Implementation Guide

Automated Forensics Orchestrator for Amazon EC2 and EKS

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Automated Forensics Orchestrator for Amazon EC2 and EKS: Implementation Guide

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Table of Contents

Guidance overview **1**
Cost **3**
Architecture overview **7**
Guidance components **9**
Forensic triage service 9
Interaction view 9
Implementation view 10
Forensic memory and disk acquisition service 11
Interaction view 11
Implementation view 11
What happens to instances after isolation? 13
Disk forensics acquisition workflow 13
Forensic investigation and reporting service 14
Interaction view 15
Implementation view 15
Forensic investigation and reporting workflow 16
Forensic image and SSM Document builder service 17
Security **19**
IAM roles 19
AWS Key Management Service (KMS) Keys 19
Network configuration 19
Data protection 20
Supported deployment Regions **21**
Deployment **22**
Prerequisites 22
Tools 22
Forensic AMI 22
Compromised instance memory size and investigation instance mount disk volume 23
CDK context configurations 23
Deployment overview 23
Forensic Orchestrator Guidance deployment in Forensic AWS account 24
Security Hub aggregator account deployment in a new VPC 26
Application account deployment 28
Support for Red Hat Enterprise Linux (RHEL 8.6 and above) 28

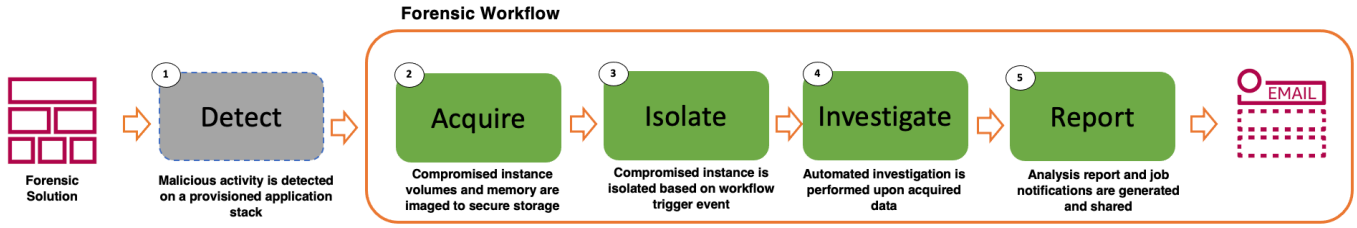
Post deployment: Plugin points 29
Memory forensics analysis using LiME and Volatility 3 29
Steps to build LiME module and volatility profile using SSM document 30
Automate the creation of LiME and Volatility 3 symbol tables 31
Usage of Forensic Guidance 31
Step 1. Sign in to the Security Hub AWS Account AWS Management Console and initiate forensic analysis 31
Step 2. Sign in to the Forensic AWS Account AWS Management Console and view step functions flow 32
Sample AppSync API to query forensic details 33
Performance considerations 34
AWS services used in this Guidance 35
Uninstall the Guidance 39
Using the AWS Command Line Interface (CLI) 39
Using the AWS Management Console 39
Troubleshooting 40
Zero-byte files reported as part of memory and disk investigation 40
ForensicSecHubStack failed to deploy 40
(Optional) Additional configuration Cloud9 environment setup 42
Guidance customizations 43
Forensic investigation instance 43
AWS Systems Manager documents 43
Memory acquisition 44
Memory investigation 44
Disk investigation 45
Customization of CDK context configurations 45
Additional resources 49
Source code 50
Contributors 51
Revisions 52
Notices 53

A self-service Guidance to capture and examine data from EC2 instances or EKS clusters and attached volumes for forensic analysis in the event of a potential security issue being detected

Automated Forensics Orchestrator for Amazon EC2 and EKS is a self-service Guidance that customers can deploy to quickly set up and configure a forensics orchestration workflow for their Security Operations Center (SOC). It allows their SOC to capture and examine data from EC2 instances and attached volumes as digital forensics evidence for forensic analysis, in the event a potential security branch. The Guidance currently supports EKS clusters hosted on EC2 instances.

This Guidance provides a framework to orchestrate and automate key forensics processes from the point at which a threat is first detected. This includes isolation of the affected EC2 instances, EKS clusters, data volumes, capture of memory and disk images to secure storage, and initiation of automated actions or tools for investigation and analysis of such artifacts. The Guidance reports findings and provides process notifications. It allows the SOC to continuously discover and analyze patterns of fraudulent activities across multi-account and multi-region environments. The Automated Forensics Orchestrator for Amazon EC2 Guidance leverages AWS services and is underpinned by a highly available, resilient, a serverless architecture, security, and operational monitoring features.

Forensic workflow



Digital forensics is a four-step process of acquisition, isolation, investigation and reporting. The Automated Forensics Orchestrator for Amazon EC2 and EKS Guidance provides the capability to act on security events by imaging or acquisition of breached resources for examination and generating a forensic report about the security breach. In the event of a security breach, it allows customers to automatically capture and store targeted data for forensic examination and analysis, and their SOC

to discover and analyze patterns of fraudulent activities. The Guidance supports EC2 instances and EKS clusters on EC2 instances distributed across multiple accounts and regions.

This Guidance is intended for deployment in an enterprise by IT infrastructure and security architects, Incident Response team, security administrators, developers, and SecDevOps professionals who have practical experience with the AWS Cloud.

Note

We make no claim as to the suitability of Automated Forensics Orchestrator for Amazon EC2 and EKS in the detection or investigation of crime, nor the ability of data or forensics evidence captured by this Guidance to be used in a court of law. You should independently evaluate the suitability of Automated Forensics Orchestrator for Amazon EC2 and EKS for your use case.

Cost

You are responsible for the cost of the AWS services used to run the Automated Forensics Orchestrator for Amazon EC2 and EKS Guidance. As of the recent revision, the monthly cost for running this Guidance with the default settings in the US East (N. Virginia) AWS Region is approximately **$235 assuming an average of one forensic instance is 50% utilized for performing forensic analysis** with 512GB of volume attached to the instance. Prices are subject to change. For full details, refer to the pricing page for each AWS service used in this Guidance.

The total cost to run this Guidance depends on the following factors:

- The number of forensic incidents reported
- The frequency of forensic orchestration
- The Guidance assumes a forensic instance runs 12 hours a day

This Guidance uses the following AWS components, which incur a cost based on your configuration.

Service	Usage estimate	Monthly cost (USD)
AWS Step Functions	Workflow requests (10 per day), State transitions per workflow (20)	$1
Amazon CloudWatch	Number of Metrics (includes detailed and custom metrics) (20) Number of Custom/Cross-account events (100,000) Number of Dashboards (1) Number of Standard Resolution Alarm Metrics (20) Number of High-Resolution Alarm Metrics (20) Number of Canary runs (5)	$47

Service	Usage estimate	Monthly cost (USD)
	Number of Lambda functions (10) Number of requests per function (5 per day) Number of Contributor Insights rules for DynamoDB (5) Total number of events for DynamoDB (1 million events per month) Total number of matched log events for CloudWatch (1 million matched log events per month) Number of Contributor Insights rules for CloudWatch (5) Standard Logs: Data Ingested (1 GB) Logs Delivered to S3: Data Ingested (1 GB)	
Amazon DynamoDB	Average item size (all attributes) (20 KB) Data storage size (0.5 GB)	$26

Service	Usage estimate	Monthly cost (USD)
Amazon Simple Notification Service (SNS)	DT Inbound: Not selected (0 TB per month) DT Outbound: Not selected (0 TB per month) Requests (100,000 per month) HTTP/HTTPS Notifications (100,000 per month) EMAIL/ EMAIL-JSON Notifications (100,000 per month) SQS Notifications (100,000 per month) AWS Lambda (1 million per month)	$2
Amazon EC2	Operating system (Linux) Quantity (1) Pricing strategy (On-Demand Instances) Storage amount (100 GB) Instance type (`M5.2Xlarge`) - OnDemand based on the forensic analysis performed - Currently we are leveragin g Ubuntu Server 20.04 LTS (HVM) SSD Volume Type	$142

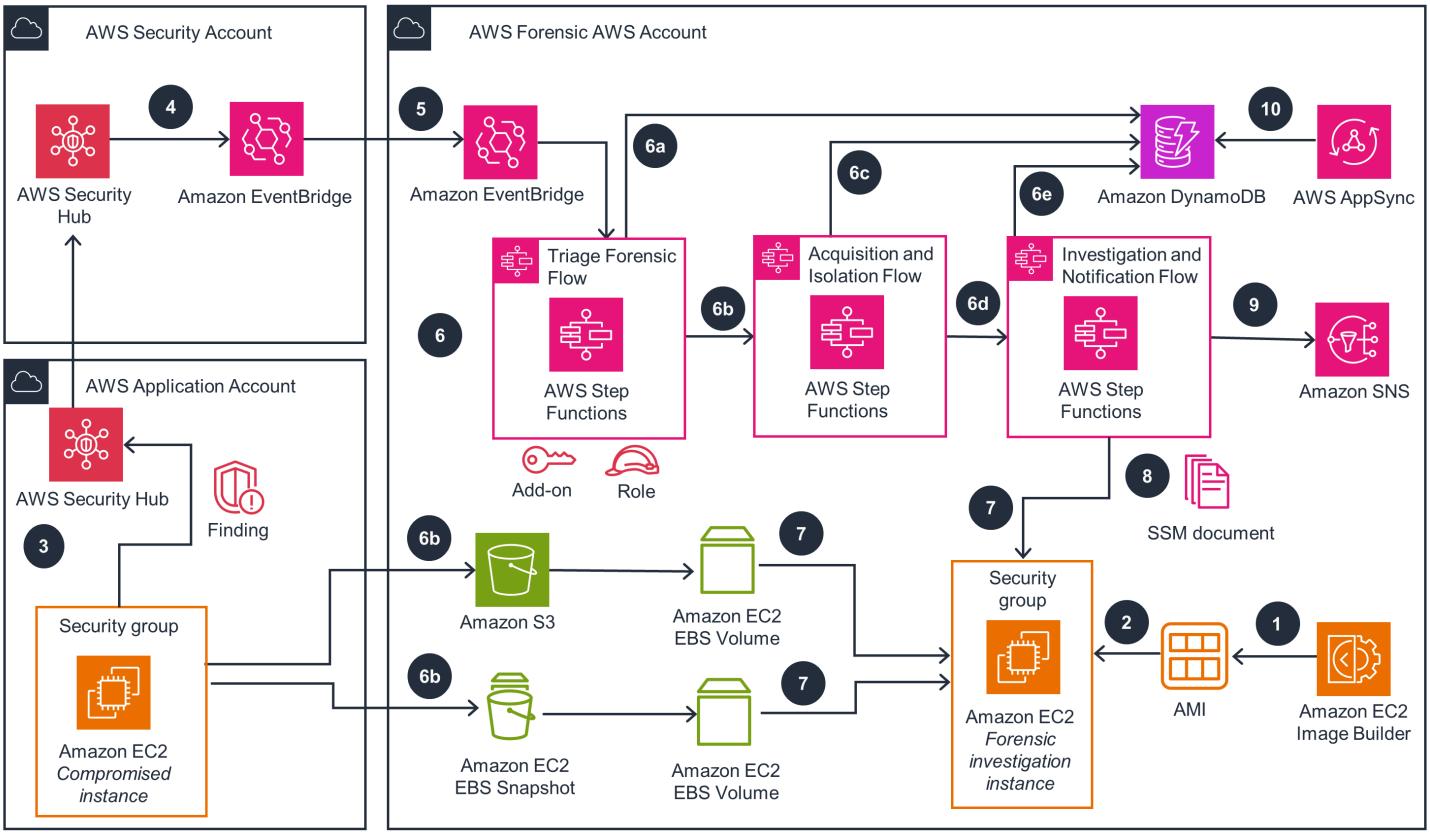
Service	Usage estimate	Monthly cost (USD)
AWS Lambda	10,000 requests, 60 seconds per lambda function, 512MB of Memory	$10
AWS KMS Key	1 KMS key, 1,990,000 requests (2,010,000 total requests - 20,000 free tier requests) x $0.03 / 10,000 requests	$7
	Total	**~$235 USD/ month**

