Lab 2: Symmetric Key

Objective: The key objective of this lab is to understand the range of symmetric key methods used within symmetric key encryption. We will introduce block ciphers, stream ciphers and padding. The key tools used include OpenSSL, Python and JavaScript.

🕮 **Web link (Weekly activities):** https://asecuritysite.com/appliedcrypto/unit02

Demo: https://youtu.be/N3UADaXmOik

A OpenSSL

OpenSSL is a standard tool that we used in encryption. It supports many of the standard symmetric key methods, including AES, 3DES and ChaCha20.

No	Description	Result

A.1	Use:
	
	`openssl list -cipher-commands`
	
	`openssl version`
		Outline five encryption methods that are supported:
		
		Outline the version of OpenSSL:

A.2	Using openssl and the command in the form: `openssl prime –hex 1111`	Check if the following are prime numbers: 42 [Yes][No] 1421 [Yes][No]
A.3	Now create a file named myfile.txt (either use Notepad or another editor). Next encrypt with aes-256-cbc `openssl enc -aes-256-cbc -in myfile.txt -out encrypted.bin -pbkdf2` and enter your password.	Use the following command to view the output file: `cat encrypted.bin` Is it easy to write out or transmit the output: [Yes][No] What does the `-pbkdf2` part do?
A.4	Now repeat the previous command and add the –base64 option. `openssl enc -aes-256-cbc -in myfile.txt -out encrypted.bin –base64 -pbkdf2`	Use following command to view the output file: `cat encrypted.bin` Is it easy to write out or transmit the output: [Yes][No]
A.5	Now Repeat the previous command and observe the encrypted output.	Has the output changed? [Yes][No]

	`openssl enc -aes-256-cbc -in myfile.txt -out encrypted.bin –base64 -pbkdf2`	Why has it changed?
A.6	Now let's decrypt the encrypted file with the correct format: `openssl enc -d -aes-256-cbc -in encrypted.bin -pass pass:napier -base64 -pbkdf2`	Has the output been decrypted correctly? What happens when you use the wrong password?

A.7	If you are working in the lab, now give your secret passphrase to your neighbour, and get them to encrypt a secret message for you. To receive a file, you listen on a given port (such as Port 1234):
	
	`nc -l -p 1234 > enc.bin`
	
	And then send to a given IP address with:
	
	`nc -w 3 [IP] 1234 < enc.bin`
		Did you manage to decrypt their message? [Yes][No]

A.8. With OpenSSL, we can define a fixed salt value that has been used in the ciphering process. For example, in Linux:

```
echo -n "Hello" | openssl enc -aes-128-cbc -pass pass:"london" -e -base64 -
S 241fa86763b85341 -pbkdf2
```

and then decrypt:

```
echo 9Z+NtmCdQSpmRl+eZebFXQ== | openssl enc -aes-128-cbc -pass
pass:"london" -d  -base64 -S 241fa86763b85341 -pbkdf2

Hello
```

For a ciphertext for 256-bit AES CBC and a message of "Hello" with a salt value of `241fa86763b85341`, try the following passwords, and determine the password used for a ciphertext of `tZCdiQE4L6QT+Dff82F5bw==` [qwerty][inkwell][london][paris][cake]

A.9. Now, use the decryption method to prove that you can decrypt the ciphertext.

```
echo tZCdiQE4L6QT+Dff82F5bw== | openssl enc -aes-256-cbc -pass
pass:"password" -d  -base64 -S 241fa86763b85341 -pbkdf2
```

Did you confirm the right password? [Yes/No]

A.10. Investigate the following commands by running them several times:

```
echo -n "Hello" | openssl enc -aes-128-cbc -pass pass:"london" -e -base64 -
S 241fa86763b85341 -pbkdf2
```

```
echo -n "Hello" | openssl enc -aes-128-cbc -pass pass:"london" -e -base64 -
salt -pbkdf2
```

What do you observe? Why do you think causes the changes?

A.11. We don't always need to use a file to save the cipher, too. With the following, we will encrypt the plaintext of "melon":

```
echo "melon" | openssl enc -e -aes-128-cbc  -pass pass:stirling -base64 -
pbkdf2
U2FsdGVkX18cryB3vdNj+Tax1PGecO6ZOW2WL1LmdKQ=
```

and then we can decrypt with:

```
echo "U2FsdGVkX18cryB3vdNj+Tax1PGecO6ZOW2WL1LmdKQ=" | openssl enc -d -aes-
128-cbc -pass pass:stirling -base64 -pbkdf2

melon
```

Now crack the following cipher using a Scottish city as a password (the password is in lower case):

```
U2FsdGVkX1+7VpBGwevibQGgescaz5nsArtGLNqFaXk=
```

What is the fruit in the plaintext?

Now try:

```
U2FsdGVkX18vpjgccu7VkPZrkncqADuy1kVKU9LbLec=
```

What is the fruit?

