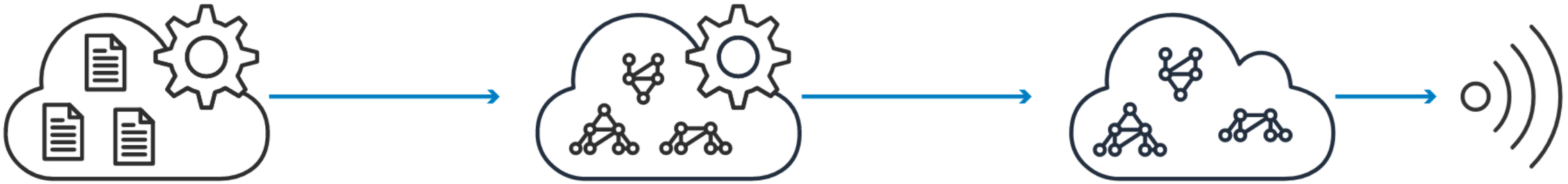
SageMaker Workflow



Notebook

Availability of AWS and SageMaker SDKs and sample notebooks to create training Jobs and deploy models.

Create notebook instance

Training

Train and tune models at any scale. Leverage high performance AWS algorithms or bring your own.

- **Training jobs**
- **Hyperparameter tuning jobs**

Inference

Create models from training jobs or import external models for hosting to run inferences on new data.

- **Models**
- **Endpoints**
- **Batch transform jobs**

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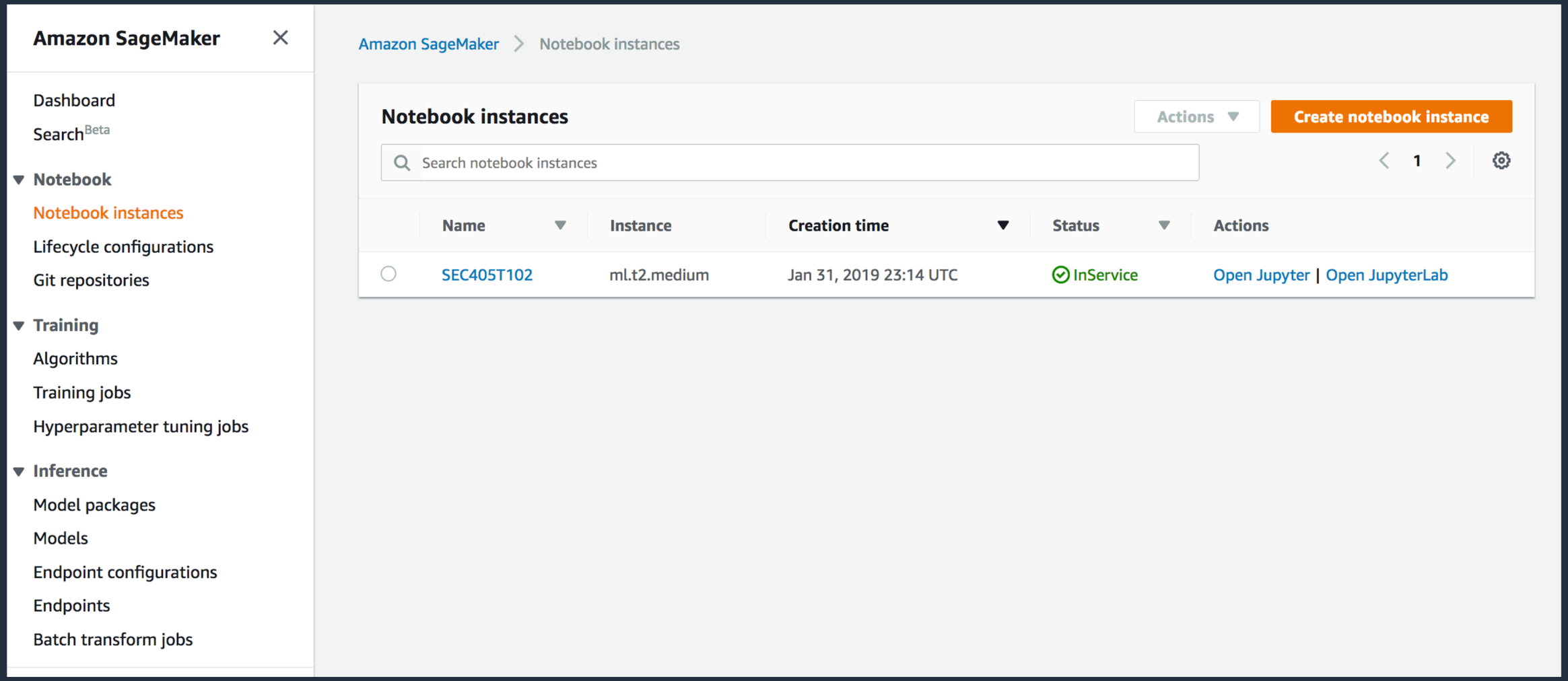
SageMaker Dashboard



