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FOR509.2 | Enterprise Cloud Forensics and Incident Response

Amazon AWS

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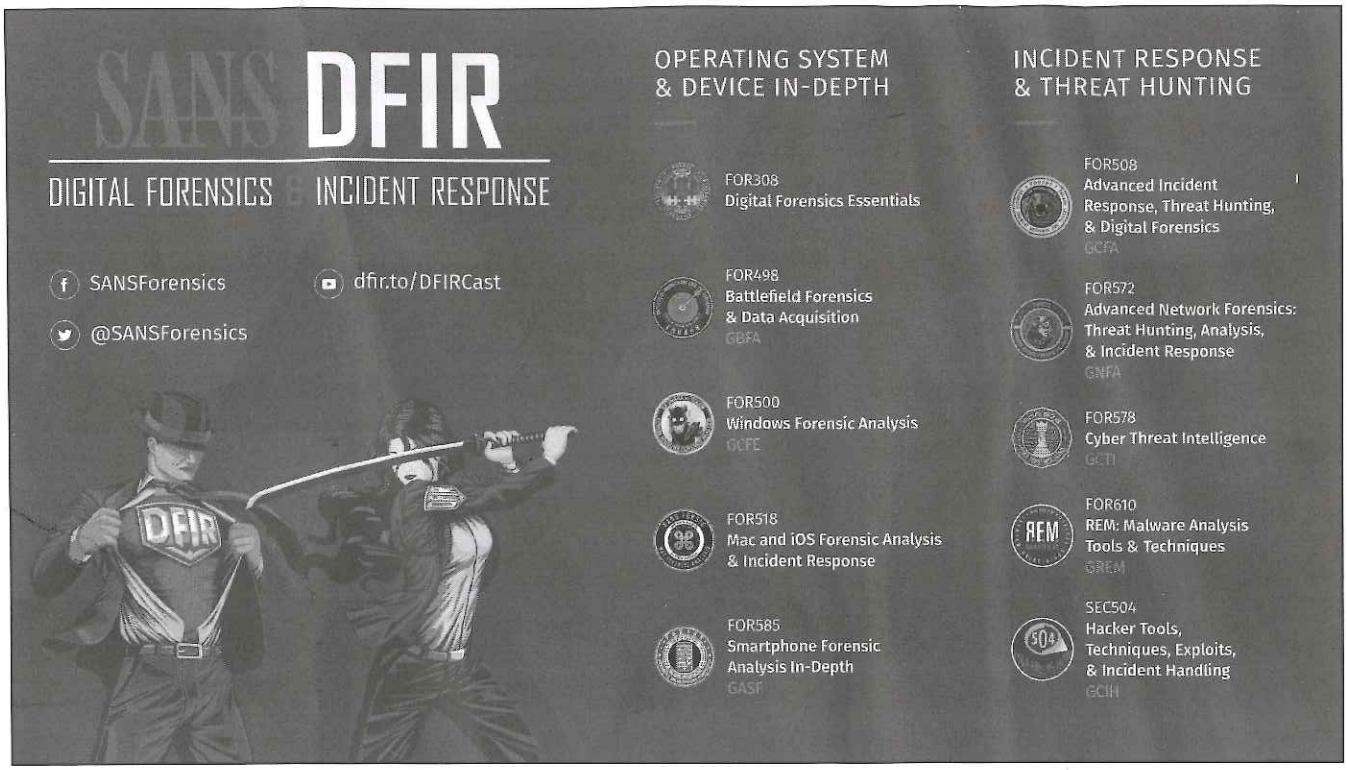

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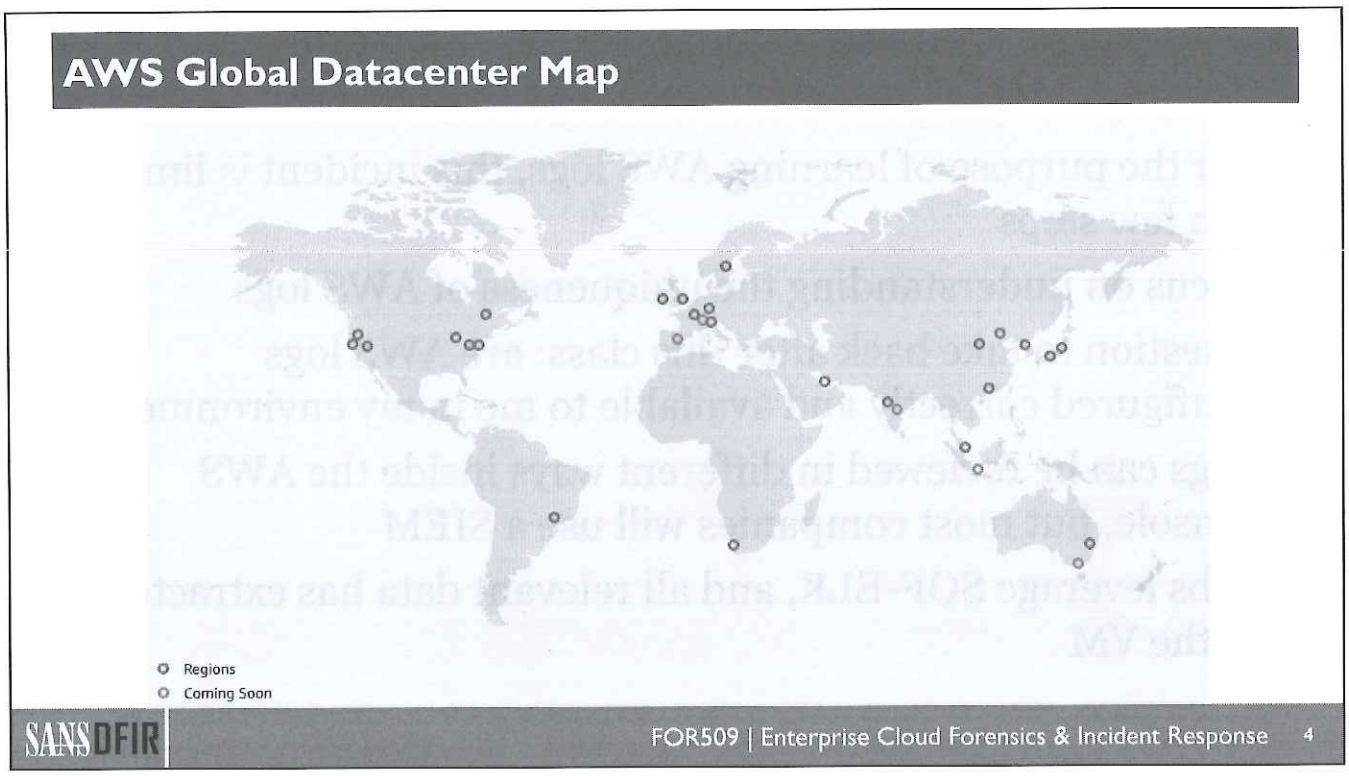
Sample Incident: Pymtechlabs

- For the purpose of learning AWS logs, this incident is limited to a few steps
- Focus on understanding the uniqueness of AWS logs
- Question to take back after this class: are AWS logs configured correctly and available to me in my environment?
- Logs can be reviewed in different ways inside the AWS console, but most companies will use a SIEM
- Labs leverage SOF-ELK, and all relevant data has extracted to the VM

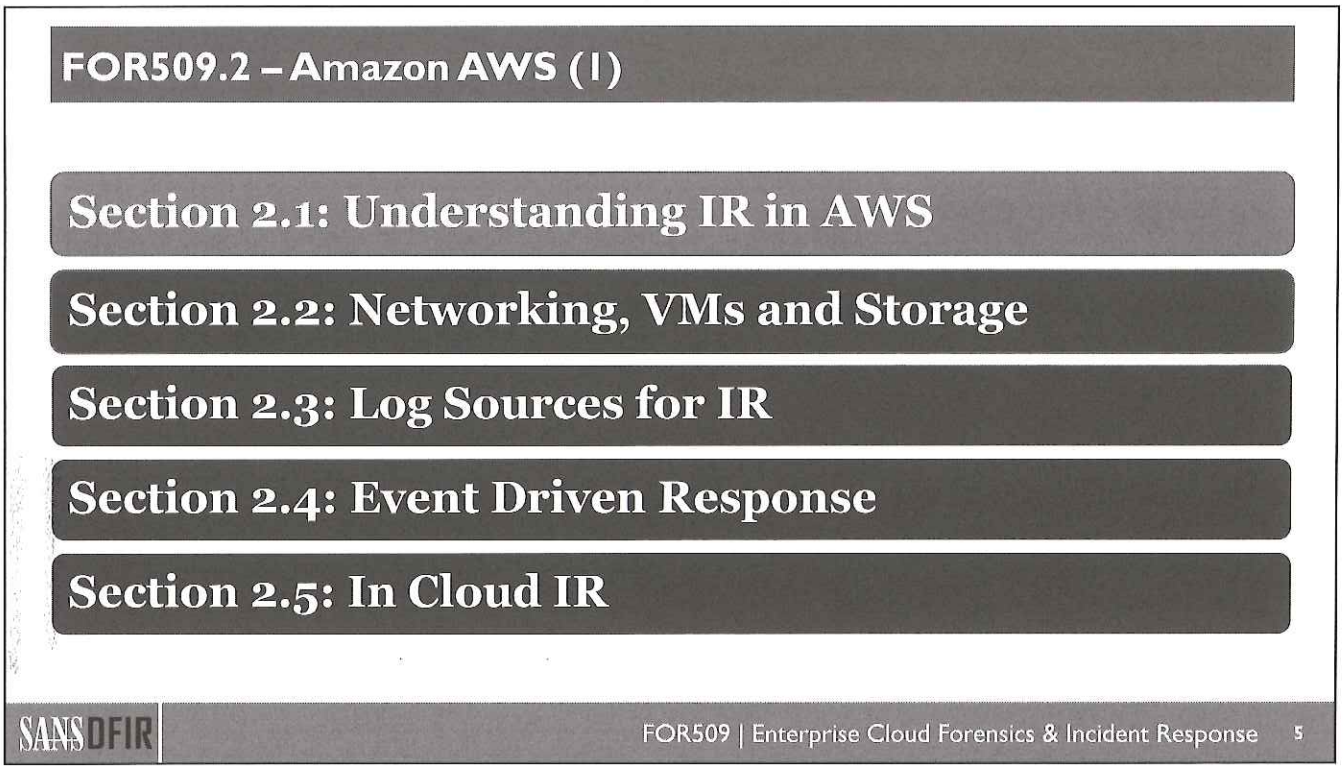
To further the educational experience, we have created a simple scenario that will facilitate learning about the different logs. All the data has been imported into SOF-ELK to facilitate your analysis.



Credit: Amazon AWS

Picture as of 4/17/21

Source: https://aws.amazon.com/about-aws/global-infrastructure/



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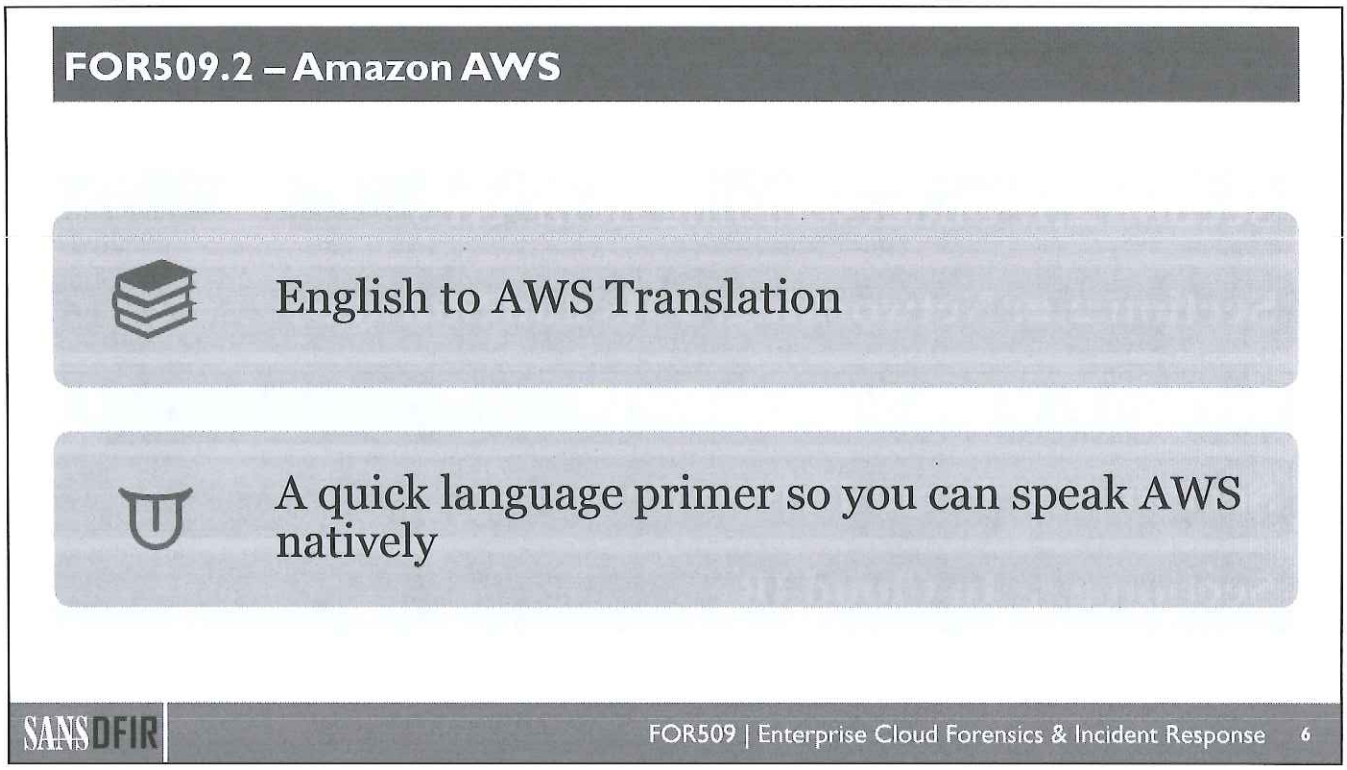


This section will introduce you to the language of AWS. The major services that are involved with most environments as well as the forensic data we can expect to receive from them. This course is not meant to teach how to configure, maintain or deploy AWS services but how to investigate and respond to breaches within them.

When talking to AWS professionals having the ability to speak their language will go a long way in their ability to assist you in your investigation.

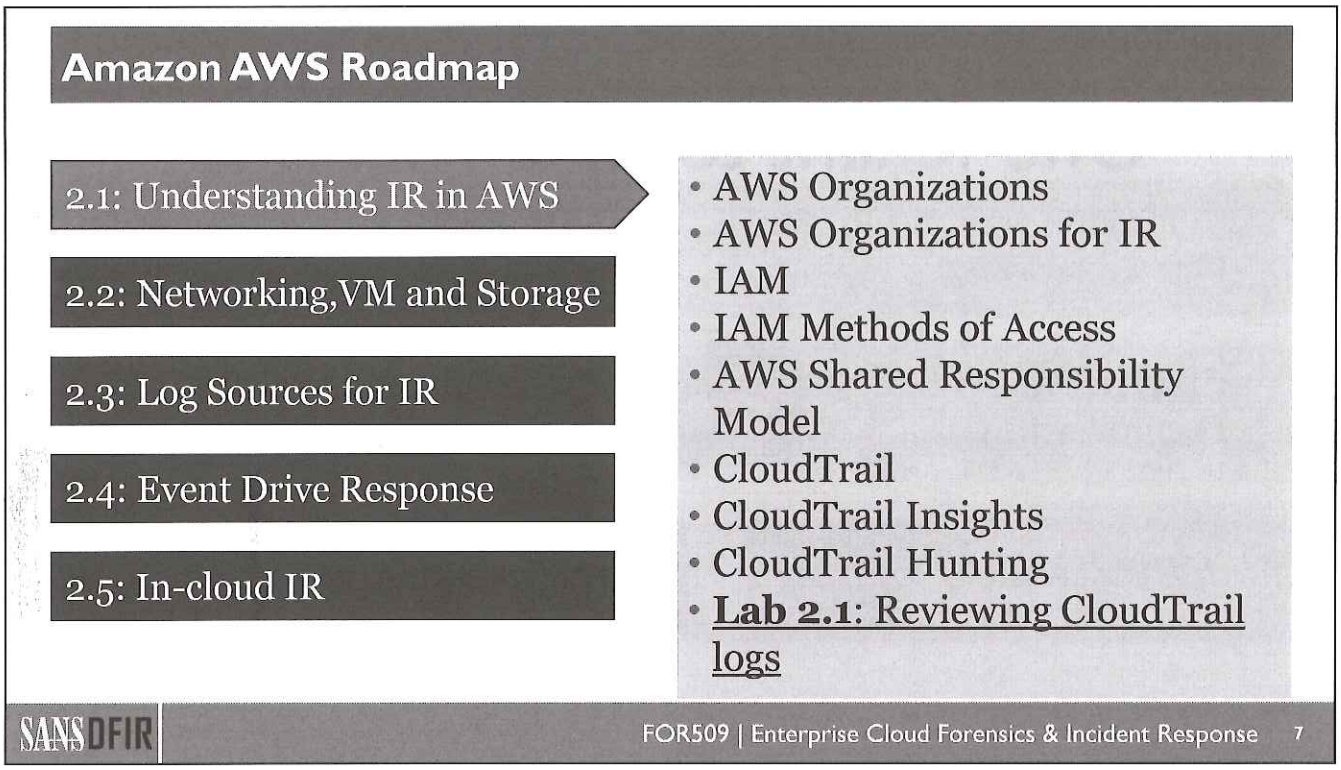
For instance here are several questions that result in good forensic data:

"Where do you store CloudTrail logs?

"Do you have flow logs for this VPC?"

"Can this AKS cluster reach the metadata service?"

Don't understand what all these things mean? No problem that's what this section will help you understand while making sure those in the AWS world can understand you!



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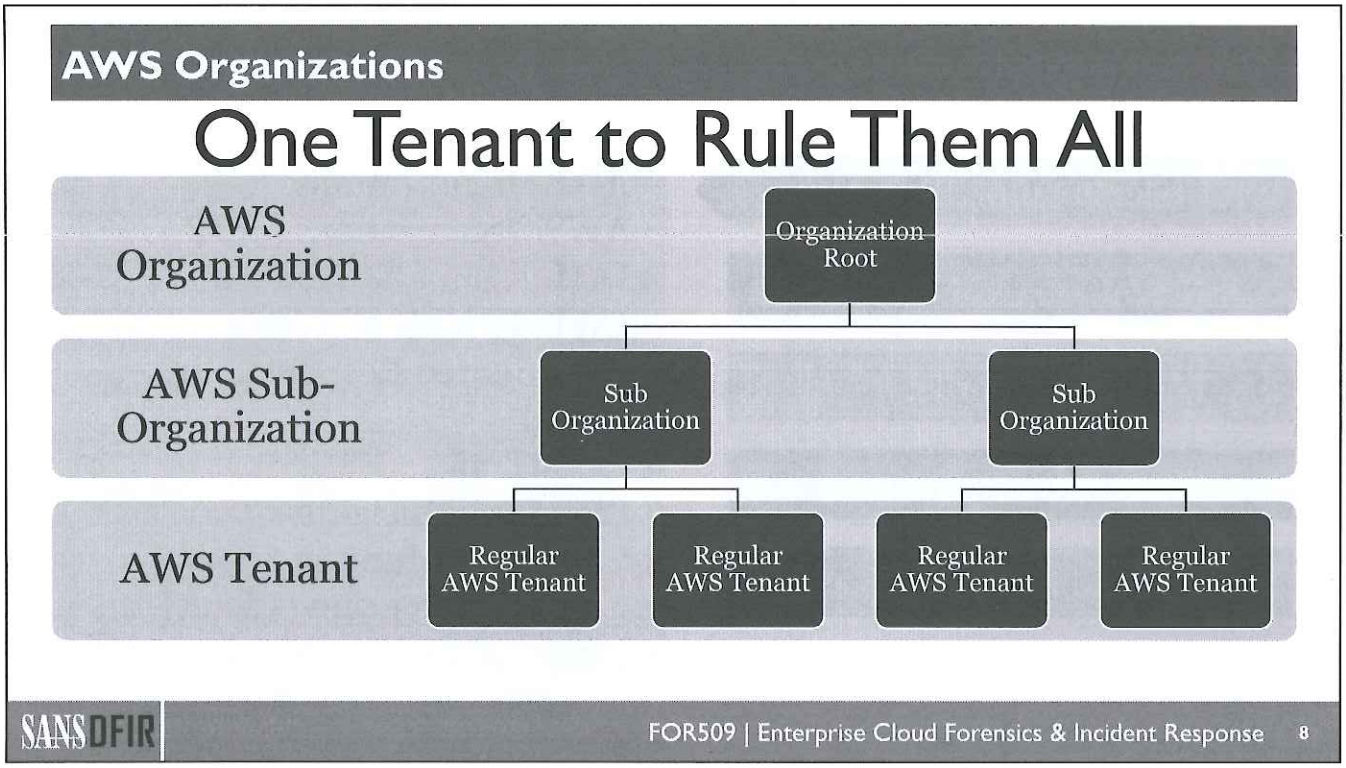
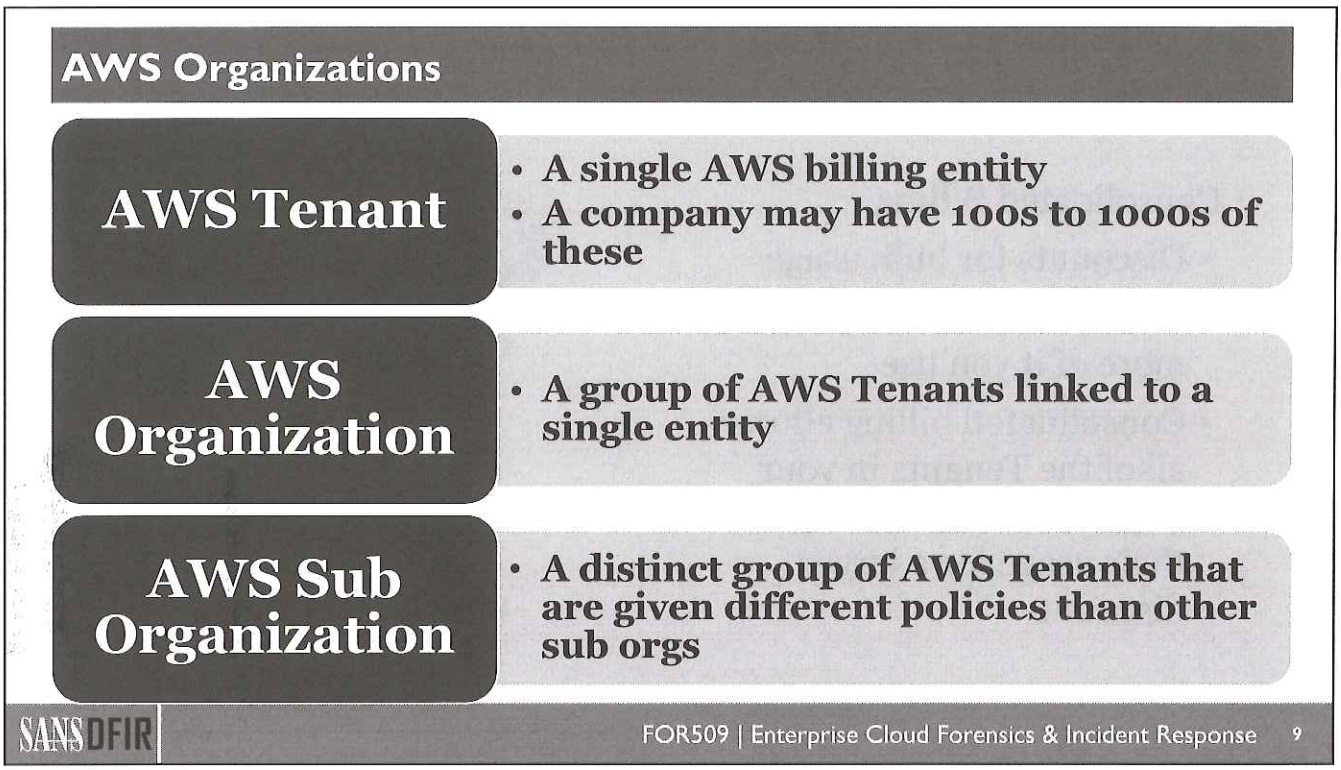


AWS Organizations are a way to group all your companies AWS Tenants into one tree so that you can:

- Manage access between AWS Tenants
- Establish single sign on across your AWS Tenants
- Recognize cost savings by allowing you usage to be accumulated across all Tenants for volume discounts

You can learn more about them here: https://aws.amazon.com/organizations/



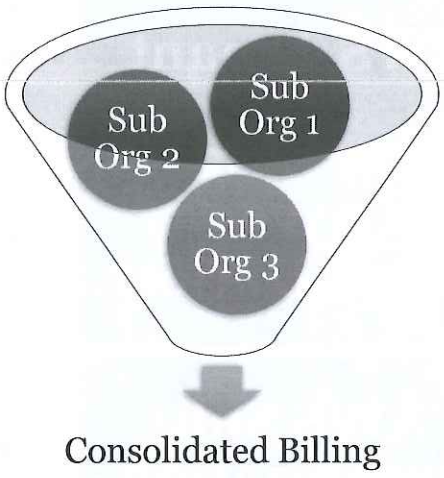
AWS Tenant – A single AWS tenant that you've created with Amazon Web services. If you've just started with AWS, then you likely have one of these. In large organizations each department could have an AWS Tenant per project, per group or per department. It's not unusual as cloud adoption grows to find over 100 AWS tenants operating for one company.

AWS Organization – A group of AWS Tenants with one tenant serving as the master.

AWS Sub Organization -

Why use Organizations? (1)

- Consolidated Billing
  - Discounts for bulk usage
  - AWS Provides discounts the more of it you use
  - Consolidated billing allows all of the Tenants in your Organization to add up all their usage for a larger discount



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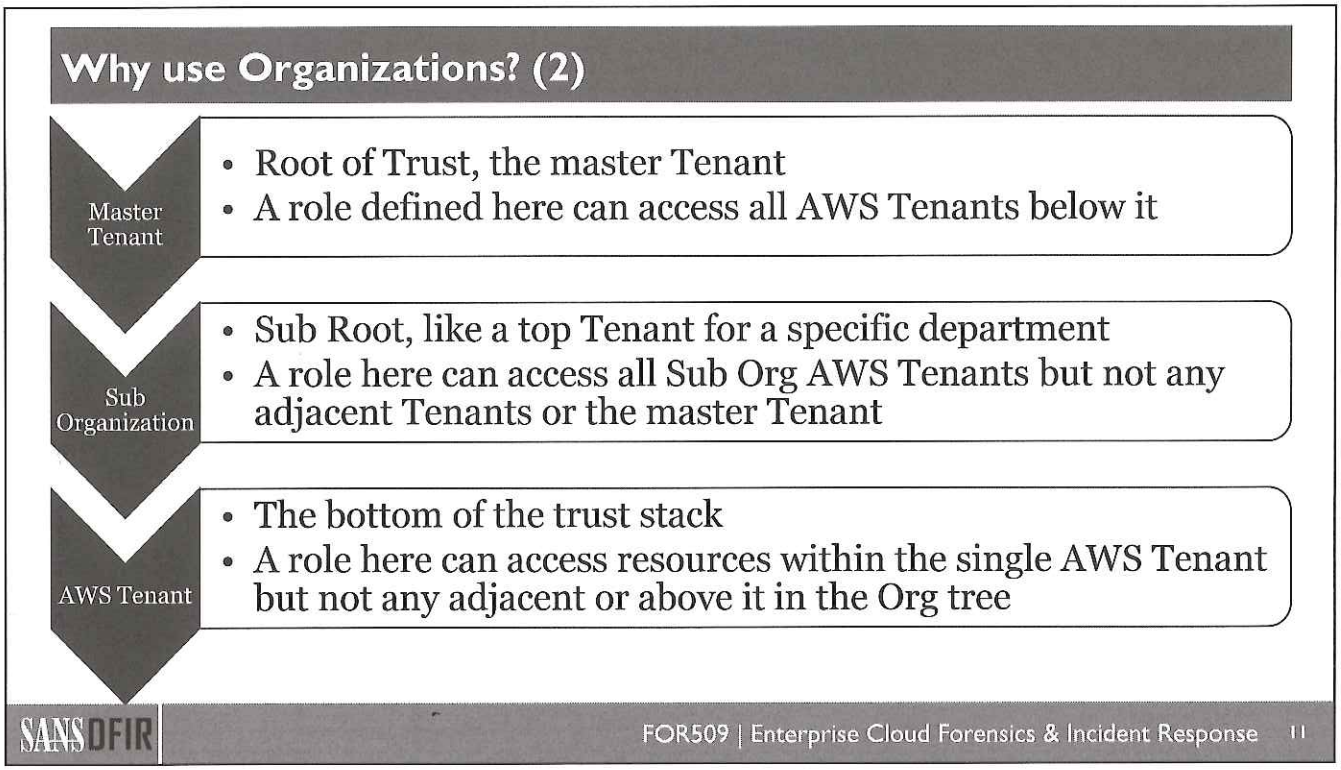

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IR Roles in Organizations

Automatic Write Blocking!

You can define read only global access too:

S3 Buckets
EC2 Virtual Machines
EBS Data Stores
Databases
Containers
And More!