B Padding (AES)

With encryption, we normally use a block cipher, and where we must pad the end blocks to make sure that the data fits into a whole number of block. Some background material is here:

📖 **Web link (Padding):** http://asecuritysite.com/encryption/padding

In the first part of this tutorial we will investigate padding blocks:

No	Description	Result
B.1	With AES which uses a 256-bit key, what is the normal block size (in bytes).	Block size (bytes): Number of hex characters for block size:
B.2	Go to: 📖 **Web link (AES Padding):** http://asecuritysite.com/symmetric/padding	CMS:

	Using 256-bit AES encryption, and a message of “kettle” and a password of “oxtail”, determine the cipher using the differing padding methods (you only need to show the first six hex characters). If you like, copy and paste the Python code from the page, and run it on your Ubuntu instance.	
B.3	For the following words, estimate how many hex characters will be used for the 256-bit AES encryption (do not include the inverted commas for the string to encrypt):	Number of hex characters: “fox”: “foxtrot”: “foxtrotanteater”: “foxtrotanteatercastle”:

C Padding (DES)

In the first part of this lab we will investigate padding blocks:

No	Description	Result
C.1	With DES which uses a 64-bit key, what is the normal block size (in bytes):	Block size (bytes): Number of hex characters for block size:
C.2	Go to: 🕮 **Web link (DES Padding):** http://asecuritysite.com/symmetric/padding_des Using 64-bit DES key encryption, and a message of “kettle” and a password of “oxtail”, determine the cipher using the differing padding methods. If you like, copy and paste the Python code from the page, and run it on your Ubuntu instance.	CMS:
C.3	For the following words, estimate how many hex characters will be used for the 64-bit key DES encryption:	Number of hex characters: “fox”: “foxtrot”:

		“foxtrotanteater”: “foxtrotanteatercastle”:

D Python Coding (Encrypting)

In this part of the lab, we will investigate the usage of Python code to perform different padding methods and using AES. In the following we will use a 128-bit block size, and will pad the plaintext to this size with CMS, and then encryption with AES ECB. We then decrypt with the same key, and then unpad:

```
from cryptography.hazmat.primitives.ciphers import Cipher, algorithms, modes
from cryptography.hazmat.primitives import padding

import hashlib
import sys
import binascii

val='hello'
password='hello'

plaintext=val

def encrypt(plaintext,key, mode):
    method=algorithms.AES(key)
    cipher = Cipher(method, mode)
    encryptor = cipher.encryptor()
    ct = encryptor.update(plaintext) + encryptor.finalize()
    return(ct)

def decrypt(ciphertext,key, mode):
    method=algorithms.AES(key)
    cipher = Cipher(method, mode)
    decryptor = cipher.decryptor()
    pl = decryptor.update(ciphertext) + decryptor.finalize()
    return(pl)

def pad(data,size=128):
    padder = padding.PKCS7(size).padder()
    padded_data = padder.update(data)
    padded_data += padder.finalize()
    return(padded_data)

def unpad(data,size=128):
    padder = padding.PKCS7(size).unpadder()
    unpadded_data = padder.update(data)
    unpadded_data += padder.finalize()
    return(unpadded_data)

key = hashlib.sha256(password.encode()).digest()

plaintext=pad(plaintext.encode())

print("After padding (CMS): ",binascii.hexlify(bytearray(plaintext)))

ciphertext = encrypt(plaintext,key,modes.ECB())
print("Cipher (ECB): ",binascii.hexlify(bytearray(ciphertext)))

plaintext = decrypt(ciphertext,key,modes.ECB())

plaintext = unpad(plaintext)
print("  decrypt: ",plaintext.decode())
```

Run the program, and prove that it works. And identify the code which does the following:

Generates key:

Pads and unpads:

Encrypts and decrypts:

D1. Now update the code so that you can enter a string and the program will show the cipher text. The format will be something like:

```
python d_01.py hello mykey
```

where "hello" is the plain text, and "mykey" is the key. A possible integration is:

```
import sys

if (len(sys.argv)>1):
	val=sys.argv[1]

if (len(sys.argv)>2):
	password=sys.argv[2]
```

Now determine the cipher text for the following (the first example has already been completed – **just add the first four hex characters**):

Message	Key	CMS Cipher
"hello"	"hello123"	0a7e (c77951291795bac6690c9e7f4c0d)
"inkwell"	"orange"	
"security"	"qwerty"	
"Africa"	"changeme"	

D2. Now copy your code and modify it so that it implements **64-bit DES** and complete the table (Ref to: https://asecuritysite.com/symmetric/padding_des2):

Message	Key	CMS Cipher
"hello"	"hello123"	4cd9 (24baf0c9ac60)
"inkwell"	"orange"	
"security"	"qwerty"	
"Africa"	"changeme"	

Now modify the code so that the user can enter the values from the keyboard, such as with:

```
cipher=input('Enter cipher:')
password=input('Enter password:')
```

E Python Coding (Decrypting)

Now modify your coding for 256-bit AES ECB encryption, so that you can enter the cipher text, and an encryption key, and the code will decrypt to provide the result. You should use CMS for padding. With this, determine the plaintext for the following (note, all the plain text values are countries around the World):

CMS Cipher (256-bit AES ECB)	Key	Plain text
b436bd84d16db330359edebf49725c62	"hello"	
4bb2eb68fccd6187ef8738c40de12a6b	"ankle"	
029c4dd71cdae632ec33e2be7674cc14	"changeme"	
d8f11e13d25771e83898efdbad0e522c	"123456"	

Now modify your coding for 64-bit DES ECB encryption, so that you can enter the cipher text, and an encryption key, and the code will decrypt to provide the result. You should use CMS for padding. With this, determine the plaintext for the following (note, all the plain text values are countries around the World):