*average usage cost of Amazon EC2

Architecture overview

Deploying this Guidance with the default parameters builds the following environment in the AWS Cloud.

Automated Forensics Orchestrator for Amazon EC2 and EKS architecture diagram



Prior to running the workflow, you will need a forensic Amazon Machine Image (AMI). You can use Amazon EC2 Image Builder to build a new forensic AMI or an existing forensic AMI. . AWS Step Functions leverages the forensic AMI to perform memory and disk investigation. . In the AWS application account, AWS Config managed rules, Amazon GuardDuty, and third-party tools detect malicious activities that are specific to Amazon Elastic Compute Cloud (Amazon EC2) and Amazon Elastic Compute Cloud (Amazon EKS) resources. For example, an EC2 instance queries a low reputation domain name that is associated with known abused domains. The findings are sent to AWS Security Hub in the security account through their native or existing integration. . By default, all Security Hub findings are then sent to Amazon EventBridge to invoke automated downstream workflows. . For a specified event, EventBridge provides an instance ID for the forensics process to target, and initiates the Step Functions workflow. . Step Functions triages the request through the

following approach: It first gets the instance information. It then determines if isolation is required based on the Security Hub action and if acquisition is required based on tags associated with the instance. Finally, it initiates the acquisition flow based on triaging output.

+ .. Amazon DynamoDB stores triaging details. .. Two acquisition flows are initiated in parallel: The Memory Forensics Flow is a Step Functions workflow that captures the memory data and stores it in Amazon Simple Storage Service (Amazon S3). Post memory acquisition, the instance is isolated using security groups. To help ensure the chain of custody, a new security group gets attached to the targeted instance and removes any access for users, admins, or developers. Isolation is initiated based on the selected Security Hub action. The Disk Forensics Flow is a Step Functions workflow that takes a snapshot of an Amazon Elastic Block Store (Amazon EBS) volume and shares it with the forensic account. .. DynamoDB stores acquisition details. .. Once the disk or memory acquisition process is complete, a notification is sent to an investigation Step Functions state machine to begin the automated investigation of the captured data. .. When the Step Functions jobs are complete, DynamoDB stores the state of forensic tasks and their results. . Investigation Step Functions starts a forensic instance from an existing forensic AMI loaded with customer forensic tools. Step Functions loads the memory data from Amazon S3 for investigation, creates an EBS volume from the snapshot, and attaches the EBS volume for disk analysis. . AWS Systems Manager documents (SSM documents) run forensic investigation. . Amazon Simple Notification Service (Amazon SNS) shares investigation details with customers. . AWS AppSync can query the forensic timeline. For more details, refer to Sample AppSync API to query forensic details.

Note

Using a forensics AMI with the required tooling, and the installed AWS Systems Manager Agent (SSM Agent), the state machine will provision an EC2 instance, attach the previously captured snapshots and mount the memory data captured, making the data ready for investigation. Systems Manager using SSM Run Command runs scripts using the forensic tools installed to perform forensic investigative processes such as timelining against the captured data.

Guidance components

The Guidance comprises of the following five key components that collaborate to provide EC2 and EKS forensic orchestration capability:

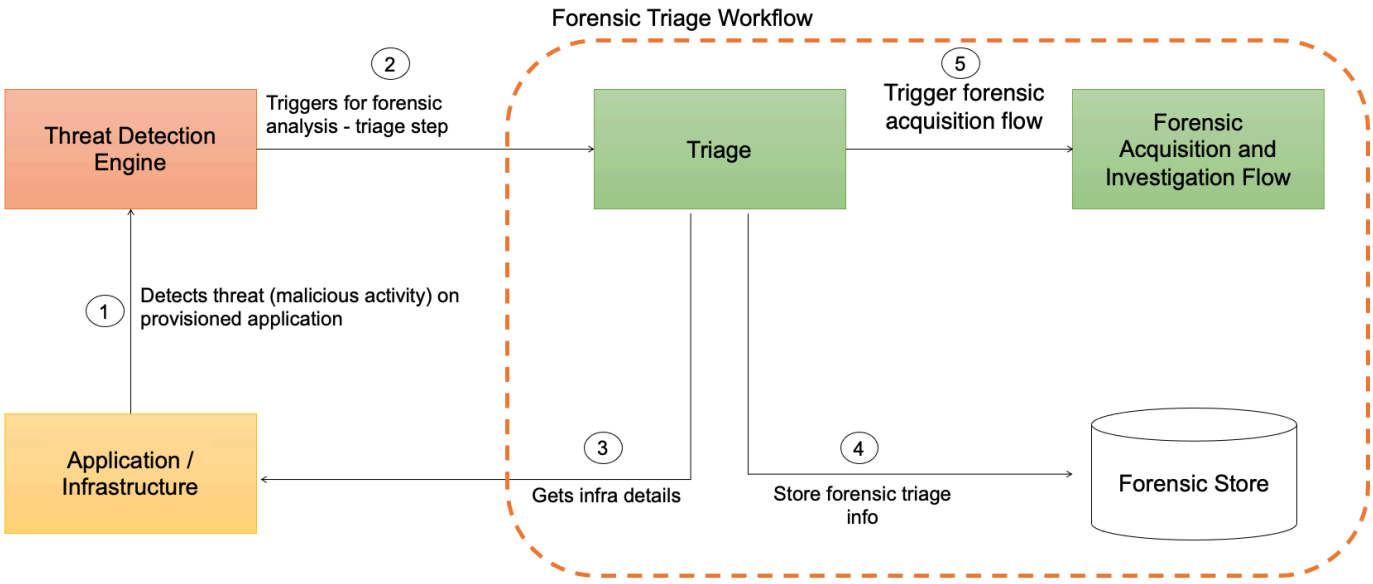
- Forensic triage service
- Forensic memory acquisition service
- Forensic disk acquisition service
- Forensic investigation and reporting service
- Forensic image and AWS Systems Manager document builder service

Forensic triage service

The diagram below represents the logical interaction view of the forensic triage service. A security event (Application security event) is reported by the Threat Detection Engine. The Threat Detection Engine initiates triaging function to determine the severity of threat based on the threat and infrastructure information. The triaging function initiates forensic acquisition and investigation flow for further analysis.