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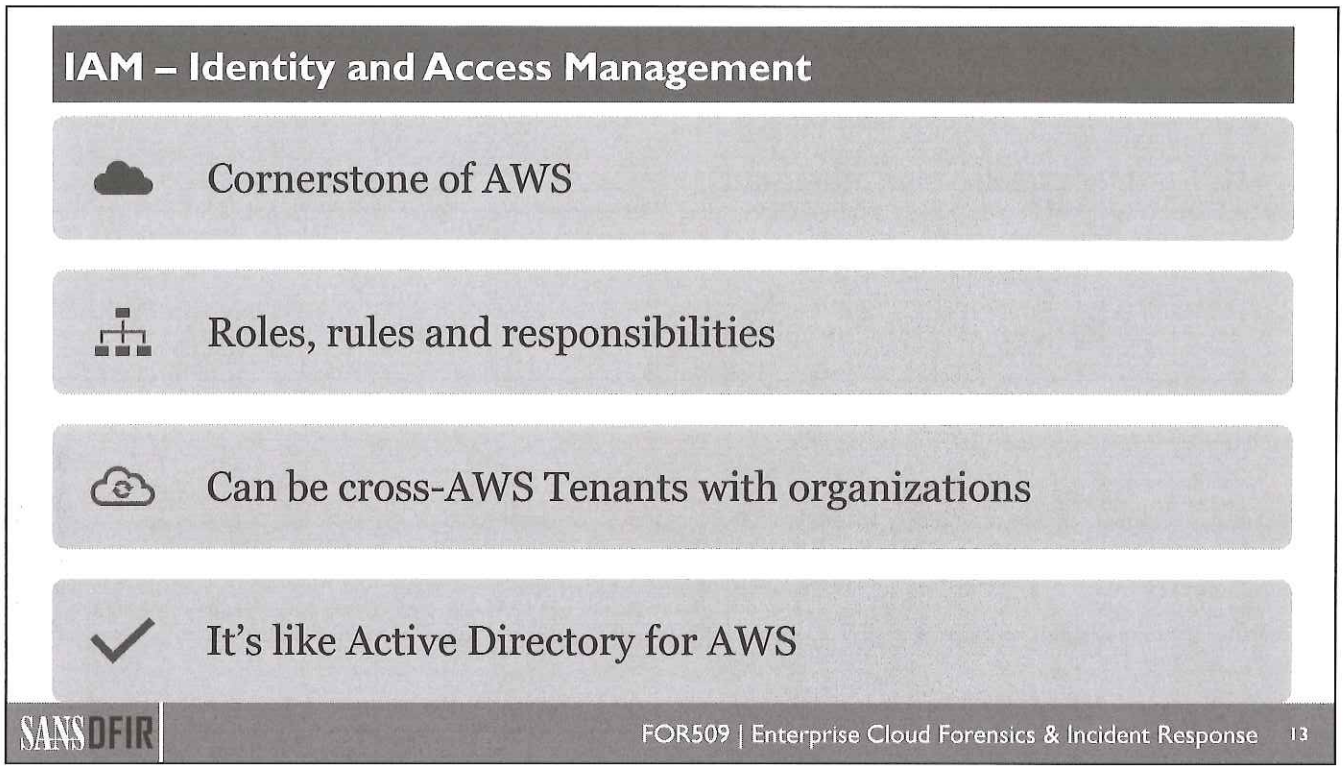

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Ways of Accessing AWS

Username and password = Tired

API Key = The New Normal

SAML Token = Cool Kids Club

IAM Roles Assigned = Robot Uprising

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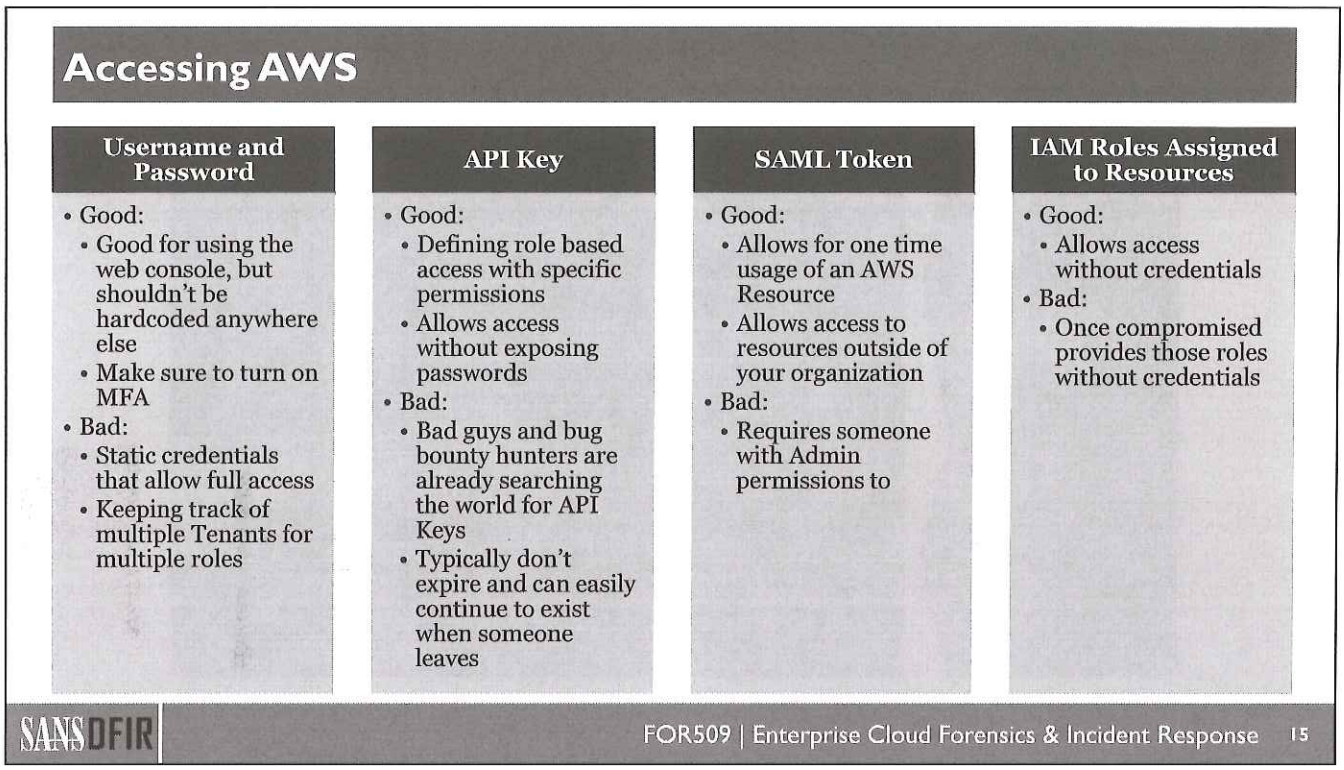

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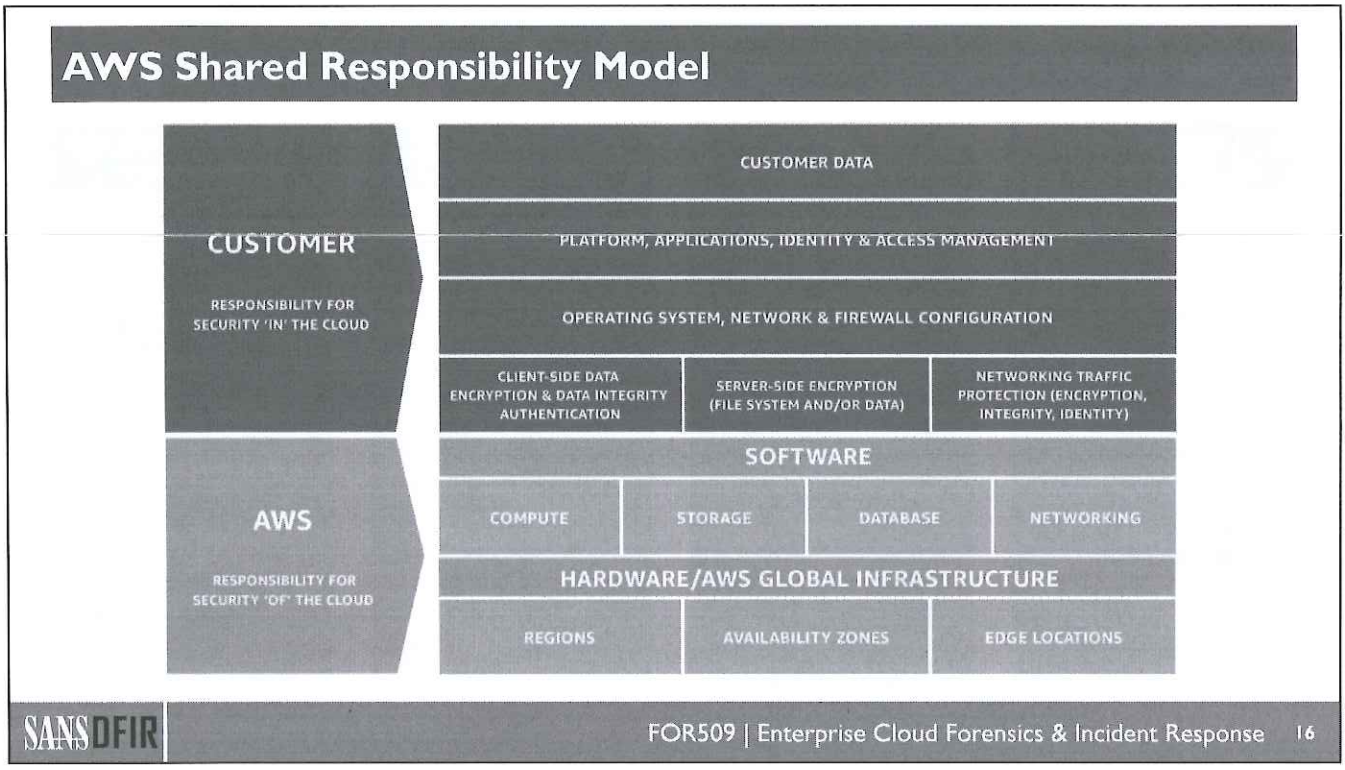

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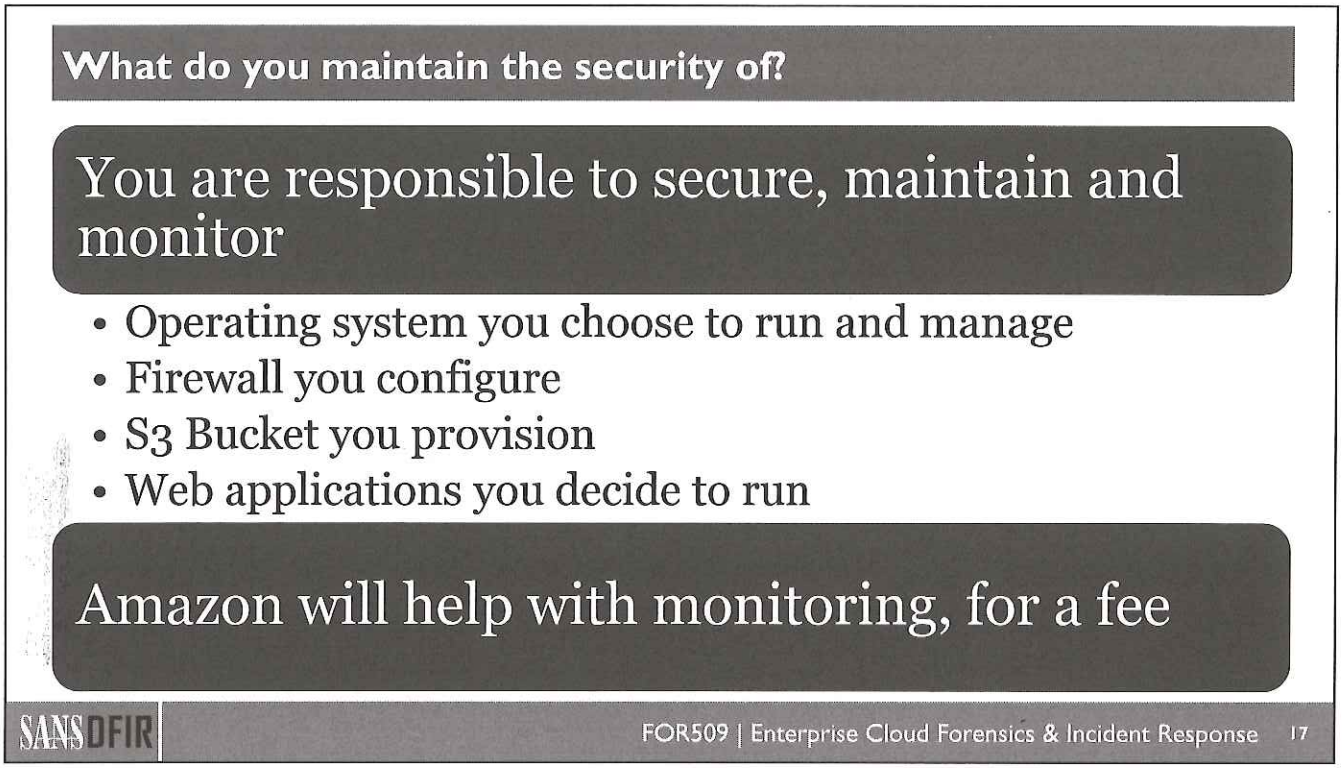

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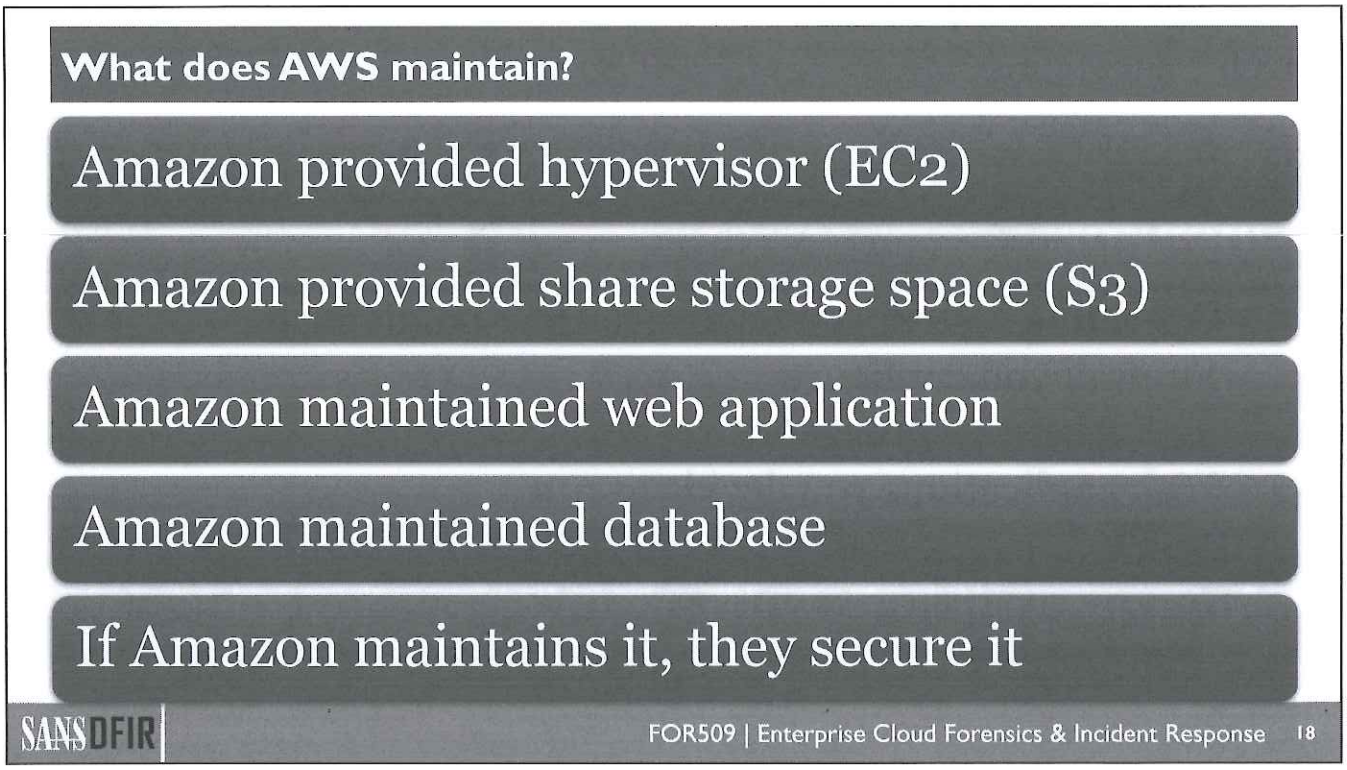

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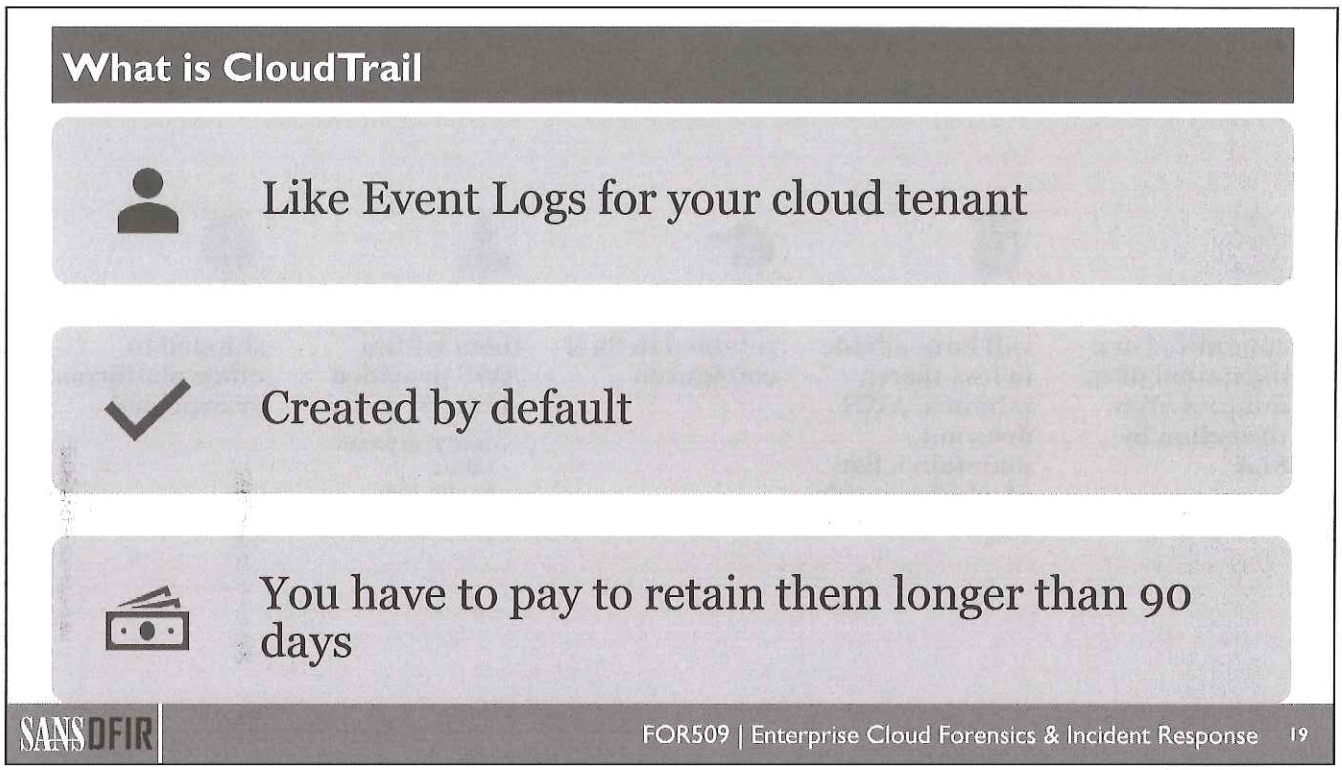

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CloudTrail

Records are committed at a maximum of 15 minutes after the action by SLA

Some records will be available in less than 5 minutes, AWS does not maintain a list of which get this SLA

Logs can be retained in S3 if configured

You can search them within AWS provided services

- CloudTrail portal
- Athena
- Security Hub

Can also be shipped to other platforms or exported

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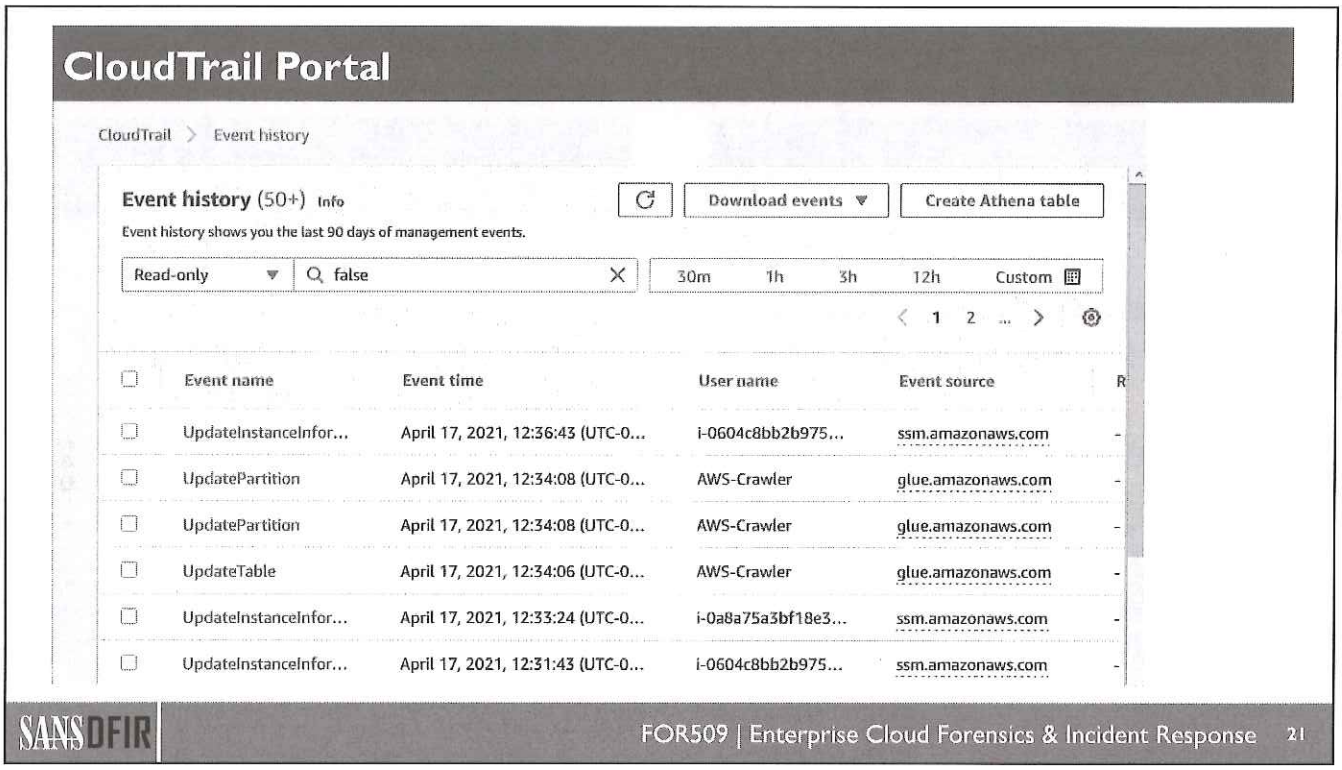

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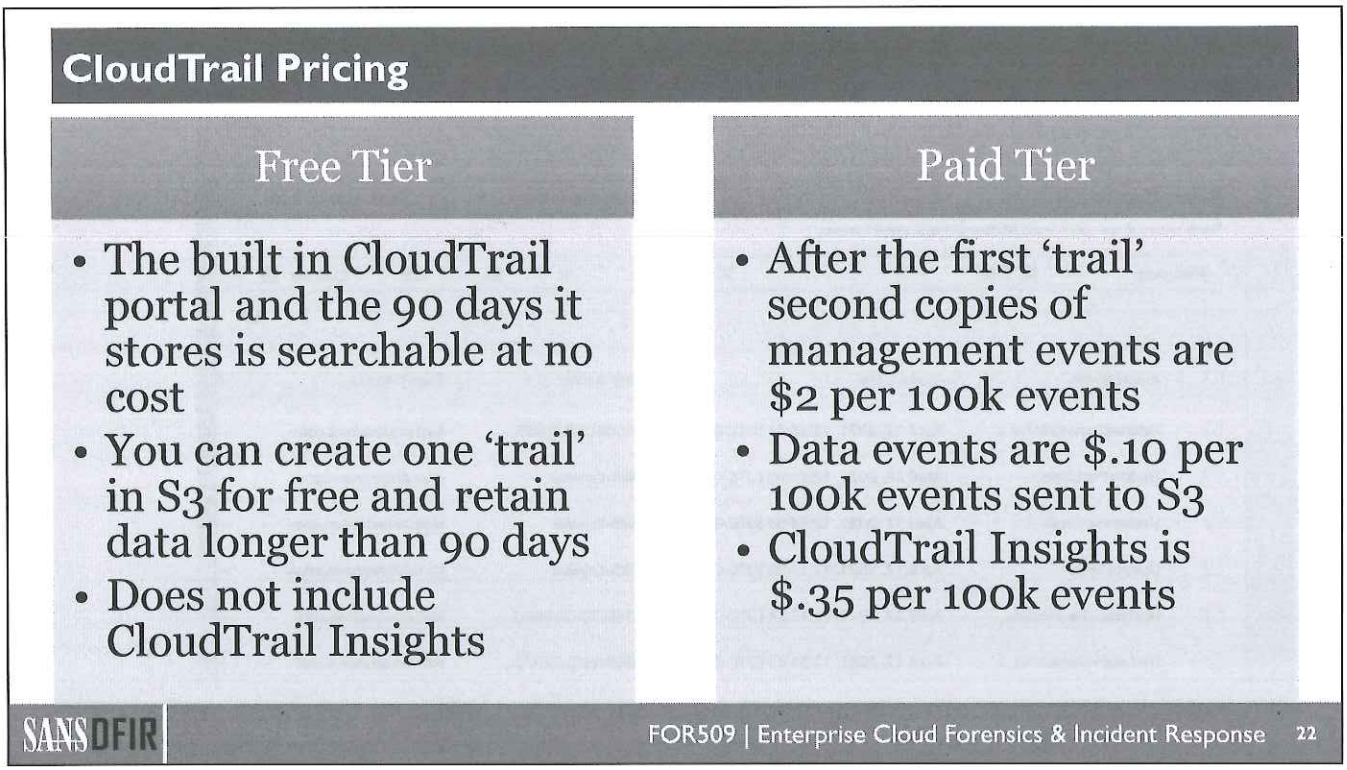

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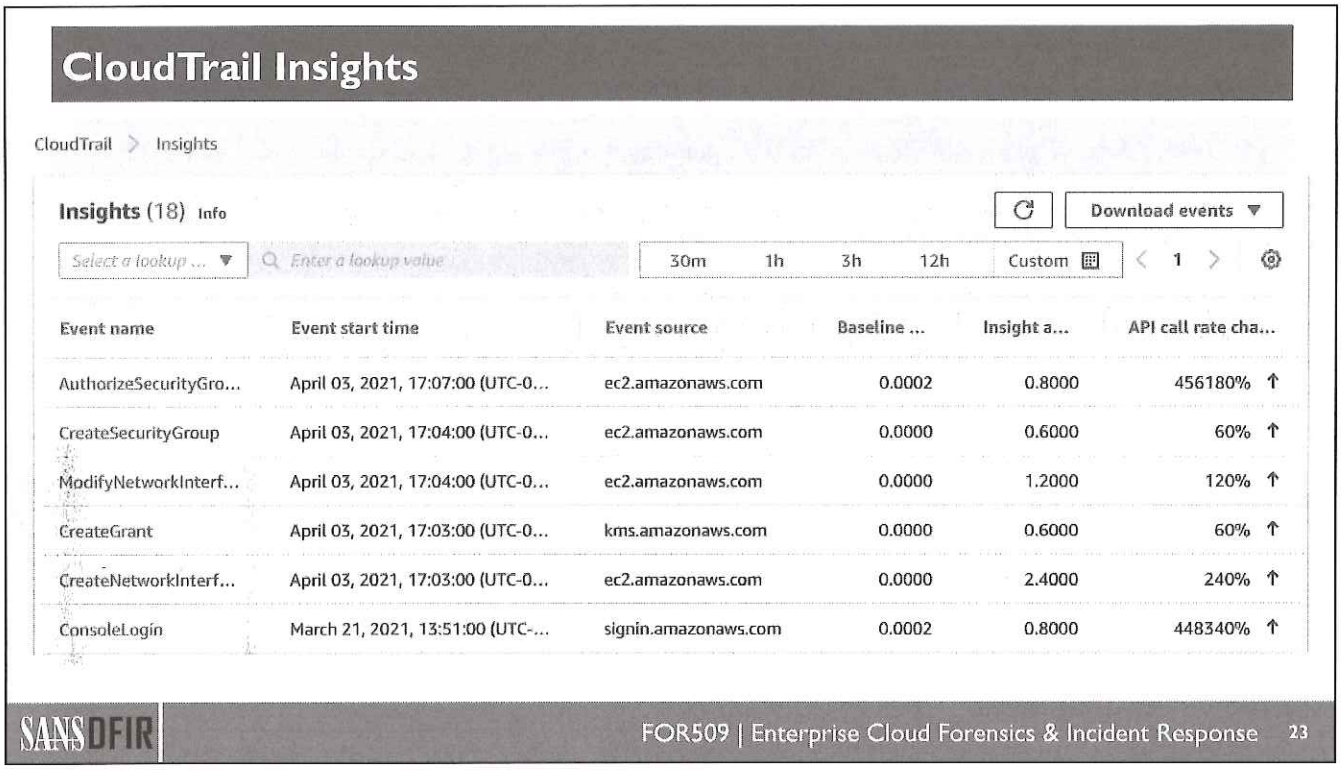

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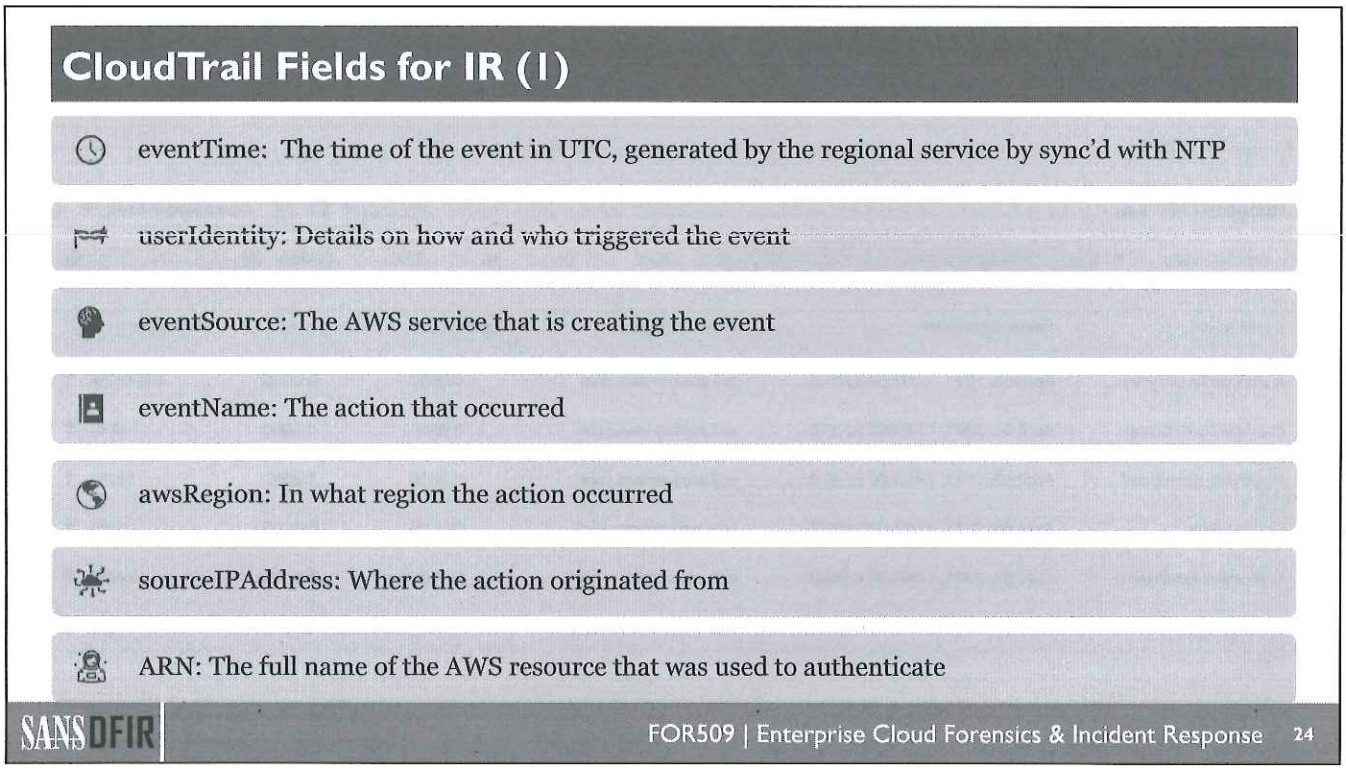