CMS Cipher (128-bit DES ECB)	Key	Plain text
0b8bd1e345e7bbf0	"hello"	
6ee95415aca2b33c	"ankle"	
c08c3078bc88a6c3	"changeme"	
9d69919c37c375645451d92ae15ea399	"123456"	

Now update your program, so that it takes a cipher string in Base-64 and converts it to a hex string and then decrypts it. From this now decrypt the following Base-64 encoded cipher streams (which should give countries of the World):

CMS Cipher (256-bit AES ECB)	Key	Plain text
/vA6BD+ZXu8j6KrTHi1Y+w==	"hello"	
nitTRpxMhGlaRkuyXWYxtA==	"ankle"	
irwjGCAu+mmdNeu6Hq6ciw==	"changeme"	
5I71KpfT6RdM/xhUJ5IKCQ==	"123456"	

PS … remember to add "`import base64`".

F Catching exceptions

If we try “1jDmCTD1IfbXbyyHgAyrdg==” with a passphrase of “hello”, we should get a country. What happens when we try the wrong passphrase?

Output when we use “hello”: Output when we use “hello1”:

Now catch the exception with an exception handler:

```
try:
      plaintext = Padding.removePadding(plaintext,mode='CMS')
      print "  decrypt: "+plaintext
except:
      print("Error!")
```

Now implement a Python program which will try various keys for a cipher text input, and show the decrypted text. The keys tried should be:

["hello","ankle","changeme","123456"]

Run the program and try to crack:

“1jDmCTD1IfbXbyyHgAyrdg==”

What is the password:

Part 2: Advanced Lab

G Stream Ciphers

The Chacha20 cipher is a stream cipher which uses a 256-bit key and a 64-bit nonce (salt value). Currently AES has a virtual monopoly on secret key encryption. There would be major problems, though, if this was cracked. Along with this AES has been shown to be weak around cache-collision attacks. Google thus propose ChaCha20 as an alternative, and actively use it within TLS connections. Currently it is three times faster than software-enabled AES and is not sensitive to timing attacks. It operates by creating a key stream which is then X-ORed with the plaintext. It has been standardised with RFC 7539.

G.1 We can use Python to implement ChaCha20:

```
from cryptography.hazmat.primitives import hashes
from cryptography.hazmat.primitives.ciphers import Cipher, algorithms
import sys
import binascii
from cryptography.hazmat.backends import default_backend

msg = "edinburgh"
key = "qwerty"

if (len(sys.argv)>1):
  msg=str(sys.argv[1])

if (len(sys.argv)>2):
  key=str(sys.argv[2])

print ("Data:\t",msg)
print ("Key:\t",key)

digest = hashes.Hash(hashes.SHA256(),default_backend())
digest.update(key.encode())
k=digest.finalize()

nonce = b'\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0'
add=''

algorithm = algorithms.ChaCha20(k, nonce)
cipher = Cipher(algorithm, mode=None, backend=default_backend())
encryptor = cipher.encryptor()
ct = encryptor.update(msg.encode())
pt = cipher.decryptor()
pt=pt.update(ct)

print ("\nKey:\t",binascii.b2a_hex(key.encode()).decode())
print ("Nonce:\t",binascii.b2a_hex(nonce).decode())
print ("\nCipher:\t",binascii.b2a_hex(ct).decode())
print ("Decrypted:\t",pt.decode())
```

If we use a key of “qwerty”, can you find the well-known fruits (in lower case) of the following ChaCha20 cipher streams:

```
e47a2bfe646a
ea783afc66
e96924f16d6e
```

What are the fruits?

What can you say about the length of the cipher stream as related to the plaintext?

How are we generating the key and what is the key length?

What is the first two bytes of the key if we use a pass-phrase of "qwerty"?

What is the salt (nonce) used in the this code?

How would you change the program so that the cipher stream was shown in in Base64?

How many bits will the salt use?

Why would the salt (nonce) value always be generated randomly?

G.2 RC4 is a standard stream cipher and can be used for light-weight cryptography. It can have a variable key size. The following is a Python implementation:

```
from cryptography.hazmat.primitives import hashes
from cryptography.hazmat.primitives.ciphers import Cipher, algorithms
import sys
import binascii
from cryptography.hazmat.backends import default_backend



msg = "edinburgh"
key = "napier"

if (len(sys.argv)>1):
    msg=str(sys.argv[1])

if (len(sys.argv)>2):
    key=str(sys.argv[2])

print ("Data:\t",msg)
print ("Key:\t",key)

digest = hashes.Hash(hashes.SHA256(),default_backend())
digest.update(key.encode())
k=digest.finalize()

algorithm = algorithms.ARC4(k)
cipher = Cipher(algorithm, mode=None, backend=default_backend())
encryptor = cipher.encryptor()
ct = encryptor.update(msg.encode())
pt = cipher.decryptor()
pt=pt.update(ct)
```

```
print ("\nKey:\t",binascii.b2a_hex(key.encode()).decode())

print ("\nCipher:\t",binascii.b2a_hex(ct).decode())
print ("Decrypted:\t",pt.decode())
```

For a password of “napier”, find out the fruits used for these RC4 cipher streams:

```
8d1cc8bdf6da
911adbb2e6dda57cdaad
8907deba
```

What are the fruits?

What happens to the cipher when you add an IV (salt) string?