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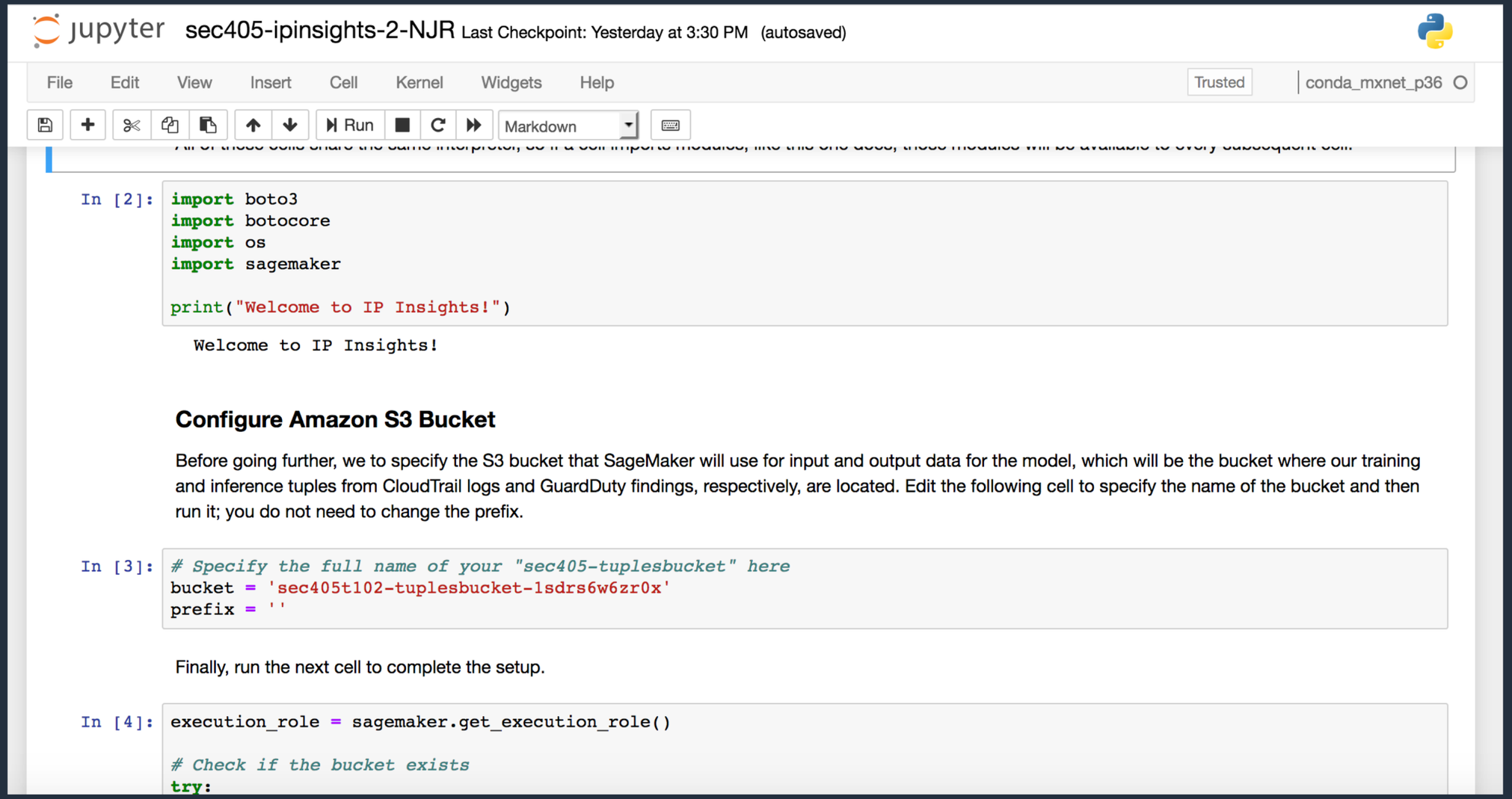
SageMaker (Jupyter) Notebook



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ML Model

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IP Insights Model

Learn a measure of association between users and IP addresses using legitimate activity to answer the question of “How normal it is to see a given user using a given IP”