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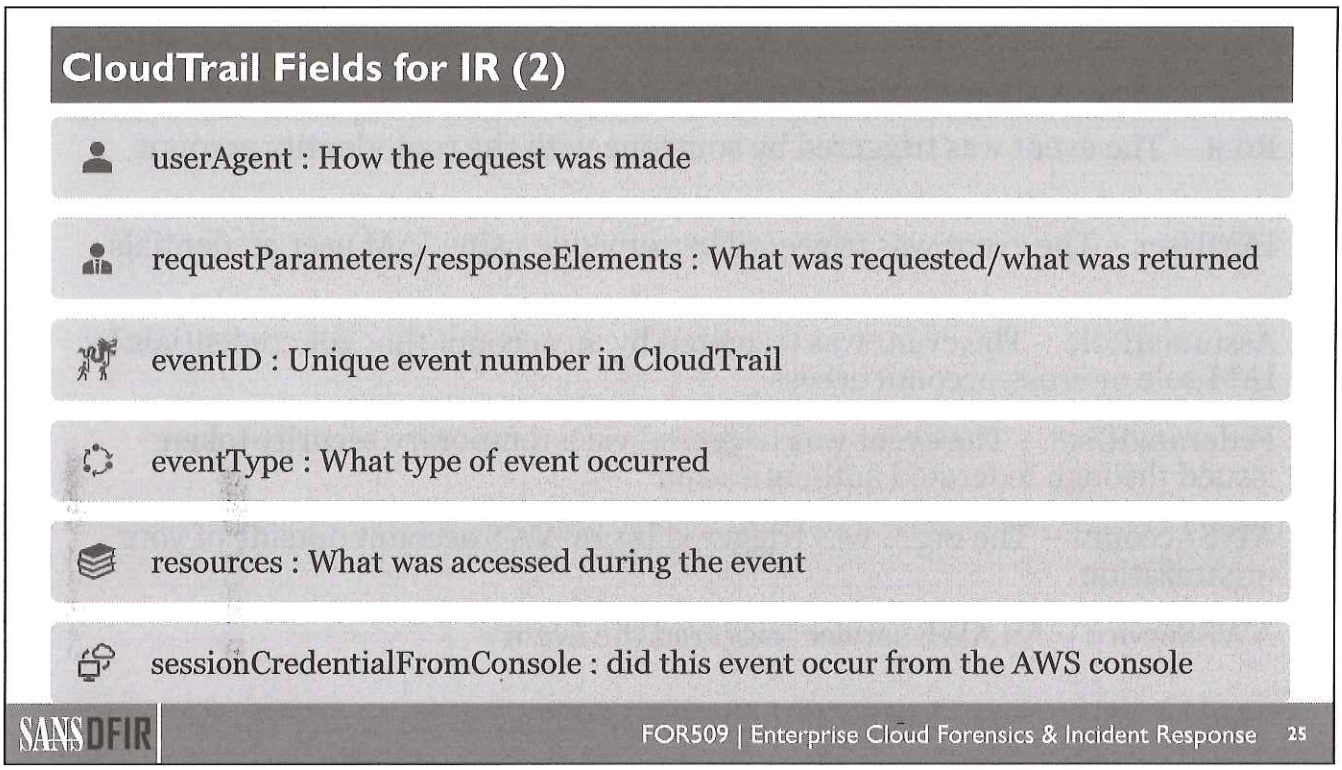

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CloudTrail userIdentity Types

Root – The event was triggered by someone with the root identity account

IAMUser – The event was triggered by someone using IAM user credentials

AssumedRole - The event was triggered by an account that got credentials by IAM role or cross-account access

FederatedUser – The event was triggered via a temporary security token issued through federated authentication

AWSAccount – The event was triggered by an AWS account outside of your organization

AWSService – An AWS service triggered the event

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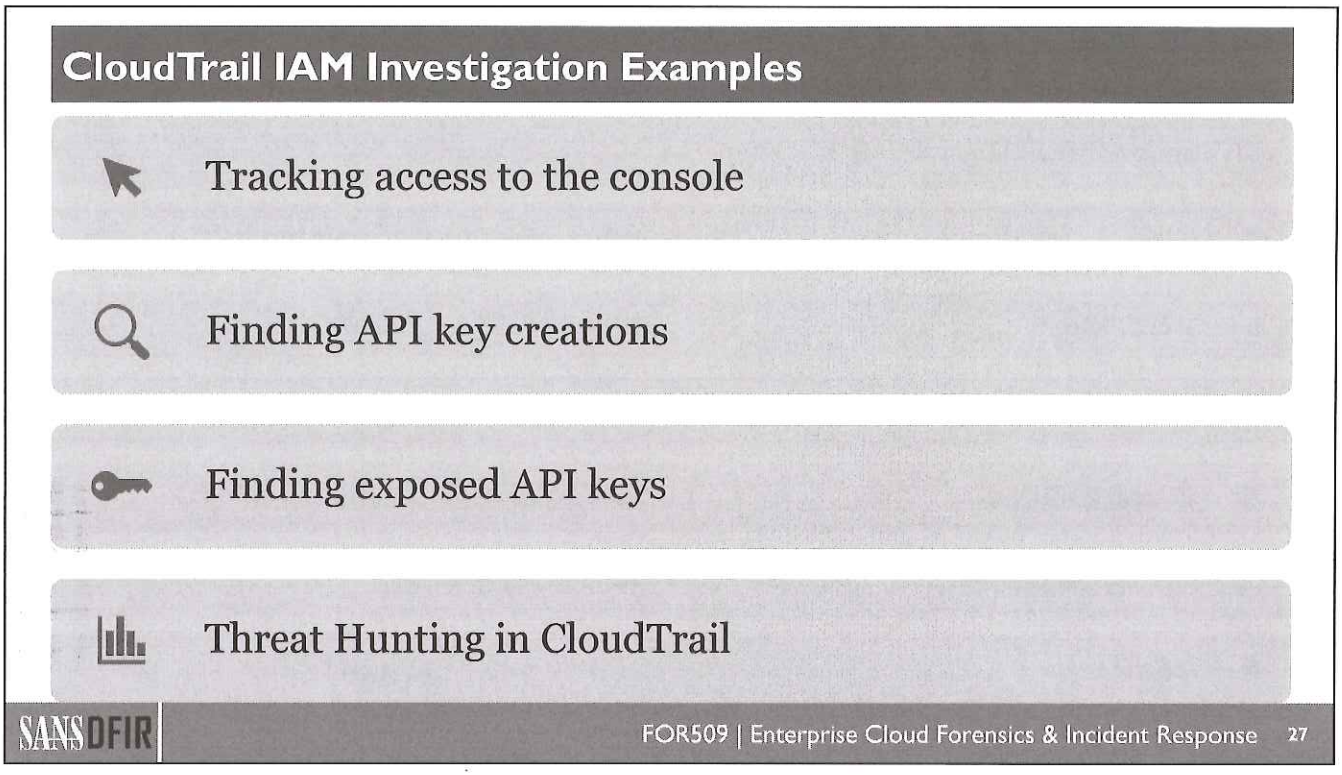

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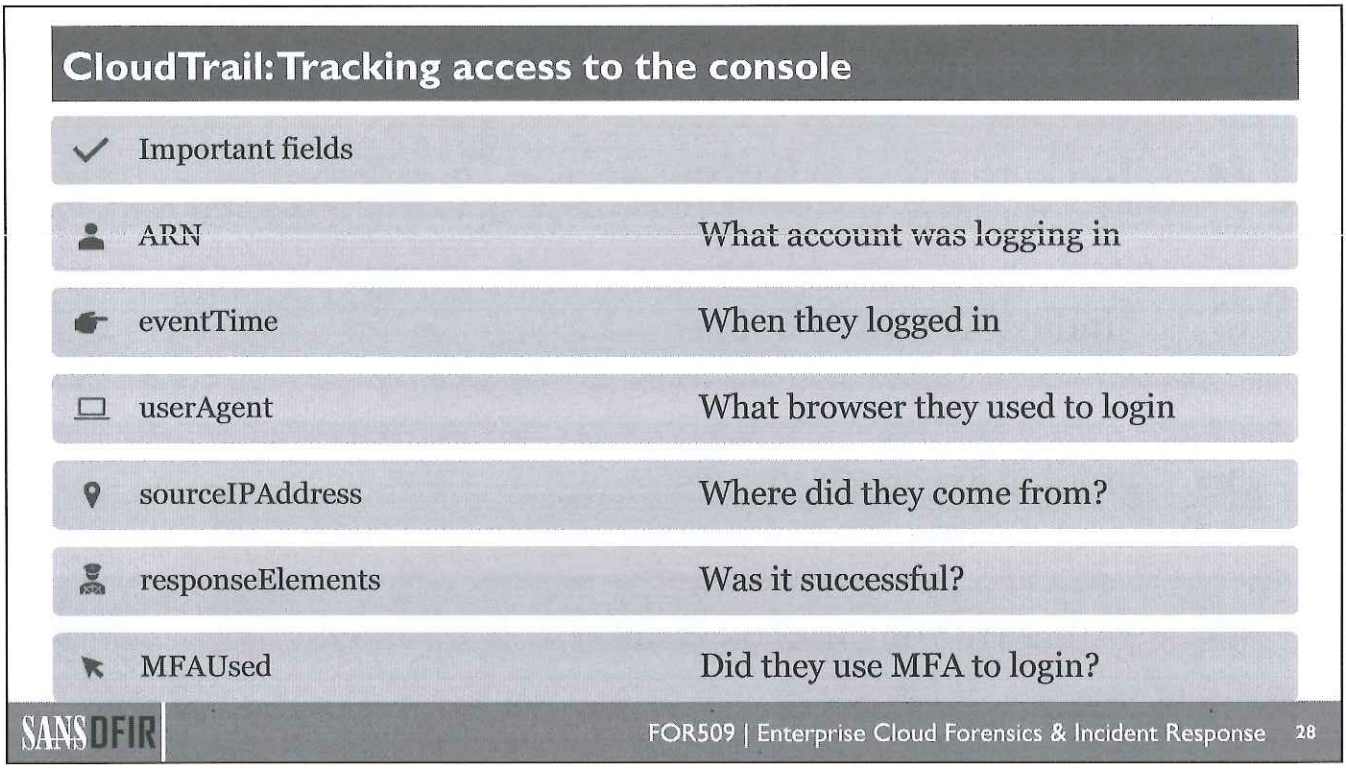

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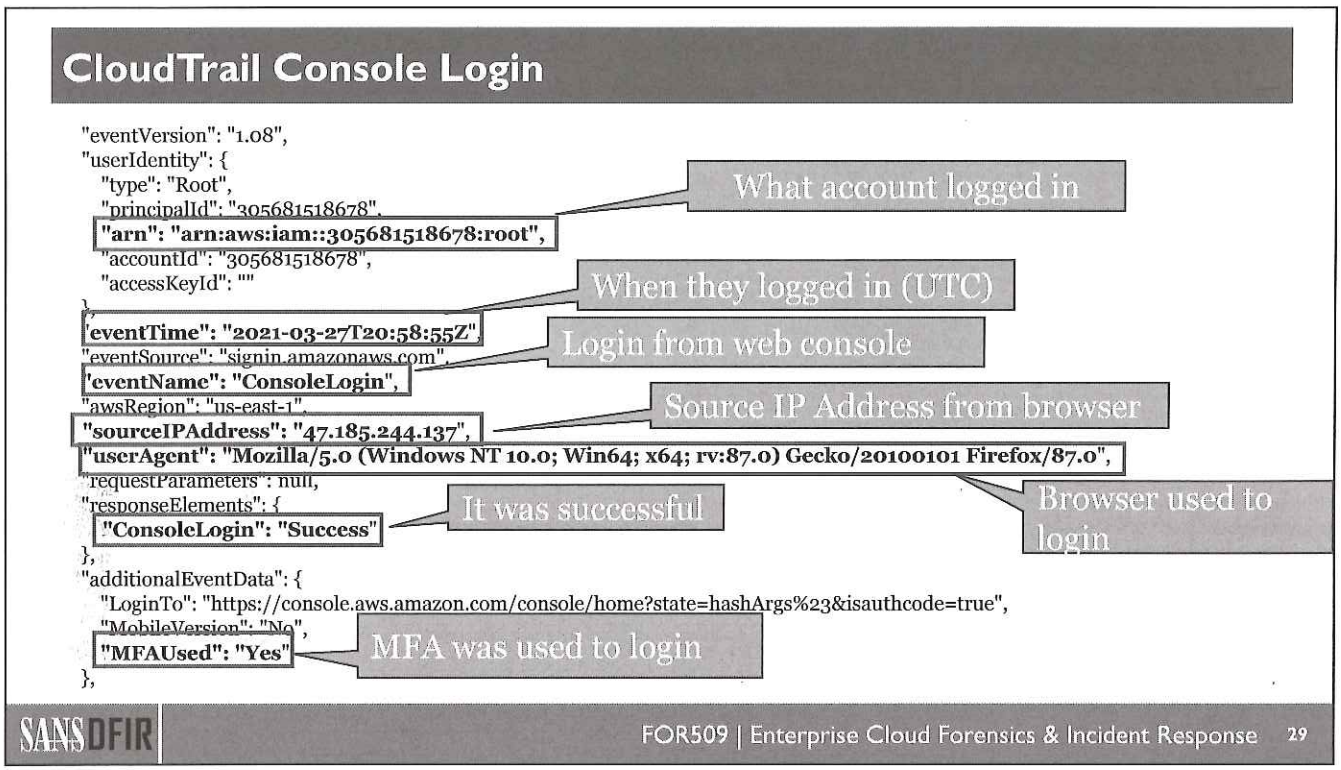

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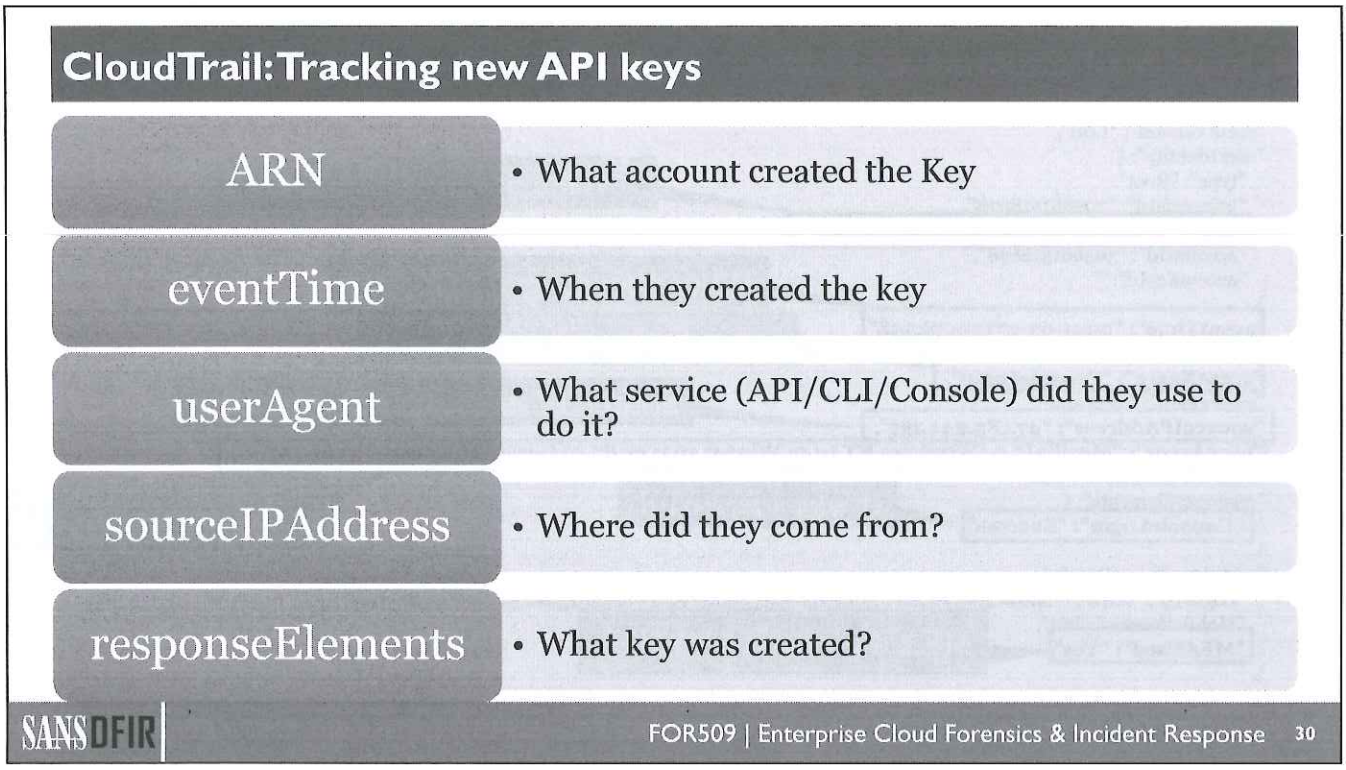

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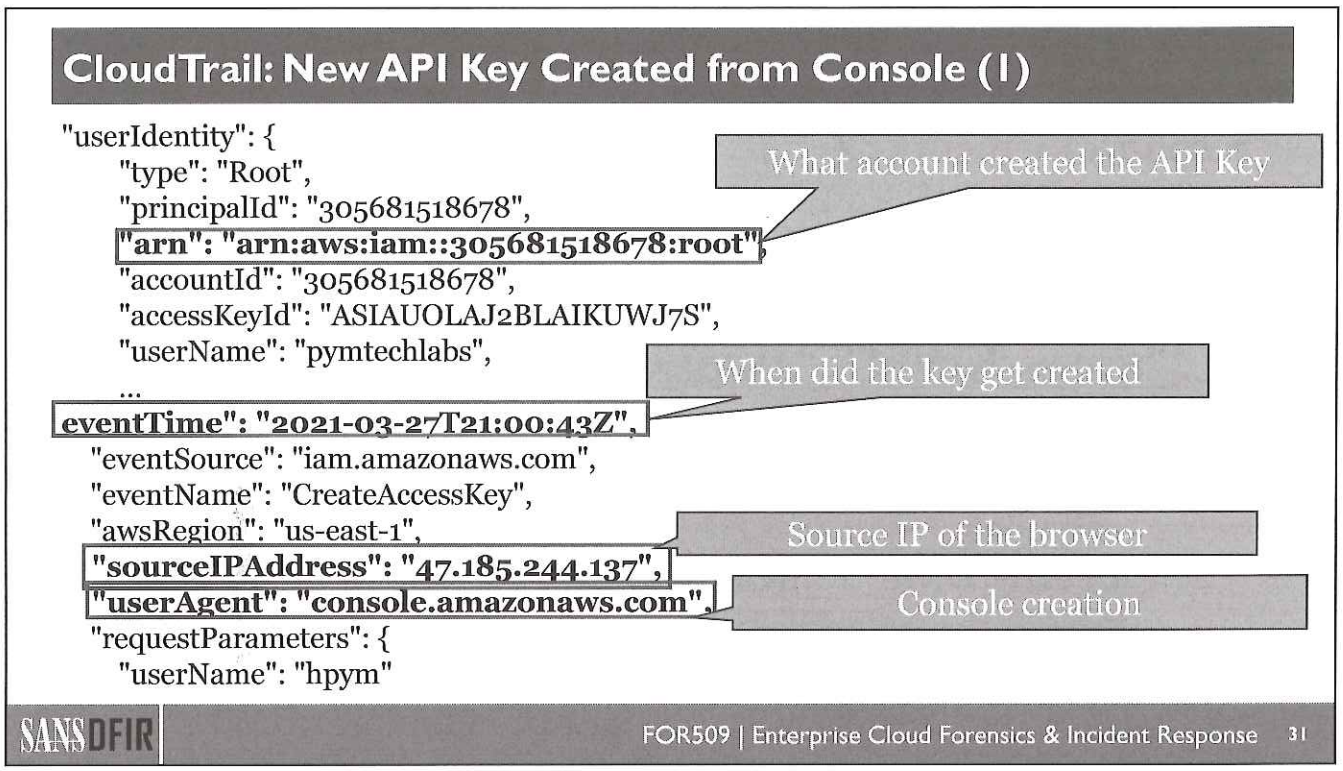

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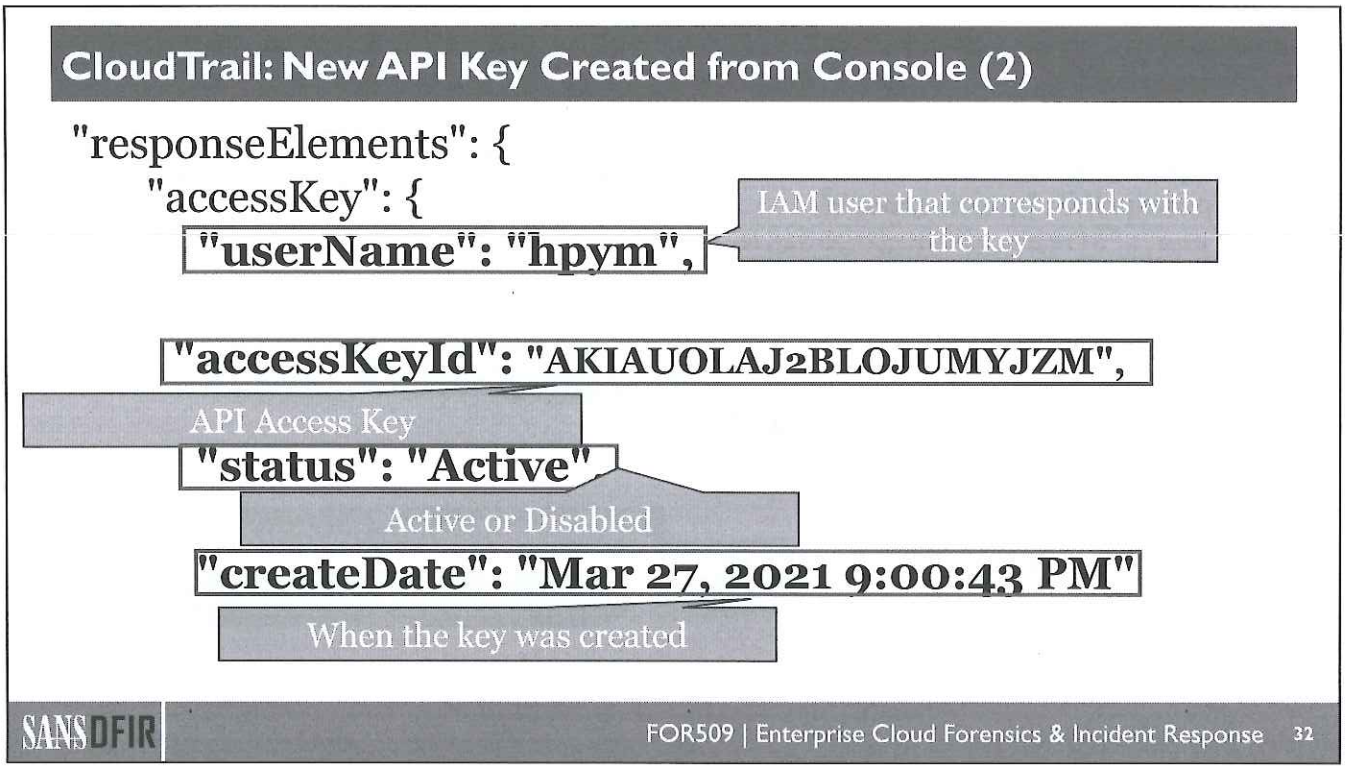

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CloudTrail: Finding Exposed API Keys

Role Enumeration

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2021-04-03T18:43:36Z	iam.amazonaws.com	ListGroupsForUser	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"userName":"hpym"}	AwsApiCall
2021-04-03T18:43:36Z	iam.amazonaws.com	GetUser	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	null	AwsApiCall
2021-04-03T18:43:37Z	iam.amazonaws.com	GetPolicy	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"policyArn":"arn:aws:iam::aws:policy/AdministratorAccess"}	AwsApiCall
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2021-04-03T18:43:37Z	iam.amazonaws.com	ListAttachedGroupPolicies	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"groupName":"admin-access"}	AwsApiCall
2021-04-03T18:43:37Z	iam.amazonaws.com	ListAttachedUserPolicies	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"userName":"hpym"}	AwsApiCall
2021-04-03T18:43:37Z	iam.amazonaws.com	GetPolicyVersion	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"policyArn":"arn:aws:iam::aws:policy/AdministratorAccess","versionId":"v1"}	AwsApiCall
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eventtime	eventsource	eventname	sourceipaddress	useragent	requestparameters	eventtype
2021-04-03T18:36:36Z	iam.amazonaws.com	ListRoles	47.185.244.137	aws-cli/2.1.32 Python/3.8.8 Windows/10 exe/AMD64 prompt/off cmd/null		AwsApiCall
2021-04-03T18:43:36Z	iam.amazonaws.com	ListGroupsForUser	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"userName":"hpym"}	AwsApiCall
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2021-04-03T18:43:37Z	iam.amazonaws.com	ListAttachedGroupPolicies	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"groupName":"admin-access"}	AwsApiCall
2021-04-03T18:43:37Z	iam.amazonaws.com	ListAttachedUserPolicies	47.185.244.137	Boto3/1.17.44 Python/3.9.1 Windows/10 Botocore/1.20.44	{"userName":"hpym"}	AwsApiCall
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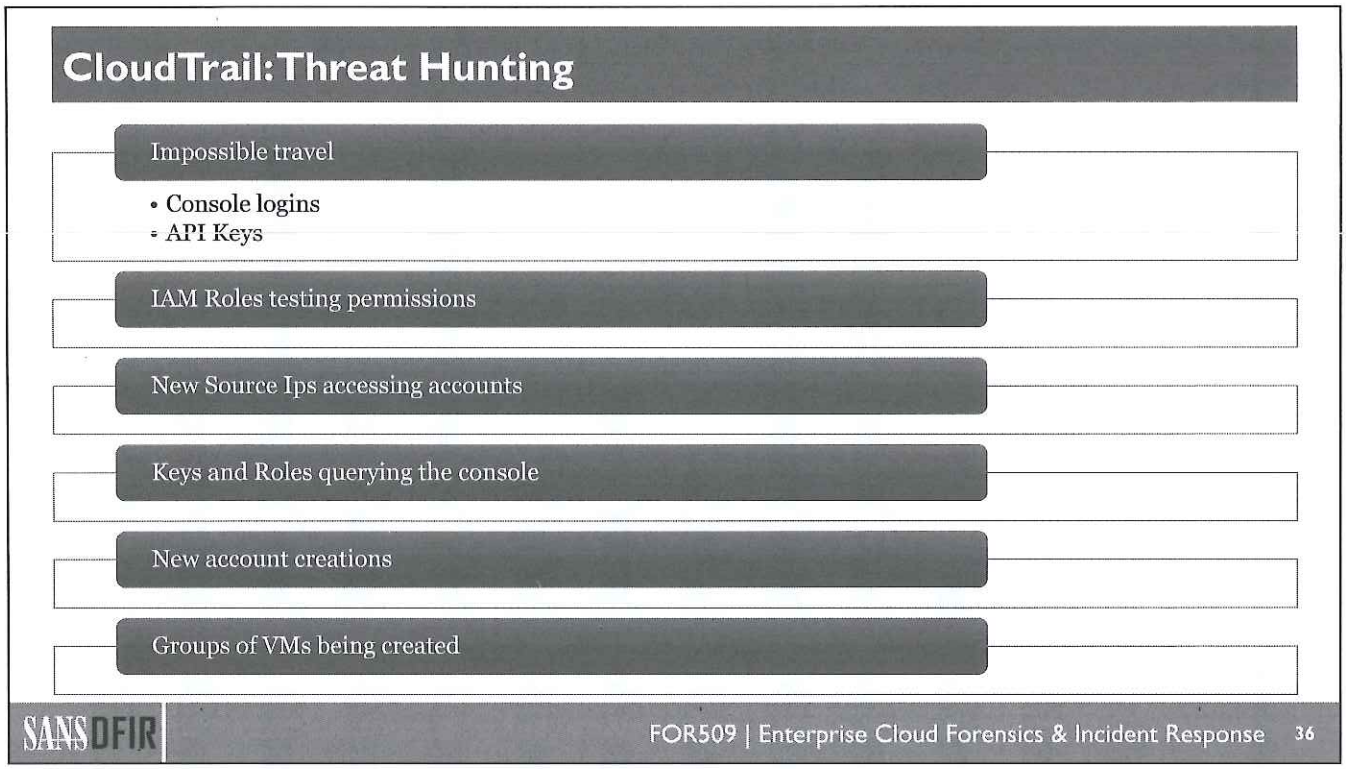

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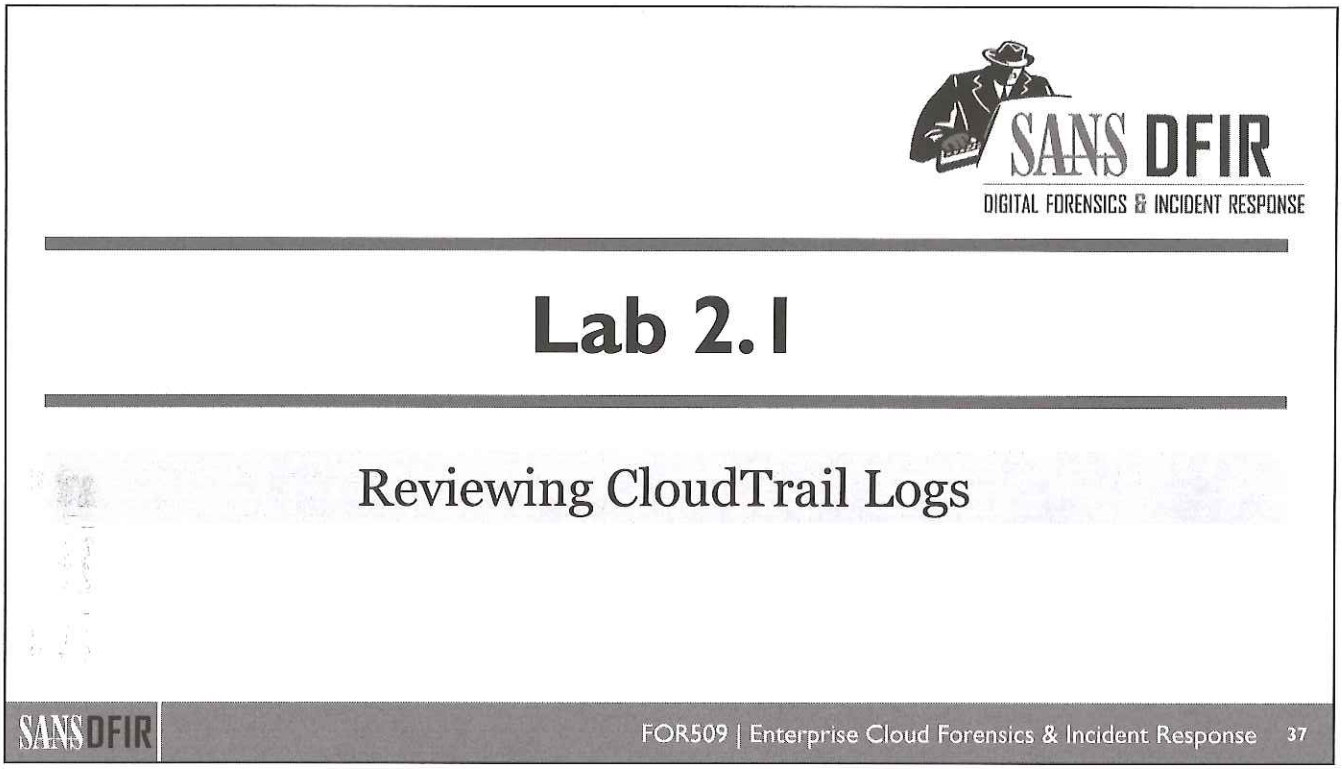

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Guard Duty (1)

Now that you've learned how to manually review CloudTrail logs, don't you wish there was an easier way to find that likely threat?