For light-weight cryptography, what is the advantage of having a variable key size:

How might we change the program to implement RC4 with a 128-bit key?

H Node.js for encryption

Node.js can be used as a back-end encryption method. In the following we use the crypto module (which can be installed with “**npm crypto**”, if it has not been installed). The following defines a message, a passphrase and the encryption method.

```
var crypto = require("crypto");

function encryptText(algor, key, iv, text, encoding) {
        var cipher = crypto.createCipheriv(algor, key, iv);
        encoding = encoding || "binary";
        var result = cipher.update(text, "utf8", encoding);
        result += cipher.final(encoding);
        return result;
    }
function decryptText(algor, key, iv, text, encoding) {
        var decipher = crypto.createDecipheriv(algor, key, iv);
```

```
        encoding = encoding || "binary";

        var result = decipher.update(text, encoding);
        result += decipher.final();

        return result;
    }


var data = "This is a test";
var password = "hello";
var algorithm = "aes256"

#const args = process.argv.slice(3);

#data = args[0];
#password = args[1];
#algorithm = args[2];

console.log("\nText:\t\t" + data);
console.log("Password:\t" + password);
console.log("Type:\t\t" + algorithm);

var hash,key;

if (algorithm.includes("256"))
{
        hash = crypto.createHash('sha256');
        hash.update(password);



        key = new Buffer.alloc(32,hash.digest('hex'),'hex');
}
else if (algorithm.includes("192"))
{
        hash = crypto.createHash('sha192');
        hash.update(password);

        key = new Buffer.alloc(24,hash.digest('hex'),'hex');
}

else if (algorithm.includes("128"))
{
        hash = crypto.createHash('md5');
        hash.update(password);

        key = new Buffer.alloc(16,hash.digest('hex'),'hex');
}


const iv=new Buffer.alloc(16,crypto.pseudoRandomBytes(16));

console.log("Key:\t\t"+key.toString('base64'));
console.log("Salt:\t\t"+iv.toString('base64'));

var encText = encryptText(algorithm, key, iv, data, "base64");

console.log("\n===============");

console.log("\nEncrypted:\t" + encText);

var decText = decryptText(algorithm, key, iv, encText, "base64");

console.log("\nDecrypted:\t" + decText);
```

Save the file as “h_01.js” and run the program with:

```
node h_01.js
```

Now complete the following table:

Text	**Pass phrase**	**Type**	**Ciphertext and salt (just define first four characters of each)**
This is a test	hello	`Aes128`	
France	Qwerty123	`Aes192`	
Germany	Testing123	`Aes256`	

Now reset the IV (the salt value) to an empty string (“”), and complete the table:

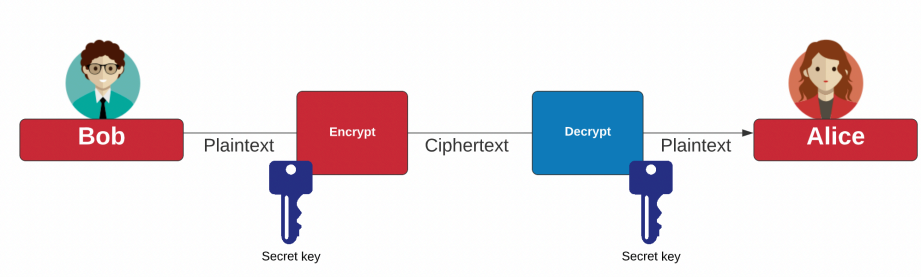
Text	**Pass phrase**	**Type**	**Ciphertext**
This is a test	hello	`Aes128`	
France	Qwerty123	`Aes192`	
Germany	Testing123	`Aes256`	

Does the ciphertext change when we have a fixed IV value?

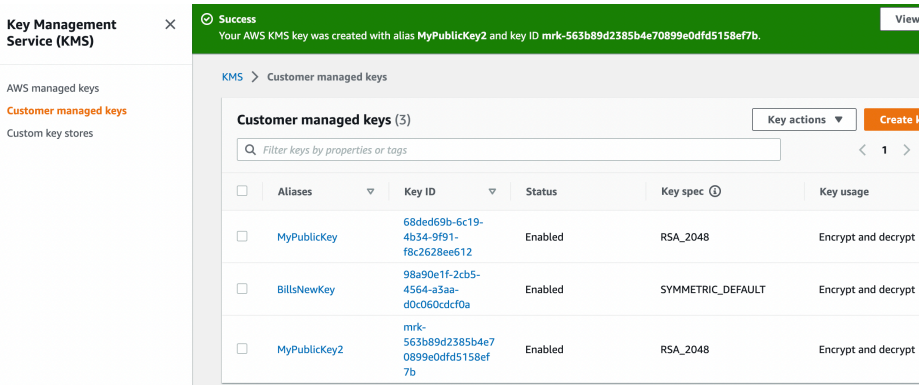
Using an Internet search, list ten other encryption algorithms which can be used with `createCipheriv`:

Part 3: AWS Encryption

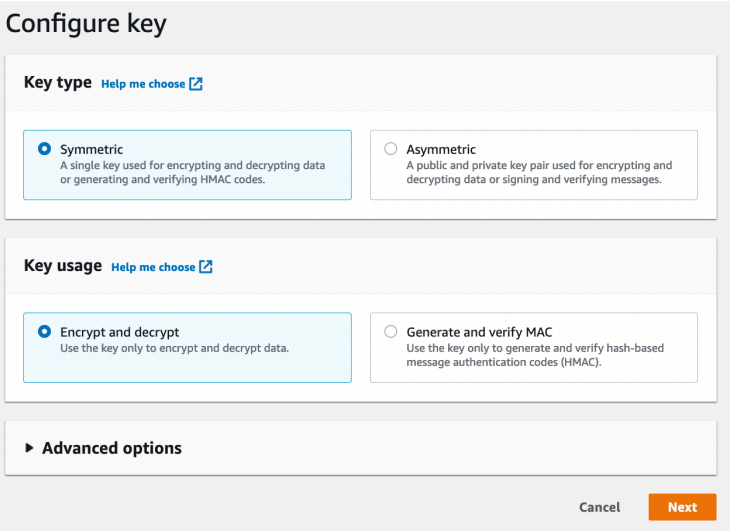
You should have access to your AWS Learner Lab, and where we will use AWS KMS (Key Management System) to generate encryption keys, and use symmetric key encryption. With symmetric key encryption, Bob and Alice use the same encryption key to encrypt and decrypt. In the following case, Bob and Alice share the same encryption key, and where Bob encrypts plaintext to produce ciphertext. Alice then decrypts with the same key, in order to recover the plaintext:



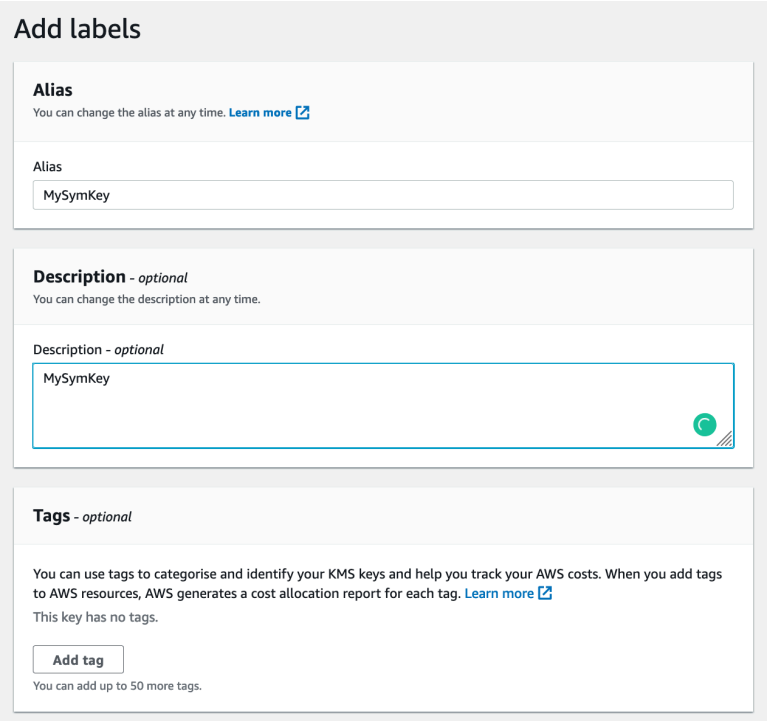
Normally we use AES encryption for this. Initially in KMS, we create a new key within our **Customer managed keys**:



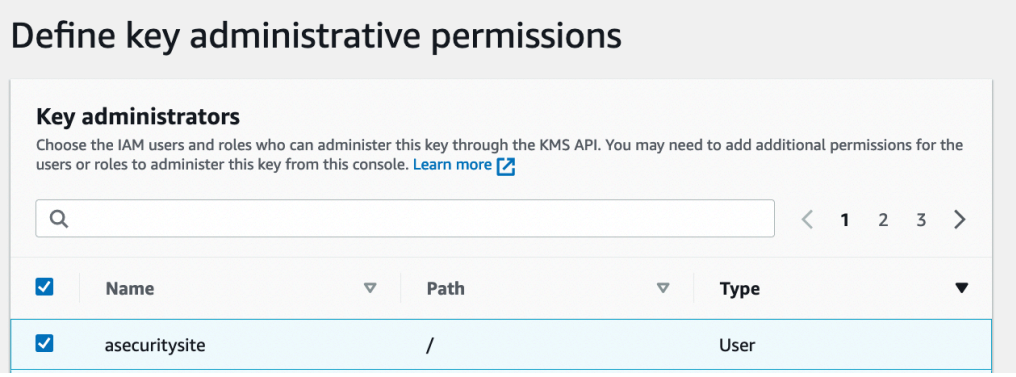
and then create the key:



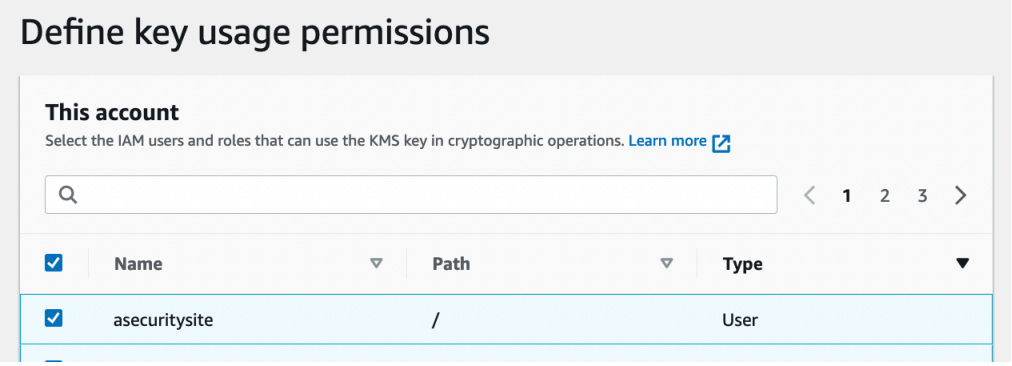
Next, we give it a name:



And then define the administrative permission (those who can delete it):



And the usage:



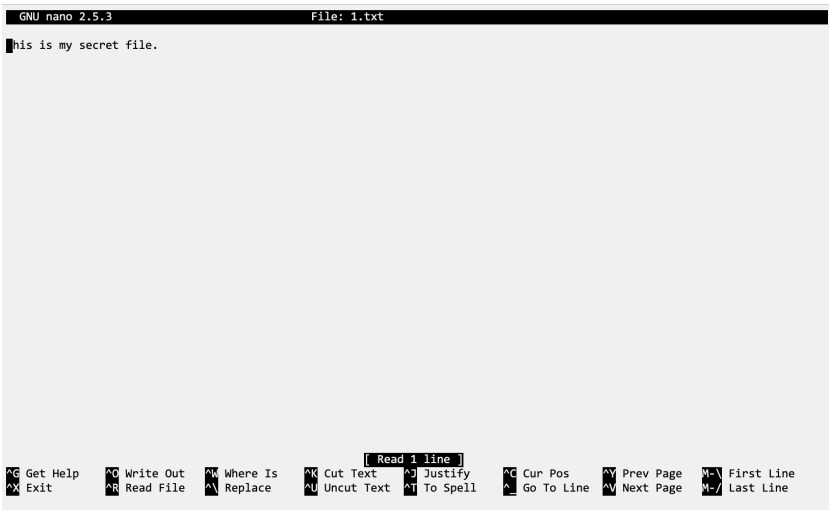
The policy is then:

```
{
    "Id": "key-consolepolicy-3",
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "Enable IAM User Permissions",
            "Effect": "Allow",
            "Principal": {
                "AWS": "arn:aws:iam::22222222:root"
            },
            "Action": "kms:*",
            "Resource": "*"
        },
        {
            "Sid": "Allow access for Key Administrators",
            "Effect": "Allow",
            "Principal": {
                "AWS": [
                    "arn:aws:iam::22222222:role/LabRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/trustedadvisor.amazonaws.com/AWSServiceRoleForTrustedAdvisor",
                    "arn:aws:iam::22222222:role/aws-service-
role/events.amazonaws.com/AWSServiceRoleForCloudWatchEvents",
                    "arn:aws:iam::22222222:role/EMR_EC2_DefaultRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/elasticache.amazonaws.com/AWSServiceRoleForElastiCache",
                    "arn:aws:iam::22222222:role/aws-service-
role/organizations.amazonaws.com/AWSServiceRoleForOrganizations",
                    "arn:aws:iam::22222222:role/EMR_DefaultRole",
                    "arn:aws:iam::22222222:role/EMR_AutoScaling_DefaultRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/cloud9.amazonaws.com/AWSServiceRoleForAWSCloud9",
                    "arn:aws:iam::22222222:role/aws-service-
role/support.amazonaws.com/AWSServiceRoleForSupport"
                ]
            },
            "Action": [
                "kms:Create*",
                "kms:Describe*",
                "kms:Enable*",
                "kms:List*",
                "kms:Put*",
                "kms:Update*",
                "kms:Revoke*",
                "kms:Disable*",
                "kms:Get*",
                "kms:Delete*",
                "kms:TagResource",
                "kms:UntagResource",
                "kms:ScheduleKeyDeletion",
                "kms:CancelKeyDeletion"
            ],
            "Resource": "*"
        },
        {
            "Sid": "Allow use of the key",
            "Effect": "Allow",
            "Principal": {
                "AWS": [
                    "arn:aws:iam::22222222:role/LabRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/trustedadvisor.amazonaws.com/AWSServiceRoleForTrustedAdvisor",
                    "arn:aws:iam::22222222:role/aws-service-
role/events.amazonaws.com/AWSServiceRoleForCloudWatchEvents",
                    "arn:aws:iam::22222222:role/EMR_EC2_DefaultRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/elasticache.amazonaws.com/AWSServiceRoleForElastiCache",
                    "arn:aws:iam::22222222:role/aws-service-
role/organizations.amazonaws.com/AWSServiceRoleForOrganizations",
                    "arn:aws:iam::22222222:role/EMR_DefaultRole",
                    "arn:aws:iam::22222222:role/EMR_AutoScaling_DefaultRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/cloud9.amazonaws.com/AWSServiceRoleForAWSCloud9",
                    "arn:aws:iam::22222222:role/aws-service-
role/support.amazonaws.com/AWSServiceRoleForSupport"
                ]
            },
```

```
            "Action": [
                "kms:Encrypt",
                "kms:Decrypt",
                "kms:ReEncrypt*",
                "kms:GenerateDataKey*",
                "kms:DescribeKey"
            ],
            "Resource": "*"
        },
        {
            "Sid": "Allow attachment of persistent resources",
            "Effect": "Allow",
            "Principal": {
                "AWS": [
                    "arn:aws:iam::22222222:role/LabRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/trustedadvisor.amazonaws.com/AWSServiceRoleForTrustedAdvisor",
                    "arn:aws:iam::22222222:role/aws-service-
role/events.amazonaws.com/AWSServiceRoleForCloudWatchEvents",
                    "arn:aws:iam::22222222:role/EMR_EC2_DefaultRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/elasticache.amazonaws.com/AWSServiceRoleForElastiCache",
                    "arn:aws:iam::22222222:role/aws-service-
role/organizations.amazonaws.com/AWSServiceRoleForOrganizations",
                    "arn:aws:iam::22222222:role/EMR_DefaultRole",
                    "arn:aws:iam::22222222:role/EMR_AutoScaling_DefaultRole",
                    "arn:aws:iam::22222222:role/aws-service-
role/cloud9.amazonaws.com/AWSServiceRoleForAWSCloud9",
                    "arn:aws:iam::22222222:role/aws-service-
role/support.amazonaws.com/AWSServiceRoleForSupport"
                ]
            },
            "Action": [
                "kms:CreateGrant",
                "kms:ListGrants",
                "kms:RevokeGrant"
            ],
            "Resource": "*",
            "Condition": {
                "Bool": {
                    "kms:GrantIsForAWSResource": "true"
                }
            }
        }
    ]
}
```