Statistical modeling and neural networks to capture associations

If the vector <principal ID, IP address> are close together, then it is likely for the principal to access the account from that IP address, even if it has never accessed it before

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Solution

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Exercise Workflow

- Using our “normal” CloudTrail data (User, IP address pairs), train SageMaker – using the IP Insight ML algorithm - to build a baseline model of normal IP usage
- As GuardDuty alerts come in, feed the alerting <User, IP> pairs to our model to determine a fit score. Low scores → Anomalous
- *[Blend anomaly score with findings from Amazon GuardDuty to create an aggregated list of suspicious activity] – See the IPInsights tutorial*

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Building Blocks

AWSCloudTrail

Amazon GuardDuty

AWS Lambda

Amazon SageMaker

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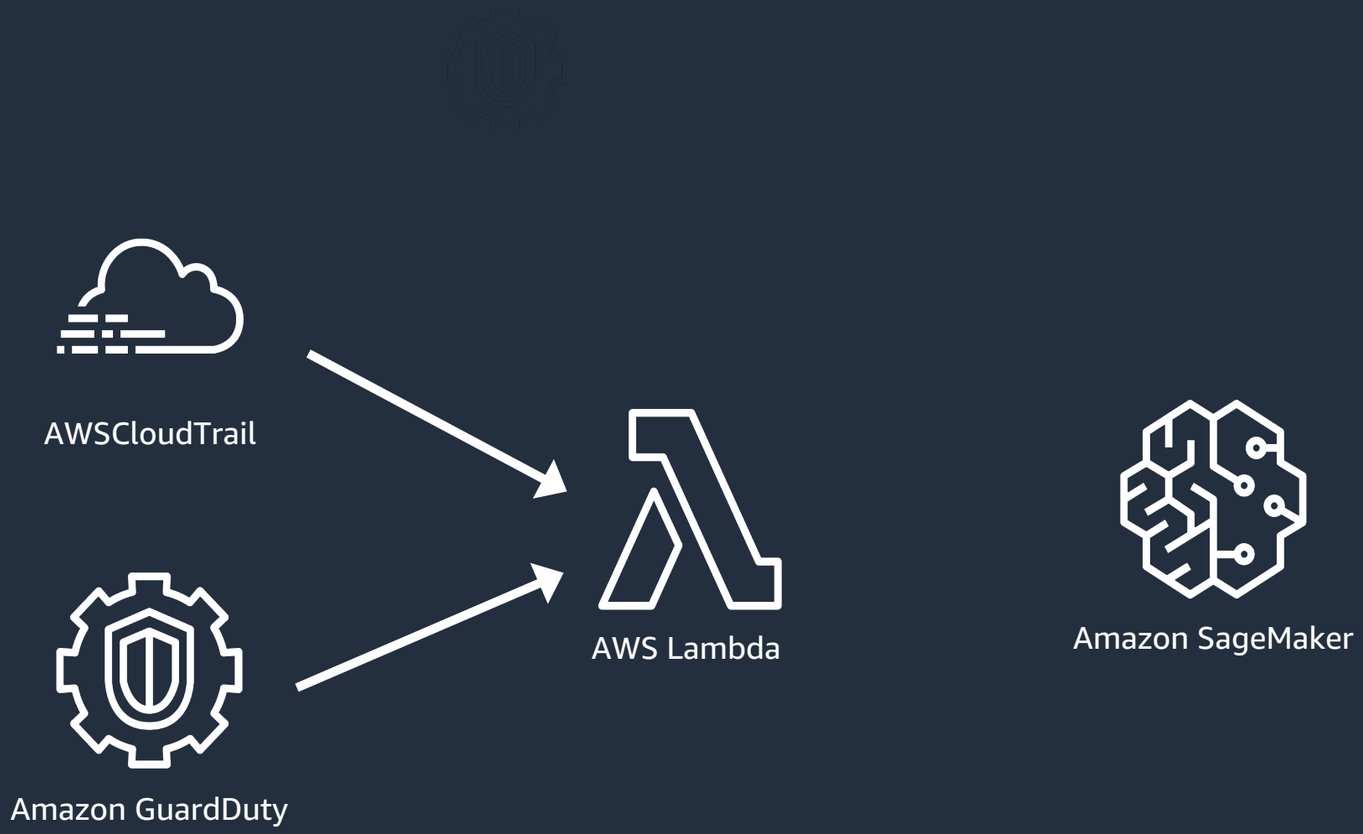
Building Blocks