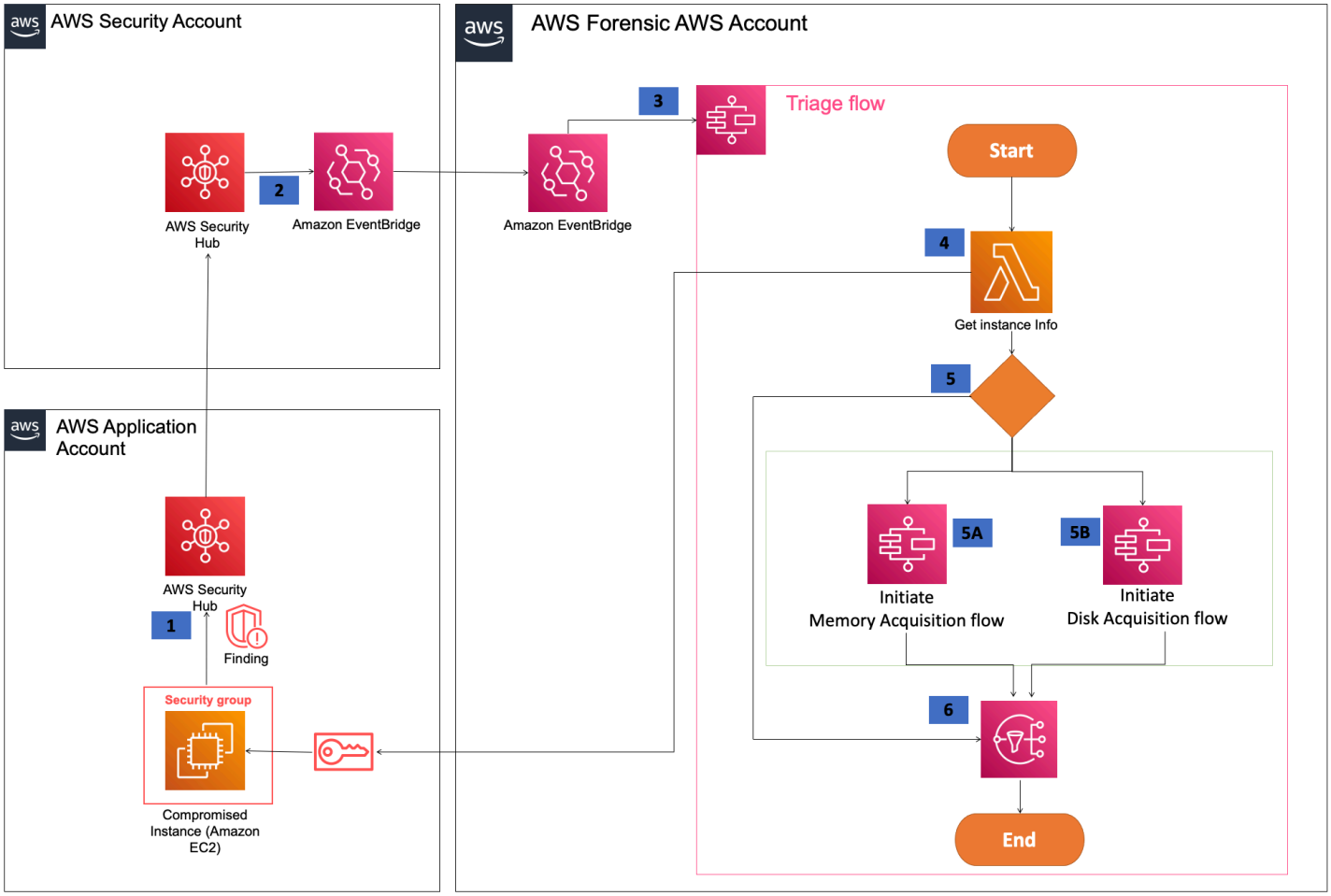
Interaction view

Forensic triage workflow



Implementation view

Forensic triage - implementation view



AWS Security Hub operating in AWS application account is reported with details of the compromised instance and the findings get aggregated to AWS Security Hub administrator AWS master Account. . The security administrator initiates one of the following forensic actions in Security Hub.

+ .. Forensic triage .. Forensic isolation . Amazon EventBridge initiates the *triage* Step Functions flow. . *Get Instance* Lambda function assumes role into compromised application account and retrieves instance information. . The *triage flow* triggers *acquisition flow* in parallel unless the instance tag **IsTriageRequired** is set to `false`.

+ .. *Forensic memory acquisition flow* initiates the memory acquisition Step Functions. .. *Forensic disk acquisition flow* initiates the disk acquisition Step Functions. . Once completed, the acquisition flow triage results are sent to SNS.

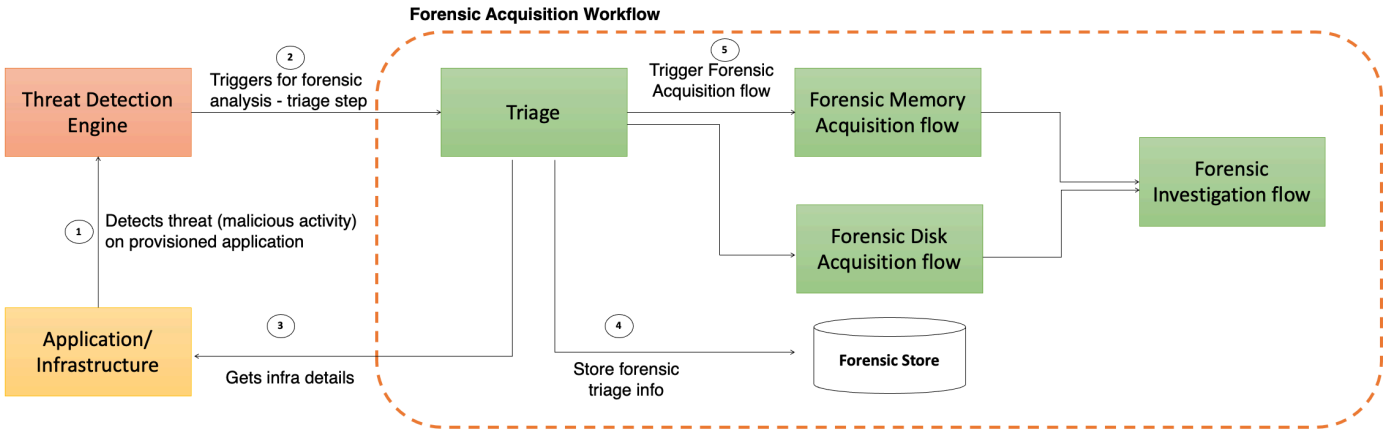
Forensic memory and disk acquisition service

The diagram below represents the logical interaction view of the forensic memory and disk acquisition service. The Forensic triaging step function initiates forensic acquisition flow to perform memory and disk acquisition. Following memory and disk acquisition, the investigation function is initiated.

Isolation of EC2 instance or EKS cluster is done based on the Security Hub action event types - Forensic triage and Forensic isolation.

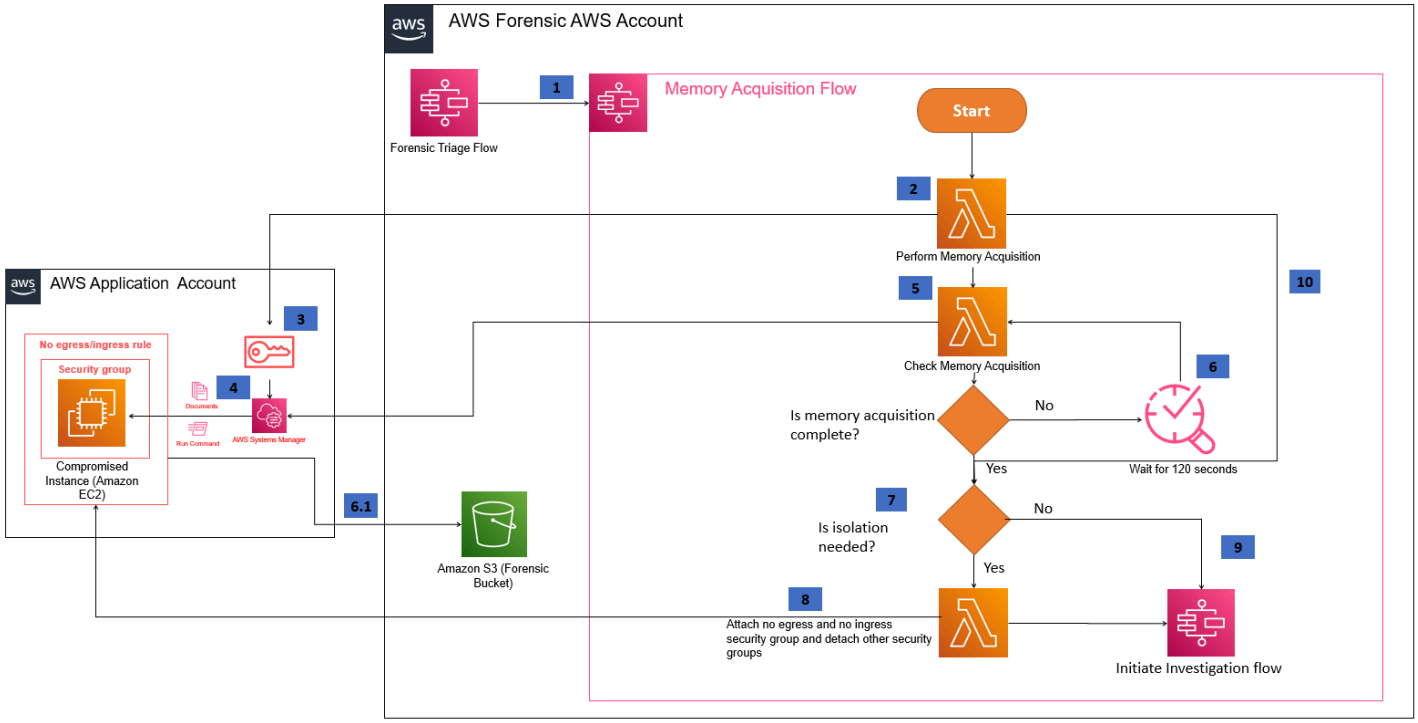
Interaction view

"Forensic memory disk acquisition



Implementation view

Memory forensics acquisition workflow implementation



The *Forensic triage* Step Function initiates the *memory acquisition* flow. . The *Memory acquisition* Lambda function in workflow leverages the SSM command to run SSM document in the compromised instance. . The *Memory acquisition* Lambda function assumes a role in the application account and passes the SSM document to be run along with credentials to copy the memory dump into an S3 bucket. . AWS Systems Manager runs a memory acquisition document via the Run Command.

+ **The memory dump is stored in an S3 bucket of the forensic account.** The memory dump has associated meta data tags to indicate the underlying OS and kernel the dump is associated with, assisting the *memory analysis flow* further downstream. . The *Check memory acquisition* Lambda function checks for SSM Run Command to be completed. . If the response from SSM Run Command status is `Pending` or `Delayed` or `In Progress`, it waits for 120 seconds. . If the response from SSM Run Command status is `Success`, it checks if isolation is needed. . If **isolation** is set to `true`, then the Lambda function assumes role into the application account and attaches a security group with no egress and ingress security group, and detaches the existing security group. Isolation is set to `true` during the triaging phase based on security event type. . This initiates investigation flow with forensic type as `MEMORY`. . If any error occurs during the memory acquisition process, the EC2 instance or EKS cluster isolation will be performed based on the `isolation` flag.

> **Note**
>
> When the isolation flag is set to `true`, isolation is still performed regardless of the memory acquisition result.

What happens to instances after isolation?