Enter Guard Duty!

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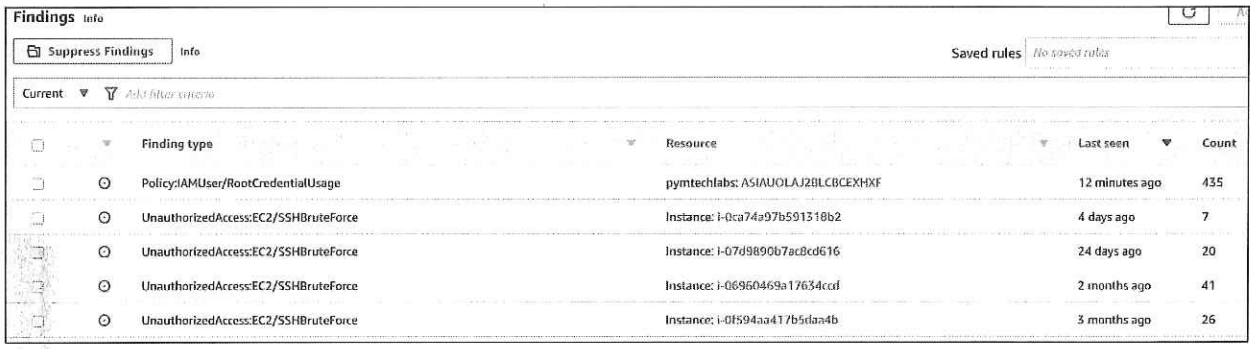
Guard Duty (2)



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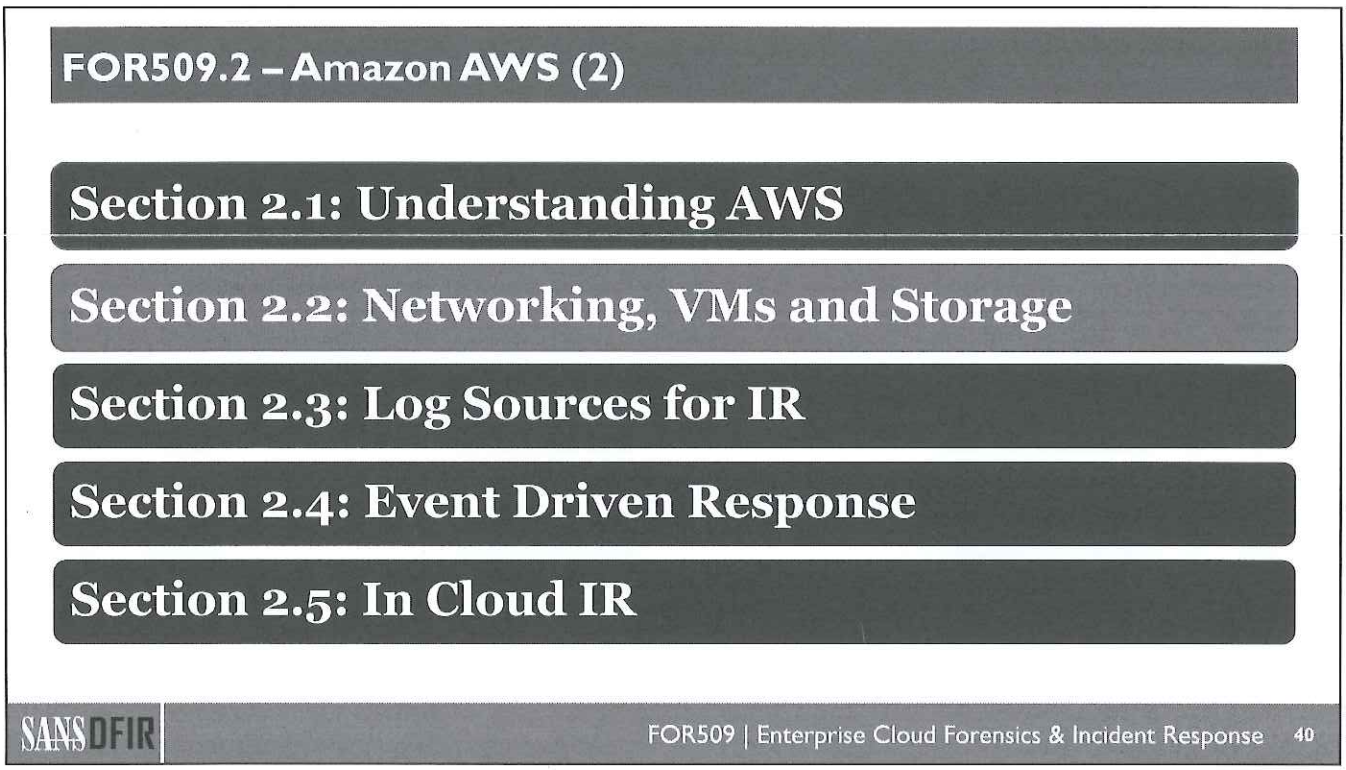

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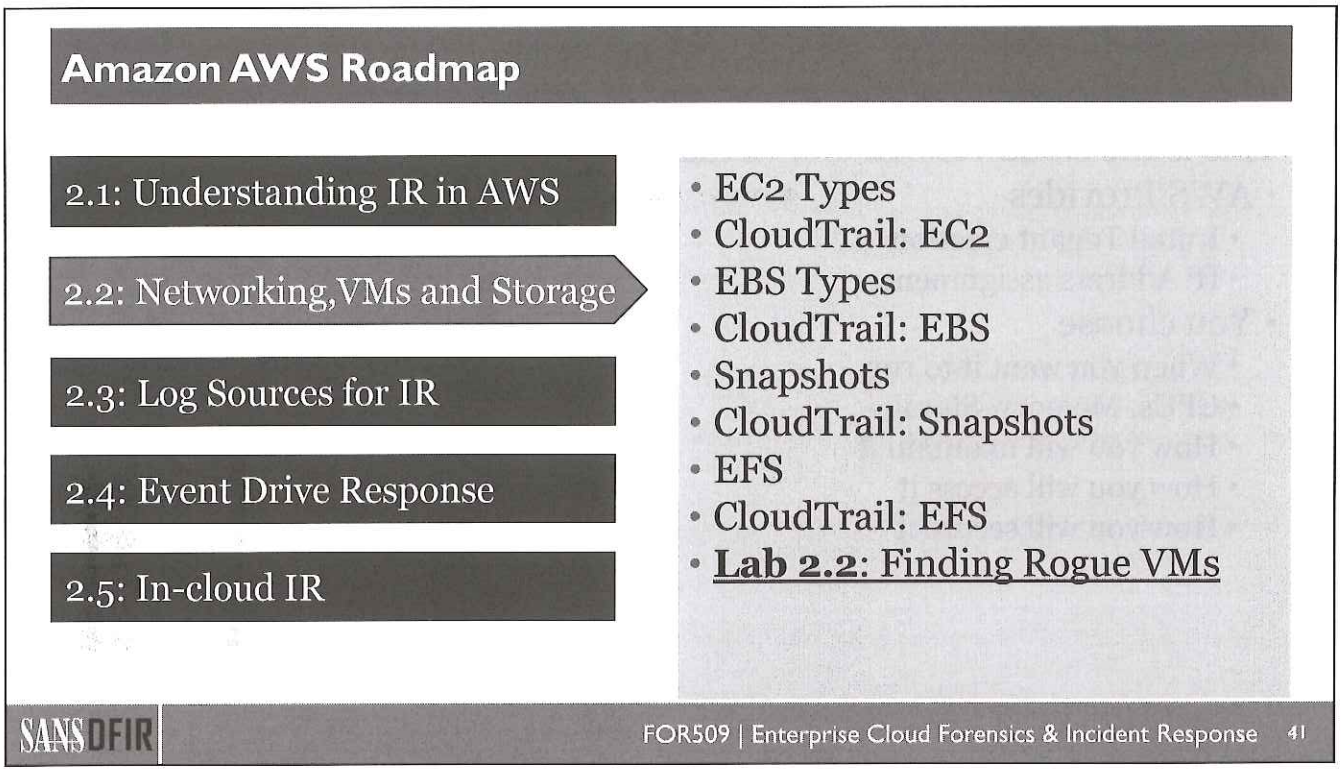

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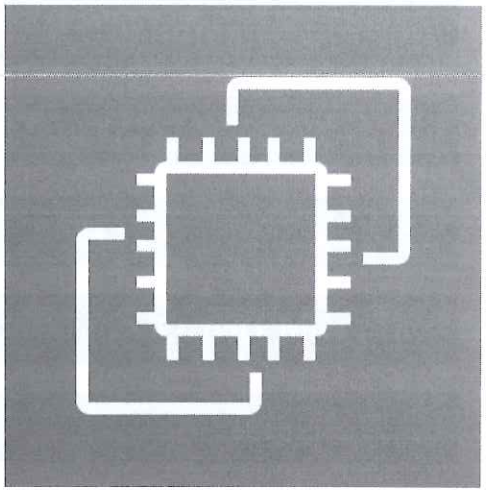
EC2 – Elastic Compute Cloud

This is the cloud version of a virtual machine

- AWS Provides
  - Initial Tenant creation
  - IP Address assignment
- You choose
  - When you want it to run
  - CPUs, Memory, Storage
  - How you will maintain it
  - How you will access it
  - How you will secure it



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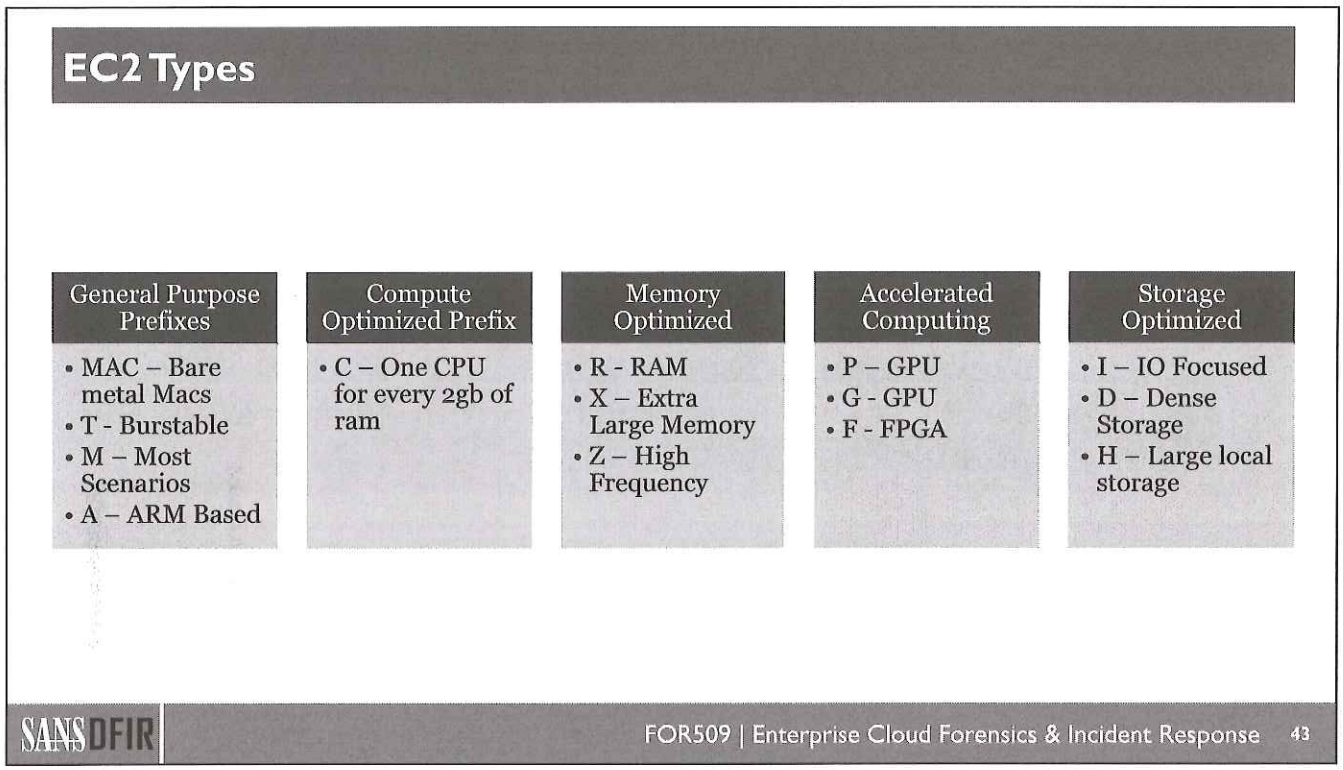

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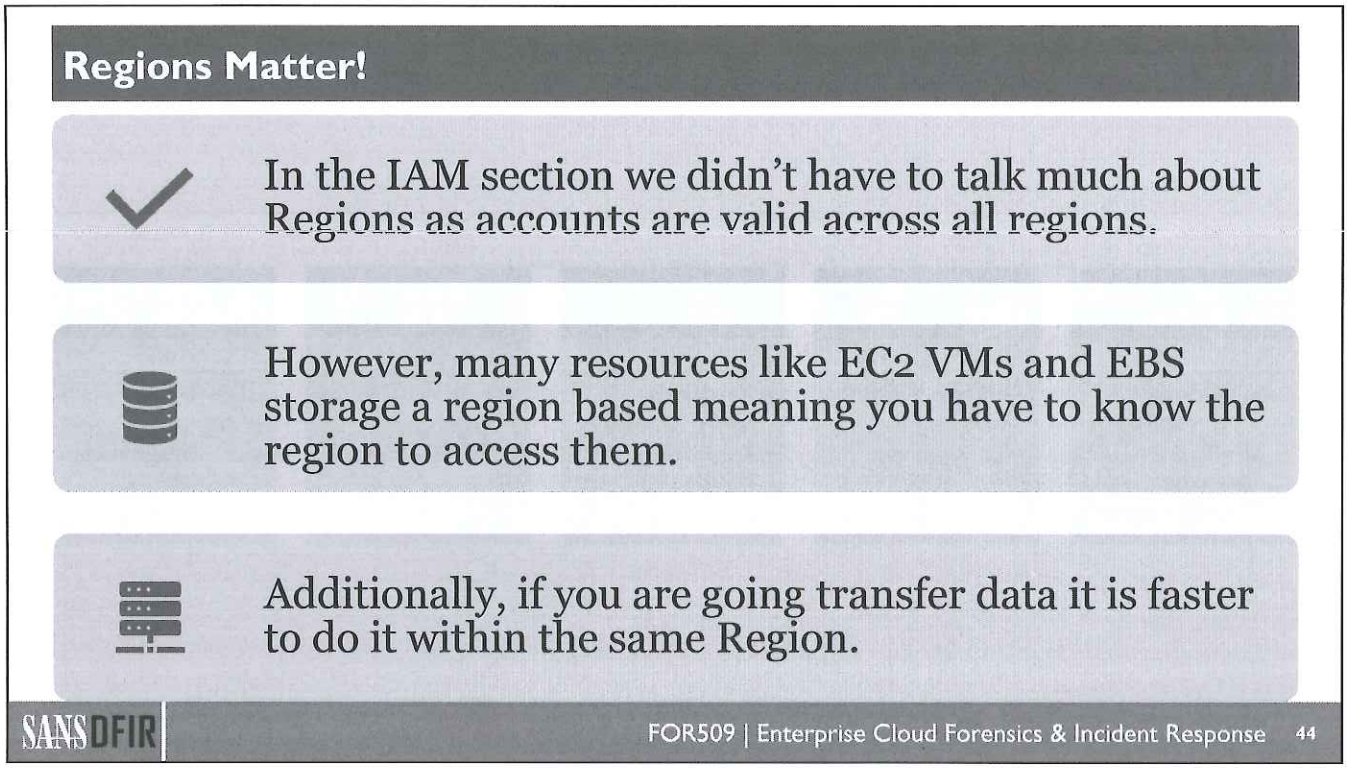

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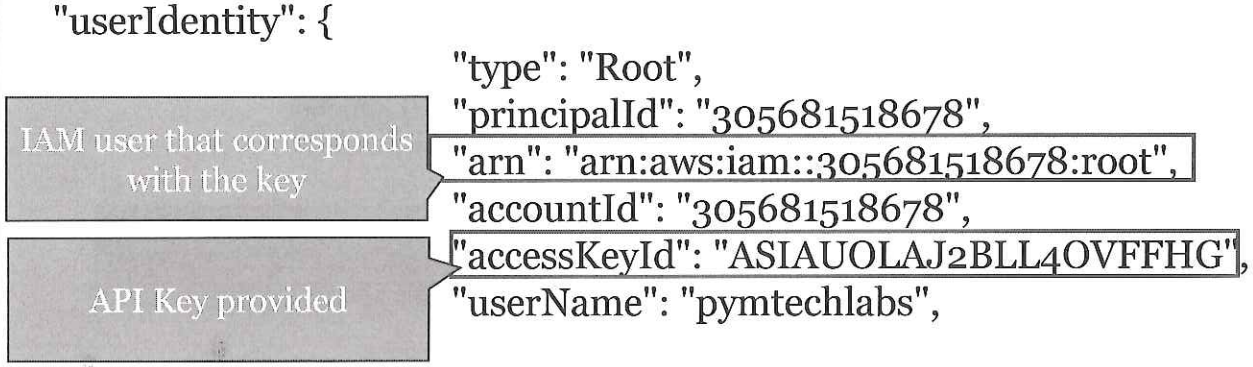
CloudTrail: Creating an EC2 Instance (1)



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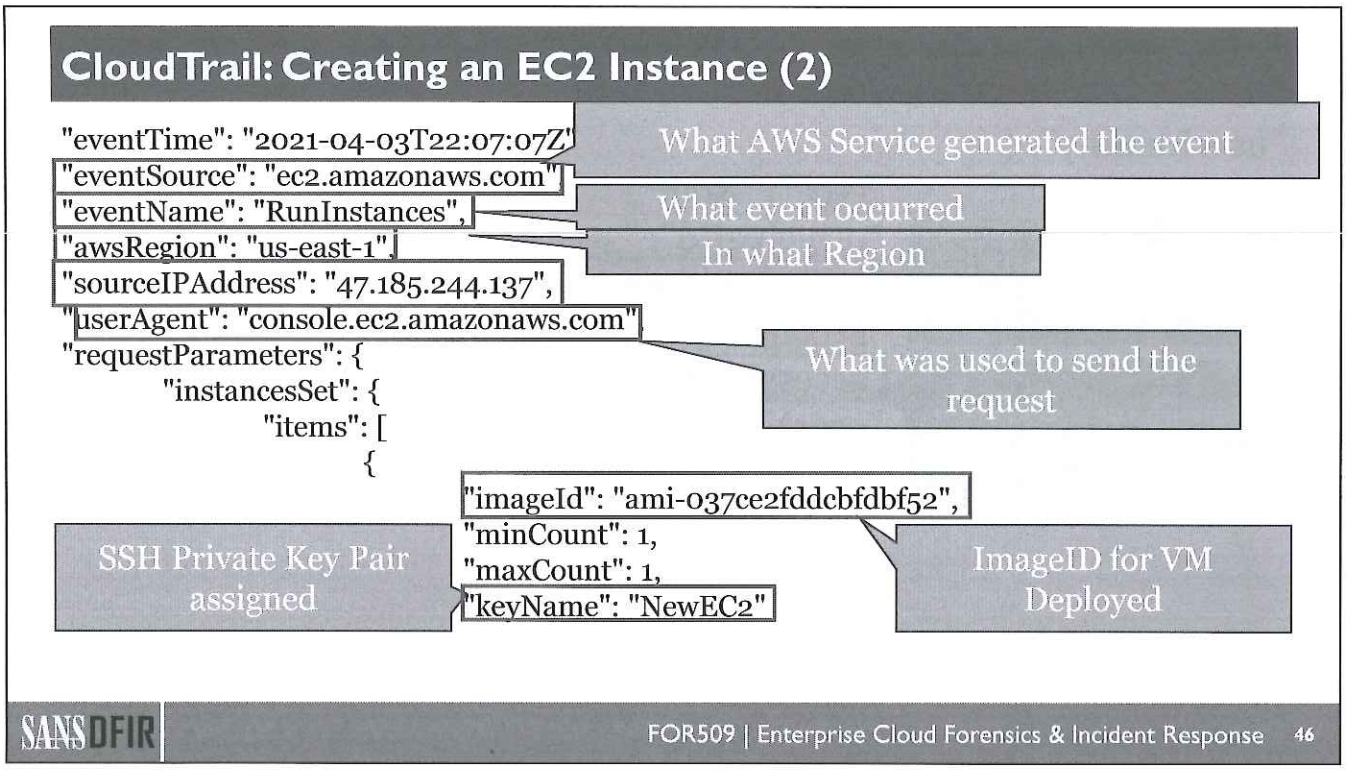

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CloudTrail: Creating an EC2 Instance (3)


```
"attributes": {
                "mfaAuthenticated": "true",
                "creationDate": "2021-04-01T12:03:50Z"
                        "groupSet": {
                                "items": [
                                        {
                                        "groupId": "sg-00b98f2f5d3339900"
                                        },
                                        {
                                        "groupId": "sg-044c410b2327cc21f"
                                        }
                                        ]
                                },
                "userData": "<sensitiveDataRemoved>",
                "instanceType": "t2.micro",
```


The type of EC2 VM that was created

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CloudTrail: Creating an EC2 Instance with GPU


```
"attributes": {
                    "mfaAuthenticated": "true",
                    "creationDate": "2021-04-03T18:03:51Z"
                        "groupSet": {
                "items": [
                    {
                        "groupId": "sg-00b98f2f5d3339900"
                    },
                    {
                        "groupId": "sg-044c410b2327cc21f"
                    }
                ]
            },
            "userData": "<sensitiveDataRemoved>",
            "instanceType": "g4ad.4xlarge",
```


A GPU Enabled VM was created

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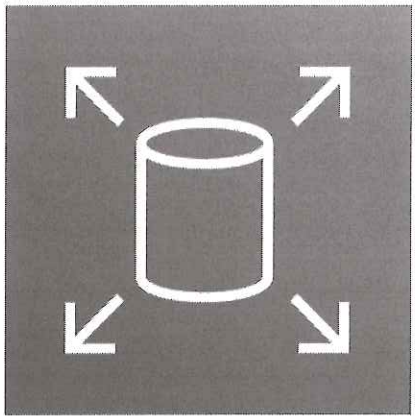
EBS – Elastic Block Store

- Virtual Storage for EC2
  - In virtual machine terms – VMDKs, VDIs, VHDs
- You can have as many virtual storage devices as you need



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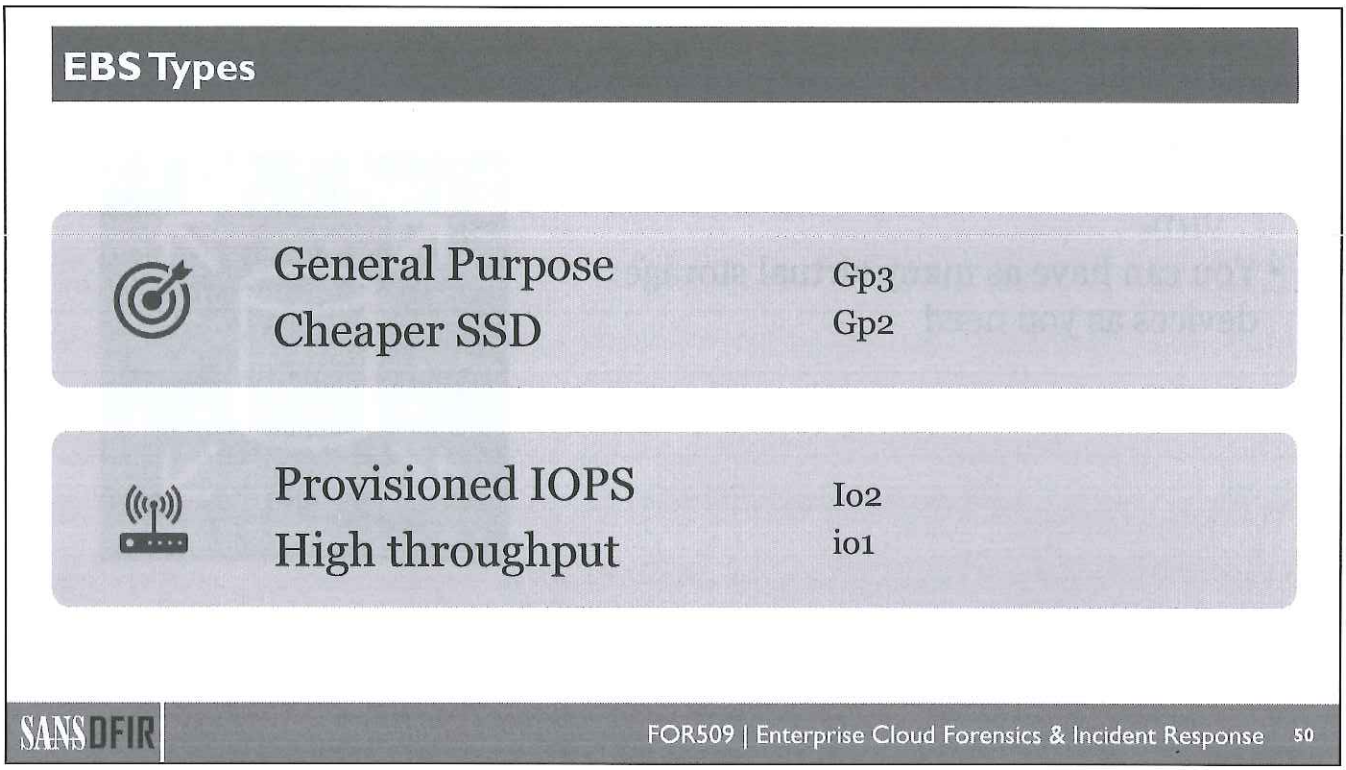

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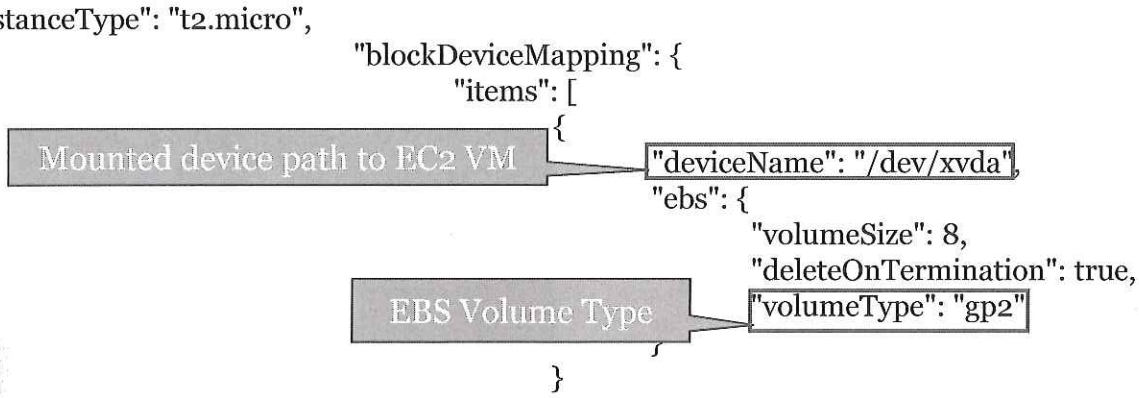
CloudTrail: Creation of EBS



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Snapshots

- Creates a disk image of the current state of the disk through the hypervisor
- First snapshot contains all data
- Subsequent snapshots only contain differences on a per block basis
- Copying snapshots between regions will get hit with a data transfer charge ($.01 - $.02 per GC)

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Snapshot Pricing

- Storage – Storage is charged on total space allocated, free space is not included
  - Free Tier
    - 1GB of snapshot storage
  - Paid Tier
    - $.05 GB/month of data sored
- Fast Snapshot Restoration
  - $.75 per 1 DSU hour (Data Service Hours)
- Direct Block Access
  - List Blocks - $.0006 per thousand requests
  - Get Blocks - $.003 per thousand units
  - Put Blocks -$.006 per thousand units

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Making a snapshot with the CLI

```
aws ec2 create-snapshot --volume-id <volumeid>
     --description "Making a snapshot"
{
    "Description": "Making a snapshot",
    "Encrypted": false,
    "OwnerId": "305681518678",
    "Progress": "",
    "SnapshotId": "snap-096a35e714244ea98",
    "StartTime": "2021-04-17T21:22:48+00:00",
    "State": "pending",
    "VolumeId": "<volumeid>",
    "VolumeSize": 8,
    "Tags": []
}
```