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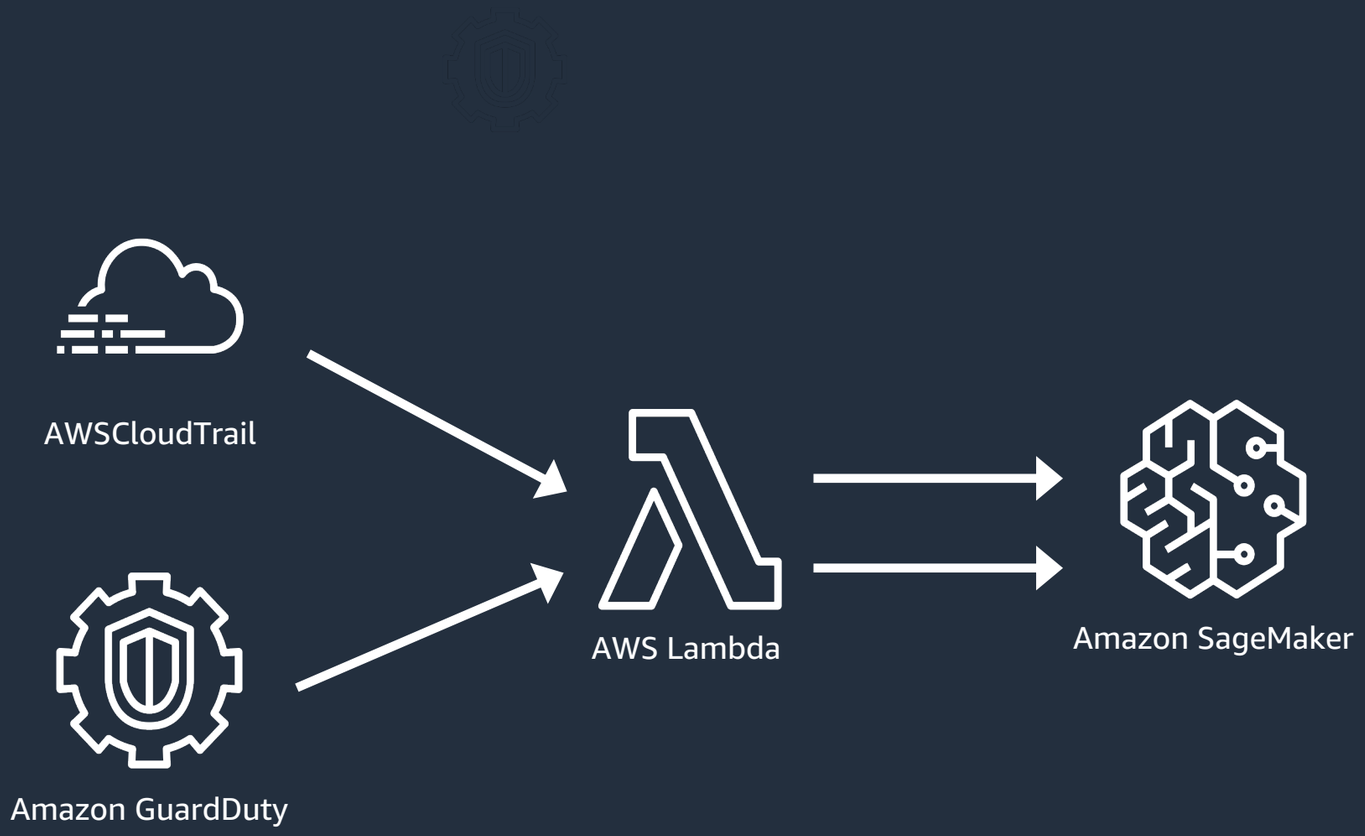
Building Blocks



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Exercise Steps

Browse to https://awssecworkshops.com/getting-started/

Work through the steps

- If you already have an account you can skip the first step
- Skip “Create a Cloud9 instance” for this workshop

Next, open the top left menu and browse to:

Workshops -> Detection with Machine Learning

URL: https://ml-threat-detection.awssecworkshops.com/

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Putting This Into Practice

- Use this as-is: score specific console logins tagged by GuardDuty
- Tuning
  - Parameters and training sets
  - When to retrain the IP Insights model?
- Use IP Insights on different classes of behavior
  - Specific application usage (e.g., monitoring apps, bastion hosts)
- Thinking bigger – Adding additional detectors and models
  - Leverage GuardDuty, Macie findings
  - Build your own
  - Leverage broad classes of algorithms and prior work
  - Build application-specific models
- Remember the importance of Subject Matter Expertise

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Thank you!

https://github.com/aws-samples/aws-security-workshops/detection-ml-workshop/

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Baris: barisco@amazon.com (GuardDuty Team)

Rima: tanashr@amazon.com (Security Hub Team)

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