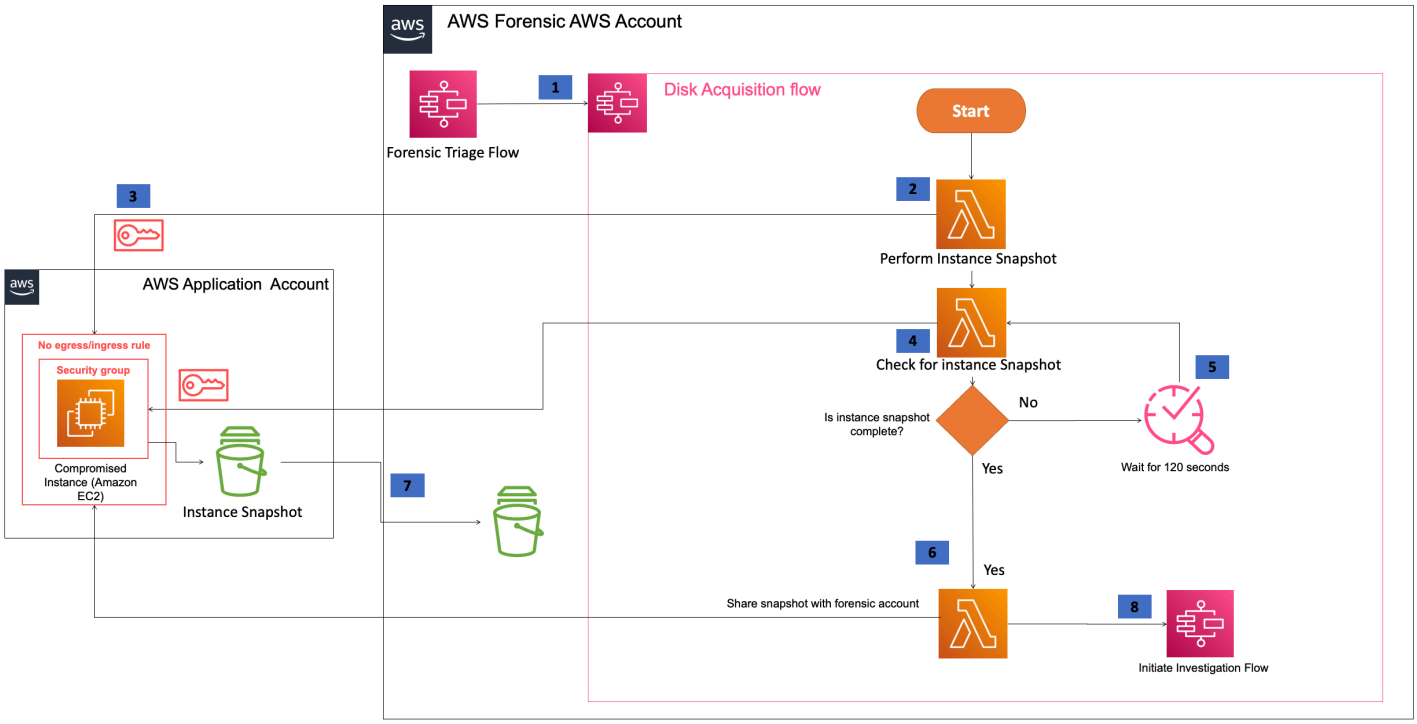
Instances after isolation will have:

- Termination protection for the compromised EC2 instance or EKS cluster is set to `true`
- Shutdown behavior set to STOP
- Any EIP assigned to the compromised instance will be disassociated
- EBS volumes attached to the compromised instance will be preserved
- Instance profile will be updated to a strict profile
- All open credentials session based on the compromised instance role will be invalidated.

> **Note**
>
> On isolation, instances sharing the same role with the compromised instance would be impacted as the credentials will be invalidated. If your application does not have the correct retry mechanism to renew new credentials, it can result in failure of the application. For more information, refer to the Using temporary credentials with AWS resources topic about creating new credentials. Applications using AWS CLI will not be impacted as the credentials will be refreshed automatically

Disk forensics acquisition workflow

Disk forensics acquisition workflow



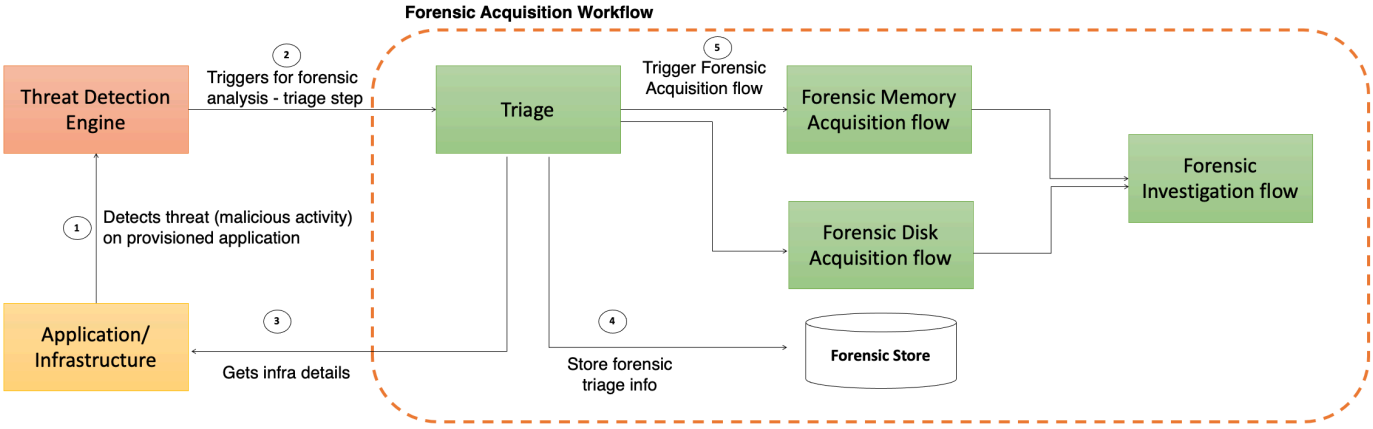
The *Forensic triage* Step Function initiates *disk acquisition flow*. . The *Perform Instance Snapshot* Lambda function performs an instance snapshot. . The *Perform Instance Snapshot* Lambda function assumes a role in the application account and initiates an instance snapshot API call. . *Check for Instance Snapshot* Lambda function assumes a role in the application account and checks for snapshot completion. . If the response is `Pending` or `In Progress` it waits for 120 seconds. . The disk acquisition flow copies the compromised instance snapshot using AWS KMS keys shared with the forensic account. . After the copy snapshot operation of the compromised instance, the disk acquisition flow shares the copied EBS snapshot with the forensic account. . To keep the copy of snapshot in the forensic account, copy the shared copy of compromised instance snapshot using Forensic KMS keys. This step allows protection of the shared snapshot with a local copy to perform forensics in case of the AWS account being compromised, or the shared snapshot being deleted by the security team. . Post copy flow the step functions initiates the investigation flow with forensic type as `DISK`.

Forensic investigation and reporting service

The diagram below represents the logical interaction view of forensic memory and disk investigation service. Once forensic acquisition is completed, forensic investigation flow is initiated, isolation of EC2 instance or EKS cluster is done based on the AWS Security Hub event type.