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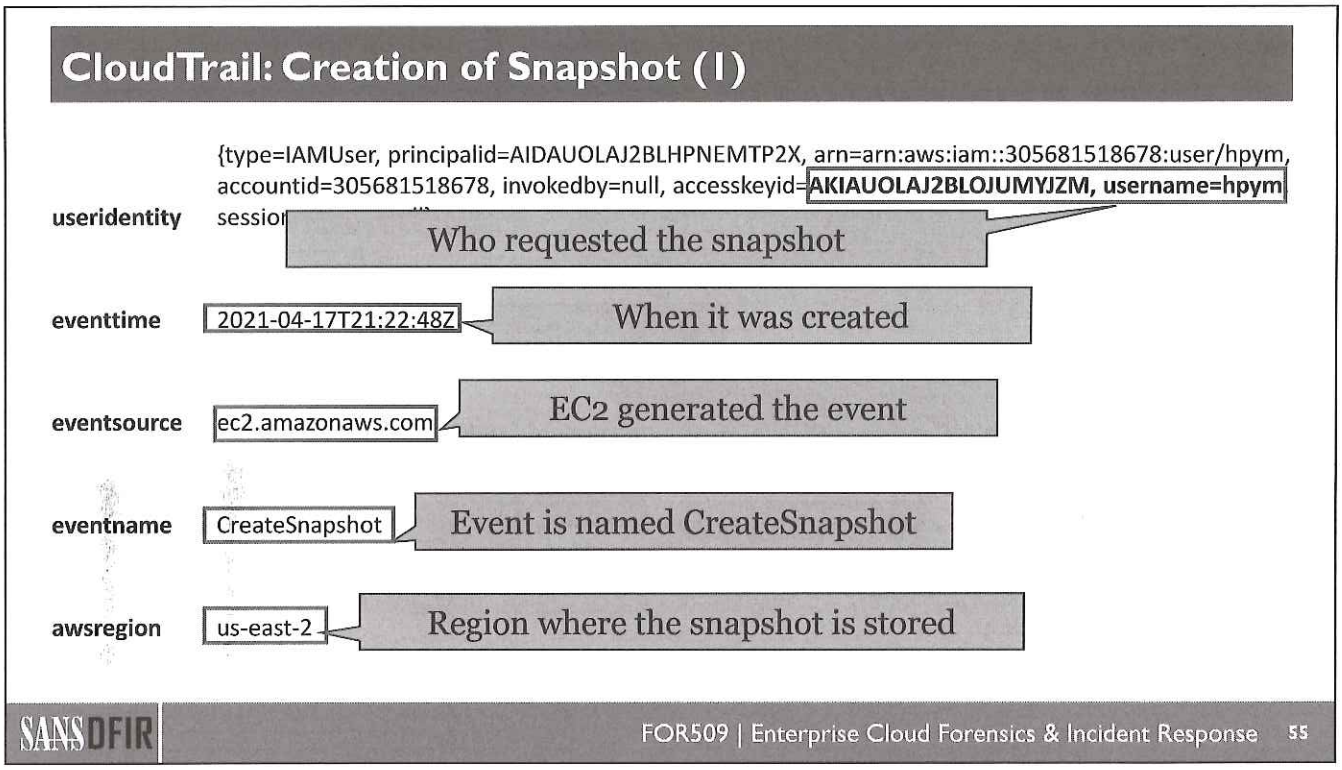

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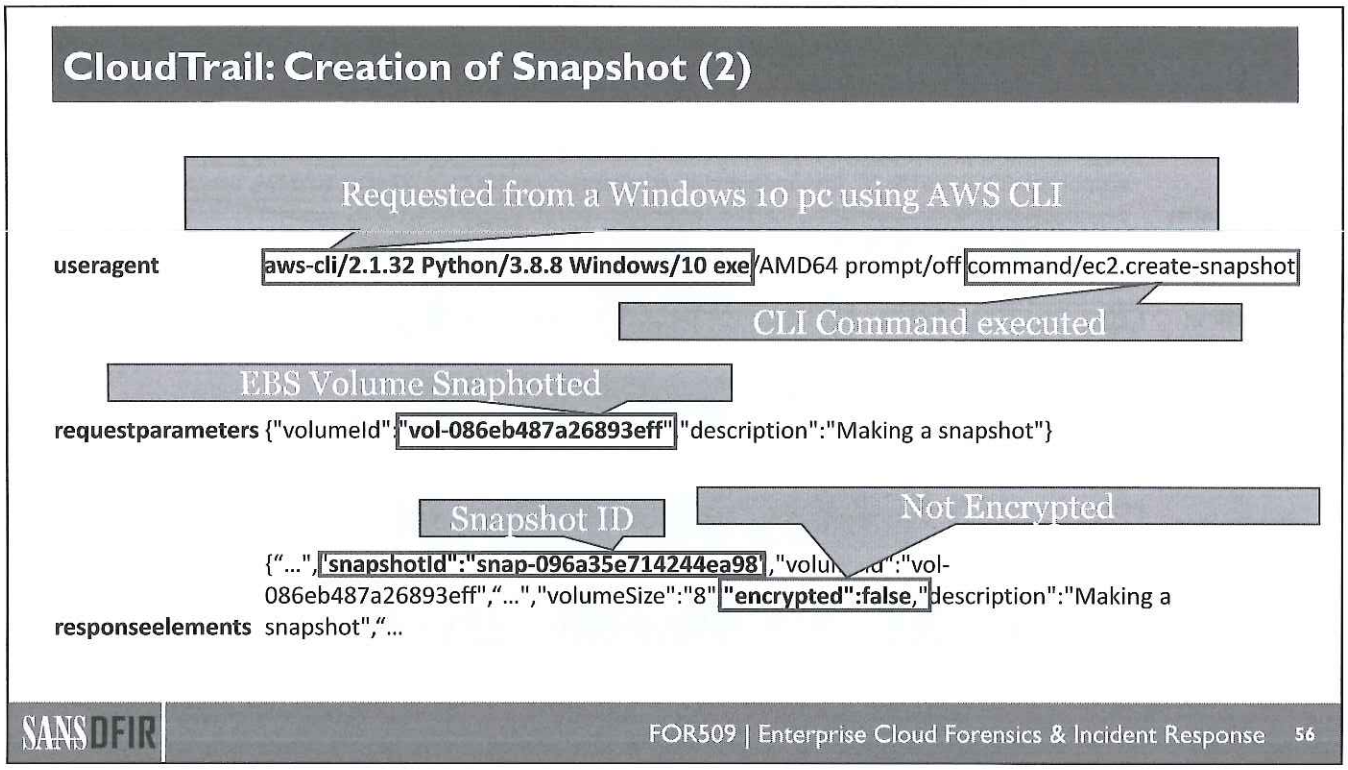

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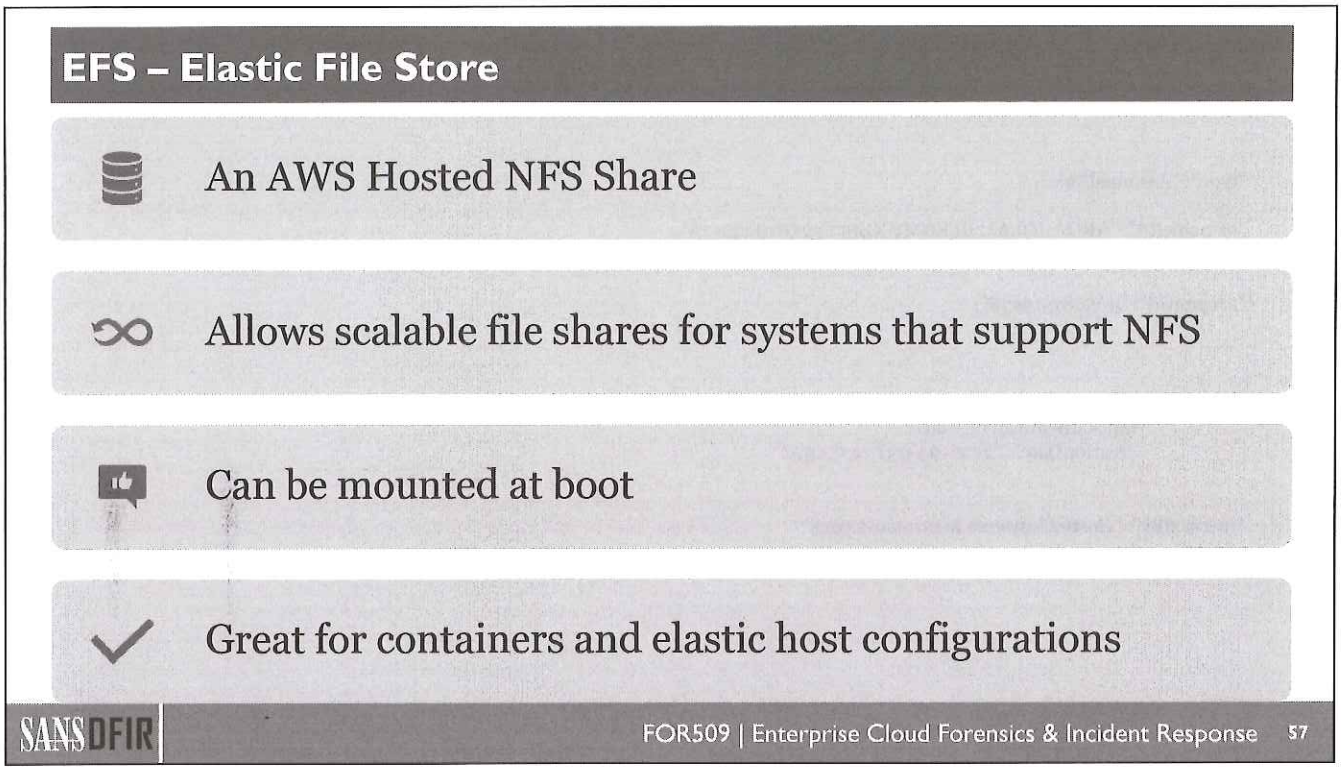

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CloudTrail: Mounting EFS (1)


```
"type": "AssumedRole",

"principalId": "AROAUOLAJ2BLEGMUX2J52:523670242123",
    "arn": "arn:aws:sts::305681518678:assumed-role/AWSServiceRoleForAmazonElasticFileSystem/523670242123",

"accountId": "305681518678",

            ...

"attributes": {
            "mfaAuthenticated": "false",
            "creationDate": "2021-04-03T22:03:52Z"
            },

"invokedBy": "elasticfilesystem.amazonaws.com"
```


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CloudTrail: Mounting EFS (2)


```
},
                "eventTime": "2021-04-03T22:03:53Z",
                "eventSource": "ec2.amazonaws.com",
                "eventName": "CreateNetworkInterface",
                "awsRegion": "us-east-1",
                "sourceIPAddress": "elasticfilesystem.amazonaws.com",
                "userAgent": "elasticfilesystem.amazonaws.com",
                "requestParameters": {
                        "subnetId": "subnet-0fceba79524beb4ed",
                        "description": "EFS mount target for fs-747766c1 (fsmt-7bd116ce)",
                        "groupSet": {},
                        "privateIpAddressesSet": {}
                },
```


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CloudTrail: Mounting EFS (3)


```
"responseElements": {
                        "requestId": "cfcf5ad0-8855-4e27-936d-c4bf6abda234",
                        "networkInterface": {
                                "networkInterfaceId": "eni-0bb4b98b581305086",
                                "subnetId": "subnet-0feeba79524beb4ed",
                                "vpcId": "vpc-09edf30a76f46ad91",
                                "availabilityZone": "us-east-1e",
                                "description": "EFS mount target for fs-747766c1 (fsmt-7bd116ce)",
                                ...
                                "macAddress": "06:62:de:b6:ca:15",
                                "privateIpAddress": "172.31.54.64",
                                "privateDnsName": "ip-172-31-54-64.ec2.internal",
                                "sourceDestCheck": true,
```


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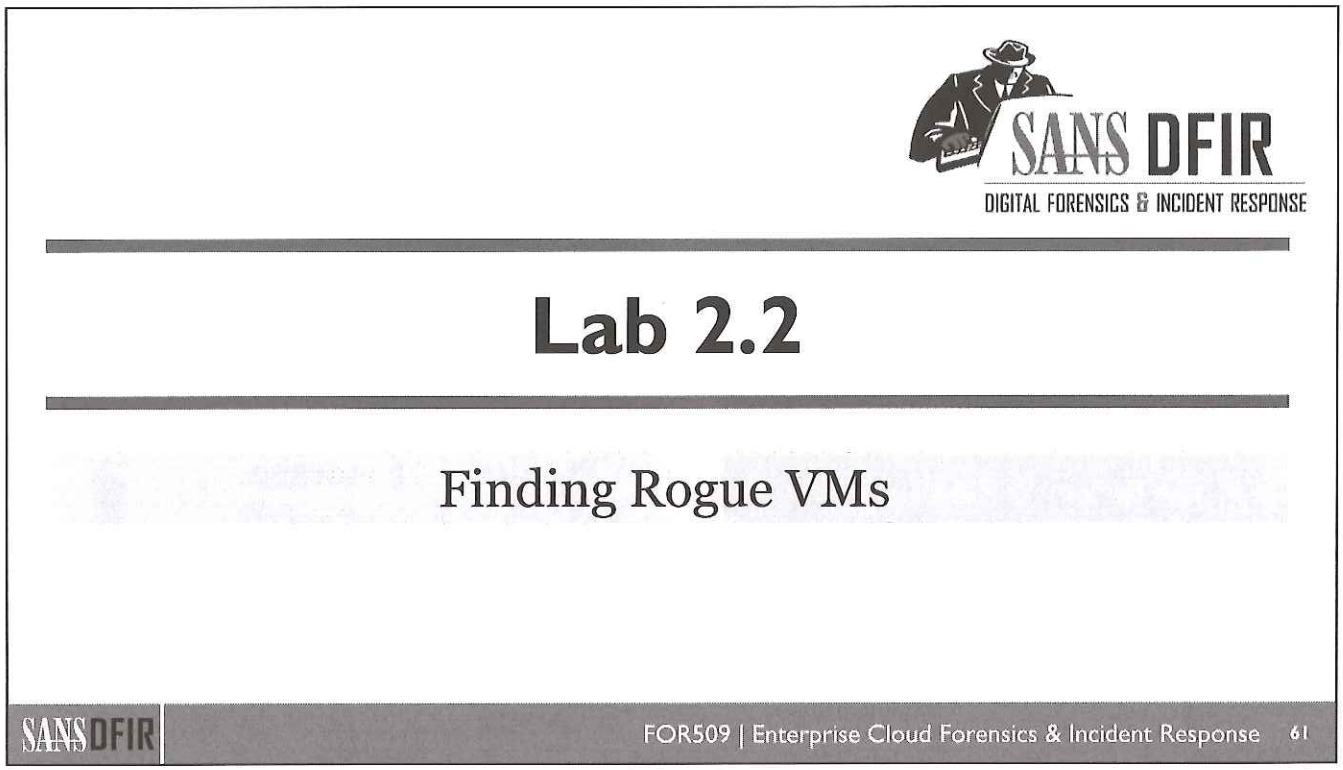

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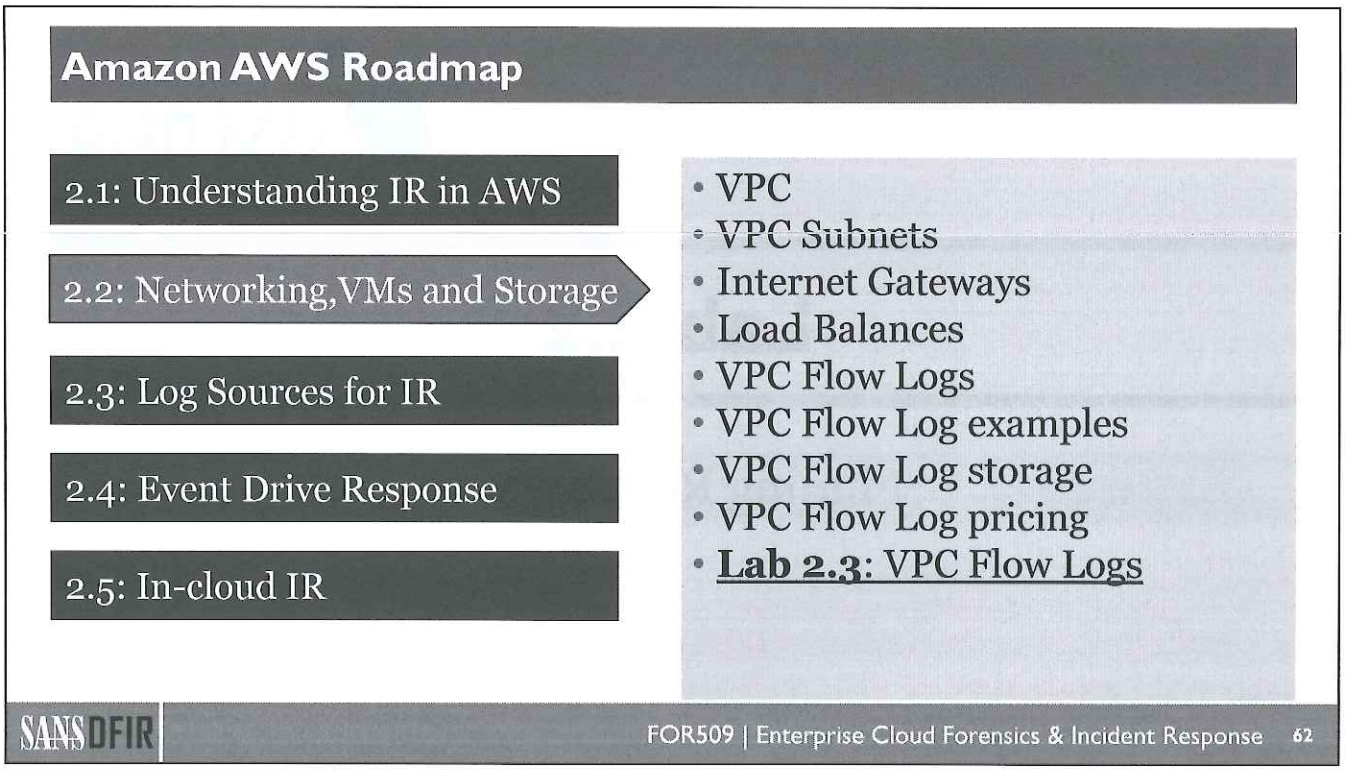

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Virtual Private Cloud

- A collection of resources grouped into a group
- A VPC can contain
  - Subnets (Private/Public)
  - EC2 VMs
  - Network Security Groups
  - Proxy Servers
  - Internet Gateways
  - Load Balancers

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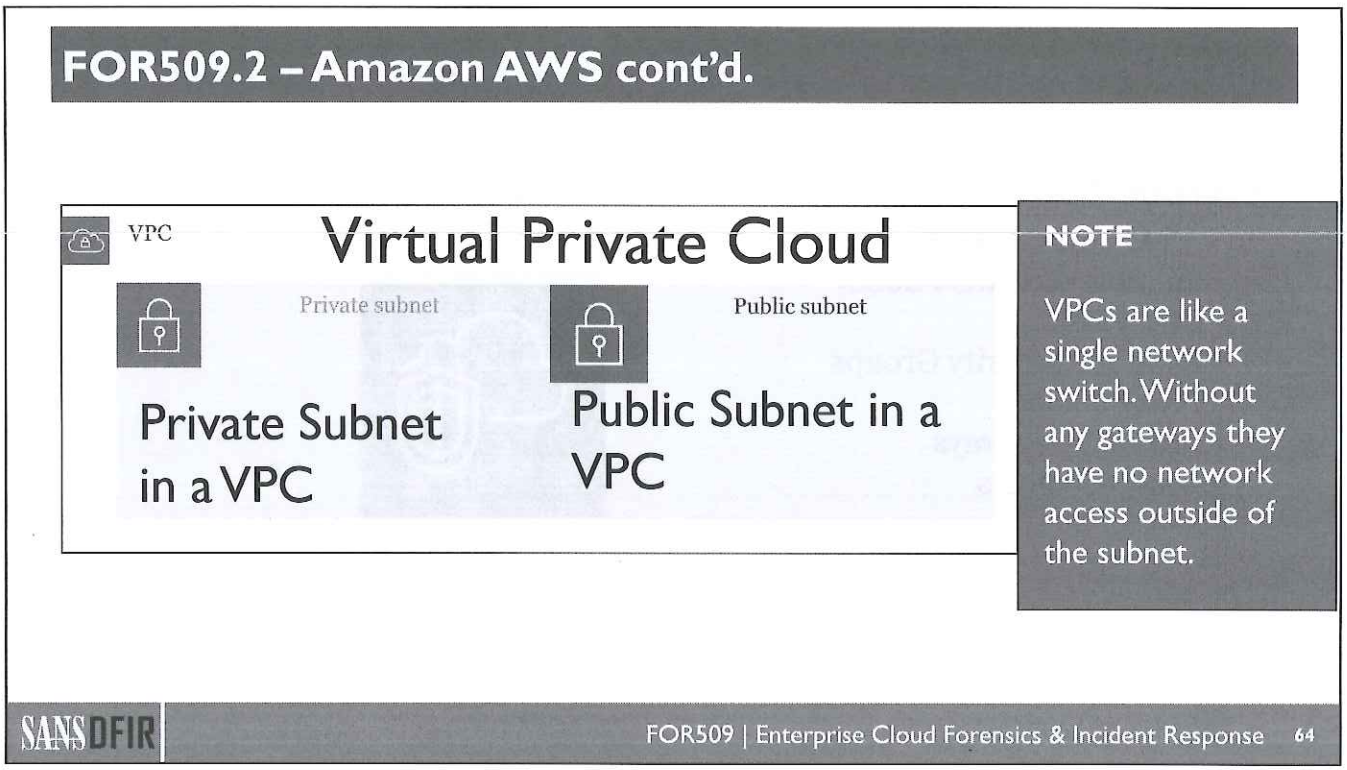

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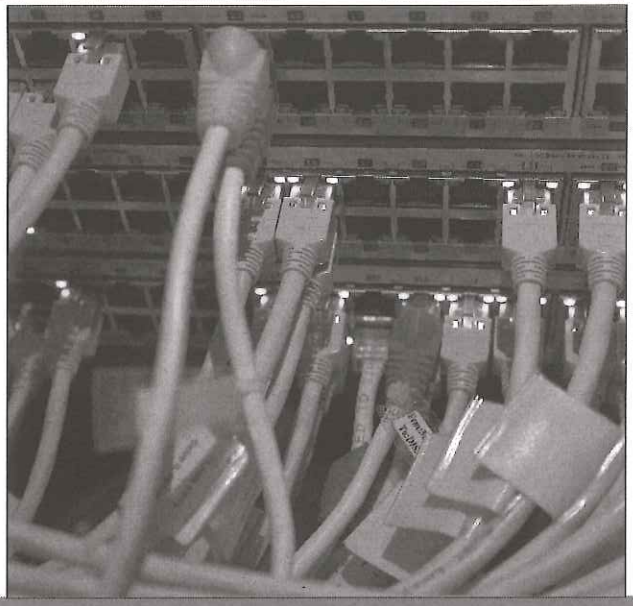
VPC Subnets

- Subnets within VPCs
  - Within a VPC you can have both public and private subnets
  - What makes a private subnet is no direct routing ability to the internet
  - What makes a public subnet is a default route that leads to the internet
  - Subnets can have different security policies and features than each other than still live in the same VPC
  - Subnets are like VLANs, each has its own IP address space
  - You can create routes between subnets, by default they are isolated



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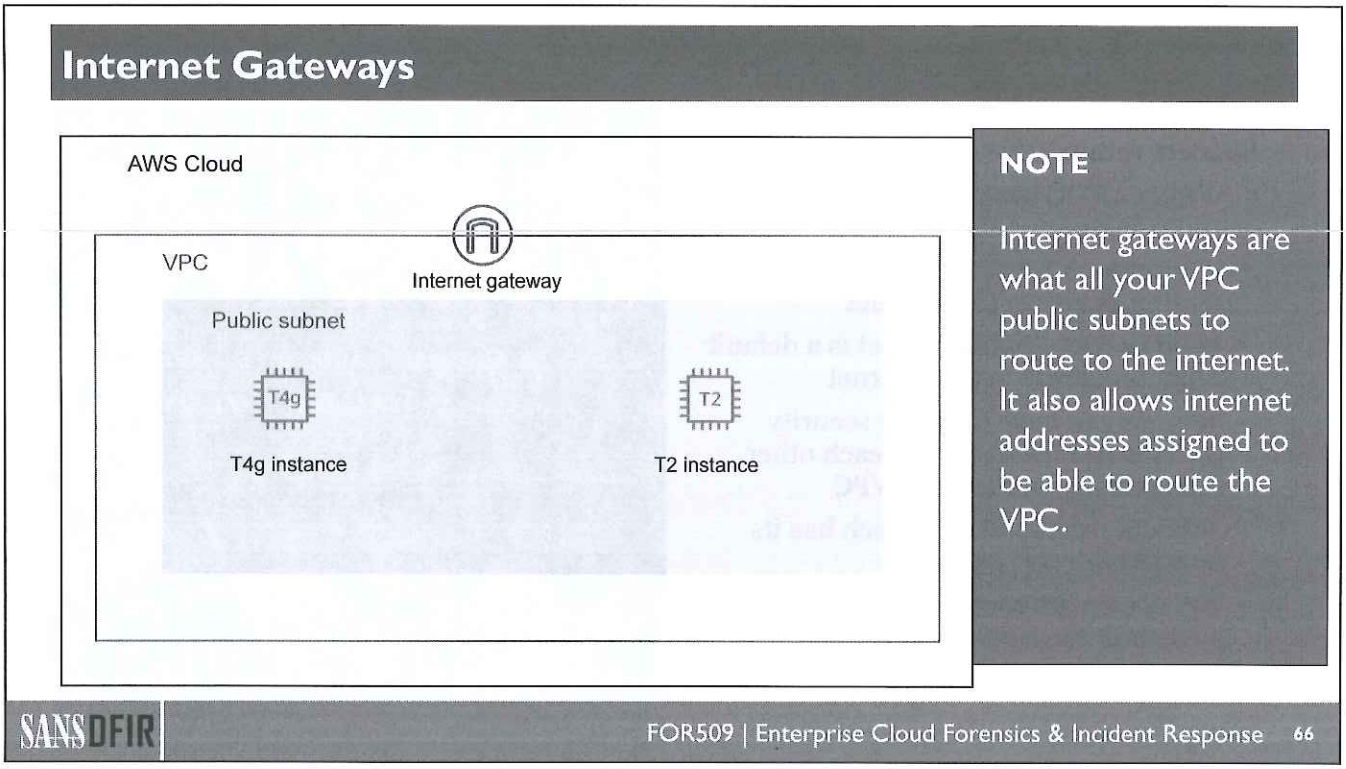

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AWS Load Balancers

- AWS load balancers work one of four ways:
  - Application load balancer
    - Understands HTTP and can route requests between sets of web servers
  - Classic load balancer
    - Balances traffic by routing traffic based on weights or rotation
  - Network load balancer
    - Balances loads across multiple VPCs

NOTE

If a AWS load balancer is in place the external address of the attacker may not be passed on to the underlying instance you are analyzing. Make sure to get load balancer logs!

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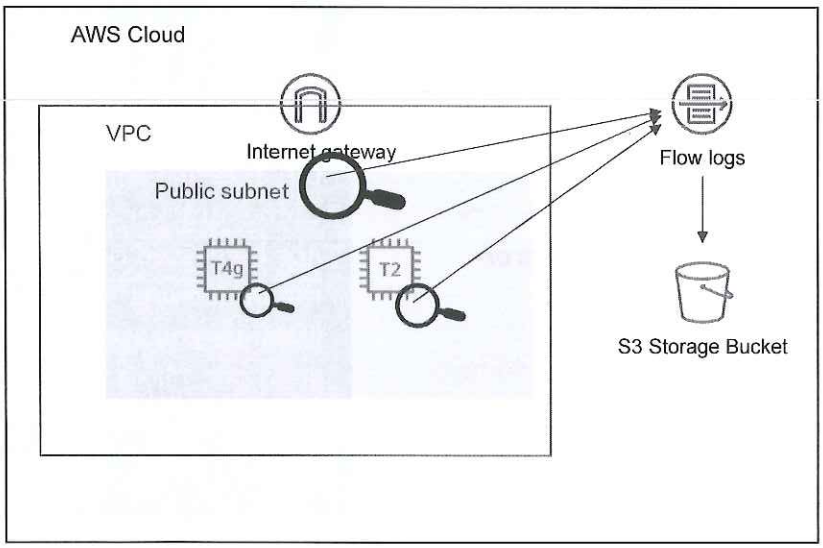
VPC Flow Logs



NOTE

Flow logs can be enabled at the:

- VPC
- Subnet
- Network interface

They put no load on your network and are collected out of band.

You can enable them at any time.