Setting up encryption

Now create a file named 1.txt, and enter some text:



Once we have this, we can then encrypt the file using the “aws kms encrypt” command, and then use “fileb://1.txt” to refer to the file:

```
aws kms encrypt  --key-id alias/MySymKey   --plaintext fileb://1.txt
  --query CiphertextBlob --output text > 1.out
cat 1.out
```

This produces a ciphertext blob, and which is in Base64 format:

```
AQICAHgTBDpVTrBTrduWKdNnvMoMMUWjObqp+GqbghUx7qa6JwEQ7F2Fzubd+pcz3I06
bFuLAAAAdjB0BgkqhkiG9w0BBwagZzBlAgEAMGAGCSqGSIb3DQEHATAeBglghkgBZQME
AS4wEQQMgl3vWRVPyL7KK3klAgEQgDP+dQ4KsqT94hiARF8zlybFAtXJJBIucc8M952K
HmkJzBGQQP4f8YQQ7ODELV97ZXizzME=
```

We could transmit this in Base64 format, but we need to convert it into a binary format for us to now decrypt it. For this we use the “Base64 -d” command:

```
$ base64 -i 1.out  --decode > 1.enc
$ cat 1.enc
```

The result is a binary output:

```
$ cat 1.enc
x:UNS)g
00e0`  1`He.0']3*:l[v0t *H
]YO7+y%3u
D_3&$.q
i        @@-_{exddd_v1_w_W3n_145559
```

Now we can decrypt this with our key, and using the command of:

```
$ aws kms decrypt --key-id alias/MySymKey   --output text --query
Plaintext --ciphertext-blob fileb://1.enc > 2.out
$ cat 2.out
```

The output of this is our secret message in Base64 format:

```
VGhpcyBpcyBteSBzZWNyZXQgZmlsZS4K
```

and now we can decode this into plaintext:

```
$ base64 -i 2.out  --decode
This is my secret file.
```

The commands we have used are:

```
aws kms encrypt  --key-id alias/MySymKey   --plaintext
fileb://1.txt  --query CiphertextBlob --output text > 1.out
echo "== Ciphertext (Base64)"
cat 1.out
echo "== Ciphertext (Binary)"
base64 -i 1.out  --decode > 1.enc
cat 1.enc
```

```
aws kms decrypt --key-id alias/MySymKey  --output text --query
Plaintext --ciphertext-blob fileb://1.enc > 2.out
echo "== Plaintext (Base64)"
cat 2.out
echo "== Plaintext"
base64 -i 2.out  --decode
```

and the result of this is:

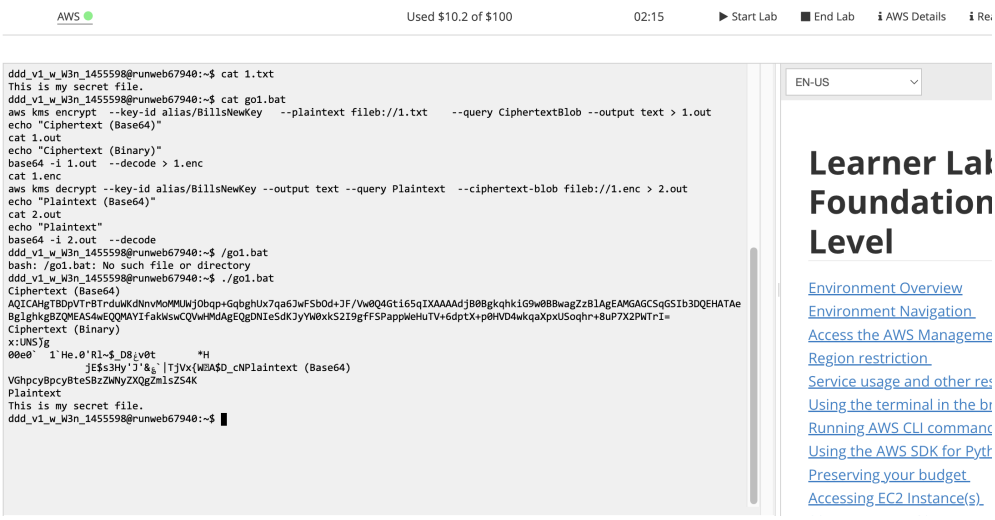
```
== Ciphertext (Base64)
AQICAHgTBDpVTrBTrduWKdNnvMoMMUWjObqp+GqbghUx7qa6JwEfz+s9z3e0Mw0tOzuB
5LuYAAAAdjB0BgkqhkiG9w0BBwagZzBlAgEAMGAGCSqGSIb3DQEHATAeBglghkgBZQME
AS4wEQQMqqwXsxB5QlQGVqZWAgEQgDOyBv6KYg4wN2bU/ZKSJ+5opJXMrjQj9GGvuuD2
/Jeto9Er5yS91/iCb896CzCSeqUYJeo=

== Ciphertext (Binary)
x:UNS)g
00e0`v0t`He.0'=w*H
yBTVV3b07f'ђ4#a+$oz
0z%

== Plaintext (Base64)
VGhpcyBpcyBteSBzZWNyZXQgZmlsZS4K

== Plaintext
This is my secret file.
```