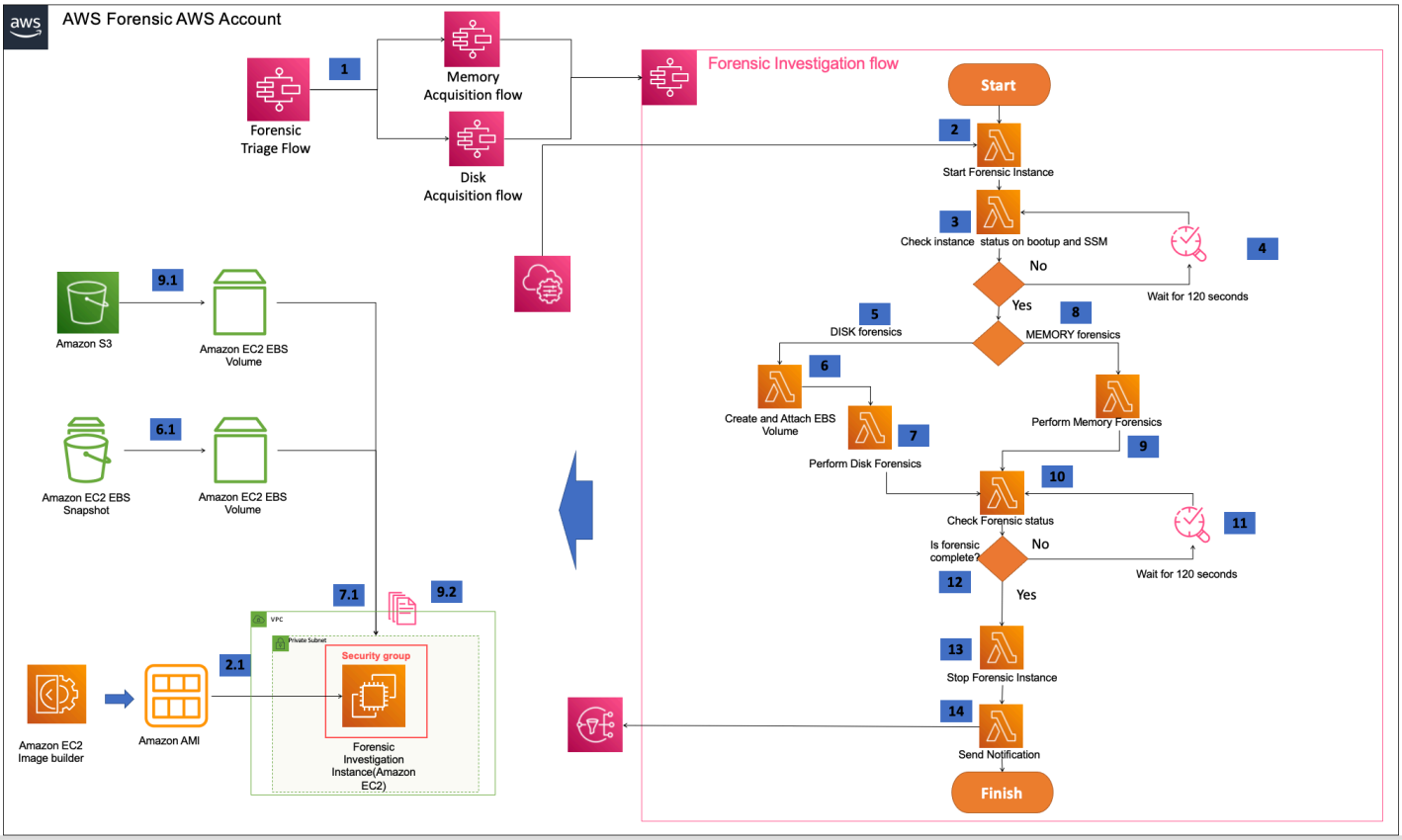
Interaction view

Forensic investigation and reporting service - interaction view



Implementation view

Forensic investigation and reporting service



Forensic investigation and reporting workflow

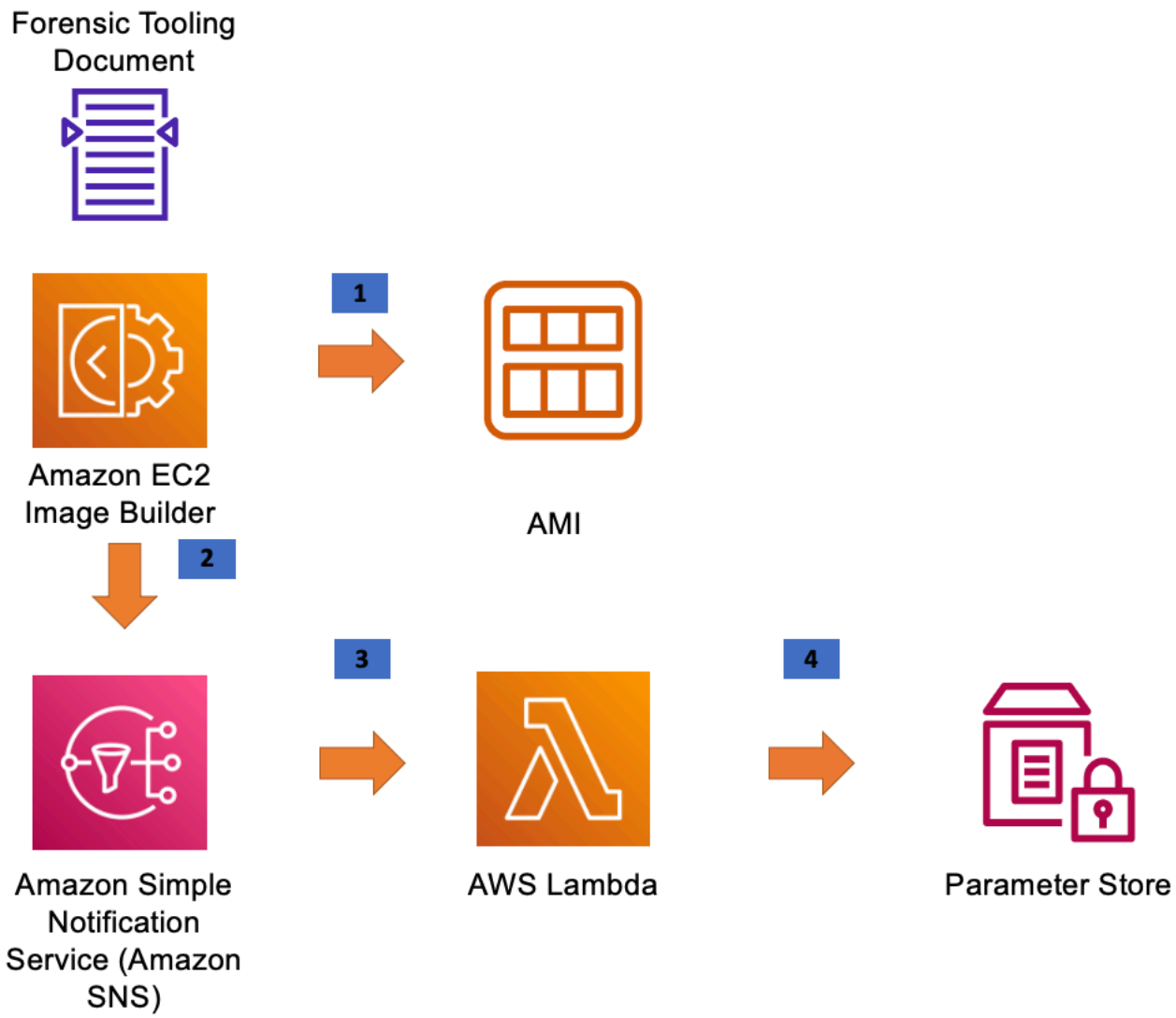
1. After the acquisition flow, the investigation flow (Step Functions) is initiated.
2. The *Create Instance* Lambda function retrieves the AMI information from AWS Systems Manager Parameter Store and starts an instance in the forensic account.
3. The *Check Instance Lambda* function validates the instance has the necessary tools required for forensic investigation, such as determining the instance is in the running state, AWS Systems Manager is installed and forensic tools are up and running.
4. If the response from SSM Command is `Pending` or `In Progress` it waits for 120 seconds and checks again.
5. Disk forensics investigation flow is initiated for **forensictype** variable set to `DISK`.
6. Disk forensics investigation lambda function creates a volume from the snapshot shared with the forensic account and attaches the volume to the instance started in step 2.
7. The Disk forensics investigation Lambda function leverages the SSM document to perform disk forensics.
8. The Memory forensics investigation flow is initiated for **forensictype** variable set to `MEMORY`.
9. The Lambda function leverages the SSM document to load memory dump from S3 to the EBS volume for memory analysis.
   - The SSM document containing details of the forensic investigation is initiated to *perform disk or memory forensics*.
   - The *Memory forensics flow* retrieves the appropriate meta data tag associated with the memory dump and loads the matching kernel Volatility symbol table from a configurable S3 location.
10. The Lambda function checks if AWS Systems Manager Run Command is complete.
11. The Lambda function waits for 120 seconds before checking again if AWS Systems Manager Run Command is complete.
12. Once complete, the *Terminate Forensic Instance* Lambda function is initiated.
13. The forensic instance is terminated.
14. Details about forensic ID, compromised Amazon EC2 instance or EKS cluster, Amazon S3 bucket location of the results, and Amazon DynamoDB table details about disk and memory analysis are sent as SNS.

Forensic image and SSM Document builder service

The forensic image builder pipeline creates the forensic AMI with necessary forensic tools needed to perform forensic investigation. The diagram below represents the overall implementation.

> **Note**
>
> Customers can use your own forensic AMI or leverage the Amazon EC2 Image Builder samples to build a forensic Image.

Forensic image and SSM document builder service



Amazon EC2 Image Builder initiates the EC2 Image Builder pipeline to build the EC2 Image based on the forensic tools configured in the document. . After successful creation of the AMI, it drops the message as an Amazon SNS topic. . The AWS Lambda function listens to the Amazon SNS topic and gets initiated for each message. . The AWS Lambda function stores the AMI ID in Parameter Store and is used to launch the forensic instance.

Security

When you build systems on AWS infrastructure, security responsibilities are shared between you and AWS. This shared model reduces your operational burden because AWS operates, manages, and controls the components including the host operating system, the virtualization layer, and the physical security of the facilities in which the services operate. For more information about AWS security, visit the AWS Cloud Security.

IAM roles

AWS Identity and Access Management (IAM) roles allow customers to assign granular access policies and permissions to services and users in the AWS Cloud. This Guidance creates IAM roles that grant the Guidance's automated functions access to perform remediation actions within a narrow scope set of permissions specific to each remediation.

AWS Key Management Service (KMS) Keys

The Automated Forensics Orchestrator for Amazon EC2 and EKS Guidance allows you to provide your own AWS KMS keys to encrypt data stored. We recommend referring to Security best practices for AWS Key Management Service to enhance the protection of your encryption keys.

AWS recommends that customers encrypt sensitive data in transit and at rest. This Guidance automatically encrypts file data, and metadata at rest with Amazon S3 Server-Side Encryption (SSE) with AES256 algorithm.

Additionally, this Guidance's Amazon DynamoDB are encrypted at rest using SSE with AWS Key Management Service (AWS KMS).

Network configuration

The Automated Forensics Orchestrator for Amazon EC2 and EKS Guidance is deployed in Amazon VPC, with the Lambda functions in a private subnet. Traffic in and out of the subnet is controlled by security groups. To prevent unauthorized access to the data storage layer, by default, the security group rules only allow inbound traffic from the Lambda function's private subnet.

Data protection

All data committed to Automated Forensics Orchestrator for Amazon EC2 and EKS is encrypted at rest, this includes data stored in Amazon S3 and Amazon DynamoDB.

Communications between the Guidance's different components are over HTTPS to ensure data encryption in transit.

Supported deployment Regions

This Guidance uses the AWS Step Functions, AWS Lambda, Amazon DynamoDB, AWS EC2 Image Builder, Amazon CloudWatch, Amazon SQS, which are currently available in specific AWS Regions only. Therefore, you must launch this Guidance in an AWS Region where these AWS services are available. For the most current service availability by Region, refer to the AWS Regional Services List.

Automated Forensics Orchestrator for Amazon EC2 and EKS can be deployed in the following AWS Regions in accordance with the regional availability of its constituent services:

Region ID	Region name
us-east-1	US East (N. Virginia)
us-east-2	US East (Ohio)
us-west-1	US West (N. California)
us-west-2	US West (Oregon)
ap-southeast-1	Asia Pacific (Singapore)
ap-southeast-2	Asia Pacific (Sydney)
ap-southeast-3	Asia Pacific (Jakarta)
ap-northeast-1	Asia Pacific (Tokyo)
ap-northeast-2	Asia Pacific (Seoul)
ap-northeast-3	Asia Pacific (Osaka)
ap-south-1	Asia Pacific (Mumbai)
ca-central-1	Canada (Central)
eu-west-1	Europe (Ireland)
eu-west-2	Europe (London)

Deployment

Before you launch the Guidance, review the architecture, Guidance components, security, and design considerations discussed in this guide. Follow the step-by-step instructions in this section to configure and deploy the Guidance into your account.

Time to deploy: Approximately 30 minutes

Prerequisites

Tools

- The latest version of the AWS CLI (2.2.37 or newer), installed and configured.
- The latest version of the AWS CDK V2 (2.2 or newer).
- A CDK bootstrapped forensic AWS account and Security Hub account.
- NodeJS version 16.
- Ensure GraphQL - AppSync is activated in the forensic AWS account.
- AWS SSM agent is installed in EC2 instances or EKS clusters (Application Instances).
- AWS Security Hub must be activated as the Guidance creates custom action in AWS Security Hub.
- Python version 3.8 or above

Forensic AMI

Build a forensic AMI and update the AWS Systems Manager Parameter Store with AMI ID. For more details, refer to Sample steps to create Forensic AMI using EC2 Image Builder. Be sure to replace the image builder component yml with the sample `san-sift.yml` provided in the forensic Guidance.

> **Note**
>
> This Guidance requires knowledge of SAN SIFT, LiME and Volatility tools to customize deployment the Guidance based on your forensic requirements. For more information, refer to the Post deployment: Plugin points section.

Compromised instance memory size and investigation instance mount disk volume

The investigation instance mount volume must always be greater than the memory of the compromised instance. This ensures that memory loaded into investigation instance does not error out. The Guidance uses `M5.2Xlarge` Amazon EC2 instance type by default.