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VPC Flow Log Examples

version	*2*	The version of AWS Flow Log
account-id	*305681518678.00*	The AWS Account that this was generated in
interface-id	*eni-06fa0119bda73bdc5*	The virtual network interface that was contacted
srcaddr	*209.17.96.130*	The system that sent the connection
dstaddr	*10.0.2.99*	The system the connection was sent to
dstport	*61087*	The port that was on the destination
srcport	*990*	The port used by the sending system
protocol	*6*	The protocol number in use
packets	*1*	The number of packets in this connection
bytes	*44*	The number of bytes in this connection
start	*1618617647*	A unix time stamp of when this connection started
end	*1618617703*	A unix time stamp of when this connection ended
action	*ACCEPT*	What action the network security group took
log-status	*OK*	OK

NOTE
Flow logs record sessions every 10 minutes by default

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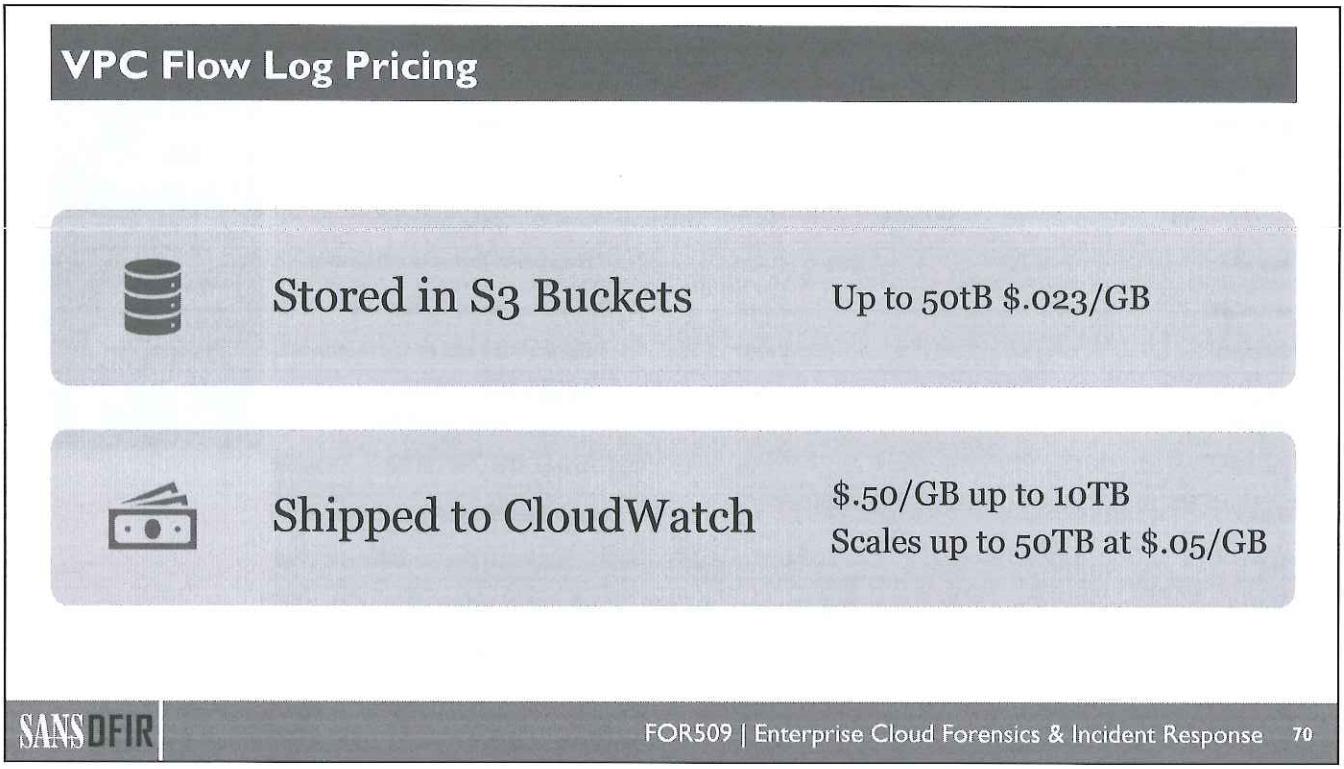

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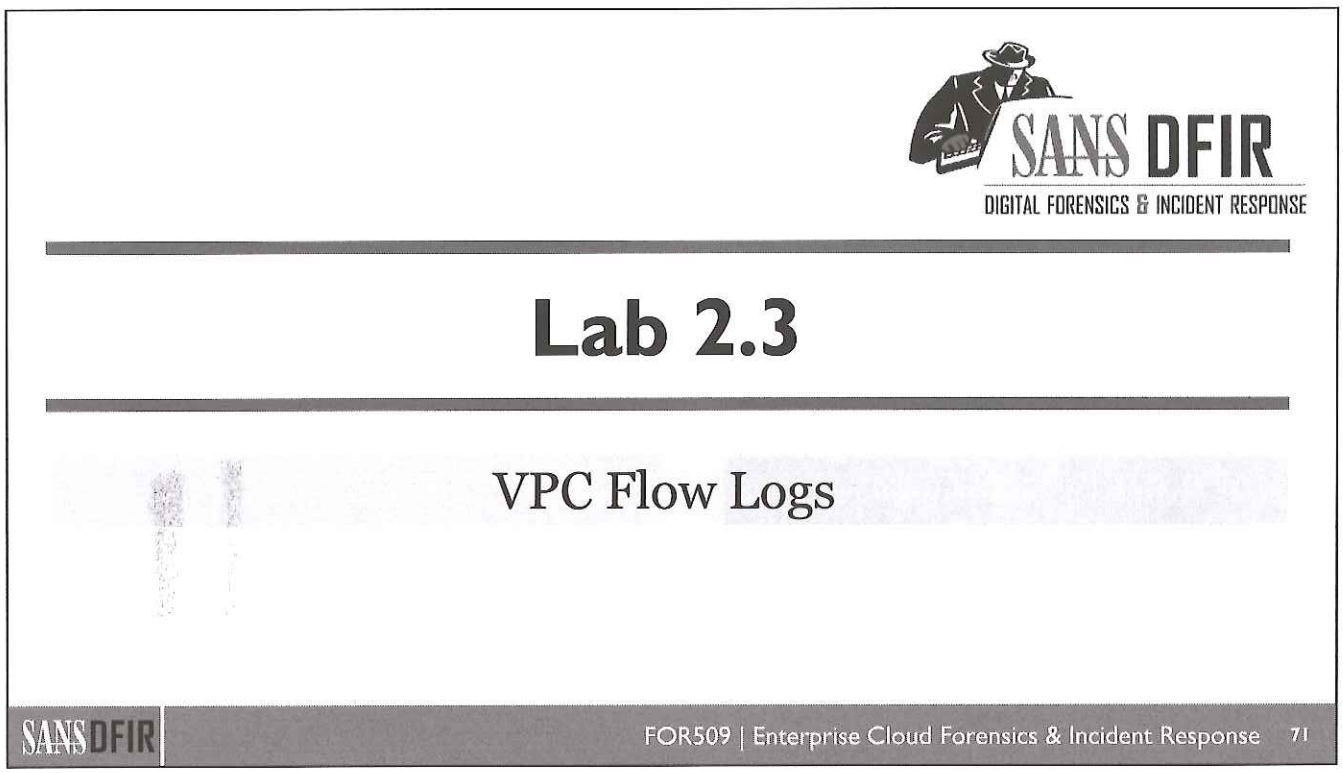

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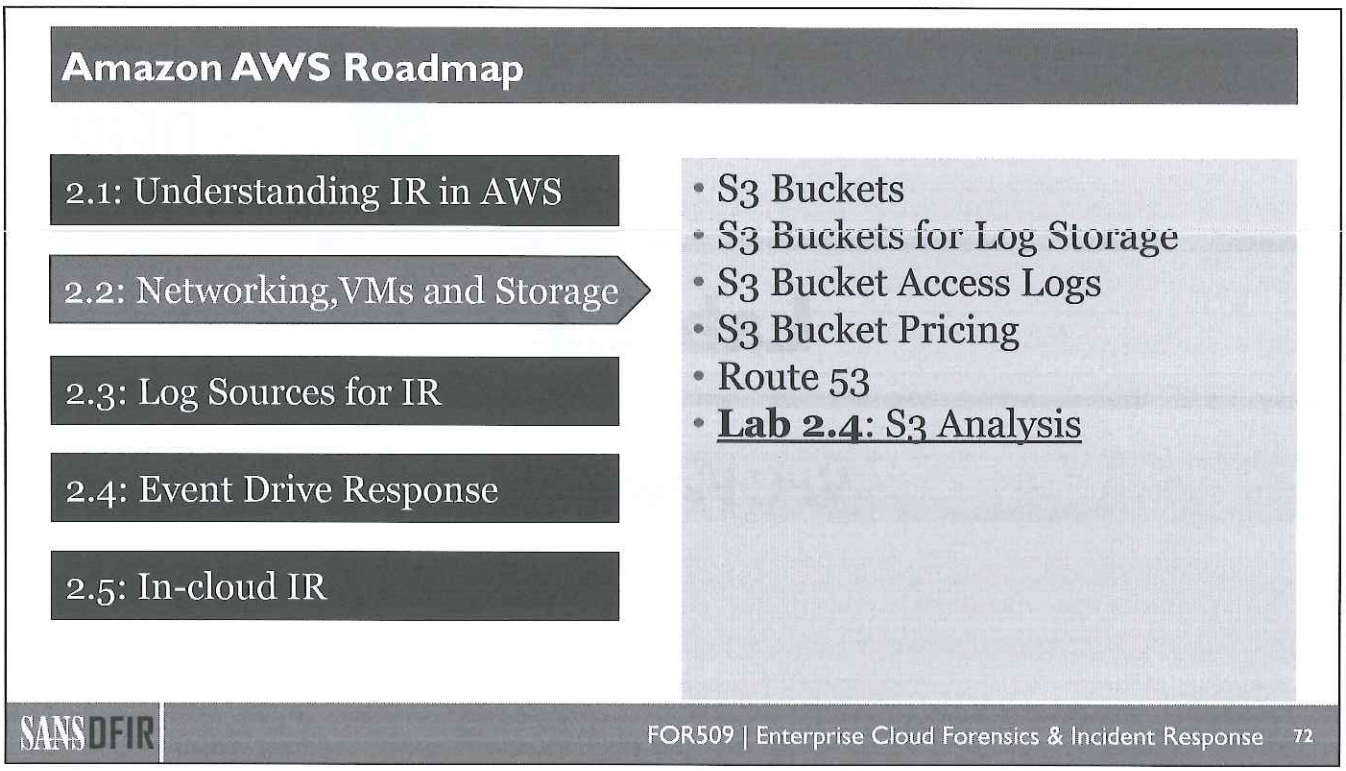

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S3 Buckets

Those things you keep reading about in the news

A file share you can upload to with a web browser

S3 Names are Universal

- That means only one customer can have a s3 bucket name in all of amazon

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S3 Buckets – Restrictions of access

- Public
  - Anyone can access the contents
- AWS User
  - Any AWS user can access
- Org User
  - A specified user(s) can access the contents
- IAM Roles
  - Specific roles can access the contents
- Tokens in URL strings
  - Anyone with the correct link, in the specified time, can access the contents

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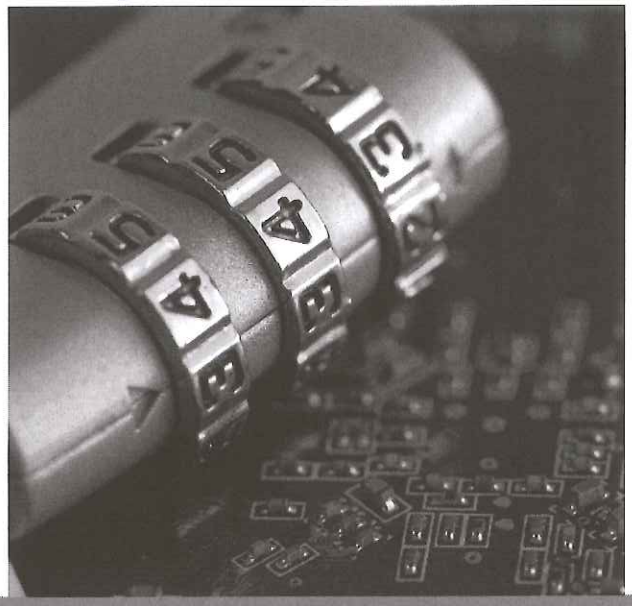
S3 Buckets – Cornerstone of AWS IR

- S3 Buckets can store
  - Snapshots
  - NetFlow logs
  - Load balancer logs
  - CloudTrail logs
  - S3 audit logs
  - Anything!



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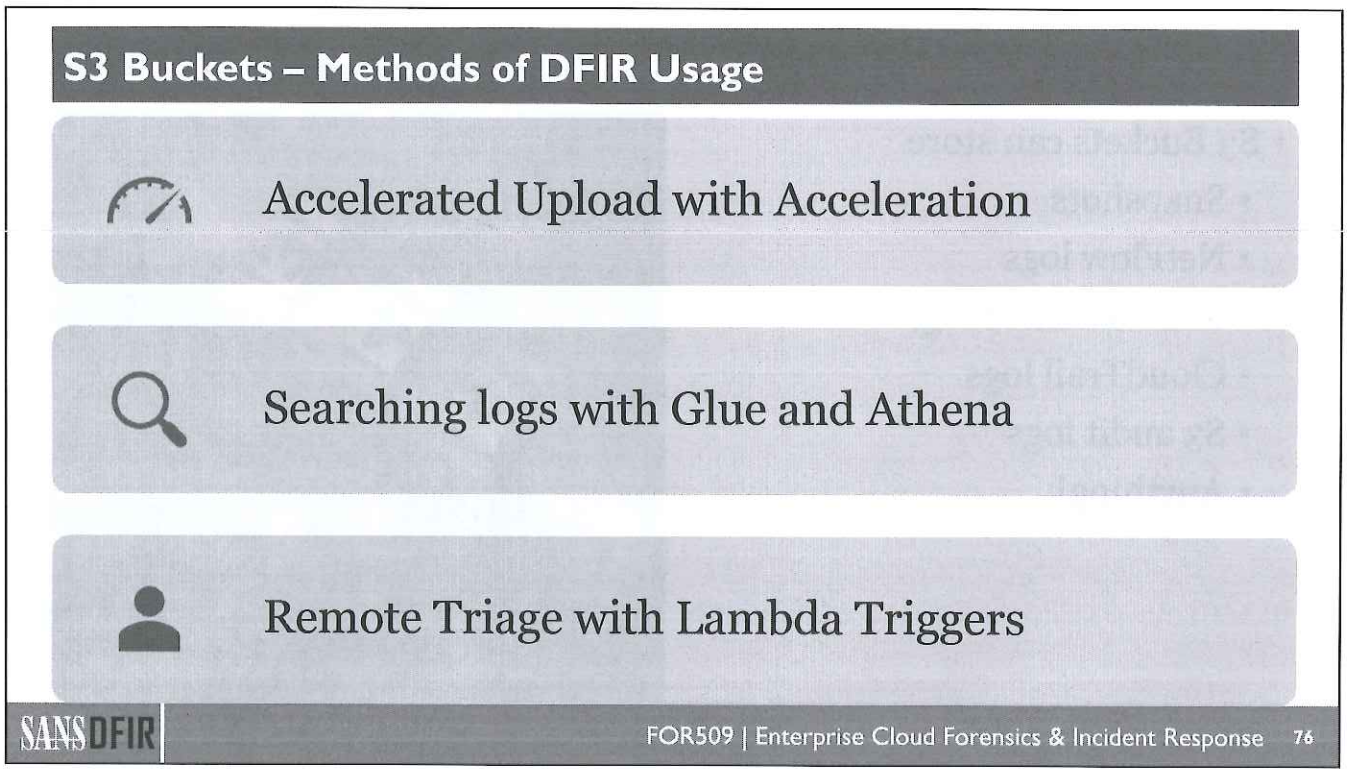

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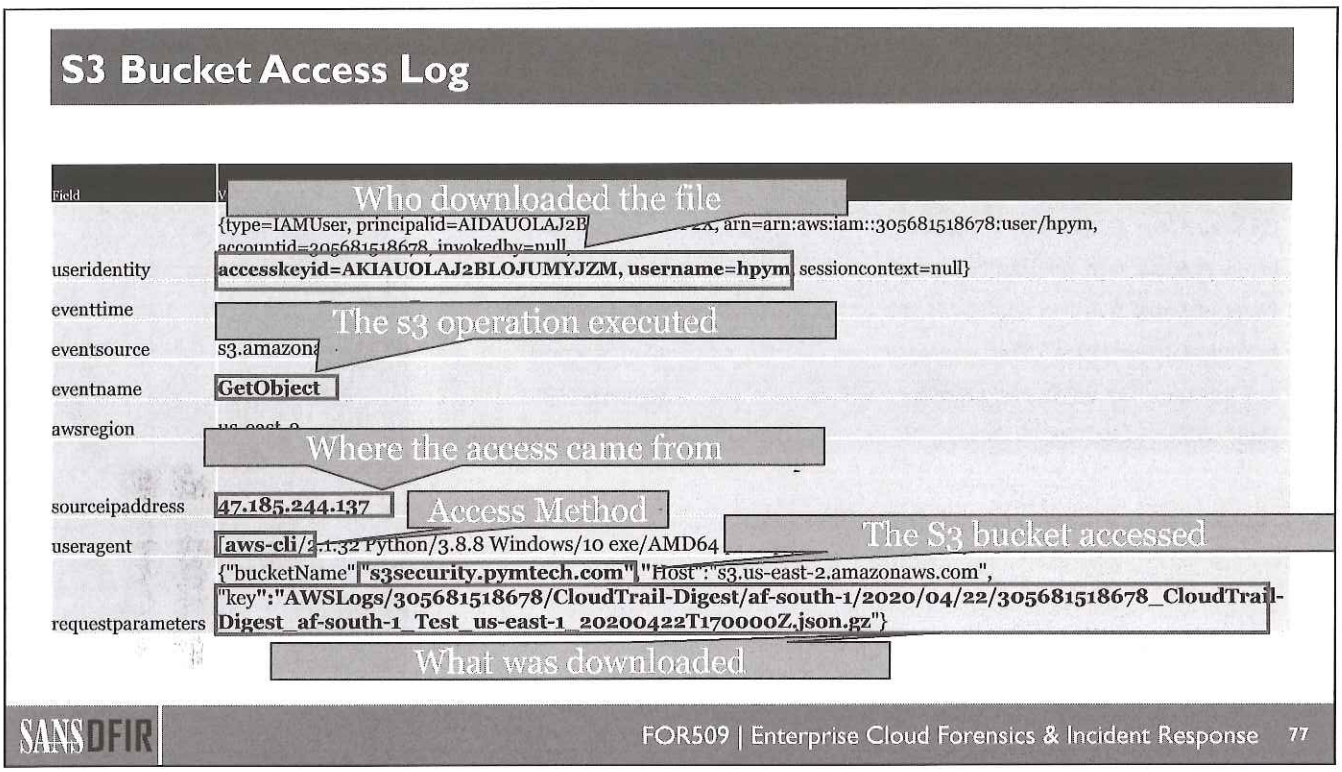

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S3 Access Log Storage Pricing

S3 Intelligent Tiering	Cost per GB
Frequent Access Tier, First 50 TB / Month	$0.023 per GB
Frequent Access Tier, Next 450 TB / Month	$0.022 per GB
Frequent Access Tier, Over 500 TB / Month	$0.021 per GB
Infrequent Access Tier, All Storage / Month	$0.0125 per GB
Archive Access Tier, All Storage / Month	$0.004 per GB
Deep Archive Access Tier, All Storage / Month	$0.00099 per GB

NOTE
S3 data access logs won't appear in the CloudTrail console.

You have to parse the CloudTrail logs in a tool like Athena to view data/object logs. API Events will appear in the CloudTrail console.

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Route 53 – AWS DNS

- Amazon's Hosted DNS Service
- DNS Zone Query Logging
  - Log queries made to your hosted DNS Domains
- Route 53 Resolver Query Logs
  - Log all DNS queries made within your VPC

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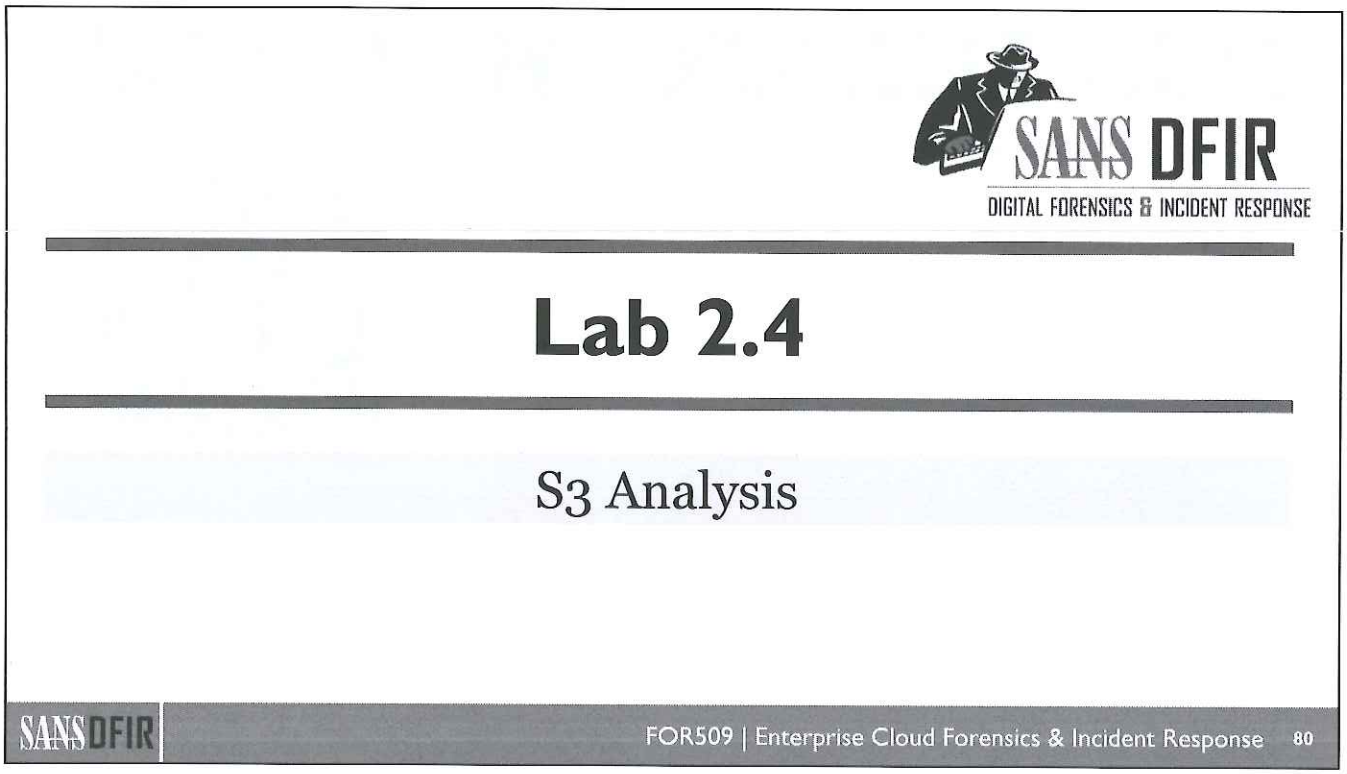

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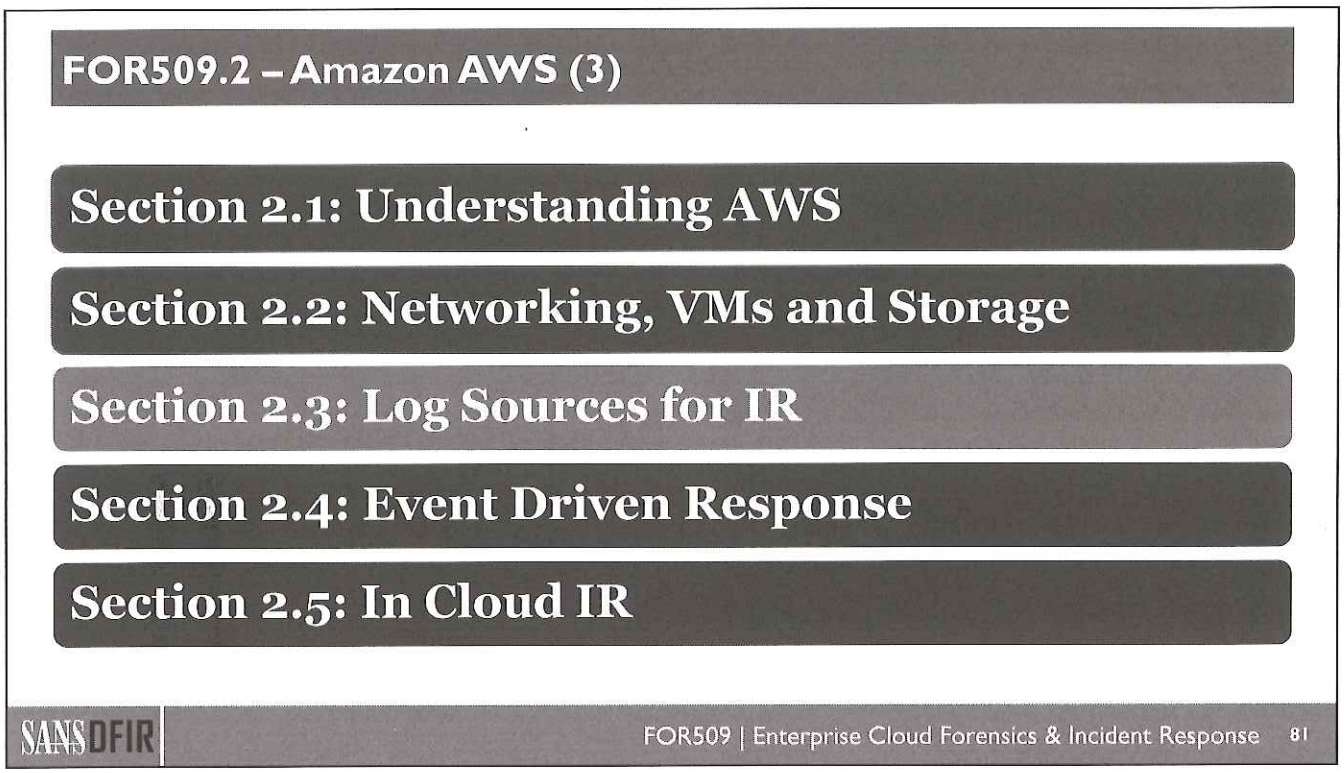

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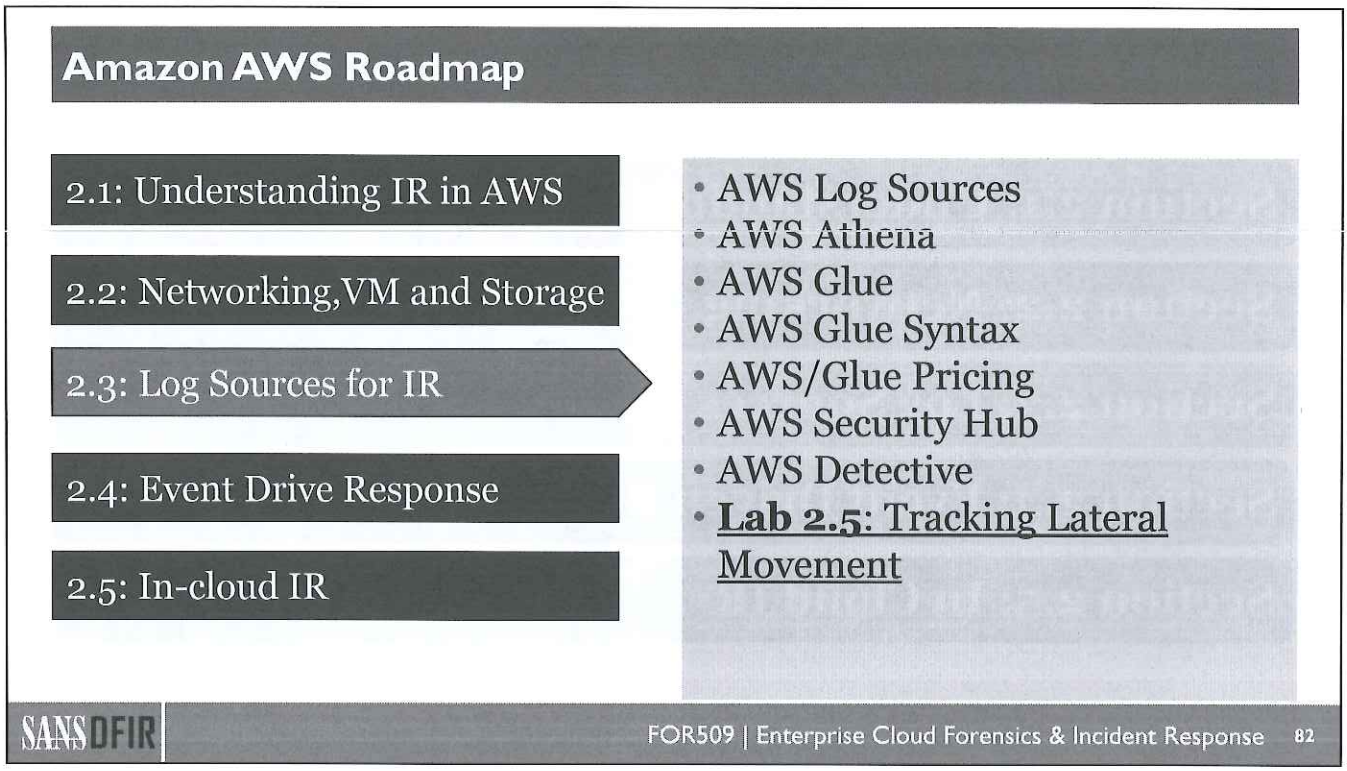

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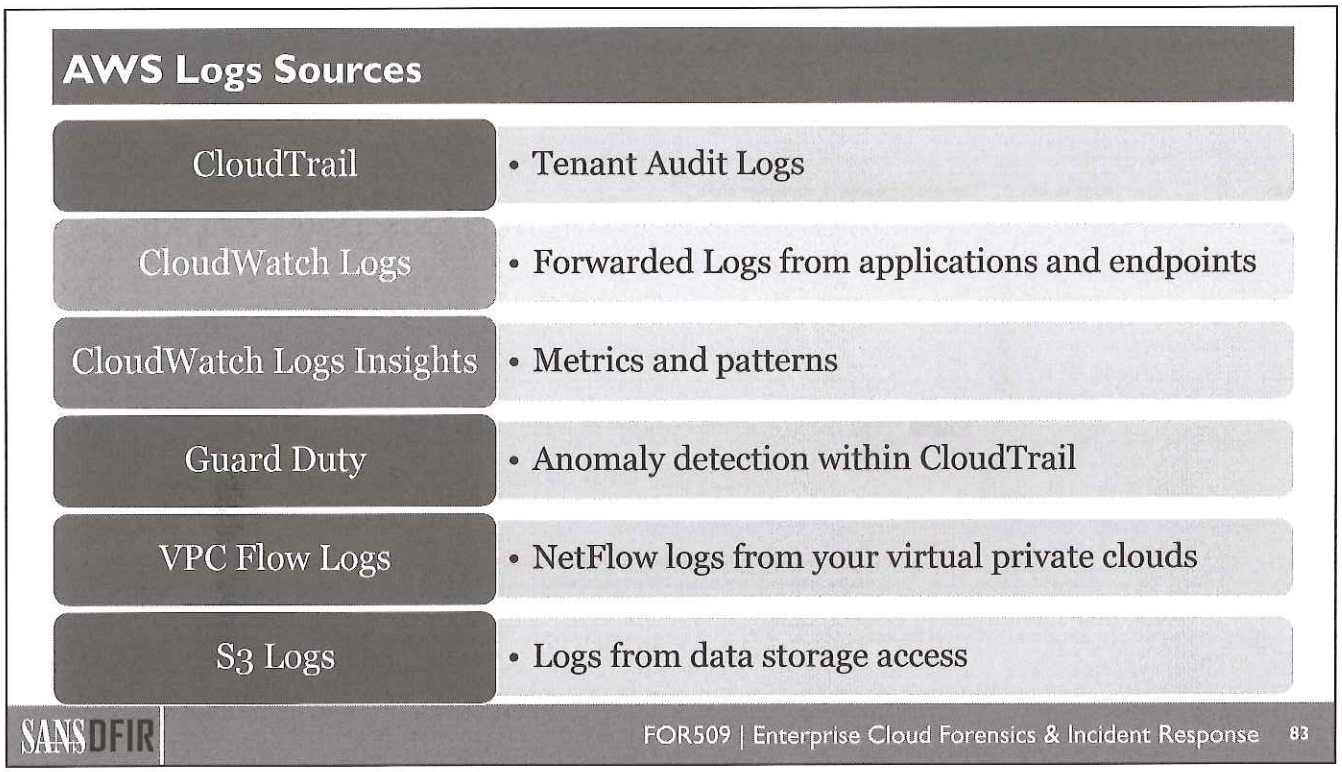
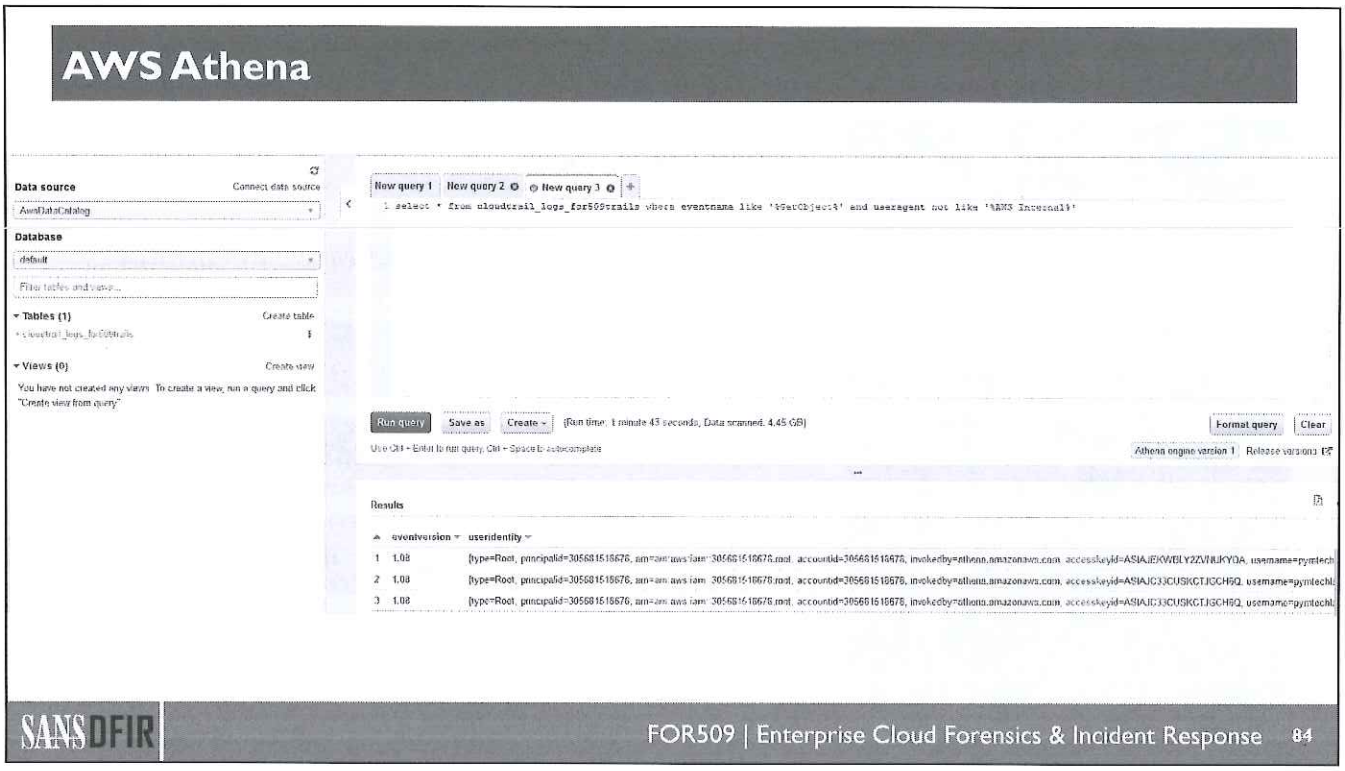


1. Tenant logs
2. Network logs
3. Storage logs

Can I do it in one slide for all three clouds???