Here's a sample run in an AWS Foundation Lab environment:



Using Python

Along with using the CLI, we can create the encryption using Python. In the following we use the boto3 library, and have a key ID of "98a90e1f-2cb5–4564-a3aa-d0c060cdcf0a" and which is in the US-East-1 region:

```
import base64
import binascii
import boto3

AWS_REGION = 'us-east-1'
```

```
def enable_kms_key(key_ID):
    try:
        response = kms_client.enable_key(KeyId=key_ID)

    except ClientError:
        print('KMS Key not working')
        raise
    else:
        return response


def encrypt(secret, alias):
    try:
        ciphertext =
kms_client.encrypt(KeyId=alias,Plaintext=bytes(secret,
encoding='utf8'),
        )
    except ClientError:
        print('Problem with encryption.')
        raise
    else:
        return base64.b64encode(ciphertext["CiphertextBlob"])


def decrypt(ciphertext, alias):
    try:
        plain_text =
kms_client.decrypt(KeyId=alias,CiphertextBlob=bytes(base64.b64decode
(ciphertext)))
    except ClientError:
        print('Problem with decryption.')
        raise
    else:
        return plain_text['Plaintext']

kms_client = boto3.client("kms", region_name=AWS_REGION)

KEY_ID = '98a90e1f-2cb5-4564-a3aa-d0c060cdcf0a'
kms = enable_kms_key(KEY_ID)
print(f'KMS key ID {KEY_ID} ')
msg='Hello'
print(f"Plaintext: {msg}")

cipher=encrypt(msg,KEY_ID)
print(f"Cipher {cipher}")
plaintext=decrypt(cipher,KEY_ID)
print(f"Plain: {plaintext.decode()}")
```

Each of the steps is similar to our CLI approach. A sample run gives:

```
KMS key ID 98a90e1f-2cb5-4564-a3aa-d0c060cdcf0a
Plaintext: Hello
Cipher
b'AQICAHgTBDpVTrBTrduWKdNnvMoMMUWjObqp+GqbghUx7qa6JwHH797e/TF4csEBEF
NmjvD5AAAAYzBhBgkqhkiG9w0BBwagVDBSAgEAME0GCSqGSIb3DQEHATAeBglghkgBZQ
MEAS4wEQQMJf0xVfikbMLfLI6jAgEQgCDYBm2NvB/I2NMxGgSw8wuWA/p6c6Jjm19/wK
4eVrLXUw=='
Plain: Hello
```

Postscript

I Reflective questions

1. If we have five ‘a’ values (“aaaaa”). What will be the padding value used for 256-bit AES with CMS:

2. If we have six ‘a’ values (“aaaaaa”). What will be the hex values used for the plain text:

3. The following cipher text is 256-bit AES ECB for a number of spaces (0x20):

```
c3f791fad9f9392116b2d12c8f6c4b3dc3f791fad9f9392116b2d12c8f6c4b
3dc3f791fad9f9392116b2d12c8f6c4b3dc3f791fad9f9392116b2d12c8f6c
4b3da3c788929dd8a9022bf04ebf1c98a4e4
```

What can you observe from the cipher text: What is the range that is possible for the number of spaces which have been used: How might you crack a byte stream sequence like this:

4. For ChaCha20, we only generate a key stream. How is the ciphertext then created:

J What I should have learnt from this lab?

The key things learnt:

- How to encrypt and decrypt with symmetric key encryption, and where we use a passphrase to generate the encryption key.
- How padding is used within the encryption and decryption processes.
- The core difference between a block cipher and a stream cipher.

Notes

The code can be downloaded from:

```
git clone https://github.com/billbuchanan/appliedcrypto
```

If you need to update the code, go into the appliedcrypto folder, and run:

```
git pull
```

To install a Python library use:

```
pip install libname
```

To install a Node.js package, use:

```
npm install libname
```

For B.2 you might need to install these:

```
pip install pycrypt
pip install padding
```

Possible solutions

Have a look at:
https://github.com/billbuchanan/esecurity/blob/master/unit02_symmetric/lab/possible_ans.md