CDK context configurations

CDK config	Description
ec2ForensicImage	Forensic AMI name stored in SSM Parameter Store. SSM Parameter Store will contain AMI ID of forensic investigation instance prebuilt with forensic tools. Guidance is tested with Ubuntu AMI.

Deployment overview

Use the following steps to deploy this Guidance on AWS. For detailed instructions, follow the links for each step,

The Guidance is deployed in the following three AWS accounts:

1. Forensic AWS account - Core Guidance components to perform forensics orchestration
2. Security Hub AWS account - Configure events and custom actions to trigger forensic orchestration flow
3. Application AWS account - IAM roles needed to establish trust between Forensic AWS account and Application AWS account

Deploying this Guidance is a three-step process.

1. Forensic Orchestrator Guidance deployment in the *Forensic AWS Account.*
2. AWS Security Hub configuration to add custom actions to trigger forensics from AWS Security Hub in the *Security Hub AWS account.*

3. *Application AWS Account* deployment to establish trust relationship with the Forensic AWS account.

> **Note**
>
> The Automated Forensics Orchestrator for Amazon EC2 and EKS can also be deployed in Security Hub AWS account. Use existing VPC steps to deploy AWS Security Hub configuration in Security Hub AWS account.

Forensic Orchestrator Guidance deployment in Forensic AWS account

The following steps deploy the Forensics Orchestrator AWS Step Functions, AWS Lambda, and AWS SSM documents into the Forensic AWS account.

1. In your terminal, clone the Guidance's source code from the GitHub repository.

```
git clone link:https://github.com/aws-solutions-library-samples/automated-forensic-orchestrator-for-amazon-ec2.git
```

2. Navigate to the source code folder created in step 1.

```
cd automated-forensic-orchestrator-for-amazon-ec2/source
```

> **Note**
>
> To deploy into existing VPC update `cdk.json` to configure **isExistingVPC** to `true` and add **vpcID** to **vpcConfigDetails** in `cdk.json`.

```
"vpcConfigDetails": {
            "isExistingVPC": true,
            "vpcID": "vpc-1234567890"
            "enableVPCEndpoints": false,
            "enableVpcFlowLog": false
}
```

3. Set AWS credentials to deploy into the AWS account.

```
AWS_ACCESS_KEY_ID=<your_access_key_id>
```

```
export AWS_SECRET_ACCESS_KEY=<your_secret_access_key>
```

```
export AWS_SESSION_TOKEN=<your_session_token>
```

```
export AWS_REGION=<Your Region - us-east-1>
```

4. Install the required NPM libraries.

```
npm ci
```

5. Compile and build AWS Lambda functions.

```
npm run build
```

6. Build the forensics AWS CloudFormation stack to be deployed in the forensic AWS account.

```
cdk synth -c account=<Forensic AWS Account Number> -c region=<Region>
 -c sechubaccount=<Security Hub Aggregator Account Number> -c
 STACK_BUILD_TARGET_ACCT=forensicAccount
```

   a. Build the necessary CDK CFN templates for deploying forensic stack. Example:

```
cdk synth -c account=1234567890 -c sechubaccount=0987654321 -c region=us-east-1 -c
 STACK_BUILD_TARGET_ACCT=forensicAccount
```

7. Deploy the forensics stack in the forensic AWS account.

```
cdk deploy --all -c account=<Forensic AWS Account Number> -c region=<Region> --
require-approval=never -c sechubaccount=<Security Hub Aggregator AWS Account Number>
 -c STACK_BUILD_TARGET_ACCT=forensicAccount
```

   Example command that deploys Forensic Guidances stack:

```
cdk deploy --all -c sechubaccount=0987654321 -c
 STACK_BUILD_TARGET_ACCT=forensicAccount -c account=1234567890 -c region=us-east-1 --
require-approval=never
```

Security Hub aggregator account deployment in a new VPC

As described above, the Guidance has a dependency on Security Hub to initiate the forensics orchestration. To initiate the forensic Step Functions deployed in the forensic account from AWS Security Hub findings through custom actions present in AWS Security Hub account, deploy the following stack in Security Hub aggregator AWS account.

> **Note**
>
> If you are reusing the existing downloaded code delete the `cdk.out` folder.

1. Clone the Guidance source code from AWS Solutions Library Samples GitHub repository.

```
git clone link:https://github.com/aws-solutions-library-samples/automated-forensic-
orchestrator-for-amazon-ec2.git
```

2. Navigate to the cloned repository created in step 1.
3. Navigate to the source folder.

```
cd automated-forensic-orchestrator-for-amazon-ec2/source
```

> **Note**
>
> To deploy into existing VPC update `cdk.json` to configure **isExistingVPC** to `true` and add **vpcID** to the vpcConfigDetails in the `cdk.json` file.

```
"vpcConfigDetails": {
            "isExistingVPC": true,
            "vpcID": "vpc-1234567890"
            "enableVPCEndpoints": false,
```

```
            "enableVpcFlowLog": false
}
```

4. Set AWS credentials to deploy into the AWS account.

```
export AWS_ACCESS_KEY_ID=<your_access_key_id>
```

```
export AWS_SECRET_ACCESS_KEY=<your_secret_access_key>
```

```
export AWS_SESSION_TOKEN=<your_session_token>
```

```
export AWS_REGION=<Your Region -us-east-1>
```

1. Install the required NPM libraries.

```
npm ci
```

2. Compile and build AWS Lambda functions.

```
npm run build
```

3. Build the forensics Security Hub AWS CloudFormation stack to be deployed in Security Hub aggregator account.

```
cdk synth -c sechubaccount=<SecHub Account Number> -c
 forensicAccount=<ForensicAccount> -c forensicRegion=us-east-1 -c sechubregion=us-
east-1 -c STACK_BUILD_TARGET_ACCT=securityHubAccount
```

   Example:

```
cdk synth -c sechubaccount=0987654321 -c forensicAccount=1234567890
 -c forensicRegion=us-east-1 -c sechubregion=us-east-1 -c
 STACK_BUILD_TARGET_ACCT=securityHubAccount
```

4. Deploy the forensics Security Hub stack in the Security Hub aggregator account.

```
cdk deploy --all -c sechubaccount=0987654321 -c account=<Security
 Hub AWS AccountNumber> -c region=us-east-1 --require-
```

```
approval=never -c forensicAccount=<Forensic AWS AccountNumber> -c
 STACK_BUILD_TARGET_ACCT=securityHubAccount -c sechubregion=us-east-1
```

Example:

```
cdk deploy --all -c sechubaccount=0987654321 -c account=0987654321 -c
 region=us-east-1 --require-approval=never -c forensicAccount=1234567890 -c
 STACK_BUILD_TARGET_ACCT=securityHubAccount -c sechubregion=us-east-1
```

Application account deployment

1. Download the cross-account-role.yml file to your local hard drive.
2. Deploy the `/deployment-prerequisties/cross-account-role.yml` template file as an AWS CloudFormation stack in the application account, and pass the forensic account as input parameter. This will establish a trust relationship between the forensic components deployed in the forensic account and the application account.

```
aws cloudformation deploy --template-file /deployment-prerequisties/
cross-account-role.yml --stack-name app-stack --parameter-overrides
 solutionInstalledAccount=<Forensic Solution AWS Account Number>
 solutionAccountRegion=us-east-1 kmsKey=<ARN of the application account EBS volume
 encryption KMS key>
```

Support for Red Hat Enterprise Linux (RHEL 8.6 and above)

Starting from the current version (1.2.0), the Guidance supports Red Hat Enterprise Linux (RHEL) 8.6 and above. To use RHEL as the target, you must build a symbol based on the target RHEL.

> **Note**
>
> You will only need to build this once per RHEL version.

To build a symbol:

1. After you deploy the Guidance, navigate to the AWS Management Console where you have deployed the Guidance.

2. Navigate to **Step Functions**, and select the `Forensic-Profile-Function` step function
3. To initiate the build, add these input parameters.

```
{
    "amiId": "ami-0b6c020bf93af9ce1",
    "distribution": "RHEL8"
}
```

where `ami-0b6c020bf93af9ce1` is the base image Amazon Machine Image (AMI) for RHEL8

> **Note**
>
> You will need a Red Hat subscription before you add this. For more information, refer to the Linux platforms page.

The `Forensic-Profile-Function` step function will build the symbol automatically. Once the symbol is built, the Guidance will support RHEL8.

Post deployment: Plugin points

The Guidance is designed to be an orchestrator and therefore allows the following plugin points where you can replace existing tooling with your preferred tool of choice. The Guidance leverages LiME for memory capture and Volatility 3 for memory investigation.

1. A LiME module and volatility symbol table for the EC2 instance must be prebuilt and available for forensic memory investigation and investigation for the EC2 instances OS and kernel version. Refer to Plugin points to build the LiME module and volatility symbol table.
2. The prebuilt LiME module and volatility symbol table must be stored in the Guidance's S3 bucket. The artifacts can be stored in the bucket created by the forensic Guidance in `cdk.json`. The prefix to the artifacts and the S3 bucket can be configured in `cdk.json` as context variable.

Memory forensics analysis using LiME and Volatility 3

As described in Memory forensics acquisition workflow implementation, memory forensics is implemented using Step Functions, which provides the orchestration mechanism and tuns the AWS Systems Manager automation documents. These automation documents can be partially or fully

replaced. In the example below, we have bootstrapped our memory forensics implementation to acquire memory using LiME, and to use the *Volatility 3* profile. LiME is used to extract the volatile memory, which is then analyzed downstream by the Forensics investigation workflow.

When memory is investigated using Volatility 3 (and other tools) it is important for the tool to understand the structure of the memory. In Volatility 3, that is done using symbol tables which is comprised of two parts: a Debugging With Attribute Record Formats (DWARF) and a map (symbol table used by the kernel) file. The section below demonstrates how the process flow works and ensures that it can be extended by creating a new profile and dropping it into a configurable location (bucket).

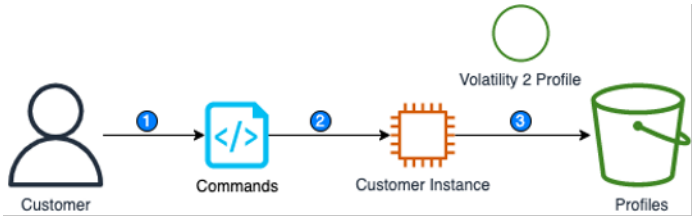
> **Note**
>
> As every OS and kernel versions have slight variations, you must create LiME and Volatility artifacts specific to the EC2 instance or EKS cluster, and make these artifacts available to the orchestrator during run-time.