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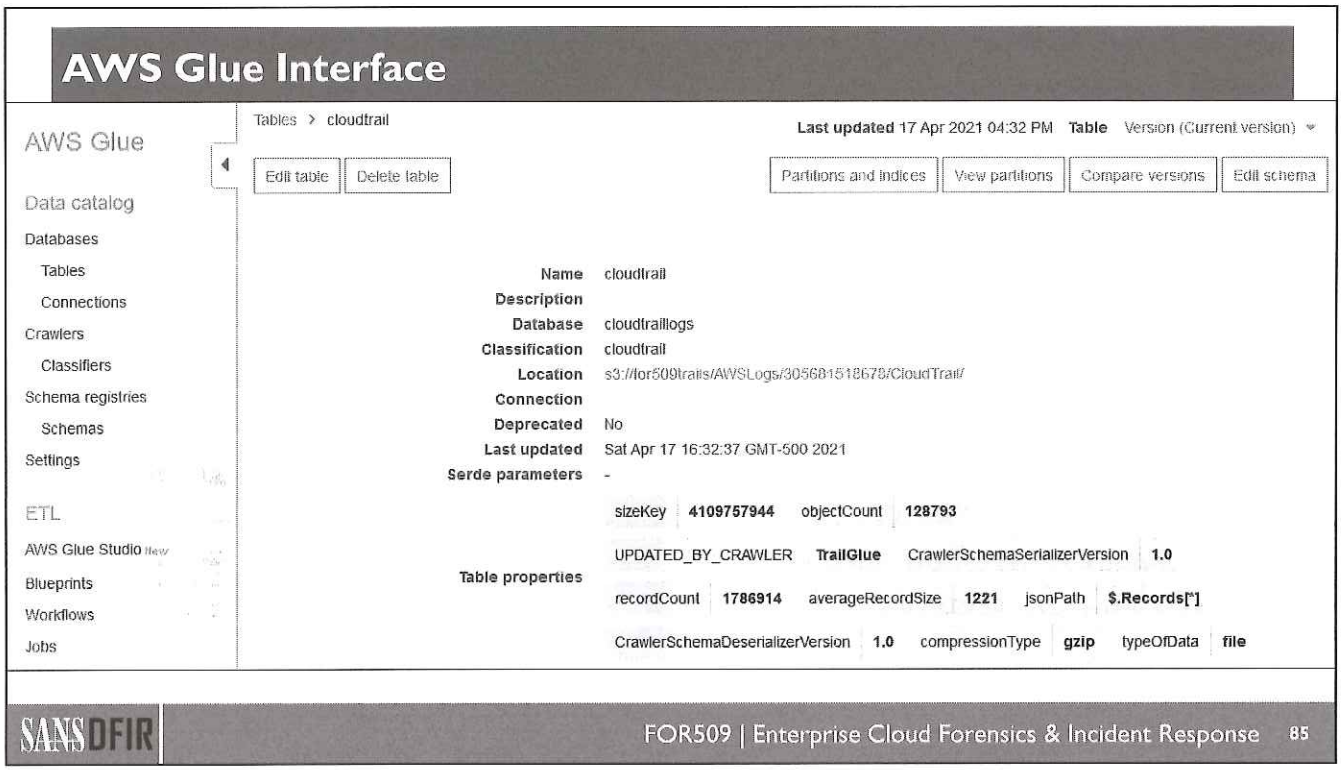

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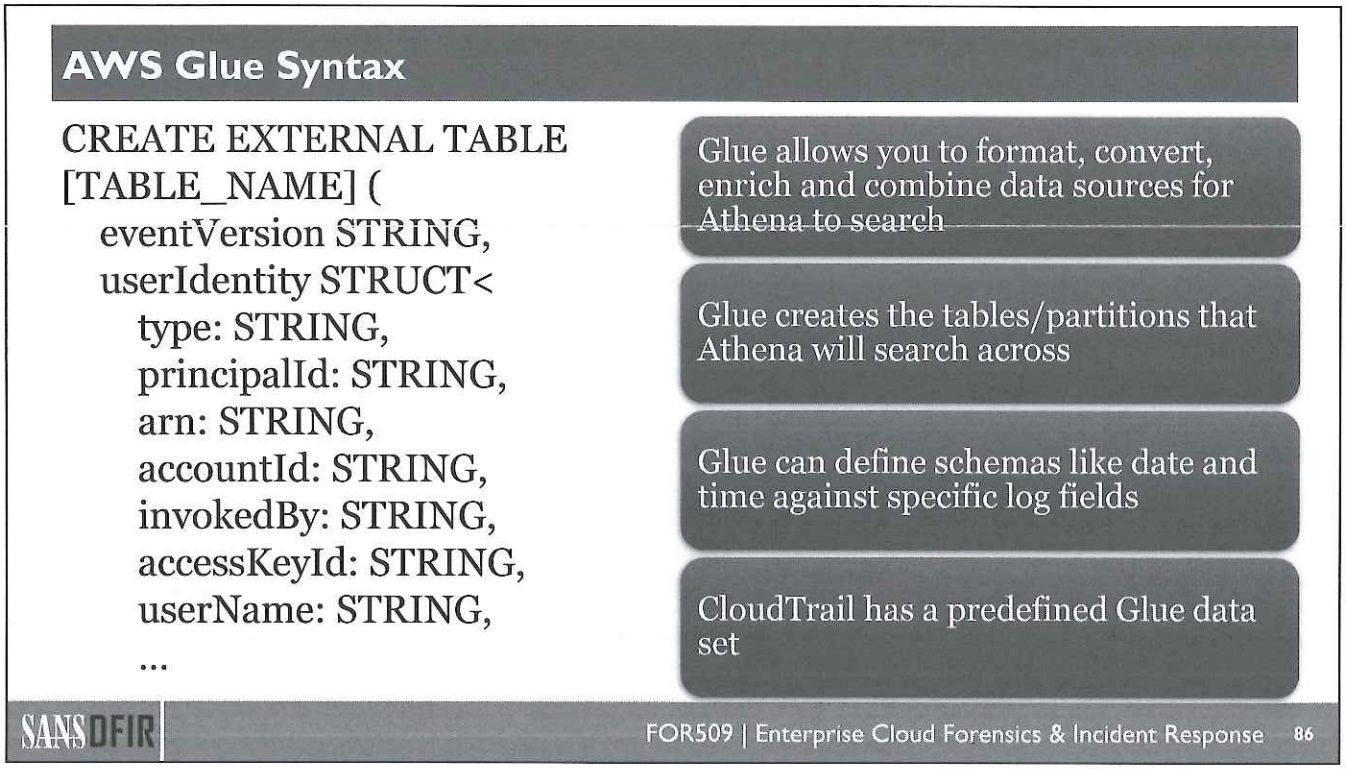

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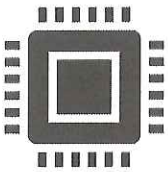
AWS Athena/Glue Pricing

Athena Searching

$5 per TB scanned while searching
Failed queries are not charged



Glue Crawling

$0.44 per DPU (Data Process Unit) hour
DPUs have 4 CPUs and 16GB of memory.
10 minute minimum billed

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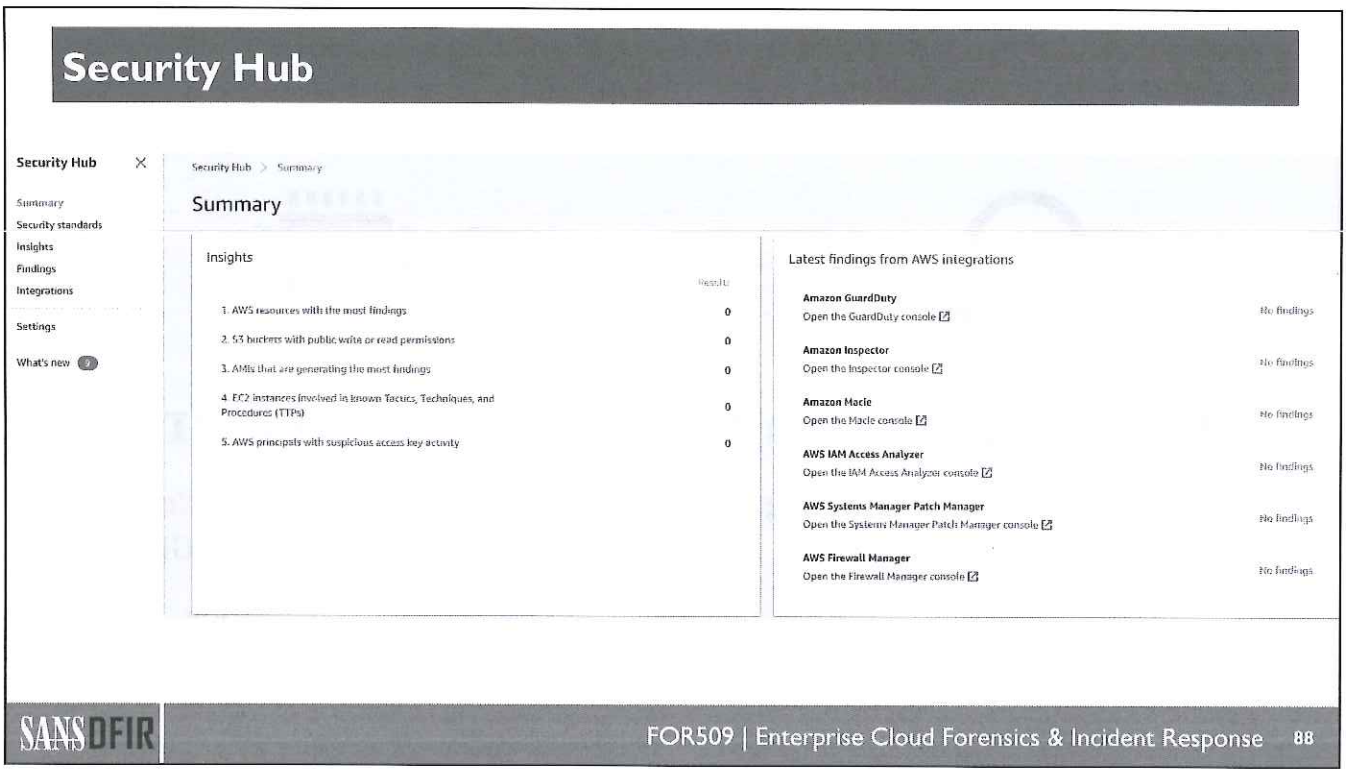

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Security Hub Pricing

- Security Checks
  - First 100,000 $.0010/check
  - >= 500,000 $.0008/check
  - >500,000 $.0005/check
- Ingestion Events
  - First 10,000 Free
  - >10,000 $.00003/finding

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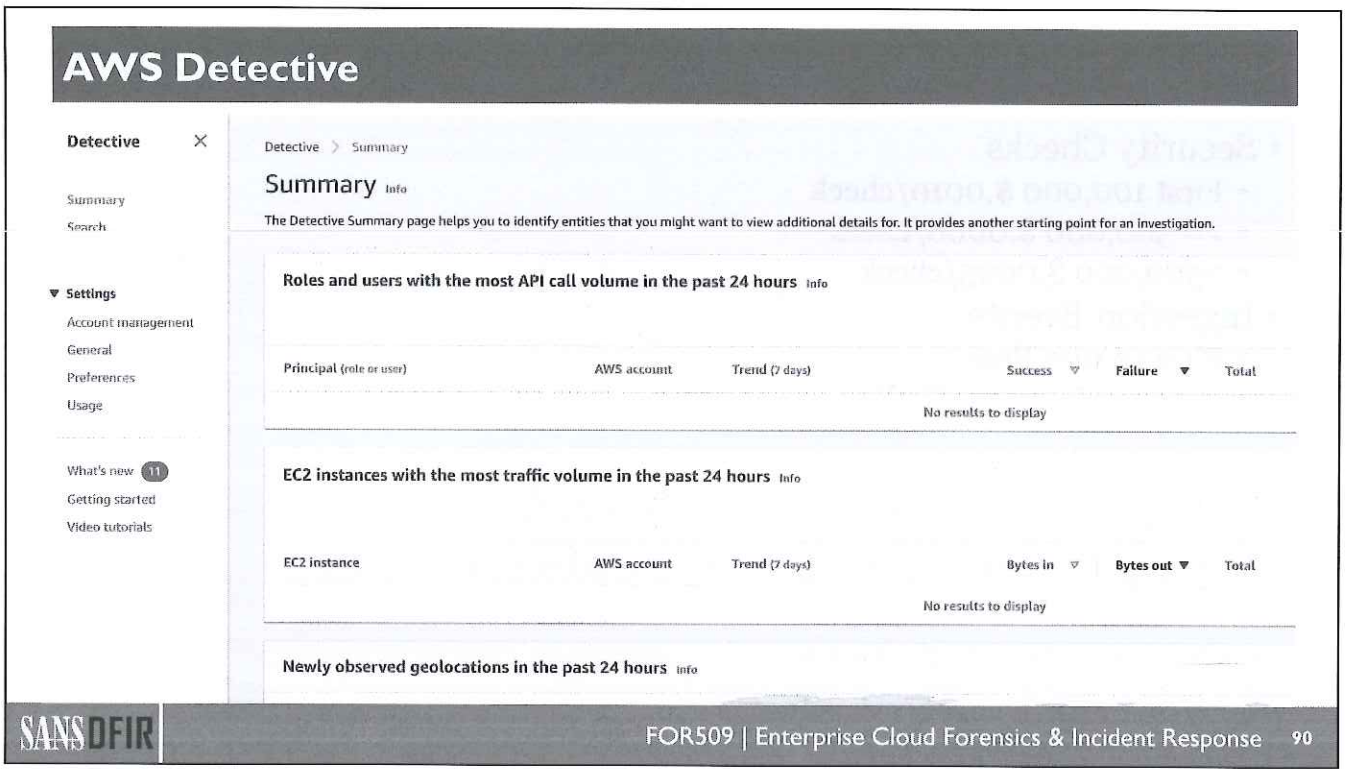

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AWS Detective Pricing

- Ingested Logs per GB
  - <= 1,000 GB $2/GB
  - <= 5,000 GB $1/GB
  - <=10,000GB $.50/GB
  - >10,000GB $.25/GB

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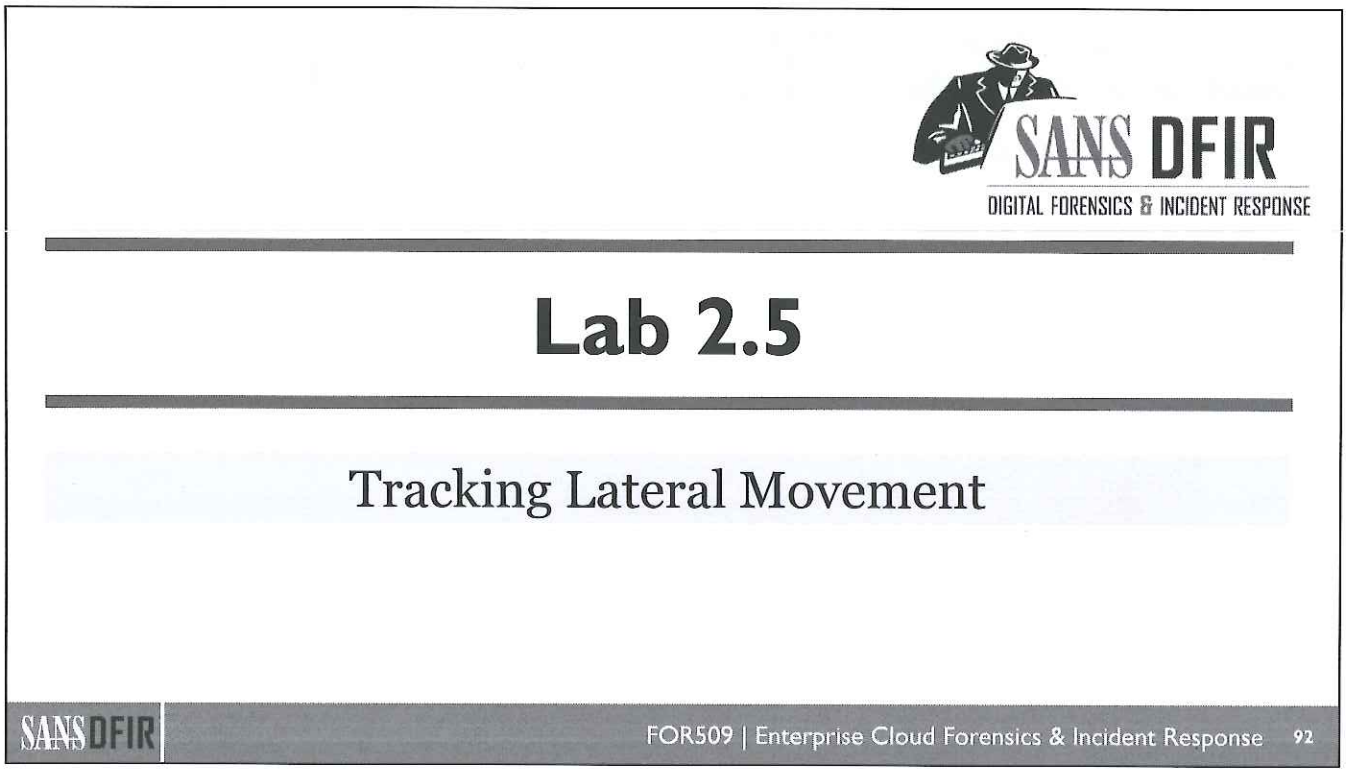

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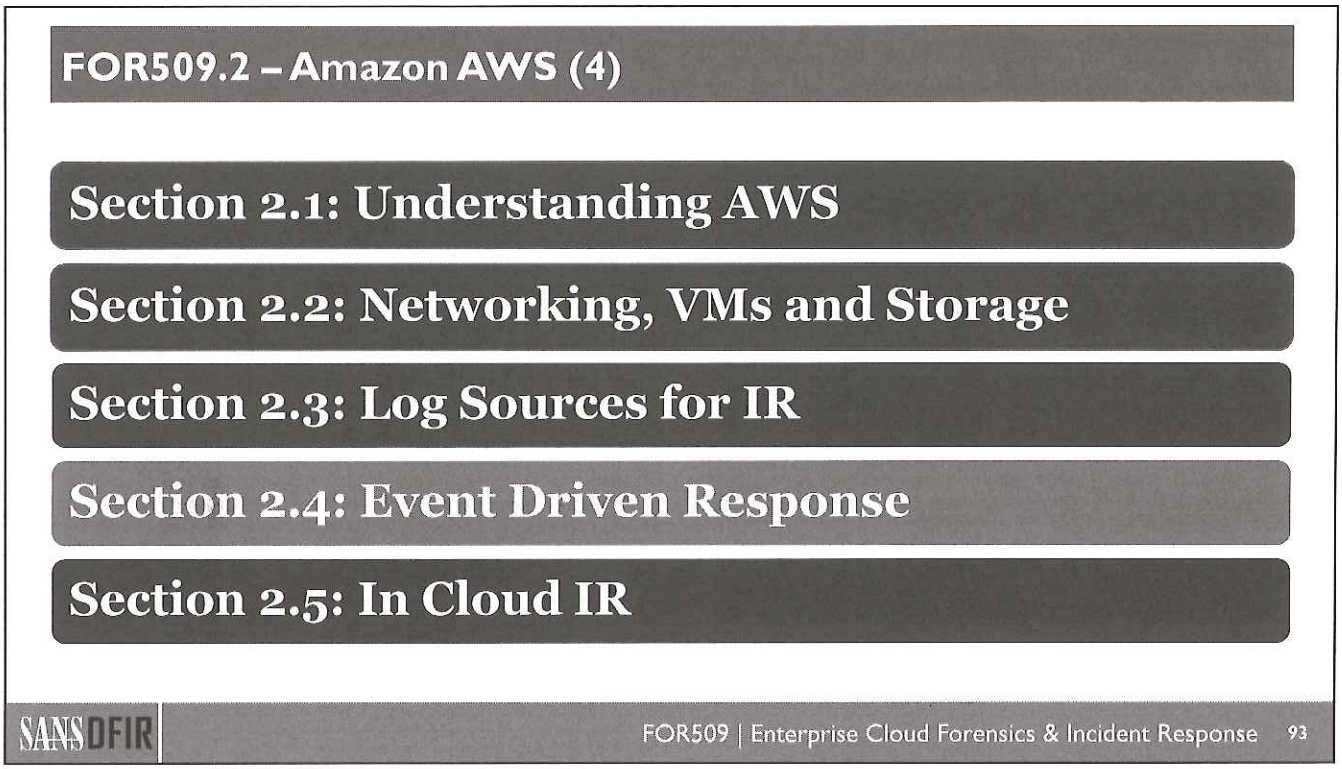

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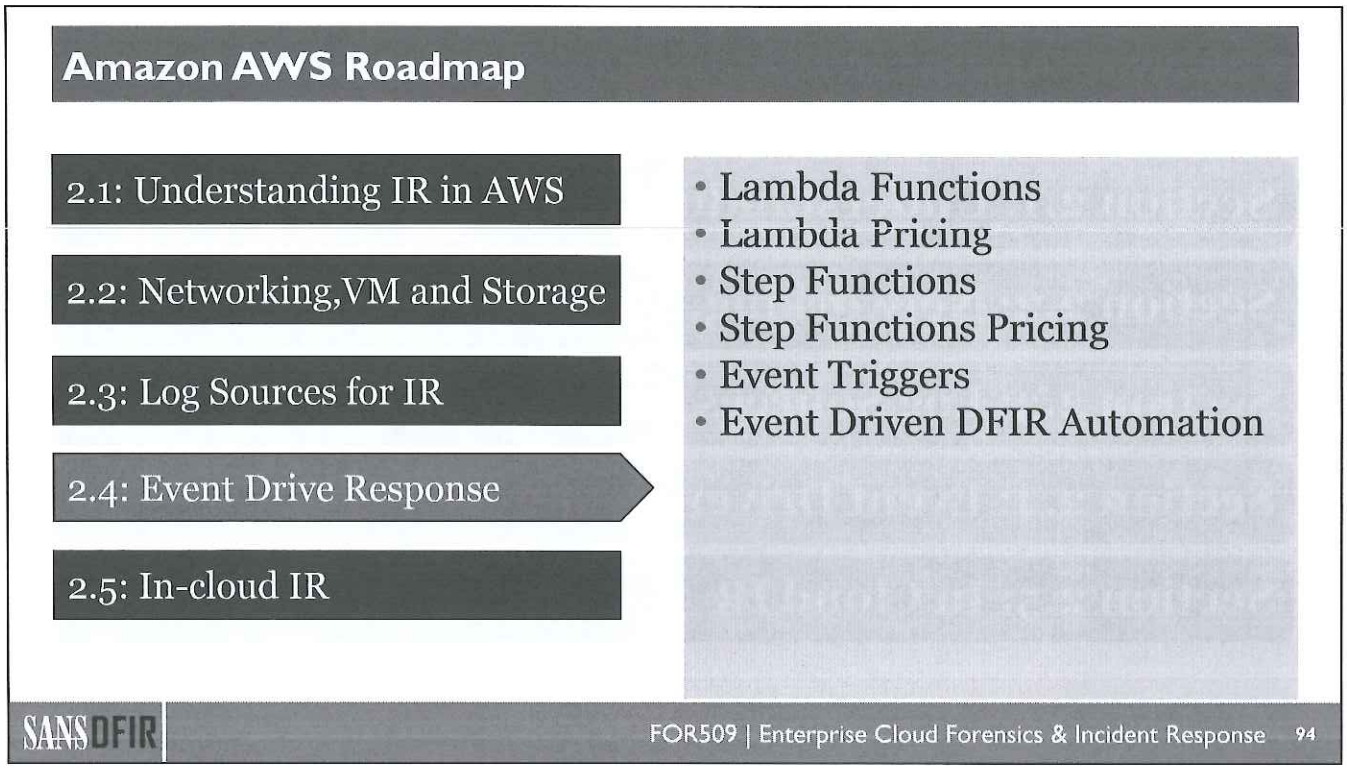

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Lambda Functions

- Lambda is AWS's version of Serverless functions
- Lambda functions can be written in several languages
  - Java
  - Go
  - PowerShell
  - Node.js
  - C#
  - Python
  - and Ruby

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Lambda Pricing

$.20 per 1 Million Requests

Also charged $0.0000166667 for every GB of ram used per second the function runs

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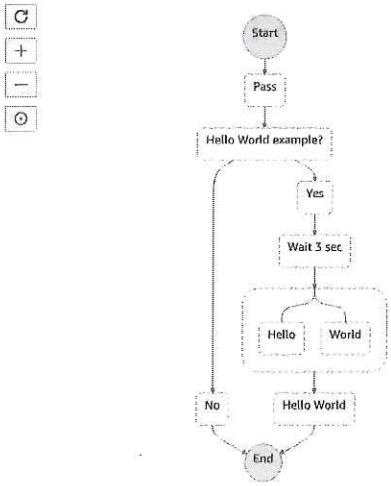
Step Functions

- Step functions allows you to chain lambda functions into a workflow where the prior output is the input for the next step.
- This allows you to divide your workflow into fast and cheap running lambda functions and build a larger IR automation tool.