In the section below, we walk through how you can build the LiME module and Volatility profile using an SSM document.

Steps to build LiME module and volatility profile using SSM document

The below diagram explains the overall architecture of building volatility profile.

steps to build volatility profile using SSM document



The diagram below details the usage of a Volatility profile in the memory investigation flow.

usage of a volatility profile in the memory investigation flow

image::images/volatility-profile-using-ssm-flow.png[scaledwidth=100%]. Launch an Amazon EC2 instance (Amazon Linux 2) to build a LiME module volatility profile. Ensure the SSM is

appropriately configured on the EC2 instance or EKS cluster. Record the instance ID. . Navigate to the AWS Systems Manager documents and select the previously created SSM document example **Documents** tab. Record the name of the SSM document to build the profile.

+ .SSM document image::images/ssm-document.png[scaledwidth=100%] Run AWS SSM document to build LiME module and Volatility 3 symbol tables for a launched Amazon EC2 instance or EKS cluster that matches the OS and kernel version.

+ NOTE: Currently the profile and tools are loaded into the S3 bucket for Amazon Linux EC2 instance. For other operating systems, modify the SSM document to create Volatility profiles.

Automate the creation of LiME and Volatility 3 symbol tables

You can incorporate the module build process for LiME and Volatility (or your preferred forensic tools) into a hardened AMI pipeline prior to allowing AMI use by developers and application teams. These modules are prerequisites for running the Automated Forensics Orchestrator for Amazon EC2 and EKS Guidance to allow the capture and analysis of volatile memory. You also need to incorporate a mechanism to build these modules for the specific kernel versions in the event they do not exist. This can occur if an EC2 instance or EKS cluster is updated after being launched or if an EC2 instance or EKS cluster was launched from a non-hardened AMI that is not managed by a central team.

For more information, refer to the How to automatically build forensic kernel modules for Amazon Linux EC2 instances blog, which will walk you through deploying a Guidance to automatically build modules for specific EC2 instance or EKS cluster OS kernel versions based on input parameters of AMI ID and kernel version. You can use the blog Guidance with the Automated Forensics Orchestrator for Amazon EC2 and EKS Guidance in the event that specific kernel module versions are missing and need to be created.

Usage of Forensic Guidance

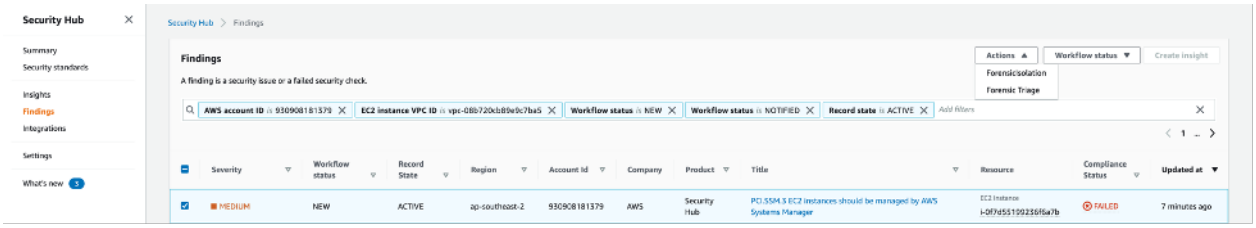
Step 1. Sign in to the Security Hub AWS Account AWS Management Console and initiate forensic analysis

After the Guidance CloudFormation stack has been deployed and launched, you can sign in to the web interface.

1. Sign in to the AWS Security Hub console.

2. To display a finding list, do one of the following:
   a. In the Security Hub navigation pane, choose **Findings**.
   b. In the Security Hub navigation pane, choose **Insights**. Select an insight, and then on the results list, select an insight result.
   c. In the Security Hub navigation pane, choose **Integrations**. Choose **See findings** for an integration.
3. Select the finding title.
4. Select the instance findings to trigger forensics.
5. In **Actions** , you can select:
   a. **Forensic Isolation** to initiate forensic analysis and perform isolation of instance.
   b. **Forensic Triage** to initiate forensic analysis.

Forensic analysis - Actions



Step 2. Sign in to the Forensic AWS Account AWS Management Console and view step functions flow

1. Sign in to the AWS Step Functions console.
2. After completion of triaging, an acquisition and investigation flow email will be sent to subscribed SNS topic.

Acquisition and investigation flow notification

image::images/investigation-flow-sns.png[scaledwidth=100%]. Check email for details of the forensic results.

Example Disk Analysis result:

Example - Disk Analysis result

image::images/disk-analysis-result.png[scaledwidth=100%]+

Example Memory Analysis result:

+ .Example - Memory Analysis result image::images/memory-analysis-result.png[scaledwidth=100%]

Sample AppSync API to query forensic details

To query forensic information, AppSync provides the following queries.

Query	Description
`allForensicRecords`	Gets all the forensic records. It can be filtered by: `* awsAccountId * awsRegion * completionTime * creationTime * diskAnalysisStatus * diskAnalysisStatusDescription * id * lastUpdatedTime * memoryAnalysisStatus * memoryAnalysisStatusDescription * resourceId * resourceInfo * resourceType * triageStatus * triageStatusDescription`
`getForensicRecord`	Gets all forensic records based on ForensicID
`listForensicRecordsForAccount`	Lists forensic records by account.
`listForensicRecordsForRegion`	Lists forensic records by account and Region.
`listForensicRecordsForResource`	Lists forensic records by account, Region and ResourceType.
`timelineEventsForRecord`	Gets timeline of events by ForensicID.

Performance considerations

SSM command timeout

For memory acquisition, memory investigation, and disk investigation SSM documents are leveraged. The timeout is set to 4,000 seconds by default. You can modify the value based on the type of compromised instance. For more details, refer to the following documentation:

- Handling timeouts in runbooks
- Understanding command statuses

Compromised instance memory size and investigation instance mount disk volume

The investigation instance mount volume must always be greater than the memory of the compromised instance. This ensures that memory loaded into investigation instance does not error out. The Guidance uses `M5.2Xlarge` Amazon EC2 instance type by default.

AWS services used in this Guidance

Name	Description
AWS Lambda	AWS Lambda is a serverless, event-driven compute service that lets you run code for virtually any type of application or backend service without provisioning or managing servers. You can initiate Lambda from over 200 AWS services and software-as-a-service (SaaS) applications, and only pay for what you use. *AWS Lambda functions are leveraged to perform forensic actions.*
Amazon DynamoDB	Amazon DynamoDB is a fully managed, serverless, key-value NoSQL database designed to run high-performance applicati ons at any scale. DynamoDB offers built-in security, continuous backups, automated multi-region replication, in-memory caching, and data export tools. *Forensic steps are recorded in Amazon DynamoDB for post analysis.*
Amazon S3	Amazon Simple Storage Service (Amazon S3) is an object storage service that offers industry-leading scalability, data availabil ity, security, and performance. This means customers of all sizes and industries can use it to store and protect any amount of data for a range of use cases, such as data lakes, websites, mobile applications, backup and restore, archive, enterprise applicati ons, IoT devices, and big data analytics.

Name	Description
	Amazon S3 provides easy-to-use managemen t features so you can organize your data and configure finely-tuned access controls to meet your specific business, organizational, and compliance requirements. Amazon S3 is designed for 99.999999999% (11 9's) of durability, and stores data for millions of applications for companies all around the world. *Forensic tools, images and other artifacts are stored in Amazon S3.*
Amazon CloudWatch	Amazon CloudWatch is a monitoring and observability service built for DevOps engineers, developers, site reliability engineers (SREs), and IT managers. CloudWatch provides you with data and actionable insights to monitor your applications, respond to system-wide performance changes, optimize resource utilization, and get a unified view of operation al health. CloudWatch collects monitoring and operational data in the form of logs, metrics, and events, providing you with a unified view of AWS resources, applications, and services that run on AWS and on-premises servers. You can use CloudWatch to detect anomalous behavior in your environments, set alarms, visualize logs and metrics side by side, take automated actions, troubleshoot issues, and discover insights to keep your applications running smoothly. *Forensic orchestration is logged and monitored using Amazon CloudWatch.*

Name	Description
Amazon EventBridge	Amazon EventBridge is a serverless event bus that makes it easier to build event-driven applications at scale using events generated from your applications, integrated Software-as-a-Service (SaaS) applications, and AWS services. EventBridge delivers a stream of real-time data from event sources such as Zendesk or Shopify to targets like AWS Lambda and other SaaS applications. You can set up routing rules to determine where to send your data to build application architectures that react in real-time to your data sources with event publisher and consumer completely decoupled.
Amazon SNS	Amazon Simple Notification Service (Amazon SNS) is a fully managed messaging service for both application-to-application (A2A) and application-to-person (A2P) communication. The A2A pub/sub functionality provides topics for high-throughput, push-based, many-to-many messaging between distributed systems, microservices, and event-driven serverless applications. Using Amazon SNS topics, your publisher systems can fanout messages to a large number of subscriber systems including Amazon SQS queues, AWS Lambda functions and HTTPS endpoints, for parallel processing, and Amazon Data Firehose. The A2P functionality enables you to send messages to users at scale via SMS, mobile push, and email. *Forensic notification and reporting is done via Amazon SNS.*

Name	Description
Amazon EC2 Image Builder	EC2 Image Builder simplifies the building, testing, and deployment of Virtual Machine and container images for use on AWS or on-premises. *Amazon EC2 Image Builder can be leveraged to create forensic AMI.*
AWS Step Functions	AWS Step Functions is a low-code visual workflow service used to orchestrate AWS services, automate business processes, and build serverless applications. Workflows manage failures, retries, parallelization, service integrations, and observability so developers can focus on higher-value business logic_. AWS Step Functions is leveraged to implement Forensic Orchestration flow._

Uninstall the Guidance

Using the AWS Command Line Interface (CLI)

- Run `cdk destroy --all` from the `sources` folder, or
- Delete the stack from the CloudFormation console in Forensic, Application, and Security Hub AWS Account.

Using the AWS Management Console

1. Sign in to the AWS CloudFormation console.
2. On the **Stacks** page, select this Guidance's installation stack.
3. Choose **Delete**.

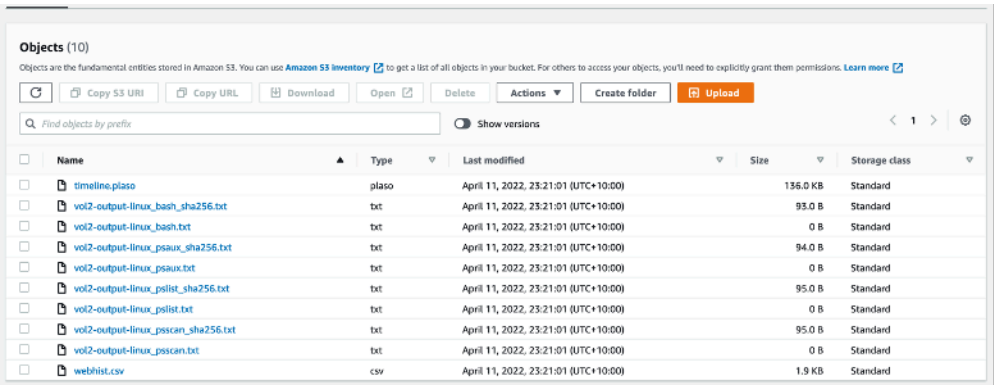
Troubleshooting

This section provides troubleshooting instructions for deploying and using the Guidance.

Zero-byte files reported as part of memory and disk investigation

Issue : The memory analysis and disk analysis results in S3 could result in zero-byte files.

Troubleshooting - zero-byte files



This could be a problem with the Volatility symbol table. Review the symbol table associated with the instance as well as the error logs in the Run Command history.

Troubleshooting - Run Command history

```
Cloning into 'volatility'...
fatal error: An error occurred (404) when calling the HeadObject operation: Key
"volatility2/profiles/5.10.102-99.473.amzn2.x86_64.zip" does not exist
Volatility Foundation Volatility Framework 2.6.1
Volatility Foundation Volatility Framework 2.6.1
ERROR : volatility.debug : Invalid profile selected
```

Resolution : This is caused due to an error in SSM document run. Review the SSM error to fix the SSM document. It is necessary to review the Volatility symbol table and kernel version to ensure it matches the kernel version of running on the compromised EC2 instance.

ForensicSecHubStack failed to deploy

Issue : ForensicSecHubStack failed to deploy. Received response status [FAILED] from custom resource. Message returned: InvalidAccessException: An error occurred (InvalidAccessException)

when calling the CreateActionTarget operation: Account *<Account>* is not subscribed to AWS Security Hub. See details in CloudWatch Log Stream.

Resolution : Activate Security Hub and redeploy ForensicSecHubStack.

(Optional) Additional configuration: Cloud9 environment setup

1. Ensure Python version is 3.8 and above.
2. Set up Python version 3.8 if it is not available (link:https://docs.aws.amazon.com/cloud9/latest/user-guide/sample-python.html).

```
sudo amazon-linux-extras enable python3.8
sudo yum install python3.8
sudo update-alternatives --install /usr/bin/python python
alias python='python3.8'
sudo python -m pip install pip-tools
python -m pip install pip-tools
```

3. (Optional) Update `/source/lambda/requirements.txt` as cloud9 does not support specific versions.

```
arnparse
aws-xray-sdk
boto3
botocore
certifi
charset-normalizer
codeguru-profiler-agent
future
idna
jmespath
jsonpickle
python-dateutil
python2-secrets
requests
s3transfer
six
urllib3
wrapt
```

Guidance customizations

Forensic investigation instance

We recommend using `M5.2Xlarge` instance to perform memory and disk investigation, and initial mount disk volume size as 512 GB to support up to 512 GB of memory. Based on the forensic tools, you can modify the instance type post deployment.

You can update this configuration based on the memory of the compromised instance.

1. Download the CLI tool to manage a SIFT install.

```
wget link:https://github.com/teamdfir/sift-cli/releases/download/v1.13.1/sift-cli-linux
wget link:https://github.com/teamdfir/sift-cli/releases/download/v1.13.1/sift-cli-linux.sig
wget link:https://github.com/teamdfir/sift-cli/releases/download/v1.13.1/sift-cli.pub
```

2. Replace the Image Builder document in `san-sift.yml` with S3 copy commands.

   Sample S3 command:

```
aws s3 cp s3://mybucket/san-sift
```

> **Note**
>
> The Guidance uses SANS SIFT to build necessary tools required to perform forensic investigation, and the Amazon EC2 Image Builder to build SANS SIFT image.

AWS Systems Manager documents

The Guidance uses SSM documents to perform memory acquisition, memory investigation, and disk investigation. You can update the tools leveraged in memory acquisition, memory investigation, and disk investigation with other tools based on forensic requirements.

Memory acquisition

For memory acquisition, the Guidance provides a sample SSM document, which leverages Linux Memory Extractor (LiME) to perform memory acquisition.

You can update the memory acquisition step with other tools by updating the SSM commands. The sample command clones the GitHub link to set up LiME in the compromised instance. The updated SSM command below downloads the LiME components from an internal S3 bucket to the AWS account.

In SSM document `linux_lime-memory-acquisition.json`, change the following sample command from:

```
git clone link:https://github.com/504ensicsLabs/LiME
```

to:

```
aws s3 cp s3://mybucket/Lime
```

Memory investigation

You can update the memory investigation step with other tools by updating the SSM commands. The sample command clones the GitHub link to set up Volatility in the compromised instance. The updated command below downloads the Volatility components from an internal S3 bucket to the AWS account. The Guidance depends on the Volatility symbol table of the OS and kernel version of the compromised instance. The Volatility symbol table is a prerequisite to perform memory investigation.

For memory investigation, the Guidance provides a sample SSM document which leverages Volatility 3 to perform memory investigation.

In SSM document `lime-memory-load-investigation.json`, change the following command from:

```
git clone link:https://github.com/volatilityfoundation/volatility.git
```

to the sample command:

```
aws s3 cp s3://mybucket/volatility
```

Disk investigation

For disk investigation, the Guidance provides the sample command leveraging `log2timeline` to perform disk investigation.

You can update the memory investigation step with other tools by updating the SSM commands. The current sample leverages the SANS SIFT image which contains Plaso in the forensic instance.

> **Note**
>
> The forensic tools code shared in the section are example codes. You are responsible for managing and maintaining the tools used in the Guidance.

Customization of CDK context configurations

CDK config	Default value	Description
diskSize	`512`	Determines the disk size of forensic investigation instance. We recommend allocating the disk size more than RAM for the compromised instance.
vol3-symboltables-bucket	n/a - leverages the bucket created	Bucket to store Volatility symbol tables based on kernel version of the compromised instance to perform memory forensics. Ensure forensic investigation IAM role is updated to and has read-only access to S3 bucket.
vol3-symboltables-key	`/volatility3/symboltables/`	Prefix in the vol3-symboltables-bucket to store the symbol tables.

CDK config	Default value	Description
customerManagedCMKArns: { forensicsnsEncryptionKey: ""}	n/a	KMS key to encrypt the messages sent to SNS topic.
customerManagedCMK Arns:{ forensicBucketEncr yptionKey: ""}	n/a	KMS key to encrypt the objects stored in Amazon S3.
customerManagedCMKArns: { ebsVolumeKey: ""}	n/a	KMS key to encrypt to EBS Volume.
ssmExecutionTimeout	`1800`	SSM timeout to perform forensic operation. It is set to `1800` seconds by default.
forensicBucketComp lianceMode	`false`	True sets S3 object lock retention mode to complianc e else to governance. Refer to S3 Object Lock for more details.
forensicBucketRete ntionDays	`30`	Configures the retention period that protects an object version for a fixed amount of time.
applicationAccounts	*	Contains the list of all accounts the forensic functions can assume role, and perform memory and disk acquisition.
ssm-documents-dir	`0/ssm-documents`	SSM directory in source code to load SSM documents into forensic account as part of the deployment.

CDK config	Default value	Description
ForensicImageName	`sansift`	Forensic AMI name stored in SSM Parameter Store. SSM Parameter Store will contain AMI ID of forensic investiga tion instance prebuilt with forensic tools.
ForensicIsolationInstancePr ofileName	`target_profile_name`	Customer profile for isolation . By default it would be the profile provided by this Guidance's CDK stack.
vpcInfo	[source,json] ---- "vpcInfo": { "vpcCidr": "10.1.0.0/16", "ma xAZs": 2, "bastionInstance": false, "enableVpcFlowLog": true, "enableVPCEndpoints": true, "subnetConfig": [{ "cidr Mask": 24, "name": "external DMZ", "subnetType": "Public" }, { "cidrMask": 24, "name ": "service", "subnetType": "Private" }, { "cidrMask": 24, "name": "database", "subnetType": "Isolated" }, { "cidrMask": 24, "name": "internalDMZ", "subnetType": "Isolated" }] } ----	Contains VPC configurations to create a new VPC.
vpcConfigDetails	[source,json] ---- "vpcConf igDetails": { "isExistingVPC": false, "enableVPCEndpoints" : false, "enableVpcFlowLog": false } ----	Contains details about existing VPC configurations [source,json] ---- "isExist ingVPC": false, "vpcID": "vpc-1234567890", ----

CDK config	Default value	Description
deployApi	`false`	Setting it to `true` deploys GraphQL API. Setting it to `false` will not deploy GraphQL API.
apiNotifications	`false`	Setting it to `true` turns on GraphQL API notification. Setting it to `false` turns off GraphQL API notification.
apiAllowedIps	[]	Provides list of all IPs allowed to access AppSyncAPI. WAF is configured to restrict the IP address.
apiRateLimit	`1000`	WAF is configured with `ratelimit .`

Additional resources

AWS services	
* AWS Identity and Access Management (IAM) * Amazon Virtual Private Cloud (Amazon VPC) * AWS Lambda * Amazon Simple Storage Service (Amazon S3) * Amazon DynamoDB * Amazon EventBridge	* Amazon CloudWatch * AWS X-Ray * Amazon Simple Queue Service (Amazon SQS) * AWS Step Functions * AWS Security Hub * Amazon GuardDuty

Source code

Visit our GitHub repository to download the source files for this Guidance and to share your customizations with others. The Amazon Forensic Orchestrator for Amazon EKS and EKS templates are generated using the AWS Cloud Development Kit (AWS CDK). Refer to the README.md file for additional information.

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Revisions

Visit the CHANGELOG.md in our GitHub repository to track version-specific improvements and fixes.

Notices

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