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Step Functions Pricing

- 4,000 State Transitions are Free per month
- More than 4,000 state transactions are $.025 per 1,000 state transactions

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Event Triggers

- Lambda functions can be triggered with AWS events
- Examples of Events include
  - S3 Uploads
  - CloudTrail events
  - EC2 Changes
  - EFS Changes
  - Amazon Config changes

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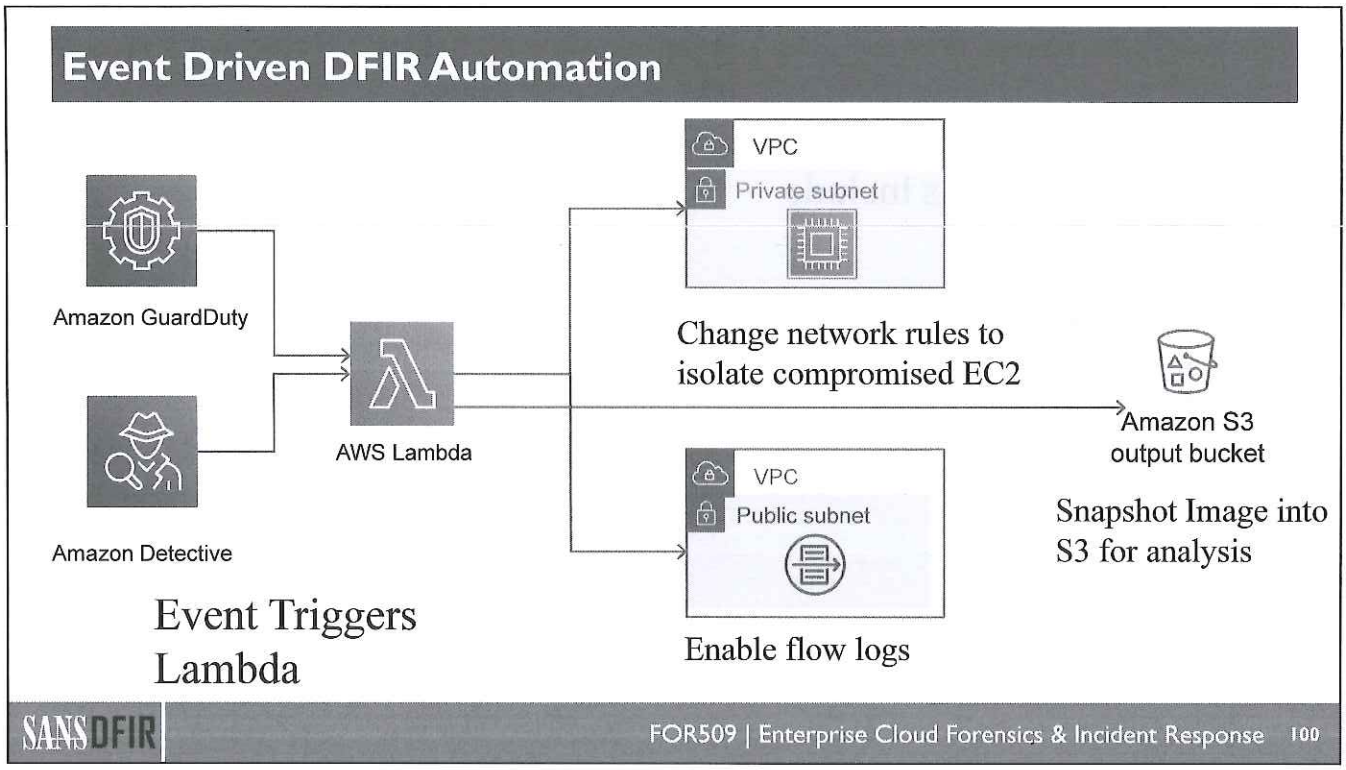

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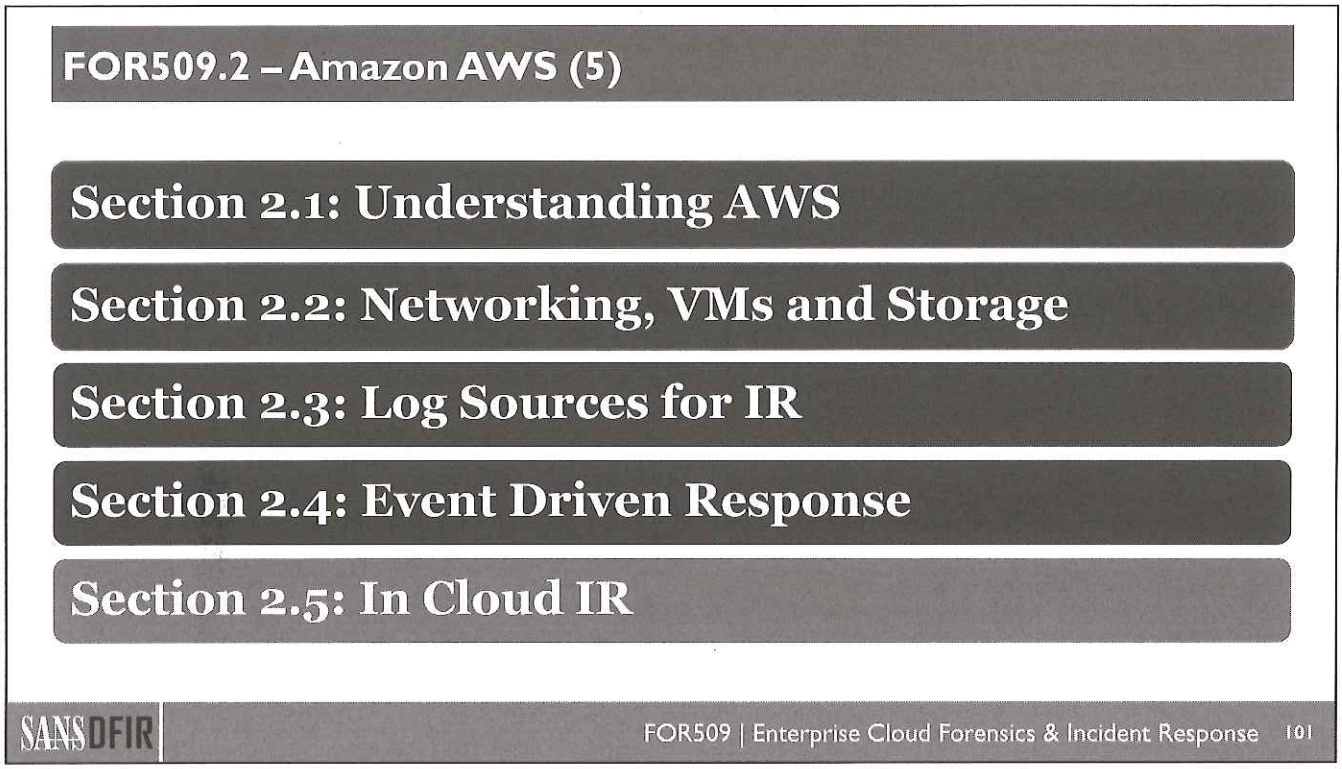

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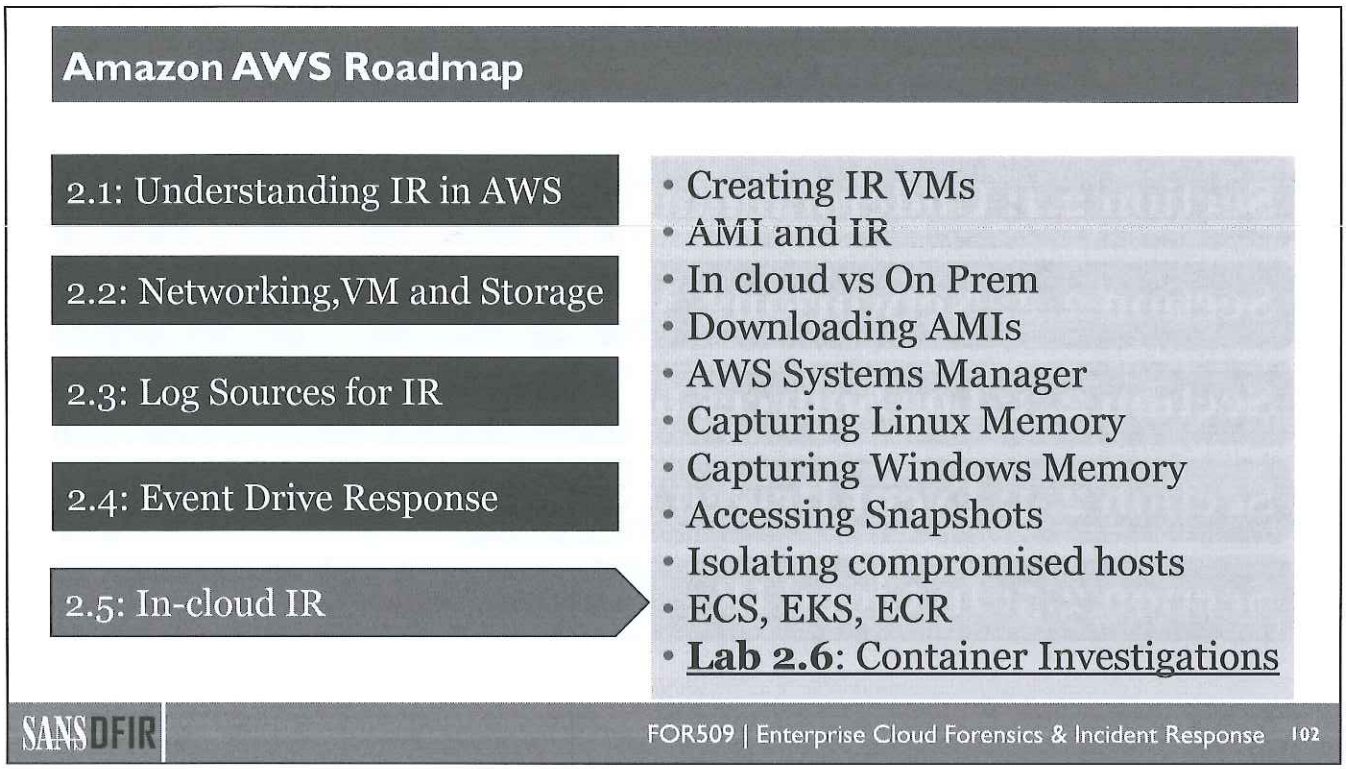

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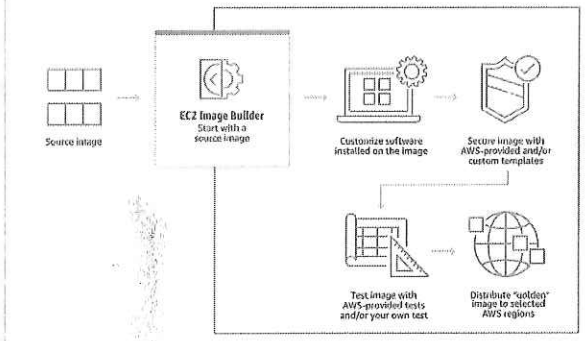
Creating IR VMs

How it works



Amazon makes it easy to create a custom IR VM

The EC2 Image Builder lets you pick a base image (Windows, Linux, etc..)

You can then configure the base system and then upload them as a template for your organization to deploy on demand anywhere in the world.

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AMIs and IR

- AMIs can be examined in two ways
  - Within AWS
    - You can snapshot the running system and attach it to a DFIR AMI that is running
    - Run all of your tools against the Snapshots
    - Snapshots are basically raw disks that can be accessed like a DD Image
  - Outside of AWS
    - You can snapshot the running system and then download the data
    - You can power off the running system and download the AMI
    - The time to download could be longer than it takes to do the examination within AWS

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In cloud vs. On Prem AMI examination

In Cloud

- Pros
  - Fastest time to access data
  - Able to process and load data using Amazon provided services:
    - Elastic auto scaling clusters
    - Athena for log searching
    - Containers for scalable processing
  - On demand DFIR lab anywhere in the world
- Cons
  - Cost for every examination
  - If the entire organization is compromised your DFIR account may be too

On Prem

- Pros
  - After initial investment in hardware, software and people there is no cost per incident to run the DFIR systems.
  - Isolated labs can be outside of compromised cloud environment
- Cons
  - Time to download cloud data
  - Time to process data
  - Data speeds can be slower on international transfers
  - Infrastructure maintenance costs

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Downloading AMIs

- Requires an S3 bucket to write to
- Requires the AWS CLI
- Exporting an Instance

```
aws ec2 create-instance-export-task --instance-id instance-id --target-environment vmware --export-to-s3-task file://C:\file.json
```

- Exporting an AMI

```
aws ec2 export-image --image-id ami-id --disk-image-format VMDK --s3-export-location S3Bucket=my-export-bucket,S3Prefix=exports/
```


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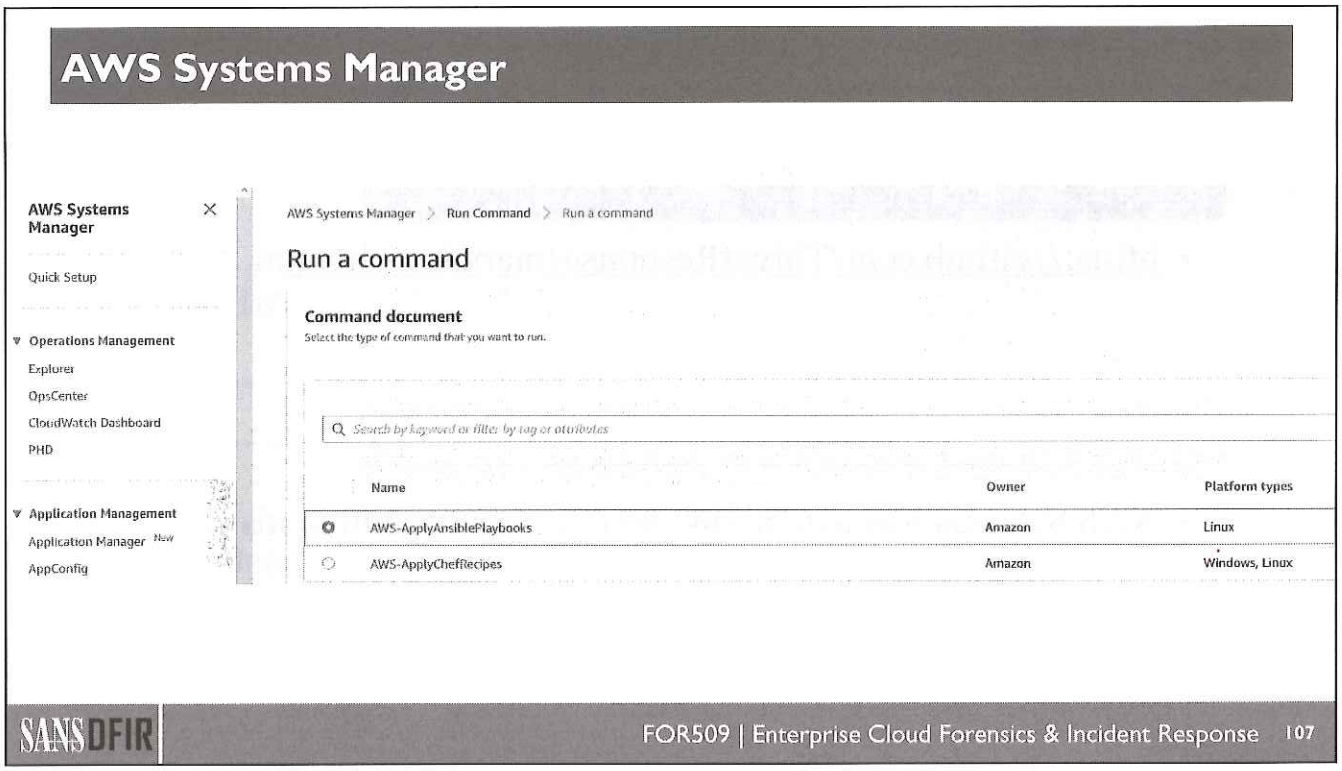

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Capturing Linux Memory

Margarita Shotgun

- https://github.com/ThreatResponse/margaritashotgun
- Logs into a running EC2 instance via SSH and runs LiME to capture memory

AVML and AWS Systems Manager

- AWS Systems Manager allows you to execute commands across instances that have the system manager agent installed
- AVML can be statically compiled meaning it does not require compromised systems have kernel headers

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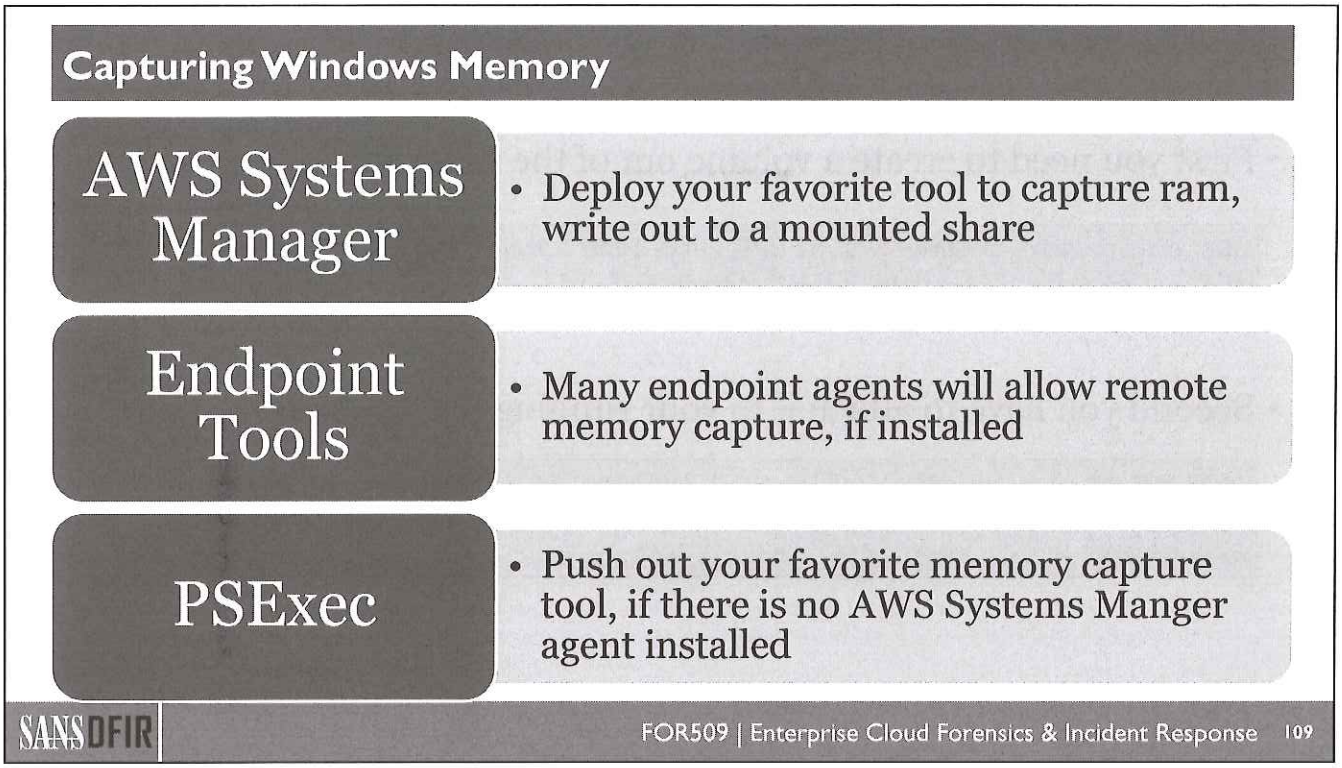

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Accessing Snapshots from DFIR AMIs

- First you need to create a volume out of the snapshot

```
aws ec2 create-volume --availability-zone <zone where your DFIR
AMI is running>  --snapshot-id <snapshot-id>
```

- Second you have to attach it to your running EC2 instance

```
aws ec2 attach-volume --volume-id <volume id returned from prior
command> --instance-id <your DFIR EC2 instance> --device
</dev/sdX>
```


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Isolating Compromised Hosts

- Need to isolate a compromised host?
  - Virtual firewalls can be configured on demand
  - Lambda to change ec2 security group

```
def modifyInstanceAttribute(instanceId,securityGroupId):
          response = ec2Client.modify_instance_attribute(
                    Groups=[securityGroupId], InstanceId=instanceId)
```

  - Lambda to place it in the isolated security group

```
def createSecurityGroup(groupName, descriptionString, vpcId):
resource = boto3.resource('ec2')
securityGroupId = resource.create_security_group(GroupName=groupName,
          Description=descriptionString, VpcId=vpcId)
          securityGroupId.revoke_egress(IpPermissions= [{'IpProtocol': '-
1','IpRanges':     [{'CidrIp': '0.0.0.0/0'}],'Ipv6Ranges':
[],'PrefixListIds': [],'UserIdGroupPairs': []}])
          return securityGroupId.
```


Reference: https://aws.amazon.com/blogs/security/automate-amazon-ec2-instance-isolation-by-using-tags/

Regions and Response

- Regions Matter!
- Every region is physically resident in the country it's named after
- Transferring data between regions:
  - Takes time
  - Costs money
- Consider spinning up your DFIR AMIs in the region where you want to analyze the data

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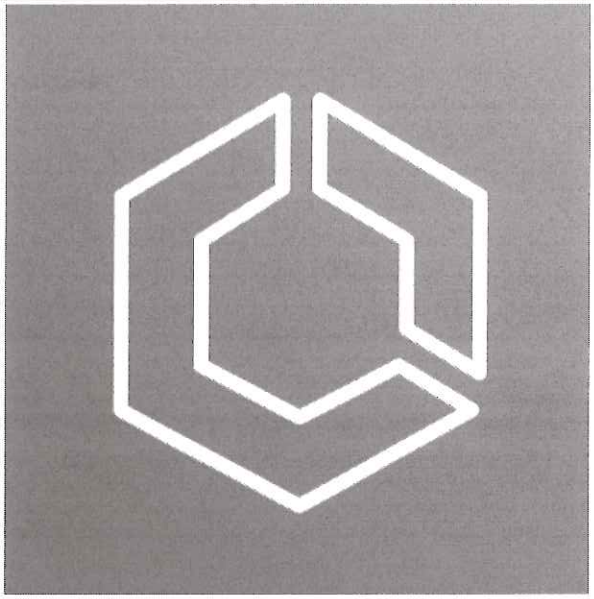
ECS - Elastic Container Service

- Amazon's version of Kubernetes
- Allows for a lower overhead container cluster
- Runs docker containers at scale and manages spinning up more as needed.



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Container Registry

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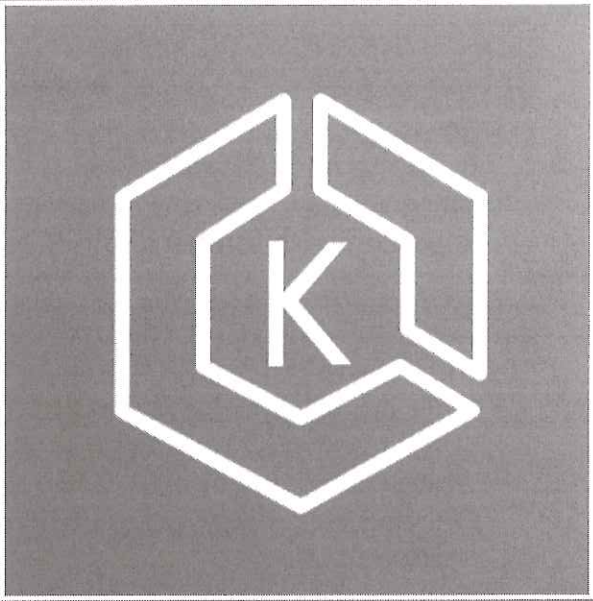
EKS – Elastic Kubernetes Service

- The real Kubernetes
  - Requires more administration than ECS
  - Can spin up any number of containers from the container registry



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Most Common Container Investigations

Vulnerable applications from the AWS Marketplace

- Many developers will launch preconfigured container applications from the AWS Marketplace
- Many of these preconfigured applications are out of date and can be launched with known exploitable services

Stolen IAM roles through the Metadata service

- Once an attacker has access to the container environment, they can reach the Metadata service unless the NSG prevents it
- Always available at http://169.254.169.254/latest/meta-data/
- Once accessed IAM roles and credentials applied to the instance can be stolen

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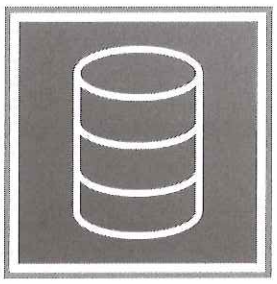
Amazon Hosted Databases

- Rather than running a database in EC2 Amazon provides hosted databases where you only must manage the data within them.
- Databases supported:
  - Amazon Aurora
  - PostgreSQL
  - MySQL
  - MariaDB
  - Oracle Database
  - MS SQL Server



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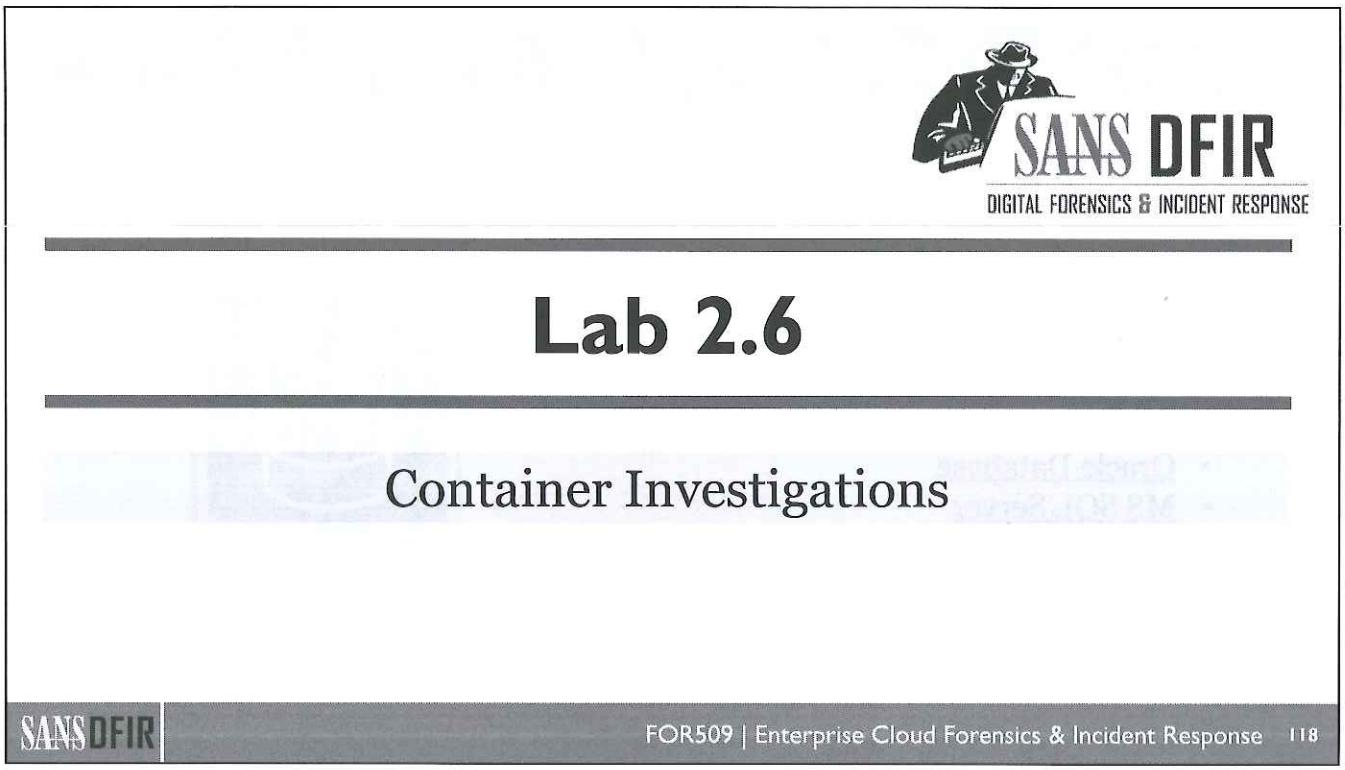

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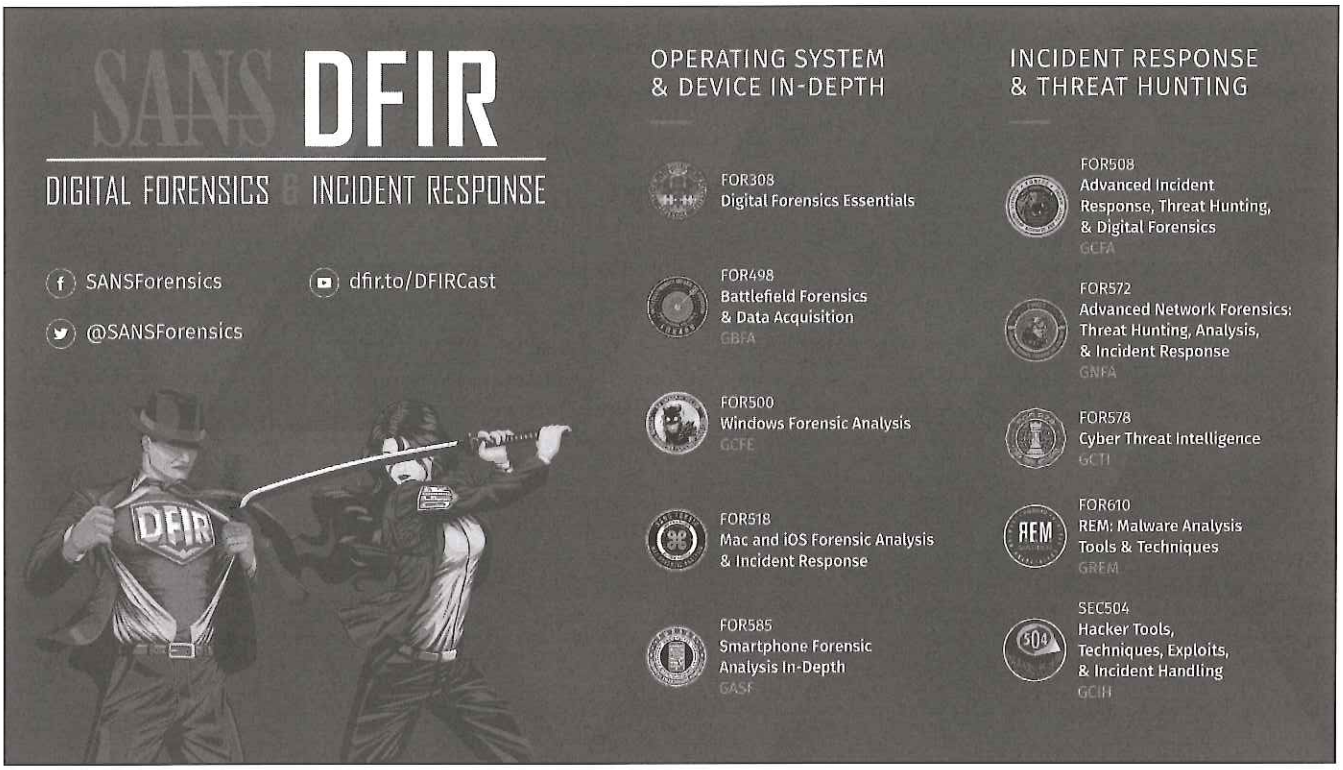

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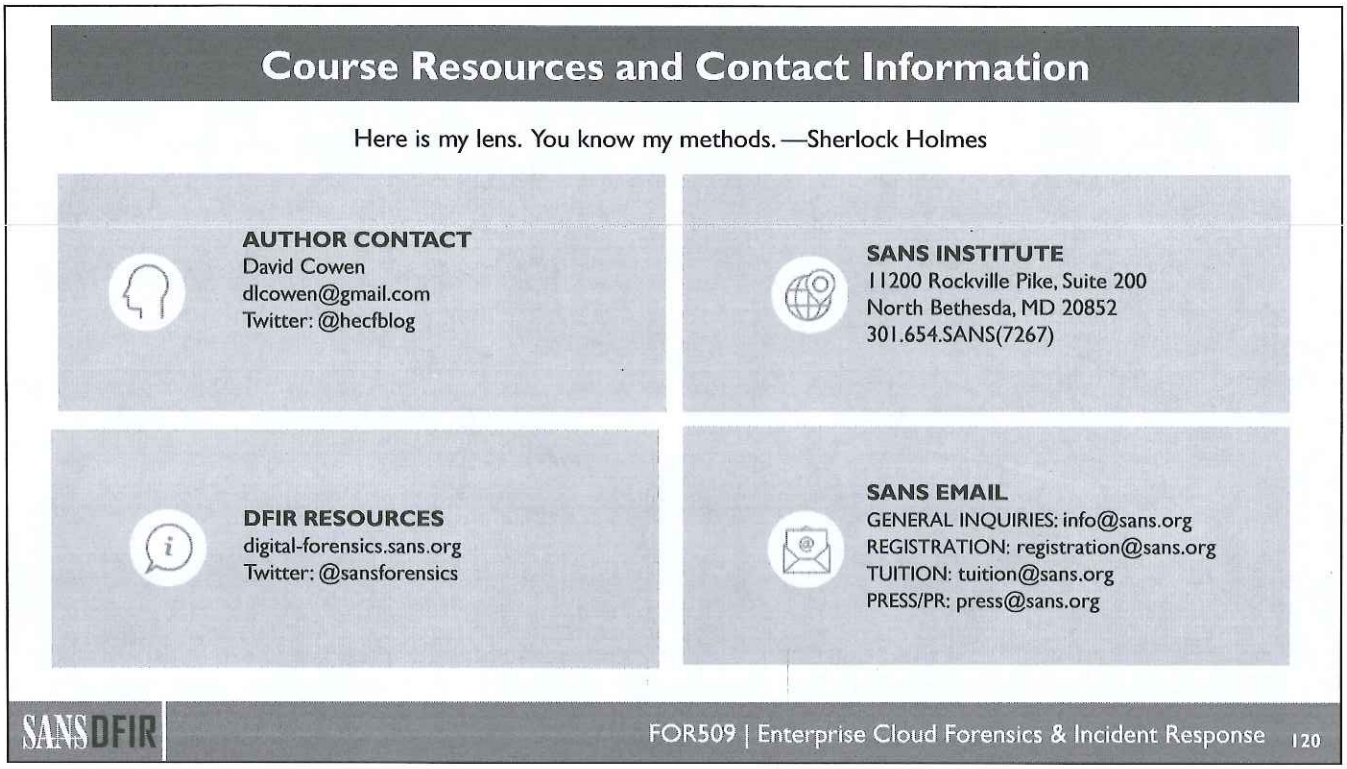

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